2026 MIDWEST VEGETABLE PRODUCTION GUIDE

FEATURING PRODUCTION MANAGEMENT STRATEGIES FOR DISEASES, WEEDS, INSECTS, AND FERTILITY. THIS COMPREHENSIVE GUIDE CAN BE UTILIZED BY COMMERCIAL GROWERS OF ALL SCALES

Acknowledgments and Disclaimers

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Letter to Readers

Welcome to the 2026 edition of the Midwest Vegetable Production Guide. The bug folks went hard on this one, fleshing out some non-pesticide options for management of lots of pests across all chapters. There is also a new crop of research/extension specialists all across the region. Please take time to reach out to them and say hello to weed scientists, Ram Yadav at OSU, Albert Kwarteng at Lincoln, and Josh Miranda at MSU; plant pathologists, Cesar Escalante at Purdue and Andres Sanabria-Velazquez at OSU; and entomologist Ashley Leach at OSU!

Best of luck this year!

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Soil Fertility and Nutrient Management

Reviewed by Liz Maynard and Ajay Nair – Apr 2022
Reviewed by Ben Phillips – Oct 2024

Soil tests aid vegetable growers with their soil fertility and fertilizer application programs. Soil tests are most useful when growers keep accurate records for each field that include the amount of fertilizers and other soil amendments they applied, crop yields, and rotations. These records allow growers to determine trends in soil fertility and crop response to applied fertilizers over several years.

Efficient vegetable production relies on growers adjusting lime and fertilizer applications to their soils' existing pH and fertility levels. Growers can increase their net returns if they maintain proper soil fertility, which can reduce crop losses from physiological disorders. Applying nutrients based on crop needs and existing soil nutrient levels also reduces the movement of nutrients into groundwater and surface waters.

Take soil samples at the same time each year, preferably in the fall or early spring. Soil pH varies seasonally, so comparing winter and summer samples is difficult. A typical soil test for plants usually determines pH, lime index (also called buffer pH), available Bray P1 phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg), and cation exchange capacity. It also includes the% base saturation of Ca, Mg, and K.

In addition to the routine pH test, growers should test soils that are susceptible to large variations in soil pH for salt pH. The salt pH provides a more accurate estimate of the true acidity in these soil types by simulating the effects of fertilizer salts on soil pH.

There are also tests to determine organic matter and other nutrients, including sulfur (S), manganese (Mn), boron (B), and zinc (Zn). Some labs test for microbial activity and water-soluble carbon, which can predict the release of nitrogen and phosphorus from organic sources.

Your land-grant university or extension service can provide you with a list of soil testing labs in your area.

Soilless Growing Media

Test soilless growing media used in transplant or crop production for pH and total soluble salts before using it. Request a test specifically for "soilless media" from the lab. If the crop will be grown in soilless media for more than a month, regularly test the media or plant tissue to catch any nutrient imbalances that may affect crop growth and yield.

Interpretation of Standard Soil Test Results

Organic matter (O.M.) content of the soil is usually reported as a% by weight, determined in a lab by loss-on-ignition. It is composed of the remains of living things after initial decomposition has occurred. This relatively stable O.M. commonly ranges from 1% to 7% in mineral soils. Soil that has received heavy applications of compost may have higher values. Soils with O.M. greater than 20% are categorized as organic or 'muck' soils. Nutrient and lime recommendations differ for muck and mineral soils. O.M. content also influences the effectiveness of some soil applied herbicides. In sandy and sandy loam soils, organic matter improves water-holding capacity.

When management takes these factors into account, vegetables are successfully grown in soils with a wide range of O.M. However, O.M. in cultivated soils declines over time to the detriment of soil fertility. You can add O.M. to the soil by various methods using green manure crops, cover crops, crop residues, animal manures, mulches, and composts. Additions of undecomposed or partially decomposed materials feed soil microorganisms and increase biological activity in the soil. This promotes development of soil aggregates, thus improving drainage, soil tilth, and soil structure. Some laboratories use additional methods to measure less stable forms of soil organic matter that support microbial growth.

Soil pH (sometimes called active soil acidity) is based on the pH scale, which measures the acidic or basic reaction of the soil. A pH less than 7 is acidic; a pH greater than 7 is alkaline. When soil pH is too low for good crop growth, adding lime will raise the pH. Natural processes and agricultural practices tend to lower pH over time, so it is important to measure it every year or two. When soils are alkaline, the testing laboratory may recommend applying sulfur (S) to lower the pH to a level that allows nutrient availability in the soil.

Lime index (sometimes called "buffer pH") measures reserve soil acidity. The lime index is used to make limestone recommendations. It usually takes lime four to six months to correct soil acidity. Your land-grant university or extension service can provide you with liming recommendations specific to your state.

Phosphorus may be reported as P (phosphorus) or P_2O_5 (phosphate). The units for P and other nutrient values may be given as parts per million (ppm) or pounds per acre. The value is an estimate of the amount of phosphorus in the soil that the

plant can use for growth. Applying P_2O_5 fertilizer at 100 pounds per acre will increase the soil P test level by about 10 pounds per acre.

Potassium may be reported as K (potassium) or K_2O (potash). The test value estimates the amount of K available per acre. About 50% of the potassium applied in fertilizers is fixed in the soil and is not immediately available to plants — this can vary by soil type and clay content. Soil K declines due crop removal, leaching, and soil erosion.

Calcium (Ca) and magnesium (Mg) soil test values represent the amount of Ca and Mg available in the soil. Ca and Mg values generally are low when soils are acidic. Levels are usually sufficient when pH and the lime test index are at proper levels.

Cation exchange capacity (CEC) is a measure of the soil's ability to hold exchangeable cations such as hydrogen (H), Ca, Mg, K, sodium (Na), iron (Fe), and aluminum (Al). CEC is measured in terms of milliequivalents (meq) per 100 grams of soil. Soil type and soil organic matter determine CEC. Clay-, silt- and loam-type soils generally have a higher CEC than sandy soils because they have many more exchange sites to hold cations. High-CEC soils generally hold nutrients better than low-CEC soils. High-CEC also lose smaller amounts of nutrients due to leaching.

Here are the typical CEC ranges of various soil types:

Soil Texture	CEC Range
Sands	5-15
Silts	8-30
Clays	25-50
Organic soils	50+

Base saturation is the percentage of the total CEC occupied by basic cations such as Ca, Mg, and K. Base saturation is related to soil pH and soil fertility. On acid soils, the% base saturation of Ca and Mg is low. The saturation of the different cations is important because plants take up some cations more easily than others. The base saturation for Ca should be 60% or more; Mg should range between 10 and 15%; K should range from 1 to 5%. Excess levels of one cation can reduce the uptake of another. Some soil scientists believe that there should be specific Ca:Mg ratios and Mg:K ratios (2:1). Most horticulturists believe that if base saturation levels are at the minimum levels suggested here, then it is not important to maintain specific proportions or ratios.

Crop Nutrient Requirements

Vegetable crops require 17 essential elements (nutrients) for development and reproduction. In addition to carbon (C), hydrogen (H), and oxygen (O), plants need macronutrients in large concentrations and micronutrients in relatively small concentrations.

Each crop has a crop nutrient requirement (CNR) for particular nutrients. The CNR is defined as the total amount of the nutrient (in pounds per acre) the crop requires to produce optimum economic yield. The concept of optimum economic yield is important in vegetable production, because applying a certain amount of a nutrient might produce a lot of biomass, but may produce negligible marketable product due to small fruit size, small number of fruits, or large number of culls and small number of marketable fruits. Always consider fruit number, size, and quality in the CNR concept for vegetable production.

The best way to achieve the CNR is to begin with a soil test. The results from a soil lab analysis include recommendations for the amount of lime or sulfur needed to balance the soil pH, and indicate the amount of fertilizer needed to deliver the CNR.

Macronutrients

Nitrogen (N), phosphorus (P), and potassium (K) are the primary macronutrients, and they are commonly applied in fertilizers for field vegetable production. Plant nutrient recommendations are often given as pounds of N, pounds of phosphate (P_2O_5) and pounds of potash (K_2O) per acre.

It is up to growers to figure how much fertilizer or product they must apply to meet the suggested recommendations. This can be tricky, because growers may need more than one kind of fertilizer product to meet the recommendations.

Fertilizer products are required to list the% N, P_2O_5, and K_2O equivalent they contain — and the products are listed in the order: N-P-K. For example, a fertilizer labeled 10-10-10 contains the equivalent of 10% N, 10% P_2O_5, and 10% K_2O. So a pound of this fertilizer would contain 0.1 pound each of N, P_2O_5, and K_2O. Urea labeled 46-0-0 contains 46% N, 0% P_2O_5, and 0% K_2O. Potassium chloride (muriate of potash) labeled 0-0-60 contains 0% N, 0% P_2O_5, and 60% K_2O. Organic fertilizers are also labeled this way — a 3-2-2 product contains 3% N, 2% P_2O_5, and 2% K_2O. It is important to note that some of the N and P in organic fertilizers require warm, moist soil and microbial activity before it is available to plants.

Let's say a nutrient recommendation calls for 100 pounds of N and 100 pounds of K_2O per acre.

A grower could meet that recommendation by using 217 pounds of urea (217 pounds of urea X 0.46 N = 100 pounds of N) and 167 pounds of potassium chloride (167 pounds of potassium chloride X 0.60 K_2O = 100 pounds of K_2O).

A grower could also meet that recommendation by using 1,000 pounds of premixed 10-10-10 fertilizer (1,000 pounds of fertilizer X 0.10 N = 100 pounds of N; 1,000 pounds of fertilizer X 0.10 K_2O = 100 pounds of K_2O).

But that same fertilizer would also supply 100 pounds of P_2O_5 that is not needed. So, using such a fertilizer could be a waste of money and could pollute surface or ground water.

If you choose a premixed fertilizer, select the ratio of nutrients that comes closest to the amount of recommended nutrients. It is not necessary to be exact as long as any differences are reasonable. If you can't get to the recommended nutrient application using premixed fertilizers, it is fine to first make a base application using a standard fertilizer ratio, and then apply individual elements to reach the recommended nutrient levels.

For example, you can supply extra N with urea or urea ammonium nitrate (UAN) solution; you can supply extra K with muriate of potash. Custom-blended fertilizers can be made to almost any desired ratio.

Nitrogen (N)

Standard soil tests aren't very useful for predicting how much N fertilizer you need to apply to optimize yield and quality. The recommendations in this guide are based on data from relevant field trials. Adjust these recommendations according to experience, soil type, pH, cropping history, additions of organic matter, and crop culture system.

For example, suppose your vegetable crop is following soybeans, alfalfa, or a grass-legume hay crop. If your soils have more than 3% organic matter, you may not need to add any sidedressed N. If your soils have less than 3% organic matter, then half the total N can be applied preplant and the other half sidedressed early in the crop growth cycle. Now suppose your vegetable crop is following corn, rye, oats, wheat, or a previous vegetable crop. There may be no residual soil N available, so the crop may benefit from additional sidedressed N.

Plants can take up N in the form of ammonium (NH_4^+) or nitrate (NO_3^-). In the soil, ammonium is converted into nitrate, and vice versa, by particular sets of microbes. When soil pH is near neutral (pH 7), and the soil is moist and warm, the microbial conversion of ammonium to nitrate (nitrification) is rapid, and crops generally take up nitrate. In acid soils (pH lower than 6), nitrification is slow, and plants will take up a higher percentage of N as ammonium.

Volatilization from N fertilizers that contribute ammonium to the soil (such as urea) is likely to be high at higher soil pH levels. However, depending on soil temperature and moisture, volatilization can be significant at lower soil pH levels, too, especially if the soil is dry and the fertilizer is not incorporated. To minimize volatilization, apply N in just the quantities plants need during the growing season, incorporate it into the soil, and use slow-release sources when possible.

Soil pH is also an important factor in the N nutrition of legumes. Plants in this family are able to fix N from the soil with the help of several genera of soil bacteria known collectively as Rhizobia. As soils become more acidic, Rhizobia decline in activity, fixing less N.

Phosphorus (P)

P recommendations for vegetables are based on the soil test value, the type of crop, and estimates of crop removal. On mineral soils, most vegetables will benefit from P fertilization if the soil test is less than 35-40 ppm P using the Bray-Kurtz P1 extraction method. If a soil tests report P values based on the Mehlich-3 extraction, multiply these values by 1.35. If the soil test on a mineral soil is more than 80 ppm P, then no additional P is recommended for most vegetables.

Plants absorb P from the soil solution in the form of soluble phosphates. P does not move readily in the soil, and applied P easily reacts with soil minerals so that it is unavailable to the plant. The amount of P in solution at any time is usually extremely low — often less than 1 pound per acre. That is why phosphate fertilizer is applied in bands near the crop when possible, and transplant starter solutions that are high in P are recommended.

The type of mineral that gets formed in the soil depends on the soil's pH. In alkaline soils, P in fertilizers such as mono-ammonium phosphate (11-55-0) usually react with Ca to form calcium phosphate minerals. The P in calcium phosphate minerals is not available to plants, but as plants remove P from the soil solution, the minerals gradually dissolve to replenish the supply of P in the soil solution. Greenhouse and field research has shown that more than 90% of the fertilizer P tied up in calcium phosphate minerals will be available to crops in future years.

In acid soils, P usually reacts with Al and Fe, instead of Ca. Aluminum and iron phosphates do not dissolve as readily as

calcium phosphates, so in acid soils, applied P tends to be tied up more than in alkaline soils.

Potassium (K)

K recommendations for vegetables are based on the soil test value, the soil CEC, the type of crop, and estimates of crop removal. The soil test values below are based on ammonium acetate extraction. If a soil tests report K values based on Mehlich-3 extraction, multiply these values by 1.14.

Vegetables usually benefit from K fertilization if the soil test is:

- Less than 85 ppm K in soil with low CEC (4 meq/100 g).
- Less than 115 ppm K in soil with med CEC (16 meq/100 g).

The maximum annual K recommendation for most vegetables is 300 pounds of K_2O per acre. K fertilization is not usually recommended if the soil test is more than 135 ppm K on a soil with low CEC, or more than 165 ppm K on a soil with medium CEC.

In soils with certain types of clay, K is fixed at specific sites between clay layers. In acid conditions, Al occupies the binding sites that would otherwise trap K, and so K is unbound to soil and is leachable. Liming increases K stability in these soils.

Calcium (Ca), Magnesium (Mg), Sulfur (S)

Calcium (Ca), Magnesium (Mg) and Sulfur (S) are considered secondary macronutrients because plants require them in smaller amounts than N, P, and K.

Ca and Mg usually are deficient in acid soils, and adding the appropriate form of lime solves most Ca and Mg deficiency problems (see Soil pH and Adjustment). When Ca is deficient and there is no need to increase soil pH, you may use gypsum (calcium sulfate) as a source of Ca. Similarly, you can add Mg without affecting pH by using Epsom salts (magnesium sulfate, 10% Mg), sul-po-mag (11% Mg), or finely ground magnesium oxide (e.g., MAGOX, 58% Mg).

If a soil test shows low Mg (less than 50 ppm in Minnesota or less than 40 ppm in other states), apply Mg at 100 pounds per acre broadcast or 20 pounds per acre in the row.

If a soil test shows medium Mg (51-100 ppm in Minnesota or 40-69 ppm in other states) apply Mg at 50 pounds per acre broadcast or 10 pounds per acre in the row.

You can make foliar sprays of Epsom salts at the rate of 10 to 15 pounds in a least 30 gallons per acre to temporarily solve Mg deficiencies during the growing season.

Plants absorb sulfur as sulfate (SO_3^{2-}), and sulfate availability is little affected by soil pH, though elemental sulfur compounds can be used to lower pH. If a soil test indicates a need for sulfur and there is no need to adjust pH, materials such as gypsum (calcium sulfate), Epsom salts (magnesium sulfate), ammonium sulfate, potassium sulfate, or potassium-magnesium sulfate can be used. Make sure to account for the nutrients in addition to sulfur that these materials supply.

Micronutrients

Micronutrients include boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn). Of these nutrients, those most likely to be lacking in Midwest soils used for vegetable production are B and Mn. Zn may also be a concern in some areas.

Deficiencies of micronutrients Mn, Fe, Cu, Zn, and B are more likely in high pH soils, and toxicities are more likely in low pH soils. Conversely, Mo deficiency is more likely in low pH soils.

Manganese (Mn)

Mn deficiency is common in some areas. Mn deficiency occurs primarily on lakebed and fine-textured, dark- colored soils with high pH. Cool, wet conditions tend to intensify Mn deficiency. Beans, beets, onions, spinach, and tomatoes have high requirements, but deficiencies also are reported for cucumbers, peppers, and turnips.

Apply manganese sulfate at 2 to 4 pounds per 100 gallons per acre to eliminate deficiency problems observed during the growing season. Fungicides containing Mn can also help correct deficiencies.

Boron (B)

B leaches readily, so responsive crops often need annual applications on sandy loam, loamy sand, sandy, and muck soils. Deficiency symptoms include browning on cauliflower heads, cracked stems on celery, blackheart on beet, and internal browning on turnip.

Broccoli, cauliflower, celery, beet, turnip, and rutabaga are likely to respond to B applications of 3 to 4 pounds per acre when soil levels are low. Cabbage, carrot, lettuce, parsnip, radish, spinach, and tomato show a medium response and usually benefit from 1 to 2 pounds of B per acre.

Bean, peas, and cucumber are sensitive to B, so do not apply it to these crops.

You can add B to the soil with Borax (which contains 10.6% B) or Solubor (which contains 20.5% B). B applications are most effective if applied with the fertilizer at preplant or at the time of transplanting.

Mid- or late season foliar applications are not as effective as early granular or foliar applications. It is important not to exceed recommended B rates to avoid toxicity in subsequent B-sensitive crops. Carryover is most likely after a dry fall and winter.

Other micronutrient deficiencies are rare in field-grown vegetable crops in this region.

Fertilizer and the Environment

Nitrogen from both natural (manure, compost, green manure) and synthetic sources can be lost from fields, which can pollute water and increase greenhouse gasses that contribute to climate change. Similarly, natural and synthetic sources of P can move out of cropped areas and pollute waterways. With proper fertilizer management, vegetable producers can minimize environmental impacts and improve fertilizer use efficiency. Growers should know their crops, account for the nutrient values of all soil amendments, and test soils and plants to support their fertilizer decisions.

Split N applications — applying some N before planting and sidedressing the rest during the season — are generally more efficient than complete preplant applications. However, split applications require growers to pay attention to crop growth and sidedress at the appropriate times: before crops are stressed, and early enough to allow crops to mature.

Banding P at planting (with or without some P being broadcast/incorporated) is generally more efficient than broadcasting all P. Sidedressing P is not recommended because it is not mobile in soils.

Generally, K and the minor elements do not contribute significantly to groundwater pollution, but growers should manage them properly to minimize costs and maximize efficiency.

Minimizing soil erosion, timing irrigation properly, and avoiding excess irrigation will also improve fertilizer use efficiency and reduce losses from the field.

Animal Manures and Composts as Fertilizers

Animal manures and composts can provide significant nutrients to plants. The nutrient content of manures varies among animal species and within each species. Nutrients in composts can vary even more and depend on parent material and processing. Test manures and composts to determine the potential nutrient contributions and plan application rates based on their nutrient content. Avoid using composts of unknown origin or parent material. Improperly made composts, be they of rural or urban origin, can contain heavy metals, inorganic debris, diseases, and insects that are unwelcome on your fields.

It is important to consider the timing of manure and compost applications. Fresh manure has potential to “burn” a crop because it often contains high levels of ammonia, and fresh or casually “aged” manure often contains human pathogens. For these reasons, it is rarely acceptable to apply fresh or “aged” manure to food crops while they are growing. Generally, a fall application is acceptable, ideally to a cover crop, and at least nine months before harvesting the next vegetable crop.

Any use of manure or composts should follow current Good Agricultural Practices (GAPs), and mandates of the Food Safety Modernization Act (FSMA). The demands of a particular market may be more stringent. For guidance about GAPS and FSMA, see Produce Food Safety section.

Fertilizer Application Methods

Fertilizer application timing and methods vary from farm-to-farm depending on cultural practices and equipment. This section outlines common practices of efficient fertilizer placement and utilization. These practices can be modified to suit particular situations.

Usually, growers can apply at preplant and disk into the soil 50-60% of the recommended N and all of the P and K fertilizer. This is especially true when the rates of a complete fertilizer will require more than 400 pounds per acre.

We recommend band application for many direct-seeded vegetable crops. This technique applies a concentrated line of fertilizer 2 inches to the side and 2 inches below the seed furrow. This is an efficient way to apply fertilizer, and much of the P and K fertilizer can be applied this way. However, do not make banded fertilizer applications exceeding 80 pounds per acre of N plus K — this can injure seed.

For crops grown on plastic mulch (with or without a raised bed) growers may apply fertilizer just to the bed area. As with broadcast applications, growers can apply a portion of the recommended N, and all of the P and K before planting. If N will be supplied through fertigation during the season, apply only 20 to 50% of the total N before planting. Apply the remaining N with regular drip irrigation at 5 to 10 pounds of N per week until the total recommended for the season has been applied. K may also be applied through drip irrigation if the crop needs more than has been applied to the soil before planting. For more information on the equipment required for fertigation, and its calibration and use, please refer to the Chemical Application and Safety Chapter.

If you apply only part of the recommended N before planting, apply the remainder as a sidedressing when the plants are still young, or apply N through fertigation before and during the period of rapid crop growth. Early sidedress applications are especially important with crops such as sweet corn, broccoli, and cabbage. The total N applied during the growing season (broadcast, plus banded, plus transplant starter, plus sidedressed, plus fertigated) should equal the recommended N rate. Applying more than the recommended rate of N may be necessary when there are leaching rains.

Transplanted crops often respond to a small amount of water-soluble fertilizer in the transplanting water. Special fertilizer grades (such as 14-28-14, 10-52-10, 23-21-17) are used at a rate of 3 pounds per 50 gallons of water. The high-P liquid 10-34-0 can also be used at the rate of 2 quarts per 50 gallons of water. Apply starter solutions at 8 ounces per plant. If dry weather is prevalent, irrigate after setting the plants.

Soil pH and Adjustment

Soil pH describes whether the soil solution is acidic or alkaline. The native pH of Midwest soils varies from quite acidic (pH 5.0 or lower) to quite alkaline (pH 7.5 or higher). Most vegetable crops prefer a pH range of 6.0-6.8 on mineral soils. On muck soils, a pH of 5.5-5.8 is considered adequate. Vegetables grown under acid soil conditions lack vigor and yield poorly. Acid soils restrict the uptake of nutrients such as P and K. Acid soils also make elements such as aluminum (Al) and manganese (Mn) more available to plants so that the plant may absorb enough to be toxic to the plant. Under severe conditions, visible foliage injury can result from magnesium (Mg) deficiency and/or Mn toxicity. Physiological disorders such as blossom end rot are more common on acid soils. In contrast, when soil pH is high, Mn, B, iron (Fe), and certain other micronutrients become less available for plant uptake. Deficiencies of these micronutrients are most likely to occur on mineral soils with pH greater than 7.4.

Liming Recommendations

Fields usually require lime every few years because Ca and Mg are removed in harvested portions of the crop, leached out of surface soil by rainfall, and lost from the field when soil erodes. Lime is also needed to neutralize acidity produced by acid-forming fertilizers.

Growers sometimes need to add lime to correct subsoil acidity. In that case, apply enough lime to bring the surface soil to pH 6.8. The subsoil pH will increase only if you maintain the surface pH near 6.5 or more. Over time, rain will leach the Ca and Mg into the subsoil, raising its pH. Because this downward movement takes several years, the sooner the lime is applied, the better.

In most cases, make split applications when the recommendation is more than 4 tons per acre. This will achieve a more thorough mixing with the acidic soil.

Apply half the lime before primary tillage and half before soil finishing. For best results, apply the lime at least six months before seeding a legume.

If you have a recommendation for a maintenance application of 2 tons per acre or less, you can apply it at any time in the cropping sequence.

Several types of lime that may be used to manage soil pH and/or Ca and Mg are described below.

Calcitic lime (also called high-calcium lime — 50-56% CaO, 1-4% MgO) is the most soluble form and is the preferred type when soil Ca is low and soil Mg is high. It generally reacts the fastest and is the most common form available in some areas.

Magnesian lime (also called hi-mag lime — 32-42% CaO, 5-15% MgO) is intermediate in solubility and is the preferred type when pH, Ca, and Mg are low. The continued use of high-Mg liming materials increases the base saturation of Mg and decreases Ca saturation, which may result in Ca deficiencies during stress periods.

Dolomitic lime (30% CaO, 20% MgO) is the preferred type when Mg is particularly low. Dolomitic lime is the least soluble of the materials.

Hydrated lime (60% CaO, 12% MgO) reacts most rapidly with the soil, but unlike the ground limestones described above, it does not continue to provide liming activity over a period of years. Hydrated lime is caustic to humans and plants, and applicators must take care not to burn plants. Use hydrated lime only in emergencies when rapid changes in soil pH are needed.

Gypsum is not a liming material and does not affect soil pH. It is a crude calcium sulfate product consisting chiefly of calcium sulfate with combined water ($CaSO_4$ $2H_2O$). Although gypsum is not capable of neutralizing soil acidity, it is a source of calcium and sulfur.

Fluid lime is a suspension of finely ground limestone in water, and may contain other dispersing agents. Finely ground limestone reacts with soil more quickly than normal limestone. In fluid lime, 100% of the liming material must pass through a 100-mesh screen, and nearly 80 to 90% must pass through an even smaller 200-mesh screen. The principles of effectiveness of ground agricultural lime also apply to fine or fluid lime. Lime suspensions do not possess any special capabilities compared with conventional agricultural lime that contains a high degree of 60-mesh or finer particles.

Pelletized lime, or pell-lime, is finely ground lime that has been formed into pellets for easy application. Because it is finely ground, it will react quickly in the soil. Unlike regular ag lime, it will not provide residual liming activity over a few years.

Acidifying Recommendations

Ammonium-releasing nitrogen fertilizers have an acidifying effect on soils over time. Elemental sulfur (90% S) can be used to reduce soil pH more drastically if it is too high for good crop growth. The amount required depends on the pH of the soil, the desired pH, and the soil texture or CEC. To achieve a soil pH of 6.5, use the following amounts of sulfur:

Sandy soil pH 8: 1,200 lb./A or 27.5 lb./1000 sq.ft.
Sandy soil pH 7.5: 500 lb./A or 11.5 lb./1000 sq.ft.
Loamy soil pH 8: 1,500 lb./A or 34.4 lb./1000 sq.ft.
Loamy soil pH 7.5: 800 lb./A or 18.4 lb./1000 sq.ft.

Incorporate sulfur into the soil. pH will gradually decrease when the soil is warm (>55 F) and moist enough for biological activity; don't expect it to occur overwinter or in dry soil. In high tunnels where an increase in soil pH results from alkaline irrigation water, smaller annual applications of sulfur can be used to counteract the alkalinity and prevent gradual increase in soil pH.

Plant Tissue Analysis

Plant tissue analysis for nutrients is a useful tool in managing plant health, and a tissue test is usually required to confirm a diagnosis of nutrient deficiency. Tissue testing can be especially helpful when growing a new crop or a familiar crop in a new production system.

Regular tissue tests, especially early in the growing season, will provide early notice of nutrient imbalances so they can be corrected before yield or quality is affected. With high value greenhouse crops regular tissue testing is often a standard part of production.

Concentrations of nutrients in plant tissue that are normal, deficient, or excessive have been identified for most vegetables. The concentrations depend on the plant part and stage of growth. Before collecting plant tissue, contact a tissue testing lab and request instructions for collecting and submitting samples. The specific plant part to collect for tissue analysis varies depending on the crop; often it is a recently mature leaf. The stage of crop growth is important because normal tissue nutrient concentrations change with growth.

If the tissue test is being used to diagnose a specific symptom, collect separate samples from each of these groups:

- Symptomatic plants
- Healthy plants
- Plants with minor symptoms

Comparing the results of these three samples, along with results of soil tests, can help in determining the problem. For assistance in interpreting plant tissue tests, contact your local extension vegetable specialist.

Cover Crops

Cover crops can improve soil biology, chemistry, and physical characteristics in ways that translate into better crop growth. They can help avoid soil erosion, manage soilborne diseases, and retain nutrients.

Growers typically plant winter cover crops after harvest in late summer or fall and terminate the crop the following spring. Depending on the cover crop, termination is accomplished through natural winter-kill, tillage, herbicide, roller-crimping, or tarping, Additional N may be needed to hasten the decomposition of the cover crop and avoid tie-up of soil nitrogen. This is especially important with winter rye, which should be terminated before it is 18 inches tall if it will be incorporated into the soil.

The overwintering capacity of any cover crop is dependent on prevailing winter temperatures and conditions. Depending on winter weather, a cover crop may overwinter in one region and winter-kill in another. Field peas and crimson clover generally winter-kill, but sometimes they do not and must be terminated in the spring.

Spring and summer cover crops are planted before and/or after an annual cash crop. These crops generally are terminated

before they are mature. At this stage, the plants usually contain the greatest amount of N and other nutrients, plus an adequate amount of moisture for rapid decay. However, sometimes they are terminated or tilled under in the mature dry stage. At that stage, they do not decompose as readily, and additional N may be needed to aid decomposition.

Crops planted especially for increasing soil fertility are often called green manures. They include legumes such as clovers, alfalfa, and soybean that increase soil N through their partnership with *Rhizobia* bacteria. Also, non-legumes such as thickly sown field corn, sudangrass, or buckwheat serve as green manures by scavenging nutrients and adding fresh organic matter.

Different cover crops frequently require different soil conditions for optimum growth. For example, alfalfa does best on well-drained soils, while Ladino clover grows on poorly drained soils. Some crops, such as cereal rye, have fibrous root systems, whereas others, such as sweet clover, have large tap roots. Whenever it is possible to use a mixture of these crops, the combination results in more organic matter for the soil.

Cover Crops for Vegetable Farms

This table describes some characteristics of cover crops that may be used for vegetable crops. For more information about cover crops, visit the Midwest Cover Crops Council website, midwestcovercrops.org, or refer to the SARE resource, *Managing Cover Crops Profitably*, at sare.org/resources/managing-cover-crops-profitably-3rd-edition.

Type	Cover Crop	Pounds/ Bushel	Quantity of Seed per Acre (pounds)	Desirable Seeding Dates
Grasses	Rye	60	90-120 (alone) 90 (mixture)	Sept. 1-Nov. 10
Grasses	Perennial or common ryegrass	24	15-20 (alone) 5-8 (mixture)	Aug. 1-Sept. 15
Grasses	Sudangrass	40	20-30	May 15-July 1
Grasses	Field corn	56	50-60	May 15-July 1
Grasses	Winter barley	48	80-100	2-3 weeks before fly-safe date
Grasses	Wheat	60	90-120	Hessian fly-safe date
Legumes	Sweet clover	60	16-20 (alone) 10-12 (mixture)	March 1-April 15 July 15-Aug. 20
Legumes	Red clover	60	10-15 (alone)	Feb. 1-April 1
Legumes	Soybean	60	90-100	May 15-July 1
Legumes	Alfalfa	60	12-18	March-April
Legumes	Hairy vetch	60	15-20 (mixture)	Sept. 1-Nov. 1
Mixtures	Rye/ hairy vetch		90/15-20	Sept. 1-Oct. 1
Mixtures	Ryegrass/ Sweet clover		5-8 12-15	July 15-Aug. 20
Mixtures	Sweet clovers/ Orchardgrass		6-8	March 1-April 15

Examples of Integrating Cover Crops

Below are examples of five, four-year cropping sequences that you can use with vegetable crops. Each cover crop rotation sequence is designed to take advantage of legumes for N-fixation, grass or buckwheat to suppress weeds, and brassica cover crops for bio-fumigation and reducing soil compaction. These rotations won't work on every farm. Growers should try likely rotations in manageable areas to develop the best strategy for their farms.

Example 1

Year 0
Fall before Year 1: Plant oats and peas as cover crops

Year 1
March: If field peas do not winter kill, terminate by mowing, tillage, or herbicide
April-August: Onion production
August-November: Crimson clover as a cover crop

Year 2
March: If crimson clover does not winter kill, terminate by tillage or herbicide
April-August: Potato production
August-November: Sorghum-sudangrass as a cover crop

Year 3
March-May: Leave winter-killed sorghum-sudangrass
May-October: Sweet potato production
October-June of Year 4: Cereal rye as a cover crop

Year 4
April-May: Terminate cereal rye by tillage, herbicide, or roller-crimping
June-September: Cucumber production
September-November: Oats and field peas as a cover crop

Year 5
Return to Year 1

Example 2

Year 0
Fall before Year 1: Cereal rye and hairy vetch as cover crops

Year 1
March-June: Terminate cereal rye and hairy vetch, leave residue on surface
June-October: Pumpkin production
November-May of Year 2: Cereal rye as a cover crop

Year 2
March-May: Terminate cereal rye as cover crop

May-September: Tomato production
September-November: Buckwheat as a cover crop

Year 3
March: Leave winter-killed buckwheat
April-August: Carrot production
August-November: Crimson clover as a cover crop

Year 4
March-May: If crimson clover does not winter kill, terminate by tillage or herbicide
May-September: Sweet corn production
September-November: Cereal rye and hairy vetch as cover crops

Year 5
Return to Year 1

Example 3

Year 0
Fall before Year 1: Oilseed radish as cover crop

Year 1
March: Leave winter-killed oilseed radish
April-June: Lettuce production
July-August: Buckwheat as cover crop
August-November: Cauliflower production
November-June of Year 2: Cereal rye as a cover crop

Year 2
March-June: Terminate cereal rye cover crop
June-October: Eggplant or pepper production
October-May of Year 3: Triticale as cover crop

Year 3
March-May: Terminate triticale
May-September: Onion production
September-November: Oats and field peas as cover crops

Year 4
March-May: Leave winter-killed oats; terminate field peas if not winter-killed
May-September: Cucumber production
September-November: Oilseed radish as cover crop

Year 5
Return to Year 1

Example 4

Year 0
Fall before Year 1: Cowpea as cover crop

Year 1
March-May: Leave winter-killed cowpea
May-August: Sweet corn production
August-October: Buckwheat as cover crop
October-August of Year 2: Garlic production

Year 2
March-August: Leave garlic
August-November: Sorghum-sudangrass as cover crop

Year 3
March-June: Leave winter-killed sorghum-sudangrass
June-November: Pumpkin or winter squash production
November-April of Year 4: Cereal rye as cover crop

Year 4
March: Terminate cereal rye cover crop
April-August: Potato production
August-October: Cowpea as cover crop

Year 5
Return to Year 1

Example 5

Year 0
Fall before Year 1: Yellow mustard as cover crop

Year 1
March-May: Leave winter-killed mustard
May-September: Cantaloupe production
September-June of Year 2: Cereal rye and hairy vetch as cover crops

Year 2
March-June: Terminate cereal rye and hairy vetch cover crops
June-October: Sweet potato production
October-April of Year 3: Triticale as cover crop

Year 3
March: Terminate triticale cover crop
April-July: Cauliflower production
July-August: Buckwheat as cover crop
August-November: Lettuce or spinach production
November-May of Year 4: Cereal rye as cover crop

Year 4
March-May: Terminate cereal rye cover crop
May-September: Pepper production
September-November: Mustard as cover crop

Year 5
Return to Year 1

Transplant Production

Reviewed by Liz Maynard, Brad Bergefurd – Apr 2022

Transplant production has replaced direct seeding for many vegetable crops. One of transplanting's primary advantages is earlier fruit production, allowing growers to capture better market conditions. In addition, the high cost of hybrid seed makes it desirable to use each seed as efficiently as possible. Transplanting also gives the crops a competitive advantage against weeds. This section addresses the special skills and knowledge required for successful transplant production.

Most growers use polyethylene-covered greenhouse structures to provide warmth and protection from the environment. Although cole crops do not need the more moderating conditions a greenhouse provides, they can be grown in coldframes, lean-tos, or covered wagon beds.

The heater is one of the most critical features of a transplant ghouse. Vegetable transplants must be kept at the appropriate temperatures. However, if heaters are improperly exhausted, the transplants can be stunted or deformed. To prevent heater fumes from returning into the greenhouse, chimneys should extend two feet above the ridge of the greenhouse.

There should be some provision for bringing fresh air into the greenhouse. Some heaters vent fresh air into the greenhouse every time the furnace operates. For others, a hole or holes should be cut in the greenhouse wall and fitted with tubes to feed outside air to the heater. Avoid space heaters that may "spit" diesel or gasoline onto nearby plants. Heated air should be circulated using a perforated "sock" or tube that runs the length of the greenhouse, or fans placed on opposite sides of the greenhouse and blowing in opposite directions. Place thermometers in several locations to measure the temperature at plant level. At least one high-low thermometer is a good investment.

For detailed information about greenhouse structures, see *Greenhouse Engineering* (NRAES-33), available from Cornell University Library, ecommons.cornell.edu .

Transplant Containers

A wide variety of transplant containers are available, each with advantages and disadvantages. The most common ones are:

- Styrofoam trays (e.g., Speedling)
- Polystyrene or PVC flats or trays.
- Peat strips, pots or pellets (e.g., Jiffy).

Peat pot containers have the advantage that the root system need not be disturbed upon planting. Peat pots also are more forgiving of overwatering than other containers. If peat pots are planted partially above ground, moisture is "wicked" away from the plant, often resulting in plant death — peat pellets do not have this disadvantage.

Polystyrene and Todd planter flats are both designed so that transplants must be "popped" out of the trays, thus disturbing the root system. This is particularly true if the roots are allowed to grow into the ground beneath the tray. Avoid this problem by raising the flats off the ground. Both the polystyrene and Todd planter flats must be watered with care. Todd planter flats have a pyramidal design that forces roots downward to an open bottom where the roots are air pruned. Some polystyrene containers have open bottoms — tube types have open bottoms, groove types have small drainage holes.

In general, peat type containers are the most expensive, followed by the Todd planter type, then the polystyrene type.

The number of plants in a tray depends on the cell size for each plant. Vegetables are commonly grown in trays with 30 to 300 cells. In general, larger cells lead to greater early yield in fruiting crops. Larger cells are also easier to manage because the greater soil volume holds more water and nutrients. Due to the expense of building and maintaining greenhouse space, many growers have moved to smaller cell volumes so more transplants can be grown in the limited space available. Some growers use two different cell sizes: a larger size for crops they expect to harvest earlier, and a smaller size for crops they expect to harvest later.

Seeding and Growing

Most vegetable transplants are sown one seed per cell. As a general rule, plant vegetable seeds at a depth two times their diameter. Vegetable seeds temperature requirements vary; most vegetable seeds germinate in the 70 F to 90 F range. The time from seeding to transplanting varies from three to four weeks (e.g., cantaloupe) to 10 to 12 weeks (e.g., celery).

Vegetable seed may be ordered with special features, including seed priming and pelletizing. Primed seeds have been partially hydrated, then dried down, resulting in earlier germination and better uniformity. Priming may be useful for hard-to-germinate seed such as triploid watermelon. Seed may be pelletized to make it easier to handle. In this process, varieties with small seeds, or irregular seeds (such as lettuce) are coated to make the seed larger and uniform in size and shape. This process makes mechanized planting easier.

The growing mix should be well-drained and free of disease-causing organisms (pathogens). Most commercial mixes fit this description and perform well. These mixes are often referred to as "soilless mixes" since they are composed primarily of peat or coconut coir, perlite or vermiculite, and sometimes bark or ash. These mixes usually come in bales or bags and have been pasteurized (sufficiently heated to kill soil microorganisms capable of causing disease problems). It is advisable to test the mix before using it to make sure the pH is within an acceptable range (between 5.5 and 6.5) and to determine the initial nutrient content of the mix.

Most mixes include a small amount of fertilizer, but transplants usually benefit from additional regular nitrogen (N), phosphorus (P), and potassium (K) fertilization once true leaves appear. Depending on the initial nutrient level in the mix, including calcium (Ca) and magnesium (Mg) in the fertilizer solution may also be advised. Soluble synthetic fertilizers (21-5-20, 20-10-20) and liquid organic fertilizers (e.g. fish emulsion) are commonly used. The best rate, frequency, and method of fertilization will depend on your potting mix and watering practices. Common alternatives include a 50 to 200 ppm N solution applied at every watering, or a 300 to 500 ppm N solution applied weekly. Mixes that contain significant amounts of compost may not benefit from additional fertilizer until several weeks into transplant growth.

To make a 100 ppm N solution, use 0.42 pounds (6.6 ounces) of a 20% nitrogen fertilizer for every 100 gallons of water, or 4 fluid ounces of a liquid fertilizer containing 3% nitrogen for 10 gallons of water. Over-application of ammoniacal N can be detrimental to transplants. This problem can be minimized by not over-applying N, and by using fertilizer in which most N is in the nitrate form. Check the bag label.

Transplants that are too tall and tend to fall over are often referred to as "spindly," "shanky," or "leggy." Such transplants may have low survival rates in the field. Spindly transplants are produced under low light conditions, high fertilizer rates, and/or overwatering. Cloudy weather or greenhouse structures that don't let in adequate light could be the culprits. Artificial lights could be helpful during inclement weather, but may be cost prohibitive.

Under such conditions, use a fertilizer containing a lower percentage of P. For instance, try 21-5-20 rather than 20-20-20. It is important to provide adequate P, but not too much. Under fertilization with P will produce short plants, but yields also will suffer. Hot days and cold nights favor leggy transplants. If night temperatures are equal to or higher than day temperatures, stem elongation will be reduced. It may be sufficient to lower the temperatures for a two-hour period starting at dawn.

To prepare transplants for the harsher environment of the field, it is necessary to harden them off. Transplants may be hardened off by withholding water and lowering temperatures moderately during the last week or so of growth. Some growers place transplants in wagons and wheel the transplants outside on appropriate days to get the plants used to field conditions. The transplants are wheeled back inside at night and during especially harsh weather.

After transplanting, plants should be irrigated as soon as possible. Some transplanters are equipped to irrigate plants at the time of transplanting. Otherwise, arrange to irrigate soon. Applying a small amount of starter fertilizer in the transplant water is often beneficial. If transplants are held in the greenhouse to replace those that don't survive, remember to avoid using transplants that have begun to vine or flower.

Diseases

Diseases that are likely to affect vegetable transplant production in the Midwest fall into two types: damping- off diseases (caused by soilborne fungi) and transplant diseases (usually associated with fungi, bacteria, or viruses that survive with seed or plant residue). These diseases can cause extensive transplant loss.

Damping-off may occur before or after seedlings emerge from the soil. Preemergence damping-off occurs when fungi infect seeds as they germinate. As infections progress, seeds rot and eventually disintegrate. Poor stands become apparent after several days or weeks.

Postemergence damping-off is usually observed in seed flats or among transplants. Fungi infect stems at or near the soil surface. The affected area of the stem takes on a water-soaked appearance and sometimes becomes constricted. Eventually, the stems are unable to maintain the structural support of seedlings, which usually collapse and die within 24 to 48 hours.

Several soilborne fungi cause damping-off on vegetables. *Fusarium*, *Phytophthora*, *Pythium*, and *Rhizoctonia* species are well known causal agents of pre- and postemergence damping-off. Control measures to prevent damping-off diseases include:

- Using uncontaminated soil mix. Use a commercially prepared soilless growing mix sold in 3 to 4 cubic foot bales or bags. A common mistake is to open a bag of "clean" soil mix and place it on a dirty floor or some other unclean surface prior to planting. Remember that your soil is only as clean as the dirtiest surface it has contacted.
- Planting seeds shallow and in warm soil.
- Using soil mixes that drain well.

Seedborne and residue-borne diseases affect most vegetable crops. The pathogens (disease-causing microorganisms) survive in or on seeds or plant residues, not in soil mixes. Outbreaks of these diseases often show up as clusters of diseased plants, and symptoms often include brown lesions with yellow halos on leaves. By contrast, environmentally induced problems often occur uniformly throughout the seedlings or only in one location (for example, close to an outside wall).

Several different fungal, bacterial, or viral pathogens may be introduced into a transplant facility via contaminated seed or transplants (Common Seedborne Diseases of Vegetable Crops Frequently Grown as Transplants).

Once introduced, these pathogens may continue to cause problems year after year if proper precautions are not taken.

Common Seedborne Diseases of Vegetable Crops Frequently Grown as Transplants

Vegetable Crop	Disease
cabbage	Alternaria leaf spot, black rot
cantaloupe	anthracnose, gummy stem blight
cucumber	angular leaf spot
pepper	bacterial spot
squash	squash mosaic (squash mosaic virus)
tomato	bacterial canker, bacterial speck, bacterial spot
watermelon	anthracnose, gummy stem blight, bacterial fruit botch

Several measures should be taken to minimize or prevent introducing seedborne or residue-borne pathogens into a transplant facility:

- Avoid saving seed unless you are specifically trained and equipped for seed production.
- Inspect seedlings frequently while they are growing.
- Separate seedlots from one another. Save all information regarding seed purchases.
- Irrigate in the morning to ensure soil and leaf surfaces dry.
- Check fungicide and bactericide labels for specific mentions of greenhouse use when treating transplants (see the Conversions for Liquid Pesticides on Small Areas table, in the Pesticide Application and Safety section, for liquid pesticide conversions).
- Practice good sanitation. Plant pathogens often survive in soil and plant residues. Therefore, sanitation is as important for a greenhouse as it is for a kitchen. Greenhouse floors should be as free of soil and residue as possible; plastic or cloth floor coverings provide a barrier between dirt floors and transplants. Transplant trays and flats should be new or cleaned and disinfected before each transplant generation.

More detailed information about disease prevention and control in the greenhouse is available in *Preventing Seedling Diseases in the Greenhouse* (Purdue Extension publication BP-61-W), and *Commercial Greenhouse and Nursery Production: Sanitation for Disease and Pest Management*, available from the Purdue Extension Education Store (HO-250-W), edustore.purdue.edu.

A few chemicals are labeled for disease control in greenhouse vegetable crops. Restricted use pesticides can only be used by certified pesticide applicators who have the greenhouse certification on their applicator licenses. Restricted use pesticides are identified prominently on the label.

If a pesticide is not restricted use and is labeled for the crop in question, check the label. If it does not mention greenhouse use, then it may be used in greenhouses. Otherwise, the label may explicitly prohibit greenhouse use. Thus, a specific label for greenhouse use for some products is not required; but you must carefully read each label to be certain the greenhouse use is not prohibited. Apply according to labeled rates and timing.

Products that may be used in the greenhouse are listed in Sanitizers Table.

Seed Treatments

Seed treatments are useful for preventing damping-off and some other root diseases in vegetable crops. Seed treatments can also eliminate certain pathogens carried in or on the seed.

There are two general types of seed treatment: eradicative and protective.

Eradicative seed treatments kill disease-causing agents on or within seed and are useful in controlling certain seedborne diseases.

Protective seed treatments are applied to the seed surface and protect the seed against decay and damping-off caused by soilborne organisms.

For more information, see *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens*, Ohio State University Extension Fact Sheet HYG-3085-05.

Hot Water Treatment

When properly used, hot water treatments kill most disease-causing organisms on or within seed. This treatment is suggested for eggplant, pepper, tomato, cucumber, carrot, spinach, lettuce, celery, cabbage, turnip, radish, and other crucifer seed. Improper treatment can injure seed. Hot-water treatment can severely damage cucurbit seed.

Prewarm seed in a loosely woven cotton bag (not over half full) for 10 minutes in 100 F water. Then, place the prewarmed seed in a water bath that will constantly hold the water at the recommended sterilizing temperature (see Water Bath Temperatures and Treatment Lengths below). The length of treatment and temperature of the water must be exact. After treatment, dip bags in cold water to stop heating action, and then spread seed out to dry. Always apply a protective seed treatment fungicide to hot-water-treated seed.

This treatment can injure old seed. Always test a small sample of any seed lot more than a year old by treating it, and testing for germination to determine the amount of injury, if any, that might occur.

Water Bath Temperatures and Treatment Lengths

The water bath temperatures and treatment lengths should be followed exactly.

Seed	Temperature (F)	Minutes
Brussels sprouts, cabbage, eggplant, spinach, tomato	122	25
Broccoli, cauliflower, cucumber, carrot, collard, kale, kohlrabi, rutabaga, turnip	122	20
Mustard, cress, radish	122	15
Pepper	125	30
Lettuce, celery, celeriac	118	30

Chlorine Treatment

Chlorine treatment effectively removes bacterial and fungal pathogens on the seed surface. Chlorine treatment is recommended for pepper, tomato, cucurbits, and other vegetables if the seeds have not been treated by another method.

Agitate seeds in a solution of 1 quart of household bleach, 4 quarts of water, and 1 teaspoon of surfactant for 1 minute. Use 1 gallon of this disinfectant solution per pound of seed and prepare a fresh solution for each batch. After placing seed in this solution, remove, and rinse thoroughly in running tap water for five minutes. After that, spread out seed to dry. Dust the seed with Thiram 75WP at 1 teaspoon per pound of seed.

Treat the seed near planting time, as viability may be reduced over time. Before you treat all seed, we recommend that you test a small sample of each seed lot first. Treat 50-100 seeds and see how they germinate. If they germinate well, treat the rest of the seed lot.

If you treat coated seed or seed treated with fungicide with hot water or bleach, always dispose of wastewater in an environmentally sound manner.

For more information, see *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens*, Ohio State University Extension Fact Sheet HYG-3085-05.

Fungicide Seed Treatment

Thiram is the most common seed-protectant fungicide. Other fungicides are recommended for specific crops. These fungicides are often combined with insecticides, and these combinations may be superior to fungicide treatment alone. Purchase treated seed, or dust seed lightly with fungicide according to label directions.

Do not use treated seed for food or feed.

Field Production

Major Update by Liz Maynard and Ben Phillips – Apr 2022
Reviewed by Dan Fillius, Wenjing Guan – Sep 2024

Vegetable Classifications

EPA Vegetable Crop Groups

EPA Crop Group	Crop
Group 1 (Root and Tuber Vegetables)	Beet, Carrot, Celeriac, Horseradish, Parsnip, Potato, Radish, Rutabaga, Sweet Potato, Turnip
Group 3 (Bulb Vegetables)	Garlic, Leek, Onion, Shallot
Group 4 (Leafy Greens and Leafy Petioles)	Arugula, Asparagus, Chicory, Chives, Celery, Cress, Endive, Escarole, Florence Fennel, Lettuce, Mizuna, Parsley, Radicchio, Rhubarb, Spinach, Swiss Chard
Group 5 (Cole Crops and Brassica Leafy Greens)	Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kale, Kohlrabi, Mustard Greens, Turnip Greens
Group 6 (Legume Vegetables)	Beans, Peas, Southern Peas/Cowpeas, Lima Beans
Group 8 (Fruiting Vegetables)	Eggplant, Pepper, Okra, Tomato
Group 9 (Cucurbit Vegetables)	Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon
Group 15 (Cereal Grains)	Sweet Corn
Group 19 (Herbs and Spices)	Basil, Cilantro, Coriander, Dill, Fennel, Florence Fennel, Lavender, Marjoram, Oregano, Parsley, Rosemary, Sage, Savory, Tarragon, Thyme

Botanically Related Vegetables

Plant Family	Crops
Amaranthaceae	Beet, Spinach, Swiss Chard
Amaryllidaceae	Chives, Garlic, Leek, Onion, Shallot
Apiaceae	Carrot, Celeriac, Celery, Cilantro, Coriander, Dill, Fennel, Florence Fennel, Parsley, Parsnip
Asparagaceae	Asparagus
Asteraceae	Chicory, Endive, Escarole, Lettuce, Radicchio, Tarragon
Brassicaceae	Arugula, Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Cress, Horseradish, Kale, Kohlrabi, Mustard Greens, Mizuna, Radish, Rutabaga, Turnip, Turnip Greens
Convolvulaveae	Sweet Potato
Cucurbitaceae	Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon
Fabaceae	Beans, Peas, Southern Peas/Cowpeas, Lima Beans
Lamiaceae	Basil, Lavender, Marjoram, Oregano, Rosemary, Sage, Savory, Thyme
Malvaeae	Okra
Poaceae	Sweet Corn
Polygonaceae	Rhubarb
Solanaceae	Eggplant, Pepper, Potato, Tomato

Temperature Tolerances of Selected Vegetables

Very Cold Tender	Cold Tender	Semi-Cold Hardy	Cold Hardy[1]
Cantaloupe, Cucumber, Eggplant, Lima Bean, Okra, Pepper, Pumpkin, Squash, Watermelon	Snap Bean, Sweet Corn, Tomato	Carrot, Cauliflower, Chinese cabbage, Lettuce, Potato	Asparagus, Broccoli, Cabbage Horseradish, Onion, Pea, Spinach

[1]Hardy crops are most tolerant of cool temperatures and frost. Very tender crops are most susceptible to frost and cool temperatures.

Using Plastic Mulch

Black plastic mulch laid before planting helps control weeds, reduces root pruning, and gives profitable increases in early yields of warm-season crops. Wavelength- selective and clear mulches typically lead to greater early yields than black plastic, but weed growth under these mulches may be a problem. This is particularly true for clear mulch. White-on-black plastic mulch applied with the white side up is sometimes used for plantings after the soil warms up. It eliminates damage to transplants caused by hot black plastic burning the stem and results in cooler soil temperatures in the summer. With any color of plastic mulch leaching is retarded, less fertilizer is lost, and total nitrogen applied can be reduced. An early sidedressing may not be needed; if nitrogen needs to be added, it can be applied later through the irrigation system.

To achieve earliness for warm season crops, try to lay plastic mulches as early in the season as possible. Plastic mulches should be laid over moist soil when the soil is dry enough to work. . Irrigate the field if soil moisture is not adequate prior to laying the mulch. If the plastic is laid over dry soil, it will actually delay subsequent transplant growth. It is better to lay out plastic at midday so it can be stretched tight. However, do not overstretch the plastic because cool nights may actually cause it to tear.

The seedbed should be as fine as possible in order to get a good covering. The plastic is laid by burying about 6 inches of each edge. Black plastic mulch is most effective in warming the soil when it is in direct contact with the soil.

A disadvantage of plastic mulch is disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches, which degrade into small pieces of plastic that remain in the environment, are available. However, the portion of plastic buried beneath the soil is not exposed to light and so doesn't break down as rapidly.

Biodegradable plastic mulches that break down completely are also available. Fully biodegradable mulches are currently more expensive, but do not need to be removed and disposed of at the end of the season, and do not leave long-lasting contamination in the environment. For more information on biodegradable mulches, see information from a nationally funded project at biodegradablemulch.tennessee.edu.

With plastic mulch, yields of pepper, eggplant, and summer squash are higher most years, and harvest can be up to seven days earlier than unmulched plantings. Clear plastic mulch is common in early sweet corn production. Growers can plant sweet corn in hills, single rows, or double rows, and apply herbicides before laying the plastic. Clear plastic mulch warms the soil and contributes to early harvest and quality produce.

Herbicides that were applied before the mulch was laid may break down before the crop matures. Unless otherwise advised, never apply herbicides over the top of plastic mulch. An alternative to the clear mulch/herbicide system is the Infra-red transmitting (IRT) or wavelength selective mulch system. IRT mulches provide similar soil warming to clear film while controlling most weeds like black plastic.

Apply all fertilizer before laying the plastic, but reduce the total amount applied by 10% to 15%, or apply some of the required fertilizer and plan to provide the rest through fertigation.

Mulch layers are available in various widths. They also can be adapted for raised beds and for the laying of trickle irrigation tubes all in one operation. Trickle irrigation combined with plastic mulch offers several advantages: it uses water economically, requires less energy for pumping, wets leaf surface less, allows for easy fertilizer application, provides a uniform moisture supply, and allows the application of certain insecticides and fungicides.

Irrigation and Water Management

Vegetables require an adequate supply of moisture throughout their entire growth. While the frequency and amount of water varies according to individual vegetable crop, its age, current soil moisture, soil type, and weather conditions, generally 1 to 1.5 acre inches of water are required each week at full growth. This water is supplied through precipitation, stored water in the soil and irrigation

Effective Rooting Depth of Selected Vegetables

Shallow (6-12 inches)	Moderate (18-24 inches)	Deep (> 36 inches)
Beet	Cabbage, Brussels sprouts	Asparagus
Broccoli	Cantaloupe	Lima bean
Carrot	Cucumber	Pumpkin
Cauliflower	Eggplant	Sweet potato
Celery	Pea	Watermelon
Greens & herbs	Potato	Squash, winter
Onion	Snap bean	
Pepper	Squash, summer	
Radish	Sweet corn	
Spinach	Tomato	

Vegetable Crops and Growth Period Most Critical for Irrigation Requirements

Crop[1]	Most Critical Periods
broccoli, cabbage, cauliflower, lettuce	head development
carrot, radish, beet, turnip	root enlargement
sweet corn	silking, tasseling, and ear development
cucumber, eggplant, pepper, melon, tomato	flowering, fruit set, and fruit development
bean, pea	flowering, fruit set, and development
onion	bulb development
potato	tuber set and enlargement

[1]For transplants, transplanting and stand establishment represent a most critical period for adequate water.

The total available water holding capacity (AWHC) for a given location depends on soil texture, organic matter, and rooting depth. AWHC estimates are best obtained from the county soil survey or the local Soil and Water Conservation District office. The table ‘Available Water Holding Capacities for Several Soil Types’ shows AWHC estimates for some typical soil textures in the upper Midwest.

Irrigation should be initiated for most crops before 50% of the available water is removed by the plants in the active root zone. In most vegetable crops, the majority of the roots are usually within the top 6 to 18 inches of soil. When using a trickle irrigation system on shallow-rooted, water sensitive crops (lettuce, peppers, etc.), the allowable depletion is generally 20% to 25% of AWHC and the system is run more frequently. With deeper rooted, more drought-tolerant crops (pumpkin, watermelon), a higher depletion allowance can be used without loss of yield orquality.

Available Water Holding Capacities for Several Soil Types

Soil Texture	Inches Water per Inch of Soil	Inches Water per Foot of Soil
Loamy fine sand	0.08-0.12	0.96-1.44
Sandy loam	0.10-0.18	1.20-2.16
Loam	0.14-0.22	1.68-2.64
Silt loam	0.18-0.23	2.16-2.76
Clay loam	0.16-0.18	1.92-2.16

Soil Water Monitoring

Two common ways of estimating soil water deficit to assist irrigation scheduling are:

1. Measuring soil water tension with soil moisture sensors.
2. Observing the feel and appearance of soil samples collected using a soil probe or shovel.

Soil water tension can be monitored at a given point in the active root zone by electrical resistance moisture blocks or tensiometers. Soil tension or suction is a measurement usually expressed in centibars that describes how tightly water is held to the soil particles. The larger the value the drier the soil.

Tensiometers directly read soil tension between 0 and 80 centibars and work best in sandy loam or lighter textured soils. If the soil texture is known, use the Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions table to estimate the inches of soil water deficit for a given tension reading; use the Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation table to estimate the point of 20% to 25% depletion.

For example, let's say you have a sandy loam soil that has an AWHC of 1.5 inches per foot. A tomato crop would be irrigated before 50% (or about 0.7 inch) has been depleted in the upper foot of soil, or when a 6-inch tensiometer reads 45 centibars (Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions). If we use the same soil for another example, a trickle-irrigated pepper crop would be irrigated when 20% to 25% (or 0.3 inch) has been depleted in the upper foot soil, or a 6-inch tensiometer reads 22 centibars (Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation).

Sensors that measure volumetric water content (VWC) are generally more expensive than tensiometers but offer the advantage of responding quickly to changes in soil moisture. To effectively guide irrigation management, it's crucial to accurately determine VWC at field capacity when using these sensors.

To obtain representative soil tension readings with any sensor, the sensors should be left installed throughout the irrigation season and preferably at two or more locations in the field. Two depths are generally desired at each location. These depths should be about one-third and two-thirds of the active root zone, or about 6 and 12 inches for a rooting depth of 18 inches.

Estimating soil moisture by feel and appearance takes some practice. The Natural Resource Conversation Service (NRCS) provides instructions in *Estimating Soil Moisture by Feel and Appearance,* available at nrcs.usda.gov, or through your local NRCS office. A soil probe or shovel is used to collect samples from the desired depths. By observing the color and texture of the soil, squeezing it into a ball, pinching it between thumb and finger to form a ribbon, noting how well the ball holds together and how long a ribbon can be made, and comparing to photos or charts, it is possible to estimate soil water depletion and the% of available water remaining.

Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions

Soil Tension values in the header of the table below are measured in centibars (cbs). Soil Water Deficit values in the body of the table are measured in Inches per Foot of Soil.

Soil Texture	10	30	50	70	100	200	1,500[1]
Coarse sands	0	0.1	0.2	0.3	0.4	0.6	0.7
Fine sands	0	0.3	0.4	0.6	0.7	0.9	1.1
Loamy sands	0	0.4	0.5	0.8	0.9	1.1	1.4
Sandy loam	0	0.5	0.7	0.9	1.0	1.3	1.7
Loam	0	0.2	0.5	0.8	1.0	1.6	2.4

[1]1,500 cbs refers to the permanent wilting point and the soil water deficit value is equal to the soil's total available water capacity.

Soil Tension Values for Different Soil Textures for Use in Scheduling Trickle Irrigation

Soil Tension values in the body of the table below are measured in centibars (cbs). Check the reading of your tensiometer when the soil is at field capacity using the middle column, and use the right-hand column to trigger irrigation.

Soil Texture	0% Depletion of Available Water Holding Capacity (Field Capacity)[1]	20-25% Depletion of Available Water Holding Capacity[2]
Sand, loamy sand	5-10	17-22
Sandy loam	10-20	22-27
Loam, silt loam	15-25	25-30
Clay loam, clay	20-40	35-45

[1]At field capacity the soil contains 100% of AWHC; any excess water in the rootzone has drained away.
[2]Start trickle irrigation for shallow-rooted crops at this point.

Information adapted from *Mid-Atlantic Commercial Vegetable Production Recommendations*, New Jersey Ag Expt. Station, Rutgers; and *Water Management in Drip-irrigated Vegetable Production* by T.K. Hartz, UC-Davis, Calif., HortTechnology 6:165-67.

Water Quality for Irrigation

Test irrigation water sources for suitability for irrigation. Many commercial labs provide this service. It is important to test for food safety; see the Food Safety chapter of this guide for information on these tests. It is also important to test for chemical characteristics including pH, alkalinity, salinity, and mineral content. If water is not suitable for irrigation it may be possible to treat it so it can be used.

In high tunnels and greenhouses where the soil or growing medium doesn't receive rainfall, one of the most common issues is high alkalinity in irrigation water. In the Midwest the alkalinity is caused by high levels of calcium and magnesium. Over time the high alkalinity leads to increases in soil or growing medium pH and eventually pH-related nutrition problems show up in crops. In greenhouses where this is a problem, treating irrigation water with acid is often used. The acid neutralizes most of the alkalinity. Acid is automatically injected into the irrigation system. The amount of acid required depends on the type of acid used and the alkalinity of the water.

The online calculator "ALKCALC" at e-gro.org provides recommendations for various concentrations of phosphoric, nitric, and sulfuric acid based on user-entered alkalinity. It is important to account for the nutrient contribution of the acid – P from phosphoric acid, N from nitric acid, and S from sulfuric acid – in the overall fertilizer plan. These acids are highly corrosive and must be handled with care. Always add acid to water; never water to acid. Wear proper face, hand and body protection. Other ways to deal with rising soil pH due to alkaline irrigation water include using sulfur to reduce soil pH (see the Soil Fertility and Nutrient Management chapter in this guide) and finding alternative water sources, for instance rainwater, to supply all or part of the irrigation need.

Chemical and Fertilizer Application Using Irrigation

Chemigation–applying ag chemicals with irrigation–and fertigation–applying fertilizers with irrigation–can be efficient ways to get materials into the root zone. See the Chemical Application and Safety chapter in this guide for more information about equipment and required safety measures.

Frost Control Using Irrigation

Irrigation can help protect vegetable crops from frost, although it is not a common practice in the Midwest. With the proper equipment, growers must begin sprinkling as soon as the temperature reaches 34 F. Place a calibrated thermometer at the lowest elevation in the field at plant level, facing skyward. Continue sprinkling plants until the air temperature is greater than 30 F and the ice has melted from the plants.

To be effective, you need approximately 0.1 inch of water per hour, the sprinkling must be continuous, and the sprinklers should rotate at least once per minute. If conditions become windy and temperatures drop, it may be necessary to increase the amount of water to as much as 0.5 inch per hour. It is the process of the water freezing that gives off the heat to protect the crop. Therefore, liquid water must be present during the freezing period to protect the plants.

Production Tables

Yield of Vegetable Crops

Crop	Average (t/ac)	Good (t/ac)	Excellent (t/ac)
Asparagus	1	1.5	2
Bean, snap	2	3	4
Cabbage	13	15	20
Cantaloupe	10	15	19
Cucumber (slicing)	9	12	15
Cucumber (pickling, hand harvest)	6	10	12
Onion	13	18	23
Pepper, green	14	17	20
Potato (fall)	10	15	20
Pumpkin	10	15	25
Spinach	6	8	10
Summer squash	10	13	16
Sweet corn	4.5	8	10
Sweet potato	7	12	15
Tomato (fresh market)	11	13	15
Tomato (processing)	25	29	33
Watermelon	15	20	25

This table only provides general yield estimates for new or prospective growers. The USDA-National Agricultural Statistics Service Vegetable Survey provides more accurate information.

Postharvest Handling and Storage Life of Fresh Vegetables

A lack of adequate refrigeration and cooling will shorten the shelf-life and lower the quality of fresh vegetables. Cucumber, eggplant, lettuce, green or ripe pepper, potato, snap bean, summer squash, and tomato are among the most susceptible vegetables to chilling or freezing injury. Some cold injury symptoms that can make vegetables unmarketable. The most typical include pitting, water- soaked spots, browning, surface decay, and, in pepper and tomato, failure to ripen.

The following list of recommended storage condition information is adapted from *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks* (USDA-ARS Agriculture Handbook Number 66, ars.usda.gov), *Knott's Handbook for Vegetable Growers* (Donald N. Maynard and George J. Hochmuth, 5th ed., 2007), and *Properties and Recommended Conditions for Long-Term Storage of Fresh Fruits and Vegetables* (Marita Cantwell, University of California-Davis, Postharvest Technology website, postharvest.ucdavis.edu).

Vegetable	Temp (°F)	Relative Humidity (%)	Relative Storage Life
Asparagus	36	95-100	2-3 weeks
Beans, snap	40-45	95	7-10 days
Beets & carrots, bunched	32	98-100	10-14 days
Broccoli	32	95-100	10-14 days
Cabbage, late	32	98-100	5-6 months
Cantaloupe	36-41	95	2-3 weeks
Cauliflower	32	95-98	3-4 weeks
Cucumber	50-54	85-90	10-14 days
Eggplant	50-54	90-95	1-2 weeks
Greens (collards, kale, & spinach)	32	95-100	10-14 days
Lettuce	32	98-100	2-3 weeks
Okra	45-50	90-95	7-10 days
Onions, dry	32	65-70	1-8 months
Onions, green	32	95-100	3 weeks
Peas, in pods	32	90-98	1-2 weeks
Peas, southern	40-41	95	6-8 days
Pepper, green	45-55	90-95	2-3 weeks
Pepper, ripe	42-45	90-95	1 week
Potato, early	a	90-95	a
Potato, late	b	90-95	b
Pumpkin	54-59	50-70	2-3 months
Radish	32	95-100	1-2 months
Rhubarb	32	95-100	2-4 weeks
Squash, summer	40-45	95	1-2 weeks
Squash, winter	54-59	50-70	c
Sweet corn	32	95-98	2-5 days, up to 21 days for supersweets
Sweet potato	55-59	85-95	4-7 months
Tomato, light red	50-55	90-95	1 week
Tomato, mature- green	50-60	90-95	1-2 weeks
Tomato, firm-ripe	46-50	85-90	3-5 weeks
Turnip root	32	95	4-5 months
Watermelon	50-60	90	2-3 weeks

[a]Most summer-harvested potatoes are not stored. However, they can be held 4-5 months at 40 F if cured 4-5 days at 60-70 F before storage. They can be stored 2-3 months at 50 F without curing. Potatoes for chips should be held at 70 F or conditioned for best chip quality.

[b]Fall-harvested potatoes should be cured at 50-60 F and high relative humidity for 10-14 days. Storage temperatures for seed or table stock should be lowered gradually to 38-40 F. Potatoes intended for processing should be stored at 50-55 F. Those stored at lower temperatures or with a high reducing sugar content should be conditioned at 70 F for 1-4 weeks or until trial cooking tests are satisfactory.

[c]Winter-squash varieties differ in storage life. Acorn squash can be stored for 35-55 days, butternut squash for 60-90 days, and Hubbard squash for 180 days.

High Tunnel Production

New Section by Brad Bergefurd, Ben Phillips, and Liz Maynard – Aug 2022

High tunnel systems, commonly called “hoop houses,” are an increasingly popular practice being adopted by farmers. The USDA High Tunnels System Initiative through the Environmental Quality Incentives Program (EQIP) has incentivized their use to 1) extend the growing season; 2) improve plant quality and soil quality; 3) reduce nutrient and pesticide transportation; and 4) improve air quality through reduced transportation inputs.

High tunnels are simple structures consisting of plastic-covered, tubular steel structures relying mainly on the sun’s energy to warm the soil and air. Wind circulation and ventilation allows the high tunnel to be passively cooled. Typically, high tunnels are not equipped with concrete foundations and footings, mechanical heaters, exhaust fans, or supplemental lighting. This is what differentiates them from greenhouses, although some farms modify high tunnels to include these.

High tunnels can be semi-permanent, temporary, or movable structures. Moveable high tunnels are built on skids or wheels, allowing them to be moved for crop and field rotation purposes. High tunnels are built in a variety of shapes and sizes including Quonset, gothic, narrow or wide, short or long, and single bay or multi-bay. Four-season high tunnels are built to withstand snow and ice loads, whereas three-season high tunnels have a lighter frame design and the poly covers are removed during winter months to prevent snow and ice loads.

High tunnels, being high enough for a person to stand up inside of or allow for the use of small-sized tractors and equipment, are passively heated and cooled structures, designed to extend the growing season by increasing average temperature, and protecting crops from potentially damaging weather conditions including freeze and frost events, temperature fluctuations, precipitation, wind, or excess moisture. High tunnels can reduce production risks and may enhance crop quality. High tunnels provide growers an opportunity to lengthen their production, harvest, and marketing season.

Other benefits of high tunnels include better timeliness of production operations and utilization of labor by providing work in any type of weather conditions and potentially creating year-round harvest opportunities. The protected microclimate inside a high tunnel can produce crops of a higher quality and higher yields compared to their field-grown counterparts.

High tunnels are another tool in the toolbox for farmers wishing to extend their growing and marketing seasons, but they are not for everyone. High tunnel adoption requires additional costs, risks, and management and must align with the farm’s business goals, objectives, and resources in order to be a profitable option.

Production Methods

In general, using the soil in a high tunnel is not too unlike field production, but rates of fertilizer and pesticides can be lower or less frequent because rain does not wash them out of soils or off plants. However, irrigation usage is more intensive without rain feeding the system. Vertical production with trellising materials, and combining hanging pots with soil-level plants are common methods for making use of the entire space.

Certain pests and diseases are more common in these environments than they are in the field. For example, *Botrytis* and spider mites. Ventilation, air circulation, and rapid heating in the morning are important features to reduce leaf wetness time for disease management and maintain temperatures that are not as conducive for pest issues.

Over time, with continuous in-soil production in a high tunnel, you may begin noticing lack of vigor, short plants, canopy collapse at fruit set, lower yields, and shorter yielding windows All are signs of vascular compromise or root damage by plant pathogenic fungi and nematodes that build up in protected high tunnel soils after growing the same plant species year in and year out. A concurrent trend is also a slow increase in soil pH and salinity if one is not checking on water quality, leaving nutrients unavailable to plants outside their suitable pH range or burning roots and reducing seed germination from salt levels.

What can one do to prevent this and ensure the long-term sustainability of the high tunnel?

1. Use a standard crop rotation in your high tunnel. It is tempting to grow tomatoes every year, but that selects for and enhances a soil microbiome that enjoys feeding on tomatoes.
2. Check your water pH and alkalinity and consider acidifying if your pH is over 7 and alkalinity is over 100 mg/L. These are normal values for standard field production and human consumption, but when water of this quality is the only water ever added to a system due to plastic keeping rain out, then the pH of the soil at the root zone increases over time. It is not uncommon to create a soil pH over 8.0 in high tunnels.

3. Pick a fall to change your plastic and leave it open to the sky until spring, and make a schedule of this every three or four years. This allows rain and snow percolate through the move some of the built-up fertilizer salts (organic and conventional) down and out, while also staving off pH increases because rainwater and snow have a naturally low pH and alkalinity.

Grafting

Grafting is a tool that some growers have adopted with great success in tomato hoophouses that were declining after 4 years of continuous production. There are several rootstock varieties to choose from, and the process is relatively easy to learn. However, it is more expensive and labor intensive if performing your own grafting. If the same rootstocks are chosen year in and year out, and no other preventative measures are taken, then pathogen and nematode pressure can continue to increase and in the next 3-8 years, you may find production declining again.

Soil Treatments

Chemical fumigation, high pressure steam, and biofumigation are techniques that can be deployed in high tunnels to sterilize soils. There is also a special technique developed for high tunnel growers to reduce the pathogen load in their soils while conserving beneficial soil organisms, called Anaerobic Soil Disinfestation (ASD). This technique encourages a special group of microbes, called anaerobes, to destroy air-breathing soil pathogens. For most growers, soil treatments can be applied every 3 to 5 years to keep soilborne diseases in check.

Container Culture

Container culture using pots or bags of potting mix is a great alternative to in-ground production, with plants in containers filled with potting media and the floor covered with landscape fabric. In hoophouses with compromised soils, it can be important to elevate containers off the ground to create an air gap. The main difference in production is dialing-in the irrigation and fertility program and finding time to pack the containers and dispose of old potting media.

Hydroponics

Hydroponic production removes the potting mix from container culture and replaces it with an inert material like rockwool, or perlite. Two commonly used methods are Nutrient Film Technique (NFT) with one or more layers of plant-holding rails or gutters nutrient-rich water moves through, and Deep Water Culture (DWC) with plant-holding rafts on troughs of nutrient-rich water. Water flow (in NFT) or level (in DWC) are constantly maintained with pump systems, and monitored daily for pH and nutrient content.

More information about using high tunnels in the Midwest can be found in the *Indiana High Tunnel Handbook* (HO-296), *Scheduling Fall and Winter Vegetable Production in High Tunnels* (HO-330), *Managing the Environment in High Tunnels for Cool Season Vegetable Production* (HO-297), and *High Tunnel Cucumber Production Guide* (ID-521-W) at edustore.purdue.edu. In addition, Michigan State University created a *Hoophouse Production and Marketing Guide* at canr.msu.edu, and Iowa State University maintains *Vegetable Production Budgets for a High Tunnel* at the extension.iastate.edu.

Pollination

Reviewed by Ben Phillips – Sep 2022

Pollination is the transfer of pollen from the male portions of the flower (stamens) to the female portions of the flower (pistils). This process is vital to the production of many vegetable crops, including cucumber, cantaloupe, pumpkin, squash, and watermelon. Some crops (such as tomato) are self-fertile, but wind or bees must vibrate the flowers to release pollen for fertilization.

Honey bees are often thought of as the most prevalent pollinator for vegetable crops, but studies show that many species of native bees — including bumble bees and squash bees — play a vital role in pollinating many vegetable crops. Tomato, for example, benefit from the "buzz pollination" that bumble bees can provide. Honey bees are unable to buzz pollinate, and therefore do not play a role in tomato pollination. The squash bee, a North American native, is an important pollinator of pumpkins and other squash crops. Native bees are often active earlier in the day and at cooler temperatures than honey bees.

To ensure pollination, many vegetable growers rent honey bee hives rather than manage their own hives. Since honey bee colonies are occasionally in short supply, growers should communicate frequently with their bee providers.

In addition to renting honey bee hives, growers can improve the pollination services of native and non-native bees by increasing on-farm habitats. The Xerces Society for Invertebrate Conservation (xerces.org) and Pollinator Partnership (pollinator.org) offer guides, plant lists, and other resources about building on-farm bee habitats.

At least 90 crops grown in the United States depend to some extent upon bees as pollinators, either for seed or fruit production. The exact number of honey bee hives needed to pollinate a crop depends on a number of factors, including the strength and condition of colonies, magnitude of the natural pollinator community, amount of wild flower material competing with the crop, attractiveness of the crop to bees, projected yield, and weather.

The following are guidelines for the number of honey bee hives to use when supplemental pollination is desired:

cantaloupe (2 to 3 colonies per acre)
cucumber (2 to 3 colonies per acre)
pumpkin (1 colony per acre)
squash (1 colony per acre)
watermelon (1 to 5 colonies per acre — the pollination requirements of seedless varieties are generally greater than seeded)

The following vegetables will set fruit without honey bees, but bee activity has been shown to increase yields:
eggplant **okra**
lima bean **pepper**

Honey bees do not assist in the pollination of the following crops, but will collect pollen and/or nectar from them:
pea **sweet corn**
snap bean **tomato** (but bumble bees can)

Do not place hives in a field until the crop's flowers are available to visit. If the hives are placed before the flowers are available, the bees will forage to surrounding areas and may not forage sufficiently in the crop that needs pollination. Bees forage best within about 100 yards of the colony. Therefore, if the field is large, the bees should be distributed in clusters around the field.

Bees also require a source of clean water. If not available nearby, set out a shallow container with fresh water.

Approximate Time from Pollination to Market Maturity Under Warm Growing Conditions

Vegetable	Days to Market Maturity
Bean	7-18
Cantaloupe	40-50
Corn, fresh market[1]	18-23
Corn, processing[1]	21-27
Cucumber, pickling (3/4 to 1-1/8 inch diameter)	4-5
Cucumber, slicing	15-18
Eggplant (2/3 maximum size)	25-40
Okra	4-6
Pepper, green stage (max size)	45-55
Pepper, red stage	60-70
Pumpkin, jack-o-lantern	60-90
Pumpkin, baking	65-75
Squash, summer, zucchini[2]	3-4
Squash, winter, butternut	60-70
Squash, winter, hubbard	80-90
Squash, winter, acorn	55-60
Tomato, mature green stage	34-45
Tomato, red ripe stage	45-60
Watermelon	40-50

[1]From 50% silking.
[2]For a weight of 0.25-0.5 lbs.

Bees and Pesticides

When foraging for pollen and nectar in flowering plants, honey bees, as well as bumble bees and native bees (solitary bees), may be exposed to a variety of different pesticides (insecticides and miticides) that can cause direct or indirect toxic effects. Direct toxicity occurs when honey bees are immediately killed after exposure to wet sprays or dried pesticide residues on leaves or flowers. Indirect toxicity is associated with sublethal effects on development, foraging behavior, immune system functionality, learning and memory retention, longevity, orientation, overwintering survival, and reproduction. In addition, indirect effects may be affiliated with social interactions as a result of honey bees sharing a contaminated food source.

In general, early morning or late evening applications of pesticides pose less of a hazard because this is when most bees are less active. However, this depends on temperature, as bumble bees are active at lower temperatures (40 F) whereas honey bees are active when temperatures are >50 F.

Do not apply pesticides to flowering plants or weeds. Systemic insecticides, applied as either drenches or granules, to the soil or growing medium, are less harmful to bees than foliar applications. The pesticide formulation can influence bee toxicity. For example, emulsifiable concentrates (EC) and water-soluble (WS) formulations are typically less harmful to bees than wettable powder (WP) formulations.

It is important to note that some fungicides can enhance the toxicity of certain insecticides to honey bees when mixed together. This enhanced toxicity is referred to as synergism, which means that the combined toxicity is greater than the sum of the toxicity of each pesticide applied separately. The ergosterol or sterol biosynthesis inhibiting (EBI) class of fungicides have been shown to increase the toxicity of certain insecticides in various chemical classes, including: organophosphates, pyrethroids, and neonicotinoids to honey bees. For instance, the toxicity of pyrethroid insecticides to honey bees is enhanced over a thousand fold when mixed with ergosterol biosynthesis inhibitors. In addition, mixing some neonicotinoid insecticides with certain fungicides can enhance toxicity to honey bees as much as a thousandfold.

In addition to fungicides, insect growth regulators, which are insecticides that disrupt insect growth and development, and eventually lead to death, are known to be harmful to honey bees. The three categories of insect growth regulators — chitin synthesis inhibitors, juvenile hormone mimics, and ecdysone receptor antagonists/ agonists —have been reported to be directly and/or indirectly harmful to honey bees; especially the larvae (brood).

The Fungicide Table and Insecticide Table contains Bee Precaution information based on the toxicity of oral exposure to honey bees, honey bee brood, and other bees. It is important to read the pesticide label carefully to determine the potential level of toxicity to all bee types (honey bees, bumble bees, and native bees). Furthermore, you can incorporate into pollination contracts a list of pesticides, application methods, and timing of applications that are mutually agreeable to both growers/producers and beekeepers. These tables utilize the University of California IPM *Bee precaution pesticide ratings*; a systematic review of toxicity data for most crop management chemistries found at www2.ipm.ucanr.edu/beeprecaution.

State laws may require that applicators notify beekeepers 24 hours before applying a pesticide that is directly or indirectly harmful to honey bees when; 1) the treated crop is in flower (blooming), and 2) the field is greater than a half-acre and within a half-a-mile from a registered apiary. It is important to contact your state department of agriculture to determine if there are laws or regulations that protect other pollinators (bumble bees and native bees).

For more information on bees and pesticides, refer to the extension publication, *Pesticides and Bees* (Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3428. Kansas State University; Manhattan, KS. 8 pgs, bookstore.ksre.ksu.edu).

Organic Certification

Reviewed by Ashley Adair – Apr 2022

Organic vegetable farming is a production system that relies on biological processes and natural materials to manage soil fertility and pest populations, and to promote healthy crop growth. The federal Organic Foods Production Act regulates the use of the term "organic" to describe an agricultural product in the marketplace. Vegetables sold as "organic" must be grown and handled according to the National Organic Rule and any applicable state regulations. The National Organic Rule prohibits the use of most synthetic chemicals (fertilizers, pesticides, etc.), and requires farmers to write and follow organic production plans, as well as keep farm and field records. Fields used to grow organic crops may not have had any prohibited material applied to them in the previous three years. In addition, USDA-accredited organic certification agents must inspect and certify all operations with more than $5,000 in gross annual sales of products labeled "organic."

Growers interested in transitioning to organic production should educate themselves about practices used in their area and plan carefully. Experience suggests that it can take a number of years for pest populations and soil nutrient cycles to adjust enough for successful organic production.

This guide includes recommendations for some inputs that are permitted in certified organic production, but also for many that are not. The note 'OMRI-listed' indicates pesticides that have been listed by the Organic Materials Review Institute (OMRI) as approved for use in organic production in the U.S. Growers should always check with their organic certification agents before using any product to make sure it meets their certifier's criteria.

Other organic production resources include:
eOrganic, the Organic Agriculture Community of the Extension Foundation eorganic.org

Organic Vegetable Gardening Techniques (University of Missouri Extension Guide G6220) provides an introduction to organic production techniques (available from University of Missouri Extension Publications, extension.missouri.edu/publications).

Resource Guide for Organic Insect and Disease Management (Cornell University) provides specific recommendations for pests and diseases of major vegetable crops (available at northeast.sare.org/resources/resource-guide-for-organic-insect-and-disease-management/).

Appropriate Technology for Rural Areas (ATTRA) offers a number of publications on their website: attra.org.

The National Organic Program (NOP) offers a program handbook that provides a list of materials allowed for use in organic production, plus a complete list of accredited certification agents on their website: ams.usda.gov/nop

The Organic Materials Review Institute (OMRI) publishes a list of products they have found to meet certified organic production criteria. For details, visit omri.org/.

The Sustainable Agriculture Research and Education (SARE) program offers a number of research-based publications about pest management, including organic options. A complete catalog is available at sare.org/

If you desire organic certification, you should contact a certification agent during the period of transition to organic production. The organizations listed below have been accredited by the USDA as of April 2022.

Contact them directly for information about fees and the certification procedure. The USDA lists all accredited organizations at www.ams.usda.gov/services/organic-certification/certifying-agents.

Consult your local Extension office for other resources available in your area.

Organic certifiers servicing the Midwest

Some states do not have a National Organic Program certification agency headquartered in state. However, multiple certifying agencies service the Midwest region with traveling inspectors. Many take clients on a case-by-case basis, depending on the availability of inspectors and other factors. Here is a list of certifiers that are utilized in the Midwest, with notes on their service range if it is limited.

CCOF Certification Services, LLC

2155 Delaware Ave., Ste. 150
Santa Cruz, CA 95060
Phone: (831) 423-2263
Fax: (831) 423-4528
Email: ccof@ccof.org
ccof.org

Ecocert USA

2498 Perry Crossing Way, Ste. 210
Plainfield, IN 46168

Phone: (888) 337-8246 (toll free)
Email: info.ecocertico@ecocert.com
ecocert.com

Global Organic Alliance, Inc.

P.O. Box 530
3185 Township Rd. 179
Bellefontaine, OH 43311
Phone: (937) 593-1232
Fax: (937) 593-9507
Email: goaorg@centurylink.net
goa-online.org

International Certification Services (ICS)

PO Box 517
301 5th Ave. S.E.
Medina, ND 58467
Phone: (701) 486-3578
Fax: (701) 486-3580
Email: info@ics-intl.com
ics-intl.com

Iowa Department of Agriculture and Land Stewardship Organic Certification

502 E. 9th St.
Des Moines, IA 50319
Phone: (515) 281-5783
Email: katie.hyde@iowaagriculture.gov
iowaagriculture.gov/agricultural-diversification-market-development-bureau/organic-certification-program

Midwest Organic Services Association, Inc. (MOSA)

P.O. Box 821
122 W. Jefferson St.
Viroqua, WI 54665
Phone: (608) 637-2526
Fax: (608) 492-0470
Email: mosa@mosaorganic.org
mosaorganic.org

Minnesota Crop Improvement Association

1900 Hendon Ave.
St. Paul, MN 55108
Phone: (612) 625-7766
Phone: (855) 213-4461 (toll free)
Fax: (612) 625-3748
Email: mncia@mncia.org
mciaorganic.org

Nature's International Certification Services (NICS)

224 E. State Highway 56
Viroqua, WI 54665
Phone: (608) 637-7080
Fax: (608) 637-7460
Email: nics@naturesinternational.com
naturesinternational.com

Ohio Ecological Food and Farm Association

41 Croswell Rd.
Columbus, OH 43214
Phone: (614) 262-2022
Email: organic@oeffa.org
oeffa.org

Oklahoma Department of Agriculture, Food and Forestry Organic Certification

2800 N. Lincoln Blvd.
Oklahoma City, OK 73152
Phone: (405) 522-5924
Email: jeff.stearns@ag.ok.gov
ag.ok.gov/divisions/food-safety

OneCert, Inc.

1021 D St.
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Oregon Tilth Certified Organic

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301 S.W. 4th St., Ste. 110
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Organic Crop Improvement Association (OCIA)

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Pro-Cert Organic Systems, Ltd.

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Quality Assurance International

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Quality Certification Services (QCS)

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SCS Global Services, Inc.

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Where Food Comes From Organic (formerly A Bee Organic)

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Using a Diagnostic Lab

Reviewed by Tom Creswell and Jon Bonkowski – Oct 2024

The best way to identify insects, plants and plant diseases, or diagnose plant and pest problems, is to send a sample to a diagnostic laboratory. The National Plant Diagnostic Network website (npdn.org) lists diagnostic laboratories by state and region. Contact individual laboratories for specific submission and fee information.

To ensure an accurate diagnosis, it's important to collect and ship your specimens properly. Here are a few guidelines for collecting and shipping specimens to a diagnostic lab.

1. Collect fresh specimens. Send a generous amount of material, if available.
2. Ship specimens in a crush-proof container immediately after collecting. If holdover periods are encountered, keep specimen cool. Mail packages to avoid weekend transit.
3. Incomplete information or poorly selected specimens may result in an inaccurate diagnosis or inappropriate control recommendations. Badly damaged specimens are often unidentifiable and additional samples can cause delays.

Submitting Plant Specimens for Disease/Injury Diagnosis

Herbaceous Plants. For generally declining, wilting, or dying plants, send several whole plants showing a range of symptoms (early through more advanced) with roots and adjacent soil intact. Dig up the plants carefully. Place roots and surrounding soil in a plastic bag and fasten it to the base of stem with a twist tie or string. Do not add water or moist paper towels. Soil and attached roots of smaller specimens may also be secured in a double layer of heavy-duty aluminum foil pressed around the root system. Wrap the plants in dry newspaper and place in a crush-proof container for shipment.

Leaves/fruit/tubers. When localized infections (such as leaf spots or fruit rots) are suspected, send specimens representing early and moderate stages of disease. Press leaves flat between dry paper towels, newspaper, or cardboard. Wrap fruits or tubers in dry newspaper. Place in a crush-proof container for shipment.

Submitting Insect Specimens

Package insects carefully so they aren't damaged when they arrive at the lab. Separate and label the specimens if you send more than one type in the same package. Provide the appropriate information for each specimen.

Tiny or Soft-bodied Specimens. Submit such specimens (aphids, mites, thrips, caterpillars, grubs, spiders) in a small, leak-proof bottle or vial of 70% alcohol or hand sanitizer. Rubbing alcohol (isopropyl) is suitable and readily available. Do not submit insects in water, formaldehyde, or without alcohol or they will ferment and decompose. Package carefully to assure vials do not break in shipment. Small insects found on leaves can also be submitted on the plant material. Wrap several leaves in dry newspaper, and then seal in a plastic bag to prevent insects from escaping.

Hard-bodied Specimens. Submit such specimens (flies, grasshoppers, cockroaches, wasps, butterflies, beetles) dry in a crush-proof container. *Do not* tape insects to paper or place them loose in envelopes

Submitting Samples for Nematode Analysis

In general nematode identification requires collection of at least one quart of soil from the root zone of affected plants. Include roots if the plants are actively growing.

Place the entire sample in a plastic bag. *Do not* add water or allow it to dry out. Protect the sample from extreme heat (for example, don't leave samples inside a parked vehicle in direct sunlight). It is often helpful to collect a second, similar sample from a nearby area where plant growth appears normal.

Attach a label, note, or tag identifying the sample to the outside of each bag or package.

If you need assistance finding a nematode assay laboratory, please contact the plant diagnostic clinic in your state. See university diagnostic laboratories are listed in the State Contact Information table.

Chemical Application and Safety

Reviewed by Ben Phillips – Oct 2024

Fertilizers and pesticides are chemicals. They have formulas and regulations attached to them for the safety of humans and the greater environment.

Pesticides are designed to poison or otherwise manage pests. Many pesticide products may poison people, pets, livestock, wildlife, ornamental plants, and other non-target organisms. Pesticide applicators and their families are at increased risk of pesticide exposure. It is important to keep all pesticide exposures to an absolute minimum.

You must protect your family members, field workers, and other people from pesticide injuries. Most pesticide accidents result from careless practices or lack of knowledge about safe handling. The time you spend to learn about the safe use of pesticides is an investment in the health and safety of you, your family, and others.

The U.S. Environmental Protection Agency (EPA) places certain restrictions to chemicals applied to control insects, mites, plant diseases, weeds, nematodes, and other pests. Such restrictions may prohibit the use of a chemical or allow residue tolerances on harvested vegetables. Growers must know what chemical to use on each vegetable; how to apply the products; the post– treatment re-entry interval, if any; when to use the chemicals with respect to farm worker and/or picker safety; and the environment and the harvest of each vegetable crop.

Growers must follow all label instructions regarding harvest restrictions to assure consumers that the food is free of dangerous residues and to comply with the law to prevent seizure of their crops. Here are some rules for the safe use of chemicals:

- Only mix the amount you can use in one day.
- If you do have leftover spray mix, the best way to dispose of it is by applying it to a labeled crop in a legal manner.
- Never dispose of surplus chemicals in a way that will result in the contamination of ground or surface waters.
- Rinse all empty containers three times before disposal.
- Pour the rinse water into the spray tank. Puncture or break triple-rinsed containers to facilitate drainage and to prevent reuse for any other purpose.
- Then dispose of the container according to label directions.

Pesticide Signal Words

Each pesticide container is required by law to have signal words to quickly communicate information about the product's acute toxicity. The three signal words, as provided by the National Pesticide Information Center, are:

- CAUTION. This signal word means the pesticide is slightly toxic if eaten, absorbed through the skin, or inhaled, or it causes slight eye or skin irritation.
- WARNING. This signal word means the pesticide is moderately toxic if eaten, absorbed through the skin, or inhaled, or it causes moderate eye or skin irritation.
- DANGER. This signal word means the pesticide is highly toxic by at least one route of exposure. It may be corrosive, which would cause irreversible damage to the skin or eyes. It may be highly toxic if eaten, absorbed through the skin, or inhaled. If this is the case, then POISON must also be included in red letters on the front panel of the product label.

Minimizing Pesticide Exposure

Signal words convey the acute toxicity of a pesticide. However, exposure to any pesticide, even those without signal words, can lead to long-term health effects. It's important to take precautions to minimize exposure to any and all pesticides. Check the product label for specific instructions to minimize exposure. Some label precautions include:

- Wear the proper respiratory equipment when handling or applying.
- Wear protective clothing that covers as much of the body as possible.
- Always use rubber gloves, not leather or cloth gloves, and never use bare hands to handle pesticides.
- Do not breathe in these pesticides when opening containers or mixing into spray tanks.
- Always wash hands, arms, and face immediately after handling, and before eating or smoking.
- Never smoke while handling or applying.
- Reduce all possible hazards of coming into direct contact with spray drift, and avoid spraying if conditions are too windy.
- Shower or bathe thoroughly after each day's work, and change clothes.
- Wash spray clothes separately from the family wash, then run another complete hot water and detergent wash cycle before washing other clothes.
- Wear clean overalls, underwear, socks, and cap each day you spray.
- Always keep pesticides in their original labeled containers, and store in a safe place.
- Store and dispose of containers according to information on pesticide labels.

Worker Protection Standard

All pesticides with an "Agricultural Use Requirements" box on the label are subject to the regulations of the Worker Protection Standard (WPS). The WPS requires all employers to provide annual pesticide safety training to employees in a language that employees understand. Training must be approved by the Environmental Protection Agency. The Pesticide Educational Resources Collaborative (PERC) has a library of free EPA-approved training materials available in multiple languages on its website, including videos and flip charts.

Endangered Species Act

The Endangered Species Act (ESA) wildlife protection procedures require growers to visit the Bulletins Live! Two website, click on the areas where they plan to farm within the next nine months, and collect any special use instructions for chemicals they may want to apply.

Restricted Pesticides

Most states have laws that restrict the use of certain pesticides and that describe where such pesticides can be obtained and used. Only individuals who are licensed by the state can apply restricted use pesticides.

Some restricted pesticides require applicators to notify occupants of land within 1,000 feet of the area to be treated at least 24 hours before application. Occupants also must be notified of any precautions they must take to ensure the safety of livestock and humans.

The U.S. EPA, state regulatory agencies, or pesticide companies can label specific pesticide formulations as "Restricted Use Only." To learn more about your state's laws about restricted use pesticides, contact your state department of agriculture or local extension office.

Calibrating Application Equipment

It is essential to apply pesticides at the specified rates for best control and protection and to not exceed residue tolerance. Calibrate and check sprayers carefully several times a season for accurate delivery rates. Ensure equipment is clean and functional, and replace broken parts prior to calibration.

Spreaders

Some granular spreaders are gravimetric and ground-driven, meaning that a constant rate of granules are delivered by gravity out of a feed gate, and a wheel running along the ground is attached to gears and chains that drive the rotor that displaces a fixed amount of granules per revolution. This locks the spreading rate to ground speed, as long as the feed gate is set at a consistent opening. If the feed gate opening remains the same, then **changing ground speed will not affect output**. However, **doubling the rate of granules released from the feed gate with a larger opening will double the output, and halving the rate of granules released from the feed gate with a smaller opening will halve the output**.

Some granular spreaders have a metering unit that is independent from ground speed, and is run hydraulically, electrically, or through a hand crank or the tractor PTO. If the meter rate remains constant, then **halving ground speed will double output, and doubling ground speed will halve output**. If ground speed remains constant, then **doubling meter rate will double output, and halving meter rate will halve output**.

Rotary spreaders fling the material in a fan-like pattern to either side of the spreader, drop spreaders release material in a sheet-like pattern straight down directly over the footprint of the spreader, and band spreaders meter out granules along a row.

Here are suggested steps to calibrating selected spreaders.

Granular Rotary Spreader Calibration

1. Set applicator dial or dials to give desired delivery rate of granules suggested for spreading according to manufacturer's instructions.
2. Fill hopper with granules to be used.
3. Lay out a tarp that is smaller than the spread pattern. Travel across tarp at desired speed and collect granules off of the tarp into a bag, bucket, or other container.
4. Weigh granules, and multiply by fraction of an acre that the tarp represents to find delivery per acre.

   For example: granular rotary spreader that leaves 0.25 lb. on a 20 sq. ft. tarp applies 544.5 lbs. per acre:

$$\text{weight collected (0.25 lb.)} \times \frac{\text{1 acre (43560 sq. ft.)}}{\text{area of tarp (20 sq. ft.)}} = \text{output (544.5 lb./ac.)}$$

5. Adjust each setting, and recalibrate until the desired delivery rate is obtained.

Granular Band Spreader Calibration

1. Set applicator dial or dials to give desired delivery rate of granules suggested for band treatment according to manufacturer's instructions.
2. Fill hoppers with granules to be used.
3. Travel across field at planting speed for the distance required to cover 1/16 acre (2,722 sq. ft.) per row. Collect granules for each row in a bag, bucket, or other container.

   For example: granular band application for a 40-inch row requires 817 ft. to cover 1/16 acre:

$$\frac{\text{1/16 acre (2,722 sq. ft.)}}{\text{row width (3.33 ft.)}} = \frac{\text{distance of travel}}{\text{(817 ft.)}}$$

4. Weigh granules from each row separately, and multiply by 16 to find delivery per acre for each row.
5. Adjust each setting, and recalibrate until the desired delivery rate is obtained.

Sprayers

Sprayers use a pump mechanism that runs independently from the tractor wheels, or your legs. They are often powered hydraulically, electrically, or through a hand pump or the tractor PTO. If the pressure remains constant, then **halving ground speed will double output, and doubling ground speed will halve output**. If ground speed remains constant, then **quadrupling pressure will double output, and quartering pressure will halve output.**

Boom sprayers apply a sheet-like mist along the length of the boom, band sprayers apply a narrow band over a row with one or more nozzles grouped together, wand sprayers have one nozzle used for small or irregular shaped targets, and airblast sprayers generate a high-speed directional fog.

Here are suggested steps to calibrating selected sprayers. Once output is found in gallons per acre, calculate acres per tankful of spray solution by dividing gallons per tank by gallons per acre of output, and determine the required amount of product to dilute in the tank by multiplying acres per tankful by the rate per acre of product.

Boom Sprayer Calibration

1. Fill tank with water.
2. Adjust spray pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Spray ¼ acre (10,890 sq. ft.). Distance of travel will vary with boom width.

   For example, a 22-foot boom must travel 495 feet to cover ¼ acre:

$$\frac{\text{¼ acre (10,890 sq. ft.)}}{\text{boom width (22 ft.)}} = \frac{\text{distance of travel}}{\text{(495 ft.)}}$$

4. Measure amount of water needed to refill the tank. This amount was applied to the ¼ acre; thus, four times this amount is the gallonage per acre.

Band Sprayer Calibration

1. Fill tank with water.
2. Adjust spray pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Spray ¼ acre (10,890 sq. ft.). Distance traveled will vary with number of nozzles on the sprayer and width of the band sprayed by each nozzle.

   For example, spraying a 20-inch band over 4 rows using 1 nozzle per row requires 1,630 ft. to cover ¼ acre:

$$\frac{\text{¼ acre (10,890 sq. ft.)}}{\text{band width (1.67 ft.)}} \div \frac{\text{number of}}{\text{nozzles (4)}} = \frac{\text{distance of travel}}{\text{(1,630 ft.)}}$$

4. Measure amount of water needed to refill the tank. This amount was applied to the ¼ acre; thus, four times this amount is the gallonage per acre.

Wand Sprayer Calibration

1. Fill tank with water.
2. Spray 1/128 acre (340 sq ft.) with the pace and nozzle distance you would be using for application.
3. Measure amount of water needed to refill the tank. This amount was applied to the 1/128 acre; thus, the number of fl. oz. required to refill the sprayer is equal to gallonage per acre.
4. Calculate acres per tankful of spray solution by dividing gallons per tank by gallons per acre of output, and determine the required amount of product to the tank by multiplying acres per tankful by the rate per acre of product recommended.

Airblast Sprayer Calibration

1. Fill tank with water.
2. Adjust spray pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Spray 164 ft., measure the time to complete the course, and measure the effective spray swath. For a unidirectional unit, measure the swath from the sprayer to the end of the deposition cloud. For a bidirectional unit, measure the swath from one end to the other end of the deposition cloud. Do this three times to calculate the average time to travel 164 ft, and spray swath. Record speed and PTO speed or pressure settings for reference.

4. Measure amount of water needed to refill the tank. This amount was applied to the fraction of an acre; thus, four times this amount is the gallonage per acre.

   For example, spraying a 10 ft. swath over a164 ft course used 2 gallons. The gallons per acre is calculated below:

$$\text{volume measured (2 gal.)} \times \frac{\text{1 acre (43,560 sq. ft.)}}{\text{area of swath (10 ft. x 164 ft.}} = \text{output (53 gal/ac.)}$$

Injectors for Fertigation and Chemigation

Chemigation is the process of applying an agricultural chemical (pesticide or fertilizer) to the soil or plant surface through an irrigation system. Chemigation can be an effective application option for some materials if the irrigation system can apply the chemical/water solution uniformly over the target area with the correct water depth.

There are two philosophies to chemigating through the water: 1) premix the chemical with water in a large (100 to 500 gal) stock tank and pump right out of that with an external inline water pump or gravity feed; or 2) use a water pump to pipe through a system that meters in concentrated chemical from a much smaller container. There are three primary types of injectors: venturi injectors (brand names include Hozon, Syfonex, Mazzei), water-pressure injectors (brand name EZ-Flo), and positive-displacement injectors (brand names include Dosatron, Chemilizer, MixRite). It is common to combine methods in greenhouse fertilizer programs, using a large stock tank to acidify water, and then pumping that acidified water through a fertilizer injector.

Most late-model center pivot and linear move systems provide adequate distribution but some may not be able to apply a small enough volume of water. Solid set sprinkler systems may be effective for some pesticides but require close timing of chemical movements to get complete and uniform coverage of the field. Drip irrigation can be used effectively to apply certain pesticides and fertilizers. Traveling gun and hand move systems do not provide water distribution that has high uniformity and are not recommended. Product labels provide more information about appropriate water application amounts and which irrigation systems are recommended.

Backflow prevention is important to prevent injected chemicals from backflowing into the water source. EPA and many state regulations specify that each system must contain a reduced pressure zone (RPZ) backflow prevention valve, or one or two independent check valves with low-pressure drains and vacuum relief valves, between the irrigation water source and the point of chemical injection. Also, most regulations require a power interlock between the irrigation pump and the chemical injector unit, a low pressure shut down switch and a check valve on the chemical injection hose. For specific requirements, check with the appropriate local or state agency.

It is important to accurately calibrate the irrigation system and pesticide application rate. The chemigation operator must be aware of the irrigation system's application speed (acres per hour) for the chosen water application amount and the concentration of chemical solution to determine the rate of chemical injection.

More information about the special equipment, operations, and calibration of irrigation systems is available from the University of Minnesota Extension Service resources, *Chemigation Safety Measures*, and, *Applying Nitrogen with Irrigation Water*, available at extension.umn.edu or the University of Georgia's *Fertilizer Injectors: Selection, Maintenance, and Calibration (Bulletin 1237)*, or *Drip Chemigation: Injecting Fertilizer, Acid and Chlorine* (Bulletin 1130) available at extension.uga.edu/publications.

Injector Calibration

For example, you have a target ratio of 1:100 according to the manufacturer of a soluble fertilizer and want to see if your injector is making the desired concentration.

1. Fill a graduated cylinder to a measured volume with concentrated fertilizer.
2. With the irrigation system running, fully charged, and the point of injection at the same height that it will be during actual injection, place siphon hose in graduated cylinder and note the metering ratio, PSI, or flow rate on the injector.
3. Fill a bucket with the diluted solution to a pre-measured volume. It helps to install a spigot or nozzle after the injection loop and before the irrigation header mains for this purpose.
4. Remove siphon hose from graduated cylinder and measure the new level of the concentrate.
5. Subtract the final and starting volumes of the graduated cylinder and divide from your diluted volume to find the injection ratio.

   For example, a graduated cylinder is filled to 8 fl. oz. with a concentrated chemical. Then, the hose is run until 4.25 gal. (544 fl. oz.) of dilute chemical is collected in a bucket, after which the graduated cylinder measures 2.5 fl. oz. The ratio is 1:98.9, which is very close to the manufacturer's specifications of 1:100. If this calculation was not close to the desired 1:100, make adjustments to metering ratio, PSI, or flow rate of your specific injector to dial it in from there.

$$\frac{\text{544 fl. oz.}}{\text{(8 – 2.5) fl. oz.}} = \text{98.9 fl. oz. water per 1 fl. oz. concentrate}$$

How much concentrated chemical to add to tanks?

Spray tanks

Calculate acres per tankful of spray solution by dividing gallons per tank by gallons per acre of output, and determine the required amount of product to the tank by multiplying acres per tankful by the rate per acre of product recommended.

For example, a 100 gal. tank with an output of 20 gal. per acre will cover about 5 acres with one tankful. If spraying a chemical at 6 fl. oz. per acre, it requires 30 fl. oz. per tankful.

$$\frac{100 \text{ gal.}}{1 \text{ tank}} \times \frac{1 \text{ acre}}{20 \text{ gal}} = 5 \text{ acres per tankful}$$

$$\frac{5 \text{ acres}}{1 \text{ tank}} \times \frac{6 \text{ fl. oz.}}{1 \text{ acre}} = 30 \text{ fl. oz. per tank}$$

Stock tanks for injectors

For stock tanks that are used to meter in concentrated fertilizers or pesticides, calculate the volume of the fertilizer or chemical needed for your desired area. Use liquid fertilizers and chemicals directly through the injector as concentrates. For dry products, use enough water to dissolve the material.

For example, injecting a pesticide into the drip tape at 2 fl. oz. per acre in a field with 100 rows, 400 ft. long on 4 ft. centers will require 7.34 fl. oz. of pesticide.

$$100 \text{ rows} \times \frac{(4 \times 400) \text{ sq. ft.}}{\text{row space}} \times \frac{1 \text{ acre}}{43{,}560 \text{ sq. ft..}} = 3.67 \text{ acres}$$

$$3.67 \text{ acres} \times \frac{2 \text{ fl. oz.}}{\text{acre}} = 7.34 \text{ fl. oz. needed for the area}$$

Rates for Beds

You can apply fertilizer and some pesticides in a band while shaping beds or laying plastic. You can also apply it dissolved through irrigation water and delivered by drip tape to the base of the plants. In these systems, it is helpful to calculate the rate per linear bed foot (LBF) based on the product rate per acre. To do so, you will need to know:

- Bed spacing (BS): distance in feet between bed centers
- Product rate per A (RatePerA)

Use this equation to determine the rate for linear bed foot:

(RatePerA X BS) / 43,560 = RatePerLBF

Example:

Bed spacing (BS) = 5 ft. between centers of beds
Product rate per A (RatePerA) = 100 lbs./A

(100 X 5) / 43,560 = 0.0115 lb./LBF

For a crop on six 100-foot beds, there would 600 LBF to treat. The amount of product needed to supply 100 lbs./A would be:

600 LBF X 0.0115 lb./LBF= 6.9 lbs.

The Rate per Linear Bed Foot for Various Bed Spacings and Rates table provides conversions for a number of bed spacings and product rates.

Rate per Linear Bed Foot for Various Bed Spacings and Rates

The top row of the table below lists common rates per acre in increments of 20. The values in the body of the table are the rates converted from per acre into per linear bed foot when according to the chosen bed spacing in the left column. The rates in this table are unitless. For example, if a product requires 2 fl. oz. per acre, use the “20” column and divide the answer by 10.

Bed Spacing (ft)	Linear Bed Feet (LBF) in 1 Acre	20	40	60	80	100	120
3	14,520	0.0014	0.0028	0.0041	0.0055	0.0069	0.0083
4	10,890	0.0018	0.0037	0.0055	0.0073	0.0092	0.011
5	8,712	0.0023	0.0046	0.0069	0.0092	0.0115	0.0138
6	7,260	0.0028	0.0055	0.0083	0.011	0.0138	0.0165
7	6,222	0.0032	0.0064	0.0096	0.0129	0.0161	0.0193
8	5,445	0.0037	0.0073	0.011	0.0147	0.0184	0.022
9	4,840	0.0041	0.0083	0.0124	0.0165	0.0207	0.0248
10	4,356	0.0046	0.0092	0.0138	0.0184	0.023	0.0275

Conversions for Liquid Pesticides on Small Areas

Convert per acre rates to smaller areas by first converting the rate to fl. oz. or dry oz. Then, find 100 sq. ft. rates by dividing by 435.6, or 1,000 sq. ft. rates by dividing by 43.56. You can convert fl. oz. or dry oz. back to a larger unit from there. Or, use this table, which approximates the rate reductions into common measuring increments. Containers for measuring in milliliters (ml) (or the equivalent cubic centimeters, cc) are readily available in the form of graduated cylinders or syringes used for livestock.

Rate per Acre	Rate per 1,000 Square Feet	Rate per 100 Square Feet
1 pint	0.37 fl. oz. (11 ml)	0.04 fl. oz. (1.1 ml)
1 quart	1.5 fl. oz. (43 ml)	0.15 fl. oz. (4.3 ml)
2 quarts	2.9 fl. oz. (87 ml)	0.29 fl. oz. (8.7 ml)
1 gallon	5.9 fl. oz. (174 ml)	0.59 fl. oz. (17.4 ml)
25 gallons	4.5 pt. (2.1 L)	7.2 fl. oz. 213 ml)
50 gallons	4.6 qt. (4.4 L)	15 fl. oz. (435 ml)
75 gallons	6.9 qt. (6.5 L)	22 fl. oz. (653 ml)
100 gallons	9.2 qt. (8.7 L)	29 fl. oz. (870 ml)
25 pounds	9.1 oz. (0.25 kg)	0.91 oz. (25 g)
50 pounds	18 oz. (0.51 kg)	1.8 oz. (51 g)
75 pounds	28 oz. (0.80 kg)	2.8 oz. (80 g)
100 pounds	37 oz. (1.1 kg)	3.7 oz. (104 g)
1 ton	45 lb. (20 kg)	4.5 lb. (2 kg)

Check the pesticide label for the particular crop, pest, and site of your planned use.

Evaluating Water Quality and Compatibility of Pesticides Before Tank-Mixing

Water that is added to the pesticide spray tank may vary in pH, hardness and other qualities. These variations in water types may influence the effectiveness of the pesticide application. To learn about this subject, see *The Impact of Water Quality on Pesticide Performance* (Purdue Extension publication PPP-86) available from the Education Store, edustore.purdue.edu.

Read the label and follow directions. If the label states, “Do not mix with other products,” that direction must be followed. If using different products, and one label states, “Add last to spray tank”, that direction must be followed If the label states, “Do not use adjuvants”, that direction must be followed.

Follow these steps to do a jar test of a new mixture of chemistries to ensure compatibility in the tank. These ratios will approximate 25 gallons per acre. Between each ingredient, let it stand for a few minutes to see if there is a reaction. If solids form, the material turns greasy, or heats up, don’t use it in the field. The allowable separation in the jar depends on the amount of agitation in your equipment.

1. In a 1-quart jar, add 1 pint of the same water or liquid fertilizer that will be used in the field.
2. Add and agitate 1 ½ teaspoon of any wettable dry product(s) for each pound per acre to be used. Formulation abbreviations include W, WP, WDG, DF, D, or G.
3. Next, add and agitate 1 teaspoon for each quart per acre of any liquid flowables and suspensions to be used. Formulation abbreviations include FS, F, WS, SC.
4. Next, add and agitate 1 teaspoon for each quart per acre of any microencapsulated or emulsifiable concentrates to be used. Formulation abbreviations include ME, EC, or E.
5. Finally, add and agitate 1 teaspoon for each quart per acre of any surfactants and solutions to be used. Formulation abbreviations include CS, S, or L.

Storing Pesticides for Next Season

Growers who store pesticides always should consider safety and product quality, whether they will store products for a few weeks or a year or more. It is best not to have leftover pesticides. However, there usually are surplus pesticides at the end of the season because preseason purchases often are very economical.

Before storing pesticides always:

1. Read product labels. Certain formulations or products have special storage requirements printed there.
2. Make certain the label is in good condition (legible) to know what is in the container and for directions for safe, effective, and legal use.
3. Write the purchase or delivery date on the label. Store the oldest materials near the front of the storage area and use older or opened products first. Products that are several years old may not be effective.
4. Keep an up-to-date inventory of pesticides to assist in purchase decisions and in emergencies.
    a. Maintain storage temperatures between 32 F and 100 F with good ventilation and out of direct sunlight.
5. Store herbicides away from other pesticides to prevent use mix-up, contamination, and possible plant damage. Never store pesticides with food or seed or near food or drinking water.
6. Permanently identify and lock pesticide storage areas.
7. Keep a supply of cat litter or other absorbent material in the storage to scatter over spills of liquid chemicals.
8. Have a Class B inflammable liquids fire extinguisher.

Empty Containers

Most states have regulations that regulate the disposal of pesticide containers. The regulations often require that hazardous materials containers be disposed of in designated hazardous waste sites unless commercial applicators meet triple-rinsing and other requirements.

However, farmers and private applicators may be exempt from the regulations as long as they follow all label instructions when disposing of waste pesticides and containers.

Pesticide Poisoning

800-222-1222 will automatically connect you to the poison center nearest you. Personnel at this number will give first aid instructions and direct callers to treatment centers. For immediate emergency treatment or ambulance service, always call 911.

For pets, call the Animal Poison Control Center at 888-426-4435, or the Pet Poison Helpline at 800-213-6680. A consultation fee may apply.

Pesticide Spills

For information about cleaning up or otherwise dealing with **non-emergency pesticide spills**, you can contact the National Pesticide Information Center at 800-858-7378 and the pesticide manufacturer for SDS and label information.
For emergency pesticide spills, pesticide fires, or pesticide transportation accidents first call 911, then call your state agency who handles spill response.

- Illinois Emergency Management Agency
  800-782-7860
- Indiana Department of Environmental Management
  888-233-7745
- Iowa Department of Natural Resources
  515-725-8694
- Kansas Department of Health and Environment
  785-291-3333
- Michigan Department of Agriculture and Rural Development
  800-405-0101
- Minnesota Duty Officer
  800-422-0798
- Missouri Department of Natural Resources
  573-634-2436
- Ohio Environmental Protection Agency
  800-282-9378

When federal notification is required, call the National Response Center at 800-424-8802.

Pesticide Use and Greenhouses, Chemigation, and Respirators

Before using any pesticide, always read the product label for mention of greenhouse, chemigation, and respirator restrictions. See the tables for Fungicides, Herbicides, Insecticides, and Nematicides.

Labels

For complete label and Safety Data Sheet (SDS) information, search one of the following databases.
cdms.net/label-database
agrian.com/labelcenter/results.cfm
greenbook.net

To check if a pesticide is registered at the federal level, search this database.
iaspub.epa.gov/apex/pesticides/f?p=PPLS

Produce Food Safety Strategies

Reviewed by Phil Tocco, Londa Nwadike, and Ben Phillips – Sep 2021

Produce food safety aims to reduce the risk of produce contamination by human pathogens or other contaminants during field production and postharvest handling. Good Agricultural Practices (GAPs) present a set of guidelines and practices that can prevent or reduce the risk of produce contamination by a foodborne pathogen, or other contaminant, in the field and during postharvest handling. To reduce the risk of contamination by a foodborne pathogen, vegetable growers should adopt GAPs, paying particular attention to water management, waste (manure), worker sanitation/hygiene, and wildlife. All growers should utilize Good Agricultural Practices, but only certain buyers require GAPs certification and paying for a third party audit.

Growers of a certain size who grow, harvest, pack or hold certain produce types must adopt particular GAPs to be in compliance with current Federal produce safety guidelines under the Food Safety Modernization Act Produce Safety Rule (FSMA PSR). The law codifies many GAP standards and follows the same general outline of hazards seen in GAPs. Rules regarding water used in the growing, harvest, packing and storage of fresh produce are under currently under review and will be enforced in the future. The Purdue Extension Publication, *Food Safety for Fruit and Vegetable Farms: Good Agricultural Practices for Fruit and Vegetable Farms*, gives an introduction to produce food safety, and is available at edustore.purdue.edu.

Water Management

Water can be a major source of contamination in crop production. It is important to make sure that water coming in contact with the crop is of adequate quality for its intended use. Growers should monitor the quality (presence of bacteria) of irrigation and process (postharvest) water through testing.

Water should be tested for generic *E. coli* at least annually, or as required by law or individual food safety programs. In general, current guidelines allow an average of no more than 126 colony forming units of generic *E. coli* per 100 milliliters (CFU/100 ml) of water intended for **pre**-harvest uses. Water exceeding these parameters may require a corrective action, such as water treatment, inspection and repair of the water system, or extending the time between the last irrigation and harvest. *E. coli* should be below detectable limits (typically reported as ≤ 0 CFU/ml) for postharvest uses (product cleaning, product cooling, etc.). Water quality laboratories who use the approved FDA methods for testing have been identified across the United States on a map which can be accessed at go.uvm.edu/waterlabmap.

Growers covered by the Produce Safety Rule may also be required to meet certain water testing requirements and criteria. For more water sampling information and a summary of Produce Safety Rule water testing criteria, growers should consult Purdue Extension Publication, *On-farm Food Safety for Produce Growers: Microbial Water Quality Testing,* edustore.purdue.edu.

Irrigation Water

Pathogens can be introduced into irrigation water through manure runoff from animal production facilities, sewage runoff from treatment facilities or septic systems, or directly from wildlife. Extreme rainfall, manure spills, or human waste can increase the probability of contamination occurring.

Ground water is the least likely water source to be contaminated. Well water, when used directly, bears a relatively low contamination risk, provided that the wells are properly constructed and maintained. Wellheads should be protected from contamination by elevating the wellhead above ground level and using backflow prevention devices.

Surface water (such as ponds, creeks, and rivers) carries the highest risk for contamination. Microbe levels in surface water may change rapidly. Also, surface water cannot be protected from contamination by wildlife, runoff, or other potential sources of contamination. The following measures may reduce the risk of microbial contamination in surface water:

1. Construct ponds well away from apparent sources of contamination such as livestock facilities and pastures, composting pads, and sewage systems.
2. Fence ponds to prevent wildlife and domestic animals from entering and contaminating the water and surroundings.
3. Redirect runoff to flow away from the pond by building a bank or channel.
4. Establish vegetation buffer zones around ponds to filter runoff before it gets into the pond.
5. If irrigating from a creek or river, consider using a settling pond. This will allow large particles that may contain bacteria to settle at the bottom.
6. Communicate with neighboring livestock producers and work collaboratively to maximize the distance between livestock and water used for irrigation, spraying, or other crop production practices.
7. Sediment and high microbial contamination loads may be washed in by heavy rain. Remember to use caution if using the water source after a heavy rain event.

Water application methods (drip, overhead, or furrow irrigation), timing (how close to harvest), and vegetable types (above, below, or on the soil) are also factors to consider. These factors are often interrelated and have to be considered in a combination.

Process Water

Water is used in many processing (or postharvest) operations, including washing, cooling, top-icing, and transferring product with flumes. Contaminated process water has the potential to introduce and spread contamination throughout an entire harvest lot. Process water that is not of adequate microbial quality can easily transfer pathogens from contaminated to noncontaminated produce.

To prevent cross-contamination, sanitizers may be added to process waters. Sanitizers added to process water do not "clean" the product as such. They merely sanitize the water and prevent contamination from one piece of produce from spreading to other pieces of produce.

There are a number of chemical and nonchemical (called pesticide devices by FDA) sanitizers, such as chlorine, chlorine dioxide, peracetic acid, hydrogen peroxide, ozone, and UV light. The treatment chosen depends on various factors, such as the type of produce, type of postharvest operation, market requirements, etc. Seek sound technical advice before investing in a sanitizing system. Any chemical treatment used should be labeled for its intended use. See table below for a list of EPA-registered products for use in produce wash water. Growers who use sanitizers should be prepared to monitor water pH, turbidity, temperature, and other factors that affect sanitizer performance. More information about chlorine-based monitoring systems is available in *Oxidation-Reduction Potential (ORP) for Water Disinfection Monitoring, Control and Documentation*, University of California publication 8149, available from anrcatalog.ucanr.edu.

Waste (manure)

Growers should use caution when using animal-derived soil amendments. Biological soil amendments of animal origin (BSAAO), those soil amendments such as manure, bone meal, or feather meal, that are animal-derived may contain human pathogens. Growers who use raw manure should insure a lengthy interval between application and harvest. It is generally recommended that growers use a 90-day interval between manure application and harvest for above ground crops and a 120-day interval for crops where the edible portion is in contact with the soil. Manure is considered raw (or untreated) unless it has been properly composted or has undergone a validated process to reduce microbe levels. Composting must be done in accordance with specifications set forth in the National Organic Program or materials are considered untreated. BSAAO that has been properly composted and then protected from contamination is less likely to contain human pathogens and may be applied to fields at any time without application-to-harvest intervals. When using products containing BSAAO, growers should consult the manufacturer to determine if the product has been properly treated.

Workers

Growers should monitor workers for signs of illness. Individuals who are sick should not handle produce and should be assigned to other tasks. Workers should wash hands frequently, before beginning work and before returning to work following any breaks. Growers should have policies compelling workers to wear clean clothes at the beginning of the workday and should prohibit the wearing of jewelry (except for a simple wedding band) or sequined clothing while working with, or around, produce. All workers should receive sanitation and hygiene training.

Wildlife

Excessive wildlife activity in production areas has the potential to introduce human pathogens into crops. Growers should monitor fields for signs of wildlife activity. Interventions should be used when wildlife populations rise to levels that introduce excessive risk to crops. A number of products are available for deterring wildlife from fields. Netting and fencing may be used to exclude animals. Live traps may be used to relocate animals (check with local and state regulations prior to attempting). Reflective tape and noise-making devices may be used to frighten wildlife. Vertebrate pest are highly adaptable, and as a result, growers will very likely need to employ several tactics in combination to manage populations.

Produce Safety Rule and On Farm Readiness Review

The Food Safety Modernization Act (FSMA) Produce Safety Rule became law in January 2016. The rule codifies food safety standards for vegetable growers. Depending on farm size, growers will have varying amounts of time to implement the rule on individual farms. Not all vegetable growers are covered by the rule and some growers may have qualified exemptions. The U.S. Food and Drug Administration (FDA) has developed a flowchart to help growers determine whether or not they are covered by the rule. The flowchart is available at fda.gov/media/94332/download.

Informational videos dealing with FSMA Produce Rule coverage and other very useful compliance information may be accessed at the Food Safety Resource Clearinghouse at foodsafetyclearinghouse.org.

Among other requirements, one person from each farm that is covered by the Produce Safety Rule must receive an approved training. Produce Safety Alliance (PSA) grower trainings meet the Produce Safety Rule training requirement. A directory of certified trainers is available on the PSA website at resources.producesafetyalliance.cornell.edu/directory.

The On Farm Readiness Review is a tool developed by the National Association of State Departments of Agriculture (NASDA) to help growers assess their level of compliance with the Produce Safety Rule. The review is voluntary, completely confidential, and is conducted by a team of qualified individuals. Growers who wish to request an On Farm Readiness Review should contact the lead agency for Produce Safety Rule implementation in their respective states. For example, Indiana growers should contact the Indiana Department of Health at 317-476-0056 or ProduceSafety@ISDH.in.gov to request a review.

Inspection of Covered Produce Farms

Inspection of produce farms covered by the FSMA Produce Safety Rule began in 2019. Farms with annual sales of over $500,000 were initially inspected. During the 2020 growing season, those farms with annual sales of $250,000 - $500,000 (small farms per FDA definition) will also be inspected. Inspections for very small farms, those having annual sales of $25,000 - $250,000 will begin in 2021. Inspections will vary by state and may be conducted by state departments of agriculture, state departments of health, or FDA. All inspections will be conducted using a similar process and will be based on FDA Form 4056, although states may customize this form to some degree. A copy of FDA Form 4056 may be viewed at fda.gov/media/124867/download. Regardless of the agency conducting the inspection, growers will be contacted in advance of the actual inspection in order to arrange a mutually agreed upon inspection time.

GAPs Certifications and 3rd Party Audits

A GAPs certification (also known as a 3rd party certification) is an increasingly common condition of sale for many produce buyers. GAPs certifications are not the same as receiving a certificate for attending a GAPs training or proof of completing a PSA Grower Training. GAPs certifications require an audit by an independent (3rd) party. The audit will verify that growers have implemented GAPs on their farm and are following their written food safety plan. Steps to obtaining a GAPs certification are:

1. Communicate with your buyer. Growers should make sure that they understand exactly what buyer requirements are and what audits the buyer will accept. There are several different GAPs audit schemes available to growers. Make sure you are using an audit scheme that will be accepted by your buyer.
2. Once an audit scheme is selected, growers should develop a written food safety plan using the audit scheme and audit checklist as a guide.
3. Once the plan is implemented, an auditor is contacted. The auditor will visit the farm and verify that the written plan is being followed.
4. Upon successful completion, and passing of the audit, the grower will receive their certification. These are normally valid for one year.

More information about GAPs, the Produce Safety Rule, and GAPs Certifications is available from:

Purdue University Extension: safeproducein.com

Michigan State University Extension: canr.msu.edu/agrifood_safety

Kansas State University/ University of Missouri Extension: ksre.k-state.edu/foodsafety/produce

Iowa State University Extension: safeproduce.cals.iastate.edu

GAPsNET, Cornell University, gaps.cornell.edu

U.S. FDA, fda.gov/food/food-safety-modernization-act-fsma/fsma-rules-guidance-industry

Produce Safety Alliance, producesafetyalliance.cornell.edu

Sanitizer Table

Created by Amanda Deering
Reviewed by Ben Phillips – Sep 2021

This table includes selected information about the sanitizers for use in wash water, on food contact surfaces, and irrigation water. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**.

† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production

There are three primary classes of sanitizers. Oxidizers, quaternary ammonias, and iodines. Oxidizers include calcium hypochlorite, chlorine, chlorine dioxide, hydrogen peroxide, peroxyacetic acid, sodium chlorite, and sodium hypochlorite. Oxidizers are reactive with non-stainless-steel metals. Chlorines and chlorites are sensitive to pH, temperature, and turbidity. The oxidizing sanitizers are variously-labeled for use on food contact surfaces, direct contact with produce through wash water, and also in irrigation water. Some oxidizing ingredients are available to use in organic production systems. Sodium bromides must be activated with an oxidizer, and the selection below are only labeled for use in wash water. Quaternary ammonias and iodines are only labeled for food contact surfaces.

This table is subset of data from a more complete and detailed database of *Labeled Sanitizers for Produce* version 4 updated 11/9/20, developed by the Produce Safety Alliance at producesafetyalliance.cornell.edu/resources/general-resource-listing.

Active Ingredients	Trade Names	Food Contact Surface Use	Produce Wash Water Use	Irrigation Water Use
calcium hypochlorite	ECR Calcium Hypochlorite, Accutab, Aquachlor, Aquafit, Incredipool, Induclor, Zappit	X	X	X
chlorine (gas)	Olin Chlorine	X	X	
†chlorine dioxide	Anthium BCD-200, Anthium Dioxcide, Biovex, Carnebon 200, Oxine	X	X	X
citric acid, sodium dodecylbenzene-sulfonate	Pro-san L	X		
†hydrogen peroxide	SaniDate Ready to Use, Oxidate RTU, Zerotol RTU	X		
†hydrogen peroxide	Di-Oxy Solv, SaniDate RTU		X	X
iodine	LFI Sanitizer	X		
isopropyl alcohol, octyl decyl dimethyl ammonium chloride	Alpet D2	X		
lactic acid, sodium dodecylbenzene-sulfonate	Antimicrobial Fruit and Vegetable Treatment, Market Guard 700, Simply Save Antimicrobial Produce Wash		X	
n-alkyl dimethyl benzyl ammonium chloride	Market Guard Quat, Flex Pak Quat, Oasis Compac Quat, Simple Green D, Steramine, Ster-Bac	X		
†peroxyacetic acid, hydrogen peroxide	Oxonia Active, Synergex	X		
†peroxyacetic acid, hydrogen peroxide	Victory		X	
†peroxyacetic acid, hydrogen peroxide	Jet-Ag, Jet-Ag 15%			X
†peroxyacetic acid, hydrogen peroxide	Peraclean 5, Perasan C-5, Tsunami 100	X	X	
†peroxyacetic acid, hydrogen peroxide	Zerotol 2.0, Oxidate 2.0	X		X
†peroxyacetic acid, hydrogen peroxide	Proxitane WW-12, Sanidate 12.0		X	X
†peroxyacetic acid, hydrogen peroxide	BioSide HS 15%, Maguard 5626, Peraclean 15, Perasan A, Perasan OG, PerOx Extreme, Proxitane 15:23, Proxitane EQ, Sanidate 15.0, Sanidate 5.0, VigorOX SP-15	X	X	X
sodium bromide	Bromicide 4000, Bromide Plus, Busan 6040		X	
†sodium chlorite (precursor to chlorine dioxide)	EnviroChlorite 7.5, EnviroChlorite 15			X
†sodium chlorite (precursor to chlorine dioxide)	Ercopure BCD, Selectrocide 2L500, Selectrocide 5G	X	X	X
sodium hypochlorite	Surchlor	X		
sodium hypochlorite	Agchlor 310, Dixichlor Lite, Freshgard 72, Hypo 150, Liquichlor 12.5%, Pac-chlor 12.5%, Puma, Re-Ox, Sno-Glo Beach, Ultra Clorox Brand Regular Bleach, Vertex Concentrate, Vertex CSS-12, Vertex CSS-5 Bleach, XY-12 Liquid Sanitizer, Zep FS Formula 4665, CLB, CLB I	X	X	
sodium hypochlorite	Sodium Hypochlorite 12.5 Bacticide, Agrichlor Plus, Chlor12.5, Chlorsan 125, Hypure Sodium Hypochlorite 12.5	X	X	X

Disease Management Strategies

Reviewed by Cesar Escalante and Peng Tian – Sep 2025

Plant diseases are caused by a wide variety of microbial pathogens (including fungi, bacteria, viruses, and nematodes). For a plant disease to occur, three components must be present:

1. The pathogen
2. A susceptible host (the plant)
3. An environment conducive to disease.

In addition, insects spread some diseases, which makes them a fourth component of the disease cycle. Disease management strategies target one or more of these factors to prevent and/or reduce the risk of disease. The sections below provide a broad overview of general management strategies. The crop-by-crop chapters go into much more detail for each disease.

Disease Diagnosis

Before making any management decisions, always make sure to correctly diagnose your problem first. Accurate diagnoses can save time and money because some diseases look alike but require very different management strategies.

Different pathogens have different modes of survival and dissemination. Therefore, certain management practices work for some diseases but may have no effect on others. Furthermore, disease control materials are usually effective against only a subgroup of specific diseases. For example, fungicides have no effect on viruses.

Moreover, even among the various fungi, some materials may be effective against certain diseases but not others. In particular, the pathogens Pythium, Phytophthora, and the causal agents of downy mildews that we often discuss as fungi are not true fungi, they are in a different group of organisms called oomycetes. Many materials effective against true fungi are not effective for those organisms, and vice versa.

For example, numerous materials used to manage downy mildew will have no effect or a negligible effect on powdery mildew, and vice versa. A root disease may require very different management compared to a leaf spot or fruit disease.

Moreover, there are several plant health issues that mimic plant diseases (including environmental stress, nutritional problems, herbicide injuries, air pollution, etc.). These are known as abiotic disorders.

Unwittingly treating a nutrient deficiency with pesticides wastes time and money, and does not solve the underlying condition. Submitting samples to a diagnostic laboratory is the best way to ensure the correct diagnosis. For a list of labs and instructions on how to submit plant samples, see the State Contact Information table and the section Using a Diagnostic Lab.

Healthy Plant Material

Contaminated seed or transplants can introduce pathogens, so saving vegetable seeds for next year's crop is not recommended unless you are trained and equipped to handle seed sanitation. You should not save seeds when a seedborne disease has been active. The Summary of Cultural Management Strategies for Disease table lists some diseases that may be transmitted by seed or transplants.

Whether you purchase transplants or produce them yourself, you should read Transplant Production to better understand transplant health. Be certain to inspect seedlings regularly. Examine the foliage and remove a few plants from the pots to inspect the roots. If you purchase transplants, keep newly-arrived materials away from other plants and the production area for a few days to prevent spread if a problem is found.

Talk to your local extension educator or specialist and ask questions about how to reduce disease risk when handling transplants. If you suspect a disease on received plants, take photos and contact a diagnostic laboratory, and continue to keep the plants separate. Keep good records of where plants are sourced from so that you can contact the supplier if a problem arises.

Disease-Resistant Varieties

Whenever possible, use varieties resistant to diseases. Some varieties may not be completely resistant to particular diseases; however, incomplete or partial resistance may be available. Some seed catalogs may refer to tolerance. The Summary of Cultural Management Strategies for Disease table presents information about the availability of resistant varieties.

For certain vegetables (such as tomatoes) there are rootstocks available with resistance to some soilborne pathogens. A resistant rootstock may be an option if you have a history of a known soilborne disease but wish to grow a susceptible tomato scion variety.

Tillage and Crop Rotation

If a pathogen survives from year-to-year in crop residues or soil, then crop rotation and fall tillage are very effective methods in disease management. The pathogens are unable to survive once the crop residue decomposes.

Tillage (especially fall tillage) helps control diseases by reducing the amount of inoculum (pathogen structures) that survive the winter. Rotating fields to different crop families each year also helps control diseases by preventing the build-up of certain plant pathogens in the soil. The Summary of Cultural Management Strategies for Disease provides tillage and crop rotation recommendations. A general rule is that you should not rotate a field to a crop in the same botanical family.

Unfortunately, there are several kinds of soilborne diseases that are unaffected by rotation. The first group of these diseases is caused by pathogens that produce resilient survival structures that can withstand harsh environmental conditions, the effects of time and nonhost crops. Two such diseases are Fusarium wilt, and root-knot nematode.

Another group of diseases unaffected by crop rotation has a broad host range, so they can survive indefinitely on many host crop and weed species. Examples include Sclerotinia, Rhizoctonia, and Verticillium diseases.

In addition, root-knot nematode can cause disease in multiple vegetable plant families (cucurbits, tomato, carrot, and many more) along with some field crops and even weeds.

The third group of diseases unaffected by rotation overwinter in Gulf Coast states, and then spread north by wind during the growing season. Examples include sweet corn rust and downy mildew of cucurbits.

In addition, certain viruses spread by highly motile insects (such as aphids), so rotation does not reduce these diseases either. Since the pathogen does not overwinter locally in the field, survival in residue is not a factor. Viruses can also be transmitted through seed; therefore, planting certified seed is important to prevent yield losses due to viral infections.

Consider all options before making management decisions. Rotation is a good general practice that improves or maintains good soil tilth. Tillage (especially fall tillage) often is not in accordance with recommended soil management and conservation practices. If you practice no-till or reduced tillage, you need to be even more vigilant with other strategies to reduce the risk of disease.

Two publications that may be useful for no-till or reduced tillage growers are Building Soils for Better Crops: Ecological Management for Healthy Soils, and Managing Cover Crops Profitably, and both are available from the Sustainable Agriculture Research & Education (SARE) Learning Center, sare.org.

Water and Humidity Management

Many bacterial and fungal pathogens thrive in wet conditions. Certain soilborne pathogens such as *Phytophthora* and *Pythium* species are favored by wet soils with poor drainage. Avoid planting into sites with known drainage problems. Improve drainage, and consider using raised beds.

Many leaf spot and fruit rot diseases are favored by high humidity and wet plant surfaces. Using drip irrigation instead of overhead irrigation reduces leaf wetness. If you use overhead irrigation, irrigate in the morning so that plant surfaces dry before nighttime. Avoid overhead irrigation in the evening.

Reduce plant density to allow better airflow and sunlight to penetrate, which decreases leaf wetness and humidity. With certain crops (such as tomatoes) appropriate staking or trellising also increases airflow. Reducing weed pressure in and along the sides of the crop can also improve airflow. Align rows to maximize airflow and sun exposure.

In greenhouses and high tunnels, use passive ventilation and/or fans to reduce humidity. See Transplant Production for details about water and humidity management in that setting. Avoid working in wet fields.

Scouting and Sanitation

Depending on the disease and the size of your operation, you can and should rouge (remove) infected plants. For example, there are no treatments for viral diseases, so you should remove infected plants to reduce the spread to other plants.

Bacterial canker of tomato is another disease where you should rogue out the infected plants and several neighboring plants. Flag the area and come back to check for further spread. Culls should be removed far from the field.

In greenhouse situations, remove the trash frequently, and always keep lids on trash cans to prevent pathogens (and insects) from building up in discarded plant materials. For some crops (such as tomatoes) stakes and trellises can harbor certain bacteria from one crop to the next. So always use new stakes, or at minimum disinfest them. Disinfest tools frequently, such as at the end of rows. Avoid working in fields under wet conditions.

Other Cultural Practices

Insects (such as thrips, aphids, cucumber beetles, and others) spread numerous diseases, so cultural practices that reduce the insects reduce the risk of diseases. The comments for the Summary of Cultural Management Strategies for Disease table lists some of these practices. See the Insect Management Strategies section for guidelines about cultural controls to reduce insects that may spread diseases.

Chemical Control and Resistance Management with Fungicides and Bactericides

Disease control products (fungicides, bactericides, and nematicides) are pesticides. Be sure to read the general section about Pesticide Application and Safety for information about safety, equipment, calibration, formulations, storage, and other important topics. For a disease control material to be effective, you must apply an appropriate material at the right time, in the right concentration, and in the right way.

Fungicides can be broadly classified as either contact or systemic. Within those groups, however, there are many active ingredients and multiple modes-of-action. Some fungicides are allowed in organic vegetable production, and some are designated as reduced-risk, including certain biopesticides/biological controls.

Both contact and systemic fungicides are most effective if you apply them before disease develops. Many diseases are very difficult or impossible to control with chemicals once a severe epidemic is underway. Throughout the crop-specific sections of this book there are details about when you should apply fungicides in order to be most effective (and information about when they may be ineffective).

Pathogens usually require a specific temperature and moisture range in order to cause diseases. For some diseases, knowing those specific requirements can help you time fungicide applications to coincide with disease risk. In some cases, the guidelines are informal, and may simply make you more aware that a wet season may require more applications and a dry season may require fewer. In other cases, the pathogen life cycle is understood well enough that you can use a formal disease forecasting system. Here are some resources for tracking weather and predictive models related to diseases:

- enviroweather.msu.edu
- newa.cornell.edu
- melcast.ceris.purdue.edu
- agweather.cals.wisc.edu/vdifn

Contact fungicides (also called protectant fungicides) provide a “coat” of protection on the plant’s surface when applied properly. These fungicides are designed to kill fungi on-contact on the surface of plants — hence, the name. Most contact fungicides have multiple modes of action, so fungal pathogens are unlikely to develop resistance to all of these different modes of action at the same time. For this reason, alternating contact fungicides is unnecessary. Good coverage is essential to maximize the efficacy of contact materials.

Systemic fungicides (sometimes called eradicants or curative fungicides) don’t merely coat the surface, they also enter the plant. Once inside the plant, some stay relatively localized. Others move across to the opposite leaf surface, some move upward in the plants, and a few move downward into the roots. They can sometimes eradicate or cure a portion of existing infections. Most systemic fungicides have a single mode of action, so the risk of pathogens developing resistance to these products is greater. The fungicides target a very specific function of the pathogen’s cells, and sometimes the fungus develops methods to evade the activity.

Powdery mildews and downy mildews are particularly prone to resistance development, but there are other examples. The crop sections in this guide flag diseases that are at risk for fungicide resistance. Always read and follow label directions that list how to alternate systemic fungicides and/or combine and rotate with contact fungicides to minimize the resistance development.

The Fungicide Table lists several fungicides and their modes of action to help in resistance management. Each fungicide label is marked with a FRAC (Fungicide Resistance Action Committee) code to designate a mode of action group and help growers design a rotation plan. Try to avoid using products with the same FRAC codes repeatedly to conserve their efficacy against diseases.

Bactericides (copper and antibiotic compounds) can help reduce the risk of early-season bacterial disease epidemics, but are most effective when used with other control methods. Copper compounds also are mediocre fungicides and are handled similar to protectant fungicides. Antibiotics serve a similar purpose in certain crops.

Summary of Cultural Management Strategies for Disease

This table describes several diseases listed by crop. This list is not exhaustive, but represents important Midwest diseases. Also listed are the cultural management options available for each disease. The management options are described in more detail in the text. Note that some pathogens have races. The reaction of a particular race of fungus or bacterium depends on the cultivar or variety grown. Rotation refers to the number of years that the field should be planted to a different crop.

Crop	Disease	Tillage[1]	Seedborne	Rotation[2]	Resistance	Comments
Allium garlic, onion, leek	Alternaria purple blotch, Botrytis leaf blight	3	Yes	3-4	No	Thrips-damaged tissues are more susceptible
	Aster yellows	1	Yes	NE	No	Seed transmission is low, but possible; transmission from garlic bulb/cloves occurs
	Botrytis neck rot	2	No	3	No	Cure bulbs rapidly and properly and avoid injury to neck
	Downy mildew	2	Yes	3	Yes	Resistance in onion only (limited varieties)
	Fusarium basal rot	1	No	4	Yes	
	Smut	1	No	3	No	Transmitted on sets and transplants
	White rot	1	No	NE	No	Do not move Allium spp. Into quarantine areas of the U.S. (Columbia Basin)
Asparagus	Cercospora leaf spot and rust	NA	No	NA	Yes	Remove or burn down ferns in the late fall to reduce inoculum
	Fusarium crown and root rot	NA	Yes	NA	Yes	Avoid long harvest periods to maintain vigor
	Phytophthora crown and spear rot	NA	No	NA	No	
Cruciferous vegetables	Alternaria leaf spot	3	Yes	3-4	No	
	Black leg	3	Yes	3-5		Leave ¼-mile buffer from previously infected fields, delay plant until conditions are dry
	Black rot	3	Yes	2-3	No	
	Club root	NE	No	5-7	Yes	Club root pathogen survives on some grass, clover, weedy, and other plants, which influences rotation or cover crop selection
	Downy mildew	3	Yes	2-3	Yes	Resistance in broccoli only
	Fusarium yellows	2	Yes	>6	Yes	
	Powdery mildew	3	No	3	Yes	Resistance for Brussels sprout and cabbage only, avoid over applying nitrogen and drought
	Rhizoctonia diseases	3	No	NE	No	Can form disease complex with black leg pathogen for stem canker
	Sclerotinia stem rot	2	No	NE	No	Very wide host range; rotation for greater than 3 years into grasses, onions, or corn may reduce severe infestations
	White rust	NE	Yes	3	Yes	Remove crop debris from area after harvest
Cucurbits cantaloupe, cucumber, pumpkin, squash, watermelon	Alternaria leaf blight	3	No	2	No	
	Angular leaf spot	3	Yes	2	Yes	
	Anthracnose	3	Yes	2	No	Race 1 affects mainly cucumber. Race 2 affects mainly watermelon
	Bacterial fruit blotch	3	Yes	2	No	
	Bacterial leaf and fruit spot	3	Yes	3	No	Primarily on pumpkin and winter squash
	Bacterial wilt	1	No	NE	No	Spread by cucumber beetles
	Downy mildew	1	No	NE	Yes	Resistant varieties of cucumber and cantaloupe available
	Fusarium wilt	1	Yes	5-7	Yes	
	Gummy stem blight/black rot	3	Yes	3	No	Also affects pumpkin and watermelon
	Phytophthora blight	2	No	>4	No	Avoid excess water and rotation with solanaceous crops; good drainage is important. Treating seeds with mefenoxam may prevent seedling death.
	Plectosporium blight	3	No	3-4	No	Primarily on pumpkins; manage like black rot
	Powdery mildew	2	No	2	Yes	
	Root-knot nematode	2	No	>6	No	Wide host range will affect rotation choices
	Viruses (several)	1	Yes	NE	Yes	Some are transmitted by insects and seedborne; plant crops before insect pressure becomes severe. Use certified seed. There might not be resistance to certain viral species.

Crop	Disease	Tillage[1]	Seedborne	Rotation[2]	Resistance	Comments
Leafy vegetables endive, herbs, lettuce, spinach	Botrytis gray mold	2	No	NE	No	Provide adequate spacing to reduce humidity
	Bottom rot and drop	2	No	NE	No	
	Downy mildew, white rust	NE	Yes	3	Yes	
	Lettuce mosaic virus	2	Yes	1	Yes	There are many hosts that may harbor the virus; manage aphid populations
	Powdery mildew	2	No	2	No	
Legumes cowpea, dry bean, lima bean, pea, snap bean	Anthracnose	3	Yes	3	Yes	Resistance is race-dependent
	Bacterial blights	3	Yes	2	No	
	Rust	1	No	3-4	Yes	
	Soybean cyst nematode	1	No	1-3	No	Rotation interval depends on the cyst count in soil samples
	White mold and gray mold	2	No	NE	No	
Root crops beet, carrot, parsnip, radish, turnip	Aster yellows	2	Yes	NE	No	Seed transmission is low, but possible; destroy perennial weed hosts near high-value crops
	Cercospora leaf spot, Alternaria leaf blight	3	Yes	2	Yes	Resistance availability varies by root crop and pathogen
	Downy mildew, white rust	3	Yes	3	No	Cruciferous weeds and crops are also hosts
	Root-knot nematode	2	No	>6	No	Wide host range affects rotational options
	White mold	2	No	NE	No	Avoid rotation with beans, cucurbits, celery, and cabbage
Sweet corn	Anthracnose	3	No	1-3	Yes	
	Goss' wilt	3	Yes	1	Partial	Control grassy weeds that are hosts
	Leaf blights (southern corn leaf blight, northern corn leaf blight, northern corn leaf spot)	3	No	1	Yes	
	Rust	NE	No	NE	Yes	
	Smut	2	No	NE	Yes	Maintain balanced soil fertility
	Stewart's wilt	1	Yes	NE	Partial	Spreads and survives in flea beetles
Fruiting vegetables eggplant, pepper, tomato	Anthracnose	3	Yes	3-4	No	Stake and mulch
	Bacterial canker	3	Yes	3-4	No	Disease is systemic
	Bacterial speck	3	Yes	2	Yes	Some strains are copper resistant
	Bacterial spot	3	Yes	2-3	Yes[3]	Copper resistance reported — check with your state pathologist
	Early blight	3	Yes	3-4	Partial	Some resistance to stem canker
	Fusarium crown and root rot	2	Yes	>6	Yes	Graft to resistant root stocks; use resistant varieties
	Late blight	1	No	NE	No	Does not overwinter in the Midwest
	Leaf mold	2	Yes	2	Yes	Notably a problem in high tunnels and greenhouses; infected transplants will experience disease outdoors
	Powdery mildew	2	No	2	No	
	Root-knot nematode	2	No	>6	Yes	Wide host range
	Septoria leaf spot	3	No	2-3	No	
	Southern blight	3	No	>6	No	Favored by high temperatures
	Tobacco mosaic virus	1	No	2	Yes	Spread by contact
	Tomato spotted wilt virus	1	No	NE	Yes	Spread by thrips
	Verticillium	2	No	>6	Yes	
	White mold	2	No	5-6	No	Wide host range; rotate with grasses; flood for 23 to 45 days
All vegetables	Damping-off	1	No	NE	No	Avoid excess moisture, sanitize seedling trays

[1]1=tillage has limited effect, 2=tillage is of limited help, 3=tillage is an important control
[2]Numbers refer to the number of years that the field should be planted to a different crop. NE=not effective.
[3]Pepper only

Fungicide Tables

This table includes selected information about the fungicides recommended in this guide. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**.

° = indicates that small package and ready-to-use formulations are commonly available at hardware stores and garden centers
* = indicates that some formulations may be Restricted Use Pesticides (RUP) and require a certification to purchase and use
† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production – check with your certifier
‡ = indicates additional formulations that do not currently occur elsewhere in this guide as crop protection recommendations because they are not as well understood to be effective options

The **Signal Word** is an indication of the human health hazard of the product.

The **Greenhouse Use** and **Chemigation Use** columns have one of four listings:
yes = the product label explicitly allows the use
some = the product label explicitly allows the use for certain crops (see the label for details), or certain Trade Names allow complete or partial use
no = the product label explicitly prohibits the use
silent = the product label does not mention the use — states decide if such uses are allowed

The **Respirator Use** column has one of the following listings:
no = a respirator is not required PPE
yes = a respirator is required for some part of the process (see label for details)
some = certain Trade Names may require respirators, but others may not

The **Bee Precaution** column uses the following listings:
I = Toxic to honey bees. Do not apply to plants that are flowering, or water puddles.
II = Toxic to honey bees. Do not apply to plants that are flowering, or water puddles, except at dusk
III = No bee precaution, except when required by the pesticide label or regulations
a = Toxic to honey bee brood
b = Toxic to other bee species

Active Ingredients	Trade Names	Signal Word	Greenhouse Use	Chemigation Use	Respirator Use	Bee Precaution
*1,3-dichloropropene	Telone II, Telone EC	warning, danger	no	some	yes	II a
*1,3-dichloropropene, chloropicrin	Telone C-17, Telone C-35	danger	no	no	yes	II a
acibenzolar-s-methyl	Actigard	caution	silent	some	no	III
ametoctradin, dimethomorph	Zampro	caution	no	some	no	II b
‡†allyl isothiocyanate	Dominus	danger	yes	some	yes	-
‡†*Aureobasidium pullulans* strain DSM 14940 and 14941	Botector	caution	some	no	yes	III
azoxystrobin	Acadia LFC, Aframe, Arius, Azteroid FC 3.3, Dynasty, Heritage, Quadris, Satori	caution	some	some	no	III
azoxystrobin, benzovindiflupyr	Elatus, Mural	caution	some	some	no	III
azoxystrobin, chlorothalonil	Arius Advance, Quadris Opti	warning	no	some	yes	II ab
azoxystrobin, difenoconazole	Quadris Top	caution	some	some	no	II b
azoxystrobin, propiconazole	Quilt, Quilt Xcel	warning	no	some	no	II ab
azoxystrobin, *Reynoutria sachalinensis* extract	Azterknot	caution	some	some	yes	III
azoxystrobin, tebuconazole	Custodia	warning	no	some	no	II b
†*Bacillus amyloliquefaciens* strain MBI 600	Serifel	caution	silent	some	yes	III b
°†*Bacillus amyloliquefaciens* strain D747	Double Nickel 55, Double Nickel LC	caution	silent	some	yes	III b
†*Bacillus amyloliquefaciens* strain F727	Stargus	caution	yes	some	yes	III b
†*Bacillus mycoides* isolate J	LifeGard WG	caution	yes	some	yes	-
†*Bacillus pumilus* QST 2808	Sonata	caution	yes	some	yes	-
‡†*Bacillus subtilis* strain IAB/BS03	AVIV	caution	yes	some	yes	III

Active Ingredients	Trade Names	Signal Word	Greenhouse Use	Chemigation Use	Respirator Use	Bee Precaution
†*Bacillus subtilis* strain QST 713	Cease, Serenade, Rhapsody	caution	yes	some	yes	III
‡†*Bacillus subtilis* var. *amyloliquefaciens* strain FZB24	Taegro 2	caution	yes	some	yes	III
‡†Bacteriophage active against *Clavibacter michiganensis* subsp. *michiganensis*	AgriPhage CMM	caution	yes	no	yes	-
‡†Bacteriophage active against *Xanthomonas campestris* pv. *vesicatoria* and *Pseudomonas syringae* pv. *tomato*	AgriPhage	caution	yes	no	yes	-
‡†banda de *Lupinus albus* doce (BLAD) polypeptides	Fracture, ProBlad Verde	caution	silent	some	some	-
boscalid	Endura	warning	no	some	no	II a
boscalid, pyraclostrobin	Coronet, Pageant Intrinsic, Pristine	caution	some	some	some	II a
‡†cerevisane (cell walls of *Saccharomyces cerevisiae* strain LAS117)	Romeo	caution	yes	no	no	-
°chlorothalonil	Bravo Weather Stik, Echo, Equus, Initiate	caution, warning, danger	no	some	some	II ab
chlorothalonil, cymoxanil	Cymbol Advance	caution	no	some	no	II ab
chlorothalonil, tebuconazole	Muscle ADV	caution	no	silent	no	II ab
‡†cinnamon oil	Cinnerate	caution	yes	some	no	-
‡†citric acid	FungOUT, Procidic	caution	yes	silent	no	-
‡†clove, rosemary, peppermint oil, cottonseed oil	GreenFurrow EF 400	-	some	silent	silent	II
†*Coniothyrium minitans* strain CON/M/91-08	Contans WG	caution	yes	some	yes	-
°copper diammonium diacetate complex	Copper Count N	caution	yes	some	no	-
†copper hydroxide	Champ, Kentan, Kocide, Nu-Cop, Spinnaker	caution, warning, danger	some	some	no	II
copper hydroxide, copper oxychloride	Badge SC	caution	yes	some	no	II b
°†copper octanoate	Camelot O, Cueva	caution	some	some	no	-
copper oxychloride	COC DF	caution	no	some	no	II b
copper oxychloride, copper sulfate	C-O-C-S WDG	warning	yes	no	no	II b
°†copper sulfate	Basic Copper 53, Cuprofix Ultra 40 Disperss, Cuproxat	caution, warning	some	some	no	III
‡†cottonseed oil, corn oil, garlic extract	Mildew Cure	-	silent	silent	no	-
†cuprous oxide	Nordox 75 WG	caution	silent	some	no	III
cyazofamid	Ranman 400SC	caution	some	some	no	-
cyflufenamid	Torino	caution	silent	no	no	III
cymoxanil	Curzate 60DF, Cymbol	warning	silent	some	no	III
‡cymoxanil, propamacarb	Cymbol Balance	caution	silent	some	no	III
cyprodinil	Vangard WG	caution	silent	some	yes	III
cyprodinil, fludioxonil	Switch 62.5WG	caution	silent	some	yes	III
dichloro-nitroaniline	Botran 75W	caution	some	some	yes	III
difenoconazole, benzovindiflupyr	Aprovia Top	warning	no	some	no	II b
difenoconazole, cyprodinil	Inspire Super	caution	some	some	no	II b
dimethomorph	Forum	caution	no	some	no	II b
ethaboxam	Elumin	caution	no	some	no	-
‡†extract of *Swinglea glutinosa*	EcoSwing	caution	yes	some	no	-
famoxadone, cymoxanil	Tanos	caution	silent	some	no	III
fenamidone	Reason 500SC	caution	no	some	no	III
fenazaquin	Magister SC	warning	silent	no	no	I
fenhexamid	Decree 50WDG	caution	some	no	no	III
fluazinam	Lektivar 40SC, Omega 500F	warning	silent	some	no	-
fludioxonil	Cannonball, Emblem, Maxim 4FS, Protectant, Spirato	caution	some	some	some	III
fluopicolide	Presidio	caution	no	some	no	III
fluopyram	Velum Prime	caution	silent	some	no	III
fluopyram, pyrimethanil	Luna Tranquility	caution	some	some	no	III
fluopyram, tebuconazole	Luna Experience	caution	silent	some	no	II b
fluopyram, difenoconazole	Luna Flex	caution	silent	some	no	II b
fluopyram, trifloxystrobin	Luna Sensation	caution	silent	some	no	III
fluoxastrobin	Evito, Aftershock, Tepera	caution	some	some	no	-
*fluoxastrobin, bifenthrin	Tepera Plus	caution	some	some	no	I b
flutianil	Gatten	warning	no	no	no	-
flutolanil	Moncut	caution	silent	no	no	II a
flutriafol	Rhyme, Topguard EQ	caution, warning	some	some	no	III

Active Ingredients	Trade Names	Signal Word	Greenhouse Use	Chemigation Use	Respirator Use	Bee Precaution
fluxapyroxad, pyraclostrobin	Merivon, Priaxor	caution, warning	no	some	no	III
fosetyl-aluminum	Aliette WDG	caution	silent	some	no	II ab
‡†garlic oil	Brandt Organics Aleo	warning	yes	silent	no	-
‡†*Gliocladium catenulatum* (*Clonostachys rosea*) strain J1446	LALSTOP G46 WG, Pvent	caution	yes	some	yes	-
†*Gliocladium* virens GL-21	SoilGard	caution	yes	some	no	-
†hydrogen dioxide, peroxyacetic acid	OxiDate 2, TerraClean 5, ZeroTol 2.0	danger	yes	some	no	-
iprodione	Iprodione 4L AG, Meteor, Nevado 4F, Rovral 4F	caution	silent	some	yes	II ab
isofetamid	Kenja 400SC	caution	silent	some	no	-
‡†kaolin clay	Surround WP	caution	yes	no	yes	III
°mancozeb	Dithane Rainshield, Koverall, Manzate Max, Penncozeb	caution	Some	some	some	III
mancozeb, azoxystrobin	Dexter Max	caution	some	some	yes	III
mancozeb, azoxystrobin, tebuconazole	Dexter Xcel	caution	some	some	yes	II b
mancozeb, chlorothalonil	Elixir	warning	silent	some	no	II ab
mandipropamid	Revus	caution	silent	some	no	III
mandipropamid, difenoconazole	Revus Top	caution	silent	some	no	II b
mefenoxam (metalaxyl)	Apron XL, MetaStar, Ridomil Gold SL, Subdue Maxx, Ultra Flourish, Xyler	caution, warning	some	some	no	III
mefenoxam, chlorothalonil	Ridomil Gold Bravo SC	danger	no	some	no	II ab
mefenoxam, copper hydroxide	Ridomil Gold Copper	danger	no	some	no	II
mefenoxam, mancozeb	Ridomil Gold MZ	caution	silent	some	no	III
mefentrifluconazole	Cevya	caution	no	some	no	-
*metam potassium	K-PAM HL, Sectagon K54	danger	no	some	yes	III
*metam sodium	VAPAM HL, Sectagon K42	danger	no	some	yes	III
metrafenone	Vivando	caution	silent	no	no	III
°‡†mineral oil	Purespray Green, SuffOil-X, Tri-Tek	caution	some	no	no	-
mono- and dibasic sodium, potassium, and ammonium phosphites	Alude, Phostrol	caution	silent	some	no	-
mono-dipotassium salts of phosphorous acid	Agri-Fos, Fosphite, Reliant	caution	some	some	no	-
°myclobutanil	Rally 40WSP, Sonoma 40WSP, Sonoma 20EW	caution, warning	some	some	no	II
‡†*Myrothecium verrucaria* strain AARC-0255 – dried fermentation solids & solubles	DiTera DF	caution	silent	some	no	-
°‡†neem oil	ECOWORKS EC, Rango, TerraNeem EC, Triact 70, Trilogy	caution	silent	no	no	II a
oxathiapiprolin	Orondis Gold 200	caution	some	some	no	-
oxathiapiprolin, chlorothalonil	Orondis Opti	danger	no	some	yes	II ab
oxathiapiprolin, mandipropamid	Orondis Ultrax	caution	some	some	no	III
oxathiapiprolin, mefenoxam	Orondis Gold	danger	no	some	no	III
‡†*Paecilomyces lilacinus* strain PL251	MeloCon WG	caution	silent	some	yes	-
‡†paraffinic oil	JMS Stylet-Oil	caution	yes	no	no	-
PCNB	Blocker 4F, Blocker 10G, Terraclor 75WP	caution	silent	some	yes	I
penthiopyrad	Fontelis, Vertisan	caution	some	some	no	III
picoxystrobin	Aproach	caution	silent	some	no	-
polyoxin D zinc salt	Affirm WDG, Endorse, OSO 5% SC, Ph-D	caution	some	some	no	III
‡†potassium bicarbonate	Kaligreen, Milstop	caution	yes	no	no	III
potassium phosphite	K-Phite, ProPhyt	caution	silent	some	no	-
potassium phosphite, chlorothalonil	Catamaran	caution	silent	some	no	II ab
potassium phosphite, tebuconazole	Viathon	caution	silent	some	no	II b
‡†potassium salts of fatty acids	Des-X, KOPA, M-Pede	warning	yes	no	no	-
‡potassium silicate	Sil-Matrix	caution	yes	some	no	III
propamocarb	Bruin, Previcur Flex	caution	some	some	no	-
propiconazole	Propimax EC, Tilt	warning	no	some	no	II ab
propiconazole, trifloxystrobin	Stratego	warning	silent	some	no	II ab
prothioconazole	Proline 480SC	caution	some	some	no	-
Pseudomonas chlororaphis strain AFS009	Howler, Zio	caution	some	some	yes	-
pydiflumetofen, fludioxonil	Miravis Prime	caution	some	some	no	III
pyraclostrobin	Cabrio, Headline EC	caution, warning	no	some	no	III

Active Ingredients	Trade Names	Signal Word	Greenhouse Use	Chemigation Use	Respirator Use	Bee Precaution
pyraclostrobin, metconazole	Headline AMP	warning	no	some	no	III
pyrimethanil	Scala S	caution	some	some	no	III
pyriofenone	Prolivo 300SC	caution	silent	silent	no	-
quinoxyfen	Quintec	caution	silent	no	no	III
†*Reynoutria sachalinensis* extract	Regalia, Regalia CG, Regalia RX	caution	silent	some	no	III
‡rhamnolipid biosurfactant (from *Pseudomonas aeruginosa*)	Zonix	danger	yes	some	no	-
‡†rosemary oil, clove oil, thyme oil, peppermint oil	Sporan	warning	yes	silent	no	II
‡sodium carbonate peroxyhydrate	PerCarb	danger	yes	no	no	-
‡†*Streptomyces griseoviridis* strain K61	Mycostop	caution	yes	some	yes	-
‡†*Streptomyces lydicus* WYEC 108	Actinovate AG, Actinovate STP	caution	yest	some	no	-
Streptomycin sulfate	Agri-mycin 17, FireWall, Streptrol	caution	some	no	yes	III
°†sulfur	Golden Micronized Sulfur, Kumulus DF, Micro Sulf, Microthiol Dispersss, Thiolux, Sulfur 90 DF, Sulfur 80 WDG	caution	silent	some	no	III b
sulfur, tebuconazole	Unicorn DF	caution	silent	some	no	II b
‡†tea tree oil	Timorex Act, Timorex Gold	caution, warning	yes	no	no	-
tea tree oil, difenoconazole	Regev	caution	silent	no	no	II b
tebuconazole	Folicur 3.6F, Monsoon, Onset 3.6L, Toledo 3.6F	caution	silent	some	no	II b
thiabendazole	Mertect	caution	silent	silent	no	-
thiophanate-methyl	Cercobin, Miramar, Topsin 4.5FL, Topsin M	caution	silent	some	no	III
‡†*Trichoderma asperellum* strain ICC 012, *T. gamsii* strain ICC 080	Bio-Tam 2.0, Tenet WP	caution	yes	some	yes	III
‡†*Trichoderma harzianum* strain T-22	RootShield WP, RootShield AG	caution	yes	some	yes	II
‡†*Trichoderma harzianum* strain T-22, *T. virens* strain G-41	RootShield Plus WP, G	caution	yes	some	yes	II
‡†thyme oil	Promax, Thymox Control, Thyme Guard	caution, danger	some	silent	no	
trifloxystrobin	Flint, Flint Extra, Gem	caution	some	some	no	III
triflumizole	Procure 480SC	caution	silent	no	no	II b
†*Ulocladium oudemansii* strain U3	Botrystop	caution	silent	no	no	-
‡†yeast hydrolysate of *Saccharum cerevisiae*	KeyPlex 350	caution	silent	some	no	-
zoxamide, chlorothalonil	Zing!	caution	no	some	yes	II ab
zoxamide, mancozeb	Gavel 75DF	caution	silent	some	no	-

Small package hardware and garden center fungicides

This table includes additional pesticides that you may find readily available at hardware stores and garden centers in smaller quantities. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**. RTU = Ready-To-Use without dilution, RTS = Ready-To-Spray with hose-end container.

† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production – check with your certifier

‡ = indicates additional formulations that do not currently occur elsewhere in this guide as crop protection recommendations because they are not as well understood to be effective options

Active Ingredients	Trade Names
‡†*Bacillus amyloliquefaciens* strain D747	Southern Ag Garden Friendly Fungicide, Bonide Revitalize Bio Fungicide Concentrate and RTU, Monterey Complete Disease Control RTU
chlorothalonil	Fertilome Broad Spectrum Landscape & Garden Fungicide Concentrate and RTU, GardenTech Daconil Fungicide Concentrate and RTU, Bonide Fung-onil Multipurpose Fungicide Concentrate and RTU, Southern Ag Liquid Ornamental & Vegetable Fungicide, Hi-Yield Vegetable Flower Fruit & Ornamental Fungicide, Ortho MAX Garden Disease Control Concentrate
copper diammonium diacetate complex	Southern Ag Liquid Copper Fungicide
†copper octanoate	Fertilome Captain Jack's Copper Fungicide Concentrate and RTU, Fertilome Copper Soap Fungicide Concentrate and RTU
†copper sulfate	Bonide Copper Fungicide
mancozeb	Southern Ag Dithane M-45, Bonide Mancozeb Flowable w/ Zinc Concentrate
mono-dipotassium salts of phosphorous acid	Monterey Garden Phos
myclobutanil	Fertilome F-Stop Lawn & Garden Fungicide Concentrate and RTS, Spectracide Immunox Multi-Purpose Fungicide for Gardens Concentrate, Monterey Fungi-Max
myclobutanil, permethrin	Spectracide Immunox 3-in-1 Insect and Disease Control Plus Fertilizer for Gardens RTU
‡†neem oil	Fertilome Natural Guard Neem, Bonide Captain Jack's NeemMax 4-In-1 Insecticide Fungicide Miticide Nematicide, Monterey 70% Neem Oil, Bonide Neem Oil Fungicide Miticide Insecticide, Garden Safe Neem Oil Extract Concentrate, Garden Safe Fungicide3, Monterey Neem Oil, Southern Ag Triple Action Neem Oil
‡†potassium salts of fatty acids, sulfur	Bonide Captain Jack's Tomato & Vegetable 3-In-1 Garden Spray
‡†potassium bicarbonate	Monterey Bi-Carb Old Fashioned Fungicide
‡†pyrethrins, neem oil	Fertilome Triple Action Concentrate RTU, Monterey Fruit Tree Spray Plus
‡pyrethrins, piperonyl butoxide, neem oil	Bonide Bon-Neem II RTU, Fertilome Fruit Tree Spray with Neem Py, Fertilome Triple Action Plus, Ortho Tree & Shrub Fruit Tree Spray
‡†sesame oil	AgroBioUSA Bee Safe 3-In-1 Garden Spray, AgroBioUSA Bee Safe Insect Killer
†sulfur	Hi-Yield Dusting Wettable Sulfur, GardenTech Sevin Sulfur Dust 2-in-1 Disease and Insect Control, Bonide Sulfur Plant Fungicide Dust, Southern Ag Wettable or Dusting Sulfur, Ortho Bug-Geta Slug and Snail Killer
†sulfur, pyrethrins	Ortho Insect Mite & Disease 3-In-1 RTU, Bonide Tomato & Vegetable 3-in-1 RTU and RTS

Nematode Management Strategies

Reviewed by Marisol Quintanilla – Sep 2021

The soil contains many nematode species, and some species are parasites of plants and animals. Even so, most plants can be parasitized by at least one of the plant-parasitic nematodes. Most plant-parasitic nematodes feed on roots while some feed within leaves.

Plant-parasitic nematode feeding does not necessarily result in characteristic secondary (aboveground) symptoms. For this reason, nematode problems often go undiagnosed. Typical aboveground symptoms of nematode infections include stunting, yellowing, and wilting. In some situations, nematodes can cause considerable yield losses; however, nematodes can reduce yields without plants showing any noticeable aboveground symptoms.

The best defense against nematodes is to avoid them. It is possible to prevent moving nematodes that are not present in your field by following simple sanitation methods such as washing machinery after using it in an infested field. Once a nematode is established in your field, eradicating is usually not a viable option. There are many different types of plant parasitic nematodes, some are more serious than others and some specialize on a specific crop. Most soil has at least a few plant parasitic nematode species. Due to their microscopic nature and abundance in soil, avoiding nematodes is nearly impossible, so nematode infestations in some fields are inevitable, but it is possible to prevent or delay the movement of nematodes not found in your field with sanitary practices.

Nematodes can travel long distances on machinery, human foot traffic, in plant material, on animals, in water, and in the wind. The bottom line: Anything that moves soil, may move nematodes. Many of these factors are uncontrollable. However, growers can control how they move and sanitize their machinery. If field samples indicate that pathogenic nematode species are present at damage threshold levels, take steps to reduce the population densities of these organisms.

Here are five effective tactics for controlling nematode populations.

Cultural Controls

Cultural nematode management are one of the most effective methods of managing nematodes. Cultural methods that can be effective are: crop rotation with non-hosts, options include choosing crop plants or cover crops that are not hosts for the problem nematode, selecting the optimal planting date, planting companion plants, and so on. We recommend rotating with a non-host. For example, grasses are non-hosts to northern root-knot nematodes, so rotating with a grass (such as corn, wheat, etc.) will reduce northern root knot nematode populations. Using cultural tactics requires you to properly identify which plant-parasitic nematodes are present.

Genetic Controls

Plant resistance is often one of the most sustainable control tactics. For example, many tomato varieties have resistance to root-knot nematodes. However, most vegetables do not have resistance against nematodes, and currently, there are no genetically modified varieties available. Some vegetable varieties may better tolerate nematode feeding, but this information is not always readily available.

Chemical Controls

Nematicides are compounds that kill nematodes. There are two main types of synthetic nematicides: fumigants and nonfumigants.

Fumigants are typically sold as liquids or gases that react with water in the soil to produce gases that kill a wide variety of organisms (including plants) depending on the compound. They are wide- spectrum biocides. If you fumigate, you should do it in the fall (preferably) or spring when soil temperatures are adequate and before the crop is planted. Fumigating can be effective, but also quite costly, so in many cases using a nonfumigant nematicide will make more economic sense.

Nonfumigant nematicides do not volatilize in soil water. They can be applied before, during, or even after planting in some situations. These compounds are often not as broad in their spectrum as fumigants. Nonfumigants may be less detrimental to beneficial organisms since some of these compounds are more specifically targeted to nematodes and some are systemic in the plant and thus target mostly nematodes feeding on the plant. It is important to select a nematicide to meet your nematode management needs and economic thresholds.

Fumigant and nonfumigant nematicides labeled for use in vegetable production are shown in the Nematicide Table.

Biological Controls and Bionematicides

Most nematodes in the soil are beneficial. They typically feed on bacteria, fungi, or small animals including other nematodes. Some methods to increase soil health is crop rotation, reducing tillage, using cover crops, and using compost and manures.

In addition, many other organisms are parasites or pathogens of nematodes. Most of these occur naturally in soils, but they often do not sufficiently control plant-parasitic nematodes enough to keep their population densities below damage threshold levels. Some manufacturers market products as biological nematicides. See Nematicide Table.

Physical Controls

Physical nematode control options include using heat, steam, or water (flooding) to reduce nematode population densities. In field situations, these types of controls are often not feasible in the Midwest. However, in glasshouse or poly-house production, growers may use heat or steam to sterilize growing media.

Sampling Nematode Populations

Plant-parasitic nematodes are microscopic organisms with aggregate (often highly clumped) distributions in fields. As a result, the symptoms their feeding causes often occur in circular or elliptical patterns. If you observe plant symptoms are uniformly distributed, the cause of the problem is typically not nematodes.

All sound nematode management programs include rigorous sampling. Since nematodes are microscopic and typically do not always produce noticeable symptoms that indicate their presence, it is necessary to sample to detect nematodes and avoid problems.

A great deal of research has gone into sampling nematode populations. Here are three important points:

1. Due to their microscopic nature, the only way to diagnosis a plant-parasitic nematode problem is to collect a soil and/or plant tissue sample(s) and send it to a nematode diagnostic lab for analysis (see State Contact Information table). It is critical to properly identify the nematode's genus or species to provide specific management recommendations. Please refer to any bulletin or other publication devoted to sampling for these organisms for more detailed instructions.
2. When collecting soil samples for plant-parasitic nematodes, the more soil cores you can gather, the better the sample. Collecting roughly 20 soil cores is usually adequate. You can combine and mix these
3. cores. A lab usually only requires you to submit a pint to a quart of soil. You should place nematode samples in plastic bags and close them to retain moisture. Keep the samples out of the sun and heat to ensure that nematodes arrive in good condition for identification at the diagnostic lab.
4. Use different methods for different sample areas. It may be a good idea to separate different areas of the field when sampling. For example, high or low areas of the field or changes in soil types may require different samples.

Nematicide Table

This table includes selected information about the nematicides recommended in this guide. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**.

* = indicates that some formulations may be Restricted Use Pesticides (RUP) and require a certification to purchase and use

† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production – check with your certifier

‡ = indicates additional formulations that do not currently occur elsewhere in this guide as crop protection recommendations because they are not as well understood to be effective options

The **Signal Word** is an indication of the human health hazard of the product.

The **Chemigation Use** columns have one of four listings:

yes = the product label explicitly allows the use

some = the product label explicitly allows the use for certain crops (see the label for details), or certain Trade Names allow complete or partial use

no = the product label explicitly prohibits the use

silent = the product label does not mention the use — states decide if such uses are allowed

The **Leaching Risk** and **Runoff Risk** columns have one of four listings:

v. low = the product is not likely to move with water

low = the product has a low likelihood of moving with water

med = the product has an intermediate likelihood of moving with water

high = the product has a high likelihood of moving with water

The **Respirator Use** column has one of the following listings:

no = a respirator is not required PPE

yes = a respirator is required for some part of the process (see label for details)

some = certain Trade Names may require respirators, but others may not

Active Ingredients	Trade Names	Signal Word	Chemigation Use	Leaching Risk	Runoff Risk	Respirator Use
*1,3-dichloropropene	Telone II, Telone EC	warning, danger	some	med	low	yes
*1,3-dichloropropene, chloropicrin	Telone C-17, Telone C-35	danger	no	med	low	yes
‡†allyl isothiocyanate	Dominus	danger	yes	some	yes	-
‡†azadirachtin	Aza-Direct, AzaGuard, AzaSol, Azatin O, Azatrol EC, Ecozin Plus 1.2 ME, Molt-X	caution	yes	some	no	II
†*Burkholderia spp.* Strain A396	BioST Nematicide 100, Majestene, Venerate	caution	yes	some	yes	II
*ethoprop	Mocap 15G, Mocap EC	danger	some	high	low	yes
fluensulfone	Nimitz	caution	some	-	-	no
fluopyram	Velum Prime	caution	some	-	-	no
*metam potassium	K-PAM HL, Sectagon K54	danger	some	-	-	yes
*metam sodium	VAPAM HL, Sectagon K42	danger	some	med	low	yes
‡*Myrothecium verrucaria* strain AARC-0255 – dried fermentation solids & solubles	DiTera DF	caution	silent	some	no	-
°‡†neem oil	ECOWORKS EC, Rango, TerraNeem EC, Triact 70, Trilogy	caution	some	no	no	II a
*oxamyl	Vydate C-LV, Vydate L	danger	some	low	low	yes
‡†*Paecilomyces lilacinus* strain 251	MeloCon WC	caution	silent	some	yes	-
spirotetramat	Movento, Kontos	caution	some	-	-	no
‡†thyme oil	Promax, Thymox Control, Thyme Guard	caution, danger	some	silent	no	

Insect Management Strategies

Reviewed by Raymond Cloyd, Marissa Schuh– Feb 2022

Effective insect, mite, and slug management relies on applying IPM strategies which include the following tools:

1. Preventive practices.
2. Properly identifying key pest insects, mites, slugs, and beneficial organisms.
3. Monitoring and early detection of insect, mite, and slug populations.
4. Determining the pest's economic loss potential
5. Selecting the proper pest control option.
6. Evaluating the effectiveness of employed control options.

Preventive Insect Management Practices

There are a number of practices that can reduce insect numbers before you actually see the insects in the crop. Often, decisions about these practices must be made based on past experience with the pest.

Many of these practices are good management practices for weeds and diseases as well, so they can easily be incorporated into production practices that yield multiple benefits.

Resistant Varieties: There are not many vegetable varieties that have been bred exclusively for insect resistance. However, there are many varieties that target resistance to insect-vectored plan pathogens. This information is often printed in seed catalogs or available directly from seed suppliers. Varieties that are resistant to pathogens may still sustain direct damage from the pest; ask your seed provider. The information on crop resistance to insects, mites, and slugs directly is harder to find. Some varieties of cabbage are resistant to onion thrips. Selection of sweet corn varieties that have husks that completely cover the ear tip and fit tightly around the ear can reduce the amount of corn earworm damage. Short season varieties of potatoes should be grown when possible to give Colorado potato beetles less time to feed and reproduce. This is not resistance, but it is a method that growers can use to reduce insect damage by varietal selection.

Crop Rotation: Rotating crops can reduce the severity of a number of pest problems. Rotating potato fields can greatly increase the amount of time it takes Colorado potato beetles to colonize a field, thereby reducing the time the beetles have to damage the crop. Rotating cucurbit crops can be equally effective for cucumber beetle management. Don't plant crops that are susceptible to wireworm or white grub damage in fields that were previously in sod or heavily infested with grassy weeds. In addition, it is a good idea not to plant cabbage or onions next to small grain fields, because onion thrips build up to very high levels in small grains and may move into cabbage or onions when the small grains dry down or are harvested. The effectiveness of rotation for pest management relies on the host range of the pest (what crops can/does it feed on) and its dispersal capabilities (how far will it have to go to find a suitable host).

Crop Refuse and Volunteer Destruction: Destroying the plant residue after harvest can reduce the damage experienced the next year from a number of insects. Destroying squash and pumpkin vines after completion of harvest can greatly reduce the overwintering population of squash bugs and squash vine borers. Early vine killing in potatoes will reduce the potato beetle populations for the following year. Volunteers that resprout from last year's crop can serve has a harborage and a source population for insect pests on field edges or as weeds in another crop, and should be destroyed.

Tillage: Fields that receive reduced amounts of tillage or have some sort of grass windbreaks are often more susceptible to damage from insects such as cutworms and armyworms. These cultural practices may have other advantages that outweigh the potential insect problems, but growers should be aware of the potential for increased insect activity. Tillage can also be effective to directly damage insects that reside in the soil over winter or between crops.

Time of Planting or Treatment: Many pest insects go through life according to heat units, and are subject to weather, just like plants. Growing Degree Day (GDD) models and weather forecasting tools have been developed for several pests that detail when they are likely to be at a stage that is damaging, or blow in from another area, or when they are at a life stage that is easy to control or avoid. Because insects tend to become active at specific times each year, varying the time of planting can sometimes help prevent serious insect problems.

Corn earworms and fall armyworms are usually a much more serious problem on late-planted sweet corn. If the option is available, planting sweet corn so that it has no green silks before large numbers of earworm moths are flying can reduce earworm problems. Root maggots are usually more serious during cool, wet weather. Waiting until soil temperatures are adequate for rapid plant growth will help reduce maggot problems. Here are some resources for tracking weather and predictive models related to insect pests:

- enviroweather.msu.edu
- newa.cornell.edu
- insectforecast.com

Conservation Biological Control: Conserving natural enemies is one aspect of biological control that can effectively reduce pest populations and damage. This can be accomplished in several ways, but the most important is careful selection of pesticides and reducing the overall number of applications. When selecting an insecticide, consider the impact that application will have on beneficial insects. *Bacillus thuringiensis* (Bt) products, for example, only have efficacy against the targeted organisms (most often caterpillars). Other products, such as flonicamid, are selective at killing insects with piercing-sucking feeding habits, targeting aphids and plant bugs. Choosing a chemical option that has been approved by the EPA as a Reduced Risk product is another way to minimize the impact on nontarget organisms, including natural enemies and parasitoid, when an application is necessary.

Proper Identification

Properly identifying pests is the foundation on which a good insect management program is built. If the pest is not properly identified, the chances of selecting the correct control strategies are greatly diminished. Many insects and mites can be correctly identified simply because they are encountered so often. However, it never hurts to back up your knowledge base with some reference materials. Your county Extension office has a number of bulletins available that will help you properly identify insect pests. There also are a number of good books available with color photographs of many of the common insect pests. Most entomologists don't like to admit it, but we often identify unfamiliar insects by comparing them to pictures in a book. For a small fee, samples can be submitted to a local plant and pest diagnostic lab.

Beneficial organisms can be important components of an effective insect management program. Being able to distinguish the good insects from the bad insects may help you avoid unnecessary and possibly disruptive pesticide sprays.

Some common beneficial organisms all growers should be able to identify include lady beetle larvae and adults, lacewing eggs, larvae and adults, parasitized aphid "mummies", minute pirate bugs, and syrphid fly larvae.

In addition to proper identification, it is helpful to know as much as possible about the insect's biology including how to identify the various life stage, location or habitat where each portion of their lifestage occurs and the host range of the pest.

Insects with incomplete metamorphosis have juvenile stages — called nymphs — that resemble the adults, except that they are smaller and don't have wings. The feeding behavior is usually the same for nymphs and adults. For example, squash bugs and aphids are insects with incomplete metamorphosis.

Insects with complete metamorphosis have a larval stage that is completely different in appearance from the adult. Adult insects never grow, so little beetles don't grow up to be big beetles. For example, caterpillars are the immature (larvae form) of moths and butterflies. Insects who undergo complete metamorphosis also have an intermediate stage, known as a pupa, between the larval and adult stages. For caterpillars this is called a chrysalis or cocoon. larvae never have wings and are not capable of reproducing. Larvae go through a series of molts (shedding their skins) in order to grow. Larvae and adults frequently, although not always, feed differently and move between plants or plant parts as they develop. In many instances, the immature stage feeds below ground while the mature is found above, or vice versa. Beetle larvae (think Japanese beetles, wireworms, rootworms) feed below ground on plant roots while the adults (again Japanese beetles, click beetles, rootworms) are found above ground feeding on plant foliage. Thrips spend their larval and adult stages above ground, but pupate in the soil.

For important insect, mite, and slug pests, it also is helpful to know the overwintering stage, life cycle length, and number of generations per year that can be expected. Again, most of this information can be found in Extension bulletins.

Monitoring

Vegetable growers must make insect, mite, and slug pest management decisions on an almost daily basis during the growing season. To make the best decisions, it is often useful to have information regarding the current status of a pest's population. This can be accomplished through some sort of sampling or monitoring program. There are several methods to monitor insect populations.

Pheromone traps can be used to determine when pests are flying, often times in relation to searching for a mate. This information can be used in several ways. First, catching pests in the trap can alert growers to begin looking for the pest in the field. This can save time because the grower won't be looking for the pest before it is present. Second, pheromone trap catches can be used to time insecticide applications. Third, for some pests, such as corn earworms, the need to spray can be determined from the number of moths caught in the trap. Pheromones are available for many of the moth stages of caterpillar pests of vegetables, and swede midge.

Another method for monitoring insects is by scouting fields. Scouting can be formal, such as counting insects on a given number of plants throughout the field, or it can be informal, with the grower walking through the field and looking for the signs and symptoms of insects on the plants. Formal scouting may be more accurate, but the most important thing is for growers to regularly walk their fields looking for insects or insect damage. Most can be monitored just by close inspection of the plants. Others may require the use of equipment such as a sweep net or a beat cloth. Some pests, such as mites, may require the use of a hand lens to see. Familiarizing yourself with the damage they induce can aid in their detection. For example, the stippling of leaves from mites. Alternatively you can shake the plant over a sheet or piece of paper to dislodge the pest. This is effective for mites and thrips. Regular (weekly) monitoring will allow growers to make informed management decisions.

In protected environments, yellow sticky cards may serve as a passive monitoring method. The cards should be placed strategically around the crops to intercept pests as they move into the growing space (near ventilation openings) or between crops in the same space. Cards will not control pests but can aid in their detection. They should be checked often (at least weekly) and changed when the surface gets full or is no longer sticky.

Determining the Potential for Economic Loss

Unfortunately, we do not have economic thresholds for many vegetable insect pests. Whenever possible, we have listed the best thresholds available along with control options in the crop-specific sections of this manual.

Although some of these estimates have not been verified by research in each state, they have been derived from scientific research or extensive observations. Growers may wish to adjust these thresholds based on past experience. Extension bulletins also are useful sources of information regarding potential losses from insects.

Growers should remember that some crops, such as snap beans and potatoes, can suffer a great deal of defoliation before there is any effect on yield. Sometimes, plants with considerable amounts of insect damage will yield as well as plants that have no insect feeding. If the pest is one that feeds on the marketable portion of the plant, then less damage can be tolerated.

Proper Selection of a Pest Control Option

In vegetable crops, the selection of a control option during the growing season usually means doing nothing or selecting a pesticide. Although we always encourage growers to read and follow label directions, the one area where the label is not necessarily the best source of information is concerning which insects the insecticide will control. The insecticides recommended in this book for control of various pests are listed because they are legal to use and because they have been found to be effective by the authors. Consider insecticide or biological control agent costs, application costs, relative effectiveness, gain in profits that can be expected from the application, whether it will control other pests, and how it will affect predators, parasites, and pollinators. Growers should refrain from “revenge spraying,” that is, spraying after the damage is already done. At that point, spraying is a waste of money and may actually increase pest damage by killing beneficial insects.

Evaluation

Growers should always evaluate the effectiveness of a pest control action. Inspecting the field a couple of days after an insecticide is applied will help the grower determine the necessity for additional control measures in that field, as well as provide information about the insecticide’s effectiveness for future reference. Growers should pay attention to whether the insecticide killed all stages of the pests or if only small larvae or nymphs were killed. They should also notice the effects on other pests in the field and on beneficial insects.

Resistance Management

It is important to rotate products with different modes of action in order to reduce the potential of insect, mite, and slug populations developing resistance to products with specific modes of action. A pesticide’s mode of action is how it affects the metabolic and physiological processes in the pest (in this case, the pests are insects, mites, or slugs). Many product labels contain resistance management information or guidelines that will help vegetable growers determine which products they should rotate with others, including an Insecticide Resistance Action Committee (IRAC) code, that describes the mode of action with a number and/or letter. Try to avoid using products with the same IRAC code repeatedly to conserve its efficacy on pests. Biopesticides derived from fungal and bacterial insect pathogens and live biological control insects can also be deployed against insect pests, further preserving the efficacy of certain insecticides.

Summary of Nonchemical Insect and Mite Pest Management Practices

Practice	Notes
Floating row covers	Placing floating row covers over vegetable crops during the growing season prevents insect pests, such as caterpillars and beetles, from feeding on vegetable crops.
Trap cropping	Trap plants placed around the perimeter of the main vegetable crops attract insect pests, thus mitigating plant damage.
Reflective mulches	Using reflective mulches reduces insect infestations and the incidence of virus transmission by insect pests such as aphids, thrips, and whiteflies.
Planting time	Planting early or later in the growing season avoids plant damage to vegetable crops from insect pests.
Crop rotation	Rotating among vegetable and non-vegetable crops, such as alfalfa, avoids the build-up of insect populations in the soil.
Weed management	Removing or eliminating weeds is important because many weeds harbor insect and mite pests, and serve as a source of viruses transmitted by insect pests such as aphids, leafhoppers, thrips, and whiteflies.
Overhead irrigation	Overhead irrigation of vegetable crops reduces problems with caterpillar pests such as the diamondback moth.
Crop management	Implementing proper cultural practices such as watering, fertility, and plant spacing helps to alleviate problems with insect and mite pests.
Sanitation	Remove and destroy all vegetable crop debris after the growing season because insect pests, such as the squash bug, overwinter in vegetable crop debris.

Insecticide Tables

This table includes selected information about the insecticides recommended in this guide. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**.

° = indicates that small package and ready-to-use formulations are commonly available at hardware stores and garden centers
* = indicates that some formulations may be Restricted Use Pesticides (RUP) and require a certification to purchase and use
† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production – check with your certifier
‡ = indicates additional formulations that do not currently occur elsewhere in this guide as crop protection recommendations because they are not as well understood to be effective options

The **Signal Word** is an indication of the human health hazard of the product.

The **Greenhouse Use** and **Chemigation Use** columns have one of four listings:
yes = the product label explicitly allows the use
some = the product label explicitly allows the use for certain crops (see the label for details), or certain Trade Names allow complete or partial use
no = the product label explicitly prohibits the use
silent = the product label does not mention the use — states decide if such uses are allowed

The **Respirator Use** column has one of the following listings:
no = a respirator is not required PPE
yes = a respirator is required for some part of the process (see label for details)
some = certain Trade Names may require respirators, but others may not

The **Bee Precaution** column uses the following listings:
I = Toxic to honey bees. Do not apply to plants that are flowering, or water puddles.
II = Toxic to honey bees. Do not apply to plants that are flowering, or water puddles, except at dusk
III = No bee precaution, except when required by the pesticide label or regulations
a = Toxic to honey bee brood
b = Toxic to other bee species

Active Ingredients	Trade Names	Signal Word	Greenhouse Use	Chemigation Use	Respirator Use	Bee Precaution
*1,3-dichloropropene	Telone II, Telone EC	warning, danger	no	some	yes	II a
*1,3-dichloropropene, chloropicrin	Telone C-17, Telone C-35	danger	no	no	yes	II a
*abamectin	Agri-Mek SC, Abba Ultra	warning	some	no	no	I b
*abamectin, *zeta-cypermethrin	Gladiator	caution	silent	no	no	I b
acephate	Bracket 97, Orthene 97	caution	no	some	yes	I b
acequioncyl	Kanemite 15SC, Shuttle 15SC	caution	some	no	no	III
acetamiprid	Assail 30SG, Assail 70WP, Tristar 8.5SL	caution	some	some	some	I b
afidopyropen	Sefina Inscalis, Versys Inscalis	caution	no	some	no	-
‡†allyl isothiocyanate	Dominus	danger	yes	some	yes	-
†azadirachtin	Aza-Direct, AzaGuard, AzaSol, Azatin O, Azatrol EC, Ecozin Plus 1.2 ME, Neemix, Molt-X	caution	yes	some	no	II
†azadirachtin, pyrethrins	Azera	caution	yes	some	yes	I b
°†*Bacillus thuringiensis* sub. *Kurstaki* strain ABTS-351	Biobit HP, DiPel DF, DiPel ES, LEAP ES	caution	some	some	yes	III
†*Bacillus thuringiensis* sub. *Kurstaki* strain EVB-113-19	BT NOW	caution	yes	some	yes	III

Active Ingredients	Trade Names	Signal Word	Greenhouse Use	Chemigation Use	Respirator Use	Bee Precaution
°†*Bacillus thuringiensis* sub. *Kurstaki* strain SA-12	Deliver	caution	some	no	yes	III
†*Bacillus thuringiensis* sub. *aizawai* strain ABTS-1857	XenTari	caution	some	some	yes	II a b
‡†*Beauvaria bassiana* strain ANT-03	BioCeres WP	caution	yes	some	yes	II b
‡†*Beauvaria bassiana* strain GHA	BotaniGard ES, BotaniGard MAXX, Mycotrol ESO, Mycotrol WPO	caution	yes	some	yes	II b
*beta-cyfluthrin	Baythroid XL	warning	silent	some	yes	I
bifenazate	Acramite 50WS, Floramite	caution	some	some	no	II b
°*bifenthrin	Bifenture EC, Brigade WSB, Capture LFR, Discipline 2EC, Sniper	caution, warning	some	some	no	I b
*bifenthrin, *abamectin	Athena	caution	silent	no	no	I b
*bifenthrin, *Bacillus amyloliquefaciens* strain D 747	Ethos XB	warning	silent	no	yes	I b
*bifenthrin, *zeta-cypermethrin	Hero, HERO EW, Steed	caution, warning	silent	some	no	I b
†*Burkholderia* spp. Strain A396	BioST Nematicide 100, Majestene, Venerate	caution	yes	some	yes	II
°carbaryl	Sevin 4F, Sevin XLR	caution	silent	some	some	I b
‡†capsaicin, garlic oil, canola oil	Captiva	caution	yes	silent	no	II
chlorantraniliprole	Coragen	caution	no	some	no	III
chlorantraniliprole, *lambda-cyhalothrin	Besiege	warning	no	some	no	I b
‡chlorethoxyfos, bifenthrin	Index, SmartChoice HC	warning, danger	silent	no	some	I b
†*Chromobacterium subtsugae* strain PRAA4-1	Grandevo	caution	yes	some	yes	I
clothianidin	Belay, Poncho	caution	silent	some	no	I b
°‡†cottonseed oil, clove oil, garlic oil	Mite-X	caution	yes	silent	no	II
cyantraniliprole	Exirel, Verimark	caution	some	some	no	-
cyantraniliprole, *abamectin	Minecto Pro	warning	some	no	no	I b
cyclaniliprole	Harvanta	caution	no	some	no	-
cyflumetofen	Nealta	caution	no	no	no	-
°*cyfluthrin	Tombstone (2EC)	danger	silent	some	yes	I b
*cypermethrin	Ammo 2.5EC, Holster, Up-Cyde 2.5EC	caution, warning	silent	some	no	I b
cyromazine	Trigard	caution	no	no	no	I b
°‡†diatomaceous earth	Celite 610, Deadzone	caution	silent	silent	yes	-
*diazinon	Diazinon AG500, Diazinon AG600 WBC	caution	no	some	yes	I b
dicofol	Dicofol 4E	caution	silent	no	yes	III
dimethoate	Dimethoate 2.67EC, Dimethoate 400, Dimethoate 4EC	warning	some	some	yes	I b
dinotefuran	Safari 20 SG, Scorpion 35SL, Venom 70SG	caution	some	some	no	I ab
*emamectin benzoate	Proclaim	caution	no	no	yes	I b
*esfenvalerate	Asana XL, S-FenvaloStar	warning	silent	some	no	I b
*ethoprop	Mocap 15G, Mocap EC	danger	silent	some	yes	II b
fenazaquin	Magister SC	warning	silent	no	no	I
*fenpropathrin	Danitol 2.4EC	warning	silent	no	no	I b
*fipronil	Regent 4SC	warning	silent	no	yes	I b
flonicamid	Beleaf	caution	some	some	no	III b
fluensulfone	Nimitz	caution	silent	some	no	-
*fluoxastrobin, bifenthrin	Tepera Plus	caution	some	some	no	I b
flupyradifurone	Sivanto 200, Sivanto Prime	caution	silent	some	no	II
†*Helicoverpa armigera* nucleopolyhedrovirus strain BV-0003	Helicovex	caution	yes	some	yes	-
‡†*Helicoverpa zea* nucleopolyhedrovirus	Gemstar LC	caution	silent	some	yes	III
hexythiazox	Onager Optek, Hexygon	caution	some	some	no	II b

Active Ingredients	Trade Names	Signal Word	Greenhouse Use	Chemigation Use	Respirator Use	Bee Precaution
°imidacloprid	Admire Pro, Mantra 60WSP, Marathon 60 WP, Nuprid	caution	some	some	no	I ab
indoxacarb	Avaunt	caution	some	some	no	I b
°†iron phosphate	Sluggo 1B	caution	yes	silent	no	-
‡†*Isaria fumosorosea* Apopka strain 97	Preferal	caution	yes	some	yes	II
‡†kaolin clay	Surround WP	caution	yes	no	yes	III
°*lambda-cyhalothrin	Grizzly Too, Lambda-Cy 1EC, Warrior II	warning	silent	some	no	I b
°malathion	Malathion 5, Malathion 57, Malation 8	caution, warning	some	some	no	I b
metaldehyde	Deadline Bullets, Deadline GT, Deadline M-Ps, Durham 3.5G	caution	silent	silent	no	III
*metam potassium	K-PAM HL, Sectagon K54	danger	no	some	yes	III
*metam sodium	VAPAM HL, Sectagon K42	danger	no	some	yes	III
methomyl	Lannate LV, Lannate SP, Nudrin LV, Nudrin SP	danger	silent	some	yes	I b
methoxyfenozide	Intrepid 2F	caution	some	some	no	II
°‡†mineral oil	Purespray Green, SuffOil-X, Tri-Tek	caution	some	no	no	-
°‡†neem oil	ECOWORKS EC, Rango, TerraNeem EC, Triact 70, Trilogy	caution	some	no	no	II a
*oxamyl	Vydate C-LV, Vydate L	danger	silent	some	yes	I b
‡†*Paecilomyces lilacinus* strain 251	MeloCon WC	caution	silent	some	yes	-
‡†paraffinic oil	JMS Stylet Oil	caution	yes	no	no	-
°*permethrin	Perm-Up 25DF, Perm-Up 3.2EC, Pounce 25 WP	warning	silent	some	no	I b
*phorate	Thimet 20G	danger	silent	silent	yes	III b
°piperonyl butoxide, pyrethrins	EverGreen Pro, Pyrenone	caution	yes	some	yes	I b
°†potassium salts of fatty acids	Des-X, KOPA, M-Pede	warning	yes	no	no	-
‡†potassium silicate	Carbon Defense, Sil-Matrix	caution	yes	some	no	-
°†pyrethrins	Pyganic	caution	yes	some	no, yes	I b
pymetrozine	Fulfill	caution	silent	some	no	II
pyrifluquinazon	PQZ	caution	silent	no	no	-
pyriproxyfen	Distance, Knack	caution	some	some	no	II ab
‡†rosemary oil, geraniol, peppermint oil	Ecotrol Plus	warning	yes	silent	no	III
spinetoram	Radiant 1SC	caution	no	some	no	II
°†spinosad	Blackhawk, Entrust, Entrust SC, Regard SC	caution	some	some	some	II b
spiromesifen	Oberon 2SC	caution	silent	some	no	II a
spirotetramat	Movento, Kontos	caution	some	some	no	II ab
sulfoxaflor	Sequoia, Transform WG	caution, danger	some	some	no	I
tebufenozide	Confirm 2F	caution	silent	some	no	II a
*tebupirimphos, cyfluthrin	Aztec 4.67G, Aztec HC	warning	silent	silent	yes	I b
*tefluthrin	Force CS, Force Evo, Force 3G, Force 10G HL	caution, warning	silent	silent	no	-
*terbufos	Counter 20G	danger	silent	silent	yes	-
thiamethoxam	Actara, Cruiser 5FS, Flagship 25WG, Platinum 2SC	caution	some	some	no	I b
thiamethoxam, chlorantraniliprole	Durivo, Voliam Flexi	caution	no	some	no	I b
thiamethoxam, *lambda-cyahlothrin	Endigo ZCX	warning	no	some	no	I b
tolfenpyrad	Torac	warning	silent	some	no	III b
°*zeta-cypermethrin	Mustang Maxx	warning	silent	some	no	I

Small package hardware and garden center insecticides

This table includes additional pesticides that you may find readily available at hardware stores and garden centers in smaller quantities. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**. RTU = Ready-To-Use without dilution. RTS = Ready-To-Spray with hose-end container.

† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production

‡ = indicates additional formulations that do not currently occur elsewhere in this guide as crop protection recommendations because they are not as well understood to be effective options

Active Ingredients	Trade Names
†azadirachtin, pyrethrins	Monterey Azera Gardening
†*Bacillus thuringiensis* subsp. kurstaki strain ABTS-351	Southern Ag Dipel Dust, Southern Ag Thuricide Bt Caterpillar Control
†*Bacillus thuringiensis* subsp. kurstaki strain SA-12	Bonide Captain Jack's Bt *Bacillus thuringiensis* RTU, Bonide Thuricide *Bacillus thuringiensis* (BT), Monterey B.t. RTU, Fertilome Caterpillar Killer Spray with Bt, Garden Safe Bt Worm & Caterpillar Killer
bifenthrin	Bonide Eight Flower & Vegetable Soil Insect Granules, Hi-Yield Vegetable & Ornamental Insect Control Granules, Fertilome Broad Spectrum Insecticide, GardenTech Sevin Insect Killer Dust, Ortho Outdoor Insect Killer, Monterey Vegetable Garden Soil Insecticide, Monterey Mite & Insect Control
carbaryl	Fertilome Carbaryl Garden Spray, GardenTech Sevin 5% RTU dust, GardenTech Sevin RTU liquid
‡†canola oil	Fertilome Natural Guard Horticultural Oil
‡†cottonseed oil, clove oil, garlic oil	Bonide Mite-X RTU
cyfluthrin	BioAdvanced Tomato & Vegetable Insect Killer RTU, BioAdvanced Vegetable & Garden Insect Spray
‡deltamethrin	Ortho Insect Killer Flower & Vegetable Garden Dust
esfenvalerate	Monterey Bug Buster II
‡†diatomaceous earth (silicon dioxide)	Bonide Diatomaceous Earth Crawling Insect Killer
gamma-cyhalothrin	Spectracide Triazicide Insect Killer for Lawns & Landscapes Concentrate
imidacloprid	BioAdvanced Fruit, Citrus & Vegetable Insect Control Concentrate, Monterey Fruit Tree & Vegetable Systemic Soil Drench
†iron phosphate	Bonide Captain Jack's Slug Magic, Garden Safe Slug and Snail Bait, Monterey Sluggo
†iron phosphate, spinosad	Bonide Captain Jack's Bug & Slug Killer, Fertilome Bug Slug and Snail Bait, Monterery Sluggo Plus
lambda-cyhalothrin	Bonide Eight Garden & Home RTU, GardenTech Sevin Insect Killer, Spectracide Triazicide Insect Killer for Lawns & Landscapes RTU
malathion	Hi-Yield 55% Malathion, Southern Ag Malathion 50% EC, Bonide Malathion Insect Control, Spectracide Malathion Insect Spray Concentrate, Max Malathion, Ortho MAX Malathion Insect Spray Concentrate
‡†mineral oil	Bonide All Seasons Horticultural Oil Concentrate RTU and RTS, Southern Ag Parafine Horticultural Oil
‡†neem oil	Fertilome Natural Guard Neem, Bonide Captain Jack's NeemMax 4-In-1 Insecticide Fungicide Miticide Nematicide, Monterey 70% Neem Oil, Bonide Neem Oil Fungicide Miticide Insecticide, Garden Safe Neem Oil Extract Concentrate, Garden Safe Fungicide3, Monterey Neem Oil, Southern Ag Triple Action Neem Oil
permethrin	Bonide Eight Insect Control Garden Dust, Bonide Eight Insect Control Yard & Garden, Bonide Eight Insect Control Vegetable Fruit & Flower Concentrate, Bonide Garden Pet & Livestock Insect Control, Fertilome Indoor/Outdoor Broad Use Insecticide, Southern Ag Permetrol Lawn Insecticide, GardenTech Garden Insect Dust RTU
permethrin, myclobutanil	Spectracide Immunox 3-in-1 Insect and Disease Control Plus Fertilizer for Gardens RTU
‡†potassium salts of fatty acids	Bonide Insecticidal Soap Insect Killer RTU, Fertilome Natural Guard Insecticidal Soap, Safer Brand Insect Killing Soap
‡†potassium salts of fatty acids, spinosad	Bonide Captain Jack's Insecticidal Super Soap RTU, Fertilome Natural Guard Spinosad Soap
‡†potassium salts of fatty acids, sulfur	Bonide Captain Jack's Tomato & Vegetable 3-In-1 Garden Spray
†pyrethrins	Monterey Bug Buster-O
‡†pyrethrins, canola oil	Monterey Take Down Garden Spray, Garden Safe Houseplant & Garden Insect Killer RTU, Garden Safe Rose & Flower Insect Killer RTU , Garden Safe Multi-Purpose Garden Insect Killer RTU
‡†pyrethrins, neem oil	Fertilome Triple Action Concentrate RTU, Monterey Fruit Tree Spray Plus
pyrethrins, piperonyl butoxide	Bonide Pyrethrin Garden Spray Concentrate, Bonide Japanese Beetle Killer RTU, Southern Ag Pyrethrin Concentrate, Garden Sage Multi-Purpose Garden Insect Killer, Spectracide Triazicide Insect Killer for Landscapes and Gardens Outdoor Fogger
‡pyrethrins, piperonyl butoxide, neem oil	Bonide Bon-Neem II RTU, Fertilome Fruit Tree Spray with Neem Py, Fertilome Triple Action Plus, Ortho Tree & Shrub Fruit Tree Spray
‡†sesame oil	AgroBioUSA Bee Safe 3-In-1 Garden Spray, AgroBioUSA Bee Safe Insect Killer
†spinosad	Bonide Captain Jack's Dead Bug Brew Concentrate RTS and RTU, Bonide Captain Jack's DeadBug Brew Flower and Vegetable Garden Dust, Bonide Colorado Potato Beetle Beater, Southern Ag Conserve Naturalyte Insect Control, Fertilome Natural Guard Spinosad, Monterey Garden Insect Spray
†sulfur	Hi-Yield Dusting Wettable Sulfur, GardenTech Sevin Sulfur Dust 2-in-1 Disease and Insect Control, Bonide Sulfur Plant Fungicide Dust, Southern Ag Wettable or Dusting Sulfur, Ortho Bug-Geta Slug and Snail Killer
‡†sulfur, pyrethrins	Ortho Insect Mite & Disease 3-In-1 RTU, Bonide Tomato & Vegetable 3-in-1 RTU and RTS
zeta-cypermethrin	GardenTech Sevin Insect Killer Concentrate RTU
zeta-cypermethrin, bifenthrin	GardenTech Sevin Insect Killer Lawn Granules

Weed Management Strategies

Reviewed by Dan Brainard – Sep 2021

Weed management requires a multifaceted approach built on an understanding of weeds and the crop. Successful weed management entails preventative strategies to reduce weed populations before planting, cultural practices to give crops a competitive advantage over weeds, and direct approaches including chemical physical, and biological tactics.

The aim of any weed management strategy should be to manage the weed population so it is below a level that will reduce your economic return (economic threshold). It is important to consider the impact of weeds on yield and quality of the current crop, as well as the potential for increasing weed problems in future years if weeds go to seed. Deciding which methods to use depends on environmental concerns, marketing opportunities, desired management intensity, labor availability, weed pressure, and the crop. In some instances, the cost of controlling weeds may be more than the economic return from any yield increase that season. This situation occurs when a few weeds are present or the weeds germinate late in the season. In those instances, the best strategy may be to do nothing, or to do the minimum required to prevent seed production and dispersal. In other situations, weed populations and other considerations may require combining herbicides with nonchemical approaches.

Weed Identification

The first step in weed management is to identify the weeds and understand their life cycles and susceptibility to different weed management practices. Consult identification guides, such as *Weeds of the North Central States* (University of Illinois Agricultural Experiment Station Bulletin 772), for assistance.

Weeds can be categorized by life cycles, and management strategies developed accordingly.

Annual weeds complete their life cycles in one year and reproduce solely by seeds. Annuals can be divided into summer or winter annuals, depending on when they grow. Primary tillage operations often control winter annuals before a crop is planted in the spring. The most common vegetable crop weeds (e.g., barnyard grass, giant foxtail, crabgrass, common purslane, redroot pigweed, and common lambsquarters) are summer annuals.

Perennial weeds live for more than two years and can reproduce by seed or vegetative structures (stolons, rhizomes, corms, bulbs, tubers, or roots). Because perennial weeds are difficult to manage in vegetable crops, it is usually better not to use a field with severe perennial weed problems. Among the most common perennial weeds encountered in Midwest vegetable crops are quackgrass, horsenettle, and yellow nutsedge.

Many nonchemical weed management methods are common sense farming practices. These practices are of increasing importance due to consumer concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

Prevention and Weed Seedbank Management

Prevention is a critical component of successful weed management. Many weed species produce thousands of seeds that survive for decades in the soil, making up the weed seedbank. Avoiding “deposits” to the weed seedbank by preventing weeds from shedding seed is important for reducing the number of weeds emerging each year. This may mean mowing, tilling or applying herbicides after crop harvest to manage weed escapes, or planting a thick cover crop in non-crop areas to suppress weed growth and reproduction. The seedbank may also be depleted by encouraging “withdrawals” of seeds through repeated cultivation which stimulates seed germination and kills emerging weeds. Stale (or false) seedbed techniques aim to deplete weed seeds in the top few inches of soil through repeated shallow disturbance to stimulate seed germination followed by herbicide applications or flame weeding prior to planting the crop. This approach can be highly effective for late-planted vegetable crops such as fall carrots or beets, but is less practical for crops planted early in the spring. Additional details on weed seedbank management strategies can be found in the web resource, *Manipulating Weed Seed Banks to Promote their Decline* at eorganic.org/node/2807.

Cultural Practices

Site Selection. Farm practices should aim to establish a vigorous crop that competes effectively with weeds. This starts with land selection. A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially perennial weeds. Crop selection can reduce the effects of weed competition. One criterion in selecting a crop should be the weed problems of the field. Plant the most competitive crops in the most weed-infested fields, and the least competitive crops in the cleanest ones. Consider planting

heavily infested fields as long-term set-aside acres or in non-row crops such as alfalfa. Permanent cover should help prevent buildup of annual weeds.

Crop Rotation. Crop rotation is another practice that can reduce weed problems. The characteristics of the crop, the methods used to grow it, and the herbicides used, inadvertently allow certain weeds to escape control. Rotation also affects the weed management tools at your disposal.

Rotating between crops will improve crop growth and competitiveness. Related vegetables should not be grown in the same location in successive years (see Botanically Related Vegetables). This is important both to ensure healthy crop growth for weed competitiveness, but also to avoid buildup of problematic weed species that are well adapted to specific vegetable crops. Crop rotation helps keep weeds 'off-balance' by applying different selective pressures including variations in the timing of tillage and type of herbicides applied.

Wild proso millet is an example of a problem weed where rotation is important for management. Rotation from sweet corn to early-planted peas, or alfalfa almost completely eliminates wild proso millet because these crops are established before the soil is warm enough for wild proso millet seed germination. A rotation from sweet corn to broadleaf crops also allows the use of postemergence grass herbicides to manage wild proso millet.

Competitive Cultivars and Planting Methods. Each crop has a Critical Weed Free Period (table below) for which weed competition should be eliminated to ensure a good crop. Use adaptive, vigorous varieties resistant to diseases and insects. Unhealthy plants cannot effectively compete with weeds. Varieties suited for cultivation in regions covered by this publication are listed in some sections of this guide.

Narrower row spacings and proper plant densities assure crop canopy closure. Closed canopies shade out later emerging weeds and prevent germination of weed seeds that require light. Weeds seldom are a problem after canopy closure. Proper row spacing and plant density also allow row cultivation.

Correct planting time is another cultural method that can improve crop competitiveness. Crops can be divided into warm- or cool-season plants, depending on the optimum temperature for their growth. Planting date affects the time until emergence and the crop's early seedling vigor, both of which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures, so compete better against early emerging weeds than warm-season crops.

Critical Weed Free Period[1]	Crop
First third of cultivation period	Potato, Pumpkin, Sweet Corn
First half of cultivation period	Asparagus, Beans, Cole Crops, Lettuce, Pepper, Tomato
2 weeks after first half of cultivation period	Carrots, Celery, Beet, Peas
4 weeks after first half of cultivation period	Garlic, Leek, Onion
None	Chives, Parsley, Fennel, Swiss Chard, Spinach

[1]Modified from *Practical weed control in arable farming and vegetable cultivation without chemicals* PPO 352 (2006), from Wageningen University & Research Applied Plant Research unit, at edepot.wur.nl/24553.

Mulches. Mulching can be useful in managing weeds. Mulches can be classified as either natural (e.g., straw, leaves, paper, and compost) or synthetic (plastics). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1 to 1.5 inches thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough so they will not be easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil and do not need to be disposed of at the end of the season.

Synthetic mulches are easy to apply, control weeds within the row, conserve moisture, and increase soil temperature. Black or clear plastic mulches are the most common and are effective in improving early- season growth of warm-season crops such as tomato, cantaloupe, watermelon, or pepper. Fast early-season growth of these crops improves their competitive ability against weeds. Plastic mulches used in combination with trickle irrigation can also improve water use efficiency.

A disadvantage of plastic mulch whichs disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches have been developed, but their season-long persistence has been a problem, and they degrade into small pieces of plastic that contaminate the environment. Biodegradable plastic mulches are available.

Mechanical Practices

Mechanical weed management relies on a wide range of primary and secondary tillage implements including moldboard plows, disks, rotary hoes, row cultivators and various 'in-row' tools. It typically begins with primary tillage with a moldboard or chisel plow, followed by disking, field cultivating and bed formation. These operations are important for successful production of most vegetable crops for several reasons including formation of a good seed bed, incorporation

of soil amendments, and breaking the life cycle of pests. For weed management, these tillage operations help eliminate established winter annual and perennial weeds, as well as summer annuals that emerge prior to planting.

A good introduction to mechanical cultivation be found in the publication *Steel in the Field* available online at sare.org/wp-content/uploads/Steel-in-the-Field.pdf, and video footage demonstrating the nuances of many of these tools and techniques can be seen in the North Central SARE-funded videos *In-Row Mechanical Weed Control Options for Farmers Large and Small*, as well as in the *Weed 'Em and Reap Part 1: Tools for Organic Weed Management in Vegetable Cropping Systems* video series found at eorganic.org/node/3411.

Pre-plant, or pre-crop emergence weeds. After bed preparation, shallow cultivation tools including rotary hoes and flextine cultivators can be used to uproot small weeds including those that have germinated but not yet emerged from the ground (white thread stage). These tools can be used prior to planting to drain weed seeds from the top 1-2" of soil without bringing new seeds to the soil surface (see stale seed bed above). For large-seeded vegetable crops such as sweet corn, snap beans or cucurbits, flextine cultivators may also be used after planting but before crop emergence.

Weeds after crop emergence. Many cultivation tools are available, and are generally categorized as either between-row, near-row, or in-row tools, based on the zone they target. The flextine cultivator mentioned above can also be used after crops have emerged and are firmly anchored (1-2 leaf growth stage), scratching the soil of between- and in-row areas uprooting and burying weeds at their white-thread stage.

Between-row weeds. Removing weeds between crop rows is relatively easy, and there are several options available. Between row tools include various row-crop cultivators equipped with knives and sweeps that are capable of killing larger weeds. These tools may also be used to throw soil into the crop row at later crop growth stages, burying small weed seedlings. Other between-row tools include basket weeders (e.g. Buddingh or Tilmor) and rolling cultivators (e.g. Lilliston or Hillside). Basket weeders are designed to work close to the crop row, throwing minimal soil while uprooting small weeds. They require level soil that is relatively stone free. Rolling cultivators are more aggressive tools that are equipped with sets of toothed discs (spider gangs) that can be easily adjusted to accommodate different levels of desired soil disturbance and angles. They are particularly useful on edges of beds and in situations where crop or cover crop residue would interfere with less forgiving knives or sweeps.

Near-row weeds. Tools such as side knives (sometimes referred to as beet knives or tender plant hoes) or cutaway disks are designed to disturb soil near the row without disturbing the crop, leaving a 1.5-3" band of undisturbed soil centered on the crop row. Success with these tools requires straight rows, and attention to precise steering and depth control. To best accomplish this, they should be mounted on parallel linkage with gauge wheels and steered either on the belly of a cultivating tractor, or on a steerable toolbar.

In-row weeds. Weeds in the row are the most challenging to manage without disturbing the crop. This zone may be managed by burying small weeds by throwing soil into the row using sweeps, hilling disks or ridgers. Alternatively, specialized in-row tools such as finger weeders or torsion weeders may be used to reach into the crop row and uproot small weeds. In all cases, a size difference between the crop and weed is essential for success. As with near-row tools, these tools also require investments in depth control and steering for optimal performance.

In some vegetable crops, such as asparagus, mowing can be an effective weed management tool. Mowing can prevent weed seed production and kill upright weeds, reducing competition. Mowing must be carefully timed to eliminate perennial, biennial, or annual weeds that would compete strongly in vegetables because of their upright growth habits. Timely, repeated mowing also helps deplete the food reserves (root systems) of perennial weeds.

Mechanical control has many limitations that must be considered when designing weed management systems. Because mechanical management relies on relatively dry soil, a rainy period may prevent the use of mechanical weed management options and lead to severe weed competition. Relying entirely on mechanical practices to manage weeds is labor intensive, and many growers will use herbicides combined with nonchemical approaches to control especially difficult weeds. Some of these difficult-to-control weeds include wild proso millet in sweet corn, Canada thistle, hemp dogbane, field bindweed, quackgrass, and johnsongrass. Newly introduced problem weeds often show up in scattered patches along headlands and field borders. These are best controlled or eradicated with herbicides before large areas are infested.

Cover Crops for Biological Weed Suppression

One biological system that has potential in the Midwest is the use of cover crops to suppress weed development. Cover crops can reduce weed pressure in a variety of ways: they can compete with weeds to reduce weed seed production, release allelochemicals that suppress weed seed germination and

growth, or produce residue that acts as a mulch to suppress weed growth.

Successful cover cropping for weed suppression in vegetables requires use of competitive species that match the season and soil type. Summer cover crops with good weed suppressive ability include sorghum-sudangrass and buckwheat. Cool season cover crops like oats and oilseed radish can effectively suppress weeds beginning in late summer through the fall before winter killing in most areas of the Midwest. Winter cover crops such as winter rye or hairy vetch may provide weed suppression during the winter as well as a weed suppressive mulch if allowed to grow through early spring.

One cover crop system that works well in parts of the Midwest for some large-seeded vegetable crops like pumpkins involves growing winter rye as a weed suppressive mulch. Winter rye is planted in late summer or early fall and overwinters. In the spring, the rye is killed two weeks prior to planting the desired crop. Rye can be killed using herbicides, or, once it has reached the reproductive stage, by mowing, or rolling and crimping. The rye is left as a mulch on the soil surface, and the crop is no-till planted. The system can provide early season control of many annual weeds, but generally this requires a thick uniform stand that is at least 4 feet tall to adequately suppress weeds. In most cases,additional herbicides and or mechanical control may be required. The system should be evaluated in small areas before it is adopted.

Refer to Examples of Integrating Cover Crops section, the Summary of Nonchemical Weed Management Practices table, and the *Weed 'Em and Reap Part 2: Reduced Tillage Strategies for Vegetable Cropping Systems* video series found at eorganic.org/node/3409 for additional information. The most effective weed management system is an integrated approach that combines many different practices. This approach must be adaptive, aiming to prevent weed problems or cope with any that occur.

Chemical Weed Management Strategies

Several herbicides are often labeled for a particular crop. Scouting your area to determine which weeds are present will allow you to select the herbicides that will give you the best control.

All the herbicides labeled for a crop are not necessarily listed in this guide. If you are unfamiliar with an herbicide, conduct a small test under your environmental conditions and cultural practices before using the herbicide extensively.

Herbicide Labels

Always Read and Understand the Herbicide Label Before Use. Reading the herbicide label is a very profitable use of your time. Information on the label will direct you to the correct uses, application methods, rates, and potential environmental hazards of the product.

Follow label directions for the best possible control with minimal crop injury and environmental contamination. The label contains restrictions on use and discusses environmental and soil conditions that affect crop injury, influence the effectiveness of weed control, and can cause nontarget site effects.

Do Not Use Any Herbicide Unless the Label States That It Is Cleared for Your Particular Use and Crop. Using a nonregistered pesticide can cause harmful residues in the vegetable crop, which can result in crop seizure and consumer injury. The label also states whether the herbicide is a restricted-use or general- use pesticide. Restricted-use pesticide labels contain a statement that the products are restricted and that only licensed applicators can buy them and supervise their application. The information in this production guide is current as of the date of publication. Watch for notices of changes in the U.S. Environmental Protection Agency (EPA) registration of herbicides from your state Extension service.

Herbicides for Reduced Tillage Systems

Reduced tillage systems combat soil erosion. These systems often include the use of glyphosate or paraquat outside the normal growing season to control emerged weeds. Weeds should be growing actively, and the application must be made before the crop has emerged. If you are applying glyphosate to control perennial weeds, apply it before the soil is disturbed. After it is applied, glyphosate must be allowed to translocate throughout the perennial weed for several days, or incomplete control may result. Follow glyphosate label directions carefully for rates and timing of applications. If perennial weeds are not a major problem, you can eliminate early weed flushes by applying glyphosate or paraquat to all weeds that emerge. Plant the crop with minimal working of the soil. Never apply glyphosate or paraquat to an emerged crop because severe crop injury or death will occur.

Glyphosate and paraquat will control most annual broadleaf and grass weeds. Neither herbicide has any soil residual activity, so other weed control measures will be necessary during the growing season. Paraquat will suppress perennials

by killing their shoots, but it does not control regrowth of perennial weeds from rhizomes or other underground storage organs. Glyphosate is better for controlling perennials because it will kill shoots and translocate to destroy underground parts. Glyphosate will only suppress some particularly hard-to-control perennials such as bindweed, hemp dogbane, and milkweed. To control these perennials, high application rates, repeat applications of glyphosate (within label guidelines), or mechanical removal may be necessary.

Herbicide Rates and Guidelines for Use in Vegetable Crops

All herbicide rates given in this guide are in amount of product per broadcast acre. Adjust amounts accordingly for banded applications. Make preemergence applications before weeds emerge or after removing any weeds present. Make postemergence applications after weeds have emerged. Several materials may be used between crop rows if appropriate steps are taken to prevent spray from contacting the crop. Some of these materials require shielded sprayers, while others require hooded sprayers. The herbicide recommendations in this guide do not replace careful reading of current herbicide labels. Re-registration of older herbicides has affected the availability of many products. Some of the older herbicides not re-registered are not listed in this bulletin, but may be available, and old stocks can still be used.

Environmental and Health Hazards of Herbicides

Herbicides can have nontargeted effects, so it is very important that you educate yourself about these effects and consider them when designing weed management systems. The following section contains discussions of some of the potential environmental and health hazards of herbicides.

Environmental Hazards

Adverse environmental effects from herbicides can have long-term consequences that are difficult to correct, and must be avoided. Some environmental hazards, such as herbicide drift and carryover, will mainly affect your operation, while other hazards, such as water contamination, affect all residents in the area. The following sections discuss some of the potential hazards and methods to avoid them.

Herbicide carryover. Herbicide carryover from persistent herbicides has been a particular problem to vegetable crop growers. Persistence depends on herbicide characteristics (method of degradation, water solubility, and rate of application) and site characteristics (soil type, rainfall, and temperature). Avoid carryover because correcting carryover problems after they have occurred is virtually impossible. The most important method to avoid herbicide carryover is to follow label rotation restrictions. The Corn Herbicide Rotation Restrictions table and Soybean Herbicide Rotation Restrictions table summarizes some of the label restrictions. Always refer to the label for specific information. If there are differences between the table and herbicide label, always follow label information.

Herbicide drift. Another frequent hazard to vegetable growers is crop injury from herbicide drift. Certain herbicides, if not used correctly, can injure nontarget plants. Herbicides such as clomazone (Command), dicamba, and 2,4-D can drift up to a mile and seriously damage grapes, tomatoes, peppers, other vegetables, fruit trees, and ornamental plants. Before spraying clomazone, dicamba, or 2,4-D, survey the area for desirable plants. Spray only on calm days, and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use an amine formulation of 2,4-D to reduce vapor drift. Spray clomazone, dicamba, and 2,4-D when the temperature is expected to be lower than 80 F to 85 F for several days after treatment. Avoid applying clomazone to wet soils.

Spray tank residuals. Dicamba or 2,4-D residues in spray tanks also can injure susceptible vegetable crops. Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

Herbicide resistance. More than 180 weed species have developed resistance to one or more herbicides. Herbicide-resistant populations tend to develop when herbicides with the same mode of action for killing weeds are used every year in the same field. The Herbicide Resistance Action Committee (HRAC) groups herbicides according to their modes of action.

Weeds resistant to herbicides in HRAC Group 2 (ALS inhibitors) make up 30% of the documented resistant biotypes. Sandea, Permit, Matrix, Raptor, and Pursuit are vegetable herbicides in this group.

Weeds resistant to herbicides in HRAC Group 5 (Photosystem II inhibitors) make up another 20% of the documented resistant biotypes. Atrazine, Sencor, and Sinbar are in this group. Widespread glyphosate use in agronomic crops has led to the development of glyphosate-resistant weeds, although they still only represent 3.5% of resistant biotypes.

Approaches that aim to prevent herbicide resistance combine the use of herbicides, mechanical (cultivation), and cultural

(crop rotation) weed management practices. It is important to avoid relying on herbicides from a single HRAC group year after year. Rotate between, or use tank-mixes of, herbicides with different modes of action. For example, in asparagus rotate between Sencor and Treflan. Use tillage to control weeds that escape from herbicide applications. To minimize any weed resistance that does occur, it is especially important to scout your fields, paying special attention to any patches of a weed normally controlled by the herbicide. Herbicide labels may contain additional information about avoiding

Water quality. Residues of some herbicides such as atrazine, metolachlor, and metribuzin have been found in surface and ground water. Detected levels have normally been low, but contamination of water resources is a growing concern. For example, groundwater contamination from pesticides and nitrates is a particular concern in areas of the Midwest with sandy soils and shallow groundwater.

Factors determining the potential for groundwater and surface water contamination include herbicide solubility in water, rate of degradation, volatility, and tendency for the herbicide to attach to soil particles or organic matter. Herbicides that have high water solubility and long persistence are a particular concern.

Site characteristics (soil type, soil depth, water table depth, slope, and weather) also can lead to contamination of water resources from herbicides. You should be aware of the potential problem of herbicide contamination and take all possible steps to avoid contamination of surface and subsurface water resources.

Summary of Nonchemical Weed Management Practices

Practice	Notes
Land selection	Avoid fields with a history of weed problems.
Crop selection	Grow the most competitive crops in fields with histories of weed problems.
Crop rotation	Rotate between vegetables and non-row crops such as alfalfa. Rotate between vegetables in different botanical categories.
Adapted crop varieties	Select crop varieties adapted for your area.
Proper row spacings and plant densities	Use row spacings and plant densities that assure rapid crop canopy closure.
Correct planting times	Plant crops when soil temperatures favor rapid germination and emergence. Do not plant warm-season crops too early in the season.
Appropriate crop management	Vigorous, healthy crops are more competitive against weeds and insects.
Mulch	Natural mulches may be appropriate on small acreages. Synthetic (plastic) mulches are useful to manage weeds within the row in warm-season crops. Consider disposal problems when using plastic mulches.
Moldboard plowing	This can eliminate emerged annual weeds.
Rotary hoeing	This is useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap bean, lima bean, and pea.
Row cultivator	Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems.
Mowing	Mow weeds as soon as flowers appear so no viable weed seed is produced.
Flame weeding	Flame weeding, or using a hot flame to kill weeds, is effective for stale seedbed weed removal or weeds that emerge before the vegetable crop. Flame weeding is effective for weed control in vegetables such as onions, parsnips, and carrots. Some growers have successfully used flame weeding on transplanted onions that are 8-10 in. tall. Sweet corn that has just emerged and potatoes up to 2 in. tall can be flame weeded.
Cover crops and living mulches	Cover crops and intercrops can reduce weed pressure in a variety of ways: they can compete with weeds to reduce weed seed production, release allelochemicals that suppress weed seed germination and growth, or produce residue that acts as a mulch to suppress weed growth.
Insect or disease pests or weeds	No current systems use insects or diseases to manage weeds in common vegetables.

Herbicide Tables

This table includes selected information about the herbicides recommended in this guide. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**.

° = indicates that small package and ready-to-use formulations are commonly available at hardware stores and garden center

***** = indicates that some formulations may be Restricted Use Pesticides (RUP) and require a certification to purchase and use

† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production – check with your certifier

‡ = indicates additional formulations that do not currently occur elsewhere in this guide as crop protection recommendations because they are not as well understood to be effective options

The **Signal Word** is an indication of the human health hazard of the product.

The **Leaching Risk** and **Runoff Risk** columns have one of four listings:

v. low = the product is not likely to move with water

low = the product has a low likelihood of moving with water

med = the product has an intermediate likelihood of moving with water

high = the product has a high likelihood of moving with water

The **Respirator Use** column has one of the following listings:

no = you do not need to use a respirator

yes = you do need some sort of respirator for some part of the process (see label for details)

some = certain Trade Names may require respirators, but others may not

Active Ingredients	Trade Names	Signal Word	Leaching Risk	Runoff Risk	Respirator Use
°2,4-D	Formula 40, Savage, Weedar	danger	med	low	some
*acetachlor, atrazine	Degree Xtra, Fultime, Harness Extra, Keystone	caution, warning	high	med	no
acetochlor	Breakfree , Harness, Surpass EC, TopNotch	warning	med	low	no
*acetochlor, atrazine	Breakfree ATZ, Breakfree ATZ Lite	warning	high	med	no
acifluorfen	Ultra Blazer	danger	high	med	no
‡allyl isothiocyanate	Dominus	danger	-	-	yes
‡†ammoniated soap of fatty acids	Final-San-O	warning	-	-	no
ammonium nonanoate	AXXE	warning	low	low	no
*atrazine	Aatrex 4L, Aatrex Nine-O, Cornbelt 4L, Cornbelt 90DF, Infantry 4L, Infantry 90DF	caution	high	med	some
*atrazine, mesotrione, s-metolachlor, bicyclopyrone	Acuron	caution	high	med	no
*atrazine, pyroxasulfone, fluthiacet-methyl	Anthem ATZ	warning	high	med	no
*atrazine, s-metolachlor	Bicep II Magnum, Bicep Lite II Magnum Lexar	caution	high	med	no
benefin	Balan DF	warning	-	-	no
bensulide	Prefar 4E	caution	med	high	yes
bentazon	Basagran, Bashazon, Broadloom, Biscayne	caution, danger	med	low	no
bentazon, sethoxydim	Rezult	caution	low	low	no
bicyclopyrone	Optogen	caution	low	med	
bromacil	Hyvar X	caution	high	med	yes
bromoxynil	Moxy 2E	warning	low	med	no
°‡†caprylic acid, capric acid	HomePlate	caution	-	-	no
carfentrazone	Aim EC	caution	low	low	no
carfentrazone, sulfentrazone	Spartan Charge	caution	high	med	no
clethodim	Clethodim 2E, Select Max	caution, warning	low	low	no
clomazone	Caravel, Command 3ME	caution	med	low	no
clopyralid	Spur, Stinger	caution	high	low	no
‡†clove oil, rosemary oil, peppermint oil, cottonseed oil	GreenFurrow EF 400	exempt	low	med	no
°‡†corn gluten	Preen Organic Weed Preventer	caution	low	med	no
cycloate	Ro-Neet	caution	med	low	yes
DCPA	Dacthal Flowable	caution	low	high	no

Active Ingredients	Trade Names	Signal Word	Leaching Risk	Runoff Risk	Respirator Use
dicamba	Banvel, Clarity	warning	high	low	no
dichlobenil	Casoron 4G	caution	med	med	no
dimethenamid-p	Outlook	warning	med	low	no
*dimethenamid-p, atrazine	Commit ATZ, Guardsman Max	warning	high	med	no
diquat	Reglone	warning	v. low	high	no
*diuron (*MI only)	Direx 4L, Karmex DF, Parrot 4L, Parrot DF	caution	med	med	yes
EPTC	Eptam 7E, Eptam 20G	caution, warning	low	low	yes
ethalfluralin	Curbit EC, Sonalan HFP	danger	low	high	no
ethalfluralin, clomazone	Strategy	caution	med	high	no
ethofumesate	Ethotron SC, Nortron SC	caution	med	low	no
fluazifop-P	Fusilade DX	caution	low	med	yes
flumioxazin	Chateau SW, Valor SX	caution	low	med	yes
fluroxypyr	Starane Ultra	warning	med	low	no
fluthiacet-methyl	Cadet	warning	low	low	no
fomesafen	Reflex	danger	high	med	no
foramsulfuron	Option	caution	med	low	no
glufosinate	Liberty 280 SL, Rely 280	warning	low	low	yes
°glyphosate	Roundup PowerMax, Roundup Ultra, Touchdown	caution	low	high	no
glyphosate, sulfentrazone	Spartan Advance	caution	high	high	no
halosulfuron	Permit, Sandea	caution	med	low	no
imazamox	Raptor	caution	high	med	no
imazethapyr	Pursuit	caution	high	med	no
imazethapyr, saflufenacil	Optill	caution	high	med	no
imazosulfuron	League	caution	med	low	no
linuron	Linex 4L, Lorox DF	caution	med	med	no
MCPB	Thistrol	danger	low	low	no
mesotrione	Callisto, Quartz	caution	high	low	no
*mesotrione, atrazine	Callisto Xtra	caution	high	med	no
metribuzin	TriCor DF, TriCor 4F	caution	high	low	no
napropamide	Devrinol DF-XT	caution	med	med	no
nicosulfuron	Accent Q	caution	high	low	no
nicosulfuron, mesotrione	Revulin Q	caution	high	low	no
norflurazon	Solicam DF	caution	med	med	no
oxyfluorfen	Goal 2XL, GoalTender	caution, warning	v. low	med	no
*paraquat	Firestorm, Gramoxone SL	danger	v. low	high	yes
pelargonic acid	Scythe	warning	-	-	no
pendimethalin	Prowl 3.3 EC, Prowl H2O, Satellite Hydrocap	caution	low	high	no
pendimethalin, metribuzin	Tripzin ZC	caution	high	high	no
*phenmedipham	Spin-Aid	danger	low	med	no
phenmedipham, desmedipham	Betamix	warning	low	med	no
primisulfuron	Beacon	caution	high	low	no
prometryn	Caparol 4L	caution	med	med	yes
*pronamide	Kerb SC	caution	-	-	no
pyraflufen	Venue	caution	low	med	no
pyridate	Tough	warning	v. low	Low	no
pyroxasulfone	Zidua	caution	med	low	yes
pyroxasulfone, fluthiacet-methyl	Anthem Maxx	caution	low	low	no
quinclorac	QuinStar 4L	caution	high	med	no
quizalofop	Assure II, Targa	danger	med	high	no
rimsulfuron	Matrix SG	caution	med	low	no
saflufenacil	Sharpen	caution	med	low	no
°sethoxydim	Poast	warning	low	low	no
s-metolachlor	Dual Magnum, Dual II Magnum, Stalwart C	caution	high	med	no
*s-metolachlor, atrazine, mesotrione	Lexar, Lumax, Stalwart 3W	caution	high	med	no
sodium chlorate	Defol 5	caution	high	med	no
sulfentrazone	Spartan 4F, Portfolio 4F, Sulfin 4SC, Zeus XC, Zone 4F	caution	high	med	no
tembotrione	Laudis	caution	high	med	no
terbacil	Sinbar WDG	caution	high	med	no
tolpyralate	Shieldex	caution	low	low	no
topramezone	Armezon, Impact	caution	high	med	no
topramezone, dimethenamid-p	Armezon Pro	caution	high	med	yes
topramezone, glufosinate	Sinate	caution	high	med	no
°trifluralin	Treflan 4EC, Triflurex HFP	caution	low	high	no

Small package hardware and garden center herbicides

This table includes additional pesticides that you may find readily available at hardware stores and garden centers in smaller quantities. The products are listed alphabetically by **Active Ingredient**, with a selection of **Trade Names**. RTU = Ready-To-Use without dilution. RTS = Ready-To-Spray with hose-end container.

† = indicates biorational formulations that may be listed by the Organic Materials Research Institute (OMRI) and may be allowed in organic production – check with your certifier

‡ = indicates additional formulations that do not currently occur elsewhere in this guide as crop protection recommendations because they are not as well understood to be effective options

Active Ingredients	Trade Names
2,4-D amine	Hi-Yield 2,4-D amine
‡†ammoniated soap of fatty acids	Fertilome Grass & Weed Killer Non-Selective Concentrate and RTU
‡†caprylic acid, capric acid	Bonide Botanical KleenUp, Bonide BurnOut FII
‡†corn gluten	Bonide Maize Weed Preventer, Espoma Organic Weed Preventer, Preen Natural Weed Preventer, Preen Organic Weed Preventer
glyphosate	Bonide KleenUp Super Concentrate HE and RTU, Southern Ag Weed Pro
sethoxydim	Bonide Grass Beater II, Hi-Yield Grass Killer, Fertilome Over-The-Top II, Monterey Grass Getter
trifluralin	Hi-Yield Herbicide Granules Weed and Grass Preventer, Preen Garden Weed Preventer, Monterey Vegetable & Ornamental Weeder

Herbicide Efficacy Table

This table includes efficacy information about the herbicides recommended in this guide. The products are listed alphabetically by **Active Ingredient**, with their common **Placement relative to weeds**. Weed control will vary with soil type and weather. Italics indicates the rating occurred in the MSU E0433 bulletin. Non-italics indicates the rating is original to the Midwest Veg Guide.

E=excellent
G=good
F=fair
P=poor
N=none

Active Ingredient	Placement relative to weeds	Barnyardgrass	Crabgass, Large	Fall Panicum	Foxtails (green, giant, yellow)	Goosegrass	Lambsquarters, Common	Purslane, Common	Ragweed, Common	Galinsoga	Nightshade	Pigweed, Amaranth	Smartweeds, Ladysthumb	Velvetleaf	Jimsonweed	Morningglory, Annual	Yellow Nutsedge
2,4-D	Weeds <3”	N	N	N	N	N	G	P	G	G	G	G	P	F	F	G	N
acetochlor	Surface Pre	G	G	G	G	G	G	F	F	G	G	G	P	P	P	P	G
alachlor	Surface Pre	G	G	G	G	G	F	G	P	G	G	G	P	N	P	N	F
ametryn	Weeds <3”	G	G	G	G	G	G	F	G	G	F	G	G	G	G	G	F
atrazine	Surface Pre	G	G	P	F	G	G	G	G	G	G	G	G	F	G	F-G	F
atrazine	Weeds <3”	*G*	*G*	*F*	*G*	-	*E*	*E*	*E*	*G*	*G*	*E*	*E*	*G*	-	-	*P*
benefin	Incorp Pre	G	G	G	G	G	F	P	P	P	P	G	P	P	P	P	P
bensulide	Incorp Pre	G	G	G	G	G	F	F	N	N	N	F	N	N	N	N	N
bentazon	Weeds <3”	N	N	N	N	N	F	F-G	F	G	P	P	G	G	G	F	G
bromoxynil	Weeds <3”	N	N	N	N	N	G	P	G	N	G	F	G	G	G	G	N
carfentrazone	Weeds <3”	N	N	N	N	N	G	N	F	N	G	F-G	F	G	N	G	N
clethodim	Weeds <3”	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
clomazone	Surface Pre	G	G	G	G	G	G	G	G	P	P	P	G	G	F	F	N
clopyralid	Weeds <3”	N	N	N	N	N	P	N	G	G	F	P	F	N	G	N	N
cycloate	Incorp Pre	G	G	G	G	G	F	F	P	F	P	G	P	P	N	N	F
DCPA	Surface Pre	G	G	G	G	G	F	F	N	P	N	F	N	N	P	N	N
dicamba	Weeds <3”	N	N	N	N	N	G	G	G	G	G	G	G	G	F	G	N
dimethenamid-p	Incorp Pre	G	G	G	G	G	F	G	P	G	G	G	P	N	P	N	F
diuron	Surface Pre	G	F	F	G	G	G	G	G	G	G	G	G	G	G	G	P
EPTC	Incorp Pre	G	G	G	G	G	F	G	P	P	F-P	G	P	F	N	P	F
ethafluralin	Incorp Pre	G	G	G	G	G	F-G	F-G	N-P	N-F	F	F-G	P	N	N	N	N
ethofumesate	Surface Pre	*P*	*F*	*P*	*F*	-	*F*	*F*	*P*	*P*	*F*	*F*	*G*	*P*	-	-	*F*
ethofumesate	Weeds <3”	*P*	*P*	*P*	*F*	-	*F*	*F*	*P*	*P*	*G*	*P*	*G*	*P*	-	-	*F*
fluazifop-P	Weeds <3”	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
flumioxazin	Surface Pre	F	F	F	F	F	G	G	G	N	G	G	G	G	G	G	N
flumioxazin	Weeds <3”	*N*	*N*	*N*	*N*	-	*E*	*E*	*G*	*G*	*E*	*E*	*G*	*G*	-	-	*P*
fluroxypyr	Weeds <3”	N	N	N	N	N	P	G	G	N	F	P	P	G	F	G	N
fluthiacet-methyl	Weeds <3”	N	N	N	N	N	F	N	N	N	F	F	N	G	F	N	N
fomesafen	Surface Pre	*P*	*P*	*P*	*P*	-	*G*	*E*	*G*	*G*	*G*	*E*	*F*	*P*	-	-	*N*
fomesafen	Weeds <3”	N	N	N	N	N	N	N	F-G	N	F-G	N	N	N	N	N	N
foramsulfuron	Weeds <3”	G	F	G	G	G	G	G	G	P	G	G	F	G	G	F	P
glyphosate	Weeds <3”	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	F
halosulfuron	Surface Pre	P	P	P	P	P	G	F	G	G	P	G	G	G	P	N	G
halosulfuron	Weeds <3”	N	N	N	N	N	P	N	G	G	N	F-G	F-G	G	N	F	G
imazamox	Weeds <3”	G	G	N	G	N	F	F	P-F	N	G	G	G	G	G	P-F	P-F
imazethapyr	Surface Pre	P	P	P	G	P	F	G	P	G	G	G	G	F	F	P	P
imazethapyr	Weeds <3”	*F*	*G*	*N*	*G*	-	*F*	*P*	*G*	*P*	*E*	*E*	*G*	*F*	-	-	*P*
imazosulfuron	Surface Pre	F	F	N	F	N	G	G	G	G	F	G	N	N	N	N	G
imazosulfuron	Weeds <3”	F	F	N	N	N	N	G	N	G	N	G	F	N	N	G	G
linuron	Surface Pre	F	F	F	F	F	G	G	G	G	F	G	G	G	F	P	N
linuron	Weeds <3”	F	F	F	F	F	G	G	G	G	G	G	G	G	F	G	N
MCPB	Weeds <3”	N	N	N	N	N	F	N	N	N	N	F	F	N	N	F	N

Active Ingredient	Placement relative to weeds	Barnyardgrass	Crabgass, Large	Fall Panicum	Foxtails (green, giant, yellow)	Goosegrass	Lambsquarters, Common	Purslane, Common	Ragweed, Common	Galinsoga	Nightshade	Pigweed, Amaranth	Smartweeds, Ladysthumb	Velvetleaf	Jimsonweed	Morningglory, Annual	Yellow Nutsedge
mesotrione	Surface Pre	N	N-P	N	N	N	G	N	P	G	G	G	G	G	G	F	N
mesotrione	Weeds <3”	N	N-P	N	N	N	G	N	F	G	G	G	G	G	G	F	N
metribuzin	Surface Pre	F	F	F	F-G	F	G	G	G	G	N	G	G	G	F	N	N
metribuzin	Weeds <3”	F	F	F	F	F	G	G	G	G	P	G	G	G	F	F-G	N
napropamide	Incorp Pre	G	G	G	G	G	F	G	N	P	N	G	P	N	N	N	N
nicosulfuron	Weeds <3”	G	P	G	G	G	P-F	P	P	P	P	G	G	P	G	G	P
norflurazon	Surface Pre	G	G	G	G	G	F	F	G	G	F	F	F	F	N	N	F
oxyfluorfen	Surface Pre	P	F	F	P	P	G	G	G	G	G	G	G	F	F-G	F	N
oxyfluorfen	Weeds <3”	P	P	P	P	P	F	G	G	G	G	F	F	F	G	F	N
paraquat	Weeds <3”	G	G	G	G	G	G	G	G	F-G	G	G	G	G	G	G	*G*
pendimethalin	Incorp Pre	G	G	G	G	G	G	G	P	N	P	G	P	P	N	N	N
phenmedipham	Weeds <3”	N	N	N	N	N	G	G	G	G	F	P	G	F	F	F	N
primisulfuron	Weeds <3”	*P*	*P*	*G*	*F*	-	*F*	*N*	*E*	*N*	*G*	*E*	*G*	*G*	-	-	*F*
prometryn	Surface Pre	*F*	*G*	*F*	*F*	-	*E*	*G*	*G*	*F*	*G*	*E*	*F*	*F*	-	-	*P*
prometryn	Weeds <3”	*F*	*F*	*F*	*F*	-	*E*	*G*	*E*	*G*	*G*	*E*	*F*	*F*	-	-	*P*
pronamide	Surface Pre	F	F	P	F	F	F	G	F	P	P	P	F	P	P	P	P
pyroxasulfone	Surface Pre	G	G	G	G	G	F	G	P	G	G	G	P	N	P	P	F
quinclorac	Weeds <3”	*G*	*G*	-	*G*	-	*F*	-	*F*	-	-	-	-	*F*	-	-	-
quizalofop	Weeds <3”	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
rimsulfuron	Surface Pre	G	P-F	G	G	G	F	F	P-F	N	P	G	F	F	F	P	P
rimsulfuron	Weeds <3”	G	P-F	G	G	G	F	F	P-F	N	P	G	F	F	N	F	F
saflufenacil	Surface Pre	N	N	N	N	N	G	F-G	G	G	G	G	G	G	F-G	P-F	N
sethoxydim	Weeds <3”	G	F-G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
s-metolachlor	Surface Pre	G	G	G	G	G	F	G	P	G	G	G	P	N	P	N	F-G
sulfentrazone	Surface Pre	F	F	F	F	F	G	G	N	G	F	G	G	F	G	G	G
sulfentrazone	Weeds <3”	*P*	*P*	*F*	*F*	-	*G*	*F*	*F*	*F*	*G*	*E*	*G*	*G*	-	-	*F*
tembotrione	Weeds <3”	G	G-F	F	F-G	G	G	N	G	G	G	G	G	G	P	F	N
terbacil	Surface Pre	G	G	G	F-G	G	G	G	G	G	G	F-G	G	G	G	F-G	P
terbacil	Weeds <3”	*F*	*P*	*F*	*P*	-	*E*	*E*	*G*	*G*	*G*	*F*	*G*	*F*	-	-	*P*
tolpyralate	Weeds <3”	F	G	N	G	F	G	N	G	N	F	G	F	G	N	F	N
topramezone	Weeds <3”	F	F	P	P-F	F	G	N	G	G	G	G	G	G	G	P	N
trifluralin	Incorp Pre	G	G	G	G	G	G	G	P	N	P	G	P	P	N	F	N
triflusulfuron	Weeds <3”	*P*	*P*	*P*	*N*	-	*P*	*P*	*F*	*F*	*F*	*F*	*F*	*G*	-	-	*P*

Corn Herbicide Rotation Restrictions

This is rotational restriction information for corn herbicides. The products are listed alphabetically by **Trade Names**, and the body of the table shows the **Number of Months** you must wait to plant different vegetables after applying that herbicide.

AT=anytime herbicide labeled for the crop or no rotation restriction exists
FB= field bioassay required before planting the crop
NNY= not next year, the crop cannot be planted the following year
NY=the crop can be planted the year after application
V=variable, intervals vary by crop variety or other conditions specified on label
*Transplanted tomatoes only

Trade Names	Tomato	Pea	Snap Bean	Sweet Corn	Cucurbits	Potato	Cole Crops
Aatrex and others	NNY	NNY	NNY	AT	NNY	NNY	NNY
Accent, soil pH < 6.5	10	10	10	10	10	10	10
Accent, soil pH > 6.5	18	18	18	18	18	18	18
Acuron	18	18	18	AT	18	18	18
Aim	AT	AT	AT	AT	V	V	12
Anthem, Anthem ATZ	18	11	11	AT	18	4	18
Balance Pro	18V	18V	18V	6	18V	6	18V
Basis	1	10	10	10	18	AT	18
Beacon	18	8	8-18	8	18	8-18	18
Bicep II Magnum	NNY	NNY	NNY	AT	NNY	NNY	NNY
Callisto	18	18	18	AT	18	18	18
Camix	18	18	18	AT	18	18	18
Celebrity Plus	10-18V	10	10	10-15V	10-18V	10-18V	10-18V
Corvus	17-24V	17-24V	17-24V	9-17V	17-24V	17-24V	17-24V
Define	12	12	12	AT	12	1	4-12V
Harness Xtra	NNY	NNY	NNY	AT	NNY	NNY	NNY
Hornet	26	10.5-18V	10.5-18V	10.5-18V	26	18	26
Impact	18	9-18V	9-18V	AT	18	9	18
Lariat, Bullet	NNY	NNY	NNY	AT	NNY	NNY	NNY
Laudis	10	10	10	AT	18	10	18
Leadoff	1	10	10	10	10-18	1	18
Lightning	40	9.5	9.5	18	40	26	40
Lumax, Lexar	18	18	18	AT	18	18	18
Marksman	NNY	NNY	NNY	NY	NNY	NNY	NNY
Northstar	18	8	8	8	18	8	18
Permit	2-8*	9	2-9	3	2-9	9	15-18
Prequel	18	18	10-18V	10	18	6	18
Princep	NNY	NNY	NNY	AT	NNY	NNY	NNY
Resolve DF, Resolve Q	1-1.5	10	10	10	18	18	18
Revulin Q	18	18	18	10-15V	18	18	18
Spirit	10-18V	10V	10V	8V	18	18	18
Steadfast	10-18V	10	10	10-15V	10-18V	10-18V	10-18V
Stinger	18	18	18	AT	18	18	AT
Surestart	26+FB	NY	26+FB	10.5-18V	26+FB	40+FB	26+FB
Surpass, TopNotch, FulTime	NNY	NNY	NNY	NY	NNY	NNY	NNY
Zidua	18	4-11	11	0	18	4	18

Soybean Herbicide Rotation Restrictions

This is rotational restriction information for soybean herbicides. The products are listed alphabetically by **Trade Name**, and the body of the table shows the **Number of Months** you must wait to plant different vegetables after applying that herbicide.

AT=anytime herbicide labeled for the crop or no rotation restriction exists
FB= field bioassay required before planting the crop
NNY= not next year, the crop cannot be planted the following year
NY=the crop can be planted the year after application
V=variable, intervals vary by crop variety or other conditions specified on label
*Transplanted tomatoes only
**In Indiana only, 18m for transplanted tomatoes and peppers, cabbage, melons, and cucumbers

Trade Names	Tomato	Pea	Snap Bean	Sweet Corn	Cucurbits	Potato	Cole Crops
Authority Assist	30+FB	10	10	18	30+FB	26	18-40V
Authority First, Sonic	30+FB	9-12-30+FB,V	30+FB	18	30+FB	18	30+FB
Boundary	12	8	12	4	12	0	12
Canopy, Canopy EX	9-10*	9-12	9-12	18	18-30V	18-30	18-30V
Classic	10*	12	12	18	18-30	30	30
Command	9	AT	9	9	AT	9	V
Envive	12*	12	12	18	18-30V	18-30V	18-30V
Extreme	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	26	18-40+FB,V
FirstRate	18	9	9	18	18	18	18
Flexstar	10*	4	0	10	10-12	0	18
Optill	40+FB	4	4	18	40+FB	26	40+FB
Prefix	10	10	0	10	18	1	18
Pursuit**	40+FB	AT	2	18	40+FB	26	40+FB
Python	26	4	4	10.5-18V	26	12	26
Raptor	9	AT	AT	9	9	9	V
Reflex	10*	4	0	10	10-12	0	18
Scepter	18	18	11	18	18	18	18
Sencor	4	8	18	4	18	12	18
Spartan	AT*	12	12	18	12	12	12V
Synchrony XP	9*	9-12	9-12	18	18-30	18	18-30
Valor SX or EZ	4-12	3-4	3-4	3-4	4-12	4-10	4-12
Valor XLT	12	12	12	18	18	18	18
Xtendimax	1-6V	1-6V	1-6V	1-6V	1-6V	1-6V	1-6V

Special Labels by State

State	Product	Crop	Expiration	Type
IL	Aim	Basil	Dec 31, 2028	24c
IL	Reflex	Pumpkins and squash	Apr 28, 2026	Indemnified 24c
IN	Chateau	Melon row middles	NA	Indemnified 24c
IN	Command 3ME	Banana peppers	Dec 31, 2028	24c
IN	Dual Magnum	Many crops	Dec 31, 9999	Indemnified 24c
IN	Reflex	Peas, peppers, pumpkins, squash, tomatoes, watermelon	Dec 31, 2027	Indemnified 24c
IN	Spartan 4F	Mint	Dec 31, 2025	24c
KS	Dual Magnum	Vine crops	Dec 31, 2026	Indemnified 24c
KS	Dual Magnum	Dry bulb onions	Dec 31, 2026	Indemnified 24c
KS	Reflex	Pumpkins, squash, watermelons	Dec 31, 2026	Indemnified 24c
MI	Actigard	Bell peppers	Dec 31, 2027	24c
MI	Cannonball	Asparagus crowns	Dec 31, 2027	24c
MI	Caparol 4L	Dill	Renewal in process	24c
MI	Command 3ME	Banana peppers	Dec 31, 2029	24c
MI	Dual Magnum	Many crops	Dec 31, 2026	Indemnified 24c
MI	GoalTender	Cabbage, broccoli, cauliflower	Dec 31, 2025	24c
MI	GoalTender	Dry bulb onions	Dec 31, 2025	24c
MI	Gramoxone	Lettuce	Jun 8, 2026	24c
MI	Kerb 50-W	Rhubarb, lettuce	Dec 31, 2026	24c
MI	Prowl H20	Green onions	Apr 16, 2029	24c
MI	Reflex	Peas, peppers, pumpkins, squash, tomatoes	Dec 31, 2028	Indemnified 24c
MN	Dual Magnum	Many crops	Dec 31, 2025	Indemnified 24c
MN	Dual Magnum	Carrots	Dec 31, 2027	Indemnified 24c
MN	Reflex	Peas, peppers, pumpkins, squash, tomatoes	Dec 31, 2025	Indemnified 24c
MN	Reflex	Lima beans	Dec 31, 2028	Indemnified 24c
MO	Dual Magnum	Sweet potatoes	Jul 22, 2026	Indemnified 24c
MO	Reflex	Watermelon	Dec 31, 2026	Indemnified 24c
OH	Command 3ME	Banana peppers	Dec 31, 2030	24c
OH	Diazinon	Potatoes	Dec 31, 2025	24c
OH	Dual Magnum	Many crops	Dec 31, 2026	Indemnified 24c
OH	Tripzin ZC	Tomatoes	Dec 31, 2026	24c

Asian Vegetables - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Brad Bergefurd – Apr 2022

Crop Description

U.S. demand for ethnic vegetables is increasing rapidly—from a growing ethnic Asian population and from other consumers seeking variety.

Asian vegetables are those that have originated from East Asia (China, Japan, and Korea) and Southeast Asia (Indonesia, Laos, the Philippines, Singapore, Thailand, Vietnam, etc.), as well as South Asia (India and Pakistan). The crops listed here are adapted to production in the Midwest. The short-season crops might be suitable in double crop situations, such as following wheat or an early cabbage or sweet corn crop.

The information below should be considered an introduction to Asian vegetables. More detailed information can be found in the resources section. General pest management recommendations for the crop families described below can be found in the corresponding crop chapters in this Guide. Although not all of the specific crops mentioned in this chapter will be associated with pesticides in the crop chapters of this guide, pesticide labels will list crops on which specific products may be used.

Asian vegetables have different names in different languages. You must properly identify the crop to market it properly and to select the appropriate pest control measures. Below are descriptions and horticultural information for some of these crops that are not otherwise discussed in other chapters.

Brassica Leafy Greens

Chinese cabbage (*Brassica rapa*), and Mustard greens (*Brassica juncea*) are grown as salad or braising greens or as heading crops. Their leaves are not waxy, and most of them are Asian in origin. They can be grown as components of a salad mix. Crops in this group are more susceptible to damage from flea beetles but tend to be less attractive to caterpillars than cole crops such as broccoli. Chinese cabbage is especially sensitive to bolting in response to cold temperatures and other stressful conditions.

Chinese cabbage: Chinese cabbage has been grown in Asia since the fifth century. It is a cool-season annual vegetable. It grows best with short days and moderate to cool temperatures (60 F to 70 F). Its cultural requirements are similar to those of cabbage and lettuce. Chinese cabbage is fairly quick to mature. It varies from 40 days from sowing to harvest for some cultivars to 75 days for the longer-maturing ones. Chinese cabbage is a term applied to a wide range of types and varieties. The main types and varieties of Chinese cabbage are:

Group I: Napa cabbage
Napa cabbages form broad-leafed, compact heads of layered leaves and are also known as pe-tsai, perstai, hsin pei tsai, celery cabbage, Chinese white cabbage, Peking cabbage, won bok, nappa (Japanese), hakusai (Japanese), and pao. There are two types, Che-foo and Chihili.

Che-foo types form a compact, round head of green-bladed, white-petioled leaves. Chihili types of Napa cabbage form a cylindrical head 18 inches long and 6 inches in diameter, with an erect, upright growing habit.

Recommended spacing for Napa cabbage is 18 inches within the rows and 24 inches between rows.

Group II: Bok choy
Bok choy is a non-heading form of Chinese cabbage, with several thick white leafstalks. The smooth, glossy, dark green leaf blades form a celery-like cluster. The most commonly accepted designations are bok choy or pak choy. Many refer to it as Chinese mustard.

Recommended spacing for Bok choy is 8 to 12 inches within the row and 24 inches between rows.

Mustard and other greens: Other brassica greens, such as mizuna, mibuna, tatsoi, komatsuna, and mustard are usually direct seeded. Some varieties are prone to premature flowering, which is enhanced by cold temperatures in the spring. Transplanting, which is less common than direct seeding, can also increase premature flowering in the spring due to increased plant stress. Plant populations vary tremendously and should be geared toward the intended harvest age and size. See Leafy Greens and Herbs chapter for more information.

Stem and Leafy Vegetables (Non-Brassica)

Celtuce (*Lactuca sativa* var. *augustana*): This vegetable is closely related to standard head lettuces, with similar cultivation practices. But, celtuce is grown for its thick stem. Plants are cut at the base when the stem is 8 to 10 inches long, and all the leaves are removed except at the tip.

Garlic scapes (*Allium sativum*): In the production of hard neck garlic, a flower shoot, called a “scape”, is produced. The

scapes must be clipped off to maximize bulb size, and can be bunched or bagged for sale.

Malabar spinach (*Basella alba*): This vegetable is not related to spinach, but has a similar flavor, and can be grown in the hot summer months. In its native range of Southeast Asia it grows as a perennial. But it can be seeded as a frost-killed annual in the midwestern United States. It grows as a vine, and should be trellised like peas or runner beans.

Pea shoots and leaves (*Pisum sativum*): Before, during, and after pod formation on pea plants, young shoots from the middle and top sections of the plant can be clipped 3 to 4 inches from the growing tip for bunching or bagging.

Sweet potato vines and leaves (*Ipomoea batatas*): This vegetable is grown all over the world for its sweet storage roots. But the leaves are commonly consumed in Asia too. Harvest the top 10 inches of vines for bunching or bagged loose leaf.

Cucurbit Vegetables

Bittermelon *(Mormodica charantia)*: This vegetable is native to India. Like cucumbers and squashes, bittermelon is a member of the Cucurbit family. It is a warm-season vegetable. It is usually grown on a trellis system and its fruit is about the size of a summer squash. The trellis should be 6-feet high and 4 to 6 feet apart. The seeds can be planted directly in the field or grown as seedlings and then transplanted to a field spacing of 1-1/2 to 2 feet between plants and 3 to 5 feet between rows. Bittermelon is harvested green before there is any color change. Bright orange fruits are saved for seed collection.

Calabash (*Lagenaria siceraria*): Also known as snake gourd, bottle gourd, or opo. This vegetable is grown like winter squash for the ornamental hard-shelled mature fruit and used for making food and drink utensils and vessels, and instruments. In Asia, fruits are also harvested young and tender for eating, like a summer squash.

Smooth luffa (*Luffa cylindrica*) and **angled luffa (***Luffa acutangula*): These vegetables originated in India and were later taken to China. It is mainly grown for the young squash-like edible fruits. If left to mature on the plant, both smooth and angled luffa gourds produce the familiar “luffa sponge” found in stores, but smooth luffas make a better-quality sponge. Some of the smooth luffa cultivars are Smooth Boy, Smooth Beauty, and Southern Winner. Some angled luffa cultivars are Hybrid Green Glory, Hybrid Asian Pride, Lucky Boy, and Summer Long. Luffa plants are warm-season vegetables and need to be trellised.

Winter melon (*Benincasa hispida*): This vegetable is also known as ash gourd or wax gourd and is a vegetable native to Southeast Asia. It is grown like a watermelon and matures into a large green fruit with a waxy bloom and white flesh. When mature, it keeps for several months like a hard squash. The flavor is bland and it is used in soups and other dishes to absorb flavor of other ingredients, and candied for sweet chewy dried treats.

Fruiting Vegetables

Asian Eggplants (*Solanum melongena*): This crop is native to tropical Asia and very popular in Japan, China, India, Thailand, and the Philippines. Many varieties are available. They can be light or dark purple, brown, or green in skin color; and round and slender in shape. Culture is similar to standard eggplant.

Legumes

Asparagus (Yardlong) Bean (Chinese Long Bean, *Vigna sesquipedalis*): This long, trailing vine should be grown on trellises. This plant is more closely related to Southern peas (cowpeas, black-eyed peas) than to the common green snap bean, but it vines like a pole bean, and needs support to make long straight bean pods. Dark and light green varieties are available as well as a red type. The darker varieties are generally preferred. It is a warm-season vegetable. Yardlong beans are cut into 2-inch pieces and added to various stir fries. The paler green is sweeter and more tender than the dark green.

Edamame (*Glycine max*): This vegetable is the immature pod of a soybean plant. These can be grown like soybeans, but with a larger between-row spacing like a bush bean, for easier hand-harvesting. They are harvested 35 to 40 days after flowering when pods are plump, bright green, and succulent. Popular varieties include Envy, Butterbeans, Sayamusume, Shiromufi, Tohya, Midori Giant, and Chiba Green.

Sugar Snap Pea and Snow Pea (*Pisum sativum*): These cool-season vegetables should be sowed in April for a spring crop or sowed in July for a fall crop. Plants deteriorate quickly in the heat of summer. The plants of sugar snap pea and snow pea grow similarly to bush beans. It is often helpful to grow them on trellises to facilitate picking; however, if grown for the tender shoot tips, they are usually left untrellised.

Root and Rhizome Vegetables

Many root vegetables popular in Asia are long-lived perennial plants that are not suitable for our climate in the midwestern United States. However, a few can be grown in the field (sweet potato and daikon radish) and others can be grown in protected culture (ginger and turmeric).

Daikon Radish (*Raphanus sativus*, var. *longipinnatus*) is also called Chinese radish and is closely related to the common

radish crop. The main planting time for daikon is spring and fall, but some varieties can be planted almost year-round. April planting generates spring harvest, and July planting generates fall harvest. Spacing should be 4 to 6 inches within the rows and 3 feet between rows. To accommodate the large roots, it is recommended to plant in high raised beds that are amended with organic matter, such as compost. At each cultivation, move soil higher and higher around the roots, as they grow, to prevent greening of the root. Most daikon radishes reach their useable size in 60 to 70 days.

Ginger (*Zingiber officinale*) and **Turmeric** (*Curcuma longa*): These perennial crops are grown in tropical environments for their rhizomes, which creep laterally under the soil surface like irises. In the Midwest, they can be grown from 1-inch rhizome cuttings as a long-season annual planted in hoophouses that maintain minimum 50 F soil temps and 70 F air temps. Trench, hill, and irrigate like potatoes. Harvest and sell as "new" or "baby" ginger in mid-late fall. Our season is not long enough (5 to 7 months) to produce large mature and cured rhizomes, which require 8 to 10 months.

Sweet potato (*Ipomoea batatas*): Sweet potato varieties of Asian origin are starchier than more commonly grown varieties, and often are white or purple fleshed, instead of orange. Varieties include Murasaki, Okinawa Purple, Molokai Purple, Red Japanese, and Stokes Purple. Murasaki has been adopted in the Mid-Atlantic region of the United States and is easier to get than the others. However, most of these varieties take 120 to140 days to mature, unlike orange-fleshed varieties which take 90 to 110 days; Red Japanese is an exception at 110 days. The longer-maturing varieties can be grown in a hoophouse.

Marketing

Growers who want to diversify their farming operations by including Asian vegetables need to be very cautious before beginning production. Marketing information for Asian crops is not widely published. Since many Asian crops are niche items, only specialized produce companies deal in them. Most of these buyers deal with restaurants, some chain stores, and specialty food stores. Growers who market directly to consumers or restaurants often have more opportunity to educate customers about how to use the crops. It is more and more common to see Asian crops included in salad mixes at farmers markets.

Do your homework. Establish markets and buyers before buying any seed. Calculate budgets and collect economic data on any crop to determine its profit potential. And remember that all of these crops are very labor intensive, so you will need a strong and dependable labor force for timely harvest and proper cultural management.

Resources

"Ethnic Vegetables: Asian," University of Kentucky Extension, uky.edu/ccd/content/ethnic-vegetables-asian

"Asian Vegetables: Selected Fruit and Leafy Types," Purdue University Center for New Crops and Plants Products, hort.purdue.edu/newcrop/proceedings1996/v3-488.html

"Asian Vegetables," Purdue University Center for New Crops and Plants Products, hort.purdue.edu/newcrop/proceedings1990/V1-387.html

Specialty and Minor Crops Handbook, second edition, University of California Agriculture and Natural Resources publication 3346, available from ANRCatalog, anrcatalog.ucanr.edu/

Minor Vegetables Fact Sheets, University of Florida IFAS, available from AskIFAS edis.ifas.ufl.edu/entity/topic/minor_vegetables

Asparagus - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Ben Werling – Oct 2022

Crop Description

Hybrid varieties of asparagus (*Asparagus officinalis*) have improved vigor, disease tolerance, and higher yields, and are grown from seeds or crowns. All-male hybrids have higher yields and do not produce seed. Absence of seed production is desirable because seeds develop into volunteer asparagus seedlings that are a weed problem. Order hybrids well in advance.

Some varieties are available for purchase as one-year old crowns. Others are only available as seed. Crown growers turn the seed into crowns as custom work for retailers and wholesalers who store and sell crowns to gardeners and small-scale growers, and others grow crowns for direct sale to growers involved in large-scale commercial spear production.

All-male hybrids: Jersey Knight (crowns available), Guelph Millennium (crowns available, industry standard), Guelph Eclipse, Guelph Equinox, Sequoia, Spartacus, Walker Deluxe (crowns available),

Hybrids (not all-male): Pacific Challenger 2

Non-hybrids: Mary Washington (crowns available).

Specialty: Purple Passion (crowns available).

Planting and Spacing

Crowns: Use only 1-year old crowns. Transplant April 15 to May 15. Use 4- to 5-foot rows and an in-row spacing that achieves 14,000-15,000 crowns per acre. Set the crowns in 8-inch furrows in light soils and 5- to 6-inch furrows in heavy soils. Cover with 2 to 3 inches of soil. Select deep, well-drained sandy loam soils. Start cultivating when spears begin to emerge and continue periodically until furrows are level at end of first season. Fields can be leveled with a disk the year after planting.

Seedling transplant: 10- to 14-week old seedling transplants can be mechanically transplanted. Transplant in either the spring or fall.

Fertilizing

pH: Maintain a soil pH of 6.7 to 7.0. If possible, apply lime the year before planting.

New plantings: Before planting new crowns, apply 50 pounds N per acre, 0 to 160 pounds P_2O_5 per acre, and 0 to 150 pounds K_2O per acre based on soil test results and recommendations from your state. Broadcast the fertilizer and plow it under when preparing the land for the planting furrows. In addition, apply 30 pounds P_2O_5 per acre in the bottom of the trench and cover with 1 inch of soil before setting crowns. For transplanted seedlings, apply 4 ounces of transplant solution (e.g. 2-3 lbs. of 10-52-17 or 9-45-15 in 50 gallons of water) to each transplant.

Established plantings: Each year before emergence, apply 20 to 40 pounds N per acre by broadcasting and incorporate by lightly tilling. After harvests conclude, apply 40 to 60 pounds N per acre. The total amount of N from fertilizer should be 80 pounds N per acre. No P_2O_5 is necessary if adequate fertilization was achieved prior to planting. Apply K_2O based on a soil test.

Harvesting

Roots are the “gas tank” of asparagus, storing photosynthates to power coming years’ harvests. Shoots that are picked during harvest represent a withdrawal of carbohydrates, that does not pay back via photosynthesis. Harvest ends to allow the crowns to grow fern, produce sugar via photosynthesis, and move it to the crowns in fall. As you establish a new planting, gradually increase harvest intensity to help plants invest photosynthates in building their root system early in a stand’s life. One example could be:

- Planting year (yr 1): No harvest
- Year after planting (yr 2): Harvest 2-3 times to avoid freeze injury to emerging shoots, or not at all
- Year 3: Harvest two weeks
- Year 4: Harvest four weeks
- Year 5 and beyond: Harvest full season, about 6 weeks

Harvest asparagus early in the morning for best quality. Allow the ferns to grow vigorously after this period to accumulate food reserves for the next season. As much care should be put into maintaining a healthy fern as into harvest.

Asparagus - Diseases

Reviewed by Dan Egel, Mary Hausbeck – Aug 2023

Crown and Root Rot of Asparagus - Fusarium Fungus

The Fusarium pathogen can be seed borne. Try to source material for new plantings from fields fumigated with chloropicrin.

Non-Pesticide

The disease is promoted by acidic (low pH) and poorly drained soil. Prepare soil to support good stand establishment for the long term. Establish production fields with blemish-free crowns produced in virgin soil. Avoid fields with a history of crown and root rot. Use tolerant, vigorous varieties if available, and avoid long harvest periods to maintain vigor in the plant over years.

Pesticide

Cannonball (fludioxonil) | 0.5 oz. per 100 gals. of water. *Michigan 24c label only.* Submerge and soak crowns for 10 minutes and allow to drain before planting. REI: 12-hour. PHI: 365-day. FRAC 12.

Crown and Spear Rot of Asparagus - Phytophthora Oomycete

Non-Pesticide

Avoid excessive irrigation. Provide good spacing between rows to promote good air circulation. Choose well-drained planting sites. Establish production fields from blemish-free crowns obtained from virgin soil. Avoid long harvest periods to maintain vigor in the plant over years.

Pesticide

mefenoxam/metalaxyl products (mefenoxam) | Several formulations (MetaStar, Ridomil Gold, Ultra Flourish, and Xyler) are labeled. Several formulations are labeled as soil-surface sprays at various rates between 1 pt. and 4 pt. per acre. Apply 30 to 60 days before the first cutting. Apply again just before the beginning of harvest. REI: 48-hour. PHI: 1-day. FRAC 04.

Orondis Gold (oxathiapiprolin, mefenoxam) | 28-55 fl. oz. per acre. REI: 4-hour. PHI: 1-day. FRAC 49, FRAC 04.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) | Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. Apply the product to fully expanded ferns. Do not apply to ferns that are beginning to senesce. Thorough coverage is required. REI: 4 to 12-hour. PHI: see label. FRAC P07.

Leaf Spot of Asparagus - Cercospora Fungus

Cercospora leaf spot is favored by warm, humid conditions. The disease may be spread by splashing rain or irrigation water. Crop residue may harbor the fungal pathogen.

Non-Pesticide

Reduce crop residues that may harbor the pathogen by removing or mowing senescent and dried ferns in the fall/winter.

Pesticide

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.75-5.75 pt. per acre. Use 54% (720) formulations at 2-4 pt. per acre. Use 82.5% (WDG) formulations at 1.8-3.6 lb. per acre. REI: 12-hour. PHI: 190-day. FRAC M05.

Dexter Max (mancozeb, azoxystrobin) | 2-2.2 lbs. per acre. REI: 24-hour. PHI: 180-day. FRAC M03, FRAC 11.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb, Roper DF). Use 37% formulations at 1.6 qt. per acre. Use 75% and 80% formulations at 2 lb. per acre. REI: 24-hour. PHI: 180-day. FRAC M03.

Phytophthora Blight of Multiple Crops - Phytophthora Oomycete

Pesticide

Orondis Gold 200 SC (oxathiapiprolin) | 4.8-9.6 fl oz per acre. For new planting: Used as plant soak prior to planting. Established plants: Make the first application to established

asparagus beds at least 14 days prior to harvest (first cutting). Make a second application on the first cutting. Make no more than 2 sequential applications of Orondis Gold 200 before rotating to a fungicide with a different mode of action. REI: 4-hour. PHI: 1-day. FRAC 49.

Purple Spot of Asparagus - Stemphylium Fungus

Weather forecasting tools, such as TOM-CAST, can help asparagus farmers schedule their fungicide applications for control of purple spot. NOTE: Products labeled for rust may be helpful for purple spot control.

Non-Pesticide

Reduce crop residues by removing or mowing senescent and dried fern in the fall/winter.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 100-day. FRAC 11.

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.75-5.75 pt. per acre. Use 54% (720) formulations at 2-4 pt. per acre. Use 82.5% (WDG) formulations at 1.8-3.6 lb. per acre. REI: 12-hour. PHI: 190-day. FRAC M05.

Dexter Max (mancozeb, azoxystrobin) | 2-2.2 lbs. per acre. REI: 24-hour. PHI: 180-day. FRAC M03, FRAC 11.

Flint Extra (trifloxystrobin) | 3-3.8 fl. oz. per acre. Apply on a 14-day interval as needed. Make uniform applications to the fern stage only using a minimum of 30 gal. per acre of water. Mow down the asparagus ferns (or allow the ferns to senesce) between the last fungicide application and harvest. REI: 12-hour. PHI: 180-day. FRAC 11.

Rust of Multiple Crops - Puccinia Fungus

Non-Pesticide

Reduce crop residues that may harbor the pathogen by removing or mowing senescent and dried ferns in the fall/winter. Scout for the early appearing bright orange aecial pustules in the spring, especially on new or young plantings that are not harvested the full season. Remove volunteer plants on field edges and ditchbanks. Plant crop rows with ample spacing and in the direction of the prevailing winds to increase air movement and minimize periods of prolonged leaf wetness. Reduce crop residues by removing or mowing senescent and dried fern in the fall/winter.

Pesticide

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.75-5.75 pt. per acre. Use 54% (720) formulations at 2-4 pt. per acre. Use 82.5% (WDG) formulations at 1.8-3.6 lb. per acre. REI: 12-hour. PHI: 190-day. FRAC M05.

Dexter Max (mancozeb, azoxystrobin) | 2-2.2 lbs. per acre. REI: 24-hour. PHI: 180-day. FRAC M03, FRAC 11.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb, Roper DF). Use 37% formulations at 1.6 qt. per acre. Use 75% and 80% formulations at 2 lb. per acre. REI: 24-hour. PHI: 180-day. FRAC M03.

Rally 40WSP (myclobutanil) | 5 oz. per acre. REI: 24-hour. PHI: 180-day. FRAC 03.

Sonoma 40WSP (myclobutanil) | 5 oz. per acre. REI: 24-hour. PHI: 180-day. FRAC 03.

tebuconazole products (tebuconazole) | 4-6 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI: 12-hour to 18-day. PHI: 180-day. FRAC 03.

Unicorn DF (tebuconazole, sulfur) | 2-3.75 lbs. per acre. REI: 12 to 24-hour. PHI: 180-day. FRAC 03, FRAC M02, IRAC UN.

Asparagus - Insects

Major update by Laura Ingwell, Zsofia Szendrei, Marissa Schuh, Ashley Leach, Dan Fillius, Vicki Morrone – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Treat when less than 5% of ferns have aphids present.

Non-Pesticide

Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Assail 30SG (acetamiprid) | Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.1-2.3 oz. per acre. For control on spears during harvest, to prevent egg laying and feeding injury. REI: 12-hour. PHI: 1-day. IRAC 04A.

Fulfill (pymetrozine) | 2.75 oz. per acre. Apply to fern only after harvest has been completed. REI: 12-hour. PHI: 170-day. IRAC 09B.

Asparagus Beetles

Asparagus beetles overwinter as adults in field debris, emerging in the spring as asparagus develops. Adults mate and feed on spears, with females laying clusters of 3-10 eggs near the spear tips. Adults continue feeding and laying eggs during the harvest season (May-June), but since spears are regularly harvested, the eggs don't develop into larvae until after harvest. Post-harvest, all beetle life stages are present, with larvae and adults feeding on the ferns, which reduces the plant's photosynthetic capacity. Larvae eventually pupate in the soil, there are 2-3 generations until adults overwinter starting in September. Beetles can be found by visually surveying plants.

At Harvest: Treat when 5-10% of plants are infested, or 2% of spears have eggs.

At Fern: Treat when 10% of plants are defoliated, or 50% of plants have larvae.

Non-Pesticide

Regular harvest limits the number of eggs that survive to become a summer generation. Removing ferns in the fall reduces overwintering habitat in the field, forcing adults to overwinter in field edges, where more predation may occur. *Tetrastichus asparagi* is a tiny metallic green parasitoid wasp that preys on asparagus beetle eggs. Umbelliferous flowers blooming at time of oviposition may enhance parasitoid populations.

Pesticide

Assail 30SG (acetamiprid) | Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.1-2.3 oz. per acre. For control on spears during harvest, to prevent egg laying and feeding injury. REI: 12-hour. PHI: 1-day. IRAC 04A.

Dimethoate 4EC (dimethoate) | 1 pt. per acre. Use 4EC, LV-4 and 400 EC formulations at 1 pt. per acre. REI: 48-hour. PHI: 180-day. IRAC 01B.

Entrust SC (spinosad) | Use 2SC formulations at 4-6 fl. oz. per acre. Use 80WP formulations at 1.25-2.0 oz. per acre. REI: 4-hour. PHI: 60-day. IRAC 05. *OMRI-listed.*

Lannate LV (methomyl) | 1.5 - 3.0 pts. per acre. REI: 48-hour. PHI: 1-day. IRAC 01A. *RUP.*

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 3.2-6.4 oz. per acre. Use 3.2EC formulations at 2-4 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) | 4-8 fl. oz. per acre. Postharvest protection of ferns only. REI: 4-hour. PHI: 60-day. IRAC 05.

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. Use low rate for control on seedlings and or spears during harvest, to prevent egg laying and feeding injury. Use high rate for control on fern growth after harvest is over. REI: 12-hour. PHI: 1-day. IRAC 01A.

Caterpillars

For cutworm caterpillars: Treat when 5% of crowns are infested at harvest. Treat in the fall when there is 1 larvae per 20 plants.

Pesticide

Coragen (chlorantraniliprole) | 3.5-5.5 fl. oz. per acre. For armyworms. REI: 4-hour. PHI: 1-day. IRAC 28.

Lannate LV (methomyl) | 1.5 - 3.0 pts. per acre. For armyworms, and cutworms. REI: 48-hour. PHI: 1-day. IRAC 01A. *RUP.*

Perm-Up 25DF (permethrin) | For cutworms. Use 25W, 25WP or 25DF formulations at 3.2-6.4 oz. per acre. Use 3.2EC formulations at 2-4 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Sevin 5B (carbaryl) | 20 lbs. per acre. For cutworm control on spears during harvest, to prevent egg laying and feeding injury. Do not exceed more than 3 applications to spears. REI: 12-hour. PHI: 1-day. IRAC 01A.

Sevin XLR Plus (carbaryl) | For cutworms. Use low rate for control on seedlings and or spears during harvest, to prevent egg laying and feeding injury. Use high rate for control on fern growth after harvest is over. REI: 12-hour. PHI: 1-day. IRAC 01A.

Japanese Beetle

Japanese beetles have one generation per year, overwintering as grubs in the soil. In late June to August, adults emerge to feed, mate, and lay eggs, living for one to two months. Adults feed on many plants, including asparagus, and are active throughout the fern season. Japanese beetle feeding can reduce the amount reduce amount of energy produced by ferns. Control focuses on the adult stage. Scout for beetles by checking asparagus ferns. Note that beetles are often feeding when asparagus is flowering and attractive to bees.

Pesticide

Assail 30SG (acetamiprid) | Use 30SG formulations at 5.3 oz. per acre. Use 70WP formulations at 2.3 oz. per acre. Apply to fern only after harvest has been completed. REI: 12-hour. PHI: 1-day. IRAC 04A.

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 3.2-6.4 oz. per acre. Use 3.2EC formulations at 2-4 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Tarnished Plant Bug

Pesticide

Assail 30SG (acetamiprid) | Use 30SG formulations at 5.3 oz. per acre. Use 70WP formulations at 2.3 oz. per acre. Apply to fern only after harvest has been completed. REI: 12-hour. PHI: 1-day. IRAC 04A.

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 3.2-6.4 oz. per acre. Use 3.2EC formulations at 2-4 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Asparagus - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Apr 2025

All Weeds

Before establishing an asparagus planting, reduce perennial weeds in the area to be planted with systemic broad-spectrum herbicides. Herbicide options are limited in the planting year.

After the first year of establishment, a typical weed control program in asparagus includes a preemergence herbicide with a long residual applied before asparagus emerges. If needed, a preemergence herbicide may be applied again after harvest is finished and a clean mowing.

Postemergence herbicides may be applied before asparagus emergence or during or after the harvest season. Some require directed or shielded spray applications to avoid spraying asparagus.

It is important to use herbicides with different modes of action from year to year with this perennial crop to avoid buildup of weed species not controlled by a particular mode of action.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Good weed control in the planting year is especially important. Multivators, tines, rolling cultivators, and flame weeders work well before emergence of asparagus, but it is important to avoid damaging crowns when cultivating. Cultivate row-middles and hand-hoe after plant emergence. Flame weeders can also be used after clean harvest or mowing. Once established, straw mulch can be applied any time, but is easier for picking when mulch is applied after final harvest.

Pesticide

2,4-D (2,4-D) POST | Available as both amine and choline formulations. Use 3-4 pts. per acre of liquid formulations with 3.8 lbs. per gal. acid equivalent. Apply before, during, or after the harvest season. During harvest season apply immediately after cutting. Discard deformed spears. Use drop nozzles for treatments after harvest to avoid spraying fern. Wait at least 30 days between applications. REI: 48-hour. PHI: 3-day. HRAC 04.

Aim EC (carfentrazone) POST | 0.5-1.92 fl. oz. per acre. Include COC (1% v/v) or NIS (0.25% v/v). Broadcast after spear harvest. Emerged asparagus will be injured. Do not exceed 3.8 fl. oz. per acre per season. Wait at least 20 days between applications. REI: 12-hour. PHI: 5-day. HRAC 14.

Callisto (mesotrione) POST PRE | 3-7.7 fl. oz. per acre. Apply in spring before spears emerge after mowing, disking, or tilling; after final harvest; or both. For postharvest applications use drop nozzles or other equipment that will minimize contact with crop. Adding COC (1% v/v) or NIS (0.25% v/v) alone or with UAN or AMS will improve emerged weed control and increase crop injury risk in postharvest applications. Do not exceed 2 applications per year, or 7.7 fl. oz. per acre per year. REI: 12-hour. HRAC 27.

Chateau SW (flumioxazin) PRE | 6 oz. per acre of Chateau SW or 6 fl. oz. per acre of Chateau EZ. *Established plantings only.* Apply to dormant asparagus at least 2 weeks before spears emerge. Crop injury may result if asparagus is not dormant. May be tank-mixed with paraquat to control emerged weeds. Or, apply after final harvest for the season before fern emerges. Do not exceed 6 oz. per acre per growing season. REI: 12-hour. HRAC 14.

Clarity (dicamba) POST | 0.5-1.0 pt. per acre. Apply in 40-60 gals. of water per acre immediately after cutting. Discard crooked spears at harvest. Clarity can injure nearby broadleaf crops and garden plants. Maximum 1 pt. per acre per year. REI: 24-hour. PHI: 1-day. HRAC 04.

clethodim products (clethodim) POST | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). Use Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max per acre per season. REI: 24-hour. PHI: 1-day. HRAC 01.

clopyralid products (clopyralid) POST | 8-10.7 fl. oz. per acre. Apply Spur before or during harvest. May cause

some crooking of spears. Controls Canada thistle, marestail, mayweed, nightshade, plantain, smartweeds. Do not exceed 10.7 fl. oz. per acre per year. Avoid application 2 years in succession. REI: 12-hour. PHI: 2-day. HRAC 04.

diuron products (diuron) PRE | *Established plantings only. Do not apply to young plants during the first year.* Use 80DF formulations at 1-4 lbs. per acre, and do not exceed 6 lbs. per acre per season. Use 4L formulations at 0.8-3.2 qts. per acre and do not exceed 4.8 qts. per acre per season. Use lower rates on light-colored soils with less than 2% organic matter. Apply after tillage or chopping fern in the spring and again after harvest, if necessary. See product label for split application rates. 6-8 weeks of residual activity. *RUP in Michigan only.* REI: 12-hour. HRAC 05. *RUP.*

Dual Magnum (s-metolachlor) PRE | 1.33-2.0 pts. per acre. *Special 24c label only.* Apply before asparagus and weeds emerge in spring or after the harvest season. Needs moisture for activation. Do not exceed 1 application per crop. REI: 24-hour. PHI: 16-day. HRAC 15.

Fusilade DX (fluazifop-P) POST | 8-12 fl. oz. per acre. Include COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. Rates may be doubled if asparagus will not be harvested for 12 months. Wait at least 14 days between applications. Do not exceed 48 fl. oz. per acre per season on bearing asparagus. REI: 12-hour. PHI: 1-day. HRAC 01.

glyphosate products (glyphosate) POST | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Apply to emerged weeds at least 7 days before spears emerge or immediately after last harvest. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. If spears are allowed to regrow, delay application until ferns have developed and apply as a directed or shielded spray. Contact of the spray with asparagus fern may result in crop injury. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

Lorox DF (linuron) POST | PRE | 2-4 lbs. per acre. *Established crowns*: Apply before spears emerge, before cutting season or immediately after cutting, or as directed spray in ferns. *New planted crowns:* To control small emerged weeds apply 1-2 lbs. per acre, up to 2 applications when ferns are 6-18 inches tall. *Newly seeded crops*: Apply a 1-inch band of activated charcoal over the row at planting, then apply Lorox. Use charcoal at 300 lbs. per acre of actual area sprayed, which is equivalent to 15 lbs. per acre of crop with a 20-inch row-spacing. Or, use the low rate of Lorox when ferns are 6-18 inches tall and weeds are less than 4 inches tall. Do not use on sand, loamy sand, or soils with less than 1% organic matter. Maximum 4 lbs. or 3 applications per acre per year. REI: 24-hour to 8-day. PHI: 1-day. HRAC 05.

metribuzin products (metribuzin) POST | PRE | *Established plantings only. Do not apply to young plants during first year.* Use 75DF formulations at 0.6-2.6 lbs. per acre. Use 4F formulations at 2-4 pts. per acre. See product label for split application rates. Use low rate if combined with diuron. 6-8 weeks residual activity. Two sprays necessary for season long sandbur control. Do not exceed 2.6 lbs. or 4 pts. per acre per year. REI: 12-hour. PHI: 14-day. HRAC 05.

paraquat products (paraquat) POST | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Include COC (1% v/v) or NIS (0.25% v/v). Apply before crop emergence or after last harvest before fern regrows. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. PHI: 6-day. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE | 2.4-8.2 pts. per acre. Use formulations with 3.8 lbs. active ingredient per gallon. Apply at least 14 days before first harvest and prior to spear emergence. If spears are present, remove before application. On sandy soil use no more than 2.4 pts. per acre. Do not apply to newly seeded asparagus during first year. REI: 24-hour. PHI: 14-day. HRAC 03.

Poast (sethoxydim) POST | 1-1.5 pts. per acre. Include COC (1% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. REI: 12-hour. PHI: 1-day. HRAC 01.

QuinStar 4L (quinclorac) POST | 12.6 fl. oz. per acre. Include COC (1% v/v). Apply after final harvest for the year. Controls bindweed, Canada thistle, barnyardgrass, large crabgrass. Do not exceed 1 application per year. REI: 12-hour. HRAC 04.

Sandea (halosulfuron) POST | PRE | 0.5-1.5 oz. per acre. Apply before, during, or after harvest. Drop nozzles and using COC (1% v/v) or NIS (0.25% v/v) are recommended for applications after harvest. For first year transplants do not apply sooner than 6 weeks after fern emergence. Do not exceed 2 applications per crop cycle, or 2 oz. per acre per 12-month period. Has residual soil activity. Effective on nutsedge. REI: 12-hour. PHI: 1-day. HRAC 02.

Sinbar WDG (terbacil) POST | PRE | 0.62-1.5 lbs. per acre. Established crowns or direct-seeded crops only. Do not use on sandy soil or on soil with less than 1% organic matter. *Established crowns:* Apply in spring after cutting fern and prior to spear emergence. May also be applied after a clean cutting. *Seeded crops:* At planting spray activated charcoal at 300 lbs.per acre of actual area treated in a 1-inch band over the row (equivalent to 15 lbs. per acre of crop with 20-inch row spacing), then apply Sinbar. Do not plant other crops within 2 years of application. 8-12 weeks residual activity. REI: 12-hour. PHI: 5-day. HRAC 05.

Solicam DF (norflurazon) PRE | 2.5-5 lbs. per acre. *Established plantings only.* Do not apply within 12 months of planting. Apply preemergence to soil free of weeds and debris. REI: 12-hour. PHI: 14-day. HRAC 12.

Spartan 4F (sulfentrazone) PRE | 4.5-12 fl. oz. per acre. *Michigan only - applicators must have a supplemental label. Established plantings only*. Apply in spring before crop emerges. Use low rate on light soil. Do not use on soils with less than 1% organic matter. Do not exceed 1 application and 12 fl. oz. per acre per season. REI: 12-hour. PHI: 14-day. HRAC 14.

trifluralin products (trifluralin) PRE |

Established plantings only. Use 4EC formulations at 2-4 pts. per acre. Use 10G formulations at 10-20 lbs. per acre. Use lower rates on coarse soils. Apply and incorporate 1-2 inches early in the spring when spears are at least 4 inches below soil surface. See product label for split application instructions. 4-6 weeks of residual activity. REI: 12-hour. HRAC 03.

Tripzin ZC (pendimethalin, metribuzin) POST | PRE |

| 116-172 fl. oz. per acre. Broadcast 14 days before emergence. Do not apply to seedlings or first-year transplants. REI: 24-hour. PHI: 14-day. HRAC 03, HRAC 05.

Celery - Horticulture

Major update by Ben Phillips, Liz Maynard, Ben Werling – Oct 2020
Reviewed by Liz Maynard – Sep 2024

Crop Description

Commercial celery (*Apium graveolens*) production in the United States began in Michigan in the 1800s. Numbered commercial varieties are maintained by a small breeding effort supported directly by the largest growers of the commodity. Other seed sources are available for smaller-scale growers, and include bushier thin-stalked types, and taller thick-stalked types. The standard green varieties can be blanched to maintain a lighter white color of the inner stalks through soil-hilling or by dense plant spacing. There are also red varieties. Seeds are produced in the second year of production if plants are overwintered under mulch.

Planting and Spacing

Celery seed is small and difficult to germinate, thus all commercial celery is planted from greenhouse-grown transplants produced in plug trays using peat-based media. Allow 8 to 10 weeks for transplant production.

In early February, seeds are sown in greenhouses and are ready for transplanting to the field in about eight weeks. Transplanting begins 6 to 8 weeks before last frost, and ends 6 to 8 weeks after last frost. Schedule planting so that a uniform quantity of celery is ready to harvest every week. Using transplants instead of direct seeding ensures uniform stands and faster maturing crops. Often, succession plantings are started every three weeks.

Harden off transplants by reducing water, not temperature. Celery is a cool-season crop that produces best at temperatures of 60 to 80 F. Plants can withstand light frosts, but prolonged frosts below 28 F will cause damage. Plants may form seed stalks (bolt) if exposed to temperatures below 55 F for 7 days or longer.

Traditionally, celery has been grown on muck soils, but it can be grown on coarse-textured mineral soils. Regardless of soil type, high fertility and moisture are necessary for tender succulent stalks.

Rotate celery with other crops whenever possible to avoid building up pests in the soil. Onions and corn are common rotational crops on muck soils. At the end of the season, consider planting a winter cover crop of barley or rye to reduce erosion and add active organic matter to the soil.

Typical spacing for celery is rows 2 feet apart with plants 6 inches apart in the row. One plant per square foot.

Fertilizing

pH: Maintain the soil pH above 5.5 in muck soils and 6.5 in mineral soils.

Before planting, apply 40 pounds N per acre, 0 to 230 pounds P_2O_5 per acre, and 0 to 500 pounds K_2O per acre based on soil test results and recommendations from your state. Celery is responsive to B. Apply 2 to 4 pounds of B per acre in banded or broadcast fertilizer to avoid stem cracking.

Banding fertilizer at transplanting can help when soil is less than 55 F. In these cases, band up to 40 pounds N per acre, up to 100 pounds P_2O_5 per acre, and up to 40 pounds K_2O per acre, and subtract those amounts from the preplant application.

Sidedress with 40 to 50 pounds N per acre two or three times, three or four weeks apart, starting six weeks after transplanting, or apply equivalent amount of N through fertigation. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer (including starter) and other credits should be 200 pounds per acre on mineral soils and 150 pounds per acre on muck soils

Use overhead sprinkler or drip irrigation to apply water frequently to the shallow-rooted crop. If the soil gets too dry, physiological disorders such as blackheart (a calcium deficiency), will develop.

Harvesting

Once celery reaches marketable size, there is a narrow harvest window (about six to eight days) before quality declines significantly. Both fresh market and processing celery can be harvested either by hand or mechanically. Time from transplanting to harvest ranges between 100 and 130 days.

Harvest celery by pulling the entire plant. Cut off the roots and trim the tops. Wash if necessary and cool quickly with water or forced air. Maintain a cold chain to market for best quality. Ideal storage conditions are near freezing and high humidity.

Celery - Diseases

Reviewed by Dan Egel, Mary Hausbeck – Aug 2023

Anthracnose of Celery - Colletotrichum Fungus

Disease and symptom development are favored by periods of warm temperatures (>68 F) combined with high humidity. Symptoms include curled/cupped leaves, sporadic leaf margin discoloration, twisted petioles and small, oval lesions on petioles. Symptoms of anthracnose can be confused with those associated with aster yellows except that the affected foliage remains green.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre, or 0.24-0.48 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre, or 0.4-0.8 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre or 0.5-1.0 fl. oz. per 1000 row feet. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) | 12-16 oz. per acre. Do not apply more than 0.8 lb a.i. pyraclostrobin (64 oz. Cabrio) per acre per season. Do not make more than two (2) sequential applications of Cabrio before alternating to a labeled non-Group 11 fungicide with a different mode of action. REI: 12-hour. PHI: 0-day. FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) | 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Pristine 38WG (boscalid, pyraclostrobin) | 10-15 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Rhyme (flutriafol) | 5-7 fl. oz. per acre. Apply preventively or when conditions are favorable for disease development. Do not apply more than 4 applications per year. REI: 12-hour. PHI: 7-day. FRAC 03.

Topguard EQ (flutriafol, azoxystrobin) | 6.0-8.0 fl. oz. per acre. Not a single application may exceed 8 fl. oz. of product per acre. Do not apply more than 4 applications per year. REI: 12-hour to 3-day. PHI: 0-day. FRAC 03, FRAC 11.

Aster Yellows (Purple-Top Wilt) of Multiple Crops - Phytoplasma Mollicutes

Pesticide

Insecticides | Use an insecticide to control leafhoppers that transmit the disease. Leafhoppers must be controlled before they feed. See Insect section.

Bacterial Blight of Celery - Pseudomonas Bacteria

Symptoms include leaf blight and extensive leaf death that requires additional trimming at harvest, resulting in yield loss. May be seedborne.

Non-Pesticide

Use disease-free seed. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 118 F for 30 minutes for celery. Rotate to non-host crops for 2 years. Varieties with partial resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) | Several formulations of copper (Badge, Champ, Kocide, Previsto) are labelled for use and may slow the spread of bacterial blight. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Crater Rot of Celery - Rhizoctonia Fungus

Non-Pesticide

Clean and sanitize transplant trays, benches, and tools. Rogue infected transplants. Avoid field work in wet conditions. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3%

formulations at 3.9-9.7 fl. oz. per acre, or 0.24-0.48 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre, or 0.4-0.8 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre or 0.5-1.0 fl. oz. per 1000 row feet. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Catamaran (potassium phosphite, chlorothalonil) | 4-5 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC P07, FRAC M05.

chlorothalonil products (chlorothalonil) | Several formulations of chlorothalonil (Bravo, Echo, Equus) are labeled at various rates. See label for directions. REI: 12-hour. PHI: 7-day. FRAC M05.

Endura (boscalid) | 8-9 fl. oz. per acre. Begin applications of Endura prior to the onset of disease development and continue 7-day interval. For crater rot, make the first application just prior to row closure with subsequent applications two weeks later. Use the higher rate when disease pressure is high. Do not make more than 2 applications per year for application made at maximum rate per application. Additional applications are permitted when lower product use rate per application is used, as long as the maximum product rate per year (18 ozs/A contain 0.792 lb boscalid) is not exceeded. not limit the potential for development of resistance DO NOT make no more than two (2) sequential applications of Endura before alternating to a labeled fungicide with a different mode of action. Suppression only. REI: 12-hour. FRAC 07.

Evito (fluoxastrobin) | Rate depends on formulation. Also available as Tepera and Aftershock. Do not apply more than 4 applications per acre per year, with a minimum re-treatment interval of 7-day between applications REI: 12-hour. PHI: 3-day. FRAC 11.

Luna Sensation (fluopyram, trifloxystrobin) | 4-5.8 fl. oz. per acre Apply using ground, aerial or chemigation equipment. Apply at the critical timings for disease control. Refer to university and/or extension guidelines for best application timings. Continue as needed on a 14-day interval. Do not apply more than 15.3 fl. Oz. of Luna Sensation per acre per year. Do not make more than 2 sequential application of Luna sensation or any group 7 or group 11 containing fungicide before rotating with fungicide from a different Group. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) | Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart, Sparra) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. REI: 4 to 12-hour. PHI: see label. FRAC P07.

Quadris Opti (azoxystrobin, chlorothalonil) | 2.4-3.7 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC M05.

Tepera Plus (fluoxastrobin, bifenthrin) | 9.2-17 fl. oz per acre. For optimum results, begin application preventively and continue as needed on a 7-to 10-days interval. Thorough coverage is essential to achieve control. Do not apply more than 17 fl oz (0.11 lb ai fluoxastrobin + 0.11 lb ai bifenthrin) of product per acre per single application. Do not apply more that 0.72 lb active ingredient fluoxastrobin per acre per year. Do not apply more than 0.5 lb active ingredient bifenthrin per acre per year. Do not make more than 4 applications per year. Do not make applications less than 7 days apart. REI: 12-hour. PHI: 7-day. FRAC 11, IRAC 03A. *RUP.*

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Michigan State University research has found *Pythium* spp. causing damping-off of celery in greenhouses can result in poor field establishment.

Non-Pesticide

Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid excess moisture to the transplants in the greenhouse by monitoring irrigation frequency. Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Pesticide

mefenoxam/metalaxyl products (mefenoxam) | For damping-off caused by Pythium spp. Several formulations (Apron, MetaStar, Ridomil Gold, Ultra Flourish, and Xyler) are labeled. Several formulations are labeled as pre-plant incorporated or surface broadcast and banded applications at various rates between 1 pt. and 8 pt. per acre. A 2.5% granular formulation can be used at 20-40 lb. per acre. A 33.3% seed treatment formulation can be used at 0.085-0.64 fl. oz. per 100 lb. of seed. REI: 48-hour. PHI: 7-day. FRAC 04.

Uniform (mefenoxam, azoxystrobin) | 0.34 fl. oz. per 1,000 ft. of row. Make one application per crop per season. REI: 0-hour. PHI: 0-day. FRAC 04, FRAC 11.

Early Blight of Celery - Cercospora Fungus

Early blight (Cercospora leaf blight) symptoms include small, yellow spots that rapidly enlarge to tan or gray lesions. All above ground tissues of celery can become infected, resulting in losses of 50% or more when blighted stalks or leaves have to be removed at harvest. May be seedborne.

Non-Pesticide

Use disease-free seed. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 118 F for 30 minutes for celery. Rotate to non-host crops for 2 years. Varieties with partial resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre, or 0.24-0.48 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre, or 0.4-0.8 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre or 0.5-1.0 fl. oz. per 1000 row feet. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) | 12-16 oz. per acre. Do not apply more than 0.8 lb a.i. pyraclostrobin (64 oz. Cabrio) per acre per season. Do not make more than two (2) sequential applications of Cabrio before alternating to a labeled non-Group 11 fungicide with a different mode of action. REI: 12-hour. PHI: 0-day. FRAC 11.

Catamaran (potassium phosphite, chlorothalonil) | 4-5 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC P07, FRAC M05.

chlorothalonil products (chlorothalonil) | Several formulations of chlorothalonil (Bravo, Echo, Equus) are labeled at various rates. See label for directions. REI: 12-hour. PHI: 7-day. FRAC M05.

Evito (fluoxastrobin) | Rate depends on formulation. Also available as Tepera and Aftershock. Do not apply more than 4 applications per acre per year, with a minimum re-treatment interval of 7-day between applications REI: 12-hour. PHI: 3-day. FRAC 11.

Flint Extra (trifloxystrobin) | 2.5-2.9 fl. oz. per acre. Use Gem as low as 1.9 fl. oz. per acre. Use Flint (50%) formulation up to 3 fl. oz. per acre. Apply with a minimum of 30 gal. per acre of water. Do not apply more than 4 applications of this or any other strobilurin fungicides per season. REI: 12-hour. PHI: 0-day. FRAC 11.

Fontelis (penthiopyrad) | 14-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

Luna Sensation (fluopyram, trifloxystrobin) | 4-5.8 fl. oz. per acre Apply using ground, aerial or chemigation equipment. Apply at the critical timings for disease control. Refer to university and/or extension guidelines for best application timings. Continue as needed on a 14-day interval. Do not apply more than 15.3 fl. Oz. of Luna Sensation per acre per year. Do not make more than 2 sequential application of Luna sensation or any group 7 or group 11 containing fungicide before rotating with fungicide from a different Group. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) | 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Miravis Prime (pydiflumetofen, fludioxonil) | 9.2-13.4 fl. oz. per acre. Do not make more than two consecutive applications of Miravis prime or other group 7 and 12 fungicides before alternation with a fungicide is no in Group 7 or 12. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 12.

Pristine 38WG (boscalid, pyraclostrobin) | 10-15 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) | 4 fl. oz. per acre. Propiconazole products include PropiMax EC, Bumper, Fitness Fungicide, Tilt, Propi-Star EC, Propicure 3.6F, Slant, Omni Brand Propiconazole 41.8% EC are labeled. See label for directions. REI: 12-hour. PHI: 14-day. FRAC 03.

Quadris Opti (azoxystrobin, chlorothalonil) | 2.4-3.7 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC M05.

Quilt (azoxystrobin, propiconazole) | 14 fl. oz. per acre. Pre-mixes of propiconazole and azoxystrobin (propiconazole and azoxystrobin) product include Cover XL, MiCrop Fungicide, AFrame Plus, Atticus Aquila XL, Avaris 2XS, Quilt Xcel, Quilt (SE). See label for directions. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Reason 500SC (fenamidone) | 8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 11.

Rhyme (flutriafol) | 5-7 fl. oz. per acre. Apply preventively or when conditions are favorable for disease development. Do not apply more than 4 applications per year. REI: 12-hour. PHI: 7-day. FRAC 03.

Topguard EQ (flutriafol, azoxystrobin) | 6.0-8.0 fl. oz. per acre. Not a single application may exceed 8 fl. oz. of product per acre. Do not apply more than 4 applications per year. REI: 12-hour to 3-day. PHI: 0-day. FRAC 03, FRAC 11.

Late Blight of Celery - Septoria Fungus

Late blight (Septoria leaf blight) include irregularly-shaped brown spots on leaves with pycnidia similar in appearance to grains of ground black pepper. Over time, these leaf spots expand and cause the entire leaf to die. May be seedborne.

Non-Pesticide

Use disease-free seed. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 118 F for 30 minutes for celery. Rotate to non-host crops for 2 years. Varieties with partial resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre, or 0.24-0.48 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre, or 0.4-0.8 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre or 0.5-1.0 fl. oz. per 1000 row feet. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) | 12-16 oz. per acre. Do not apply more than 0.8 lb a.i. pyraclostrobin (64 oz. Cabrio) per acre per season. Do not make more than two (2) sequential applications of Cabrio before alternating to a labeled non-Group 11 fungicide with a different mode of action. REI: 12-hour. PHI: 0-day. FRAC 11.

Catamaran (potassium phosphite, chlorothalonil) | 4-5 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC P07, FRAC M05.

chlorothalonil products (chlorothalonil) | Several formulations of chlorothalonil (Bravo, Echo, Equus) are labeled at various rates. See label for directions. REI: 12-hour. PHI: 7-day. FRAC M05.

Evito (fluoxastrobin) | Rate depends on formulation. Also available as Tepera and Aftershock. Do not apply more than 4 applications per acre per year, with a minimum re-treatment interval of 7-day between applications REI: 12-hour. PHI: 3-day. FRAC 11.

Flint Extra (trifloxystrobin) | 2.5-2.9 fl. oz. per acre. Use Gem as low as 1.9 fl. oz. per acre. Use Flint (50%) formulation up to 3 fl. oz. per acre. Apply with a minimum of 30 gal. per acre of water. Do not apply more than 4 applications of this or any other strobilurin fungicides per season. REI: 12-hour. PHI: 0-day. FRAC 11.

Fontelis (penthiopyrad) | 14-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

Luna Sensation (fluopyram, trifloxystrobin) | 4-5.8 fl. oz. per acre Apply using ground, aerial or chemigation equipment. Apply at the critical timings for disease control. Refer to university and/or extension guidelines for best application timings. Continue as needed on a 14-day interval. Do not apply more than 15.3 fl. Oz. of Luna Sensation per acre per year. Do not make more than 2 sequential application of Luna sensation or any group 7 or group 11 containing fungicide before rotating with fungicide from a different Group. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) | 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Miravis Prime (pydiflumetofen, fludioxonil) | 9.2-13.4 fl. oz. per acre. Do not make more than two consecutive applications of Miravis prime or other group 7 and 12 fungicides before alternation with a fungicide is no in Group 7 or 12. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 12.

Pristine 38WG (boscalid, pyraclostrobin) | 10-15 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) | 4 fl. oz. per acre. Propiconazole products include PropiMax EC, Bumper, Fitness Fungicide, Tilt, Propi-Star EC, Propicure 3.6F, Slant, Omni Brand Propiconazole 41.8% EC are labeled. See label for directions. REI: 12-hour. PHI: 14-day. FRAC 03.

Quadris Opti (azoxystrobin, chlorothalonil) | 2.4-3.7 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC M05.

Quilt (azoxystrobin, propiconazole) | 14 fl. oz. per acre. Pre-mixes of propiconazole and azoxystrobin (propiconazole and azoxystrobin) product include Cover XL, MiCrop Fungicide,

AFrame Plus, Atticus Aquila XL, Avaris 2XS, Quilt Xcel, Quilt (SE). See label for directions. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Reason 500SC (fenamidone) | 8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 11.

Rhyme (flutriafol) | 5-7 fl. oz. per acre. Apply preventively or when conditions are favorable for disease development. Do not apply more than 4 applications per year. REI: 12-hour. PHI: 7-day. FRAC 03.

Switch 62.5WG (cyprodinil, fludioxonil) | 11-14 oz. per acre. Make no more than two applications of Switch 62.5 WG. Another formulation, Alterity 62.5 WG, allows up to 56 oz. per acre per season. REI: 12-hour. PHI: 0-day. FRAC 09, FRAC 12.

Tepera Plus (fluoxastrobin, bifenthrin) | 9.2-17 fl. oz per acre. For optimum results, begin application preventively and continue as needed on a 7-to 10-days interval. Thorough coverage is essential to achieve control. Do not apply more than 17 fl oz (0.11 lb ai fluoxastrobin + 0.11 lb ai bifenthrin) of product per acre per single application. Do not apply more that 0.72 lb active ingredient fluoxastrobin per acre per year. Do not apply more than 0.5 lb active ingredient bifenthrin per acre per year. Do not make more than 4 applications per year. Do not make applications less than 7 days apart. REI: 12-hour. PHI: 7-day. FRAC 11, IRAC 03A. *RUP.*

Topguard EQ (flutriafol, azoxystrobin) | 6.0-8.0 fl. oz. per acre. Not a single application may exceed 8 fl. oz. of product per acre. Do not apply more than 4 applications per year. REI: 12-hour to 3-day. PHI: 0-day. FRAC 03, FRAC 11.

Nematodes

Non-Pesticide

Grow cover crops such as sunn-hemp, sorghum-Sudan, cereal rye, lupine, crimson clover and hairy vetch. These non-hosts plants help to reduce root knot nematodes. If nematodes are present, rotate crops out of a susceptible crop for 2-3 years.

Pesticide

K-PAM HL (metam potassium) | 30-62 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place K-PAM HL or Sectagon K54 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Nimitz (fluensulfone) | 3.5-7 pts. per acre. Do not use on direct-seeded plants. May be broadcast, banded, or drip-applied in the spring up to 7 days before planting at a depth of 8 inches. Effectiveness is reduced on muck and clay soils. REI: 12-hour. IRAC UN.

Telone C-17 (1,3-dichloropropene, chloropicrin) | *Muck soils*: Use C-17 formulation at 27.4-30 gals. per acre, and C-35 formulation at 33-36 gals. per acre. *Mineral soils*: Use C-17 formulation at 10.8-17.1 gals. per acre, and C-35 formulation at 13-20.5 gals per acre. In the fall, when soil at 6 inches is above 50 F and moist, place Telone C-17 or C-35 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing, irrigation, or plastic. Or, in the spring, InLine may be applied through drip irrigation under unperforated plastic beds at 13-20.5 gals. per acre on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 3-5-day. IRAC 8A, FRAC NC, IRAC 08B. *RUP.*

Telone II (1,3-dichloropropene) | *Muck soils*: Use at 25 gals. per acre. *Mineral soils*: Use at 9-12 gals. per acre. In the spring or fall, when soil at 6 inches is above 50 F and moist, place Telone II about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, Telone EC may be applied through drip irrigation under unperforated plastic beds at 9-18 gals. per acre on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 8A, FRAC NC. *RUP.*

VAPAM HL (metam sodium) | 37.5-75 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place VAPAM HL or Sectagon K42 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Vydate L (oxamyl) | 0.5-2 pts. per acre. *MI, and OH only.* Apply as a banded or shank-injected pre-plant, at-plant in-furrow or directed post-plant soil treatment with at least 20 gals. water per acre incorporated 2-4 inches deep by water or mechanical means. Start post-plant applications 3 weeks after

transplanting. Allow 14 days between applications. Do not exceed 5 total applications, or 24 pts. per acre per season. REI: 48-hour. PHI: 21-day. IRAC 01A. *RUP.*

Rust of Multiple Crops - Puccinia Fungus

Non-Pesticide

Reduce foliar moisture by using drip irrigation and allowing adequate space between rows and plants so foliage can dry quickly.

Pesticide

Flint Extra (trifloxystrobin) | 2.5-2.9 fl. oz. per acre. Use Gem as low as 1.9 fl. oz. per acre. Use Flint (50%) formulation up to 3 fl. oz. per acre. Apply with a minimum of 30 gal. per acre of water. Do not apply more than 4 applications of this or any other strobilurin fungicides per season. REI: 12-hour. PHI: 0-day. FRAC 11.

Luna Sensation (fluopyram, trifloxystrobin) | 4-5.8 fl. oz. per acre Apply using ground, aerial or chemigation equipment. Apply at the critical timings for disease control. Refer to university and/or extension guidelines for best application timings. Continue as needed on a 14-day interval. Do not apply more than 15.3 fl. Oz. of Luna Sensation per acre per year. Do not make more than 2 sequential application of Luna sensation or any group 7 or group 11 containing fungicide before rotating with fungicide from a different Group. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) | 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Wettable Sulfur (sulfur) | Rates vary by product. Use 80% sulfur products at 4-6 lb. per acre (Microthiol Disperss, Sulfur Dry Flowable, Sulfur 80 WDG, Thiolux). Use 90% sulfur at 3-10 lb. per acre (Golden Micronized Sulfur). REI: 24-hour. PHI: 0-day. FRAC M02, IRAC UN. *OMRI-listed.*

Celery - Insects

Major update by Laura Ingwell, Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Treat when more than 3% of plants are infested **or** there are more than 6 aphids per 100 sweeps.

Non-Pesticide

Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. REI: 12-hour. PHI: 45-day. IRAC 04A.

Assail 30SG (acetamiprid) | Use 30SG formulations at 2-4 oz. per acre. Use 70WP formulations at 0.8-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Beleaf (flonicamid) | 2-2.8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Brigade 2EC (bifenthrin) | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Durivo (thiamethoxam, chlorantraniliprole) | 10-13 fl. oz. per acre. Apply as a soil treatment. REI: 12-hour. PHI: 30-day. IRAC 04A, IRAC 28.

Exirel (cyantraniliprole) | 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. REI: 12-hour. PHI: 1-day. IRAC 28.

Fulfill (pymetrozine) | 2.75 oz. per acre. May require 5-7 days for aphid mortality. REI: 12-hour. PHI: 0-day. IRAC 09B.

Malathion 5EC (malathion) | Use 5EC formulations at 1.5 pts. per acre and 57EC formulations at 2.4 pts. per acre. REI: 24-hour. REI: 12-hour. PHI: 7-day. IRAC 01B.

Movento (spirotetramat) | 4-5 fl. oz. per acre. Must be tank-mixed with an adjuvant with spreading and penetrating properties. REI: 24-hour. PHI: 3-day. IRAC 23.

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Nuprid 2SC (imidacloprid) | 10-24 fl. oz. per acre. Apply as a soil treatment. REI: 12-hour. PHI: 45-day. IRAC 04A.

Orthene 97 (acephate) | 8-16 oz. per acre. REI: 24-hour. PHI: 21-day. IRAC 01B.

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Sivanto 200 (flupyradifurone) | 10.5-12.0 fl. oz. per acre. Apply as a foliar spray. REI: 4-hour. PHI: 1-day. IRAC 04D.

Torac (tolfenpyrad) | 17-21 fl. oz. per acre. Do not apply until 14 days after transplanting. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Transform WG (sulfoxaflor) | Use Transform WG at 0.75-1 oz. per acre. Use Sequoia at 1.5-2 fl. oz. per acre. Use high rate when pest pressure is heavy. REI: 24-hour. PHI: 7-day. IRAC 04C.

Verimark (cyantraniliprole) | 6.75-13.5 fl. oz. per acre. Apply as a soil treatment. REI: 4-hour. PHI: 0-day. IRAC 28.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4-7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A, IRAC 28.

Carrot Weevil Beetle

Non-Pesticide

Use crop rotation to reduce buildup of carrot weevil populations. Disk crop residue at the end of the growing season to eliminate food resources and reduce overwintering survival of life stages remaining in the field. Prior to transplanting, use carrot-baited monitoring traps to determine level of carrot weevil pressure in the field. Begin insecticide applications in the spring when plants have 3-true leaves (celery petioles) and direct applications at the base of the plant where adult weevils are active.

Pesticide

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. Apply as a transplant drench or other soil treatment at planting to target larvae as they hatch. REI: 12-hour. IRAC 04A.

Baythroid XL (beta-cyfluthrin) | 2.4-3.2 fl. oz. per acre. REI: 12-hour. IRAC 03A. *RUP.*

Exirel (cyantraniliprole) | 7-13.5 fl. oz. per acre. Use an effective adjuvant for best performance. REI: 12-hour. IRAC 28.

Malathion 5EC (malathion) | Use 5EC formulations at 1.5 pts. per acre and 57EC formulations at 2.4 pts. per acre. REI: 24-hour. REI: 12-hour. PHI: 7-day. IRAC 01B.

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. IRAC 03A. *RUP.*

Verimark (cyantraniliprole) | 5.0-13.5 fl. oz. per acre. For armyworm and looper caterpillars and carrot weevil beetles. Apply as a soil treatment at-plant. REI: 4-hour. PHI: 0-day. IRAC 28.

Vydate L (oxamyl) | 4 pts. per acre. *Michigan and Ohio only.* Apply as a soil-directed spray with at least 20 gals. water per acre, incorporated 2-4 inches deep by water or mechanical means. REI: 48-hour. PHI: 21-day. IRAC 01A. *RUP.*

Caterpillars

There are many caterpillar pests of celery, including cabbageworms, diamond back moth caterpillars, earworms, corn borers, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Apply preventative treatments within 4 weeks of harvest. Treat as needed before that.

Pesticide

Avaunt (indoxacarb) | 3.5 oz. per acre. For armyworms, and loopers. REI: 12-hour. PHI: 3-day. IRAC 22A.

Baythroid XL (beta-cyfluthrin) | 0.8-3.2 fl. oz. per acre. For armyworms, cutworms, and loopers. Use high rate for armyworms and target 1st and 2nd instar caterpillars. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | For armyworms, cutworms, and loopers. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Bt (Bacillus thuringiensis) products for caterpillars (Bacillus thuringiensis aizawai strain ABTS-1857, Bacillus thuringiensis aizawai strain GC-91, Bacillus thuringiensis kurstaki strain ABTS-351, Bacillus thuringiensis kurstaki strain EVB-113-19, Bacillus thuringiensis kurstaki strain SA-11) | For armyworms, cutworms, and loopers. Various Bt products (Agree, Biobit, Dipel, Javelin, etc.) are available for control of young caterpillars however, different Bt products can vary in the effectiveness against caterpillars. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Confirm 2F (tebufenozide) | 6-8 fl. oz. per acre. For armyworms, and loopers. REI: 4-hour. PHI: 7-day. IRAC 18.

Coragen (chlorantraniliprole) | 3.5-7.5 fl. oz. per acre. For armyworms, and loopers. Can be applied as a foliar spray or soil treatment. REI: 4-hour. PHI: 1-day. IRAC 28.

Durivo (thiamethoxam, chlorantraniliprole) | 10-13 fl. oz. per acre. For armyworms, and loopers. Apply as a soil treatment. REI: 12-hour. PHI: 30-day. IRAC 04A, IRAC 28.

Entrust SC (spinosad) | For armyworms, and loopers. Use 2SC formulations at 1.5-8.0 fl. oz. per acre. Use 80WP formulations at 0.5-2.5 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) | 7.0-17.0 oz. per acre. For armyworms, and loopers. REI: 12-hour. PHI: 1-day. IRAC 28.

Intrepid 2F (methoxyfenozide) | 4-10 oz. per acre. For armyworms, and loopers. REI: 4-hour. PHI: 1-day. IRAC 18.

Lannate LV (methomyl) | 1.5 - 3.0 pts. per acre. For armyworms, cutworms, and loopers. REI: 48-hour. PHI: 7-day. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | For armyworms, and loopers. Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Proclaim (emamectin benzoate) | 2.4-4.8 oz. per acre. For armyworms, and loopers. REI: 12-hour. PHI: 7-day. IRAC 06. *RUP.*

Radiant 1SC (spinetoram) | 5-10 fl. oz. per acre. For armyworms, and loopers. REI: 4-hour. PHI: 1-day. IRAC 05.

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. For armyworms. REI: 12-hour. PHI: 14-day. IRAC 01A.

Verimark (cyantraniliprole) | 5.0-13.5 fl. oz. per acre. For armyworm and looper caterpillars and carrot weevil beetles. Apply as a soil treatment at-plant. REI: 4-hour. PHI: 0-day. IRAC 28.

Leafhoppers

Aster leafhopper and potato leafhopper are common in our region and crops. They don’t survive the winter in northern areas, and migrate from southern areas every growing season. A condition known as "hopperburn" is caused by potato leafhopper feeding, and aster yellows is a disease vectored by aster leafhopper feeding. The amount of aster yellows present in any leafhopper population varies by year and location. Some states in the region have programs that test for and track the percentage of aster leafhoppers that are carrying aster yellows. Leafhoppers can move into vegetable fields when neighboring grain or alfalfa is harvested.

Management efforts can be stopped 2-3 weeks before harvest, as plants that are infected during that time will be harvested before symptoms manifest.

Treat when there are more than 14 leafhoppers per 100 sweeps.

Repeat as needed, depending on number of leafhoppers.

Non-Pesticide

Avoid planting near early harvested grain or alfalfa fields.

Pesticide

Actara (thiamethoxam) | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. REI: 12-hour. PHI: 45-day. IRAC 04A.

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Brigade 2EC (bifenthrin) | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Durivo (thiamethoxam, chlorantraniliprole) | 10-13 fl. oz. per acre. Apply as a soil treatment. REI: 12-hour. PHI: 30-day. IRAC 04A, IRAC 28.

Lannate LV (methomyl) | 1.5 - 3.0 pts. per acre. REI: 48-hour. PHI: 7-day. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Nuprid 2SC (imidacloprid) | 10-24 fl. oz. per acre. Apply as a soil treatment. REI: 12-hour. PHI: 45-day. IRAC 04A.

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Scorpion 35SL (dinotefuran) | *Soil treatment*: Use Scorpion 35SL at 9.0-13.0 oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar treatment*: Use Scorpion 35SL at 2.0-5.25 oz. per acre, or Venom 70SG at 1.0-3.0 oz. per acre. REI: 12-hour. PHI: 21-day as soil application, 7-day as foliar application IRAC 04A.

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. REI: 12-hour. PHI: 14-day. IRAC 01A.

Sivanto 200 (flupyradifurone) | 7.0-10.5 fl. oz. per acre. Apply as a foliar spray. REI: 4-hour. PHI: 1-day. IRAC 04D.

Torac (tolfenpyrad) | 14-21 fl. oz. per acre. Do not apply until 14 days after transplanting. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4-7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A, IRAC 28.

Leafminers

Treat as soon as visible mines appear and repeat every 7 days as needed.

Pesticide

Actara (thiamethoxam) | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. REI: 12-hour. PHI: 45-day. IRAC 04A.

Agri-Mek SC (abamectin) | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15EC formulations at 8-16 fl. oz. per acre. Use with a nonionic surfactant. REI: 12-hour. PHI: 7-day. IRAC 06. *RUP.*

Baythroid XL (beta-cyfluthrin) | 0.8-3.2 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) | 5.0-7.5 fl. oz. per acre. Can be applied as a foliar spray or soil treatment. REI: 4-hour. PHI: 1-day. IRAC 28.

Dimethoate 4EC (dimethoate) | Use 4EC, LV-4, and 400 EC formulations at 1 pt. per acre. REI: 48-hour. PHI: 7-day. IRAC 01B.

Durivo (thiamethoxam, chlorantraniliprole) | 10-13 fl. oz. per acre. Apply as a soil treatment. REI: 12-hour. PHI: 30-day. IRAC 04A, IRAC 28.

Entrust SC (spinosad) | Use 2SC formulations at 6-10 fl. oz. per acre. Use 80WP formulations at 2-3 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) | 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. REI: 12-hour. PHI: 1-day. IRAC 28.

Platinum 2SC (thiamethoxam) | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Radiant 1SC (spinetoram) | 6-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05.

Scorpion 35SL (dinotefuran) | *Soil treatment*: Use Scorpion 35SL at 9.0-13.0 oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar treatment*: Use Scorpion 35SL at 2.0-5.25 oz. per acre, or Venom 70SG at 1.0-3.0 oz. per acre. REI: 12-hour. PHI: 21-day as soil application, 7-day as foliar application IRAC 04A.

Trigard (cyromazine) | 2.66 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 17.

Verimark (cyantraniliprole) | 6.75-13.5 fl. oz. per acre. Apply as a soil treatment. REI: 4-hour. PHI: 0-day. IRAC 28.

Mites

Pesticide

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. REI: 12-hour. PHI: 45-day. IRAC 04A.

Agri-Mek SC (abamectin) | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15EC formulations at 8-16 fl. oz. per acre. Use with a nonionic surfactant. REI: 12-hour. PHI: 7-day. IRAC 06. *RUP.*

Dimethoate 4EC (dimethoate) | Use 4EC, LV-4, and 400 EC formulations at 1 pt. per acre. REI: 48-hour. PHI: 7-day. IRAC 01B.

Oberon 2SC (spiromesifen) | 7.0-8.5 fl. oz. per acre. *For the treatment of Two-Spotted Spider Mites with Michigan 24c label only.* REI: 12-hour. PHI: 7-day. IRAC 23.

Verimark (cyantraniliprole) | 6.75-13.5 fl. oz. per acre. Apply as a soil treatment. REI: 4-hour. PHI: 0-day. IRAC 28.

Slugs and Snails

Slugs and snails may occasionally damage seedlings, low growing leafy vegetables, and/or ripening fruit. Slug and snail feeding causes hollowed out areas, which can be found on fruit, but the damage is usually on the stem. Slugs and snails produce a silvery trail on the surface of leaves and fruit. Slugs and snails are active at night and they inhabit moist soil and organic mulch. Slugs and snails overwinter as eggs in moist soil.

Bait products can be placed on the soil surface around the perimeter of the planting area. Bait products can also be placed on the soil surface in a band between rows. Apply bait products in the evening after a rain or irrigation. Avoid contacting edible crops with bait products.

Non-Pesticide

Slug and snail hiding places, such as, boards, stones, weedy areas, and mulch should be eliminated. Raised beds will dry out faster than flat beds, which will reduce problems with slugs and snails. Black plastic mulch can be used to reduce problems with slugs and snails.

Pesticide

Deadline M-Ps (metaldehyde) | 25 lbs. per acre. Scatter bait around the perimeter of plantings or between rows. Apply in evening after a rain or irrigation. Avoid contact with edible product. REI: 12-hour. PHI: 1-day. IRAC UN.

Sluggo 1B (iron phosphate) | 20-44 lbs. per acre, or at 05.-1 lb. per square ft. Prevent infestation by scattering bait products to the soil surface around the perimeter of the planting. Make a rescue treatment by scattering the bait products on the soil as a band between rows. Apply in evening after a rain or irrigation. REI: 0-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Tarnished Plant Bug

Treat if there are 2-4 tarnished plant bugs per 20 plants.

Pesticide

Baythroid XL (beta-cyfluthrin) | 0.8-3.2 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Beleaf (flonicamid) | 2-2.8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. REI: 12-hour. PHI: 14-day. IRAC 01A.

Torac (tolfenpyrad) | 17-21 fl. oz. per acre. Do not apply until 14 days after transplanting. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Thrips

Thrips populations spike in hot dry weather, and when neighboring small grains or alfalfa is harvested. Damage appears as white flecks on leaves. Thrips transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Selective chemistries (e.g. abamectin, spinetoram, spirotetramat, and spinosad) that target thrips help to preserve natural enemies.

Non-Pesticide

A heavy rain or overhead irrigation washes thrips out of plants. Avoid planting near early harvested grain or alfalfa fields. Preserve and encourage natural enemies. Minute pirate bugs, and lacewings are common predators.

Pesticide

Exirel (cyantraniliprole) | 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. REI: 12-hour. PHI: 1-day. IRAC 28.

Radiant 1SC (spinetoram) | 6-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05.

Torac (tolfenpyrad) | 21 fl. oz. per acre. Do not apply until 14 days after transplanting. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Whiteflies

Whiteflies are present late in the season, especially if the summer has been dry.

Pesticide

Assail 30SG (acetamiprid) | Use 30SG formulations at 2-4 oz. per acre. Use 70WP formulations at 0.8-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Exirel (cyantraniliprole) | 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. REI: 12-hour. PHI: 1-day. IRAC 28.

Movento (spirotetramat) | 4-5 fl. oz. per acre. Must be tank-mixed with an adjuvant with spreading and penetrating properties. REI: 24-hour. PHI: 3-day. IRAC 23.

Sivanto 200 (flupyradifurone) | 10.5-14.0 fl. oz. per acre. Apply as a foliar spray. REI: 4-hour. PHI: 1-day. IRAC 04D.

Transform WG (sulfoxaflor) | Use Transform WG at 2-2.75 oz. per acre. Use Sequoia at 4.25-5.75 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 04C.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4-7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A, IRAC 28.

Celery - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Celery is nearly always started as transplants. Early season plantings in cool soils are at greater risk of herbicide injury. There are several herbicides labeled for the control of weeds preemergence, applied before celery is transplanted, or directed between the rows only after transplanting.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Weed control in celery often relies heavily on cultivation and hand-weeding for full season weed control. These operations are most efficient when planting arrangements are designed with weed control in mind and are designed to work with available weed control equipment. Specialized weeding equipment for celery includes basket weeders, narrow-bladed hoes, finger weeders, and others. A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides.

Pesticide

Caparol 4L (prometryn) POST | PRE | 1-2 qts. per acre. Make 1 or 2 applications 2-6 weeks after transplanting but before weeds are 2 inches tall. Do not exceed 2 qts. per acre per year. REI: 12-hour. HRAC 05.

Chateau SW (flumioxazin) PRE | 3 oz. per acre of Chateau SW or 3 fl. oz. per acre of Chateau EZ Apply before transplanting or 3-7 days after transplanting for control of many annual broadleaf weeds and grasses. Do not tank mix with other pesticides. REI: 12-hour. HRAC 14.

clethodim products (clethodim) POST | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). Use

Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max per acre per season. REI: 24-hour. PHI: 30-day. HRAC 01.

Dual Magnum (s-metolachlor) PRE | 1-2 pts. per acre. *Special 24c label only.* Apply before or immediately after transplanting. Will control annual grass and small-seeded broadleaf weeds and nutsedge. Use high rate on muck soils. Follow with 0.25-inch water within 7 days. REI: 24-hour. PHI: 62-day. HRAC 15.

glyphosate products (glyphosate) POST | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Apply to emerged perennials before planting, or after harvest in the fall. See label for suggested application volume and adjuvants and rates for specific weeds. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

Lorox DF (linuron) POST PRE | 1.5-2 lbs. per acre. Apply after transplants are established but before celery is 8 inches tall. Do not exceed 40 PSI pressure. Do not apply when temperatures exceed 85 F, and do not mix with wetting agents or other pesticides. REI: 24-hour to 8-day. PHI: 45-day. HRAC 05.

Poast (sethoxydim) POST | 1-1.5 pts. per acre. Apply to actively growing grasses. Include COC (1% v/v). Do not exceed 3 pts. per acre per season. REI: 12-hour. PHI: 30-day. HRAC 01.

trifluralin products (trifluralin) PRE | Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Apply and incorporate 1-2 inches before, during, or immediately after planting. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour. HRAC 03.

Zidua SC (pyroxasulfone) PRE | 3.25 fl. oz. per acre. Use only on muck soil with greater than 20% organic matter. Apply to transplanted celery 1-6 days after transplanting. REI: 12-hour. HRAC 15.

Cole Crops and Brassica Leafy Greens - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Dan Fillius and Liz Maynard – Oct 2024

Crop Description

The term "cole crops" refers to leafy brassicas, with waxy leaves, of the species *Brassica oleracea*. Cabbage, cauliflower, broccoli, Brussels sprouts, kale, collards, and kohlrabi are hardy crops and well adapted to cool weather. Mustard and turnip greens, although not cole crops, are also frost-hardy and adapted to cool weather. Careful selection of the planting date and cultivars is crucial to a good harvest in the Midwest. Many cole crop varieties need 80 days or fewer to mature and can be sequentially planted in the spring through mid-summer for sequential harvests starting in the summer through late fall. Some cabbage, and cauliflower varieties – and all Brussels sprouts varieties – need over 100 days to mature, and require a full season. Plants maturing under cool weather conditions are the highest in quality.

Broccoli: There are heading-types of broccoli that form a distinct domed head, and sprouting "broccolini" types that produce smaller sprigs of flower buds for multiple harvests. There are purple varieties as well. Broccoli is relatively fast-maturing, and varieties can be planted in spring for summer harvest and summer for fall harvest. Varieties have been bred to perform in each of these situations, with some performing best with heat at a young age and cooler conditions at maturity while others perform best with cool conditions early and tolerating heat at maturity.

Brussels sprouts: Brussels sprouts require the entire season from spring to fall to produce small cabbage-like buds in a spiral around the stalk of the plant at the base of each leaf.

Cabbage: Among the brassica crops, cabbage is the most widely grown. Small-headed varieties of cabbage (3 to 4 lbs.) are the most desired varieties for fresh market sales. Some varieties can be planted in spring for summer harvest, and in summer for fall harvest. Others require the entire season from spring to fall to mature.

Cauliflower: Cauliflower is relatively more difficult to grow. The most common problems associated with cauliflower production are failure to head properly and poor curd quality. Cauliflower "buttoning" is the premature formation of curd. When the curd is formed very early in the plant's life, the leaves of the plant are not large enough to sustain its development to a marketable size. Cold temperatures during seedling production or at transplanting encourage buttoning. In order to produce a white curd, leaves are tied over the developing head when it is about the size of a baseball to block out sunlight and blanch it. Self-blanching varieties produce leaves that naturally shade the curd, but they need to be planted closer together to effectively self-blanch, resulting in smaller head sizes. Orange-, green-, and purple-colored varieties, and greenish Romanesco-types do not require blanching. Some varieties can be planted in spring for summer harvest, and in summer for fall harvest. Others require the entire season from spring to fall to mature.

Collards: Varieties differ in leaf color and texture, tendency to head, and tendency to bolt. Some varieties may be tender enough to harvest at young stage for salad mixes.

Kale: Types and varieties differ in leaf color, texture, and shape. Scotch or Curly kale varieties have frilly leaf margins; cultivar examples include Winterbor, Darkibor, and Redbor (purple-red leaves). Lacinato, also called Tuscan or dinosaur kale, has long narrow leaves with smooth leaf margins and a puckered leaf surface; examples include Black Magic and Toscano. Siberian kale is a different species: *Brassica napus* var. *pabularia*. Siberian kale has wavy lobed leaf margins and is somewhat more tender in terms of eating quality than the curly kales; young leaves do well in salad mixes. Varieties White Russian and Dwarf Siberian are examples. The variety Red Russian has sharply lobed leaves with purple veins; leaves are commonly harvested at a small size for salad mixes. Kale flavor is best when grown in cool weather and harvested after a light frost.

Kohlrabi: The edible stem of kohlrabi looks like a turnip growing on top of the ground with sprouting leaves over the surface. Green and purple varieties are available. It can be ready to harvest sooner than most cole crops and therefore can fit well as a crop for farmers markets early in the season. Varieties have been bred for storage as well. Cold storage allows growers to hold these for later sale into early spring.

Mustard: Mustards are *B. juncea*, and come in a wide variety of leaf shapes, colors, and textures. Leaves may be harvested for salad or braising mixes when young, or allowed to grow to full size and sold in bunches.

Turnip Greens: This *B. rapa* species plant is grown for both a root and its tops. Some varieties are bred more for their tops as true turnip greens.

Other leafy greens: See the Asian Vegetables and Leafy Greens and Herbs chapters.

Planting and Spacing

Brassicas can be planted from seed, but, aside from baby greens, are more commonly established as transplants. Raised beds (6 inches high, 40 inches wide, with 2 or more rows on beds) may be desirable under certain conditions.

Broccoli: Rows 3 feet apart. Plants 12 to 18 inches apart in row.

Brussels sprouts: Rows 3 feet apart. Plants 18 to 24 inches apart in row. Removing the growing point at the top of the plant when the oldest sprouts are about half their full size can speed development of the remaining buds. Doing this less than 60 days before harvest evens out the bud sizes up and down the stalk.

Cabbage for Market: Rows 2 to 3 feet apart. Plants 12 to 15 inches apart in row.

Cabbage for Kraut: Rows 3 feet apart. Plants 18 inches apart in row.

Cauliflower: Rows 3 feet apart. Plants 15 to 18 inches apart in row, or 12 to 15 inches apart in row for self-blanching types.

Collards: Rows 3 to 3.5 feet apart. Plants 18 to 24 inches apart in row. Seed 1 to 2 pounds per acre.

Kale: Rows 2 to 3 feet apart. Plants 8 to 16 inches apart in row. Seed 2 to 4 pounds per acre. Use denser plantings if harvesting small leaves for salad or braising mixes.

Kohlrabi: Rows 2 to 3 feet apart. Plants 4 to 12 inches apart in row. Plant more densely to harvest small plants early and allow later harvested plants to grow larger.

Mustard: Rows 1 to 1-1/2 feet apart. Plants 10 to 12 inches apart in row. Seed 3 to 5 pounds per acre. Use denser plantings if harvesting small leaves for salad or braising mixes.

Turnip greens: Rows 6 to 12 inches apart. Plants 1 to 4 inches apart in row.

Fertilizing

pH: Maintain a soil pH of 6.0 to 6.5.

Broccoli, Brussels sprouts, cabbage, cauliflower, and kohlrabi:

Before planting, apply 50 to 60 pounds N per acre, 25 to 200 pounds P_2O_5 per acre, and 0 to 250 pounds K_2O per acre based on soil test results and recommendations from your state. Cole crops, particularly cauliflower, are responsive to B on low organic matter soils, sandy soils, or where the pH is greater than 7.0. If B is needed, apply 1 to 2 pounds B per acre broadcast. Soil test and/or perform plant analysis on the previous crop to be sure B is needed. High soil B can be detrimental to rotational crops such as sweet corn, peas, or beans. At transplanting, a starter solution at a rate of 1 cup (8 ounces) per plant is recommended. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

Sidedress with 40 pounds N per acre three to four weeks after transplanting and again three weeks later. On organic soils only one sidedressing is needed. Avoid excessive N fertilization with broccoli as it can cause too rapid growth and a hollow flower stalk. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer (including starter) and other credits should be 140 pounds per acre.

Collards, kale, and mustard:
Before planting, apply 50 to 60 pounds N per acre, 0 to 150 pounds per acre P_2O_5, and 0 to 200 pounds K_2O per acre based on soil test results and recommendations from your state.

Sidedress with 30 pounds N per acre two to three weeks after transplanting on soils with more than 3% organic matter and following a legume crop. For greens on soils with less than 3% organic matter and following legume crops, apply 45 pounds N per acre. For greens following corn, small grains, or a vegetable crop, apply 60 pounds N per acre. The total amount of N from fertilizer (including starter) and other credits should be 120 pounds per acre.

Harvesting

Broccoli: Harvesting is done by hand while the head is still compact and before the flowers open. The central heads should be dark blue or green and 4 to 6 inches across when mature. If harvesting too late or when the heads are over mature, woodiness in the stems will develop. Depending on your marketing requirements, cut the main head with 8 to 10 inches of stem. Sometimes a second harvest of side shoots can be obtained. Broccoli for processing should be cut with a shorter stem (6 to 7 inches) and with few or no leaves. Fresh market broccoli should be cut longer, with little trimming. Broccoli quality is based on the degree of compactness,

leafiness, head trimness, damage, and freedom from insects and extraneous debris. During the critical period of head formation, prolonged periods of heat (over 85 F) result in poor head quality. Broccoli varieties range in maturity from 55 to 75 days.

Brussels sprouts: Harvest when the buds are about 1 inch in diameter, firm, tight and of good color. Sprouts can be harvested as they reach marketable size, or during one single harvest at the end of the season. In a once-over harvest, sprouts can be harvested individually, or entire stalks can be cut. Harvesting the entire stalk saves on labor in the field and extends the shelf life of the buds. The flavor is best after the first frosts of the season. Brussels sprouts are generally long season crops ranging from 80 to 110 days to maturity and harvested in the fall.

Cabbage for fresh market and processing: Cut cabbage when the head has reached a marketable size of 6 to 12 inches in diameter. Peel off the first few wrapper leaves for fresh market sale. Cabbages for processing into kraut are harvested similarly. Cabbage for the bagged salad market are sometimes field-cored. Cabbage varieties range in maturity from 60 to 120 days.

Cauliflower: When ready to harvest, the heads should be compact and clean white. Typical harvest size for wholesale markets is a diameter of approximately 6 inches, but heads can reach 12 inches in diameter and sell well. Delaying harvest usually will not result in obtaining larger heads. If larger heads are desired consider cultivar selection and wider plant spacing. Cauliflower should be hand-harvested and cut with 1 to 2 whorls of leaves to protect the head. Cauliflower varieties range in maturity from 55 to 100 days.

Greens (collards, kale, mustards, turnip greens): Greens are ready to harvest when the leaves reach the size that your markets desire. Leaves are grabbed by the handful and cut with knives or plucked by hand by snapping handfuls of leaf stalks downwards, and then quickly bunching them with rubber bands or twist-ties. Specialized greens harvesters can be used for baby-leaf greens. From seed to harvest ranges from 30 to 75 days.

Kohlrabi: Harvest when its diameter reaches 1-1/2 to 2 inches for best quality. Varieties bred for storage can maintain optimal texture at a larger size, though any larger than a softball can intimidate customers. Kohlrabi allowed to grow past the optimal size is often tough and stringy. Kohlrabi varieties range in maturity between 45 to 60 days.

Cole Crops and Brassica Leafy Greens - Diseases

Reviewed by Dan Egel– Aug 2023

Black Leg of Brassicas - Phoma Fungus

Black leg is an important disease of broccoli, Brussel sprouts, cauliflower and turnip. May be seedborne.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Use disease-free seed and transplants. Hot water seed treatment may help to reduce this seedborne pathogen. Use temperatures and times of 122 F for 25 minutes for Brussels sprouts and cabbage, 122 F for 15 minutes for mustard greens, and 122 F for 20 minutes for other Brassicas. Since oilseed rape is particularly susceptible to black leg, avoid planting crucifer crops close to oilseed rape. Leave 1/4-mile buffer from previously infected fields, delay planting until conditions are dry. Rotate to a non-Brassica crop for 3-5 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

iprodione products (iprodione) *Broccoli* | 2 pts. per acre. Formulations of iprodione include Nevado and Rovral. REI: 24-hour. PHI: 0-day. FRAC 02.

Priaxor (fluxapyroxad, pyraclostrobin) *Broccoli, Cabbage, Cauliflower, Collards, Kale, Mustard Greens* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Black Rot of Brassicas - Xanthomonas Bacteria

Black rot is an important bacterial disease of cole crops. May be seedborne.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Use disease-free seed and transplants. Hot water seed treatment may help to reduce this seedborne pathogen. Use temperatures and times of 122 F for 25 minutes for Brussels sprouts and cabbage, 122 F for 15 minutes for mustard greens, and 122 F

for 20 minutes for other Brassicas. Rotate to a non-Brassica crop for 2-3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Black rot spreads easily when the crop is wet. Avoid field work in infected areas when they are wet to limit the spread.

Pesticide

Actigard (acibenzolar-s-methyl) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 0.5-1.0 oz. per acre. Suppression only. Do not apply to stressed plants. REI: 12-hour. PHI: 7-day. FRAC P01.

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may slow the spread of black rot. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Bottom Rot of Cabbage - Rhizoctonia Fungus

This soil disease can form a complex with black leg stem canker pathogen.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Clean and sanitize transplant trays, benches, and tools. Rogue infected transplants. Avoid field work in wet conditions. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Blocker 4F (PCNB) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 2.8-3.75 gals. per acre of 4F formulation or 3.4 lbs. per 1,000 feet of linear row of 10G formulation. See label for other application methods and rates. The 10G formulation is labeled for wirestem and bottom rot on cauliflower only. REI: 12-hour. FRAC 14.

Endura (boscalid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower. FRAC 07.

Club Root of Brassicas - Plasmodiophora Fungus

Club root is a long-surviving pathogen that can live on some grasses, clovers, weeds, and other plants, which makes crop rotation difficult. The disease tends to be more prevalent in soils with acidic pH.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Use disease-free transplants. Choose resistant varieties. Rotate to a non-Brassica crop for 5-7 years. Avoid poorly drained soils with a history of club root. Serious losses can be avoided by raising the pH to 7.2 -7.3.

Pesticide

Blocker 4F (PCNB) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 3 pts. per acre of 4F formulation or 5.15 lbs. per 1,000 feet of linear row of 10G formulation. See label for other application methods and rates. REI: 12-hour. FRAC 14.

Omega 500F (fluazinam) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | Transplant: 6.45 fl. oz. per 100 gal. Soil incorporation: 41.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day for cabbage; 20-day for collars, kale, and mustard greens; 50-day for broccoli, Brussels sprouts, cauliflower, and kohlrabi. FRAC 29.

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid excess moisture to the transplants in the greenhouse by monitoring irrigation frequency. Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Pesticide

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | see label. Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. REI: 4 to 12-hour. PHI: 0-day. FRAC P07.

Downy Mildew of Brassicas - Hyaloperonospora Oomycete

May be seedborne.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Use disease-free seeds and transplants. Hot water seed treatment may help to reduce this seedborne pathogen. Use temperatures and times of 122 F for 25 minutes for Brussels sprouts and cabbage, 122 F for 15 minutes for mustard greens, and 122 F for 20 minutes for other Brassicas. Resistant broccoli varieties are available. Rotate to a non-Brassica crop for 2-3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Actigard (acibenzolar-s-methyl) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 0.5-1.0 oz. per acre. Suppression only. Do not apply to stressed plants. REI: 12-hour. PHI: 7-day. FRAC P01.

azoxystrobin products (azoxystrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 12-16 oz. per acre. Suppression only of wire stem and white mold. REI: 12-hour. PHI: 3-day for collard, kale and mustard; 0-day for all other brassicas. FRAC 11.

chlorothalonil products (chlorothalonil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | Several formulations of chlorothalonil (Bravo, Echo, Equus) are labeled at various rates. See label for directions. REI: 12-hour. PHI: 7-day. FRAC M05.

Forum (dimethomorph) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 40.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 1.75-2.5 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC 49, FRAC M05.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 5.5-8.0 fl. oz. per acre. REI: 4-hour. PHI: 1-day. FRAC 49, FRAC 40.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | see label. Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. REI: 4 to 12-hour. PHI: 0-day. FRAC P07.

Presidio (fluopicolide) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 3-4 oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 43.

Ranman 400SC (cyazofamid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.75 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 21.

Reason 500SC (fenamidone) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard*

Greens, Turnip Greens | 5.5-8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 11.

Revus (mandipropamid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 8 fl. oz. per acre. REI: 4-hour. PHI: 1-day. FRAC 40.

Ridomil Gold Bravo SC (mefenoxam, chlorothalonil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 1.5 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC 04, FRAC M05.

Zampro (ametoctradin, dimethomorph) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 45, FRAC 40.

Leaf Spot of Brassicas - Alternaria Fungus

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Use disease-free seed and transplants. Hot water seed treatment may help to reduce this seedborne pathogen. Use temperatures and times of 122 F for 25 minutes for Brussels sprouts and cabbage, 122 F for 15 minutes for mustard greens, and 122 F for 20 minutes for other Brassicas. Rotate to a non-Brassica crop for 3-4 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 12-16 oz. per acre. Suppression only of wire stem and white mold. REI: 12-hour. PHI: 3-day for collard, kale and mustard; 0-day for all other brassicas. FRAC 11.

chlorothalonil products (chlorothalonil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | Several formulations of chlorothalonil (Bravo, Echo, Equus) are labeled at various rates. See label for directions. REI: 12-hour. PHI: 7-day. FRAC M05.

Endura (boscalid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower. FRAC 07.

Fontelis (penthiopyrad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Inspire Super (difenoconazole, cyprodinil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 09.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 1.75-2.5 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC 49, FRAC M05.

Priaxor (fluxapyroxad, pyraclostrobin) *Broccoli, Cabbage, Cauliflower, Collards, Kale, Mustard Greens* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Procure 480SC (triflumizole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 03.

Quadris Top (azoxystrobin, difenoconazole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 03.

Reason 500SC (fenamidone) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 11.

Ridomil Gold Bravo SC (mefenoxam, chlorothalonil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 1.5 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC 04, FRAC M05.

Switch 62.5WG (cyprodinil, fludioxonil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi,*

Mustard Greens, Turnip Greens | 11-14 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Powdery Mildew of Multiple Crops - Erysiphe Fungus

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Resistant Brussels sprouts and cabbage varieties are available. Rotate to a non-Brassica crop for 3 years. Avoid over-applying nitrogen and drought stress. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 12-16 oz. per acre. Suppression only of wire stem and white mold. REI: 12-hour. PHI: 3-day for collard, kale and mustard; 0-day for all other brassicas. FRAC 11.

Endura (boscalid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower. FRAC 07.

Fontelis (penthiopyrad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Inspire Super (difenoconazole, cyprodinil) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 09.

Procure 480SC (triflumizole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 03.

Wettable Sulfur (sulfur) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Rates vary by product. Use 80% sulfur products at 3-5 lb. per acre (Sulfur Dry Flowable), or 3-10 lb. per acre (Microthiol Disperss, Sulfur 80 WDG, Thiolux). Use 90% sulfur at 3-5 lb. per acre (Sulfur 90W), or 3-10 lb. per acre (Golden Micronized Sulfur). REI: 24-hour. PHI: 0-day. FRAC M02, IRAC UN. *OMRI-listed.*

White Mold (Timber Rot, Drop, Stem Rot) of Multiple Crops - Sclerotinia Fungus

This soil pathogen is long-lived in the soil, and has a wide host range on broadleaved crops and weeds, including beans, vine crops, lettuce, tomatoes, peppers, and cole crops. It goes by other names in other crops, such as Drop, White Mold, Stem Rot, and Timber Rot.

It is more commonly found where humidity and temperatures are high. The fungus often infects flowers, which then drop off and infect the stems that they land on. The stems take on a woody appearance and can split open. On cole crops, the pathogen infects the root, crown, and stem of the plant, which makes the leaves drop and rot. Inspection of the stems will reveal small black pellets that are the overwintering body of the pathogen.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Rotate to a non-broadleaf crop, such as grass, grains or sweet corn for >3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Cabrio EG (pyraclostrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 12-16 oz. per acre. Suppression only of wire stem and white mold. REI: 12-hour. PHI: 3-day for collard, kale and mustard; 0-day for all other brassicas. FRAC 11.

Endura (boscalid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and

mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower. FRAC 07.

Fontelis (penthiopyrad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards* | 16 to 30 fl. oz. REI: 12-hour. PHI: 0-day. FRAC 07.

White Rust of Multiple Crops - Albugo Oomycete

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Use disease-free seeds and transplants. Hot water seed treatment may help to reduce this seedborne pathogen. Use temperatures and times of 122 F for 25 minutes for Brussels sprouts and cabbage, 122 F for 15 minutes for mustard greens, and 122 F for 20 minutes for other Brassicas. Resistant varieties are available. Rotate to a non-Brassica crop for 3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 12-16 oz. per acre. Suppression only of wire stem and white mold. REI: 12-hour. PHI: 3-day for collard, kale and mustard; 0-day for all other brassicas. FRAC 11.

Priaxor (fluxapyroxad, pyraclostrobin) *Broccoli, Cabbage, Cauliflower, Collards, Kale, Mustard Greens* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Reason 500SC (fenamidone) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 11.

Wirestem of Brassicas - Rhizoctonia Fungus

This soil disease can form a complex with black leg stem canker pathogen.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Clean and sanitize transplant trays, benches, and tools. Rogue infected transplants. Avoid working field under wet conditions. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Blocker 4F (PCNB) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 2.8-3.75 gals. per acre of 4F formulation or 3.4 lbs. per 1,000 feet of linear row of 10G formulation. See label for other application methods and rates. The 10G formulation is labeled for wirestem and bottom rot on cauliflower only. REI: 12-hour. FRAC 14.

Cabrio EG (pyraclostrobin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 12-16 oz. per acre. Suppression only of wire stem and white mold. REI: 12-hour. PHI: 3-day for collard, kale and mustard; 0-day for all other brassicas. FRAC 11.

Priaxor (fluxapyroxad, pyraclostrobin) *Broccoli, Cabbage, Cauliflower, Collards, Kale, Mustard Greens* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Yellows of Multiple Crops - Fusarium Fungus

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Use disease-free seed and transplants. Hot water seed treatment may help to reduce this seedborne pathogen. Use temperatures and times of 122 F for 25 minutes for Brussels sprouts and cabbage, 122 F for 15 minutes for mustard greens, and 122 F for 20 minutes for other Brassicas. Resistant varieties are available. Rotate to a non-Brassica crop for >6 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Cole Crops and Brassica Leafy Greens - Insects

Laura Ingwell, Marissa Schuh, Ashley Leach, Dan Fillius – Apr 2025

Aphids

The most common species on cole crops are cabbage aphids and green peach aphids. Cabbage aphids can be harder to control because of their waxy coating. Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Broccoli, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower, 7-day PHI for leafy greens. IRAC 04A.

Admire Pro (imidacloprid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | *Soil Application*: 4.4-10.5 fl. oz. per acre. *Foliar Application*: 1.3 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil application, 7-day for foliar application. IRAC 04A.

Assail 30SG (acetamiprid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 30SG formulations at 2.0-5.3 oz. per acre on leafy cole crops or 2.0-4.0 oz. per acre for heading cole crops. Use 70WP formulations at 0.8-2.3 oz. per acre on leafy cole crops or 0.8-1.7 oz. per acre on heading cole crops. REI: 12-hour. PHI: 3-day for leafy cole crops, 7-day for heading cole crops. IRAC 04A.

Beleaf (flonicamid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.0-2.8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Dimethoate 4EC (dimethoate) *Kale, Mustard Greens* | Use 2.67EC formulations at 0.75 pt. per acre on kale and mustard greens or 0.75-1.0 pt. per acre on broccoli, Brussels sprouts, or cauliflower. Use 4EC, LV-4, and 400 EC formulations at 0.5 pt. per acre on kale and mustard greens or 0.5-1.0 pt. per acre on broccoli and cauliflower. REI: 48-hour. PHI: 7-day for heading cole crops, 14-day for leafy cole crops. IRAC 01B.

Fulfill (pymetrozine) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.75 oz. per acre. REI: 12-hour. PHI: 7-day PHI. IRAC 09B.

Harvanta (cyclaniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 10.9-16.4 fl. oz. per acre. Use with adjuvant. REI: 4-hour. PHI: 1-day. IRAC 28.

Hero (bifenthrin, zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 4.0-10.3 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

M-Pede (potassium salts of fatty acids) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 1-2% volume. Must contact aphids to be effective. Works best in tank mix with other insecticide. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Movento (spirotetramat) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 23.

Mustang Maxx (zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Brussels Sprouts, Cauliflower* | 0.5-1.0 lb. per acre. REI: 24-hour. PHI: 14-day. IRAC 01B.

Platinum 2SC (thiamethoxam) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a

soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Sequoia (sulfoxaflor) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 1.5-2.0 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 04C.

Sivanto 200 (flupyradifurone) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 7-12 fl. oz. per acre. Apply as foliar spray. REI: 4-hour. PHI: 1-day. IRAC 04D.

Caterpillars

There are four species of caterpillar found across all cole crops ; diamondback moth, imported cabbage worm, cabbage looper, and cross-striped cabbageworm. Diamondback moth tends to show up first, followed by imported cabbageworm, then the migratory cabbage looper. The colorful cross-striped cabbageworm can gather en masse in discrete areas.

Use selective chemistries that target caterpillars (e.g. *Bacillus thuringensis*, methoxyfenozide).

State level thresholds exist for some states in our region. A general, conservative threshold is...

From transplant to early head/first curd/cupping

No need to treat unless 35% of plants are infested

From early head/first curd/cupping to harvest

Treat when 10-15% are infested if diamondback moth, imported cabbageworms, or cabbage loopers are present.

Treat when 5% are infested if cross-striped cabbage worms are present.

Non-Pesticide

Broccoli, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Exclusion netting can prevent egg-laying. Destroy the finished crop by tilling and remove all plant debris from the area.

Pesticide

Asana XL (esfenvalerate) *Broccoli, Cabbage, Cauliflower, Collards, Mustard Greens* | 2.9-9.6 fl. oz. per acre. For armyworms, cabbageworms, and loopers. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Avaunt (indoxacarb) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.5-3.5 fl. oz. per acre. For armyworms, cabbageworms, diamondback moth, and loopers. REI: 12-hour. PHI: 3-day. IRAC 22A.

Baythroid XL (beta-cyfluthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 0.8-3.2 fl. oz. per acre. For armyworms, cabbageworms, cutworms, diamondback moths, and loopers. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.1-6.4 fl. oz. per acre. For armyworms, cabbageworms, cutworms, diamondback moths, and loopers. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations on heading cole crops only at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Bt (Bacillus thuringiensis) products for caterpillars (Bacillus thuringiensis aizawai strain ABTS-1857, Bacillus thuringiensis aizawai strain GC-91, Bacillus thuringiensis kurstaki strain ABTS-351, Bacillus thuringiensis kurstaki strain EVB-113-19, Bacillus thuringiensis kurstaki strain SA-11) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | See labels. For cabbageworms, diamondback moths, and loopers. Various Bt products (Agree, Biobit, Dipel, Javelin, etc.) are available for control of young caterpillars however, different Bt products can vary in the effectiveness against caterpillars. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Confirm 2F (tebufenozide) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 6.0-8.0 fl. oz. per acre. For armyworms, cabbageworms, and loopers. REI: 4-hour. PHI: 7-day. IRAC 18.

Coragen (chlorantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 3.5-7.5 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. Can be applied as a foliar spray or soil treatment. REI: 4-hour. PHI: 3-day. IRAC 28.

Entrust SC (spinosad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 1.5-6.0 fl. oz. per acre. For cabbageworms, diamondback moths, and loopers. Use 2SC formulations at 1.5-6.0 fl. oz. per acre. Use 80WP formulations at 0.5-2.0 oz.

per acre. Allow 4 days between applications. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 7-17 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. Do not apply more than twice within a generation or two successive generations. REI: 12-hour. PHI: 1-day. IRAC 28.

Harvanta (cyclaniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 10.9-16.4 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. Do not apply more than twice within a generation or two successive generations. REI: 4-hour. PHI: 1-day. IRAC 28.

Hero (bifenthrin, zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 4.0-10.3 fl. oz. per acre. For cabbageworms, diamondback moths, and loopers. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Intrepid 2F (methoxyfenozide) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 4-10 fl. oz. per acre. For armyworms, cabbageworms, and loopers. REI: 4-hour. PHI: 1-day. IRAC 18.

Mustang Maxx (zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.24-4.0 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. Do not apply more than twice within a generation or two successive generations. REI: 12-hour. PHI: 14-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Brussels Sprouts, Cauliflower* | 1 lb. per acre. For cabbageworms, diamondback moths, and loopers. REI: 24-hour. PHI: 14-day. IRAC 01B.

Perm-Up 25DF (permethrin) *Broccoli, Brussels Sprouts, Cauliflower, Mustard Greens* | For armyworms, cabbageworms, diamondback moths, and loopers. Use 25W, 25WP, and 25DF formulations at 3.2-12.8 oz. per acre for cabbage, or 3.2-6.4 oz. per acre for broccoli, brussels sprouts and cauliflower. Use 3.2EC formulations at 2-8 fl. oz. per acre for cabbage, or 2-4 fl. oz. per acre for broccoli, Brussels sprouts and cauliflower. *For use on collards in Illinois only at 2-6 fl. oz. per acre.* REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Proclaim (emamectin benzoate) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.4-4.8 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. REI: 12-hour. PHI: 7-day for heading cole crops, 14-day for leafy cole crops. IRAC 06. *RUP.*

Radiant 1SC (spinetoram) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 5-10 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. An adjuvant can improve control. REI: 4-hour. PHI: 1-day. IRAC 05.

Rimon 0.83EC (novaluron) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 6-12 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. REI: 12-hour. PHI: 7-day. IRAC 15.

Sevin XLR Plus (carbaryl) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 1-2 qts. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. Do not apply more than twice within a generation or two successive generations. REI: 12-hour. PHI: 3-day for heading cole crops, 14-day for leafy cole crops. IRAC 01A.

Verimark (cyantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Apply 5-10 fl. oz. per acre to the soil at planting, as a transplant drench within 72 hours of planting, or through drip chemigation. REI: 4-hour. IRAC 28.

Warrior II (lambda-cyhalothrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 0.96-1.92 fl. oz. per acre. For armyworms, cabbageworms, diamondback moths, and loopers. Do not apply more than twice within a generation or two successive generations. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Flea Beetles

Crucifer and striped flea beetles are the main species in our area. Young plants are most susceptible to extreme damage.

Thresholds range from an average of 1 beetle/plant for small plants to 2-5 beetles per plant for older plants. Use the lower thresholds for crops where flea beetles damage the marketable parts.

Non-Pesticide

Broccoli, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Rotate away from cole

crops because flea beetles spend the winter in the soil where they fed the previous year. Row covers, when paired with rotation, can be used to exclude flea beetles, and are especially valuable in protecting young plants.

Pesticide

Actara (thiamethoxam) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower, 7-day PHI for leafy greens. IRAC 04A.

Asana XL (esfenvalerate) *Broccoli, Cabbage, Cauliflower, Collards, Mustard Greens* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day for heading crops, 7-day for collards and mustard greens. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.4-3.2 fl. oz. per acre. REI: 12-hour. IRAC 03A. *RUP.*

Belay (clothianidin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil application, 7-day for foliar application. IRAC 04A.

Brigade 2EC (bifenthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations on heading cole crops only at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Exirel (cyantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 13.5-20 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Harvanta (cyclaniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 10.9-16.4 fl. oz. per acre. Use high rate for flea beetles. REI: 4-hour. PHI: 1-day. IRAC 28.

Hero (bifenthrin, zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 4.0-10.3 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Cabbage* | Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Sevin XLR Plus (carbaryl) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 0.5-1 qt. per acre. REI: 12-hour. PHI: 3-day for heading cole crops, 14-day for leafy cole crops. IRAC 01A.

Verimark (cyantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Apply 6.75-13.5 fl. oz. per acre to the soil at planting, as a transplant drench within 72 hours of planting, or through drip chemigation. REI: 4-hour. IRAC 28.

Warrior II (lambda-cyhalothrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Leafminers

This is a minor pest in our region.

Pesticide

Entrust SC (spinosad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2SC formulations at 4.0-10.0 fl. oz. per acre. Use 80WP formulations at 1.25-3.0 oz. per acre. Adjuvants can improve leafminer control. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 13.5-20 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Harvanta (cyclaniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 10.9-16.4 fl. oz. per acre. Use high rate for flea beetles. REI: 4-hour. PHI: 1-day. IRAC 28.

M-Pede (potassium salts of fatty acids) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 1-2% by volume. Works best in tank mix with other insecticide. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Mustang Maxx (zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 6-10 fl. oz. per acre. Control may be improved with the use of an adjuvant. REI: 4-hour. PHI: 7-day. IRAC 05.

Rimon 0.83EC (novaluron) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 15.

Scorpion 35SL (dinotefuran) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1.0-4.0 oz. per acre. REI: 12-hour. PHI: 21-day for soil applications, 1-day for foliar applications. IRAC 04A.

Trigard (cyromazine) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.66 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 17.

Seed and Root Maggots

The primary root maggot of concern is cabbage maggot. Cabbage maggot causes the biggest problems during cool, wet springs when plants are growing slowly. Egg-laying adults are attracted to the smell of decaying organic matter, and are attracted to fields where green manures, cover crops, and weeds have been recently killed. Foliar applications of pyrethroids are only partially effective, and require careful timing. Degree day models exist for states across the region, and can be used to time management actions.

Non-Pesticide

Broccoli, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Rotate as far as possible from the previous year's cole crops. Avoid using brassica cover crops between cole crop plantings. Brassica weeds, such as shepherd's purse, yellow rocket, and wild mustard can harbor later generations of cabbage maggot. Consequently, remove all weeds from planting areas. Destroy the finished crop by tilling and remove all plant debris from the area. Avoid planting into areas with high organic matter residues or wait to plant until residues have degraded. Delay planting until after the first generation of adult females have emerged and laid eggs based on growing degree days. Row covers can be placed over crops to exclude flies, and degree day models can be used to time row cover deployment.

Pesticide

Capture LFR (bifenthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 3.4-6.8 fl. oz. per acre. Can be used pre-plant broadcast, pre-plant incorporated, or banded at-plant. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Diazinon AG500 (diazinon) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | Use 50W formulations at 4-6 lbs. per acre as a pre-plant broadcast or 0.5-1.0 lbs per 100 gallons of transplant water at planting. Use AG500 formulations at 64-96 fl. oz. per acre as a pre-plant broadcast or 8-16 fl. oz. per acre in 100 gallons of transplant water at planting. Use AG600 formulations at 51-76.5 fl. oz. per acre as a pre-plant broadcast or 6.5-12.0 fl. oz. per acre in 100 gallons of transplant water at planting. Water treatments may reduce stands due to plants stress at time of transplanting. Cabbage maggot exhibit resistance to diazinon. REI: 2 to 4-day. IRAC 01B. *RUP.*

Entrust SC (spinosad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | Use 2SC formulations at 5.0-10.0 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Radiant 1SC (spinetoram) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | For Cabbage Maggot control. 5-10 fl. oz. per acre. *Suppression only.* See label for specific use directions. REI: 4-hour. PHI: 1-day. IRAC 05.

Verimark (cyantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Apply 10-13.5 fl. oz. per acre to the soil at planting or as a transplant drench within 72 hours of planting. REI: 4-hour. IRAC 28.

Slugs and Snails

Slugs and snails may occasionally damage seedlings, low growing leafy vegetables, and/or ripening fruit. Slug and snail feeding causes hollowed out areas, which can be found on fruit, but the damage is usually on the stem. Slugs and snails produce a silvery trail on the surface of leaves and fruit. Slugs and snails are active at night and they inhabit moist soil and

organic mulch. Slugs and snails overwinter as eggs in moist soil.

Bait products can be placed on the soil surface around the perimeter of the planting area. Bait products can also be placed on the soil surface in a band between rows. Apply bait products in the evening after a rain or irrigation. Avoid contacting edible crops with bait products.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Eliminate slug and snail hiding places, such as, boards, stones, weedy areas, and mulch. Raised beds will dry out faster than flat beds, which will reduce problems with slugs and snails. Black plastic mulch can be used to reduce problems with slugs and snails.

Pesticide

Deadline M-Ps (metaldehyde) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 25 lbs. per acre. Scatter bait around the perimeter of plantings or between rows. Apply in evening after a rain or irrigation. Avoid contact with edible product. REI: 12-hour. PHI: 0-day. IRAC UN.

Sluggo 1B (iron phosphate) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 20-44 lbs. per acre, or at 05.-1 lb. per square ft. Prevent infestation by scattering bait products to the soil surface around the perimeter of the planting. Make a rescue treatment by scattering the bait products on the soil as a band between rows. Apply in evening after a rain or irrigation. REI: 0-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Stink Bugs

Pesticide

Azera (azadirachtin, pyrethrins) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 16-56 fl. oz. per acre. Use lower rates for nymphs. Use 48 fl. oz. per acre for adults. Use 56 fl. oz. per acre when pest pressure is extreme or plant canopy is dense. REI: 12-hour. PHI: 0-day. IRAC UN, IRAC 03A. *OMRI-listed.*

Baythroid XL (beta-cyfluthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 2.4-3.2 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil applications, 7-day for foliar applications. IRAC 04A.

Brigade 2EC (bifenthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations on heading cole crops only at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Harvanta (cyclaniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 10.9-16.4 fl. oz. per acre. For suppression of nymphs only. REI: 4-hour. PHI: 1-day. IRAC 28.

Malathion 5EC (malathion) *Collards* | *Harlequin Bugs only.* Use 5EC formulations at 1.0 pt. per acre and 57EC formulation at 1.5 pts. per acre. REI: 12-hour. PHI: 7-day. IRAC 01B.

Mustang Maxx (zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 3.2-4 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Rimon 0.83EC (novaluron) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 12 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 15.

Scorpion 35SL (dinotefuran) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1.0-4.0 oz. per acre. REI: 12-hour. PHI: 21-day for soil applications, 1-day for foliar applications. IRAC 04A.

Sevin XLR Plus (carbaryl) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 0.5-2 qts. per acre. Use low rates for Harlequin bugs. Use higher rates for other stink bugs. REI: 12-hour. PHI: 3-day for heading cole crops, 14-day for leafy cole crops. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Swede Midge

Swede midge feeds on many brassicas, including broccoli, cauliflower, cabbage, and Brussels sprouts. Some insecticides labeled for use against flea beetles and caterpillars may inadvertently manage swede midge populations. Products include Admire Pro, Coragen, Exirel, Orthene, Verimark, and Warrior II.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Rotate as far as possible from the previous year's cole crops. Avoid using brassica cover crops between cole crop plantings. Brassica weeds, such as shepherd's purse, yellow rocket, and wild mustard, can harbor populations of the Swede midge. Consequently, remove all weeds from planting areas. Destroy the finished crop by tilling and remove all plant debris from the area.

Pesticide

Assail 30SG (acetamiprid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 30SG formulations at 4.0-5.3 oz. per acre on leafy cole crops or 4.0 oz. per acre for heading cole crops. Use 70WP formulations at 1.7-2.3 oz. per acre on leafy cole crops or 1.7 oz. per acre on heading cole crops. REI: 12-hour. PHI: 3-day for leafy cole crops, 7-day for heading cole crops. IRAC 04A.

Movento (spirotetramat) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 23.

Thrips

Onion thrips are most likely to damage cabbage. Thrips populations spike in hot dry weather, and when neighboring small grains or alfalfa is harvested. Damage appears as white flecks on leaves. Thrips transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Selective chemistries (e.g. abamectin, spinetoram, spirotetramat, and spinosad) that target thrips help to preserve natural enemies.

Non-Pesticide

Brussels Sprouts, Cabbage | A heavy rain or overhead irrigation washes thrips out of plants. Avoid planting near early harvested grain or alfalfa fields. Preserve and encourage natural enemies. Minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 3.0-5.5 oz. per acre. REI: 12-hour. PHI: 0-day for broccoli, Brussels sprouts, cabbage, and cauliflower, 7-day for leafy greens. IRAC 04A.

Admire Pro (imidacloprid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 4.4-10.5 fl. oz. per acre. Apply as a soil treatment. REI: 12-hour. PHI: 21-day. IRAC 04A.

Assail 30SG (acetamiprid) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 30SG formulations at 4.0-5.3 oz. per acre on leafy cole crops or 4.0 oz. per acre for heading cole crops. Use 70WP formulations at 1.7-2.3 oz. per acre on leafy cole crops or 1.7 oz. per acre on heading cole crops. REI: 12-hour. PHI: 3-day for leafy cole crops, 7-day for heading cole crops. IRAC 04A.

Baythroid XL (beta-cyfluthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 0.8-1.6 fl. oz. per acre. REI: 12-hour. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations on heading cole crops only at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Entrust SC (spinosad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2SC formulations at 4.0-10.0 fl. oz. per acre. Use 80WP formulations at 1.25-3.0 oz. per acre. Adjuvants can improve leafminer control. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 13.5-20 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Mustang Maxx (zeta-cypermethrin) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Broccoli, Brussels Sprouts, Cauliflower* | Use 25W, 25WP, and 25DF formulations are 3.2-6.4 oz. per acre. Use 3.2EC formulations at 2-4 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Radiant 1SC (spinetoram) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 6-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05.

Sequoia (sulfoxaflor) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 5.75 fl. oz. per acre. *Suppression only.* REI: 12-hour. PHI: 3-day. IRAC 04C.

Torac (tolfenpyrad) *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Mustard Greens, Turnip Greens* | 21 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Cole Crops and Brassica Leafy Greens - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Cole crops are cool-season plants, but are nearly always started as transplants. When growers transplant cole crops into plastic mulch, no herbicides are labeled for use under the plastic because of the risk of damaging the crop. Early season plantings into cool soils are at greater risk of herbicide injury. There are several herbicides labeled for the control of weeds preemergence, applied before cole crops are transplanted, or directed between the rows only after transplanting.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Design bed and row spacing to match equipment that will be used and other crops with similar space requirements. A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. Mulches provide good weed control when planted into, when used for between row spaces, or in combination in-row and between-row. Materials include landscape cloth, plastic, biodegradeable plastic, or straw applied before weeds emerge. Weeds between beds and along the edges of beds can be controlled with a combination of cultivation, mowing, or hand hoeing/pulling. Weeds along the edge of the mulches can be a particular challenge to avoid ripping the mulch.

Pesticide

Aim EC (carfentrazone) POST *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Apply with hooded sprayers as a directed application between crop rows. Use COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do

not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. HRAC 14.

clethodim products (clethodim) POST *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kohlrabi* | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season. Use Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Do not exceed 64 fl. oz. of Select Max per acre per season. Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 14-day for leafy brassicas, 30-day for heading cole crops. HRAC 01.

clopyralid products (clopyralid) POST *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 4-8 fl. oz. per acre. Apply Spur or Stinger (40.9% formulations only) at any crop stage. Kills composite weeds, legumes, and nightshade. Do not exceed 2 applications and 8 fl. oz. per acre per year. REI: 12-hour. PHI: 30-day. HRAC 04.

Command 3ME (clomazone) PRE *Broccoli, Cabbage* | 0.67-1.3 pts. per acre. For **cabbage:** apply before seeding or transplanting or after seeding before crop emerges. Use low rate for seeded cabbage. For **broccoli:** apply low rate within 48 hours of transplanting. May cause early stunting or discoloration. REI: 12-hour. PHI: 45-day for cabbage. HRAC 13.

Devrinol DF-XT (napropamide) PRE *Broccoli, Brussels Sprouts, Cabbage, Cauliflower* | 2 lbs. per acre. Apply and incorporate 1-2 inches before seeding or transplanting or apply after seeding and irrigate to wet soil 2-4 inches deep. After harvest or prior to planting succeeding crops, deep moldboard or disk plow. Do not seed alfalfa, small grains, sorghum, corn, or lettuce for 12 months after application. Most effective when combined with GoalTender. REI: 24-hour. HRAC NC.

Dual Magnum (s-metolachlor) PRE *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens | Special 24c label only.* For **heading cole crops:** apply *0.5-1.3 pts. per acre* to soil surface before transplanting or within 48 hours of transplanting. Reduce risk of crop injury by applying after transplanting and by using a directed spray rather than spraying over the top of transplants. Do not tank-mix with pendimethalin for post-transplant application. Do not apply with GoalTender or other products containing oxyfluorfen. For **leafy brassicas:** apply *0.67-1.3 pts. per acre* after seeding before weeds or crop emerge, or apply broadcast after crops have 1-2 true leaves. Do not exceed 1.3 pts. per acre or 1 application per crop per season. REI: 24-hour. PHI: 30-day for leafy brassicas, 60-day for heading cole crops. HRAC 15.

glyphosate products (glyphosate) POST *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. See product labels for rates, application volume, and adjuvants. Broadcast before seeding or transplanting, after seeding but before crop emergence, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

GoalTender (oxyfluorfen) PRE *Broccoli, Cabbage, Cauliflower* | Apply GoalTender at 0.5-1 pt. per acre after preparing soil but before transplanting, or Goal 2X at 1-2 pts. per acre. Crop safety can be improved by applying to prepared land, irrigating, and then waiting 3 days before transplanting. *With special 24c label only* another application of GoalTender is allowed at 4-8 fl. oz. per acre to well-established transplants at least 2 weeks in the field, or to direct-seeded plants with at least 4 true leaves. Do not exceed 16 fl. oz. pre- and postemergence. Use lower rate on coarse-textured soils. Do not add adjuvant. Do not apply with Dual Magnum or other chloroacetamide herbicides. REI: 24 to 48-hour. PHI: 35-day for postemergence application in Michigan only. HRAC 14.

Optogen (bicyclopyrone) POST PRE *Broccoli* | 3.5 fl. oz. per acre. For **broccoli**: apply after emergence or after transplanting as a row middle or post-directed application, avoiding contact with crop foliage. If weeds are present, add COC (1% v/v) or NIS (0.25% v/v). Spray grade ammonium sulfate (AMS) may also be added to improve weed control consistency. Apply to weeds less than 2 inches. Do not exceed 1 application per year. Do not exceed 3.5 fl. oz. per acre per year. Do not apply preemergence on mineral soils. REI: 24-hour. PHI: 14-day. HRAC 27.

paraquat products (paraquat) POST *Broccoli, Cabbage, Cauliflower, Collards* | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Include COC (1% v/v) or NIS (0.25% v/v). Apply before seeding or transplanting, or after seeding but before crop emergence. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Apply formulations with 3.8 lbs. active ingredient per gallon at 1.0-2.1 pts. per acre to soil as a broadcast before transplanting, or apply between the rows of established transplants and direct-seeded crops with 2-4 leaves for heading cole crops, or 4-5 leaves for leafy brassicas. Spray contact with plants may cause crop stunting. Do not use the roots from treated turnip greens for food. REI: 24-hour. PHI: 21-day for leafy brassicas; 60-day for broccoli; 70-day for Brussels sprouts, cabbage, cauliflower, and kohlrabi. HRAC 03.

Poast (sethoxydim) POST *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens* | 1-1.5 pts. per acre. Include COC (1% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 2.5 pts. per acre per season for turnip greens, or 3 pts. per acre per season for other crops. REI: 12-hour. PHI: 14-day for turnip greens. 30-day for all others. HRAC 01.

Prefar 4E (bensulide) PRE *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply before planting and incorporate 1-2 inches or apply after seeding before crop emerges and irrigate within 24 hours. REI: 12-hour. HRAC NC.

Spartan 4F (sulfentrazone) PRE *Cabbage* | 2.25-12 fl. oz. per acre. *Transplanted cabbage for processing only. Do not use on cabbage for fresh market or on direct seeded cabbage.* Apply preemergence before transplanting as a broadcast or banded spray or band to row middles within 72 hours after transplanting. May be incorporated no deeper than 2 inches before transplanting. Do not use on soils classified as sand, with less than 1% organic matter. Controls pigweeds. REI: 12-hour. HRAC 14.

Spartan Charge (carfentrazone, sulfentrazone) POST PRE *Cabbage* | 2.9-15.2 fl. oz. per acre. *Transplanted cabbage only*. Apply up to 60 days before transplanting as a broadcast on emerged weeds, or band between rows within 72 hours after transplanting. May also be incorporated no deeper than 2 inches before transplanting. Do not use on sandy soils with less than 1% organic matter. Has not been tested on all varieties. Refer to label for additional precautions. Maximum 15.2 fl. oz. per acre. REI: 12-hour. HRAC 14.

Sulfen 4SC (sulfentrazone) PRE *Broccoli, Brussels Sprouts, Cabbage, Collards, Kale, Kohlrabi, Mustard Greens* | For **broccoli**, **Brussels sprouts**, **cauliflower**, and **kohlrabi**: Apply 2.25-9.0 fl. oz. per acre in the spring, up to 72 hours before transplanting. For *transplanted* **cabbage** in *Michigan and Minnesota only*: Apply 2.25-12.0 fl. oz. per acre 60 days prior to transplanting as a broadcast application or up to 72 hours after transplanting as a directed spray between rows. For **collards**, **kale**, and **mustard greens**: Apply 2.25-6.4 fl. oz. per acre in the spring, up to 72 hours before transplanting. Do not use on sandy soil with <1% organic matter (OM). Observe label rates for soil type. Use lower rate for soil with pH >7. REI: 12-hour. HRAC 14.

trifluralin products (trifluralin) PRE *Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard Greens, Turnip Greens* | Use 4EC formulations at 1-1.5 pts. per acre for seeded crops, up to 2 pts. per acre for transplanted crops. Use 10G formulations at 5-7.5 lbs. per acre for seeded crops, up to 10 lbs. per acre for transplanted crops. Apply before planting and incorporate 2-3 inches immediately. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. The 4D and HFD formulations are labeled for direct-seeded kohlrabi at 1-1.5 pts. per acre. REI: 12-hour. HRAC 03.

Cucurbit Crops - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Wenjing Guan – Apr 2022

Crop Description

Cucumber
Several types of cucumbers are grown in the Midwest, all of which are the species *Cucumis sativus*. Fresh market slicing cucumbers have thick, dark skin and a few large spines. They are commonly grown in the field with no support. European greenhouse cucumbers are long with thin skin, no spines, no seeds, and are grown on trellises in greenhouses. Beit alpha cucumber types are shorter but also have thin skin with no spines and may be grown in the field or in protected structures. Pickling cucumbers are short with thin skins and large spines. They are adapted for field production. Pickling cucumbers can also be marketed for fresh use.

Gynoecious cucumber varieties produce mainly female flowers and, unless they are also parthenocarpic, require a pollenizer variety to supply pollen for good fruit set. Pollenizers are usually included when you buy gyneocious seed. Parthenocarpic varieties will set fruit without pollination and no seeds will develop. Parthenocarpic varieties produce seeds if they get pollinated.

Melon
The most commonly cultivated melon is the netted skin cantaloupe, also known as a muskmelon (*Cucumis melo* subsp. *melo*). Cantaloupes grown in the Midwest are primarily eastern types. Typical varieties include Athena and Aphrodite. Melons are warm-season crops that achieve prime quality when grown under warm, sunny conditions. Cool, cloudy weather results in melons with inferior quality. Melons perform best on sandy and sandy loam soils. Production on plastic mulch and light soils produces an early crop that commands a premium price.

Melon types with distinctive fruit attributes are referred to as specialty melons. These melons with unique fruit characteristics attract consumers at local food markets. Common specialty melons fall into two major groups of *Cucumis melo* subsp. *melo*: the netted melons (Cantalupensis Group), including ananas, Charentais, galia, and Persian types; and the smooth-skinned melons (Inodorus Group), including canary, Crenshaw, and honeydew types. Asian melon types are in the Makuwa Group of *Cucumis melo* subsp. *agrestis*. Some specialty melon skins tend to crack with excessive water (such as ananas, Charentais, and galias). Greenhouse or high tunnel environments are more suitable for growing these melons in the Midwest. Note that there is disagreement among horticulturalists and scientists about the best way to categorize the many kinds of melons into groups, so other publications may use different group names.

Pumpkin and Winter Squash
Jack-o-lantern pumpkins grown for ornamental display and carving come from two species, *Cucurbita pepo,* and *C. maxima.* This market calls for a fruit up to 30 pounds. For giant pumpkins, the *C. maxima* varieties such as Atlantic Giant or Prize Winner are used. Varieties with hull-less or "naked" seed are favored as a source of seeds for eating. Many specialty pumpkins are also edible winter squash, such as fairytale and Cinderella pumpkins. Most of the "pie" pumpkins sold to consumers are used for decorating, but some varieties are still used for home baking. Pumpkins that are processed into pie filling and other products are normally grown under contract to processors, and the varieties are more like winter squash than jack-o-lantern pumpkins.

Common winter squash types include *C. pepo* types (acorn, delicata, and spaghetti), *C. maxima* types (buttercup, hubbard, kuri, and kabocha), and *C. moschata* types (butternut). Some varieties have a bush growth habit, instead of producing long vines.

Summer Squash
Common summer squash types are *C. pepo* fruit, including zucchini, yellow straightneck and yellow crookneck. Many specialty types also perform well, including golden zucchini, Middle-Eastern types, patty pan, and cocozelle. Most varieties have a bush growth habit.

Watermelon
Watermelons (*Citrullus lanatus*) are either seedless (triploid) or seeded (diploid). Seedless watermelons produce fruit that has few if any true seeds. For seedless watermelons to set fruit, growers must plant diploid watermelons (either non-edible pollenizer plants or seeded watermelons) near the triploid plants. Typically, there is one pollenizer plant for every two to four seedless plants in the row, or one row of seeded watermelons for every two to four rows of seedless watermelons.

Watermelons produce a wide range of fruit sizes. Seeded watermelons generally have large and oval-shaped fruit, single fruit weight may be over 20 lb. Fruit weight of standard-size seedless watermelons are in the range of 9 to 20 lb. Personal-size or mini watermelons product fruit 6-7 lb. Seed companies provide information on the fruit size, but the actual size may vary in different production regions and with

management practices. The Midwest Vegetable Trial Report may be used as a reference. The shapes of most standard-size watermelons are blocky or oblong. Personal-size watermelons tend to be round.

Watermelons differ in rind patterns. The standard watermelons have striped patterns on a dark or light green background. Some varieties (e.g. Sweet Gem) have a pure dark green rind that may be particularly attractive at the local market.

Although watermelons with red flesh are most familiar, yellow, orange and white-fleshed varieties are available.

Planting and Spacing

All cucurbits should be planted after the danger of frost is past, unless frost protection is used, because they are not frost-tolerant. Air temperatures below 50 F cause chilling injury and so it is best to wait until minimum temperatures are above that. For proper germination of direct-seeded crops, soil temperature must be above 60 F. Planting too early (when the soil is too cold and wet) results in poor seedling emergence.

Cucumbers for fresh market: Rows 4 to 6 feet apart. Plants 15 to 18 inches apart in row.

Cucumber pickles for machine harvest: Rows 18 to 20 inches apart. Plants 5 to 7 inches apart in row.

Maximum cucumber yields and fruit quality result only if plants receive adequate and timely moisture. Depending on your soil type, obtaining high-quality cucumbers requires approximately 1 to 2 inches of water per week. An irregular water supply, particularly during blossoming and fruit development, can negatively affect fruit quality and result in increased nubs or hooked fruit.

Melons: Transplants are often used for melon production. Transplants are grown in the greenhouse for about 4 weeks.

Rows 5 to 7 feet apart. Plants 3 to 5 feet apart in row. Plastic mulch is recommended. Clear mulch is suggested only for earliest plantings in northern areas.

Melons are moderately deep rooted and require adequate soil moisture with good drainage. Natural rainfall may not be adequate, so supplemental irrigation may be required. When irrigating, irrigate the soil in the effective root zone to field capacity. A good, steady moisture supply is critical for good melon production. Excessive moisture during fruit ripening may reduce fruit quality and result in unmarketable fruit.

Pumpkins and Squash – bush types: Rows 4-6 feet apart. Plant 18-24 inches apart in row. Seed: 4-6 pounds per acre.

Pumpkins and Squash – vining types: Rows 6-8 feet apart. Plant 2-5 feet apart in row. Seed: 2-3 pounds per acre.

Watermelons: Transplants are often used for watermelon production. Transplants are grown in the greenhouse for about 4 weeks.

Rows 6 to 12 feet apart. Plants 3 to 6 feet apart in row. One plant per hill. Plastic mulch is recommended for all transplanted watermelons.

Watermelons – mini or "personal-sized": Rows 6 to 10 feet apart. Plants 1.5 to 2 feet apart in row to allow 12 to 15 square feet per plant.

Pumpkins, winter squash, and watermelons are deep-rooted plants, so natural rainfall often is adequate, and irrigation may not be cost effective on heavier soils. Adequate soil moisture in the early growth stages will help ensure vigorous growth. Soil moisture also is critical during blossoming and fruit development.

Fertilizing

pH: Maintain a soil pH of 6.0 to 6.8, or 6.3 to 6.8 for melons. Soil pH lower than 5.5 may result in manganese toxicity. Melons are particularly sensitive to low soil pH.

Magnesium: If your soil test indicates less than 70 ppm magnesium use dolomitic limestone if lime is needed. If lime is not needed, apply 50 pounds per acre Mg broadcast preplant incorporated.

Cucumbers for fresh market, Melons, Pumpkins, Squash, and Watermelon Melon, watermelon, pumpkin and squash generally accumulate in the vegetation and fruit 145-160 pounds N, 30 to 45 pounds P_2O_5 and 160 to 180 lbs K_2O. Nitrogen fertilizer application rate should be adjusted based on soil organic matter, and take credits from green manures, legume crops grown in the previous year, and compost and animal manures applied. The actual application rate of phosphorus and potassium fertilizers should be based on soil test results.

For transplants, a complete or high phosphorus starter fertilizer in the transplant water is recommended. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated. When crops are grown on plastic mulch and using drip irrigation, weekly fertigation can be applied. In this case, apply 30-35 pounds N

per acre before planting, and fertigate weekly at 0.5 to 2 pounds N per acre daily depending on the crop growth stage. If crops are grown on plastic mulch but without irrigation, up to 100 pounds N per acre may be applied preplant and side-dress with 30-45 pounds N per acre later in the season.

For direct seeded crops on sandy soils, the preplant N application can be replaced by an early sidedressing of 40 pounds N per acre when the plants show the first true leaves. Apply the second sidedressing of 45 to 60 pounds N per acre at onset of rapid vining.

Cucumbers for processing: Before planting, apply 40 pounds N per acre, 0 to 150 pounds P_2O_5 per acre, and 0 to 200 pounds K_2O per acre based on soil test results and recommendations from your state. Sidedress with another 40 pounds N per acre.

Harvesting

Cucumbers: Unless a once-over mechanical harvester is used, cucumbers should be harvested at two- to four- day intervals to prevent losses from oversized and over-mature fruit. Desired harvest sizes range from 5 to 8 inches long and 1.5 to 2 inches in diameter for fresh market slicing types. If growing for processors, be sure to understand the specific terms of their contracts at the beginning of the growing season. Prices received are related to the quantity of fruit within specific size ranges as established by either USDA guidelines or by the processor.

Melons: During ripening, eastern type cantaloupes develop an identifiable abscission zone and form tan-colored netting. Harvest index is at three-quarter or full-slip stage. The fruit do not keep well in the field when ripe. Harvest every one to three days.

Cantaloupe varieties with long shelf life (such as Infinite Gold and Durawest) were tested in the Midwest. Long shelf-life varieties have delayed abscission compared to normal eastern type cantaloupes. They either stay in green or have a continuous color change. Color and abscission are not used as harvest indices for long shelf-life varieties. Indicators of the optimal ripeness are when there are a few vertical cracks on the peduncle but the fruit has not slipped yet. Long shelf-life varieties can hold longer in the field, allowing growers to harvest two or three times.

Honeydew, crenshaw and canary melons do not develop netting on the skin and do not form abscission zones during ripening. Color is the primary harvest index, and they must be cut from the vine.

Pumpkins and Winter Squash: For pumpkins and most winter squash it is desirable to maintain green plants as long as possible, to allow fruit to mature on the vine. Full fruit maturity typically occurs about 55 days after fruit set; this may be two or more weeks after the rind has turned to its mature color and hardened. Pumpkins and winter squash harvested before full maturity will not keep as long and have lower eating quality. Mature fruits can be windrowed in full sun without worrying about sunburn and collected over a week or more. Acorn squash should be picked and packed close to sale. Though they are considered a winter squash, they are an immature fruit, and do not respond well to field curing. They lose moisture in storage and become more susceptible to post-harvest rots.

For ornamental pumpkins, if the leaves are dying and the fruit is over 50% colored, it may be best to harvest. Fruit harvested earlier than 50% color eventually turn, but they do not become hard, mature fruit and they rot more easily. Getting immature fruit out of the field and into a dry, somewhat shady area will allow for curing without as much risk for sunburn, insect infestation and possibly some fruit rots. Cut them from the vines and clean off as much soil as you can. If you suspect fruit rots may become an issue it would be best to place them in a sanitizing dip if you can. This will not guarantee the fruit will not rot since some fruit rots can be systemic.

Avoid harvesting in wet areas likely to be infested with phytophthora, or keep that fruit separate from fruit harvested from other areas of the field. This will minimize fruit to fruit contamination. Stack and package carefully to avoid stem breakage, and to prevent stems from puncturing other fruit.

Summer Squash: Harvesting and packing summer squash is a delicate process to avoid scratching the soft, immature fruit. Pick off and discard large or damaged fruit to keep the plant producing new flowers and fruit.

Watermelons: Harvesting watermelons at the correct stage of maturity is critical and difficult. While each cultivar is different, maturity can be determined in several ways, including ground spots changing from white to yellow, browning of tendrils nearest the fruit, and a hollow or dull sound when “thumped”. Watermelons should be cut from the plant to avoid vine damage and prevent stem-end rot. Leave 1 to 2 inches of stem attached.

Fungicide Efficacy Table for Cucurbits

Reviewed by Cesar Escalante and Mohammad Babadoost – Sep 2025

This table includes efficacy information about the fungicides recommended in this guide, based on research and experience of authors. The products are listed alphabetically by **Trade Names**.

VG=Very Good, G=good, F=fair, P=poor, S=suppression

Trade Names (REI/PHI)	**Active Ingredients** MOA or FRAC code: fungicides with a number as the MOA code should be tank-mixed or alternated with a different MOA code according to the label.	**Alternaria leaf blight**	**Anthracnose**	**Bacterial fruit blotch**	**Bacterial leaf and fruit spot**	**Downy mildew**	**Gummy stem/ black rot**	**Plectosporium blight**	**Phytophthora blight**	**Powdery mildew**	**Scab**
Actigard (12h/0d)	acibenzolar-S-methyl (P1)			F	P	P				P	P
Agri-Fos, Phostrol(4h to 12 h/0d)	acid/phosphite (33)					F	F		F		
Aprovia Top (12h/0d)	difenoconazole (3), benzovindiflupyr (7)		F				F	F		G	
Bravo, Echo, Equus, Initiate (12h/0d)	chlorothalonil (M5)	G	G			F	G	F	P	P	G
Cabrio (12h/0d)	pyraclostrobin (11)	G	G			P	P	G		P	
copper (4h to 48h/0d)	copper (M1)	P	P	F	F	P	P				
Curzate (12h/3d)	cymoxanil (27)					F					
Dithane, Manzate, Penncozeb (24h/5d)	mancozeb (M3)	G	G			F	G	F			G
Elumin (12h/2d)	ethaboxam (22)					G			G		
Flint (12h/7d)	trifloxystrobin (11)					P		G		P	
Fontelis (12h/1d)	penthiopyrad (7)	G					P	F		F	
Forum 4.18SC (12h/0d)	dimethomorph (40)					P			F		
Gatten (12h/0d)	flutianil (U13)									G	
Gavel (48h/5d)	mancozeb (M3), zoxamide (22)	G				G			F		
Inspire Super (12h/7d)	difenoconazole (3), cyprodinil (9)	G	F				G	F		G	
Luna Experience (12h/7d)	fluopyram (7), tebuconazole (3)	G	F				G			G	
Luna Sensation (12h/0d)	trifloxystrobin (11), fluopyram (7)	G	G				F			F	
Merivon (12h/0d)	fluxapyroxad (7), pyraclostrobin (11)	G	G				P			F	
Miravis Prime (12h/1d)	pydiflumetofen (7), fludioxonil (12)	G					G			G	
Monsoon, Onset, Toledo (12h/7d)	tebuconazole (3)						G			F	
Omega 500F (12h/7d to 30d)	fluazinam (29)					G					
Orondis Gold 200 (4h/0d)	oxathiapiprolin (49)								F		
Orondis Opti (12h/0d)	oxathiapiprolin (49), chlorothalonil (M5)					VG			F		
Orondis Ultra (12h/0d)	oxathiapiprolin (49), mandipropamid (40)					G			VG		
Presidio 4SC (12h/2d)	fluopicolide (43)					F			G		
Previcur Flex (12h/2d)	propamocarb (28)					G					
Pristine (12h/0d)	boscalid (7), pyraclostrobin (11)	G	G			P	P			P	
Procure (12h/0d)	triflumizole (3)									VG	
Proline (12h/7d)	prothioconazole (3)									VG	
Quadris, Satori (4h/1d)	azoxystrobin (11)	G	G			P	P	G		P	
Quadris Opti (12h/1d)	azoxystrobin (11), chlorothalonil (M5)	G	G			P	P			P	
Quadris Top (12h/1d)	azoxystrobin (11), difenoconazole (3)	G	G				G	G		P	
Quintec (12h/3d)	quinoxyfen (13)									VG	
Rally (24h/0d)	myclobutanil (3)									F	
Ranman (12h/0d)	cyazofamid (21)					G			G		
Revus (4h/0d)	mandipropamid (40)					P			VG		
Rhyme (12h/0d)	flutriafol (3)									G	
Switch 62.5WB (12h/1d)	cyprodinil (9), fludioxonil (12)	G					G			F	
Tanos (12h/3d)	cymoxanil (27), famoxadone (11)	G	G	S		P			S		
Topsin M (24h/0d)	thiophanate-methyl (1)		G				F	F		F	
Torino (4h/0d)	cyflufenamid (U6)									F	
Velum Prime (12h/0d)	fluopyram (7)										
Vivando (12h/0d)	metrafenone (U8)									VG	
Zampro (12h/0d)	ametoctradin (45), dimethomorph (40)					G			F		
Zing (12h/0d)	zoxamide (22), chlorothalonil (M5)	G	G			G			F		

Cucurbit Crops - Diseases

Reviewed by Mohammad Babadoost, Cesar Escalante, Mary Hausbeck – Sep 2025

Angular Leaf Spot of Cucurbits - Pseudomonas Bacteria

Use pathogen-free seed and disease-free transplants. Resistant cucumber varieties are available. Rotate to non-cucurbit crops at least 2 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Once in the field, apply a fixed copper product tank-mixed with mancozeb 2 weeks prior to the opening of the first female bloom, at first female bloom, and 2 weeks after the first female bloom. Later in the season, fixed copper products may be applied to help reduce disease spread depending on disease pressure

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Use disease-free seed and transplants. Resistant cucumber varieties are available. Rotate to non-cucurbit crops at least 2 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use. Applications of copper plus macozeb is more effective than copper alone. See label for directions. No more than 6 applications per season. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Anthracnose of Cucurbits - Colletotrichum Fungus

Race 1 of this fungal pathogen that causes anthracnose affects mainly cucumber and melon; many watermelon varieties are resistant to Race 1. Race 2 affects mainly watermelon. Lesions of this disease may be observed from transplant stage through harvest on leaves, stems, and fruit. May be seedborne. *At vine touch*, at 7-14 day intervals or according to MELCAST - see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST,* available from the Purdue Extension Education Store, www.edustore.purdue.edu.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Watermelon | Use pathogen-free seed and disease-free transplants. Rotate to a non-cucurbit crop for 2 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important practice to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 11-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 1-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Watermelon* | 12-16 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.25-4.25 pt. per acre. Use 54% (720) formulations at 1.5-3.0 pt. per acre. Use 82.5% (WDG) formulations at 1.4-2.7 lb. per acre. Use 90% DF formulations at 1.25-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

Inspire Super (difenoconazole, cyprodinil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 09.

Luna Sensation (fluopyram, trifloxystrobin) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 7.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

mancozeb products (mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several

formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Merivon (fluxapyroxad, pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Watermelon* | 5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.75-2.5 pts. per acre. Make no more than 2 sequential applications before rotating to a different mode of action. When 3 fungicide applications are used, Orondis can be in no more than 33% of the applications. Do not follow soil applications of Orondis Gold. REI: 12-hour. PHI: 0-day. FRAC 49, FRAC M05.

Pristine 38WG (boscalid, pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 12.5-18.5 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 3.2 pts. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 03.

Tanos (famoxadone, cymoxanil) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 8 oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11, FRAC 27.

Topsin 4.5FL (thiophanate-methyl) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | Use 4FL formulation or Cercobin at 10 fl. oz. per acre, or 70WSB formulation at 0.5 lb. per acre. REI: 24-hour to 3-day. PHI: 1-day. FRAC 01.

Zing! (zoxamide, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 36 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 22, FRAC M05.

Bacterial Fruit Blotch of Cucurbits - Acidovorax Bacteria

Once in the field, apply a fixed copper product tank-mixed with mancozeb 2 weeks prior to the opening of the first female bloom, at first female bloom, and 2 weeks after the first female bloom. Later in the season, fixed copper products may be applied to help reduce disease spread depending on disease pressure

Pesticide

Actigard (acibenzolar-s-methyl) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 0.5-1 oz. per acre. Apply with two of the fixed copper product applications described for bacterial fruit blotch. REI: 12-hour. PHI: 0-day. FRAC P01.

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use. Applications of copper plus macozeb is more effective than copper alone. See label for directions. No more than 6 applications per season. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Bacterial Wilt of Cucurbits - Erwinia Bacteria

Primarily a disease of cucumber and melon. Pumpkins and squash are only affected when striped and spotted beetles feed on the plants at or before the 5 true leaf stage. Disease control depends on control of striped and spotted cucumber beetles. See insect section.

Pesticide

Insecticides *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash* | Apply systemic insecticides such as Admire or Platinum (see insect section) at transplant. Apply contact insecticides after systemic insecticides after systemic insecticides lose effectiveness (2-3 weeks). Apply foliar insecticides only when cucumber beetles are present. When large numbers are present, treatments may be required twice weekly. Scout fields regularly for cucumber beetles.

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Using treated seed may help reduce the severity of damping-off if used with the cultural methods discussed above. Seed treated with contact fungicides with the active ingredients thiram or captan may help reduce the decay of the seed prior to emergence. Systemic products are designed to move into the seedling and help manage damping-off in the first two to three weeks. Examples of systemic products include Apron XL, Dynasty, and Maxim 4FS. Seed that is treated with all three of these systemic products is available with the trade name Farmore 300. Vegetable seed that is usually for transplanting (such as muskmelon and watermelon), are less likely to benefit from fungicide seed treatments than crops that are direct seeded (such as pumpkin).

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid excess moisture to the transplants in the greenhouse by monitoring irrigation frequency. Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Pesticide

azoxystrobin products (azoxystrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 9.6% formulations (Dynasty) for seed treatment at 0.10-0.38 fl. oz. per 100 lbs. of seed. REI: 4-hour. PHI: 1-day. FRAC 11.

Maxim 4FS (fludioxonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 0.08-0.16 fl. oz. per 100 lb. of seed. Seed treatment will help prevent damping-off caused by Rhizoctonia spp. REI: 12-hour. FRAC 12.

mefenoxam/metalaxyl products (mefenoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | For damping-off caused by Pythium spp. Several formulations (Apron, MetaStar, Ridomil Gold, Ultra Flourish, Subdue Maxx, and Xyler) are labeled. Several formulations are labeled as pre-plant incorporated or surface broadcast and banded applications at various rates between 0.25 pt. and 8 pt. per acre. A 33.3% seed treatment formulation can be used at 0.32-0.64 fl. oz. per 100 lb. of seed. A 22% formulation can be used at 21.7-43.5 ml. per 1000 sq. ft. *for transplants grown for retail sale to consumers*. REI: 48-hour. PHI: 5-day. FRAC 04.

Previcur Flex (propamocarb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | For Pythium in the field, apply 0.6-1.2 pts. per acre directed to base of plant and surrounding soil, or through drip irrigation or transplant water. In the greenhouse, maintain a 1:1000 stock solution of 12.8 fl. oz. per 100 gals. of water. Use that stock at 3.4-6.8 fl. oz per plant. REI: 12-hour. PHI: 2-day. FRAC 28.

Seed treatments for diseases (various ingredients) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Rates of other options otherwise not listed here vary by product, and are often multiple premixed ingredients. Select seed treatments with ingredients such as azoxystrobin, captan, mefenoxam/metalaxyl, fludioxonil, thiabendazole, difenoconazole, prothioconazole, or thiram.

Downy Mildew of Cucurbits - Pseudoperonospora Oomycete

The fungus-like organism that causes downy mildew, *Pseudoperonospora cubensis,* has two clades. Clade 1 occurs more frequently on watermelon, pumpkin, and squash while clade 2 occurs more frequently on cucumber and cantaloupe.

The pathogen does not survive Midwest winters because it requires green, living plant tissues. That means this organism only overwinters in south Florida or in greenhouses in northern U.S and Canada. The wind carries downy mildew spores to new, living hosts in the Midwest as early as July, and sometimes not at all. Since pumpkins and winter squash are grown until relatively late in the growing season, these crops are often affected more than other cucurbits.

Clade 2 of the pathogen can quickly become resistant to fungicides, and some are no longer effective. Strobilurin fungicides (such as Cabrio, Flint, Merivon, Pristine, Quadris, Reason, Satori) and fungicides with the active ingredient mefenoxam (such as Ridomil) are particularly prone to pathogen resistance. However, Orondis Opti, Ranman, and Omega are effective for control of cucurbit downy mildew. Previcur Flex has occasionally been ineffective for management of downy mildew.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Partially-resistant varieties of cucumber and cantaloupe are available. If your market supports it, avoid late planted cucumbers that will yield after early July when disease pressure is strongest.

Pesticide

Catamaran (potassium phosphite, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6 pts. per acre. REI: 12-hour. PHI: 1-day. FRAC P07, FRAC M05.

chlorothalonil products (chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.25-4.25 pt. per acre. Use 54% (720) formulations at 1.5-3.0 pt. per acre. Use 82.5% (WDG) formulations at 1.4-2.7 lb. per acre. Use 90% DF formulations at 1.25-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

Elumin (ethaboxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8 fl. oz. per acre. Tank-mixing this product with a contact fungicide such as

chlorothalonil or mancozeb will help reduce resistance concerns. REI: 12-hour. PHI: 2-day. FRAC 22.

Gavel 75DF (zoxamide, mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.5-2.0 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

mancozeb products (mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Omega 500F (fluazinam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 12-24 fl. oz. per acre. REI: 12-hour. PHI: 7-day for cucumber and squash, 30-day PHI for watermelon, and cantaloupe/muskmelon. FRAC 29.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.75-2.5 pts. per acre. Make no more than 2 sequential applications before rotating to a different mode of action. Orondis can be in no more than 33% of the applications. Do not follow soil applications of Orondis Gold. REI: 12-hour. PHI: 0-day. FRAC 49, FRAC M05.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.5-8.0 fl. oz. per acre. Make no more than 2 sequential applications before rotating to a different mode of action. Orondis can be in no more than 33% of the applications. Do not follow soil applications of Orondis Gold. REI: 4-hour. PHI: 0-day. FRAC 49, FRAC 40.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | see label. Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. REI: 4 to 12-hour. FRAC P07.

Presidio (fluopicolide) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 43.

Previcur Flex (propamocarb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | For Pythium in the field, apply 0.6-1.2 pts. per acre directed to base of plant and surrounding soil, or through drip irrigation or transplant water. In the greenhouse, maintain a 1:1000 stock solution of 12.8 fl. oz. per 100 gals. of water. Use that stock at 3.4-6.8 fl. oz per plant. REI: 12-hour. PHI: 2-day. FRAC 28.

Ranman 400SC (cyazofamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.75 fl. oz. per acre. Mixing Ranman with a nonionic surfactant may increase efficacy. REI: 12-hour. PHI: 0-day. FRAC 21.

Zampro (ametoctradin, dimethomorph) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 45, FRAC 40.

Zing! (zoxamide, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 36 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 22, FRAC M05.

Fruit Rot of Cucurbits - Fusarium Fungus

The presence of fruit with Fusarium fruit rot may be correlated with the other disease or cultural problems. May be seedborne.

Non-Pesticide

Cantaloupe/Muskmelon, Pumpkin, Squash | Avoid fields with a history of the disease and excess water. Improve drainage with raised beds. Rotate to non-Cucurbit crops for >4 years. Manage foliar diseases for better fruit health.

Fusarium Wilt of Vine Crops - Fusarium Fungus

Non-Pesticide

Cantaloupe/Muskmelon, Watermelon | Avoid fields with a history of the disease and excess water. Improve drainage with raised beds. Rotate to non-cucurbit crops for 5-7 years. Resistant varieties are available. Some growers have success planting watermelon transplants that are grafted on resistant rootstocks.

Pesticide

Miravis Prime (pydiflumetofen, fludioxonil) *Watermelon* | 11.4 fl. oz. per acre. Apply in foliar spray over top of row; direct nozzles on both sides of row as a drench; use overhead

chemigation. See label for details. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 12.

Proline 480SC (prothioconazole) *Cantaloupe/Muskmelon, Pumpkin, Watermelon* | 5.7 fl. oz. per acre. May be applied by ground or chemigation application equipment. Do not use in water used for hand transplanting REI: 12-hour. PHI: 7-day. FRAC 03.

VAPAM HL (metam sodium) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 37.5-75 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place VAPAM HL or Sectagon K42 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Velum Prime (fluopyram) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-6.84 fl. oz. per acre. Apply through drip irrigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 5 days between applications. REI: 12-hour. PHI: 0-day. FRAC 07.

Gummy Stem Blight/Black Rot of Cucurbits - Didymella Fungus

Gummy stem blight may occur on cucurbits from transplant through harvest. The leaves and stems may be affected. Occasionally, fruit are affected, which is known as black rot. The black rot phase of the disease is more common in pumpkins than the gummy stem blight phase. May be seedborne.

Strains of the gummy stem blight fungus are known to exist in the Midwest that are resistant to some fungicides. Strobilurin fungicides in Group 11 (such as Cabrio, Flint, Merivon, Pristine, Quadris, Satori) and fungicides with the active ingredient boscalid Group 7 (such as Fontelis and Pristine) are particularly prone to resistance development. Tank-mix these products with products that have a different mode of action in situations.

At vine touch, apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST - see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST,* available from the Purdue Extension Education Store, www.edustore.purdue.edu.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Use pathogen-free seed and disease-free transplants. Rotate to non-cucurbit crops for 3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

chlorothalonil products (chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.25-4.25 pt. per acre. Use 54% (720) formulations at 1.5-3.0 pt. per acre. Use 82.5% (WDG) formulations at 1.4-2.7 lb. per acre. Use 90% DF formulations at 1.25-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

Fontelis (penthiopyrad) *Cantaloupe/Muskmelon* | 12-16 fl. oz. per acre. In the greenhouse use a rate of 0.5 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 1-day. FRAC 07.

Inspire Super (difenoconazole, cyprodinil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 09.

Luna Experience (fluopyram, tebuconazole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10-17 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Flex (fluopyram, difenoconazole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 03.

mancozeb products (mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Miravis Prime (pydiflumetofen, fludioxonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 9.2-11.4 fl. oz. per acre. An adjuvant may be

added at recommended rates. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 12.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.75-2.5 pts. per acre. Make no more than 2 sequential applications before rotating to a different mode of action. When 3 fungicide applications are used, Orondis can be in no more than 33% of the applications. Do not follow soil applications of Orondis Gold. REI: 12-hour. PHI: 0-day. FRAC 49, FRAC M05.

Proline 480SC (prothioconazole) *Cantaloupe/Muskmelon, Pumpkin, Watermelon* | 5.7 fl. oz. per acre. May be applied by ground or chemigation application equipment. Do not use in water used for hand transplanting REI: 12-hour. PHI: 7-day. FRAC 03.

Quadris Opti (azoxystrobin, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 3.2 pts. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 03.

Switch 62.5WG (cyprodinil, fludioxonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 11-14 oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 09, FRAC 12.

tebuconazole products (tebuconazole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Zing! (zoxamide, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 36 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 22, FRAC M05.

Leaf and Fruit Spot of Cucurbits - Xanthomonas Bacteria

Bacterial leaf and fruit spot, caused by *Xanthomonas cucurbitae*, occurs primarily on pumpkin and winter squash. Symptoms on leaves may occur from the 4-leaf stage through the remainder of the season. Fruit can be infected from time of set until ripen (colored). Fruit are more susceptible at early developing stages than maturing fruit. Only fruit infection is of economic importance. Bacterial leaf and fruit spots may be colonized by other organisms (such as *Fusarium* and soft-rot bacteria), which results in fruit rot.

The bacterial leaf and fruit spot pathogen can survive on infected leaf and fruit residues for more than 24 months. Also, the pathogen has been detected on and in seed for longer than 20 months from harvest. The pathogen may move from infected seed to seedling. Leaf symptoms of this disease may be similar to angular leaf spot caused by *Pseudomonas* bacterium. The only known hosts of the leaf spot pathogen (*Xanthomonas*) are plants in the Cucurbitaceae family. However, bacterial spots developed on leaves of inoculated bur cucumber (*Sicyos angulatus*) and velvetleaf (*Abutilon theophrasti*) weeds in greenhouse inoculations. In addition, the bacterium has been isolated from asymptomatic weeds in pumpkin fields during the season and after harvesting pumpkins, and the bacterium was pathogenic on pumpkin.

At planting, affected seeds can be treated in hot water. Once in the field, apply a fixed copper product tank-mixed with mancozeb 2 weeks prior to the opening of the first female bloom, at first female bloom, and 2 weeks after the first female bloom. Continue applications until fruit ripening.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Use pathogen-free seed and disease-free transplants. Hot water treatment at 131 F for 15 minutes eradicates the bacteria on and in the seed. Rotate to non-cucurbit crops for 3 years or longer. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important practice to minimize pathogen survival with plant debris.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use. Applications of copper plus mancozeb is more effective than copper alone. See label for directions. No more than 6 applications per season. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Leaf Blight of Cucurbits - Alternaria Fungus

Alternaria leaf blight (ALB) primarily affects cantaloupe. ALB symptoms may occur on leaves from May through harvest. *At vine touch,* apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST - see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST,* available from the Purdue Extension Education Store, www.edustore.purdue.edu.

Fungicide application is unnecessary within 2-3 weeks of final harvest.

Non-Pesticide

Cantaloupe/Muskmelon | Rotate to non-cucurbit crops for 2 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 11-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 1-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Watermelon* | 12-16 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.25-4.25 pt. per acre. Use 54% (720) formulations at 1.5-3.0 pt. per acre. Use 82.5% (WDG) formulations at 1.4-2.7 lb. per acre. Use 90% DF formulations at 1.25-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

Fontelis (penthiopyrad) *Cantaloupe/Muskmelon* | 12-16 fl. oz. per acre. In the greenhouse use a rate of 0.5 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 1-day. FRAC 07.

Gavel 75DF (zoxamide, mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.5-2.0 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

Inspire Super (difenoconazole, cyprodinil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 09.

Luna Experience (fluopyram, tebuconazole) *Cantaloupe/Muskmelon, Pumpkin, Watermelon* | 6-17 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Flex (fluopyram, difenoconazole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 03.

Luna Sensation (fluopyram, trifloxystrobin) *Cantaloupe/Muskmelon* | 7.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

mancozeb products (mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Merivon (fluxapyroxad, pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Miravis Prime (pydiflumetofen, fludioxonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 9.2-11.4 fl. oz. per acre. An adjuvant may be added at recommended rates. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 12.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.75-2.5 pts. per acre. Make no more than 2 sequential applications before rotating to a different mode of action. When 3 fungicide applications are used, Orondis can be in no more than 33% of the applications. Do not follow soil applications of Orondis Gold. REI: 12-hour. PHI: 0-day. FRAC 49, FRAC M05.

Pristine 38WG (boscalid, pyraclostrobin) *Cantaloupe/Muskmelon* | 12.5-18.5 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 3.2 pts. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 03.

Switch 62.5WG (cyprodinil, fludioxonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash,*

Watermelon | 11-14 oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 09, FRAC 12.

Tanos (famoxadone, cymoxanil) *Cantaloupe/Muskmelon* | 8 oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11, FRAC 27.

Velum Prime (fluopyram) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-6.84 fl. oz. per acre. Apply through drip irrigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 5 days between applications. REI: 12-hour. PHI: 0-day. FRAC 07.

Zing! (zoxamide, chlorothalonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 36 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 22, FRAC M05.

Leaf and Vine Blight of Cucurbits - Plectosporium Fungus

Plectosporium blight primarily affects pumpkin. Leaves, stems, and fruit can be affected. *At vine touch,* start applying contact/systemic fungicide applications and continue at 7-14 day intervals.

Non-Pesticide

Pumpkin, Squash | Avoid fields with a history of the disease and excess water. Rotate to non-cucurbit crops for 3-4 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 11-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 1-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Watermelon* | 12-16 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

Flint Extra (trifloxystrobin) *Pumpkin, Squash* | 2.0-3.8 fl. oz. per acre. Use Flint (50%) formulation at 1.5-2 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Inspire Super (difenoconazole, cyprodinil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 09.

mancozeb products (mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Merivon (fluxapyroxad, pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Watermelon* | 5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris Top (azoxystrobin, difenoconazole) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 03.

Nematodes

Winter/off-season: Root-knot nematodes have a host range of more than 2,000 plant species, so crop rotation is often ineffective unless a grain crop is used. Certain cover crops may lessen symptom severity.

Planting: Vydate at planting may manage moderate nematode populations. Fumigants may be used for higher nematode populations.

Harvest: Examine stunted and wilting plants for the presence of root-knot nematodes.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Collect soil samples for nematode extraction in the fall and avoid fields with high numbers. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue and displace nematodes is an important method to prevent nematode build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain nematodes.

Pesticide

K-PAM HL (metam potassium) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 30-62 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place K-PAM HL or Sectagon K54 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Nimitz (fluensulfone) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 3.5-7 pts. per acre. Do not use on direct-seeded plants. May be broadcast, banded, or drip-applied in the spring up to 7 days before planting at a depth of 8 inches. Effectiveness is reduced on muck and clay soils. REI: 12-hour. IRAC UN.

Telone C-17 (1,3-dichloropropene, chloropicrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Muck soils*: Use C-17 formulation at 27.4-30 gals. per acre, and C-35 formulation at 33-36 gals. per acre. *Mineral soils*: Use C-17 formulation at 10.8-17.1 gals. per acre, and C-35 formulation at 13-20.5 gals per acre. In the fall, when soil at 6 inches is above 50 F and moist, place Telone C-17 or C-35 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing, irrigation, or plastic. Or, in the spring, InLine may be applied through drip irrigation under unperforated plastic beds at 13-20.5 gals. per acre, on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 3-5-day. IRAC 8A, FRAC NC, IRAC 08B. *RUP.*

Telone II (1,3-dichloropropene) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Muck soils*: Use at 25 gals. per acre. *Mineral soils*: Use at 9-12 gals. per acre. In the spring or fall, when soil at 6 inches is above 50 F and moist, place Telone II about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, Telone EC may be applied through drip irrigation under unperforated plastic beds at 9-18 gals. per acre on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 8A, FRAC NC. *RUP.*

VAPAM HL (metam sodium) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 37.5-75 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place VAPAM HL or Sectagon K42 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Velum Prime (fluopyram) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-6.84 fl. oz. per acre. Apply through drip irrigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 5 days between applications. REI: 12-hour. PHI: 0-day. FRAC 07.

Vydate L (oxamyl) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Apply 1-2 gals. per acre as a banded or shank-injected pre-plant, at-plant in-furrow or directed post-plant soil treatment with at least 20 gals. water per acre incorporated 2-4 inches deep by water or mechanical means, or drip chemigate 2-4 pts. per acre after transplanting. Allow 14 days between applications. Do not exceed 8 total applications, or 3 gals. per acre per season. REI: 48-hour. PHI: 1-day. IRAC 01A. *RUP.*

Phytophthora Blight of Multiple Crops - Phytophthora Oomycete

Phytophthora may cause damping-off, vine infection, and fruit rot in cucurbits. It is often associated with heavy rains and fields with poor drainage. The first symptoms are usually observed in low areas. It has a wide host range of crops and weeds, including cucurbits, peppers, beans, nightshades and velvetleaf. Ponds and streams with run-off water from infested soil may be contaminated with Phytophthora.

At planting, treat seed with Apron XL LS to help prevent *Phytophthora* infection for 5 weeks from time of seeding. *At vine touch,* apply effective fungicides at first sign of the disease.

At harvest, if you touch an infected fruit, disinfest your hands (using soap or ethanol) before touching an uninfected fruit. Do not place uninfected fruits on soil infested with *Phytophthora*. Keep harvested fruit in dry conditions.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Avoid fields with a history of the disease and excess water. Improve drainage with raised beds. Reduce soil inoculum with weed control and rotate to non-cucurbit and non-Solanaceous crops for >4 years, with effective weed

control. Do not irrigate with surface water that receives runoff water from infested soil. Removing residue of the finished crop is an important method to reduce inoculum build-up in soil.

Pesticide

Elumin (ethaboxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8 fl. oz. per acre. Tank-mixing this product with a contact fungicide such as chlorothalonil or mancozeb will help reduce resistance concerns. REI: 12-hour. PHI: 2-day. FRAC 22.

Forum (dimethomorph) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 40.

Gavel 75DF (zoxamide, mancozeb) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.5-2.0 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

Orondis Gold (oxathiapiprolin, mefenoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 28-55 fl. oz. per acre. Use as an at-plant soil drench, banded spray in furrow, or through drip irrigation. Do not follow soil applications of Orondis Gold with foliar applications of Orondis Opti, or Orondis Ultra. REI: 4-hour. PHI: 0-day. FRAC 49, FRAC 04.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.5-8.0 fl. oz. per acre. Make no more than 2 sequential applications before rotating to a different mode of action. Orondis can be in no more than 33% of the applications. Do not follow soil applications of Orondis Gold. REI: 4-hour. PHI: 0-day. FRAC 49, FRAC 40.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | see label. Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. REI: 4 to 12-hour. FRAC P07.

Presidio (fluopicolide) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 43.

Ranman 400SC (cyazofamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.75 fl. oz. per acre. Mixing Ranman with a nonionic surfactant may increase efficacy. REI: 12-hour. PHI: 0-day. FRAC 21.

Revus (mandipropamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8 fl. oz. per acre. Suppression only. REI: 4-hour. PHI: 0-day. FRAC 40.

Tanos (famoxadone, cymoxanil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8-10 oz. per acre. Suppression only. REI: 12-hour. PHI: 3-day. FRAC 11, FRAC 27.

Zampro (ametoctradin, dimethomorph) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 45, FRAC 40.

Powdery Mildew of Cucurbits - Podosphaera Fungus

Powdery mildew is primarily a disease of cantaloupe, cucumber, pumpkin, and squash. This disease does not require leaf wetness for disease initiation or spread.

At vine touch, begin systemic fungicide applications at bush stage of pumpkin growth. Protect pumpkin vines until approximately 21 days from last harvest. Some pumpkin varieties have partial resistance to powdery mildew.

Fungicide resistance has been detected in the Midwest. Fungicides in FRAC 1 and 11 may not be effective. Fungicides that are effective include Cabrio, Flint, Gatten, Inspire Super, Luna Flex, Procure, Quintec, Quadris, Rhyme, Satori, Sovran, Torino, and Topsin. Alternate fungicides between MOA groups.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Rotate to non-cucurbit crops for 2 years. Resistant or partially resistant cantaloupe, cucumber and pumpkin cultivars are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

Fontelis (penthiopyrad) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 12-16 fl. oz. per acre. In the greenhouse use a rate of 0.5 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 1-day. FRAC 07.

Gatten (flutianil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC U13.

Inspire Super (difenoconazole, cyprodinil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 09.

Luna Experience (fluopyram, tebuconazole) *Cantaloupe/Muskmelon, Pumpkin, Watermelon* | 6-17 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Flex (fluopyram, difenoconazole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 03.

Luna Sensation (fluopyram, trifloxystrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-7.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Miravis Prime (pydiflumetofen, fludioxonil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 9.2-11.4 fl. oz. per acre. An adjuvant may be added at recommended rates. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 12.

Procure 480SC (triflumizole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Proline 480SC (prothioconazole) *Cantaloupe/Muskmelon, Pumpkin, Watermelon* | 5.7 fl. oz. per acre. May be applied by ground or chemigation application equipment. Do not use in water used for hand transplanting REI: 12-hour. PHI: 7-day. FRAC 03.

Prolivo 300SC (pyriofenone) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 4-5 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 50.

Quintec (quinoxyfen) *Cantaloupe/Muskmelon, Pumpkin, Squash, Watermelon* | 4-6 fl. oz. per acre. May cause leaf yellowing. Product is a contact fungicide. Labeled for winter squash-not summer squash. REI: 12-hour. PHI: 3-day. FRAC 13.

Rally 40WSP (myclobutanil) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.5-5.0 oz. per acre. REI: 24-hour. PHI: 0-day. FRAC 03.

Rhyme 250SC (flutriafol) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5-7 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

tebuconazole products (tebuconazole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6-8 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Torino (cyflufenamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 3.4 oz. per acre. REI: 4-hour. PHI: 0-day. FRAC U06.

Velum Prime (fluopyram) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6.5-6.84 fl. oz. per acre. Apply through drip irrigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 5 days between applications. May cause a mild yellowing of leaf margins. REI: 12-hour. PHI: 0-day. FRAC 07.

Vivando (metrafenone) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 15.4 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 50.

Wettable Sulfur (sulfur) *Cantaloupe/Muskmelon, Watermelon* | Rates vary by product. Use 80% sulfur products at 5-10 lb. per acre (Microthiol Disperss), 5-25 lb. per acre (Sulfur 80 WDG), or 20-25 lb. per acre (Sulfur Dry Flowable, Thiolux). Use 90% sulfur at 2-4 lb. per acre (Golden Micronized Sulfur) or 15-20 lb. per acre (Sulfur 90W). REI: 24-hour. PHI: 0-day. FRAC M02, IRAC UN. *OMRI-listed.*

Wettable Sulfur (sulfur) *Cucumber* | Rates vary by product. Use 80% sulfur products at 2-4 lb. per acre (Microthiol Disperss, Sulfur Dry Flowable), 2-6 lb. per acre (Thiolux), or 2-10 lb. per acre (Sulfur 80 WDG). Use 90% sulfur at 15-20 lb. per acre (Sulfur 90W). REI: 24-hour. PHI: 0-day. FRAC M02, IRAC UN. *OMRI-listed.*

Wettable Sulfur (sulfur) *Pumpkin, Squash* | Rates vary by product. Use 80% sulfur products at 5-10 lb. per acre (Microthiol Disperss, Sulfur Dry Flowable, Sulfur 80 WDG, Thiolux). Use 90% sulfur at 2-4 lb. per acre (Golden

Micronized Sulfur) or 15-20 lb. per acre (Sulfur 90W). REI: 24-hour. PHI: 0-day. FRAC M02, IRAC UN. *OMRI-listed.*

Scab of Cucurbits - Cladosporium Fungus

Scab lesions may be observed on the fruit of most cucurbit crops. Fungicides may help to reduce the severity of scab if applied before fruit development. Some fungicides used for gummy stem blight control may help. But fungicides may be ineffective when temperatures of less than 57 F persist for longer than 9 hours.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Use pathogen-free seed and disease-free transplants. Rotate to non-cucurbit crops for 3-4 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Viruses of Multiple Crops - Multiple Pathogens

Aphids transmit virus diseases, including cucumber mosaic virus, papaya ring spot virus, watermelon mosaic virus, and zucchini yellow mosaic virus. Also, seedborne squash mosaic virus occurs in the Midwest. These diseases usually appear later in the season, they most often affect pumpkin and squash. All types of vine crops are susceptible to these viruses. Squash mosaic virus is seed-borne and can be transferred by cucumber beetles. See insect section.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | It may help to kill perennial weeds (virus source plants) within 150 feet of planting. Controlling aphids (virus carriers) by insecticides can reduce secondary spread of viruses but does not reduce initial infection and rarely results in any decrease in the incidence of virus symptomatic fruit. Early planting and development of pumpkins and squash fruit before virus diseases become prevalent may reduce symptoms on fruit. Earlier planted or earlier maturing cultivars will help to avoid severe disease problems. Varieties with host resistance include cucumbers (cucumber mosaic virus) and squash (watermelon mosaic virus; zucchini yellow mosaic virus; cucumber mosaic virus; papaya ringspot virus).

Cucurbit Crops - Insects

Reviewed by Laura Ingwell, Marissa Schuh, Ashley Leach, Dan Fillius – Apr 2025

Aphids

Many species of aphids feed on cucurbits in our region, including melon aphids. Aphids can vector cucumber mosaic virus, watermelon mosaic virus, zucchini yellow mosaic virus, cucurbit-papaya ringspot potyvirus, and other minor viruses. Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.5-3.0 oz. per acre. See pollinator precautions. REI: 12-hour. PHI: 0-day. IRAC 04A.

Admire Pro (imidacloprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 7.0-10.5 fl. oz. per acre. See label for various soil application methods. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 21-day. IRAC 04A.

Assail 30SG (acetamiprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 30SG formulations at 2.5-4.0 oz. per acre. Use 70WP formulations at 1.1-1.7 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Belay (clothianidin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre, and stop once 4th true leaf on main stem has unfolded. REI: 12-hour. PHI: 21-day. IRAC 04A.

Beleaf (flonicamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2-2.8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Dimethoate 4EC (dimethoate) *Cantaloupe/Muskmelon, Watermelon* | Use 2.67EC formulations at 0.75-1.5 pts. per acre. Use 4EC, LV-4, and 400EC formulations at 0.5-1.0 pt. per acre. REI: 48-hour. PHI: 3-day. IRAC 01B.

Exirel (cyantraniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 13.5-20.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Fulfill (pymetrozine) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.75 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 09B.

Harvanta (cyclaniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.9-16.4 fl. oz. per acre. Use with adjuvant. REI: 4-hour. PHI: 1-day. IRAC 28.

Lannate LV (methomyl) *Cantaloupe/Muskmelon, Cucumber, Squash, Watermelon* | 1.5-3.0 pts. per acre. Not for pumpkins or winter squash. REI: 48-hour. PHI: 1-day for 1.5 pts. rate, 3-day for rates over 1.5 pts. IRAC 01A. *RUP.*

M-Pede (potassium salts of fatty acids) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1-2% by volume. Must contact insect to be effective. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Malathion 5EC (malathion) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 5EC formulations at 1.5-2.8 pts. per acre for cucumber and squash, 1.6 pts. per acre for melon, 1.5 pts. per acre for pumpkin, 1.6-2.8 pts. per acre for squash, or 1.5-2.5 pts. per acre for watermelon. Use 57EC formulations at 1.5 pts. per acre on cucumber, melon, pumpkin, squash, and watermelon. REI: 12-hour. PHI: 1-day. IRAC 01B.

Perm-Up 25DF (permethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6.4-12.8 oz. per acre. Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. High rate for aphids. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5-11 fl. oz. per acre. Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. Should never be used in combination with

insecticide seed treatments. REI: 12-hour. PHI: 30-day. IRAC 04A.

Scorpion 35SL (dinotefuran) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1.0-4.0 oz. per acre. See pollination precautions. REI: 12-hour. PHI: 21-day for soil applications, 1-day for foliar applications. IRAC 04A.

Sivanto 200 (flupyradifurone) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 21-28 fl. oz. per acre soil application, or 7-12 fl. oz. per acre foliar application. Should never be used in combination with insecticide seed treatments. REI: 4-hour. PHI: 21-day for soil application, or 1-day for foliar application. IRAC 04D.

Verimark (cyantraniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.0-13.5 fl. oz. per acre. Apply via drip irrigation or soil injection. REI: 4-hour. PHI: 1-day. IRAC 28.

Warrior II (lambda-cyhalothrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Cucumber Beetles

Cucumber beetles damage plants through direct feeding and transmission of bacterial wilt, squash mosaic virus, and cucurbit yellow vine decline (CYVD) to plants. Plants exhibiting symptoms, such as, wilting and stunting should be removed from the planting area. Seed treatments for direct seeded crops may be used. Soil drenches applied during planting may protect young plants from adult feeding. Contact insecticides should be applied in the evening when flowers are closed and bees are not foraging, which will reduce direct exposure to insecticide residues.

Weekly scouting is sufficient to track beetle populations and inform spray decisions. Economic damage can occur on fruit from feeding by both adult beetles and larvae. Beetles found in flowers do not pose a risk to the plant but as flowering decreases, rind feeding may increase and thresholds may need to be lowered.

From seedling to the 4-leaf stage

Treat when at 0.5 beetle per plant for cucumbers and cantaloupes/muskmelons, or 1 beetles per plant for pumpkin, squash and watermelon

From 4-leaf stage to harvest

Treat when at 1 beetle per plant for cucumbers and cantaloupes/muskmelons, or 5 beetles per plant for pumpkin, squash and watermelon

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Yellow sticky traps are attractive to cucumber beetles and can detect mass emergence during periods of heavy beetle activity. Excluding cucumber beetles with row cover can prevent feeding on vulnerable young plants in smaller plantings or by targeting susceptible varieties. While row covers can be used to protect young plants, they need to be opened at flowering to allow access to pollinators. Trap crops, such as blue hubbard squash, can be planted before and adjacent to the main crop to draw beetles out of the cash crop.

Pesticide

Admire Pro (imidacloprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 7.0-10.5 fl. oz. per acre. See label for various soil application methods. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 21-day. IRAC 04A.

Asana XL (esfenvalerate) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.5-5.3 oz. per acre. Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.1-2.3 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Azera (azadirachtin, pyrethrins) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 48 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC UN, IRAC 03A. *OMRI-listed.*

Baythroid XL (beta-cyfluthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.4-4.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre, and stop once 4th true leaf on main stem has unfolded. REI: 12-hour. PHI: 21-day. IRAC 04A.

Brigade 2EC (bifenthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 2EC formulations at 2.6-6.4 fl. oz. per acre. Use 10DF, 10WP, or

10WSB formulations at 8-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Danitol 2.4EC (fenpropathrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.67-16 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Harvanta (cyclaniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.9-16.4 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 28.

Mustang Maxx (zeta-cypermethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.8-4 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6.4-12.8 oz. per acre. Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. High rate for aphids. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Seed treatments for insects (various ingredients) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Rates vary by product, and are often multiple premixed ingredients. Seed treatments containing thiamethoxam (FarMore FI400, Cruiser 5FS) offer maximum protection against cucumber beetles and root maggots for about 2 to 3 weeks after seedling emergence. For transplanted crops and direct-seeded plants over 3 weeks old, the concentration of insecticide from seed treatments is no longer strong enough to kill beetles, but can still harm bees due to sublethal doses in the pollen and nectar. Seed treatments should never be used in combination with at-plant soil drenches with flupyradifurone (Sivanto), imidacloprid (Admire or generics), or thiamethoxam (Platinum).

Sevin XLR Plus (carbaryl) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1 qt. per acre. When applied during hot, humid conditions, carbaryl may cause some phytotoxicity, especially on seedlings and newly set plants. See pollinator precautions. REI: 12-hour. PHI: 3-day. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Leafhoppers

Aster leafhopper and potato leafhopper are common in our region and crops. They don't survive the winter in northern areas, and migrate from southern areas every growing season. A condition known as "hopperburn" is caused by potato leafhopper feeding, and aster yellows is a disease vectored by aster leafhopper feeding. The amount of aster yellows present in any leafhopper population varies by year and location. Some states in the region have programs that test for and track the percentage of aster leafhoppers that are carrying aster yellows. Leafhoppers can move into vegetable fields when neighboring grain or alfalfa is harvested.

Management efforts can be stopped 2-3 weeks before harvest, as plants that are infected during that time will be harvested before symptoms manifest.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Avoid planting near early harvested grain or alfalfa fields.

Pesticide

Admire Pro (imidacloprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 7.0-10.5 fl. oz. per acre. See label for various soil application methods. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 21-day. IRAC 04A.

Asana XL (esfenvalerate) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 30SG formulations at 2.5-4.0 oz. per acre. Use 70WP formulations at 1.1-1.7 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Baythroid XL (beta-cyfluthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 0.8-1.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre, and stop once 4th true leaf on main stem has unfolded. REI: 12-hour. PHI: 21-day. IRAC 04A.

Brigade 2EC (bifenthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 2EC formulations at 2.6-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 8-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Dimethoate 4EC (dimethoate) *Cantaloupe/Muskmelon, Watermelon* | Use 2.67EC formulations at 0.75-1.5 pts. per acre. Use 4EC, LV-4, and 400EC formulations at 0.5-1.0 pt. per acre. REI: 48-hour. PHI: 3-day. IRAC 01B.

Perm-Up 25DF (permethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6.4-12.8 oz. per acre. Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. High rate for aphids. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5-11 fl. oz. per acre. Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 30-day. IRAC 04A.

Scorpion 35SL (dinotefuran) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1.0-4.0 oz. per acre. See pollination precautions. REI: 12-hour. PHI: 21-day for soil applications, 1-day for foliar applications. IRAC 04A.

Sivanto 200 (flupyradifurone) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 21-28 fl. oz. per acre soil application, or 7-12 fl. oz. per acre foliar application. Should never be used in combination with insecticide seed treatments. REI: 4-hour. PHI: 21-day for soil application, or 1-day for foliar application. IRAC 04D.

Warrior II (lambda-cyhalothrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Mites

Mite populations spike in hot dry weather. Damage appears as white flecks on leaves, accompanied by webbing. Selective chemistries (e.g. abamectin, bifenazate, etoxazole, cyflumetofen, fenpyroximate, hexythiazox, spiromesifen) that target mites help to preserve natural enemies.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Preserve and encourage natural enemies.

Pesticide

Acramite 50WS (bifenazate) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 0.75-1 lb. per acre. REI: 12-hour. PHI: 3-day. IRAC 20D.

Agri-Mek SC (abamectin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15EC formulations at 8-16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 06. *RUP.*

Brigade 2EC (bifenthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.12-6.4 fl. oz. per acre. Use 2EC formulations at 5.12-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 12.8-16.0 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Danitol 2.4EC (fenpropathrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.67-16 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Kanemite 15SC (acequinocyl) *Cantaloupe/Muskmelon, Cucumber, Watermelon* | 31 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 20B.

Oberon 2SC (spiromesifen) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 7.0-8.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 23.

Portal (fenpyroximate) *Cantaloupe/Muskmelon, Cucumber* | 2 pts. per acre. REI: 12-hour. PHI: 1-day for cucumber, 3-day for melon. IRAC 21A.

Zeal (etoxazole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2-3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 10B.

Seed and Root Maggots

Seedcorn maggot is the root maggot of concern in our region. This pest is a problem during cool, wet springs when plants are growing slowly. Egg-laying adults are attracted to the smell of decaying organic matter, and fields where green manures, cover crops, and weeds have been recently killed are at greater risk. Degree day models can be used to time planting and management actions. Seed treatments are available. Warm, dry weather reduces risk of damage.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Plowing of cover crops and weeds 3-4 weeks before planting can result in less damage to seedling plants. Delay planting until after the first generation of adult females have emerged and laid eggs based on growing degree days. Row covers can be placed over crops to exclude egg laying flies before times of activity.

Pesticide

Seed treatments for insects (various ingredients) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Rates vary by product, and are often multiple premixed ingredients. Seed treatments containing thiamethoxam (FarMore FI400, Cruiser 5FS) offer maximum protection against cucumber beetles and root maggots for about 2 to 3 weeks after seedling emergence. For transplanted crops and direct-seeded plants over 3 weeks old, the concentration of insecticide from seed treatments is no longer strong enough to kill beetles, but can still harm bees due to sublethal doses in the pollen and nectar. Seed treatments should never be used in combination with at-plant soil drenches with flupyradifurone (Sivanto), imidacloprid (Admire or generics), or thiamethoxam (Platinum).

Verimark (cyantraniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.0-13.5 fl. oz. per acre. Apply via drip irrigation or soil injection. REI: 4-hour. PHI: 1-day. IRAC 28.

Slugs and Snails

Slugs and snails may occasionally damage seedlings, low growing leafy vegetables, and/or ripening fruit. Slug and snail feeding causes hollowed out areas, which can be found on fruit, but the damage is usually on the stem. Slugs and snails produce a silvery trail on the surface of leaves and fruit. Slugs and snails are active at night and they inhabit moist soil and organic mulch. Slugs and snails overwinter as eggs in moist soil.

Bait products can be placed on the soil surface around the perimeter of the planting area. Bait products can also be placed on the soil surface in a band between rows. Apply bait products in the evening after a rain or irrigation. Avoid contacting edible crops with bait products.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Slug and snail hiding places, such as, boards, stones, weedy areas, and mulch should be eliminated. Raised beds will dry out faster than flat beds, which will reduce problems with slugs and snails. Black plastic mulch can be used to reduce problems with slugs and snails.

Pesticide

Sluggo 1B (iron phosphate) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 20-44 lb. per acre, or 0.5-1 lb. per 1,000 sq. ft. REI: 0-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Squash Bug

Squash bugs vector cucurbit yellow vine decline (CYVD), a new disease in our region.

Squash bug nymphs are the easiest life stage to control with pesticides. Coverage on the underside of the leaf is important for good control.

A threshold of one egg mass per plant can be used, use pesticide applications within a week.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Destroy crop residue to reduce adult overwintering. Some varieties of squash, such as Butternut, Royal Acorn, and Sweet Cheese, tolerate feeding. Traps crops, such as blue hubbard squash, can be planted before and adjacent to the main crop to draw squash bugs out of the cash crop.

Pesticide

Asana XL (esfenvalerate) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.5-5.3 oz. per acre. Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.1-2.3 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Azera (azadirachtin, pyrethrins) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 32-48 fl. oz. per acre. Use higher rates for squash bug adults, or when pest pressure is extreme of plant canopy is dense. REI: 12-hour. PHI: 0-day. IRAC UN, IRAC 03A. *OMRI-listed.*

Belay (clothianidin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre, and stop once 4th true leaf on main stem has unfolded. REI: 12-hour. PHI: 21-day. IRAC 04A.

Brigade 2EC (bifenthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 2EC formulations at 2.6-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 8-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Harvanta (cyclaniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.9-16.4 fl. oz. per acre Effective on nymphs only. REI: 4-hour. PHI: 1-day. IRAC 28.

Mustang Maxx (zeta-cypermethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.8-4 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6.4-12.8 oz. per acre. Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. High rate for aphids. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Scorpion 35SL (dinotefuran) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1.0-4.0 oz. per acre. See pollination precautions. REI: 12-hour. PHI: 21-day for soil applications, 1-day for foliar applications. IRAC 04A.

Sevin XLR Plus (carbaryl) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1 qt. per acre. When applied during hot, humid conditions, carbaryl may cause some phytotoxicity, especially on seedlings and newly set plants. See pollinator precautions. REI: 12-hour. PHI: 3-day. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Squash Vine Borer

Squash vine borer is a day flying moth that does the most damage to small plantings. The window for treatment for managing squash vine borer is small, as caterpillars need to come into contact with products in between egg hatch and burrowing into the crown. Use pesticide within 7-14 days after moths are detected in pheromone traps.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Pheromone-baited traps are attractive to squash vine borers and can detect mass flights and heavy egg-laying activity. Fall tillage can disrupt overwintering success.

Pesticide

Asana XL (esfenvalerate) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.5-5.3 oz. per acre. Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.1-2.3 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Brigade 2EC (bifenthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 2EC formulations at 2.6-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 8-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.8-4 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6.4-12.8 oz. per acre. Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. High rate for aphids. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Warrior II (lambda-cyhalothrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Thrips

Thrips populations spike in hot dry weather, and when neighboring small grains or alfalfa is harvested. Damage appears as white flecks on leaves. Thrips transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Selective chemistries (e.g. abamectin, spinetoram, spirotetramat, and spinosad) that target thrips help to preserve natural enemies.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | A heavy rain or overhead irrigation washes thrips out of plants. Avoid planting near early harvested grain or alfalfa fields. Preserve and encourage natural enemies. Minute pirate bugs, and lacewings are common predators.

Pesticide

Admire Pro (imidacloprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 7.0-10.5 fl. oz. per acre. See label for various soil application methods. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 21-day. IRAC 04A.

Entrust SC (spinosad) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | Use 2SC formulations at 6.0-8.0 fl. oz. per acre. Use 80WP formulations at 2.0-2.5 oz. per acre. REI: 4-hour. PHI: 1-day for cucumber, 3-day for all others. IRAC 05. *OMRI-listed.*

Harvanta (cyclaniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.9-16.4 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 28.

Platinum 2SC (thiamethoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5-11 fl. oz. per acre. Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 30-day. IRAC 04A.

Radiant 1SC (spinetoram) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day for cucumber; 3-day for cantaloupe/muskmelon, pumpkin, squash, and watermelon. IRAC 05.

Scorpion 35SL (dinotefuran) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1.0-4.0 oz. per acre. See pollination precautions. REI: 12-hour. PHI: 21-day for soil applications, 1-day for foliar applications. IRAC 04A.

Whiteflies

Pesticide

Actara (thiamethoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 3.0-5.5 oz. per acre. See pollinator precautions. REI: 12-hour. PHI: 0-day. IRAC 04A.

Admire Pro (imidacloprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 7.0-10.5 fl. oz. per acre. See label for various soil application methods. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 21-day. IRAC 04A.

Assail 30SG (acetamiprid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.5-5.3 oz. per acre. Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.1-2.3 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Beleaf (flonicamid) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2-8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Brigade 2EC (bifenthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5.12-6.4 fl. oz. per acre. Use 2EC formulations at 5.12-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 12.8-16.0 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Exirel (cyantraniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 13.5-20.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Fulfill (pymetrozine) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 2.75 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 09B.

Knack (pyriproxyfen) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 8-10 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 07C.

M-Pede (potassium salts of fatty acids) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1-2% by volume. Must contact insect to be effective. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Neemix (azadirachtin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 6-16 fl. oz. per acre. REI: 4-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Oberon 2SC (spiromesifen) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 7.0-8.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 23.

Platinum 2SC (thiamethoxam) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 5-11 fl. oz. per acre. Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. Should never be used in combination with insecticide seed treatments. REI: 12-hour. PHI: 30-day. IRAC 04A.

Scorpion 35SL (dinotefuran) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom

70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1.0-4.0 oz. per acre. See pollination precautions. REI: 12-hour. PHI: 21-day for soil applications, 1-day for foliar applications. IRAC 04A.

Sivanto 200 (flupyradifurone) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 21-28 fl. oz. per acre soil application, or 7-12 fl. oz. per acre foliar application. Should never be used in combination with insecticide seed treatments. REI: 4-hour. PHI: 21-day for soil application, or 1-day for foliar application. IRAC 04D.

Verimark (cyantraniliprole) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 10.0-13.5 fl. oz. per acre. Apply via drip irrigation or soil injection. REI: 4-hour. PHI: 1-day. IRAC 28.

Wireworms

Wireworms are long-lived in the soil, and are most common in fields that were previously fallow or in pasture.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Avoid planting in fields that were recently in grasses.

Pesticide

Capture LFR (bifenthrin) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 0.2-0.39 fl. oz. per 1,000 linear ft. of row. REI: 12-hour. IRAC 03A. *RUP.*

Cucurbit Crops - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Weed control methods in cucurbits vary by production system.

For cucurbits that are no-till planted into a killed crop (such as a rye cover crop, or wheat) growers often use a burndown herbicide with a preemergence herbicide. For cucurbits planted into tilled soil, growers often combine one or more preemergence herbicides at planting with one or more cultivations. Sometimes, growers also apply a preemergence herbicide at the last cultivation to improve control of late-emerging weeds. Small, emerged weeds in both systems can be controlled with selective postemergence herbicides and/or shielded applications of nonselective herbicides.

When cucurbits are transplanted into plastic mulch, some growers apply a preemergence herbicide under the mulch as well as between the rows. Other growers only apply between the rows. Growers may also use one or more cultivations, and if needed, postemergence herbicides or a shielded application of a nonselective herbicide in row middles.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. Cucurbits lend themselves to this stale seedbed practice because they are often planted after common weeds have emerged in tilled soil. The more quickly vines cover the soil surface, the better they will suppress late-emerging weeds. In-row plant spacing can be decreased to close canopy more quickly. Planting on the square will allow cultivation in two directions. Cucurbits can benefit from the soil warming properties of plastic mulch in addition to the in-row weed control it provides. Materials include landscape cloth/fabric, plastic, and biodegradeable plastic. Straw mulch can delay early season growth by suppressing soil temperatures. Weeds between beds and along the edges of beds can be controlled with a combination of

cultivation, mowing, or hand hoeing/pulling. Weeds along the edge of the mulches can be a particular challenge to avoid ripping the mulch. Some fresh market plantings are often small enough to accommodate some hand hoeing or pulling. For larger plantings it may make more sense to mechanically cultivate with tow-able tools between plastic rows or between bare-soil rows.

Pesticide

Aim EC (carfentrazone) POST

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | 0.5-2 fl. oz. per acre. Apply a minimum of 1 day prior to transplanting or 7 days prior to direct-seeding, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Add COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season REI: 12-hour. HRAC 14.

Chateau SW (flumioxazin) PRE

Cantaloupe/Muskmelon, Watermelon | 4 oz. per acre. For **cantaloupe, honeydew, and watermelon** *with special 24c label only.* Use a shielded or hooded sprayer to apply before transplanting to row middles between plastic mulch-covered raised beds. Bed must be at least 4 inches higher than treated area and at least 24 inches wide. Spray must remain between raised beds and contact no more than the bottom 1 inch of plastic. Do not apply after crops are transplanted. Rainfall or irrigation over beds is required after application but before transplanting. REI: 12-hour. HRAC 14.

clethodim products (clethodim) POST

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Use lower rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 14-day. HRAC 01.

Command 3ME (clomazone) PRE

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | For **cucumber:** use 0.4-1.0 pt. per acre. For **cantaloupe/muskmelon and watermelon:** use 0.4-0.67 pt. per acre. For **summer squash:** use 0.67-1.33 pts. per acre. For **winter squash and processing pumpkins:** use 0.67-2.0 pts. per acre. *Not for jack-o-lantern pumpkins*. See label for sensitive varieties. Apply prior to seeding or transplanting, or after seeding before crop emergence. Does not control pigweed species. Rates below 1 pt. will only suppress weeds. May cause temporary bleaching of crop leaves. REI: 12-hour. PHI: 30-day for cucumber; 30-day for summer squash; 45-day for winter squash and processing pumpkins. HRAC 13.

Curbit EC (ethalfluralin) PRE

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | 3-4 pts. per acre. Use lower rates on coarse soils. *Direct-seeded crops*: apply to soil surface within 2 days after seeding. Do not incorporate. *Transplants*: apply as a banded spray between rows. Does not control large-seeded broadleaves. Needs 0.5 inch of water within 5 days of application to be effective. If no rain occurs, cultivate shallowly. Do not apply over or under hot caps, row covers, or plastic mulch. Do not broadcast over top of plants. Under cool temperatures may cause crop injury or failure. REI: 24-hour. HRAC 03.

Dual Magnum (s-metolachlor) PRE

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | **For pumpkin and winter squash in all states:** use 1.0-1.33 pts. per acre between rows after seeding and before emergence, or after emergence leaving an untreated area at least 6 inches from planted seed or pumpkin leaves. Broadcast application over top of pumpkin rows after seeding and before crop emergence permitted *with special 24c label*. **For cantaloupe/muskmelon and watermelon** *with special 24c label:* use 0.67-1.27 pts. per acre before transplanting or after seeding and before crop emergence. **For cucumber** *with special 24c label:* use 0.67-1.0 pt. per acre after seeding before weeds or crop emerge, or broadcast after cucumbers have 1-2 true leaves. **For summer squash** *with special 24c label:* use 0.67-1.33 pts. per acre as a broadcast application over top or between crop rows after seeding and before crop emergence. If growing on plastic mulch, broadcast before laying plastic. In all crops, there is less risk of crop injury if applied between rows and with transplants. Will not control emerged weeds. Do not exceed 1 application per crop per season. REI: 24-hour. PHI: 30-day for cucumbers, squash, and pumpkins; 60-day for cantaloupe/muskmelon, and watermelon. HRAC 15.

glyphosate products (glyphosate) POST

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp

ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast 3 days before transplanting, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. Remove herbicide residue from plastic mulch prior to transplanting. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

League (imazosulfuron) POST | PRE

Cantaloupe/Muskmelon, Watermelon | 4.0-6.4 oz. per acre. Use the higher rate in fields with a known history of yellow nutsedge. Apply between rows after plants are well-established and at least 5 inches wide. Avoid contact with crop and plastic mulch (if present). If emerged weeds are present include a manufacturer-recommended surfactant to control yellow nutsedge and labeled broadleaf weeds that are 1-3 inches tall. Do not exceed 1 application and 6.4 oz. per acre per year. REI: 12-hour. PHI: 48-day. HRAC 02.

Optogen (bicyclopyrone) POST | PRE

Watermelon | 3.5 fl. oz. per acre prior to transplanting or 2.6-3.5 fl. oz. per acre to row middles. If weeds are present, add NIS (0.25% v/v) or COC (1% v/v). Apply to weeds less than 2 inches. Do not exceed 1 application per year. Do not apply more than 3.5 fl. oz. per acre per year. REI: 24-hour. PHI: 14-day. HRAC 27.

paraquat products (paraquat) POST

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Add COC (1% v/v) or NIS (0.25% v/v) and apply to emerged weeds less than 6" tall prior to transplanting or after direct-seeding but before crop emergence. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE

Cantaloupe/Muskmelon, Watermelon | 2.1 pts. per acre. Apply 3.8 formulations to row middles using a shielded sprayer with 6 inches on either side of the row middles. Apply before transplanting or before emergence of direct-seeded crop. A second application may be made before vines run. Wait at least 21 days between applications. Do not exceed 2.1 pts. per acre per application or 4.2 pts. per acre per season. REI: 24-hour. PHI: 35-day. HRAC 03.

Poast (sethoxydim) POST *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* | 1-1.5 pts. per acre. Add 1COC (1% v/v). Spray on actively growing grass. Do not exceed 3 pts. per acre per growing season. REI: 12-hour. PHI: 14-day for squash, pumpkin, and watermelon; 3-day for cantaloupe and cucumber. HRAC 01.

Prefar 4E (bensulide) PRE

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply before planting and incorporate 1-2 in. or apply after seeding before crop emerges and irrigate within 24 hours. REI: 12-hour. HRAC NC.

Reflex (fomesafen) PRE *Pumpkin, Squash, Watermelon* | *Special 24c label only.* For **pumpkins:** 6-16 fl. oz. per acre. For **squash:** 8-16 fl. oz. per acre. May be applied as a broadcast or row-middle application after seeding but before emergence on bare ground, or before transplanting on bare ground (up to 7 days prior to transplanting), and as a row middle application that does not contact the plants. For **watermelon:** 10-16 fl. oz. per acre in Indiana, Kansas, and Missouri only. Applied as with squash and pumpkin, but can also be used both under and over plastic mulch before transplanting. An overhead irrigation or rainfall event between Reflex application and transplanting will ensure herbicide activation and will likely reduce the potential for crop injury due to splashing. REI: 24-hour. PHI: 32-day for squash, and pumpkin; 35-day for watermelon. HRAC 14.

Rely 280 (glufosinate) POST

Cantaloupe/Muskmelon, Cucumber, Squash, Watermelon | ***For preplant burndown applications:*** apply 29-43 fl. oz. per acre to preformed beds covered with plastic mulch. Allow 3 days and at least 0.5 inch of precipitation or overhead irrigation to remove herbicide from the plastic before transplanting. If rainfall or overhead irrigation are less than 0.5 inches, do not transplant within 27 days of application. Do not transplant within 6 inches of holes in the plastic mulch that exist at the time of application. ***For hooded postemergence row middle applications:*** use 29-62 fl. oz. per acre applied with a hooded sprayer and directed to row middles without contacting the crop. If the crop is grown on flat beds, do not spray within 6 inches of the vines. Do not exceed two applications or 64 fl. oz. per acre for burndown applications or two applications or 62 fl. oz. per acre for hooded row middle applications. When using both burndown and hooded row middle applications, do not exceed three applications or 87 fl. oz. per acre total. Allow at least 14 days

between applications. REI: 12-hour. PHI: 30-day for melons; 14-day for cucumber and summer squash. HRAC 10.

Sandea (halosulfuron) POST | PRE

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | For **cantaloupe/muskmelon, cucumber, pumpkin:** apply 0.5-0.75 oz. per acre to the soil surface after direct-seeding but prior to cracking or apply at least 7 days before transplanting. Or apply 0.5-1.0 oz. per acre either over the top or a directed/hooded spray after the crop has been transplanted for a minimum of 14 days and reached the 2-5 true leaf stage, but before the first female flowers appear. Avoid contact with the top surface of plastic mulch if present. For **watermelon in Illinois, Indiana, Kansas, Michigan, Missouri, and Ohio:** used as directed for cantaloupes/muskmelon but can also be applied under plastic mulch before laying. Wait at least 7 days after application and mulch laying before seeding or transplanting. For **processing summer squash in Missouri:** used as directed for pumpkin, but up to 1 oz. per acre can be used after direct-seeding and before emergence. If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). Not recommended for use under cool temperatures due to potential for crop injury. May delay crop maturity. Do not exceed 2 applications or 2 oz. per acre per 12-month period. REI: 12-hour. PHI: 30-day for cucumbers, pumpkins, and squash; 57-day for cantaloupes/muskmelons, and watermelons. HRAC 02.

Sinbar WDG (terbacil) PRE *Watermelon* | 2-4 oz. per acre. Apply pre-transplanting to bare ground or under plastic mulch, or to row middles. For direct-seeded crops on bare ground, apply after planting but before crop emergence. Do not allow spray to contact crop. Do not plant other crops within 2 years of application. Do not use on sand or gravel soils. Not recommended on soils with less than 1% organic matter due to crop injury potential. REI: 12-hour. PHI: 70-day. HRAC 05.

Strategy (ethalfluralin, clomazone) PRE

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | 2-6 pts. per acre. Direct-seeded: apply to soil surface within 2 days after seeding. Do not incorporate. Transplanted: apply as a banded spray between rows. Does not control large-seeded broadleaves. Needs 0.5 inch of water within 5 days of application to be effective. If no rain occurs, cultivate shallowly. Do not apply over or under hot caps, row covers, or plastic mulch. Do not broadcast over top of plants. Under cool temperatures may cause crop injury or failure. REI: 24-hour. PHI: 45-day. HRAC 03, HRAC 13.

Sulfen 4SC (sulfentrazone) PRE

Cantaloupe/Muskmelon, Watermelon | 2.25-6 fl. oz. per acre. For **cantaloupe** and **watermelon**: Apply prior to planting or transplanting or after planting and before seedling emergence. Use rate varies by soil texture, organic matter content, and soil pH. Consult the label for the proper use rate for your soil. Do not apply more than 8 fl. oz. per acre per year. Do not apply to sand or soils with less than 1% organic matter. REI: 12-hour. HRAC 14.

trifluralin products (trifluralin) PRE

Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon | Use 10G formulations at 5-10 lbs. per acre and do not exceed 20 lbs. per acre per season on fine soils. Use 4EC formulations at 1-2 pts. per acre and do not exceed 4 pts. per acre per season on fine soils. Apply as a directed spray between rows after plants have 3-4 leaves and incorporate 1-2 inches. Use higher rates on heavier soils. 4-6 weeks of residual activity. Not effective on muck or high organic matter soils. REI: 12-hour. PHI: 30-day for cantaloupe, cucumber, pumpkin, and squash, 60-day for watermelon. HRAC 03.

Fruiting Vegetables - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Liz Maynard, Brad Bergefurd – Aug 2022

Crop Description

Eggplants (*Solanum melongena*): In the Midwest the primary eggplant varieties grown are tear-drop shaped and deep purple. There are many other types of eggplant and these should be considered when there is demand for them in your markets. Traditionally many types have been associated with specific cultures or cuisines. There are longer and thinner types that look more like summer squashes, and smaller and rounder types that are shaped more like beefsteak and cherry tomatoes. They come in a variety of colors from white, green, pink, purple, brown, and striped. There are also ornamental eggplants that make bright orange and red fruits shaped like miniature pumpkins, which can be dried.

Peppers (*Capsicum annuum*, *C. chinense*, *C. baccatum*, *C. frutescens*, and *C. pubescens*): Similar to eggplants, there are pepper types that are closely tied with specific cultures. The most common species grown for midwestern markets is *C. annuum*, which includes sweet green and colored bell peppers, as well as other sweet and hot peppers including banana, Hungarian wax, Italian, jalapeño, serrano, and poblano. These are grown for both fresh market and processing. The four other cultivated species include much hotter peppers that rate above 50,000 on the Scoville scale that is used to measure pepper pungency. These can be a strong niche market, but a little goes a long way, and these smaller-fruited types produce large numbers of fruit per plant. Clearly labeling varieties from seeding to sale is important to prevent look-alike sweet and hot peppers from being confused.

Tomatoes (*Solanum lycopersicum*): There are many types of tomatoes that differ in their fruit shape, size, color, and plant growth habits. Larger beefsteak tomatoes are juicy. Roma and plum types contain less juice and are better for canning and processing. Stuffing tomatoes are large like a beefsteak but without as much flesh or juice inside, leaving a hollow cavity like a pepper. Grape and cherry types tend to be sweeter. Determinate and semi-determinate plants grow 3 to 4 feet tall when trellised. Indeterminate plants continue to grow in height for the entire season and are almost always trellised or otherwise supported.

Planting and Spacing

Fresh market eggplant, peppers, and tomatoes are often grown on raised beds covered with plastic mulch to promote earliness. Drip irrigation beneath the mulch provides a uniform water supply and can deliver fertilizer during the growing season. Typical beds are 30 inches across, 4 to 6 inches high, and centered 5 to 6 feet apart. Bare ground production uses row spacings of 2-1/2 to 5 feet.

Eggplant for fresh market: Space plants 1-1/2 to 2-1/2 feet apart in the row on beds, or 1-1/2 to 3 feet apart in bare ground rows. Eggplants may benefit from staking and support from a trellis-weave system if plants tend to break, lean, or lodge. Eggplants require full sun and well-drained soil. Eggplants grow best with warm soil, and hot weather.

Peppers for fresh market: Space plants 1 to 1-1/2 feet apart in a single or double row on beds, or 1 to 1-1/2 feet apart in bare ground rows. Peppers may benefit from staking and support from a trellis-weave system if plants tend to break, lean, or lodge. If peppers are in a double row on a bed, a row of short stakes strung with twine along the outside of each row will support the plants.

Peppers for processing: Hand harvest is common for processing peppers, and similar spacings are used as for fresh market production. For machine harvested crops, select row spacing and bed formation that will work with available harvesting equipment.

Tomatoes for fresh market: Space plants 1-1/2 to 2-1/2 feet apart in the row on beds, or 1-1/2 to 3 feet apart in bare ground rows. Tomatoes may be left to grow over the ground or may be supported by cages, stakes, strings, or a trellis-weave system. Supported tomatoes produce higher quality fruit than unsupported plants and marketable yield is usually much greater. Tomatoes supported by stakes or trellises are sometimes pruned, which involves removing several or all of the branches up to the branch just below the first flower cluster when the branches are a few inches long. For tomatoes supported by a vertical string, only one or two stems are allowed to grow and so pruning continues throughout the season to remove branches that develop above the first flower cluster. Pruned plants produce larger fruit than unpruned plants, but the quantity of fruit is reduced.

Tomatoes for machine harvest and processing: Select row spacing and bed formation that will work with available harvesting equipment. Double rows 16 to 20 inches apart on 5 to 6 feet centers are common, with plants 1 to 2 feet apart in the row.

Fertilizing

pH: Maintain a soil pH of 6.0 to 6.8.

Eggplant, Peppers, and Tomatoes for Fresh Market: Before planting, apply 30 pounds N per acre, 0 to 240 pounds P_2O_5 per acre, and 0 to 300 pounds K_2O per acre based on soil test results and recommendations from your state. At transplanting, a starter solution at a rate of 1 cup (8 ounces) per plant is recommended. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

Sidedress with 30 to 40 pounds N per acre three to four weeks after transplanting, and then again six to eight weeks after transplanting. Sidedressing may be replaced by supplying N through a drip irrigation system at about 1 pound N per acre per day. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer (including starter) and other credits should be 100 to 120 pounds per acre.

K_2O may also be supplied through drip irrigation at a rate of 1 to 1-1/2 pounds per acre per day for peppers and eggplant, and 1-1/2 to 2-1/2 pounds per acre per day for tomatoes. Reduce the amount of K_2O applied before planting by the amount that will be supplied through drip irrigation.

Tomatoes for Processing: Apply 2/3 of total N fertilizer before planting. Total fertilizer N required is 90 to 150 pounds per acre depending on previous crop, so 60 to 100 pounds may be applied before planting. Also apply 0 to 240 pounds P_2O_5 per acre, and 0 to 300 pounds K_2O per acre based on soil test results and recommendations from your state. Or, split the K_2O application and on sandy soils apply 1/3 and on heavier soils apply 2/3 of the K_2O before planting and the remainder two to three weeks after transplanting, before flowering. At transplanting, apply a starter solution containing N and P.

Sidedress with 30 to 50 pounds N per acre two to three weeks after transplanting before flowering. If using a split K_2O application, apply the remainder of K_2O at this time also. Reduce the amount of fertilizer N applied by the amount of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter.

Physiological Disorders

There are several tomato problems related to environmental and nutrient factors that are not infectious diseases caused by pathogens.

Blossom End Rot: Tomatoes and peppers are susceptible to calcium deficiency even when adequate calcium levels are present in the soil. Deficiency results in a disorder called “blossom end rot.” It often occurs under conditions of inadequate or excessive watering and/or excessive N fertilization with an ammonium source. Where the soil pH is 6.0 or higher, additional soil-applied calcium does not correct the disorder. To limit this problem, choose less susceptible varieties, avoid drastic moisture fluctuations with irrigation monitoring and mulches, and maintain soil pH and calcium levels in desired range.

Catfacing: Flower buds that have been exposed to cold temperatures very early in development have shown a higher proportion of catfaced fruit. Large-fruited varieties tend to be more susceptible to this disorder. In some heirloom varieties, nearly all fruit is catfaced so it does not detract from the fruit’s marketability. Variety selection is the most practical way to limit this problem. Exposure to some herbicides (e,g, 2, 4-D or dicamba) can lead to similar fruit deformation.

Cracks, radial and concentric: Rapidly growing fruit and fruit exposed to the sun tend to crack more readily. Cracking is more severe under hot, dry conditions followed by rainfall. To defend against growth cracks, select crack-resistant cultivars, maintain healthy foliage, and carefully manage water availability through irrigation management and the use of plastic mulch.

Micro-cracks or rain checks: Very small cracks in the epidermis (called micro-cracks or rain checks) sometimes develop on fruit shoulders under highly humid conditions. Rain check is often more severe on fruit that has been exposed due to poor leaf cover. To minimize the problem, maintain healthy foliage and select varieties with good foliage cover.

Sunscald: Fruit exposed to the sun may overheat and develop sunscald. The affected area turns white and does not ripen. The tissue may shrivel and sink in. It is most common when foliage does not shade fruit exposed to hot afternoon sun. Damage is usually confined to the area of the fruit with greatest exposure to the sun. Tomato variety, mineral nutrition, staking and pruning methods, and disease pressure can all influence the amount of foliage cover. This disorder also is observed on peppers and fruit of other vegetable crops.

Color and ripening disorders: Yellow shoulder/internal white tissue, blotchy ripening, and graywall affect color

development and ripening. They can be caused by pests, environmental conditions, and/or nutrient imbalances, but are generally complex and not well-understood. They can be a major quality issue for both fresh market and processing tomato. Inadequate potassium is linked to this disorder, and research in processing tomatoes has shown that adequate potassium early in tomato plant development is necessary, as well as during fruit development. Competing nutrients, such as magnesium and calcium are also a factor. The 'Hartz Ratio' calculator, available online through The Ohio State University provides a way to assess risk of the disorder in processing tomatoes based on soil properties.

Zipper scars: These may be caused when the blossom sticks to the developing fruit. Zipper scars are especially common during cool weather. To avoid this problem, select resistant varieties and maintain proper greenhouse temperatures.

Harvesting

Eggplant for fresh market: Harvests can take place every few days once fruits ripen to a glossy finish. Fruit sizes depend on variety. When the skin sheen gets dull and seeds turn brown, they are past their prime. Fruit quality diminishes late in the season. Fruit should be handled carefully to avoid bruising. Time from transplanting to harvest ranges from 80 to 100 days.

Peppers for fresh market and processing: Harvests can take place every few days once fruit reaches marketable size or color. Careful selection of early-ripening varieties and passing up green harvests will maximize the yield of colored fruits in our northern climate. Fruit quality diminishes late in the season. Time from transplanting to harvest ranges from 70 to 100 days.

Tomatoes for fresh market: Harvests can take place every few days once fruits start to ripen. Small-fruited varieties such as 'cocktail', grape, or cherry tomatoes can be harvested 'on the vine' by cutting clusters of fruit. To avoid unnecessary extra handling, place these clusters directly into sales containers. Time from transplanting to harvest ranges from 70 to 90 days.

Tomatoes for machine harvest and processing: Ethephon applications may be used to accelerate and concentrate fruit ripening, facilitating once-over machine harvesting of processing tomatoes. If needed, apply 3.25 pts. Ethephon 2SL in 5 to 70 gallons of water per acre as a spray over the entire planting when 10 to 30% of fruits are ripe. Harvest 15 to 21 days after treatment for optimum ripe fruit accumulation. Time from transplanting to harvest ranges from 90 to 110 days.

Fungicide Efficacy Table for Fruiting Vegetables

Reviewed by Cesar Escalante and Mohammad Babadoost – Sep 2025

This table includes efficacy information about the fungicides recommended in this guide, based on research and experience of authors. The products are listed alphabetically by **Trade Names**.

VG=Very Good, G=good, F=fair, P=poor, S=suppression

Trade Names (REI/PHI)	**Active Ingredients** MOA or FRAC code: fungicides with a number as the MOA code should be tank-mixed or alternated with a different MOA code according to the label.	**Anthracnose (tomato)**	**Anthracnose (pepper)**	**Bacterial Canker**	**Bacterial Spot/Speck**	**Botrytis Gray Mold**	**Buckeye Rot**	**Early Blight**	**Septoria Leaf Blight**	**Late Blight (tomato)**	**Phytophthora Blight (pepper)**	**Leaf Mold**	**White Mold**
Actigard (12h/14d)	acibenzolar-S-methyl (P1)				F								
Agri-Mycin 17, Streptomycin (12h/-)	streptomycin sulfate (25)				F								
Aprovia Top (12h/0d)	benzovindiflupyr (7), difenoconazole (3)	VG						VG	VG				
Botran (12h/10d)	2, 6-dichloro-4-nitroanaline (29)					G							
Bravo, Echo, Equus (12h/0d)	chlorothalonil (M5)	G	G		F	F		G	G	VG		F	
Cabrio (12h/0d)	pyraclostrobin (11)	G	G			F		VG	VG	P			S
Contans WG (4h/-)	CON/M/91-08 (NA)												F
copper (4h to 48h/0d)	copper (M1)	F	F	P	F	P		F	F	F			
Curzate 60DF (12h/3d)	cymoxanil (27)									G	F		
Dithane, Manzate, Penncozeb (24h/5d)	mancozeb (M3)	F	F		F			G	G	F		F	
Elumin (12h/2d)	ethaboxam (22)										G		
Endura (12h/0d)	boscalid (7)					VG		G					
Fontelis (12h/0d)	penthiopyrad (7)	S	S			G		VG	VG				
Gavel (48h/5d)	mancozeb (M3), zoxamide (22)						F	G	G	F		F	
Inspire Super (12h/0d)	difenoconazole (3), cyprodinil (9)	F	F				G	VG	G			G	
Luna Sensation (12h/3d)	fluopyram (7), trifloxystrobin (11)	S	VG			G			VG				G
Luna Tranquility (12h/1d)	fluopyram (7), pyrimethanil (9)							VG	VG				
Miravis Prime (12h/0d)	pydiflumetofen (7), fludioxonil (12)		VG						VG				
Orondis Gold 200 (48h/7d)	oxathiapiprolin (49), mefenoxam (4)										F		
Orondis Opti (12h/3d)	oxathiapiprolin (49), chlorothalonil (M5)									VG	G		
Orondis Ultra (4h/1d)	oxathiapiprolin (49), mandipropamid (40)									VG	VG		
Presidio (12h/2d)	fluopicolide (43)									VG	G		
Previcur Flex (12h/5d)	propamocarb hydrochloride (28)									G	F		
Priaxor (12h/0d)	fluxapyroxad (7), pyraclostrobin (11)	G	G			F		VG	G	S			S
Quadris (4h/0d)	azoxystrobin (11)	G	G			G	P	VG	VG	P			
Quadris Top (12h/0d)	azoxystrobin (11), difenoconazole (3)	G	VG			G		VG	VG			G	
Ranman (12h/0d)	cyazofamid (21)									G	G		
Reason (12h/14d)	fenamidone (11)							VG	VG	S	S		
Regalia	Extract of *Reynoutria sachalinensis* (P5)				G								
Revus Top (12h/1d)	mandipropamid (40), difenoconazole (3)	G						G	G	G		G	
Ridomil Gold (48h/7d)	mefenoxam (4)						G			G	G		
Scala (12h/1d)	pyrimethanil (9)					G		G					
Switch (12h/0d)	cyprodinil (9), fludioxonil (12)					G		VG					
Tanos (12h/3d)	cymoxanil (27), famoxadone (11)	F	G	S	S		S	G	G	G		F	
Zampro (12h/4d)	ametoctradin (45), dimethomorph (40)									G	F		
Zing (12h/5d)	zoxamide (22), chlorothalonil (M5)							G	G	G			

Fruiting Vegetables - Diseases

Reviewed by Mohammad Babadoost, Cesar Escalante – Aug 2024

Anthracnose of Fruiting Vegetables - Colletotrichum Fungus

Symptoms usually occur on ripe or over-ripe fruit. Begin fungicide applications at or shortly before fruit set.

Non-Pesticide

Eggplant, Pepper, Tomato | Use pathogen-free seed and disease-free transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for eggplants and tomato, and 125 F for 30 minutes for pepper. Rotate to non-Solanaceous crops for 3-4 years. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly break down tissue is an important method to prevent pathogen build-up. Anaerobic soil disinfestation (ASD) is an effective biological treatment for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Eggplant, Pepper, Tomato* | 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Tomato* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 6.3-7.8 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.024-0.08 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Azterknot (azoxystrobin, Reynoutria sachalinensis extract) *Tomato* | 5.9-7.4 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11, FRAC P05.

Cabrio EG (pyraclostrobin) *Eggplant, Pepper, Tomato* | 8-12 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

Cevya (mefentrifluconazole) *Eggplant, Pepper, Tomato* | 3-5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

chlorothalonil products (chlorothalonil) *Eggplant, Pepper* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 54% (720) formulations at 1.5 pt. per acre. Use 82.5% (WDG) formulations at 1.4 lb. per acre. REI: 12-hour. PHI: 3-day. FRAC M05.

Flint Extra (trifloxystrobin) *Eggplant, Pepper, Tomato* | 3.0-3.8 fl. oz. per acre. Use Gem 500 SC at same rate. Use Flint (50%) formulation at 3-4 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11.

Fontelis (penthiopyrad) *Eggplant, Pepper, Tomato* | 16-24 fl. oz per acre for all diseases listed here except anthracnose at 24 fl. oz. Suppression only for anthracnose. In the greenhouse use a rate of 0.75 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 0-day. FRAC 07.

Inspire Super (difenoconazole, cyprodinil) *Eggplant, Pepper, Tomato* | 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 09.

mancozeb products (mancozeb) *Pepper, Tomato* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.6-2.4 qt. per acre. Use 75% and 80% formulations at 0.75-3.0 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Mettle 125ME (tetraconazole) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

Pageant Intrinsic (boscalid, pyraclostrobin) *Eggplant, Pepper, Tomato* | Rates are as follow per acre: Powdery mildew at 9.7-18 oz.; gray mold at 23 oz. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Pageant Intrinsic (boscalid, pyraclostrobin) *Tomato* | Rates are as follows per acre.: Gray mold, 23 oz.; anthracnose and early blight 12.25-23 oz. Labeled for greenhouse-/high tunnel-grown tomatoes. Do not apply on seedlings meant for transplanting in the field. For Pythium and Rhizoctonia spp. use 12-18 oz. per 100 gals. water. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Priaxor (fluxapyroxad, pyraclostrobin) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. Late blight, 8 fl. oz. per acre. Gray mold and white mold suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris 2.08SC (azoxystrobin) *Pepper, Tomato* | 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Tomato* | 1.6 per pts. per acre REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Pepper, Tomato* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC 03.

Regev (tea tree oil, difenoconazole) *Eggplant, Pepper, Tomato* | 4-8.5 fl. oz. per acre. REI: 12-hour. PHI: 2-day. IRAC UNE, FRAC BM01, FRAC 03.

Revus Top (mandipropamid, difenoconazole) *Tomato* | 5.5-7.0 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day. FRAC 40, FRAC 03.

Rhyme (flutriafol) *Pepper, Tomato* | 5-7 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Serenade Opti (Bacillus subtilis strain QST-713) *Eggplant, Pepper, Tomato* | Use Serenade Opti at 14-20 fl. oz. per acre, or Serenade ASO at 2-4 qts. per acre. Can be used in a rotational program with effective fungicides to reduce synthetic fungicide use. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Tanos (famoxadone, cymoxanil) *Pepper, Tomato* | Tomato: Early blight at 6-8 oz. per acre. Late blight and anthracnose at 8 oz per acre. For suppression of bacterial diseases of tomato, 8 oz. For late blight, tank-mix with a contact fungicide with a different mode of action. Pepper: Anthracnose at 8-10 fl. oz. REI: 12-hour. FRAC 11, FRAC 27.

Bacterial Canker of Fruiting Vegetables - Clavibacter Bacteria

The bacterium becomes systemic in the plant, causing wilt and leaf/fruit/stem lesions. It can occur on tomato and pepper, but is mainly a problem on tomato.

Sanitize machinery, seedlings, and plant production materials (transplant trays, greenhouse benches, and wooden stakes) with a disinfectant such as 10% chlorine bleach or a quaternary ammonium compound solution.

Inspect seedlings for disease and discard any flats containing diseased seedlings as well as flats bordering any with diseased seedlings.

Non-Pesticide

Pepper, Tomato | Use pathogen-free seed and disease-free transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for eggplants and tomato, and 125 F for 30 minutes for pepper. Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid fields with a history of the disease and rotate to non-Solanaceous crops for 3-4 years. Stake and mulch the crops to improve air flow and reduce splashing. Avoid working in wet fields. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Tanos (famoxadone, cymoxanil) *Pepper, Tomato* | Tomato: Early blight at 6-8 oz. per acre. Late blight and anthracnose at 8 oz per acre. For suppression of bacterial diseases of tomato, 8 oz. For late blight, tank-mix with a contact fungicide with a different mode of action. Pepper: Anthracnose at 8-10 fl. oz. REI: 12-hour. FRAC 11, FRAC 27.

Bacterial Speck of Fruiting Vegetables - Pseudomonas Bacteria

Lesions of this disease can be found on leaves, stems, and fruit of peppers and tomatoes. But, it is rarely a problem for eggplants.

Sanitize machinery, seedlings, and plant production materials (transplant trays, greenhouse benches, and wooden stakes) with a disinfectant such as 10% chlorine bleach or a quaternary ammonium compound solution.

While still in the greenhouse, scout and apply fixed copper alternated with streptomycin (Agri-mycin, AG Streptomycin). Once in the field, apply a fixed copper product tank-mixed with mancozeb on 7 day schedule, depending on disease pressure, beginning within 1 week after transplanting. Airblast sprayers with high fan speed can make an outbreak worse by sandblasting plants with droplets and opening many small wounds that become infected.

Copper Resistance: Strains of the bacterium that cause bacterial speck on tomato and Pseudomonas leaf spot on pepper that are resistant to copper products occur in the

Midwest. Actigard, streptomycin products (transplant production in greenhouses only), mancozeb products, Tanos, and Serenade used as labeled may help manage copper-resistant strains.

Non-Pesticide

Eggplant, Pepper, Tomato | Use pathogen-free seed and disease-free transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for eggplants and tomato, and 125 F for 30 minutes for pepper. Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid fields with a history of the disease and rotate to non-Solanaceous crops for 2-3 years. Stake and mulch the crops to improve air flow and reduce splashing. Avoid working in wet fields. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Actigard (acibenzolar-s-methyl) *Tomato* | 0.3-0.75 oz. per acre. Begin season with lower rates and increase as plant canopy increases. Do not exceed 6 oz. per season. REI: 12-hour. PHI: 14-day. FRAC P01.

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Pepper, Tomato* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use. See label for directions. Copper-resistant strains of the bacterial spot pathogen are common in the Midwest. Mancozeb products (e.g., Dithane, Manzate, Penncozeb) when tank-mixed with copper products, allow more copper to become available on the leaf surface and so may help manage copper-resistant bacterial strains. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

LifeGard WG (Bacillus mycoides isolate J) *Eggplant, Pepper, Tomato* | 1-4.5 oz. per acre. 1-4.5 oz. per acre or 4.5 oz. per 100 gals. water. Suppression only; can be used in a rotational program with effective fungicides to reduce synthetic fungicide use REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

mancozeb products (mancozeb) *Pepper, Tomato* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.6-2.4 qt. per acre. Use 75% and 80% formulations at 0.75-3.0 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Regalia (Reynoutria sachalinensis extract) *Eggplant, Pepper, Tomato* | 1-4 qts. per acre. Use in a program with copper products. On greenhouse-produced seedlings, drench planting medium with 1-2 qts. per gal. water or dip seedlings in solution of 1-2 qts. per 100 gal. water immediately before transplanting. REI: 4-hour. PHI: 0-day. FRAC P05. *OMRI-listed.*

Serenade Opti (Bacillus subtilis strain QST-713) *Eggplant, Pepper, Tomato* | Use Serenade Opti at 14-20 fl. oz. per acre, or Serenade ASO at 2-4 qts. per acre. Can be used in a rotational program with effective fungicides to reduce synthetic fungicide use. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Tanos (famoxadone, cymoxanil) *Pepper, Tomato* | Tomato: Early blight at 6-8 oz. per acre. Late blight and anthracnose at 8 oz per acre. For suppression of bacterial diseases of tomato, 8 oz. For late blight, tank-mix with a contact fungicide with a different mode of action. Pepper: Anthracnose at 8-10 fl. oz. REI: 12-hour. FRAC 11, FRAC 27.

Bacterial Spot of Fruiting Vegetables - Xanthomonas Bacteria

Lesions of this disease can be found on leaves, stems, and fruit of eggplants, peppers and tomatoes, but it is rarely a problem for eggplants. Infection of blossom stem of tomato prevents fruit set.

Sanitize machinery, and plant production materials (transplant trays, greenhouse benches, and wooden stakes) with a disinfectant such as 10% chlorine bleach or a quaternary ammonium compound solution.

While still in the greenhouse, scout and apply fixed copper alternated with streptomycin (Agri-mycin, Firewall, Streptrol). Once in the field, apply a fixed copper product tank-mixed with mancozeb on 5-7 day schedule, depending on disease pressure, beginning within 1 week after transplanting. Airblast sprayers with high fan speed can make an outbreak worse by sandblasting plants with droplets and opening many small wounds that become infected.

Copper Resistance: Strains of the bacterium that cause bacterial spot on tomato that are resistant to copper products are common in the Midwest. Actigard, streptomycin products, mancozeb products, chlorothalonil products, Tanos, and Serenade used as labeled may help manage copper-resistant strains.

Non-Pesticide

Eggplant, Pepper, Tomato | Use pathogen-free seed and disease-free transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for eggplants and tomato, and 125 F for 30

minutes for pepper. Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid fields with a history of the disease and rotate to non-Solanaceous crops for 2-3 years. Stake and mulch the crops to improve air flow and reduce splashing. Avoid working in wet fields. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Actigard (acibenzolar-s-methyl) *Pepper, Tomato* | 0.3-0.75 oz. per acre for tomato. For ***bell peppers*** *with Michigan 24c label use at 0.25-0.33 oz. per acre.* Begin season with lower rates and increase as plant canopy increases. Do not exceed 6 oz. per season. REI: 12-hour. PHI: 14-day. FRAC P01.

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Pepper, Tomato* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use. See label for directions. Copper-resistant strains of the bacterial spot pathogen are common in the Midwest. Mancozeb products (e.g., Dithane, Manzate, Penncozeb) when tank-mixed with copper products, allow more copper to become available on the leaf surface and so may help manage copper-resistant bacterial strains. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

LifeGard WG (Bacillus mycoides isolate J) *Eggplant, Pepper, Tomato* | 1-4.5 oz. per acre. 1-4.5 oz. per acre or 4.5 oz. per 100 gals. water. Suppression only; can be used in a rotational program with effective fungicides to reduce synthetic fungicide use REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

mancozeb products (mancozeb) *Pepper, Tomato* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.6-2.4 qt. per acre. Use 75% and 80% formulations at 0.75-3.0 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Regalia (Reynoutria sachalinensis extract) *Eggplant, Pepper, Tomato* | 1-4 qts. per acre. Use in a program with copper products. On greenhouse-produced seedlings, drench planting medium with 1-2 qts. per gal. water or dip seedlings in solution of 1-2 qts. per 100 gal. water immediately before transplanting. REI: 4-hour. PHI: 0-day. FRAC P05. *OMRI-listed.*

Serenade Opti (Bacillus subtilis strain QST-713) *Eggplant, Pepper, Tomato* | Use Serenade Opti at 14-20 fl. oz. per acre, or Serenade ASO at 2-4 qts. per acre. Can be used in a rotational program with effective fungicides to reduce synthetic fungicide use. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

streptomycin products (Streptomycin sulfate) *Pepper, Tomato* | Use 17% products at 16 oz. per 100 gals of water, or 50% products at 5.3 oz. per 100 gals. of water to maintain a concentration of 200 ppm. Apply one or two times to seedlings, alternated with a fixed copper product compound beginning at the two-leaf stage. Not labeled for use after transplanting (greenhouse only). REI: 12-hour. FRAC 25.

Tanos (famoxadone, cymoxanil) *Pepper, Tomato* | Tomato: Early blight at 6-8 oz. per acre. Late blight and anthracnose at 8 oz per acre. For suppression of bacterial diseases of tomato, 8 oz. For late blight, tank-mix with a contact fungicide with a different mode of action. Pepper: Anthracnose at 8-10 fl. oz. REI: 12-hour. FRAC 11, FRAC 27.

Buckeye Rot of Tomatoes - Phytophthora Oomycete

These diseases are favored by heavy rains and waterlogged soils. Symptoms include discolored fruit and declining plants. Consider fungicide drench. Regular fungicide schedule may lessen impact of buckeye rot.

Non-Pesticide

Tomato | Rotate to non-cucurbit, non-legume, and non-solanaceous crops for 3 years. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

azoxystrobin products (azoxystrobin) *Tomato* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 6.3-7.8 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.024-0.08 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Tomato* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may improve efficacy of fungicides against

Phytophthora blight when tank mixed at labeled rates. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Gavel 75DF (zoxamide, mancozeb) *Tomato* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Tomato* | 5.5-8.0 fl. oz. per acre. Alternate with fungicides that have a different mode of action. Use either soil applications or foilar applications of oxathiapiproplin products, but not both. REI: 4-hour. PHI: 1-day. FRAC 49, FRAC 40.

Quadris 2.08SC (azoxystrobin) *Pepper, Tomato* | 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Pepper, Tomato* | 1.6 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Ridomil Gold Copper (mefenoxam, copper hydroxide) *Tomato* | *For processing tomatoes:* apply 1 pack per 3.7 acres plus 0.8 lb. a.i. per acre of mancozeb. *For fresh market tomatoes:* apply 1 pack per 2.5 acres plus 0.8 lb. a.i. per acre of mancozeb. REI: 48-hour. PHI: 14-day. FRAC 04, FRAC M01.

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Non-Pesticide

Eggplant, Pepper, Tomato | Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid excess moisture to the transplants in the greenhouse by monitoring irrigation frequency. Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Pesticide

Aliette WDG (fosetyl-aluminum) *Tomato* | 2.5-5 lbs. per acre. For Pythium spp., apply 2.5-5 lbs. per acre at 2-4 leaf stage for direct seeded plants or immediately after transplanting. REI: 12-hour. PHI: 14-day. FRAC P07.

mefenoxam/metalaxyl products (mefenoxam) *Eggplant, Pepper, Tomato* | Several formulations (Apron, MetaStar, Ridomil Gold, Ultra Flourish, Subdue Maxx, and Xyler) are labeled. Several formulations are labeled as pre-plant incorporated or surface broadcast and banded applications at various rates between 1 pt. and 8 pt. per acre. A 2.5% granular formulation can be used at 20 lb. per acre *in tomatoes only*. A 33.3% seed treatment formulation can be used at 0.32-0.64 fl. oz. per 100 lb. of seed. A 22% formulation can be used at 21.7 ml. per 1000 sq. ft. *for transplants grown for retail sale to consumers*. REI: 48-hour. PHI: 7-day. FRAC 04.

Orondis Gold (oxathiapiprolin, mefenoxam) *Eggplant, Pepper, Tomato* | 28-55 fl. oz. per acre. Use as an at-plant soil drench, banded spray in furrow, or through drip irrigation. Do not follow soil applications of Orondis Gold with foliar applications of Orondis Opti, or Orondis Ultra. REI: 4-hour. PHI: 7-day. FRAC 49, FRAC 04.

Previcur Flex (propamocarb) *Eggplant, Pepper, Tomato* | For Pythium spp., apply 1.2 pts. (eggplants or peppers) or 1.5 pts. per acre (tomato) per acre with nozzles directed at base of plants, or via drip irrigation, transplant water or sprinklers. For late blight, 0.7-1.5 pts. per acre. REI: 12-hour. PHI: 5-day. FRAC 28.

Regalia (Reynoutria sachalinensis extract) *Eggplant, Pepper, Tomato* | 1-4 qts. per acre. Use in a program with copper products. On greenhouse-produced seedlings, drench planting medium with 1-2 qts. per gal. water or dip seedlings in solution of 1-2 qts. per 100 gal. water immediately before transplanting. REI: 4-hour. PHI: 0-day. FRAC P05. *OMRI-listed.*

Ridomil Gold SL (mefenoxam) *Eggplant, Pepper, Tomato* | 1 pt. per acre. Soil treatment at 1 pt. per acre broadcast (use less for band applications) before transplanting. Subsequent directed sprays may be needed. *Phytophthora crown rot only*. Fungicides will not be effective if plants are planted in poorly drained fields with a history of the disease. Damping-off treatments for tomato are 1-2 pts. per acre. Other formulations include MetaStar, Subdue Maxx, Ultra Flourish, and Xyler. Rates vary by formulation. REI: 48-hour. PHI: 7-day. FRAC 04.

Serifel (Bacillus amyloliquifaciens strain MBI-600) *Eggplant, Pepper, Tomato* | 4-16 oz. per acre. Soil treatment in-furrow, drench, shanked in and chemigation applications at 4-16 oz. per acre for Pythium spp. damping-off and other root rots. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

SoilGard (Gliocladium virens strain GL-21) *Eggplant, Pepper, Tomato* | 0.5-2 lbs. per acre. Soil treatment in-furrow, drench, shanked in and chemigation applications at 0.5-2 lbs. per acre for Pythium, Rhizoctonia, Fusarium and other spp. causing damping-off and root rots. For greenhouse-grown

transplants, drench medium with 2-4 oz. per gal. water. REI: see label. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Early Blight of Fruiting Vegetables - Alternaria Fungus

This pathogen can infect peppers and tomatoes, but is mainly a problem in tomatoes. This disease initially causes lesions on lower leaves of the tomato plant. After field planting, begin protective fungicide applications on a 7-14 day schedule. May be seedborne.

Group 11 Resistance: Strains of the fungus that causes early blight that are resistant to group 11 fungicides have been observed in Indiana and Ohio. Group 11 products labeled for tomato and early blight include Cabrio and Quadris. Tank-mix group 11 fungicides with products that have a different mode of action, or alternate group 11 fungicides with fungicides that have a different group number.

Non-Pesticide

Eggplant, Pepper, Tomato | Use pathogen-free seed and disease-free transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for tomato. Avoid fields with a history of Fusarium and Verticillium wilts. Rotate to non-Solanaceous crops for 3-4 years. Varieties with partial resistance are available, and varieties resistant to Fusarium and Verticillium wilt will hold up better against Alternaria. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Eggplant, Pepper, Tomato* | 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Tomato* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 6.3-7.8 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.024-0.08 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Azterknot (azoxystrobin, Reynoutria sachalinensis extract) *Tomato* | 5.9-7.4 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11, FRAC P05.

Cabrio EG (pyraclostrobin) *Eggplant, Pepper, Tomato* | 8-12 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

Cevya (mefentrifluconazole) *Eggplant, Pepper, Tomato* | 3-5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

chlorothalonil products (chlorothalonil) *Tomato* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.0 pt. per acre. Use 54% (720) formulations at 1.38-2.75 pt. per acre. Use 82.5% (WDG) formulations at 1.3-2.6 lb. per acre. Use 90% DF formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

Cymbol Advance (chlorothalonil, cymoxanil) *Tomato* | 1.9-3 pts. per acre. Also available as Ariston. REI: 12-hour. PHI: 3-day. FRAC M05, FRAC 27.

Double Nickel 55 (Bacillus amyloliquefaciens strain D-747) *Eggplant, Pepper, Tomato* | 0.25-3 lbs. per acre. Suppression only; can be used in a rotational program with effective fungicides to reduce synthetic fungicide use. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Endura (boscalid) *Tomato* | Rates as follows per acre: early blight rates are 2.5-3.5 oz.; Gray mold rates are 9-12.5 oz.; white mold rates 12.5 oz. Suppression only for while mold. REI: 12-hour. PHI: 0-day. FRAC 07.

Evito (fluoxastrobin) *Eggplant, Pepper, Tomato* | Rates depend on formulation. Other products include Aftershock, Tepera. REI: 12-hour. PHI: 3-day. FRAC 11.

Flint Extra (trifloxystrobin) *Eggplant, Pepper, Tomato* | 3.0-3.8 fl. oz. per acre. Use Gem 500 SC at same rate. Use Flint (50%) formulation at 3-4 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11.

Fontelis (penthiopyrad) *Eggplant, Pepper, Tomato* | 16-24 fl. oz per acre for all diseases listed here except anthracnose at 24 fl. oz. Suppression only for anthracnose. In the greenhouse use a rate of 0.75 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 0-day. FRAC 07.

Gavel 75DF (zoxamide, mancozeb) *Tomato* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

Inspire Super (difenoconazole, cyprodinil) *Eggplant, Pepper, Tomato* | 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 09.

LifeGard WG (Bacillus mycoides isolate J) *Eggplant, Pepper, Tomato* | 1-4.5 oz. per acre. 1-4.5 oz. per acre or 4.5 oz. per 100 gals. water. Suppression only; can be used in a rotational program with effective fungicides to reduce synthetic fungicide use REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Luna Sensation (fluopyram, trifloxystrobin) *Eggplant, Pepper, Tomato* | Rates are as follows per acre: early blight, powdery mildew, Septoria leaf spot at 5-7.6 fl. oz.; anthracnose, gray mold, white mold and southern blight at 7.6 fl. oz. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Luna Tranquility (fluopyram, pyrimethanil) *Tomato* | 11.2 fl. oz. per acre. Disease suppression of powdery mildew. Labeled for field use and in greenhouses with good fungicide resistance management programs REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 09.

mancozeb products (mancozeb) *Pepper, Tomato* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.6-2.4 qt. per acre. Use 75% and 80% formulations at 0.75-3.0 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Mettle 125ME (tetraconazole) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Miravis Prime (pydiflumetofen, fludioxonil) *Pepper, Tomato* | 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 12.

Mural (azoxystrobin, benzovindiflupyr) *Tomato* | 0.6 oz. per 1,000 sq. ft. *Tomato Transplants for Home Consumer Market.* REI: 12-hour. PHI: 0-day. FRAC 11, FRAC 07.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

Pageant Intrinsic (boscalid, pyraclostrobin) *Eggplant, Pepper, Tomato* | Rates are as follow per acre: Powdery mildew at 9.7-18 oz.; gray mold at 23 oz. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Pageant Intrinsic (boscalid, pyraclostrobin) *Tomato* | Rates are as follows per acre.: Gray mold, 23 oz.; anthracnose and early blight 12.25-23 oz. Labeled for greenhouse-/high tunnel-grown tomatoes. Do not apply on seedlings meant for transplanting in the field. For Pythium and Rhizoctonia spp. use 12-18 oz. per 100 gals. water. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Priaxor (fluxapyroxad, pyraclostrobin) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. Late blight, 8 fl. oz. per acre. Gray mold and white mold suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris 2.08SC (azoxystrobin) *Pepper, Tomato* | 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Pepper, Tomato* | 1.6 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Pepper, Tomato* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC 03.

Reason 500SC (fenamidone) *Eggplant, Pepper, Tomato* | 5.5-8.2 fl. oz. per acre. Septoria leaf spot disease suppression. REI: 12-hour. PHI: 14-day. FRAC 11.

Regalia (Reynoutria sachalinensis extract) *Eggplant, Pepper, Tomato* | 1-4 qts. per acre. Use in a program with copper products. On greenhouse-produced seedlings, drench planting medium with 1-2 qts. per gal. water or dip seedlings in solution of 1-2 qts. per 100 gal. water immediately before transplanting. REI: 4-hour. PHI: 0-day. FRAC P05. *OMRI-listed.*

Regev (tea tree oil, difenoconazole) *Eggplant, Pepper, Tomato* | 4-8.5 fl. oz. per acre. REI: 12-hour. PHI: 2-day. IRAC UNE, FRAC BM01, FRAC 03.

Revus Top (mandipropamid, difenoconazole) *Tomato* | 5.5-7.0 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day. FRAC 40, FRAC 03.

Rhyme (flutriafol) *Tomato* | 3.5-7 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Scala (pyrimethanil) *Tomato* | 7 fl. oz. per acre. Tank-mix with another fungicide. Allow greenhouse/high tunnel to ventilate for 2 hours. REI: 12-hour. PHI: 1-day. FRAC 09.

Spirato GHN (fludioxonil) *Eggplant, Pepper, Tomato* | 5.0-5.7 fl. oz. per acre. This is a foliar-applied formulation of fludioxonil, which is more typically a seed treatment ingredient. Only for greenhouse/high tunnel-produced eggplant, pepper, and tomato. REI: 12-hour. PHI: 0-day. FRAC 12.

Switch 62.5WG (cyprodinil, fludioxonil) *Eggplant, Pepper, Tomato* | 11-14 oz. per acre. Do not apply to small fruited varieties in the greenhouse. REI: 12-hour. PHI: 0-day. FRAC 09, FRAC 12.

Tanos (famoxadone, cymoxanil) *Pepper, Tomato* | Tomato: Early blight at 6-8 oz. per acre. Late blight and anthracnose at 8 oz per acre. For suppression of bacterial diseases of tomato, 8 oz. For late blight, tank-mix with a contact fungicide with a different mode of action. Pepper: Anthracnose at 8-10 fl. oz. REI: 12-hour. FRAC 11, FRAC 27.

tebuconazole products (tebuconazole) *Tomato* | 8 fl. o.z per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Topguard EQ (flutriafol, azoxystrobin) *Tomato* | 4-8 fl. oz. per acre. REI: 12-hour to 3-day. PHI: 0-day. FRAC 03, FRAC 11.

Zing! (zoxamide, chlorothalonil) *Eggplant, Pepper, Tomato* | Application rate: 34 fl. oz. per acre for pepper; 36 fl. oz for tomato. REI: 12-hour. PHI: 3-day. FRAC 22, FRAC M05.

Fusarium Wilt of Fruiting Vegetables - Fusarium Fungus

May be seedborne.

Non-Pesticide

Eggplant, Pepper, Tomato | Use pathogen-free seed and disease-free transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for eggplants and tomato, and 125 for 30 minutes for pepper. Avoid fields with a history of the disease. Rotate to non-Solanaceous crops for >6 years. Varieties with resistance are available, and resistant rootstocks are available for grafting (https://vegetablegrafting.org). Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Gray Mold of Multiple Crops - Botrytis Fungus

This disease often occurs in greenhouse, high tunnel or other protected production systems with high humidity.

Non-Pesticide

Eggplant, Pepper, Tomato | Use raised beds and adequate plant spacing to improve drainage, air flow. Monitor humidity in the structure and vent appropriately. Pruning the crop will help increase airflow as well. Prompt destruction of the finished crop with tillage to rapidly break down tissue is an important method to prevent disease build-up

Pesticide

Botran 75W (dichloro-nitroaniline) *Pepper, Tomato* | 1lb. per 100 gals. of water. Labeled for stem phase of gray mold. Apply to stems up to a height of 24 inches. Young plants may be injured. REI: 12-hour. PHI: 0-day. FRAC 14.

BotryStop (Ulocladium oudemansii strain U3) *Eggplant, Pepper, Tomato* | 2-4 lbs. per acre. Suppression of Botrytis gray mold; use in a program with good cultural practices and effective fungicides. REI: 4-hour. PHI: 0-day. FRAC NC. *OMRI-listed.*

Cabrio EG (pyraclostrobin) *Eggplant, Pepper, Tomato* | 12-16 oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Eggplant, Pepper* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 54% (720) formulations at 1.5 pt. per acre. Use 82.5% (WDG) formulations at 1.4 lb. per acre. REI: 12-hour. PHI: 3-day. FRAC M05.

chlorothalonil products (chlorothalonil) *Tomato* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.0 pt. per acre. Use 54% (720) formulations at 1.38-2.75 pt. per acre. Use 82.5% (WDG) formulations at 1.3-2.6 lb. per acre. Use 90% DF formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Pepper, Tomato* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use. See label for directions. Copper-resistant strains of the bacterial spot pathogen are common in the Midwest. Mancozeb products (e.g., Dithane, Manzate, Penncozeb) when tank-mixed with copper products, allow more copper to become available on the leaf surface and so may help manage copper-resistant bacterial strains. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Cymbol Advance (chlorothalonil, cymoxanil) *Tomato* | 1.9-3 pts. per acre. Also available as Ariston. REI: 12-hour. PHI: 3-day. FRAC M05, FRAC 27.

Double Nickel 55 (Bacillus amyloliquefaciens strain D-747) *Eggplant, Pepper, Tomato* | 0.25-3 lbs. per acre. Suppression only; can be used in a rotational program with effective fungicides to reduce synthetic fungicide use. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Endura (boscalid) *Tomato* | Rates as follows per acre: early blight rates are 2.5-3.5 oz.; Gray mold rates are 9-12.5 oz.; white mold rates 12.5 oz. Suppression only for while mold. REI: 12-hour. PHI: 0-day. FRAC 07.

Fontelis (penthiopyrad) *Eggplant, Pepper, Tomato* | 16-24 fl. oz per acre for all diseases listed here except anthracnose at 24 fl. oz. Suppression only for anthracnose. In the greenhouse use a rate of 0.75 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 0-day. FRAC 07.

Howler (Pseudomonas chlororaphis strain AFS009) *Eggplant, Pepper, Tomato* | 5-15 lb. per acre. See label for other field and greenhouse uses. Suppression of Botrytis gray mold; use in a program with good cultural practices and effective fungicides. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Inspire Super (difenoconazole, cyprodinil) *Eggplant, Pepper, Tomato* | 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 09.

Luna Sensation (fluopyram, trifloxystrobin) *Eggplant, Pepper, Tomato* | Rates are as follows per acre: early blight, powdery mildew, Septoria leaf spot at 5-7.6 fl. oz.; anthracnose, gray mold, white mold and southern blight at 7.6 fl. oz. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Luna Tranquility (fluopyram, pyrimethanil) *Tomato* | 11.2 fl. oz. per acre. Disease suppression of powdery mildew. Labeled for field use and in greenhouses with good fungicide resistance management programs REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 09.

Miravis Prime (pydiflumetofen, fludioxonil) *Pepper, Tomato* | 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 12.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

OxiDate 2.0 (hydrogen dioxide, peroxyacetic acid) *Eggplant, Pepper, Tomato* | 1 qt. to 2.5 gals. per 100 gals. water Suppression of Botrytis gray mold. Use high rate in rescue situations and use preventive low rates in a program with good cultural practices and other effective fungicides. REI: 0 to 1-hour. PHI: 0-day. FRAC NC. *OMRI-listed.*

Pageant Intrinsic (boscalid, pyraclostrobin) *Eggplant, Pepper, Tomato* | Rates are as follow per acre: Powdery mildew at 9.7-18 oz.; gray mold at 23 oz. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Pageant Intrinsic (boscalid, pyraclostrobin) *Tomato* | Rates are as follows per acre.: Gray mold, 23 oz.; anthracnose and early blight 12.25-23 oz. Labeled for greenhouse-/high tunnel-grown tomatoes. Do not apply on seedlings meant for transplanting in the field. For Pythium and Rhizoctonia spp. use 12-18 oz. per 100 gals. water. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Priaxor (fluxapyroxad, pyraclostrobin) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. Late blight, 8 fl. oz. per acre. Gray mold and white mold suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Scala (pyrimethanil) *Tomato* | 7 fl. oz. per acre. Tank-mix with another fungicide. Allow greenhouse/high tunnel to ventilate for 2 hours. REI: 12-hour. PHI: 1-day. FRAC 09.

Switch 62.5WG (cyprodinil, fludioxonil) *Eggplant, Pepper, Tomato* | 11-14 oz. per acre. Do not apply to small fruited varieties in the greenhouse. REI: 12-hour. PHI: 0-day. FRAC 09, FRAC 12.

Late Blight of Potatoes/Tomatoes - Phytophthora Oomycete

This destructive pathogen causes quick plant death and can be identified by large spreading brown to black stem lesions, velvety white growth on plant surfaces, and large brown leathery spots on green fruits. It is favored by prolonged cool and damp conditions.

The pathogen overwinters on plant residue, including volunteer potatoes and potato cull piles. The first step to manage this disease is monitoring and destroying cull and volunteer potato emergence in the spring. When it is reported in your region, begin weekly preventive sprays with chlorothalonil and mancozeb for as long as favorable conditions persist. Pay attention to which pathogen strain is identified. If infections start in a field, the strain US-23 is sensitive to mefenoxam (Ridomil).

Biofungicide products like Double Nickel, Regalia, Serifel, Serenade, Sonata, and Stargus can be included in a conventional spray program to reduce the number of synthetic fungicides or in an organic program with OMRI-listed copper products. See labels for instructions.

Non-Pesticide

Tomato | Avoid fields with a history the disease. Rotate to non-solanaceous crops (including potatoes) for 3-4 years. Use raised beds, staking, pruning, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the infected crop or finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. In small plantings, remove infected plants from the field and dispose in a sealed trash container, or burn. Anaerobic soil disinfestation (ASD) is an effective biological treatment for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

chlorothalonil products (chlorothalonil) *Tomato* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.0 pt. per acre. Use 54% (720) formulations at 1.38-2.75 pt. per acre. Use 82.5% (WDG) formulations at 1.3-2.6 lb. per acre. Use 90% DF formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Tomato* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may improve efficacy of fungicides against Phytophthora blight when tank mixed at labeled rates. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Forum (dimethomorph) *Eggplant, Pepper* | 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 40.

Gavel 75DF (zoxamide, mancozeb) *Tomato* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

mancozeb products (mancozeb) *Pepper, Tomato* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.6-2.4 qt. per acre. Use 75% and 80% formulations at 0.75-3.0 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Tomato* | 5.5-8.0 fl. oz. per acre. Alternate with fungicides that have a different mode of action. Use either soil applications or foilar applications of oxathiapiproplin products, but not both. REI: 4-hour. PHI: 1-day. FRAC 49, FRAC 40.

Presidio (fluopicolide) *Eggplant, Pepper, Tomato* | 3-4 fl. oz. per acre. Must be tank-mixed with a product with a different mode of action. REI: 12-hour. PHI: 2-day. FRAC 43.

Previcur Flex (propamocarb) *Eggplant, Pepper, Tomato* | For Pythium spp., apply 1.2 pts. (eggplants or peppers) or 1.5 pts. per acre (tomato) per acre with nozzles directed at base of plants, or via drip irrigation, transplant water or sprinklers. For late blight, 0.7-1.5 pts. per acre. REI: 12-hour. PHI: 5-day. FRAC 28.

Priaxor (fluxapyroxad, pyraclostrobin) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. Late blight, 8 fl. oz. per acre. Gray mold and white mold suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Pepper, Tomato* | 1.6 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Ranman 400SC (cyazofamid) *Eggplant, Pepper, Tomato* | 2.1-2.75 fl. oz. per acre. For Buckeye rot and Phytophthora blight, apply to base of plant or in transplant water. Another formulation is Segway O. REI: 12-hour. PHI: 0-day. FRAC 21.

Reason 500SC (fenamidone) *Eggplant, Pepper, Tomato* | 5.5-8.2 fl. oz. per acre. Septoria leaf spot disease suppression. REI: 12-hour. PHI: 14-day. FRAC 11.

Revus (mandipropamid) *Eggplant, Pepper* | 8 fl. oz. per acre. Phytophthora blight suppression only. REI: 4-hour. PHI: 1-day. FRAC 40.

Revus Top (mandipropamid, difenoconazole) *Tomato* | 5.5-7.0 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day. FRAC 40, FRAC 03.

Ridomil Gold Bravo SC (mefenoxam, chlorothalonil) *Tomato* | 2.5 pts. per acre. REI: 48-hour. PHI: 5-day. FRAC 04, FRAC M05.

Ridomil Gold MZ WG (mefenoxam, mancozeb) *Tomato* | 2.5 pts. per acre. REI: 48-hour. PHI: 5-day. FRAC 04, FRAC M03.

Tanos (famoxadone, cymoxanil) *Pepper, Tomato* | Tomato: Early blight at 6-8 oz. per acre. Late blight and anthracnose at 8 oz per acre. For suppression of bacterial diseases of tomato, 8 oz. For late blight, tank-mix with a contact fungicide with a different mode of action. Pepper: Anthracnose at 8-10 fl. oz. REI: 12-hour. FRAC 11, FRAC 27.

Zampro (ametoctradin, dimethomorph) *Eggplant, Pepper, Tomato* | 14 fl. oz. per acre. REI: 12-hour. PHI: 4-day. FRAC 45, FRAC 40.

Zing! (zoxamide, chlorothalonil) *Eggplant, Pepper, Tomato* | Application rate: 34 fl. oz. per acre for pepper; 36 fl. oz for tomato. REI: 12-hour. PHI: 3-day. FRAC 22, FRAC M05.

Leaf Blight of Fruiting Vegetables - Septoria Fungus

This pathogen can infect eggplants, peppers, and tomatoes, but is mainly a problem in tomatoes. This disease initially causes lesions on lower leaves of the tomato plant. After field planting, begin protective fungicide applications on a 7-14 day schedule.

Non-Pesticide

Eggplant, Pepper, Tomato | Avoid fields with a history of Fusarium and Verticillium wilts. Rotate to non-solanaceous crops for 2-3 years. Varieties resistant to Fusarium and Verticillium wilt will hold up better against Septoria. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Eggplant, Pepper, Tomato* | 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Tomato* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 6.3-7.8 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.024-0.08 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Eggplant, Pepper, Tomato* | 8-12 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Tomato* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.0 pt. per acre. Use 54% (720) formulations at 1.38-2.75 pt. per acre. Use 82.5% (WDG) formulations at 1.3-2.6 lb. per acre. Use 90% DF formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

Flint Extra (trifloxystrobin) *Eggplant, Pepper, Tomato* | 3.0-3.8 fl. oz. per acre. Use Gem 500 SC at same rate. Use Flint (50%) formulation at 3-4 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11.

Fontelis (penthiopyrad) *Eggplant, Pepper, Tomato* | 16-24 fl. oz per acre for all diseases listed here except anthracnose at 24 fl. oz. Suppression only for anthracnose. In the greenhouse use a rate of 0.75 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 0-day. FRAC 07.

Gavel 75DF (zoxamide, mancozeb) *Tomato* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

Inspire Super (difenoconazole, cyprodinil) *Eggplant, Pepper, Tomato* | 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 09.

Luna Sensation (fluopyram, trifloxystrobin) *Eggplant, Pepper, Tomato* | Rates are as follows per acre: early blight, powdery mildew, Septoria leaf spot at 5-7.6 fl. oz.; anthracnose, gray mold, white mold and southern blight at 7.6 fl. oz. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Luna Tranquility (fluopyram, pyrimethanil) *Tomato* | 11.2 fl. oz. per acre. Disease suppression of powdery mildew. Labeled for field use and in greenhouses with good fungicide resistance management programs REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 09.

mancozeb products (mancozeb) *Pepper, Tomato* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.6-2.4 qt. per acre. Use 75% and 80% formulations at 0.75-3.0 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Mettle 125ME (tetraconazole) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Miravis Prime (pydiflumetofen, fludioxonil) *Pepper, Tomato* | 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 12.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

Priaxor (fluxapyroxad, pyraclostrobin) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. Late blight, 8 fl. oz. per acre. Gray mold and white mold suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris 2.08SC (azoxystrobin) *Pepper, Tomato* | 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Pepper, Tomato* | 1.6 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Pepper, Tomato* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC 03.

Reason 500SC (fenamidone) *Eggplant, Pepper, Tomato* | 5.5-8.2 fl. oz. per acre. Septoria leaf spot disease suppression. REI: 12-hour. PHI: 14-day. FRAC 11.

Revus Top (mandipropamid, difenoconazole) *Tomato* | 5.5-7.0 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day. FRAC 40, FRAC 03.

Topguard EQ (flutriafol, azoxystrobin) *Tomato* | 4-8 fl. oz. per acre. REI: 12-hour to 3-day. PHI: 0-day. FRAC 03, FRAC 11.

Zing! (zoxamide, chlorothalonil) *Eggplant, Pepper, Tomato* | Application rate: 34 fl. oz. per acre for pepper; 36 fl. oz for tomato. REI: 12-hour. PHI: 3-day. FRAC 22, FRAC M05.

Leaf Mold of Fruiting Vegetables - Passalora Fungus

This pathogen can infect eggplants, peppers and tomatoes, but is mainly a problem in tomatoes. This disease causes yellow lesions on the upper side of the tomato leaf. It is common in greenhouse and high tunnel tomatoes.

Non-Pesticide

Eggplant, Pepper, Tomato | Use pathogen-free seed and disease-free transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for tomato. Rotate to non-Solanaceous crops for 2 years. Resistant varieties are available. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Monitor humidity in the hoophouse and vent appropriately. Pruning the crop can help increase airflow as well. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Eggplant, Pepper, Tomato* | 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

chlorothalonil products (chlorothalonil) *Tomato* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.0 pt. per acre. Use 54% (720) formulations at 1.38-2.75 pt. per acre. Use 82.5% (WDG) formulations at 1.3-2.6 lb. per acre. Use 90% DF formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 0-day. FRAC M05.

Gavel 75DF (zoxamide, mancozeb) *Tomato* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day. FRAC 22, FRAC M03.

Inspire Super (difenoconazole, cyprodinil) *Eggplant, Pepper, Tomato* | 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 09.

mancozeb products (mancozeb) *Pepper, Tomato* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.6-2.4 qt. per acre. Use 75% and 80% formulations at 0.75-3.0 lb. per acre. REI: 24-hour. PHI: 5-day. FRAC M03.

Mettle 125ME (tetraconazole) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Miravis Prime (pydiflumetofen, fludioxonil) *Pepper, Tomato* | 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 12.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Pepper, Tomato* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC 03.

Revus Top (mandipropamid, difenoconazole) *Tomato* | 5.5-7.0 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day. FRAC 40, FRAC 03.

Tanos (famoxadone, cymoxanil) *Pepper, Tomato* | Tomato: Early blight at 6-8 oz. per acre. Late blight and anthracnose at 8 oz per acre. For suppression of bacterial diseases of tomato, 8 oz. For late blight, tank-mix with a contact fungicide with a different mode of action. Pepper: Anthracnose at 8-10 fl. oz. REI: 12-hour. FRAC 11, FRAC 27.

Nematodes

Non-Pesticide

Tomato | Collect soil samples for nematodes in the fall and avoid fields with high numbers. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue and displace nematodes is an important method to prevent nematode build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain nematodes.

Pesticide

K-PAM HL (metam potassium) *Eggplant, Pepper, Tomato* | 30-62 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place K-PAM HL or Sectagon K54 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Nimitz (fluensulfone) *Eggplant, Pepper, Tomato* | 3.5-7 pts. per acre. Do not use on direct-seeded plants. May be broadcast, banded, or drip-applied in the spring up to 7 days before planting at a depth of 8 inches. Effectiveness is reduced on muck and clay soils. REI: 12-hour. IRAC UN.

Telone C-17 (1,3-dichloropropene, chloropicrin) *Eggplant, Pepper, Tomato* | *Muck soils*: Use C-17 formulation at 27.4-30 gals. per acre, and C-35 formulation at 33-36 gals. per acre. *Mineral soils*: Use C-17 formulation at 10.8-17.1 gals. per acre, and C-35 formulation at 13-20.5 gals per acre. In the fall, when soil at 6 inches is above 50 F and moist, place Telone C-17 or C-35 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing, irrigation, or plastic. Or, in the spring, InLine may be applied through drip irrigation under unperforated plastic beds at 13-20.5 gals. per acre, on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 3-5-day. IRAC 8A, FRAC NC, IRAC 08B. *RUP.*

Telone II (1,3-dichloropropene) *Eggplant, Pepper, Tomato* | *Muck soils*: Use at 25 gals. per acre. *Mineral soils*: Use at 9-12 gals. per acre. In the spring or fall, when soil at 6 inches is above 50 F and moist, place Telone II about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, Telone EC may be applied through drip irrigation under unperforated plastic beds at 9-18 gals. per acre on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 8A, FRAC NC. *RUP.*

VAPAM HL (metam sodium) *Eggplant, Pepper, Tomato* | 37.5-75 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place VAPAM HL or Sectagon K42 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Velum Prime (fluopyram) *Eggplant, Pepper, Tomato* | 5.0-6.84 fl. oz. per acre. Apply through drip irrigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. FRAC 07.

Vydate L (oxamyl) *Eggplant* | 2-4 pts. per acre. Apply as a transplant water drench (peppers and tomatoes only), banded directed post-plant soil treatment with at least 20 gals. water per acre incorporated 2-4 inches deep by water or mechanical means, or drip chemigate after transplanting with at least 40 gals. water per acre. Allow 14 days between applications. *For eggplants,* do not exceed 16 pts. per acre per season. *For peppers*, do not exceed 24 pts. per acre per season. *For tomatoes*, do not exceed 32 pts. per acre per season. *In Kansas*, only drip treatment allowed for eggplant, only low rate allowed for peppers, and up to 8 pts. allowed for tomato drip applications. *In Missouri*, up to 8 pts. per acre allowed for tomato drip applications. REI: 48-hour. PHI: 7-day for eggplants and peppers, 3-day for tomatoes. IRAC 01A. *RUP.*

Phytophthora Blight of Multiple Crops - Phytophthora Oomycete

Phytophthora may cause damping-off, stem infection, and fruit rot in tomatoes and peppers. It is mainly a pepper disease and often associated with heavy rains and fields with poor drainage. The first symptoms are usually observed in low areas. It has a wide host range of crops and weeds, including

vine crops, beans, nightshades and velvetleaf. Ponds and streams with run-off water from infested soil may be contaminated with Phytophthora.

At planting, use a transplant drench to help prevent *Phytophthora* infection of young plants. *At fruit set,* apply contact or systemic fungicides at first sign of the disease to prevent fruit rots. Systemic fungicides are available.

Non-Pesticide

Eggplant, Pepper, Tomato | Rotate to non-cucurbit, non-legume, and non-solanaceous crops for >/=3 years. Avoid fields with a history of the disease and poor drainage. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Do not irrigate with surface water. Pepper varieties with moderate to good resistance to the crown and root rot phase of Phytophthora blight include the *Bell-types,* Paladin, Aristotle, Archimedes, Revolution, Declaration, Intruder, and Vanguard; *Jalapeno-types,* Hechicero; and *Ancho-type,* Sequoia. These varieties are susceptible to the foliar and fruit rot phases of Phytophthora blight. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

Elumin (ethaboxam) *Eggplant, Pepper* | 8 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 22.

mefenoxam/metalaxyl products (mefenoxam) *Eggplant, Pepper, Tomato* | Start soil treatments before transplanting. Subsequent directed sprays may be needed. Fungicides will not be effective if plants are planted in poorly drained fields with a history of the disease. Several formulations (Apron, MetaStar, Ridomil Gold, Ultra Flourish, Subdue Maxx, and Xyler) are labeled. Several formulations are labeled as pre-plant incorporated or surface broadcast and banded applications at various rates between 1 pt. and 8 pt. per acre. A 2.5% granular formulation can be used at 20 lb. per acre *in tomatoes only*. A 33.3% seed treatment formulation can be used at 0.32-0.64 fl. oz. per 100 lb. of seed. A 22% formulation can be used at 21.7 ml. per 1000 sq. ft. *for transplants grown for retail sale to consumers*. REI: 48-hour. PHI: 7-day. FRAC 04.

Omega 500F (fluazinam) *Eggplant, Pepper* | 16-24 fl. oz. per acre. Apply 24 fl. oz. per acre as a soil drench at transplanting. Then, begin foliar applications using low rates under low disease pressure, and high rates under high disease pressure. REI: 12-hour. PHI: 30-day. FRAC 29.

Orondis Gold (oxathiapiprolin, mefenoxam) *Eggplant, Pepper, Tomato* | 28-55 fl. oz. per acre. Use as an at-plant soil drench, banded spray in furrow, or through drip irrigation. Do not follow soil applications of Orondis Gold with foliar applications of Orondis Opti, or Orondis Ultra. REI: 4-hour. PHI: 7-day. FRAC 49, FRAC 04.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Tomato* | 5.5-8.0 fl. oz. per acre. Alternate with fungicides that have a different mode of action. Use either soil applications or foilar applications of oxathiapiproplin products, but not both. REI: 4-hour. PHI: 1-day. FRAC 49, FRAC 40.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) *Pepper, Tomato* | Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. REI: 4 to 12-hour. PHI: see label. FRAC P07.

Presidio (fluopicolide) *Eggplant, Pepper, Tomato* | 3-4 fl. oz. per acre. Must be tank-mixed with a product with a different mode of action. REI: 12-hour. PHI: 2-day. FRAC 43.

Ranman 400SC (cyazofamid) *Eggplant, Pepper, Tomato* | 2.1-2.75 fl. oz. per acre. For Buckeye rot and Phytophthora blight, apply to base of plant or in transplant water. Another formulation is Segway O. REI: 12-hour. PHI: 0-day. FRAC 21.

Revus (mandipropamid) *Eggplant, Pepper* | 8 fl. oz. per acre. Phytophthora blight suppression only. REI: 4-hour. PHI: 1-day. FRAC 40.

Ridomil Gold SL (mefenoxam) *Eggplant, Pepper, Tomato* | 1 pt. per acre. Soil treatment at 1 pt. per acre broadcast (use less for band applications) before transplanting. Subsequent directed sprays may be needed. *Phytophthora crown rot only*. Fungicides will not be effective if plants are planted in poorly drained fields with a history of the disease. Damping-off treatments for tomato are 1-2 pts. per acre. Other formulations include MetaStar, Subdue Maxx, Ultra Flourish, and Xyler. Rates vary by formulation. REI: 48-hour. PHI: 7-day. FRAC 04.

Zampro (ametoctradin, dimethomorph) *Eggplant, Pepper, Tomato* | 14 fl. oz. per acre. REI: 12-hour. PHI: 4-day. FRAC 45, FRAC 40.

Powdery Mildew of Fruiting Vegetables - Leveillula Fungus

This pathogen can infect eggplants, peppers and tomatoes, but is mainly a problem in tomatoes.

Non-Pesticide

Eggplant, Pepper, Tomato | Avoid fields with a history of the disease. Rotate to non-solanaceous crops for 2 years. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Eggplant, Pepper, Tomato* | 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Tomato* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 6.3-7.8 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.024-0.08 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Eggplant, Pepper, Tomato* | 8-16 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Eggplant, Pepper* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 54% (720) formulations at 1.5 pt. per acre. Use 82.5% (WDG) formulations at 1.4 lb. per acre. REI: 12-hour. PHI: 3-day. FRAC M05.

Flint Extra (trifloxystrobin) *Pepper* | 2.5 fl. oz. per acre. Use Gem 500SC at 2.0 fl. oz. per acre. Use Flint (50%) formulation at 1.5-2.0 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11.

Flint Extra (trifloxystrobin) *Tomato* | 3.0-3.8 fl. oz. per acre. Use Gem 500SC at the same rate. Use Flint (50%) formulation at 3.0-4.0 fl. oz. per acre REI: 12-hour. PHI: 3-day. FRAC 11.

Fontelis (penthiopyrad) *Eggplant, Pepper, Tomato* | 16-24 fl. oz per acre for all diseases listed here except anthracnose at 24 fl. oz. Suppression only for anthracnose. In the greenhouse use a rate of 0.75 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 0-day. FRAC 07.

Inspire Super (difenoconazole, cyprodinil) *Eggplant, Pepper, Tomato* | 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 09.

Luna Sensation (fluopyram, trifloxystrobin) *Eggplant, Pepper, Tomato* | Rates are as follows per acre: early blight, powdery mildew, Septoria leaf spot at 5-7.6 fl. oz.; anthracnose, gray mold, white mold and southern blight at 7.6 fl. oz. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Luna Tranquility (fluopyram, pyrimethanil) *Tomato* | 11.2 fl. oz. per acre. Disease suppression of powdery mildew. Labeled for field use and in greenhouses with good fungicide resistance management programs REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 09.

Mettle 125ME (tetraconazole) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Miravis Prime (pydiflumetofen, fludioxonil) *Pepper, Tomato* | 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 12.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Eggplant, Pepper, Tomato* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day. FRAC 49, FRAC M05.

Pageant Intrinsic (boscalid, pyraclostrobin) *Eggplant, Pepper, Tomato* | Rates are as follow per acre: Powdery mildew at 9.7-18 oz.; gray mold at 23 oz. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Priaxor (fluxapyroxad, pyraclostrobin) *Eggplant, Pepper, Tomato* | 6-8 fl. oz. per acre. Late blight, 8 fl. oz. per acre. Gray mold and white mold suppression only. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris 2.08SC (azoxystrobin) *Pepper, Tomato* | 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Pepper, Tomato* | 1.6 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Pepper, Tomato* | 8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC 03.

Revus Top (mandipropamid, difenoconazole) *Tomato* | 5.5-7.0 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day. FRAC 40, FRAC 03.

Switch 62.5WG (cyprodinil, fludioxonil) *Eggplant, Pepper, Tomato* | 11-14 oz. per acre. Do not apply to small fruited varieties in the greenhouse. REI: 12-hour. PHI: 0-day. FRAC 09, FRAC 12.

Velum Prime (fluopyram) *Eggplant, Pepper, Tomato* | 5.0-6.84 fl. oz. per acre. Apply through drip irrigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. FRAC 07.

Southern Blight of Fruiting Vegetables - Sclerotium Fungus

This disease is normally observed in southern climates or during seasons with above normal temperatures.

Non-Pesticide

Eggplant, Pepper, Tomato | Rotate to a non-broadleaf crop, such as grass grains, sweet corn, or onions for >6 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Eggplant, Pepper, Tomato* | 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day. FRAC 03, FRAC 07.

Cabrio EG (pyraclostrobin) *Eggplant, Pepper, Tomato* | 12-16 oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day. FRAC 11.

Fontelis (penthiopyrad) *Eggplant, Pepper, Tomato* | 16-24 fl. oz per acre for all diseases listed here except anthracnose at 24 fl. oz. Suppression only for anthracnose. In the greenhouse use a rate of 0.75 fl. oz. per gallon per 1,360 sq. ft. REI: 12-hour. PHI: 0-day. FRAC 07.

Luna Sensation (fluopyram, trifloxystrobin) *Eggplant, Pepper, Tomato* | Rates are as follows per acre: early blight, powdery mildew, Septoria leaf spot at 5-7.6 fl. oz.; anthracnose, gray mold, white mold and southern blight at 7.6 fl. oz. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day. FRAC 07, FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Pepper, Tomato* | 1.6 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Viruses of Multiple Crops - Multiple Pathogens

There are three main virus diseases in tomatoes: Impatiens Necrotic Spot Virus (INSV), Tomato Spotted Wilt Virus (TSWV), and Tobacco Mosaic Virus (TMV).

INSV and TSWV is carried by thrips and can cause major loss to tomatoes if they infect young plants. It is more common in greenhouse and high tunnel situations, especially where tomatoes and ornamental flowers share space.

TMV is more of a problem in fresh market tomatoes than processing tomatoes due to extensive handling. Disease can spread through smoking tobacco and tobacco residue.

Non-Pesticide

Tomato | For **INSV and TSWV:** maintain transplant greenhouse sanitation and good weed control is important. Avoid shared space with hanging basket flowers, and Solanaceous weeds like nightshades and horse nettle. Use a monitoring program to time the release of natural enemies of thrips (see insect section). Remove infected transplants and do not plant them out into fields. For **TMV**: establish and enforce break area and handwashing rules and procedures to avoid tobacco residue on tomato plants. Remove infected transplants and do not plant them out into fields.

White Mold (Timber Rot, Drop, Stem Rot) of Multiple Crops - Sclerotinia Fungus

This soil pathogen is long-lived in the soil and has a wide host range on broadleaved crops and weeds, including beans, vine crops, lettuce, tomatoes, peppers, and cole crops. It goes by other names in other crops, such as Drop, White Mold, Stem Rot, and Timber Rot.

It is more commonly found in greenhouses and high tunnels where humidity is high. The fungus often infects flowers, which then drop off and infect the stems that they land on. The stems take on a woody appearance and can split open, revealing small black pellets that are the overwintering body of the pathogen.

Non-Pesticide

Eggplant, Pepper, Tomato | Avoid fields with a history of the problem. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >6 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective biological treatment for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

Cabrio EG (pyraclostrobin) *Eggplant, Pepper, Tomato* | 12-16 oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day. FRAC 11.

Contans WG (Coniothyrium minitans strain CON/M/91-08) *Eggplant, Pepper* | 1-4 lbs per acre. 1-4 lbs. per acre in the field; 0.75-1.5 oz. per 1,000 sq. ft. for greenhouse/high tunnel applications. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Endura (boscalid) *Tomato* | Rates as follows per acre: early blight rates are 2.5-3.5 oz.; Gray mold rates are 9-12.5 oz.; white mold rates 12.5 oz. Suppression only for while mold. REI: 12-hour. PHI: 0-day. FRAC 07.

Howler (Pseudomonas chlororaphis strain AFS009) *Eggplant, Pepper, Tomato* | 5-15 lb. per acre. See label for other field and greenhouse uses. Suppression of Botrytis gray mold; use in a program with good cultural practices and effective fungicides. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

Quadris Opti (azoxystrobin, chlorothalonil) *Pepper, Tomato* | 1.6 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Wilt of Multiple Crops - Verticillium Fungus

This is a soil pathogen. Eggplants are more sensitive to it than other Solanaceous crops.

Non-Pesticide

Eggplant, Tomato | Avoid fields with a history of the disease. Rotate to non-cucurbit, non-legume, and non-solanaceous crops for >6 years. Many tomato varieties with resistance are available, and resistant tomato rootstocks are available for grafting under eggplant. Use raised beds, staking, and mulch to improve drainage, air flow, and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

K-PAM HL (metam potassium) *Eggplant, Pepper, Tomato* | 30-62 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place K-PAM HL or Sectagon K54 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Telone C-17 (1,3-dichloropropene, chloropicrin) *Eggplant, Pepper, Tomato* | *Muck soils*: Use C-17 formulation at 27.4-30 gals. per acre, and C-35 formulation at 33-36 gals. per acre. *Mineral soils*: Use C-17 formulation at 10.8-17.1 gals. per acre, and C-35 formulation at 13-20.5 gals per acre. In the fall, when soil at 6 inches is above 50 F and moist, place Telone C-17 or C-35 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing, irrigation, or plastic. Or, in the spring, InLine may be applied through drip irrigation under unperforated plastic beds at 13-20.5 gals. per acre, on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 3-5-day. IRAC 8A, FRAC NC, IRAC 08B. *RUP.*

VAPAM HL (metam sodium) *Eggplant, Pepper, Tomato* | 37.5-75 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place VAPAM HL or Sectagon K42 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Fruiting Vegetables - Insects

Reviewed by Laura Ingwell, Marissa Schuh, Ashley Leach, Dan Fillius – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Eggplant, Pepper, Tomato | Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators. For greenhouses, consider purchasing and releasing the predatory midge *Aphidoletes aphidimyza*, lady beetles *Adalia bipunctata* and *Hippodamia convergens*, and lacewings *Chrysopa carnea* and *Chrysoperla ryfilabris*. Also depending on the aphid species, consider co-releasing a parasitoid wasp like *Aphelinus abdominalis, Aphidius colemani, Aphidius ervi*, or *Aphidius matricariae*. Avoid insecticides when deploying natural enemies.

Pesticide

Actara (thiamethoxam) *Eggplant, Pepper, Tomato* | 2-3 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Admire Pro (imidacloprid) *Eggplant, Pepper, Tomato* | Use 1.3-2.2 fl. oz. per acre for foliar application on eggplant, pepper, and tomato. Use 7.0-10.5 fl. oz. per acre for soil application on eggplant and tomato, up to 14 fl. oz. per acre for pepper. REI: 12-hour. PHI: 0-day for foliar application, or 21-day for soil application. IRAC 04A.

Assail 30SG (acetamiprid) *Eggplant, Pepper, Tomato* | Use 30SG formulations at 2.0-4.0 oz. per acre. Use 70WP formulations at 0.8-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Beleaf (flonicamid) *Eggplant, Pepper, Tomato* | 2.0-4.28 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Dimethoate 4EC (dimethoate) *Pepper, Tomato* | Use 2.67EC formulations at 0.75-1.0 pt. per acre on peppers, or 0.75-1.5 pts. per acre on tomatoes. Use 4EC, LV-4, and 400EC formulations at 0.5-0.6 pt. per acre on peppers, or 0.5-1.0 pt. per acre on tomatoes. REI: 48-hour. PHI: 0-day for pepper, 7-day for tomato. IRAC 01B.

Fulfill (pymetrozine) *Eggplant, Pepper, Tomato* | 2.75 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 09B.

Lannate LV (methomyl) *Eggplant, Pepper, Tomato* | 0.75-3.0 pts. per acre. REI: 48-hour. PHI: 1-day for tomato, 3-day for pepper, 5-day for eggplant. IRAC 01A. *RUP.*

M-Pede (potassium salts of fatty acids) *Eggplant, Pepper, Tomato* | 1-2% by volume. Must contact target insects to be effective. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Malathion 5EC (malathion) *Eggplant, Pepper, Tomato* | Use 5EC formulations at 1.5-2.5 pts. per acre for eggplant, 1.0-2.5 pts. per acre for pepper, 1.5 pts. per acre for tomato. Use 57EC formulations at 1.0-1.5 pts. per acre on eggplant, 1.25-1.5 pts. per acre on pepper, 1.0-1.25 pts. per acre for tomato. REI: 12-hour. PHI: 1-day for tomato, 3-day for eggplant and pepper. IRAC 01B.

Movento (spirotetramat) *Eggplant, Pepper, Tomato* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 23.

Orthene 97 (acephate) *Pepper* | For Bell Pepper, use 0.5-1 lb. per acre. For all other peppers, use 0.5 lb. per acre. REI: 24-hour. PHI: 7-day. IRAC 01B.

Platinum 2SC (thiamethoxam) *Eggplant, Pepper, Tomato* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sivanto 200 (flupyradifurone) *Eggplant, Pepper, Tomato* | 7-12 fl. oz. per acre foliar application, or 21-28 fl. oz. per acre soil application. REI: 4-hour. PHI: 1-day for foliar application, or 45-day for soil application. IRAC 04D.

Vydate L (oxamyl) *Eggplant, Pepper, Tomato* | 2-4 pts. per acre. Apply as a foliar spray. Drip application allowed in peppers. *In Kansas*, only low rate allowed for peppers. REI: 48-hour. PHI: 1-day for eggplant, 3-day for tomato, 7-day for pepper. IRAC 01A. *RUP.*

Caterpillars

There are many caterpillar pests of fruiting vegetables, including corn earworm/tomato fruitworm, tomato hornworm, tomato pinworm, European corn borer, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Pesticide

Asana XL (esfenvalerate) *Eggplant, Pepper, Tomato* | 2.9-9.6 fl. oz. per acre. For armyworms, corn borers, cutworms, fruitworms, hornworms, loopers, and pinworms in tomatoes. For corn borers, fruitworms, and loopers in eggplants. For armyworms, corn borers, fruitworms, and loopers in peppers. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Avaunt (indoxacarb) *Eggplant, Pepper, Tomato* | 2.5-3.5 fl. oz. per acre. For armyworms, fruitworms, hornworms, and loopers in tomatoes, peppers and eggplants. For corn borers in bell peppers. REI: 12-hour. PHI: 3-day. IRAC 22A.

Baythroid XL (beta-cyfluthrin) *Eggplant, Pepper, Tomato* | 1.6-2.8 fl. oz. per acre. For armyworms, corn borers, cutworms, fruitworms, hornworms, loopers, and pinworms. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Eggplant, Pepper, Tomato* | For armyworms, corn borers, cutworms, fruitworms, and loopers in tomatoes, peppers, and eggplants. For hornworms, and pinworms in peppers and eggplants only. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-12.8 oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Bt (Bacillus thuringiensis) products for caterpillars (Bacillus thuringiensis aizawai strain ABTS-1857, Bacillus thuringiensis aizawai strain GC-91, Bacillus thuringiensis kurstaki strain ABTS-351, Bacillus thuringiensis kurstaki strain EVB-113-19, Bacillus thuringiensis kurstaki strain SA-11) *Eggplant, Pepper, Tomato* | For armyworms, corn borers, cutworms, fruitworms, hornworms, loopers, and pinworms. Various Bt products (Agree, Biobit, Dipel, Javelin, etc.) are available for control of young caterpillars however, different Bt products can vary in the effectiveness against caterpillars. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Coragen (chlorantraniliprole) *Eggplant, Pepper, Tomato* | 2.0-7.5 fl. oz. per acre. For armyworms, corn borers, fruitworms, hornworms, loopers, and pinworms. Can be applied as either a foliar application or via drip chemigation. Chemigation will provide up to 30 days of control. REI: 4-hour. PHI: 1-day. IRAC 28.

Danitol 2.4EC (fenpropathrin) *Eggplant, Pepper, Tomato* | 10.67 fl. oz. per acre. For armyworms, cutworms, fruitworms, hornworms, and loopers. REI: 24-hour. PHI: 3-day. IRAC 03A. *RUP.*

Diazinon AG500 (diazinon) *Tomato* | For cutwoms. Use 50W formulations at 4-8 lbs. per acre as a pre-plant incorporation. Use AG500 formulations at 64-128 fl. oz. per acre as a pre-plant incorporation. Use AG600 formulations at 51-102 fl. oz. per acre as a pre-plant incorporation. REI: 2 to 4-day. IRAC 01B. *RUP.*

Entrust SC (spinosad) *Eggplant, Pepper, Tomato* | For armyworms, fruitworms, hornworms, loopers, and pinworms. Use 2SC formulations at 4.0-8.0 fl. oz. per acre. Use 80WP formulations at 1.25-2.5 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Eggplant, Pepper, Tomato* | 7.0-13.5 fl. oz. per acre. For armyworms, corn borers, fruitworms, hornworms, loopers, and pinworms. REI: 12-hour. PHI: 1-day. IRAC 28.

Harvanta (cyclaniliprole) *Eggplant, Pepper, Tomato* | 10.9-16.4 fl. oz. per acre. For armyworms, corn borers, fruitworms, hornworms, loopers, and pinworms. Use with adjuvant. REI: 4-hour. PHI: 1-day. IRAC 28.

Intrepid 2F (methoxyfenozide) *Eggplant, Pepper, Tomato* | 4-16 oz. per acre. For armyworms, corn borers, hornworms, and loopers. REI: 4-hour. PHI: 1-day. IRAC 18.

Lannate LV (methomyl) *Eggplant, Pepper, Tomato* | 1.5-3.0 pts. per acre. For armyworms, fruitworms, and pinworms in eggplant. For armyworms, cutworms, fruitworms, hornworms, loopers, and pinworms in tomatoes. For armyworms, cutworms, corn borers, and loopers in peppers. REI: 48-hour. PHI: 1-day for tomato, 3-day for pepper, 5-day for eggplant. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Eggplant, Pepper, Tomato* | 2.24-4.0 fl. oz. per acre. For armyworms, corn borers, cutworms, fruitworms, hornworms, loopers, and pinworms. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Pepper* | 0.75-1.0 lb. per acre. For corn borers, hornworms, and loopers in bell pepper. REI: 24-hour. PHI: 7-day. IRAC 01B.

Perm-Up 25DF (permethrin) *Eggplant, Pepper, Tomato* | For armyworms, fruitworms, hornworms, loopers, and pinworms. Use 25W, 25WP or 25DF formulations at 3.2-12.8 fl. oz. per acre for tomato, 9.6 fl. oz. per acre for eggplant, or 6.4-12.8 fl. oz. per acre for pepper. Use 3.2EC formulations at 2-8 fl. oz. per acre for tomato, 6 fl. oz. per acre for eggplant, or 4-8 fl. oz. per acre for pepper. REI: 12-hour. PHI: 0-day for tomato, 3-day for eggplant and pepper. IRAC 03A. *RUP.*

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | For armyworms, fruitworms, hornworms, loopers and pinworms. *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Radiant 1SC (spinetoram) *Eggplant, Pepper, Tomato* | 5-10 fl. oz. per acre. For armyworms, corn borers, fruitworms, hornworms, loopers and pinworms. REI: 4-hour. PHI: 1-day. IRAC 05.

Rimon 0.83EC (novaluron) *Eggplant, Pepper, Tomato* | 9-12 fl. oz. per acre. For armyworms, corn borers, cutworms, fruitworms, hornworms, loopers, and pinworms. REI: 12-hour. PHI: 1-day. IRAC 15.

Sevin XLR Plus (carbaryl) *Eggplant, Pepper, Tomato* | 1-2 qts. per acre. For armyworms, corn borers, cutworms, fruitworms, hornworms, and pinworms. REI: 12-hour. PHI: 3-day. IRAC 01A.

Verimark (cyantraniliprole) *Eggplant, Pepper, Tomato* | 5-10 fl. oz. per acre. For armyworms, corn borers, fruitworms, hornworms, loopers, and pinworms. Can be applied as either a foliar application or via drip chemigation. REI: 4-hour. PHI: 1-day. IRAC 28.

Warrior II (lambda-cyhalothrin) *Eggplant, Pepper, Tomato* | 0.96-1.92 fl. oz. per acre. For armyworms, corn borers, cutworms, fruitworms, hornworms, loopers, and pinworms. REI: 24-hour. PHI: 5-day. IRAC 03A. *RUP.*

Colorado Potato Beetle

Colorado potato beetles spend the winter as adults near where they were feeding the previous year. Emerging overwintering adults walk to fields to feed, and can't travel very far. Management of the migrating spring adults can reduce later populations. Treatment of small larvae is more effective than treatment of large larvae; they are easier to control, and will be controlled before they do a majority of their feeding.

Thresholds vary by crop and plant growth stage.

For tomatoes, treat if plants have an average of one egg mass, larva, or adult Colorado beetle.

For peppers or eggplants under 6 inches

Treat if plants have an average of more than 2 small larvae, 1 large larvae, or 1 adult per plant

For peppers or eggplants over 6 inches

Treat if plants have an average of 4 small larvae, 2 large larvae, or 2 adults per plant.

Colorado potato beetle has cases of documented insecticide resistance. Rotate modes of action. Don't repeat insecticide classes across Colorado potato beetle generations.

Non-Pesticide

Eggplant, Pepper, Tomato | Rotating more than 0.25-0.5 miles in distance prevents overwintering adults from easily reaching this year's planting. Row covers early in the season can help plants escape early season feeding. Plastic-lined trenches can prevent the first generation from walking into fields. Straw mulch can make it more difficult for beetles to complete its lifecycle. Hand removal or flaming can be effective for small plantings.

Pesticide

Actara (thiamethoxam) *Eggplant, Pepper, Tomato* | 2-3 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Admire Pro (imidacloprid) *Eggplant, Pepper, Tomato* | Use 1.3-2.2 fl. oz. per acre for foliar application on eggplant, pepper, and tomato. Use 7.0-10.5 fl. oz. per acre for soil application on eggplant and tomato, up to 14 fl. oz. per acre for pepper. REI: 12-hour. PHI: 0-day for foliar application, or 21-day for soil application. IRAC 04A.

Agri-Mek SC (abamectin) *Eggplant, Pepper, Tomato* | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15SC formulations at 8-16 fl. oz. per acre. Greenhouse use for commercial production tomatoes only, not for transplants. REI: 12-hour. PHI: 7-day for field-grown crops, 1-day for greenhouse tomatoes. IRAC 06. *RUP.*

Asana XL (esfenvalerate) *Eggplant, Tomato* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Eggplant, Pepper, Tomato* | Use 30SG formulations at 1.5-2.5 oz. per acre. Use 70WP

formulations at 0.6-1.1 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Baythroid XL (beta-cyfluthrin) *Eggplant, Pepper, Tomato* | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Eggplant, Pepper, Tomato* | For armyworms, corn borers, cutworms, fruitworms, and loopers in tomatoes, peppers, and eggplants. For hornworms, and pinworms in peppers and eggplants only. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-12.8 oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) *Eggplant, Pepper, Tomato* | 3.5-5 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 28.

Entrust SC (spinosad) *Eggplant, Pepper, Tomato* | Use 2SC formulations at 3.0-6.0 fl. oz. per acre. Use 80WP formulations at 1.0-2.0 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Eggplant, Pepper, Tomato* | 7.0-13.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Gladiator (zeta-cypermethrin, abamectin) *Eggplant, Pepper, Tomato* | 19 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A, IRAC 06. *RUP.*

Harvanta (cyclaniliprole) *Eggplant, Pepper, Tomato* | 10.9-16.4 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 28.

Mustang Maxx (zeta-cypermethrin) *Eggplant, Pepper, Tomato* | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Eggplant, Tomato* | Use 25W, 25WP or 25DF formulations at 3.2-12.8 fl. oz. per acre for tomato or 9.6 fl. oz. per acre for eggplant. Use 3.2EC formulations at 2-8 fl. oz. per acre for tomato, or 6 fl. oz. per acre for eggplant. REI: 12-hour. PHI: 0-day for tomato, 3-day for eggplant. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Eggplant, Pepper, Tomato* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Radiant 1SC (spinetoram) *Eggplant, Pepper, Tomato* | 5-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05.

Rimon 0.83EC (novaluron) *Eggplant, Pepper, Tomato* | 9-12 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 15.

Scorpion 35SL (dinotefuran) *Eggplant, Pepper, Tomato* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1-4 oz. per acre. See pollination precautions. REI: 12-hour. PHI: 21-day as soil applications, 7-day as foliar applications. IRAC 04A.

Sivanto 200 (flupyradifurone) *Eggplant, Pepper, Tomato* | 10.5-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 04D.

Trident (Bacillus thuringiensis tenebrionis strain SA-10) *Eggplant, Pepper, Tomato* | 3-6 qts. per acre. For control of young larvae. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Verimark (cyantraniliprole) *Eggplant, Pepper, Tomato* | 5-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 28.

Vydate L (oxamyl) *Eggplant, Tomato* | 2-4 pts. per acre. REI: 48-hour. PHI: 1-day for eggplant, 3-day for tomato. IRAC 01A. *RUP.*

Warrior II (lambda-cyhalothrin) *Eggplant, Pepper, Tomato* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 5-day. IRAC 03A. *RUP.*

Flea Beetles

Flea beetles that feed on solanaceous crops include potato flea beetle.

Non-Pesticide

Eggplant, Pepper, Tomato | Rotating and immediately covering transplants with row cover can exclude flea beetles from young plants.

Pesticide

Actara (thiamethoxam) *Eggplant, Pepper, Tomato* | 2-3 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Admire Pro (imidacloprid) *Eggplant, Pepper, Tomato* | *Soil Application.* 7.0-10.5 fl. oz per acre for eggplant and tomato.

7-14 fl. oz. per acre for pepper. REI: 12-hour. PHI: 21-day. IRAC 04A.

Asana XL (esfenvalerate) *Eggplant, Pepper, Tomato* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) *Eggplant, Pepper, Tomato* | 2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Eggplant, Pepper, Tomato* | For armyworms, corn borers, cutworms, fruitworms, and loopers in tomatoes, peppers, and eggplants. For hornworms, and pinworms in peppers and eggplants only. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-12.8 oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Eggplant, Pepper, Tomato* | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Eggplant, Pepper* | Use 25W, 25WP or 25DF formulations at 9.6 fl. oz. per acre for eggplant, or 6.4-12.8 fl. oz. per acre for pepper. Use 3.2EC formulations at 6 fl. oz. per acre for eggplant, or 4-8 fl. oz. per acre for pepper. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Eggplant, Pepper, Tomato* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sevin XLR Plus (carbaryl) *Eggplant, Pepper, Tomato* | 0.5-1 qt. per acre. REI: 12-hour. PHI: 3-day. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Eggplant, Pepper, Tomato* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 5-day. IRAC 03A. *RUP.*

Fruit Flies

Pesticide

EverGreen Pro 60-6 (piperonyl butoxide, pyrethrins) *Tomato* | 1 tsp. per 12.5 pts. water. Starting 2 weeks before harvest, place bait fruits in fields in late afternoon, and examine next morning. If half of the baits show eggs, spray fields immediately at 4-6 day intervals. Treat harvested fruit and hampers as soon as filled, and move hampers to processing plant as soon as possible. REI: 12-hour. PHI: 0-day. IRAC UN, IRAC 03A.

Malathion 5EC (malathion) *Eggplant, Pepper, Tomato* | Use 5EC formulations at 1.5-2.5 pts. per acre for eggplant, 1.0-2.5 pts. per acre for pepper, 1.5 pts. per acre for tomato. Use 57EC formulations at 1.0-1.5 pts. per acre on eggplant, 1.25-1.5 pts. per acre on pepper, 1.0-1.25 pts. per acre for tomato. REI: 12-hour. PHI: 1-day for tomato, 3-day for eggplant and pepper. IRAC 01B.

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Mites

Two-spotted spider mites and broad mites are the primary pest mites in our region. Mite populations spike in hot dry weather. Damage appears as white flecks on leaves, accompanied by webbing. Selective chemistries (e.g. abamectin, bifenazate, etoxazole, cyflumetofen, fenpyroximate, hexythiazox, spiromesifen) that target mites help to preserve natural enemies.

Non-Pesticide

Eggplant, Pepper, Tomato | Preserve and encourage natural enemies. For greenhouses, consider purchasing and releasing the predatory mites *Amblyseius andersonii*, *Amblyseius californicus*, *Amblyseius fallacis*, *Galendromus occidentalis* and *Phytoseiulus persimilis*. Also consider co-releasing a flying predator such as the predatory midge *Feltiella acarisuga,* and lady beetle *Stethorus punctillum.* Avoid insecticides when deploying natural enemies.

Pesticide

Acramite 50WS (bifenazate) *Eggplant, Pepper, Tomato* | 0.75-1 lb. per acre. *Two-spotted spider mites only.* REI: 12-hour. PHI: 3-day. IRAC 20D.

Agri-Mek SC (abamectin) *Eggplant, Pepper, Tomato* | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15SC formulations at 8-16 fl. oz. per acre. Greenhouse use for commercial production tomatoes only, not for transplants. REI: 12-hour. PHI: 7-day for field-grown crops, 1-day for greenhouse tomatoes. IRAC 06. *RUP.*

Gladiator (zeta-cypermethrin, abamectin) *Eggplant, Pepper, Tomato* | 19 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A, IRAC 06. *RUP.*

Kanemite 15SC (acequinocyl) *Eggplant, Pepper, Tomato* | 31 fl. oz. per acre. *Spider mites only.* REI: 12-hour. PHI: 1-day. IRAC 20B.

Movento (spirotetramat) *Eggplant, Pepper, Tomato* | 4-5 fl. oz. per acre. *Russet mites and broad mites only.* REI: 24-hour. PHI: 1-day. IRAC 23.

Nealta (cyflumetofen) *Tomato* | 13.7 fl. oz. per acre. *Spider mites only.* REI: 12-hour. PHI: 3-day. IRAC 25A.

Oberon 2SC (spiromesifen) *Eggplant, Pepper, Tomato* | 7-8.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 23.

Portal (fenpyroximate) *Eggplant, Pepper, Tomato* | 2 pt. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A.

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Vydate L (oxamyl) *Eggplant* | 2-4 pts. per acre. REI: 48-hour. PHI: 1-day. IRAC 01A. *RUP.*

Wettable Sulfur (sulfur) *Tomato* | *Russet mites only.* Rates vary by product. Use 80% sulfur products at 10-20 lb. per acre (Sulfur Dry Flowable, Sulfur 80 WDG, Thiolux), or 5-20 lb. per acre (Microthiol Disperss). Use 90% sulfur at 2-8 lb. per acre (Sulfur 90W), or 15-30 lb. per acre (Golden Micronized Sulfur). Thorough coverage is required. Do not apply when temperatures are above 95F or during a heavy dew. REI: 24-hour. PHI: 0-day. FRAC M02, IRAC UN. *OMRI-listed.*

Zeal (etoxazole) *Eggplant, Pepper* | 2-3 oz. per acre. *Spider mites only.* REI: 12-hour. PHI: 7-day. IRAC 10B.

Slugs and Snails

Slugs and snails may occasionally damage seedlings, low growing leafy vegetables, and/or ripening fruit. Slug and snail feeding causes hollowed out areas, which can be found on fruit, but the damage is usually on the stem. Slugs and snails produce a silvery trail on the surface of leaves and fruit. Slugs and snails are active at night and they inhabit moist soil and organic mulch. Slugs and snails overwinter as eggs in moist soil.

Bait products can be placed on the soil surface around the perimeter of the planting area. Bait products can also be placed on the soil surface in a band between rows. Apply bait products in the evening after a rain or irrigation. Avoid contacting edible crops with bait products.

Non-Pesticide

Eggplant, Pepper, Tomato | Slug and snail hiding places, such as, boards, stones, weedy areas, and mulch should be eliminated. Raised beds will dry out faster than flat beds, which will reduce problems with slugs and snails. Black plastic mulch can be used to reduce problems with slugs and snails.

Pesticide

Deadline M-Ps (metaldehyde) *Tomato* | 25 lbs. per acre. REI: 12-hour. PHI: 0-day. IRAC UN.

Sluggo 1B (iron phosphate) *Eggplant, Pepper, Tomato* | 20-44 lbs. per acre, or at 05.-1 lb. per square ft. REI: 0-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Stink Bugs

Pesticide

Actara (thiamethoxam) *Eggplant, Pepper, Tomato* | 3.0-5.5 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Azera (azadirachtin, pyrethrins) *Eggplant, Pepper, Tomato* | 1-3.5 pts. per acre. REI: 12-hour. PHI: 0-day. IRAC UN, IRAC 03A. *OMRI-listed.*

Baythroid XL (beta-cyfluthrin) *Eggplant, Pepper, Tomato* | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Eggplant, Pepper, Tomato* | For armyworms, corn borers, cutworms, fruitworms, and loopers in tomatoes, peppers, and eggplants. For hornworms, and pinworms in peppers and eggplants only. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-12.8 oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Danitol 2.4EC (fenpropathrin) *Eggplant, Pepper, Tomato* | 10.67 fl. oz. per acre. REI: 24-hour. PHI: 3-day. IRAC 03A. *RUP.*

Lannate LV (methomyl) *Pepper, Tomato* | 1.5-3.0 pts. per acre. *Brown Marmorated Stink Bugs only.* REI: 48-hour. PHI: 1-day for tomato, 3-day for pepper. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Eggplant, Pepper, Tomato* | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Scorpion 35SL (dinotefuran) *Eggplant, Pepper, Tomato* | *Soil application*: Use Scorpion 35SL at 9.0-13.0 fl. oz. per acre, or Venom 70SG at 5.0-7.5 oz. per acre. *Foliar application*: Use Scorpion 35SL at 2.0-7.0 fl. oz. per acre, or Venom 70SG at 1-4 oz. per acre. See pollination precautions. REI: 12-hour. PHI: 21-day as soil applications, 7-day as foliar applications. IRAC 04A.

Warrior II (lambda-cyhalothrin) *Eggplant, Pepper, Tomato* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 5-day. IRAC 03A. *RUP.*

Thrips

Thrips populations spike in hot dry weather, and when neighboring small grains or alfalfa is harvested. Damage appears as white flecks on leaves. Thrips transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Selective chemistries (e.g. abamectin, spinetoram, spirotetramat, and spinosad) that target thrips help to preserve natural enemies.

Non-Pesticide

Eggplant, Pepper, Tomato | A heavy rain or overhead irrigation washes thrips out of plants. Avoid planting near early harvested grain or alfalfa fields. Preserve and encourage natural enemies. Minute pirate bugs, and lacewings are common predators. For greenhouses, consider purchasing and releasing the predatory mites *Amblyseius swirskii*, *Neoseiulus cucumeris* and *Stratiolaelaps scimitus*, minute pirate bug *Orius spp.* and beneficial nematode *Steinernema feltiae* to achieve pest suppression. *A. swirskii*, *N. cucumeris* and minute pirate bugs prey on life stages residing on the upper portion of the plant, *S. scimitus* and the beneficial nematodes attack the prepupae and pupae of thrips located in the soil or growing media.

Pesticide

Admire Pro (imidacloprid) *Eggplant, Pepper, Tomato* | *Soil Application.* 7.0-10.5 fl. oz per acre for eggplant and tomato. 7-14 fl. oz. per acre for pepper. REI: 12-hour. PHI: 21-day. IRAC 04A.

Agri-Mek SC (abamectin) *Eggplant, Pepper, Tomato* | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15SC formulations at 8-16 fl. oz. per acre. Greenhouse use for commercial production tomatoes only, not for transplants. REI: 12-hour. PHI: 7-day for field-grown crops, 1-day for greenhouse tomatoes. IRAC 06. *RUP.*

Assail 30SG (acetamiprid) *Eggplant, Pepper, Tomato* | Use 30SG formulations at 4.0 oz. per acre. Use 70WP formulations at 1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Azera (azadirachtin, pyrethrins) *Eggplant, Pepper, Tomato* | 2-3.5 pts. per acre. REI: 12-hour. PHI: 0-day. IRAC UN, IRAC 03A. *OMRI-listed.*

Baythroid XL (beta-cyfluthrin) *Eggplant, Pepper, Tomato* | 2.1-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Eggplant, Pepper, Tomato* | For armyworms, corn borers, cutworms, fruitworms, and loopers in tomatoes, peppers, and eggplants. For hornworms, and pinworms in peppers and eggplants only. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-12.8 oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Entrust SC (spinosad) *Eggplant, Pepper, Tomato* | Use 2SC formulations at 4.0-8.0 fl. oz. per acre. Use 80WP formulations at 1.25-2.5 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Eggplant, Pepper, Tomato* | 13.5-20.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Gladiator (zeta-cypermethrin, abamectin) *Eggplant, Pepper, Tomato* | 19 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A, IRAC 06. *RUP.*

Grandevo (Chromobacterium subtsugae strain PRAA4-1) *Eggplant, Pepper, Tomato* | 2-3 lb. per acre. REI: 4-hour. PHI: 0-day. IRAC UNB. *OMRI-listed.*

Minecto Pro (cyantraniliprole, abamectin) *Eggplant, Pepper, Tomato* | 10.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28, IRAC 06. *RUP.*

Movento (spirotetramat) *Eggplant, Pepper, Tomato* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 23.

Mustang Maxx (zeta-cypermethrin) *Eggplant, Pepper, Tomato* | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Neemix (azadirachtin) *Eggplant, Pepper, Tomato* | 4-16 fl. oz. per acre. REI: 4-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Platinum 2SC (thiamethoxam) *Eggplant, Pepper, Tomato* | 5-11 fl. oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Radiant 1SC (spinetoram) *Eggplant, Pepper, Tomato* | 6-10 fl. oz per acre. REI: 4-hour. PHI: 1-day. IRAC 05.

Rimon 0.83EC (novaluron) *Eggplant, Pepper, Tomato* | 12 oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 15.

Torac (tolfenpyrad) *Eggplant, Pepper, Tomato* | 21 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Transform WG (sulfoxaflor) *Eggplant, Pepper, Tomato* | Use Transform WG at 2.0-2.25 oz. per acre. Use Sequoia at 4.25-4.5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 04C.

Venerate (Burkholderia spp. strain A396) *Eggplant, Pepper, Tomato* | 1-8 qts. per acre. REI: 4-hour. PHI: 0-day. IRAC UNB. *OMRI-listed.*

Warrior II (lambda-cyhalothrin) *Eggplant, Pepper, Tomato* | 1.28-1.92 fl. oz. per acre. Not for use against *western flower thrips*. REI: 24-hour. PHI: 5-day. IRAC 03A. *RUP.*

Whiteflies

Non-Pesticide

Eggplant, Pepper, Tomato | For greenhouses, consider purchasing and releasing the predatory mite *Amblyseius swirskii*, lady beetle *Delphastus catalinae*, and mirid bug *Dicyphus hesperus.* Also consider co-releasing a parasitoid wasp like *Encarsia formosa,* or *Eretmocerus eremicus*. Avoid insecticides when deploying natural enemies.

Pesticide

Actara (thiamethoxam) *Eggplant, Pepper, Tomato* | 3.0-5.5 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 04A.

Admire Pro (imidacloprid) *Eggplant, Pepper, Tomato* | Use 1.3-2.2 fl. oz. per acre for foliar application on eggplant, pepper, and tomato. Use 7.0-10.5 fl. oz. per acre for soil application on eggplant and tomato, up to 14 fl. oz. per acre for pepper. REI: 12-hour. PHI: 0-day for foliar application, or 21-day for soil application. IRAC 04A.

Asana XL (esfenvalerate) *Tomato* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Eggplant, Pepper, Tomato* | Use 30SG formulations at 2.5-4.0 oz. per acre. Use 70WP formulations at 1.1-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Brigade 2EC (bifenthrin) *Eggplant, Pepper, Tomato* | For armyworms, corn borers, cutworms, fruitworms, and loopers in tomatoes, peppers, and eggplants. For hornworms, and pinworms in peppers and eggplants only. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-12.8 oz. per acre. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) *Eggplant, Pepper, Tomato* | 5.0-7.5 fl. oz. per acre. Can be applied as either a foliar application or via drip chemigation. Chemigation will provide up to 30 days of control. REI: 4-hour. PHI: 1-day. IRAC 28.

Exirel (cyantraniliprole) *Eggplant, Pepper, Tomato* | 13.5-20.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 28.

Knack (pyriproxyfen) *Eggplant, Pepper, Tomato* | 8-10 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 07C.

Movento (spirotetramat) *Eggplant, Pepper, Tomato* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 23.

Neemix (azadirachtin) *Eggplant, Pepper, Tomato* | 4-16 fl. oz. per acre. For nymph (immature) control. REI: 4-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Oberon 2SC (spiromesifen) *Eggplant, Pepper, Tomato* | 7-8.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 23.

Platinum 2SC (thiamethoxam) *Eggplant, Pepper, Tomato* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Portal (fenpyroximate) *Eggplant, Pepper, Tomato* | 2 pt. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A.

Pyganic EC 5.0 II (pyrethrins) *Eggplant, Pepper, Tomato* | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sivanto 200 (flupyradifurone) *Eggplant, Pepper, Tomato* | 10.5-14 fl. oz. per acre foliar application, or 21-28 fl. oz. per acre soil application. REI: 4-hour. PHI: 1-day for foliar application, or 45-day for soil application. IRAC 04D.

Transform WG (sulfoxaflor) *Eggplant, Pepper, Tomato* | Use Transform WG at 2.0-2.25 oz. per acre. Use Sequoia at 4.25-4.5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 04C.

Verimark (cyantraniliprole) *Eggplant, Pepper, Tomato* | 6.75-13.5 fl. oz. per acre. Apply via drip chemigation or soil injection. REI: 4-hour. PHI: 1-day. IRAC 28.

Fruiting Vegetables - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

The fruiting vegetables are warm-season crops nearly always started as transplants. When growers transplant crops into plastic mulch, they sometimes use herbicides underneath the mulch. There are several herbicides labeled for the control of weeds preemergence, applied before crops are transplanted, or directed between the rows only after transplanting.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Eggplant, Pepper, Tomato | A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. These crops can benefit from the soil warming properties of plastic mulch in addition to the in-row weed control it provides. Materials include landscape cloth/fabric, plastic, and biodegradable plastic. Straw mulch can delay early season growth by suppressing soil temperatures. Weeds between beds and along the edges of beds can be controlled with a combination of cultivation, mowing, or hand hoeing/pulling. Weeds along the edge of the mulches can be a particular challenge to avoid ripping the mulch. Some fresh market plantings are often small enough to accommodate hand-hoeing or pulling. For larger plantings it may make more sense to mechanically cultivate with tow-able tools between plastic rows or between bare-soil rows.

Pesticide

Aim EC (carfentrazone) POST *Eggplant, Pepper, Tomato* | 0.5-2 fl. oz. per acre. Apply a minimum of 1 day prior to transplanting, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Add COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. HRAC 14.

clethodim products (clethodim) POST *Eggplant, Pepper, Tomato* | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). For tomatoes, use up to 16 fl. oz per acre. Do not exceed 32 fl. oz. per acre per season. Use Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). For tomatoes, use up to 32 fl. oz. per acre. Do not exceed 64 fl. oz. per acre per season. Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 20-day. HRAC 01.

Command 3ME (clomazone) PRE *Pepper* | 10.7-42.7 fl. oz. per acre. For **bell and non-bell peppers** (*special 24c label required banana peppers*), make a single application before transplanting. Use a lower rate on coarse soils and a higher rate on fine soils. Ensure transplant roots are placed below the herbicide barrier. May cause temporary bleaching of crop leaves. Do not apply more than 42.7 fl. oz. per acre per year. Do not apply to soils that will be covered with plastic mulch. REI: 12-hour. HRAC 13.

Devrinol DF-XT (napropamide) PRE *Eggplant, Pepper, Tomato* | 2-4 lbs. per acre. Use lower rate on coarse sandy soils and higher rate on heavy clay soils and between rows. Apply and incorporate before transplanting. Applied prior to laying plastic mulch. After harvest or prior to planting succeeding crops, deep moldboard or disk plow. Do not seed alfalfa, small grains, sorghum, corn, or lettuce for 12 months after application. REI: 24-hour. HRAC NC.

Dual Magnum (s-metolachlor) PRE *Eggplant, Pepper, Tomato* | For **tomatoes in all states:** Apply 1-2 pts. per acre. For **peppers** *with special 24c label:* apply 0.5-1.0 pt. per acre. For **eggplants** *with special 24c label:* 0.5-1.33 pts. per acre. Apply to soil before transplanting or within 48 hours after transplanting. Do not incorporate. Reduce risk of crop injury by applying after transplanting and by using a directed spray rather than spraying over the top of transplants. Crop injury may occur under unfavorable growing conditions. See label for additional precautions. Do not exceed 1 application per crop. REI: 24-hour. PHI: 30-day for tomatoes at rates less than 1.33 pts. per acre; 60-day for eggplants, and peppers; 90-day for tomatoes at rates greater than 1.33 pts. per acre. HRAC 15.

glyphosate products (glyphosate) POST *Eggplant, Pepper, Tomato* | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target

rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast 3 days before transplanting, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. Remove herbicide residue from plastic mulch prior to transplanting. Do not use row-middle applications for tomatoes grown on sandy soils because crop injury may occur. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

League (imazosulfuron) POST | PRE *Pepper, Tomato* | 4.0-6.4 oz. per acre. For **peppers:** apply to row middles after peppers are well-established and at least 10 inches tall. Avoid contact with crop and plastic mulch if present. Or apply as a directed spray under the pepper canopy and contacting no more than the lower 2 inches of stem and avoiding contact with fruit. For **tomatoes:** Apply to prepared bed at least 1 day before transplanting just prior to laying plastic, if applicable. Or apply over the top or directed to row middles of transplanted tomatoes from 3-5 days after transplanting through early bloom stage. If small, emerged weeds are present include a manufacturer-approved surfactant. REI: 12-hour. PHI: 21-day. HRAC 02.

Matrix SG (rimsulfuron) POST | PRE *Tomato* | 1-4 oz. per acre. Can be applied at 2-4 oz. per acre for preemergence weed control. Apply at 1-2 oz. per acre for postemergence weed control to tomato plants of at least the cotyledon stage. Add 0.5 pt. of NIS per 25 gals. of spray solution (0.25% v/v) if emerged weeds are present. Apply when weeds are less than 1 inch tall. Soil activity requires rainfall within 5 days of application. If crop is stressed, chlorosis may occur. Do not exceed 4 oz. per acre per year. REI: 4-hour. PHI: 45-day. HRAC 02.

metribuzin products (metribuzin) POST | PRE *Tomato* | 4F formulations: 0.5-1 pt. per acre. 75DF formulations: 0.33-0.66 lb. per acre. Broadcast and incorporate before transplanting, or broadcast after transplants are established. Or, use 4F formulations at up to 2 pts. per acre, or 75DF formulations at 1.33 lbs. per acre and apply a directed spray between crop rows after transplants are established. May be applied preplant incorporated with trifluralin products for improved weed control. Crop injury may occur if applied over the top of plants within 3 days of cool, wet, or cloudy weather. Wait at least 14 days between applications. Do not exceed 2 pts. of 4F formulations, or 1.33 lbs. of 75DF formulations per acre per season. REI: 12-hour. PHI: 7-day. HRAC 05.

paraquat products (paraquat) POST *Eggplant, Pepper, Tomato* | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Add COC (1% v/v) or NIS (0.25% v/v) and apply to weeds less than 6 in. tall. Apply prior to transplanting. The lowest rate can be applied directed between rows. Do not make more than 3 applications per year. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. PHI: 30-day for tomato HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE *Eggplant, Pepper, Tomato* | 1 to 3 pts. per acre. Use 3.8 formulations. For use under plastic, apply as a band to top of bed after bed formation and before laying plastic, and/or apply to row middles after transplanting. On bare ground, apply and incorporate before transplanting, or apply before transplanting without incorporation, or apply to established plants as a directed spray. Avoid root contact with treated soil and avoid any contact with leaves or stems of crop. REI: 24-hour. PHI: 21-day for tomato, 70-day for pepper and eggplant. HRAC 03.

Poast (sethoxydim) POST *Eggplant, Pepper, Tomato* | 1.0-1.5 pt. per acre. Add COC (1% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pt. per acre per season. REI: 12-hour. PHI: 20-day for eggplant and tomato, 7-day for peppers. HRAC 01.

Prefar 4E (bensulide) PRE *Eggplant, Pepper* | 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting. REI: 12-hour. HRAC NC.

Reflex (fomesafen) PRE *Pepper, Tomato* | 1 pt. per acre. *Special 24c label only.* Apply before transplanting. Do not incorporate. For use under plastic, apply after bed formation and before laying plastic. Use only once in two years on the same soil. See rotational crop restrictions. Use on transplanted tomato and pepper only. REI: 24-hour. PHI: 60-day for pepper, 70-day for tomato. HRAC 14.

Rely 280 (glufosinate) POST *Pepper, Tomato* | ***For preplant burndown applications:*** apply 29-43 fl. oz. per acre to bare ground or preformed beds covered with plastic mulch. For bare ground plantings, allow at least 14 days between application and transplanting if precipitation is at

least 0.5 inches. If rainfall is less than 0.5 inch, do not transplant within 21 days of application. Allow 3 days and at least 0.5 inch of precipitation or overhead irrigation to remove herbicide from the plastic mulch before transplanting. If rainfall or overhead irrigation are less than 0.5 inches, do not transplant into plastic mulch within 27 days of application. Do not transplant within 6 inches of holes in the plastic mulch that exist at the time of application. ***For hooded postemergence row middle applications:*** use 29-62 fl. oz. per acre applied with a hooded sprayer and directed to row middles without contacting the crop. If the crop is grown on flat beds, do not spray within 6 inches of the crop. Do not exceed three applications or 87 fl. oz. per acre for bare ground burndown applications, two applications or 64 fl. oz. per acre for plasticulture burndown applications, or two applications or 62 fl. oz. per acre for hooded row middle applications. When using both burndown and hooded row middle applications, do not exceed three applications or 87 fl. oz. per acre total. Allow at least 14 days between applications. REI: 12-hour. PHI: 30-day. HRAC 10.

Sandea (halosulfuron) POST | PRE *Eggplant, Pepper, Tomato* | 0.5-1.0 oz. per acre. For **tomato:** apply 0.5-1.0 oz. per acre to the soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait at least 7 days before transplanting. Or apply a minimum of 14 days after transplanting over the top or as a directed/shielded spray, avoiding contact with crop and plastic mulch, if present. For **eggplant and pepper:** apply 0.5-1.0 oz per acre to row middles, avoiding contact with crop and plastic mulch, if present. If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). Do not exceed 2 applications or 2 oz. per acre per 12 month period. REI: 12-hour. PHI: 30-day. HRAC 02.

Spartan 4F (sulfentrazone) PRE *Tomato* | 2.25-8.0 fl. oz. per acre. Apply before transplanting as a broadcast or banded application. Will also control nutsedge. Do not use on soils classified as sand, which have less than 1% organic matter. Do not exceed 12 fl. oz. per year. REI: 12-hour. HRAC 14.

Sulfen 4SC (sulfentrazone) PRE *Eggplant, Pepper, Tomato* | 3-12 fl. oz. per acre. For **eggplant** and **pepper**: Apply prior to transplanting at 3-12 fl. oz. per acre. Do not apply more than 12 fl. oz. per acre, and do apply more than 12 fl. oz. per acre per year. For **tomato**: Apply prior to transplanting at 6-8 fl. oz. per acre. Do not apply more than 8 fl. oz. per acre, and do apply more than 8 fl. oz. per acre per year. Do not apply to sand or soils with less than 1% organic matter. REI: 12-hour. HRAC 14.

trifluralin products (trifluralin) PRE *Pepper, Tomato* | Use 4EC formulations at 1-2 pts. per acre and do not exceed 4 pts. per acre per season on fine soils. Use 10G formulations at 5-10 lbs. per acre and do not exceed 20 lbs. per acre per season on fine soils. For **peppers:** broadcast and incorporate before transplanting. For **tomatoes:** apply as in peppers or apply directed spray between rows after transplanting and incorporate. May cause early stunting if growing conditions are unfavorable. To minimize injury, dip transplant roots in carbon slurry (2 lbs. per gal.) prior to planting, or include 2 oz. of carbon per gal. of transplant water. Use higher rates on heavier soils. 4-6 weeks of residual activity. Not effective on muck or high organic matter soils. REI: 12-hour. HRAC 03.

Tripzin ZC (pendimethalin, metribuzin) POST | PRE *Tomato* | 1.75-2.6 pt. per acre. *With special 24c label only.* Apply with banded application between rows of transplanted tomatoes when weeds are less than 1 inch tall. Tomatoes must be at least 4 inches tall or 5 to 6 leaf stage at the time of application. Avoid contact with tomato leaves. Do not exceed 3.6 pts per acre per season. REI: 24-hour. PHI: 21-day. HRAC 03, HRAC 05.

Leafy Vegetables and Herbs - Horticulture

Major update by Ben Phillips, Liz Maynard – Dec 2020
Updated and reviewed by Ben Phillips – Sep 2022

Crop Description

Most leafy vegetables and herbs grow well under the same sunlight, fertility, soil and growing conditions, and cultural techniques similar to many other vegetable crops. Pay special attention to drainage and moisture requirements of certain herbs, as many are very sensitive to soil moisture conditions. Using plastic mulches, trickle irrigation, and raised beds may provide the necessary moisture and drainage requirements for the herb crop.

It is important to know the botanical relationships of leafy greens and herbs because similar pests will go to related plants. Herbs and leafy greens come from at least six botanical families. Within those family groups you can expect similar pests. In this guide we try to provide some precision to this. *However, when using pesticides, you must abide by the EPA Crop Groupings on pesticide labels.*

Amaranthaceae, the Pigweed family, contains Spinach and Swiss chard classified as "leafy green" or "leafy petiole" in EPA Crop Group 4. The pests of plants in this family are shared with Beets (EPA Crop Group 1) in the Root Crops chapter.

Amaryllidaceae, the Amaryllis family, contains all the onion-type aromatic plants. However, Chives are classified as a "herb" in EPA Crop Group 19. The pests of plants in this family are shared with the Onions chapter.

Apiaceae, the Carrot family, contains Cilantro, Coriander, Dill, Fennel, and Parsley classified as "herbs" or "spices" EPA Crop Group 19. Celery, Parsley and Florence Fennel are also classified as a "leafy green" or "leafy petiole" in EPA Crop Group 4. But this family also includes Carrots, and Parsnips (EPA Crop Group 1). The pests of plants in this family are shared with the Celery, and Root Crops chapters.

Asteraceae, the Sunflower family, contains Chicory, Endive, Escarole, Lettuce, and Radicchio classified as "leafy greens" in EPA Crop Group 4. But this family also includes Tarragon, classified as a "herb" in EPA Crop Group 19. Sunflowers are commonly grown as a microgreen.

Brassicaceae, the Mustard family, contains Arugula, Choy, Cress, Mizuna classified as "leafy greens' in EPA Crop Group 4. But this family also includes cole crop and mustard-type plants (EPA Crop Group 5), some of which are root crops (EPA Crop Group 1). The pests of plants in this family are shared with the Cole Crops and Brassica Leafy Greens, and Root Crops chapters.

Lamiaceae, the Mint family, contains Basil, Lavender, Marjoram, Mint, Oregano, Rosemary, Sage, Savory, and Thyme classified as "herbs" in EPA Crop Group 19.

Marketing Greens and Herbs

Fresh greens and herbs certainly make excellent cash crops. However, growers should be cautious before beginning herb production. Establish market and buyer needs before purchasing any seed. Some of the most popular greens are peppery-flavored Brassicas, bitter lettuces and chicories, and juicy chard, spinach, and microgreens. Popular culinary herbs include basil, chives, dill, French tarragon, mints, oregano, parsley, rosemary, and thyme. However, growers should do their own marketing study to determine which herbs are suited for their areas. Possible outlets for culinary herbs include health food stores, grocery stores, restaurants, farmers markets, and food manufacturing companies. For year-round production greenhouses are recommended. Detailed descriptions and management recommendations for some popular herbs follow.

Planting, Spacing, and Harvesting

Arugula
Arugula is a complex of species, but primarily *Eruca sativa*, known for their lobed and pungent peppery-tasting leaves. Like other Brassicas, it is a cool-season annual crop, and can bolt in spring as days grow longer and temperatures increase. The most common pests of arugula are flea beetles.

Arugula can be direct-seeded in tightly-spaced rows about 2 inches apart, with 5 seeds per inch in the row. To avoid bolting, sow in sequential plantings and harvest every two weeks starting a few weeks before last frost up to a few weeks before first frost. Fall planting for winter and early spring harvest in a hoophouse is also an effective production window.

Harvest arugula when the leaves are 3 to 6 inches long by cutting close to the base of the leaf stems and cut again 1 to 2 weeks later. Depending on market, the flowers and leaves after flowering can be desirable, as their flavor is more pungent.

Asian Greens
Komatsuna (*Brassica rapa* var. *pervidis*), mibuna (*B. rapa* var. *japonica*), mizuna (*B. rapa* var. *niposinica*, tatsoi (*B. rapa* var. *narinosa*) and other similar greens are commonly grown as baby leaf greens with a mild mustardy flavor. However, they can also be grown to full size as a "head" or "heart" like lettuce or celery. They are prone to bolting as days lengthen and temperatures increase. Pests include flea beetles and caterpillars.

Direct seed in rows about 2 inches apart with 3 to 5 seeds per inch and sequentially plant every 2 to 3 weeks. Increase spacing for full head production. They are amenable to fall sowing for winter hoophouses.

Harvest leaves every 2 to 3 weeks for baby leaf production after about 20 days of growth. Full size plants take closer to 45 days to reach maturity.

Basil
Basil, French basil, or sweet basil (*Ocimum basilicum*) is a popular, tender, annual herb native to India and Asia. Basil is commercially grown for its green, aromatic leaves, which are used fresh or dried as a flavoring. The common pests of basil are plant bugs, Japanese beetle, and downy mildew.

Basil can be direct-seeded or transplanted to the field in late spring after all danger of frost is over. Basil seeds normally germinate in 8 to 14 days. Basil requires full sun and prefers moist, well-drained soil with a pH of 6.0. Typical spacing for basil is 12 inches between plants, 24 to 36 inches between rows.

Trickle or overhead irrigation is necessary. Basil grown for dried leaves or essential oil is cut just prior to the appearance of flowers. The foliage should be cut at least four to six leaves above the ground to allow for regrowth and a subsequent crop.

Chives
Chives (*Allium schoenoprasum*) are a perennial native to Asia. They were first used by the Chinese and then the ancient Greeks. Fresh leaves are excellent for making herbal vinegars and butter. They are also used in salad, soup, and cheese. Chives are also used to add a mild onion flavor to fish, salads, steamed vegetables, soups, and omelets. No serious pests or diseases are reported, although chives can get downy mildew and rust.

Chives require full sun and well-drained soil with a pH of 6.0. Chive seeds require darkness, constant moisture, and a temperature of 60 F to 70 F for best results. Sow them 1/2 inch deep in pots or flats. Germination occurs in 2 to 3 weeks. Transplant seedlings to the field when they are 4 weeks old. Chives reach a height of 18 inches, a width of 1 to 2 inches the first year from seed, and 10 to 14 inches in subsequent years.

To harvest chives, cut chive leaves 2 inches above the ground.

Cilantro
Cilantro (*Coriandrum sativum*) is an herb with a unique scent and flavor. Native to Egypt, cilantro is one of the most ancient herbs still cultivated. It is also known as Mexican parsley, Chinese parsley, or coriander. The dried seedpod is known as coriander and is usually used as a spice in baking and desserts. Cilantro leaves are a well-known salsa ingredient. Cabbage looper and green peach aphid sometimes cause economic damage by curling and twisting leaves, and stunting the plant. Bacterial leaf spot, which is seedborne, and Fusarium wilt are common diseases in cilantro production. Effective management strategies involve using clean seed material and avoiding fields that have a history of Fusarium.

This annual plant does best in cool weather and should be planted in the early spring or in the fall. Optimum growing temperatures are between 50 F to 85 F. Plant seeds 1/2 inch deep and 2 to 3 inches apart. Germination may take 10 to 14 days. Cilantro grows 2 to 3 feet tall and thrives in moderately rich, light, well-drained soil in full to partial sun. Cilantro is highly salt sensitive, and soil electrical conductivity values exceeding 1 dS/m could reduce yields. Plants have shallow root systems, so frequent irrigation is needed.

To harvest, cut cilantro either just below the soil or 1-1/2 to 2 inches above the crown, bunch, and tie together with a rubber band.

Dill
Dill (*Anthum graveolens*) is native to the Mediterranean area and southern Russia. It is a hardy annual and sometimes is grown as a biennial. Dill is commonly used as a seasoning for soups, fish, and pickles. Its aromatic leaves, seeds, flowers, and stems can also be used to flavor cabbage, vinegar, butter, apple pie, cakes, and bread. Dill does not have any serious pest or disease problems. However, phoma blight, rusty root, and stem rot have been reported.

Direct-seed in spring at 1/4 to 1/2 inches deep in rows that are 2-3 feet apart. In-row spacing should be 10 to 12 inches. Since dill has long taproots, it should not be transplanted.

Fresh leaves should be harvested before flowering begins. Harvest seeds as soon as seed heads are brown and dry. Stalks with immature seed heads are frequently harvested for direct sales, paired with pickling cucumbers.

Chicory, Endive, Escarole, Radicchio
This group of leafy crops come from two species (*Cichorium endivia*, and *C. intybus*), with a diverse appearance and color in immature and mature plants. Some are all green, others are red, and others have white stalks. They are used as a bitter salad green. Frisée refers to frilly leaf varieties. Witloof, or Belgian endive, is a type of endive that is harvested in the fall as a root, and forced indoors for a tender head of tightly wrapped and blanched leaves, called a chicon. Common pest problems are leafminers and white mold.

Direct seed or transplant in rows 12 to 15 inches apart. Plants 10 to 16 inches apart in row. Seed 1 to 2 pounds per acre. For forcing Belgian endive, seed so that after 150 days roots can be dug and stored in a cool environment indoors.

To harvest field plantings, cut whole heads from the base of the plants. Some varieties will regenerate harvestable leaves for loose leaf mixes. Plants will not regenerate new marketable heads. Covering or tying outer leaf stalks together a few days before harvest can blanche the center leaves which are less bitter than full green leaves.

To force endive indoors, harvest roots in the late fall when they are 1-1/4 to 2-1/4 inches in diameter and 7 inches long and plant them indoors upright in soil about half as deep as the root. They must go through a cold conditioning of 32 F to 34 F for at least a week before raising the temperature to allow new growth to occur. Maintain soil moisture and harvest when new sprouts are about 3 inches long.

Fennel
Fennel (*Foeniculum vulgare*) is a cool-season aromatic herb that originated in the Mediterranean region. It is a perennial but is usually grown as an annual that grows to about 3 to 4 feet tall. Leaves are used as potherbs and for seasoning and garnishing purposes along with the bulb, which could be used as a fresh salad. Leaf blight and stem rot are two major diseases affecting fennel.

Plant in full sun in rich and well-drained soil. Plant seeds 1/4 to 1/2 inches deep in rows that are 2 to 3 feet apart. In-row spacing should be 10 to 12 inches. Transplant to the field early in the spring. The time from planting to harvest could range from 90 to 150 days for direct-seeded fennel; and from 110 to 125 days for transplanted fennel.

Harvest by cutting just above the bulb near the leaf bases. Bulbs are further trimmed by cutting away most of the top growth.

French Tarragon
French tarragon (*Artemisia dracunculus*) originates from southern Europe. Do not confuse it with Russian tarragon (*Artemisia dracunculoides*) which is much coarser, and has paler leaves, and a bitter taste. French tarragon is used to flavor vinegar, herbal butter, shellfish, pork, beef, poultry, many vegetables, and rice. Fresh leaves can also be used in salads, tartar sauce, and French dressing. French tarragon is prone to root rot in heavy and wet soils.

It produces few seeds and must be propagated by stem cuttings or division. Plant in full sun in rich, well-drained soil with a pH of 6.9. French tarragon is a woody perennial that eventually grows 2 feet tall. Divide the plants every three to four years.

Two harvests can generally be made each year, the first harvest six to eight weeks after setting out. Harvest until leaves turn yellow in the fall.

Lettuce
Lettuce (*Lactucus sativus*) varieties fall into four main types; leaf, romaine/cos, crisphead/iceberg, and butterhead/bibb. They are all used similarly as a fresh green eaten raw, and rarely cooked.

For full size head production, direct-seed or transplant in rows 12 to 15 inches apart. Plants 10 to 16 inches apart in row. Seed 1 to 2 pounds per acre. For harvest of small leaves with one or more cuttings, seed in bands 2 to 4 inches wide with about 60 seeds per foot.

Romaine, crisphead and bibb lettuces form heads that are harvested one time. Leaf lettuces can be harvested as heads once, or leaves can be cut two or three times, with about 4 to 6 weeks between cuttings. Multi-leaf types have a more uniform leaf size and small core that makes it easy to harvest leaves for salad mixes.

Microgreens
Microgreens are a high turnover crop that are grown in high density in shallow trays with the same or similar potting mix or soilless media used for starting transplants. There are also specialized woven mats for seed starting. Most often, single species are grown in each tray, but mixes are also common if they have similar seed sizes, germination rates, and harvest timing.

Seeds are broadcast into the trays at between 6 and 12 seeds per square inch, depending on seed size, and covered with a shallow layer of material, such as sowing mix, vermiculite, a paper towel, or clear lid. Water with a dilute fertilizer or plain water if the potting mix has fertility incorporated already. Once sprouted, switch to bottom watering or misting to reduce potting mix from splashing onto greens. Heat mats or germination chambers are used during the cool season to maintain temps between 65 F and 75 F.

After 10 to 25 days, microgreens are harvested by cutting below the cotyledons, after they are fully developed, or when the first true leaves emerge. Due to the short time to harvest, pesticides are not often labeled for use on microgreens, and not recommended. However, sometimes a sanitizer is added to cooling water before packaging and sale.

Mint

Mints (*Mentha* spp.) are a group of perennial herbs that are mostly native to Europe and Asia. Some are indigenous to South America, America, and Australia. Mint is naturalized throughout North America from southern Canada to Mexico. Japanese mint (*M. arvensis* var. *piperascens*), peppermint (*M. x piperita*), and spearmint (*M. spicata*) are the mint species mostly cultivated. Mint is susceptible to verticillium wilt, mint rust, and mint anthracnose. Pests that could bother mint include spider mites, loopers, mint flea beetles, mint root borers, cutworms, root weevils, and aphids.

Mints can be propagated by cuttings or seeds, except peppermint, which can only be propagated through cuttings. Peppermint is a sterile F1 hybrid of *M. aquatica* and *M. spicata* and does not produce seeds. Mints can be planted in full sun or partial shade, and require rich, well-drained soil with a pH of 6.5. Spaced 18 to 24 inches apart, mints can reach a height of 12 to 24 inches and grow into a thick perennial row.

Mint can be harvested almost as soon as it comes up in the spring. Young, tender leaves and stems are the best.

Oregano

Oregano (*Origanum vulgare* subsp. *hirtum* or *O. vulgare* subsp. *viridulum*) is native to the Mediterranean region and naturalized in the eastern United States. It is added to tomato sauce for a hot and peppery taste. It adds dimension to yeast breads, marinated vegetables, roasted meats, and fish. Some of the pest and disease problems for oregano include aphids, leafminers, spider mites, and root rot.

Oregano is a perennial that requires a site with full sun and well-drained soil that has a pH of 6.8. Direct-seed in the field and do not cover seeds; oregano seeds need sunlight to germinate. Because flavor can greatly vary among seed propagated plants, it is better to propagate by root divisions or cuttings from plants that are known to have strong flavor. Oregano reaches a height of 12 to 24 inches and a width of 10 to 20 inches.

Oregano sprigs can be cut off when the plant is at least 6 inches high. In June, vigorously growing plants can be cut back to the lowest set of leaves. Plants generally leaf out after two weeks and can be cut back again in August.

Parsley

Parsley (*Petroselinum crispum*) is commonly grown for its green leaves, or tops. The curled-leaf and Italian flat-leaf types are the most popular. Popular curled-leaf parsley cultivars include Moss Curled, Dark Moss Curled, Banquet, Decorator, Deep Green, Forest Green, Improved Market Gardener, Sherwood, and Perfection. Flat-leaf cultivars include Plain and Plain Italian Dark Green. Hamburg parsley is grown for its enlarged edible root.

Field-seeding begins in early April and ends in May. Row spacing should be 12 to 16 inches. In-row plant spacing should be 4 to 8 inches. Direct-seeding rate will depend on direct seeding equipment and could require 14 to 30 pounds per acre. Germination is enhanced by presoaking seeds in water for 24 hours and then allowing them to partially dry.

Parsley is cut 1-1/2 to 2 inches from ground level to allow regrowth. About three or four cuttings are made, depending on the length of the growing season.

Rosemary

Rosemary (*Rosmarinus officinalis*) is a tender perennial hardy to zones 8 to 10. It is native to the Mediterranean, Portugal, and northeastern Spain. It is pungent, somewhat piney, mint-like yet sweeter, with a slight ginger flavor that harmonizes with poultry, fish, lamb, beef, veal, pork, and game. Rosemary also enhances vegetables, cheese, and eggs. Pest and disease problems include aphids, spider mites, scale, mealybugs, root rot, and Botrytis gray mold.

Plant rosemary in a sunny location with well-drained and slightly acidic soil. Rosemary can be started from seeds, but germination rates are very low. Use fresh seeds, preferably less than two weeks old. Or, start plants from cuttings or by layering from existing plants. Rosemary eventually reaches a height of 72 inches and a width of 36 to 72 inches.

Harvesting can be done throughout the year. Cut about 4-inch pieces from the tips of the branches, being careful not to remove more than 20 percent of the growth at one time.

Spinach

Spinach (*Spinacia oleracea*) is a nutritious leafy green made popular as a canned product by the cartoon ‘Popeye the Sailor Man.’ Currently it is more commonly eaten raw as a salad green. Common problems are white rust, flea beetles, and bolting.

In the Midwest, spinach is commonly seeded in late summer or fall, and grown through the winter under row cover or in hoophouses. Late winter and early spring plantings are also successful. Direct seed or transplant in rows 12 to 18 inches

apart, with 2 to 6 plants per foot of row. Or for baby leaf spinach seed in bands 2 to 4 inches wide with about 40 seeds per foot. Seed 12 to 20 pounds per acre. Plants bolt in response to increasing daylength so overwintered and spring crops are usually finished by late spring.

Harvest spinach with sequential cuttings when leaves are 4 to 6 inches long, or desired length for your market. Depending on the time of year, they will be ready for another harvest in 4 to 6 weeks. Or do a once-over harvest when plants reach full size.

Swiss Chard
Swiss chard, sugar beets, and table beets are all the same species (*Beta vulgaris*) bred for different purposes. Chard is bred for tall, thick, colorful, and juicy leaf stems and large leaves instead of roots. The leaf stem colors range from white, to yellow, orange, pink, red, and purple. Chard seeds are an aggregation of multiple seeds, that grow multiple plants from one seedball. Some companies will "decorticate" seeds, which is a process of smoothing the rough edges of these seeds for better singulation in seeding machines, and with a side benefit of breaking up seedballs into more individual seeds. The most common pests are spinach leafminers and leaf spots from *Alternaria* and *Cercospora*.

Chard can be direct-seeded or transplanted in rows 12 to 18 inches apart, with 4 to 6 inches between plants in the row for bunching large leaves, or 1 to 2 inches for smaller leaves. Thinning may be necessary due to multigerm seeds. Transplants can be started 5 to 6 weeks ahead of transplanting. Chard is frost tolerant and can be planted a few weeks before last frost through to a few weeks before first frost in sequential sets for continuous cutting.

Harvest chard when the leaves are 3 to 6 inches long by cutting close to the base of the leaf stems. For bunching large leaves, allow growth for about 2 months. For baby leaf harvests, cut and come again 1 to 2 weeks later.

Thyme
Thyme (*Thymus vulgaris*) is native to the western Mediterranean region. It is a small, many-branched, and perennial shrub. Thyme tastes delicately green with a faint clover aftertaste. It ranks as one of the finest herbs of French cuisine. Thyme leaves and sprigs are used in clam chowder, meats, herbal butter, and vinegar. Use it with vegetables, cheese, eggs, and rice. The pest and disease problems include spider mites and root rot.

Start seeds indoors and transplant seedlings into the field once the danger of frost is over. Thyme reaches a height of 12 inches and a width of 10 to 12 inches. Thyme can be propagated from cuttings, by layering, and division.

Harvest the entire plant by cutting it back to 2 inches above ground in midsummer. One more harvest can be expected before the season ends.

Fertilizing

pH: Maintain a soil pH of 6.5 to 6.8 for **leafy greens**, and 6.0 to 7.0 for **herbs**. On muck soils maintain the pH at 5.5 to 6.0. Spinach is particularly sensitive to soil acidity.

Before planting apply 40 to 60 pounds N per acre, 0 to 150 pounds P_2O_5 per acre, and 0 to 200 pounds K_2O per acre. Adjust according to soil type, previous management, and soil test results for your state. For direct-seeded crops band an additional 40 pounds N and 40 pounds P_2O_5 per acre 2 inches to the side and 2 inches below the seed.

Sidedress with 30 to 60 pounds N per acre three to four weeks after thinning or transplanting, and again after each cutting.

Reduce the total amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3 percent organic matter. The total amount of N from fertilizer (including starter) and other credits should be 90 to 120 pounds N per acre for culinary herbs, up to 140 pounds N per acre for lettuce, and up to 170 pounds N per acre for spinach. For herbs grown for seeds, such as coriander, fennel, and dill, use 60 to 90 pounds N per acre.

Leafy Vegetables and Herbs - Diseases

Reviewed by Dan Egel – Aug 2023

Aster Yellows (Purple-Top Wilt) of Multiple Crops - Phytoplasma Mollicutes

This pathogen is transmitted by leafhoppers. Infection rates can jump when adjacent crops are harvested mid-season, such as alfalfa or wheat.

Pesticide

Insecticides *Head Lettuce, Leaf Lettuce* | Use an insecticide to control leafhoppers that transmit the disease. Leafhoppers must be controlled before they feed. See Insect section.

Bottom Rot of Lettuce - Rhizoctonia Fungus

Non-Pesticide

Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio | Clean and sanitize transplant trays, benches, and tools. Rogue infected transplants. Avoid working field under wet conditions. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Head Lettuce, Leaf Lettuce* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 0.24-0.48 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 22.9% formulations at 0.4-0.8 fl. oz. per 1000 row feet for soilborne/seedling diseases. Use 18.4% formulations at 0.5-1.0 fl. oz. per 1000 row feet. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Endura (boscalid) *Head Lettuce, Leaf Lettuce* | 8-11 oz. per acre. Suppresses Bottom Rot. REI: 12-hour. PHI: 14-day. FRAC 07.

iprodione products (iprodione) *Head Lettuce, Leaf Lettuce* | 1.5-2 pts. per acre. Formulations of iprodione include Nevado and Rovral. REI: 24-hour. PHI: 14-day. FRAC 02.

Luna Sensation (fluopyram, trifloxystrobin) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 7.6 fl. oz. per acre. Bottom rot and downy mildew suppression only. Can be applied as a band over lettuce. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Non-Pesticide

Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme | Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid excess moisture to the transplants in the greenhouse by monitoring irrigation frequency. Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Pesticide

Orondis Gold (oxathiapiprolin, mefenoxam) *Head Lettuce, Leaf Lettuce* | 13.9-27.8 fl. oz. per acre. Use as an at-plant soil drench, banded spray in furrow, or through drip irrigation. Do not follow soil applications of Orondis Gold with foliar applications of Orondis Opti, or Orondis Ultra. REI: 4-hour. PHI: 7-day. FRAC 49, FRAC 04.

Downy Mildew of Lettuce - Bremia Oomycete

Non-Pesticide

Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio | Use disease-free seed and transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 118 F for 30 minutes for lettuce. Rotate to non-host crops for 3 years. Varieties with partial resistance are available. Use raised beds and adequate plant spacing to improve drainage, air flow. Monitor humidity in the hoophouse and vent appropriately. Good weed control of Aster weeds like dandelion, groundsel, and thistles is important to limit other hosts near the crop.

Pesticide

Actigard (acibenzolar-s-methyl) *Head Lettuce, Leaf Lettuce* | 0.75-1 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC P01.

Curzate 60DF (cymoxanil) *Head Lettuce, Leaf Lettuce* | Head lettuce 3.2-5.0 oz. per acre. leaf lettuce 5.0 oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 27.

Luna Sensation (fluopyram, trifloxystrobin) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 7.6 fl. oz. per acre. Bottom rot and downy mildew suppression only. Can be applied as a band over lettuce. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

mancozeb products (mancozeb) *Head Lettuce, Leaf Lettuce* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.2-1.6 qt. per acre. Use 75% and 80% formulations at 1.6-2.0 lb. per acre. REI: 24-hour. PHI: 10-day for head lettuce, 14-day for leaf lettuce. FRAC M03.

Merivon (fluxapyroxad, pyraclostrobin) *Chive, Head Lettuce, Leaf Lettuce, Spinach* | 6-11 fl. oz. per acre. Downy mildew suppression only. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Chive, Spinach* | 5.5-8.0 fl. oz. per acre. REI: 4-hour. PHI: 1-day. FRAC 49, FRAC 40.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. Check label carefully for presence of crop of interest, especially herbs. REI: 4 to 12-hour. PHI: see label. FRAC P07.

Presidio (fluopicolide) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 3-4 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 43.

Previcur Flex (propamocarb) *Head Lettuce, Leaf Lettuce* | 2 pts. per acre. See label for tank mix rates. REI: 12-hour. PHI: 2-day. FRAC 28.

Ranman 400SC (cyazofamid) *Basil, Chive, Spinach* | 2.75 fl. oz. per acre. High rate only allowed on basil. REI: 12-hour. PHI: 0-day. FRAC 21.

Revus (mandipropamid) *Head Lettuce, Leaf Lettuce* | 8 fl. oz. per acre. REI: 4-hour. PHI: 1-day. FRAC 40.

Tanos (famoxadone, cymoxanil) *Arugula, Cress, Spinach* | 8-10 oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 27.

Tanos (famoxadone, cymoxanil) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 8-10 oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 27.

Topguard EQ (flutriafol, azoxystrobin) *Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach* | 6-8 fl. oz. per acre. REI: 12-hour to 3-day. PHI: 7-day. FRAC 03, FRAC 11.

Zampro (ametoctradin, dimethomorph) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 45, FRAC 40.

Downy Mildew of Multiple Crops - Peronospora Oomycete

Several varieties of spinach are listed with resistance to downy mildew.

Non-Pesticide

Arugula, Basil, Cress | Use disease-free seed and transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for spinach, and 122 for 15 minutes for cress. Rotate to non-host crops for 3 years. Varieties with partial resistance are available. Use raised beds and adequate plant spacing to improve drainage, air flow. Monitor humidity in the hoophouse and vent appropriately.

Pesticide

azoxystrobin products (azoxystrobin) *Arugula, Endive, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 33.4% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft REI: 4-hour. PHI: 0-day. FRAC 11.

Curzate 60DF (cymoxanil) *Spinach* | 5.0 oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 27.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Chive, Spinach* | 5.5-8.0 fl. oz. per acre. REI: 4-hour. PHI: 1-day. FRAC 49, FRAC 40.

phosphite and phosphorous acid products (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | Several phosphite or phosphorus acid products (Aliette, Phostrol, ProPhyt, Rampart) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until the disease is observed. Check label carefully for presence of crop of interest, especially herbs. REI: 4 to 12-hour. PHI: see label. FRAC P07.

Presidio (fluopicolide) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 3-4 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 43.

Ranman 400SC (cyazofamid) *Basil, Chive, Spinach* | 2.75 fl. oz. per acre. High rate only allowed on basil. REI: 12-hour. PHI: 0-day. FRAC 21.

Reason 500SC (fenamidone) *Basil, Head Lettuce, Leaf Lettuce* | Rate depends on crop. For example, lettuce is 5.5-8.2 fl oz. per acre. Basil is 6.0 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 11.

Revus (mandipropamid) *Head Lettuce, Leaf Lettuce* | 8 fl. oz. per acre. REI: 4-hour. PHI: 1-day. FRAC 40.

Topguard EQ (flutriafol, azoxystrobin) *Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach* | 6-8 fl. oz. per acre. REI: 12-hour to 3-day. PHI: 7-day. FRAC 03, FRAC 11.

Zampro (ametoctradin, dimethomorph) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 45, FRAC 40.

Gray Mold of Multiple Crops - Botrytis Fungus

This disease often occurs in greenhouse production with high humidity.

Non-Pesticide

Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme | Use raised beds and adequate plant spacing to improve drainage, air flow. Monitor humidity in the hoophouse and vent appropriately. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Botran 75W (dichloro-nitroaniline) *Endive, Head Lettuce, Leaf Lettuce* | Rate depends on crop and application method. Flowable formulations may be available. REI: 12-hour. PHI: 14-day. FRAC 14.

Endura (boscalid) *Head Lettuce, Leaf Lettuce* | 8-11 oz. per acre. Suppresses Bottom Rot. REI: 12-hour. PHI: 14-day. FRAC 07.

Fontelis (penthiopyrad) *Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 14-24 fl. oz. per acre. For lettuce drop use 16 to 24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

iprodione products (iprodione) *Head Lettuce, Leaf Lettuce* | 1.5-2 pts. per acre. Formulations of iprodione include Nevado and Rovral. REI: 24-hour. PHI: 14-day. FRAC 02.

Switch 62.5WG (cyprodinil, fludioxonil) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 11-14 oz. per acre. Powdery mildew suppression only. REI: 12-hour. PHI: 0-day. FRAC 09, FRAC 12.

Nematodes

Non-Pesticide

Head Lettuce, Leaf Lettuce | Collect soil samples for nematodes in the fall and avoid fields with high numbers. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue and displace nematodes is an important method to prevent nematode build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain nematodes.

Powdery Mildew of Multiple Crops - Erysiphe Fungus

Powdery mildew is more likely to be a problem in greenhouse lettuce than in open fields.

Non-Pesticide

Arugula, Basil, Chicory, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme | Rotate to non-host crops for 2 years. Use raised beds and adequate plant spacing to improve drainage, air flow. Monitor humidity in the hoophouse and vent appropriately. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Fontelis (penthiopyrad) *Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 14-24 fl. oz. per acre. For lettuce drop use 16 to 24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

Luna Sensation (fluopyram, trifloxystrobin) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 7.6 fl. oz. per acre. Bottom rot and downy mildew suppression only. Can be applied as a band over lettuce. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) *Arugula, Cress, Fennel, Parsley, Spinach* | 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Procure 480SC (triflumizole) *Head Lettuce, Leaf Lettuce* | 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 03.

Quintec (quinoxyfen) *Head Lettuce, Leaf Lettuce* | 4-6 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 13.

Switch 62.5WG (cyprodinil, fludioxonil) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 11-14 oz. per acre. Powdery mildew suppression only. REI: 12-hour. PHI: 0-day. FRAC 09, FRAC 12.

Topguard EQ (flutriafol, azoxystrobin) *Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach* | 6-8 fl. oz. per acre. REI: 12-hour to 3-day. PHI: 7-day. FRAC 03, FRAC 11.

Viruses of Multiple Crops - Multiple Pathogens

Lettuce Mosaic Virus (LMV) can be carried in infected seed and is spread by aphids.

Non-Pesticide

Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio | For **LMV:** use only mosaic-free indexed seed (sold as MTO). Greenhouse sanitation and good weed control of Aster weeds like dandelion, groundsel, and thistles is important to limit other hosts near the crop. Use a monitoring program to time the release of natural enemies of aphids (see insect section). Keep new lettuce plantings as far as possible with the previous production area. Remove infected transplants and do not plant them out into fields. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Insecticides *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | For **LMV:** use aphid-specific insecticides to lower the population without also reducing the population of natural enemies. See insect section.

White Mold (Timber Rot, Drop, Stem Rot) of Multiple Crops - Sclerotinia Fungus

This soil pathogen is long-lived in the soil, and has a wide host range on broadleaved crops and weeds, including beans, vine crops, lettuce, tomatoes, peppers, and cole crops. It goes by other names in other crops, such as Drop, White Mold, Stem Rot, and Timber Rot.

It is more commonly found in greenhouses and high tunnels where humidity and temperatures are high. The fungus often infects flowers, which then drop off and infect the stems that they land on. The stems take on a woody appearance and can split open. On lettuce, the pathogen infects the root crown and heart of the plant, which makes the leaves drop and rot. Inspection of the stems, or lettuce hearts, will reveal small black pellets that are the overwintering body of the pathogen.

Non-Pesticide

Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss

Chard, Tarragon, Thyme | Avoid fields with a history of the problem. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >6 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

Botran 75W (dichloro-nitroaniline) *Endive, Head Lettuce, Leaf Lettuce* | Rate depends on crop and application method. Flowable formulations may be available. REI: 12-hour. PHI: 14-day. FRAC 14.

Contans WG (Coniothyrium minitans strain CON/M/91-08) *Head Lettuce, Leaf Lettuce* | 1-6 lbs. per acre. Apply immediately after harvest or 3-4 months before planting. REI: 4-hour. FRAC BM02. *OMRI-listed.*

Endura (boscalid) *Head Lettuce, Leaf Lettuce* | 8-11 oz. per acre. Suppresses Bottom Rot. REI: 12-hour. PHI: 14-day. FRAC 07.

Fontelis (penthiopyrad) *Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 14-24 fl. oz. per acre. For lettuce drop use 16 to 24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

iprodione products (iprodione) *Head Lettuce, Leaf Lettuce* | 1.5-2 pts. per acre. Formulations of iprodione include Nevado and Rovral. REI: 24-hour. PHI: 14-day. FRAC 02.

Kenja 400SC (isofetamid) *Head Lettuce, Leaf Lettuce* | 12.3 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 07.

Luna Sensation (fluopyram, trifloxystrobin) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 7.6 fl. oz. per acre. Bottom rot and downy mildew suppression only. Can be applied as a band over lettuce. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 8-11 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Switch 62.5WG (cyprodinil, fludioxonil) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 11-14 oz. per acre. Powdery mildew suppression only. REI: 12-hour. PHI: 0-day. FRAC 09, FRAC 12.

White Rust of Multiple Crops - Albugo Oomycete

Non-Pesticide

Arugula, Cress, Spinach | Use disease-free seed and transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 25 minutes for spinach. Rotate to non-host crops for 3 years. Varieties with partial resistance are available. Use raised beds and adequate plant spacing to improve drainage, air flow. Monitor humidity in the hoophouse and vent appropriately.

Pesticide

Merivon (fluxapyroxad, pyraclostrobin) *Arugula, Cress, Fennel, Parsley, Spinach* | 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 07, FRAC 11.

Presidio (fluopicolide) *Chicory, Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 3-4 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 43.

Reason 500SC (fenamidone) *Basil, Head Lettuce, Leaf Lettuce* | Rate depends on crop. For example, lettuce is 5.5-8.2 fl oz. per acre. Basil is 6.0 fl. oz. per acre. REI: 12-hour. PHI: 2-day. FRAC 11.

Tanos (famoxadone, cymoxanil) *Arugula, Cress, Spinach* | 8-10 oz. per acre. REI: 12-hour. PHI: 1-day. FRAC 11, FRAC 27.

Topguard EQ (flutriafol, azoxystrobin) *Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach* | 6-8 fl. oz. per acre. REI: 12-hour to 3-day. PHI: 7-day. FRAC 03, FRAC 11.

Wilt of Multiple Crops - Fusarium Fungus

Non-Pesticide

Basil | Avoid fields with a history of the disease. Rotate to non-host crops for >6 years. Varieties with Fusarium wilt resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important

method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Leafy Vegetables and Herbs - Insects

Reviewed by Laura Ingwell, Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Aphid species seen in leafy crops include green peach aphid, lettuce aphid, potato aphid, melon aphid, and others. Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Seedlings: 2 aphids per plant.

Established Plants: 7 aphids per plant.

Non-Pesticide

Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme | Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 4.4-10.5 fl. oz. per acre soil application, or 1.3 fl. oz. per acre foliar application on leafy greens. 4.4-10.5 fl. oz. per acre soil application for fennel and chard. 7.0-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application on herbs. REI: 12-hour. PHI: 45-day for soil application on fennel and chard, 14-day for soil application on herbs, 21-day for soil

application on leafy greens, 7-day for foliar applications on leafy greens and herbs IRAC 04A.

Assail 30SG (acetamiprid) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | Use 30SG formulations at 2.0-4.0 oz. per acre. Use 70WP formulations at 0.8-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Belay (clothianidin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application. IRAC 04A.

Beleaf (flonicamid) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.0-2.8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Brigade 2EC (bifenthrin) *Cilantro, Coriander, Head Lettuce* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) *Head Lettuce* | 3.4-6.8 fl. oz. per acre. *Lettuce root aphid only.* See label for application methods. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Dimethoate 4EC (dimethoate) *Endive, Leaf Lettuce, Swiss Chard* | Use 2.67EC formulations at 0.75 pt. per acre. Use 4EC, LV-4, and 400 formulations at 0.5 pt. per acre. REI: 48-hour. PHI: 14-day. IRAC 01B.

Fulfill (pymetrozine) *Arugula, Chicory, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.75 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 09B.

M-Pede (potassium salts of fatty acids) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 1-2% by volume. Must contact aphids to be effective. Avoid spraying under hot conditions to minimize potential for plant injury. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Malathion 5EC (malathion) *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* | Use 5EC formulations at 1.0-2.0 pts. per acre on parsley, 1.6 pts. per acre for spinach, 2.0 pts. per acre on lettuce, or 1.5-2.0 pts. per acre on endive. Use 57EC formulations at 1.5-2.4 pts. per acre on parsley, 1.6 pts. per acre for parsley, 2.0-3.0 pts. per acre on lettuce, or 1.5-2.0 pts. per acre on endive. REI: 12-hour. PHI: 7-day for endive, parsley, and spinach; 14-day for head and leaf lettuce. IRAC 01B.

Movento (spirotetramat) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 3-day. IRAC 23.

Orthene 97 (acephate) *Head Lettuce* | 8-16 oz. per acre. REI: 24-hour. PHI: 21-day. IRAC 01B.

Platinum 2SC (thiamethoxam) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

PQZ (pyrifluquinazon) *Arugula, Chicory, Cilantro, Cress, Dill, Endive, Escarole, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.4-3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 09B.

Pyganic EC 5.0 II (pyrethrins) *Arugula, Cress, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil drench* (in greenhouse): add 0.375 fl. oz. to 5 gal. of water and apply as a soil drench to 1,000 sq. ft. of soil or non-soil media. *Foliar applications*: 4.5-15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sivanto 200 (flupyradifurone) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 10.5-12 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 04D.

Torac (tolfenpyrad) *Arugula, Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 17-21 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Versys Inscalis (afidopyropen) *Arugula, Chicory, Cress, Dill, Endive, Escarole, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* | 1.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 09D.

Caterpillars

There are many caterpillar pests of leafy vegetables and herbs, including cutworms, loopers, and armyworms. Always check

the label for the specific list of caterpillars that the product can be used on.

Treat when 5% of plants are infested.

Pesticide

Avaunt (indoxacarb) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.5-6.0 oz. per acre. For armyworms, and loopers. REI: 12-hour. PHI: 3-day. IRAC 22A.

Baythroid XL (beta-cyfluthrin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Swiss Chard* | 0.8-3.2 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Cilantro, Coriander, Head Lettuce, Spinach* | For armyworms, cutworms, and loopers. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day for cilantro and coriander; 7-day for head lettuce, 40-day for spinach. IRAC 03A. *RUP.*

Bt (Bacillus thuringiensis) products for caterpillars (Bacillus thuringiensis aizawai strain ABTS-1857, Bacillus thuringiensis aizawai strain GC-91, Bacillus thuringiensis kurstaki strain ABTS-351, Bacillus thuringiensis kurstaki strain EVB-113-19, Bacillus thuringiensis kurstaki strain SA-11) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | For armyworms, cutworms, and loopers. Various Bt products (Agree, Biobit, Dipel, Javelin, etc.) are available for control of young caterpillars however, different Bt products can vary in the effectiveness against caterpillars. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Confirm 2F (tebufenozide) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 6-8 fl. oz. per acre. For armyworms, cutworms, and loopers. Do not exceed 40 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day. IRAC 18.

Coragen (chlorantraniliprole) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | For armyworms, cutworms, and loopers. Use 3.5-7.5 fl. oz. per acre on leafy greens as a foliar spray or soil treatment. Use 3.5-5.0 fl. oz. per acre on herbs as a foliar application only. REI: 4-hour. PHI: 1-day. IRAC 28.

Entrust SC (spinosad) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | For armyworms, and loopers. Use 2SC formulations at 3.0-8.0 fl. oz. per acre for leafy greens or 4.0-6.0 fl. oz. per acre for herbs. Use 80WP formulations at 1.0-2.5 oz. per acre for leafy greens or 1.25-2.0 oz. per acre for herbs. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Arugula, Chicory, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 10-17 fl. oz. per acre. For armyworms, and loopers. Do not use adjuvants in tank mix in spinach. REI: 12-hour. PHI: 1-day. IRAC 28.

Intrepid 2F (methoxyfenozide) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | For armyworms, cutworms, and loopers. *Early season applications:* 4-8 fl. oz. per acre. *Mid-to late-season applications:* 8-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 18.

Lannate LV (methomyl) *Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* | For armyworms, cutworms, and loopers. 1.5-3.0 pts. per acre for parsley, spinach, and chard. 0.75-3.0 pts. per acre for head and leaf lettuce. REI: 48-hour. PHI: 7-day for spinach and lettuce under 1.5 pts. per acre, 10-day for parsley and chard, 10-day for lettuce over 1.5 pts. per acre. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Arugula, Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.24-4.0 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Head Lettuce* | 1 lb. per acre. For armyworms, and loopers. REI: 24-hour. PHI: 21-day. IRAC 01B.

Perm-Up 25DF (permethrin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 6.4-12.8 oz. per acre. For armyworms, and loopers. Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC

formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Pyganic EC 5.0 II (pyrethrins) *Arugula, Cress, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | For armyworms, fruitworms, hornworms, loopers and pinworms. *Soil drench* (in greenhouse): add 0.375 fl. oz. to 5 gal. of water and apply as a soil drench to 1,000 sq. ft. of soil or non-soil media. *Foliar applications*: 4.5-15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Radiant 1SC (spinetoram) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 5-10 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 4-hour. PHI: 1-day. IRAC 05.

Sevin XLR Plus (carbaryl) *Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* | 1-2 qts. per acre. For armyworms, cutworms, and loopers. REI: 12-hour. PHI: 14-day. IRAC 01A.

Flea Beetles

Seedlings: >50% plants infested and defoliation is >30%.

Pesticide

Actara (thiamethoxam) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 4.4-10.5 fl. oz. per acre soil application, or 1.3 fl. oz. per acre foliar application on leafy greens. 4.4-10.5 fl. oz. per acre soil application for fennel and chard. 7.0-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application on herbs. REI: 12-hour. PHI: 45-day for soil application on fennel and chard, 14-day for soil application on herbs, 21-day for soil application on leafy greens, 7-day for foliar applications on leafy greens and herbs IRAC 04A.

Baythroid XL (beta-cyfluthrin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.4-3.2 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application. IRAC 04A.

Brigade 2EC (bifenthrin) *Cilantro, Coriander, Head Lettuce* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) *Cilantro, Coriander* | Use 3.4-6.8 fl. oz. pre-plant broadcast, pre-plant incorporated, or banded at-plant. Use 2.8-8.5 fl. oz. per acre as foliar spray. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 5-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) *Arugula, Cress, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil drench* (in greenhouse): add 0.375 fl. oz. to 5 gal. of water and apply as a soil drench to 1,000 sq. ft. of soil or non-soil media. *Foliar applications*: 4.5-15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sevin XLR Plus (carbaryl) *Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* | 0.5-2 qts. per acre. REI: 12-hour. PHI: 14-day. IRAC 01A.

Torac (tolfenpyrad) *Arugula, Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 14-21 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Up-Cyde 2.5EC (cypermethrin) *Head Lettuce* | 2.5-5.0 fl. oz. per acre. REI: 12-hour. PHI: 5-day. IRAC 03A. *RUP.*

Warrior II (lambda-cyhalothrin) *Head Lettuce, Leaf Lettuce* | 0.96-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Leafhoppers

Aster leafhopper and potato leafhopper are common in our region and crops. They don't survive the winter in northern areas, and migrate from southern areas every growing season. A condition known as "hopperburn" is caused by potato leafhopper feeding, and aster yellows is a disease vectored by aster leafhopper feeding. The amount of aster yellows present in any leafhopper population varies by year and location. Some states in the region have programs that test for and track the percentage of aster leafhoppers that are carrying aster yellows. Leafhoppers can move into vegetable fields when neighboring grain or alfalfa is harvested.

Management efforts can be stopped 2-3 weeks before harvest, as plants that are infected during that time will be harvested before symptoms manifest.

Non-Pesticide

Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme | Avoid planting near early harvested grain or alfalfa fields.

Pesticide

Actara (thiamethoxam) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 4.4-10.5 fl. oz. per acre soil application, or 1.3 fl. oz. per acre foliar application on leafy greens. 4.4-10.5 fl. oz. per acre soil application for fennel and chard. 7.0-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application on herbs. REI: 12-hour. PHI: 45-day for soil application on fennel and chard, 14-day for soil application on herbs, 21-day for soil application on leafy greens, 7-day for foliar applications on leafy greens and herbs IRAC 04A.

Baythroid XL (beta-cyfluthrin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.4-3.2 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application. IRAC 04A.

Dimethoate 4EC (dimethoate) *Endive, Leaf Lettuce, Swiss Chard* | Use 2.67EC formulations at 0.75 pt. per acre. Use 4EC, LV-4, and 400 formulations at 0.5 pt. per acre. REI: 48-hour. PHI: 14-day. IRAC 01B.

Mustang Maxx (zeta-cypermethrin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 5-day. IRAC 03A. *RUP.*

Neemix (azadirachtin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 7-16 fl. oz. per acre. Nymphs only. REI: 4-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Orthene 97 (acephate) *Head Lettuce* | 8-16 oz. per acre. REI: 24-hour. PHI: 21-day. IRAC 01B.

Perm-Up 25DF (permethrin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) *Arugula, Cress, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil*

drench (in greenhouse): add 0.375 fl. oz. to 5 gal. of water and apply as a soil drench to 1,000 sq. ft. of soil or non-soil media. *Foliar applications*: 4.5-15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Scorpion 35SL (dinotefuran) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil treatment*: Use Scorpion 35SL at 9.0-10.5 oz. per acre, or Venom 70SG at 5.0-5.5 oz. per acre. *Foliar treatment*: Use Scorpion 35SL at 2.0-5.25 oz. per acre, or Venom 70SG at 1-3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Sevin XLR Plus (carbaryl) *Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* | 0.5-2 qts. per acre. REI: 12-hour. PHI: 14-day. IRAC 01A.

Sivanto 200 (flupyradifurone) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 7-10.5 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 04D.

Torac (tolfenpyrad) *Arugula, Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 14-21 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Up-Cyde 2.5EC (cypermethrin) *Head Lettuce* | 2.5-5.0 fl. oz. per acre. REI: 12-hour. PHI: 5-day. IRAC 03A. *RUP.*

Warrior II (lambda-cyhalothrin) *Head Lettuce, Leaf Lettuce* | 0.96-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Leafminers

Seedlings: 50% of plants infested.

Near Harvest: 5% of leaves infested.

Pesticide

Agri-Mek SC (abamectin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15EC formulations at 8-16 fl. oz. per acre. Use with a nonionic adjuvant. Do not use binder or sticker-type surfactants. REI: 12-hour. PHI: 7-day for leafy greens and chives, 14-day for all other herbs. IRAC 06. *RUP.*

Belay (clothianidin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application. IRAC 04A.

Brigade 2EC (bifenthrin) *Cilantro, Coriander, Head Lettuce* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Dimethoate 4EC (dimethoate) *Endive, Leaf Lettuce, Swiss Chard* | Use 2.67EC formulations at 0.75 pt. per acre. Use 4EC, LV-4, and 400 formulations at 0.5 pt. per acre. REI: 48-hour. PHI: 14-day. IRAC 01B.

Entrust SC (spinosad) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | For armyworms, and loopers. Use 2SC formulations at 6.0-10.0 fl. oz. per acre. Use 80WP formulations at 2.0-3.0 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Movento (spirotetramat) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 3-day. IRAC 23.

Neemix (azadirachtin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 4-7 fl. oz. per acre. Mix with oil-based adjuvant for best results. REI: 4-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Perm-Up 25DF (permethrin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) *Arugula, Cress, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Leaf*

Lettuce, Parsley, Radicchio, Spinach, Swiss Chard | *Soil drench* (in greenhouse): add 0.375 fl. oz. to 5 gal. of water and apply as a soil drench to 1,000 sq. ft. of soil or non-soil media. *Foliar applications*: 4.5-15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Radiant 1SC (spinetoram) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 5-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05.

Scorpion 35SL (dinotefuran) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil treatment*: Use Scorpion 35SL at 9.0-10.5 oz. per acre, or Venom 70SG at 5.0-5.5 oz. per acre. *Foliar treatment*: Use Scorpion 35SL at 2.0-5.25 oz. per acre, or Venom 70SG at 1-3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Trigard (cyromazine) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.66 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 17.

Mites

Mite populations spike in hot dry weather. Damage appears as white flecks on leaves, accompanied by webbing. Selective chemistries (e.g. abamectin, bifenazate, etoxazole, cyflumetofen, fenpyroximate, hexythiazox, spiromesifen) that target mites help to preserve natural enemies.

Pesticide

Agri-Mek SC (abamectin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15EC formulations at 8-16 fl. oz. per acre. Use with a nonionic adjuvant. Do not use binder or sticker-type surfactants. REI: 12-hour. PHI: 7-day for leafy greens and chives, 14-day for all other herbs. IRAC 06. *RUP.*

Brigade 2EC (bifenthrin) *Head Lettuce, Spinach* | Use 2EC formulations at 5.12-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 12.8-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) *Head Lettuce* | 3.4-6.8 fl. oz. per acre. *Bulb mites only*. Use as a foliar spray. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Pyganic EC 5.0 II (pyrethrins) *Arugula, Cress, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil drench* (in greenhouse): add 0.375 fl. oz. to 5 gal. of water and apply as a soil drench to 1,000 sq. ft. of soil or non-soil media. *Foliar applications*: 4.5-15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Slugs and Snails

Slugs and snails may occasionally damage seedlings, low growing leafy vegetables, and/or ripening fruit. Slug and snail feeding causes hollowed out areas, which can be found on fruit, but the damage is usually on the stem. Slugs and snails produce a silvery trail on the surface of leaves and fruit. Slugs and snails are active at night and they inhabit moist soil and organic mulch. Slugs and snails overwinter as eggs in moist soil.

Bait products can be placed on the soil surface around the perimeter of the planting area. Bait products can also be placed on the soil surface in a band between rows. Apply bait products in the evening after a rain or irrigation. Avoid contacting edible crops with bait products.

Non-Pesticide

Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme | Slug and snail hiding places, such as, boards, stones, weedy areas, and mulch should be eliminated. Raised beds will dry out faster than flat beds, which will reduce problems with slugs and snails. Black plastic mulch can be used to reduce problems with slugs and snails.

Pesticide

Deadline M-Ps (metaldehyde) *Florence Fennel, Spinach, Swiss Chard* | 25 lbs. per acre. Scatter bait around the perimeter of plantings or between rows. Apply in evening after a rain or irrigation. Avoid contact with edible product. REI: 12-hour. PHI: 0-day for spinach, 1-day for Florence fennel and chard. IRAC UN.

Sluggo 1B (iron phosphate) *Head Lettuce, Leaf Lettuce, Spinach, Swiss Chard* | 20-44 lb. per acre, or 0.5-1 lb. per 1,000 sq. ft. Prevent infestation by scattering bait products to the soil surface around the perimeter of the planting. Make a rescue treatment by scattering the bait products on the soil as

a band between rows. Apply in evening after a rain or irrigation. REI: 0-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Tarnished Plant Bug

Tarnished plant bug (TPB) damage to lettuce and spinach can reduce the marketability of these crops and can make them more susceptible to bacterial diseases. TPB adults and nymphs also feed on the youngest growth in the heart of the plant, which may lead to symptoms similar to blackheart.

No formal economic thresholds have been developed for this insect pest in leafy vegetables. However, in Canada, the thresholds used in celery have proven to be a suitable guideline for management decisions. Insecticide treatment is recommended whenever a threshold of 0.2 TPB per plant is reached from transplanting until three weeks before harvest. Note that in many cases, TPB damage is observed before large numbers of TPB nymphs and/or adults are detected.

Pesticide

Baythroid XL (beta-cyfluthrin) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.4-3.2 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Beleaf (flonicamid) *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 2.0-2.8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Brigade 2EC (bifenthrin) *Head Lettuce, Spinach* | Use 2EC formulations at 5.12-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 12.8-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 5-day. IRAC 03A. *RUP.*

Pyganic EC 5.0 II (pyrethrins) *Arugula, Cress, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | *Soil drench* (in greenhouse): add 0.375 fl. oz. to 5 gal. of water and apply as a soil drench to 1,000 sq. ft. of soil or non-soil media. *Foliar applications*: 4.5-15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sevin XLR Plus (carbaryl) *Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* | 0.5-2 qts. per acre. REI: 12-hour. PHI: 14-day. IRAC 01A.

Leafy Vegetables and Herbs - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Most herbs are weak competitors with weeds, and while a few herbicides are registered on many herbs, they generally are for site preparation or for preemergence control or postemergence control of emerged grasses. Herbicides are not widely labeled across the many leafy greens and herbs. Instead, herbicides are labeled based on the plant families the crops come from. For example, cilantro, dill and parsley have several herbicides that would damage any other crop. Similarly, spinach and Swiss chard have unique herbicides. Lettuces and the related crops like Chicory, Endive, Escarole, Radicchio have few labels for preemergence or over-the-top use because many weeds come from this plant family and are targeted by broadleaf herbicides.

For directed-seed crops, prepare a stale seedbed several weeks in advance of planting, allow weeds to emerge, and kill weeds without bringing new weed seeds to the surface with a burndown herbicide, flame weeder, or very shallow cultivation. In fields with lower weed pressure, it may be possible to plant seeds into some emerged weeds, and then use an approved burndown herbicide prior to crop emergence to control emerged weeds. For crops like cilantro and dill that take a long time to emerge, a burndown application made just prior to crop emergence is especially useful, but it can also pay off for faster-emerging species like lettuce or spinach.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme | Weed control in leafy vegetables and herbs often relies heavily on cultivation and hand-weeding for full season weed control. These operations are most efficient when planting arrangement is designed with weed control in mind and is designed to work with available weed control equipment. Specialized weeding equipment for leafy vegetables includes basket weeders, narrow-bladed hoes, finger weeders, and others. A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. Using transplants is helpful for weed control because the size difference between weeds and crop early in the season make mechanical control easier. Plastic and paper mulches have been used with success for transplanted crops.

Pesticide

Aim EC (carfentrazone) POST *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 1-2 fl. oz. per acre. **For leafy vegetables (not including herbs, *except basil in with special 24c label*):** Apply as burndown treatment at least 1 day before transplanting or at least 7 days before seeding. Tank-mix with another labeled burndown product for best control. **For leafy vegetables and herbs:** Apply to row middles with a hooded sprayer to control weeds up to 4 inches tall. Add COC/MSO (1% v/v) or NIS (0.25% v/v). AMS will improve weed control. Do not exceed 6.1 fl. oz. per acre per year or 2 applications per crop per year. REI: 12-hour. HRAC 14.

Balan DF (benefin) PRE *Head Lettuce, Leaf Lettuce* | 2-2.5 lbs. per acre. Apply and incorporate before seeding or transplanting. REI: 12-hour. HRAC 03.

Caparol 4L (prometryn) POST PRE *Cilantro, Dill, Florence Fennel, Parsley* | For **cilantro:** apply 2.0-3.2 pts. per acre after seeding but before crop emergence. For **dill** *with special 24c label only:* apply 3.2 pts. Per acre once after seeding and before crop emergence or apply after crop emerges. Do not exceed one application or 3.2 pts. per acre per season. For **Florence fennel:** apply 2.4-4.0 pts. per acre after seeding but before crop emergence or apply 1.6-2.0 pts. per acre after seeded crop has 2-5 true leaves and before weeds are 2 inches tall, or apply 2.4-4.0 pts. per acre after transplanting. Do not exceed one application to seeded fennel, or two applications in transplanted fennel. For **parsley:** apply 1 pt. per acre up to 14 days after planting. A second application can be made up to 30 days before harvest. A third application can be made up to 30 days before second harvest. Maximum 3 applications per year and 3 pts. per acre per year. To avoid crop injury, do not use on sand or loamy sand, or use lower rate. REI: 12-hour. PHI: 30-day for cilantro, dill, and parsley; 40-day for Florence fennel. HRAC 05.

clethodim products (clethodim) POST *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season. Use Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Do not exceed 64 fl. oz. of Select Max per acre per season. Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. Try on small area before spraying whole field. REI: 24-hour. PHI: 14-day. HRAC 01.

clopyralid products (clopyralid) POST *Spinach* | For **spinach:** apply Spur or Stinger (40.9% formulations) at 2.7-5.3 fl. oz. per acre when spinach is in the 2-5 leaf stage. Do not exceed 2 applications and 8 fl. oz. per acre per year. Kills composite weeds, legumes, nightshade and smartweeds. REI: 12-hour. PHI: 21-day for spinach; 30-day for Swiss chard. HRAC 04.

Devrinol DF-XT (napropamide) PRE *Basil, Marjoram, Rosemary, Savory* | 2-4 lbs. per acre. Apply before or after seeding and incorporate into soil, or water-in with 0.2-0.4 inch of water. REI: 24-hour. HRAC NC.

Dual Magnum (s-metolachlor) PRE *Chive, Cilantro, Head Lettuce, Leaf Lettuce, Spinach, Swiss Chard* | *Special 24c label only.* For **chive:** apply 0.67-1.33 pts. per acre postemergence starting when the crop has 2 true leaves. For **cilantro**: apply 0.67-1 pt. per acre to soil surface after seeding before crop emerges. For **head and leaf lettuce:** apply 0.67-1 pt. per acre preplant, preemergence, or after emergence or transplanting. For **spinach:** apply 0.33-1 pt. per acre to soil surface after seeding before crop emerges. For **Swiss chard**: apply 0.5-1.0 pt. per acre to soil surface after seeding before crop emerges. In all cases, use lower rate on sandy soil. Do not incorporate. Do not application per crop per season. REI: 24-hour. PHI: 20-day for head lettuce; 21-day for chives, 25 day for leaf lettuce; 30-day for cilantro; 50-day for spinach, 62-day for chard. HRAC 15.

Fusilade DX (fluazifop-P) POST *Head Lettuce, Leaf Lettuce* | 10-24 fl. oz. per acre. Use COC (1% v/v) or NIS (0.25% v/v). Apply to actively growing grasses. Effective against perennial grasses. Do not exceed 48 fl. oz. per acre per year. REI: 12-hour. PHI: 14-day. HRAC 01.

glyphosate products (glyphosate) POST *Arugula, Basil, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Apply to emerged annual and perennial weeds before planting. Transplants that contact freshly sprayed weeds can be seriously injured. Or apply between rows with a hooded or shielded sprayer. Crop will be injured if any spray contacts it. Use low rate for annuals and higher rates for perennials. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

Kerb SC (pronamide) PRE *Endive, Escarole, Head Lettuce, Leaf Lettuce, Radicchio* | 1.25-5 pts. per acre. Apply before or after seeding. Must be incorporated or irrigated into soil. Can be applied after crop emerges, but weed control will be marginal on muck soils. For **head lettuce** *on muck soils with 24c label only:* use 9.6-14.4 pts. per acre. REI: 24-hour. PHI: 55-day for head lettuce. HRAC 03. *RUP.*

Lorox DF (linuron) POST PRE *Cilantro, Coriander, Dill, Parsley* | 1-3 lbs. per acre. For **cilantro and coriander:** apply 1-2 lbs. per acre after seeding and before crop emergence, or make up to 2 postemergence applications after crop has 3 true leaves. Do not exceed 4 lbs. per acre per year. For **dill:** apply 1-2 lbs. per acre after seeding and before crop emergence, or make one postemergence application after crop has 3 true leaves. Do not exceed 4 lbs. per acre per year. For **parsley:** apply 1-3 lbs. per acre after seeding and before crop emergence. Use lower rate on sandy soil, or make one postemergence application at 1 lb. per acre after crop has 3 true leaves (*postemergence application allowed on muck soils only)*. Do not exceed 3 lbs. per acre per year. Use lower rate on sandy soil. Do not apply to soil with less than 1% organic matter. Do not spray when temperatures exceed 85F. REI: 24-hour to 8-day. PHI: 21-day for cilantro, coriander, and dill; 30-day for parsley. HRAC 05.

Optogen (bicyclopyrone) POST PRE

Lemongrass, Rosemary | 3.5 fl. oz. per acre. For **rosemary** and **lemongrass**: apply as a broadcast treatment prior to transplanting or after transplanting. If weeds are present, add COC (1% v/v) or NIS (0.25% v/v). Spray grade ammonium sulfate (AMS) may also be added to improve weed control consistency. Apply to weeds less than 2 inches. Do not exceed 1 application per year. Do not exceed 3.5 fl. oz. per acre per year. Applications made to direct-seeded **rosemary** or **lemongrass** can result in significant crop injury. REI: 24-hour. PHI: 60-day. HRAC 27.

paraquat products (paraquat) POST *Endive, Escarole, Head Lettuce, Leaf Lettuce* | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation as a banded or broadcast treatment before, during or after planting but prior to emergence. For **head and leaf lettuce** *with special 24c label only:* make one shielded application of 1.5 pts. per acre to row middles 2-3 weeks after seeding. Include 0.25% NIS v/v. Use a minimum of 40 gals. water per acre. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) *Chive* | Use 3.8 formulations at 2 pts. per acre after seeding but before crop emerges, or when crop has 2-3 true leaves. The 3.3 formulations are not labeled for chive. If both pre and post applications are used, wait 30 days after pre application before making a post application. Only apply pre to muck soils (organic matter greater than 20%) or mineral soils with greater than 3% organic matter. Do not exceed 4 pts. per acre per year. *Special 24c label only.* For mineral soils with more than 5% organic matter, use 3.8 formulations up to 4 pts. per acre or 3.3. formulations up to 4.8 pts. per acre. Use low rates on course soils. Heavy rain or excessive irrigation soon after application may cause crop injury. Will not control emerged weeds. REI: 24-hour. PHI: 30-day. HRAC 03.

Poast (sethoxydim) POST *Arugula, Cilantro, Cress, Dill, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* | 1.5 pts. per acre. Apply to actively growing grasses. Include COC (1% v/v). Do not exceed 5 pts. per acre per season for dill or 3 pts. for other listed crops. REI: 12-hour. PHI: 30-day for fennel, head lettuce, radicchio, and chard; 15-day for other crops. HRAC 01.

Prefar 4E (bensulide) PRE *Arugula, Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio* | 5-6 qts. per acre. *Mineral soils only.* Apply and incorporate before planting or apply after seeding (before crop emerges) and incorporate with irrigation. REI: 12-hour. HRAC NC.

Ro-Neet (cycloate) PRE *Spinach* | 2 qts. per acre. *Illinois and Ohio only*. Apply before planting and incorporate 2-3 inches immediately. Use on sandy mineral soils only. REI: 48-hour. PHI: 45-day. HRAC 15.

Scythe (pelargonic acid) POST *Arugula, Basil, Chive, Cress, Dill, Endive, Escarole, Fennel, Head Lettuce, Leaf Lettuce, Oregano, Parsley, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* | 5-10 gals. per acre. **For leafy greens (including herbs)**: Apply as a burndown, or as a directed or hooded spray between rows in 75-200 gals. of water per acre. Use higher rate for large and mature weeds. **For herbs (not including leafy greens)**: Apply prior to emergence of plants from seed or perennial rootstock, ensuring applications are made before crop emerges from the soil. REI: 12-hour. HRAC NC.

Spin-Aid (phenmedipham) POST *Spinach* | 3-4 pts. per acre. **For spinach grown for processing or seed only**: Apply to spinach with 4-6 leaves when temperature is below 75F. Do not spray when dew is present. Apply in 11-22 gals per acre. May cause crop stunting. REI: 12-hour. PHI: 21-day. HRAC 05. *RUP.*

trifluralin products (trifluralin) PRE *Chicory, Endive, Escarole, Radicchio* | Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Broadcast and incorporate 1-2 inches before seeding or transplanting. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour. HRAC 03.

Mint for Oil - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Petrus Langenhoven – Oct 2024

Crop Description

Mints are a group of perennial herbs that are commercially important sources of essential oils obtained by distillation of their hay. The discussion in this section refers to the production of essential oils. They are also commonly grown as a leaf herb; see the leafy vegetable section for common production practices for that product. The most common cultivated types are peppermint and spearmint.

Peppermint (*Mentha x piperita*): All peppermints are a hybrid of two other species, watermint (*M. aquatica*) and native spearmint (*M. spicata*). The varieties include Black Mitcham, Murray Mitcham, Robert's Mitcham, and Todd's Mitcham. The latter three varieties are more resistant to verticillium wilt.

Spearmint: Scotch Spearmint (*M. cardiaca*) and Native Spearmint (*M. spicata*). These two species of spearmints have distinctly different oils.

Because verticillium wilt disease is an important problem even with the more resistant varieties, growers should always use disease-free planting stock. Certified and disease-free stocks are available.

Planting and Spacing

Mints are grown from 3- to 4-inch long dormant runners dug from existing fields in the late fall or spring. They spend their first year as a row crop before spreading through runners. The following years are spent as a solid stand or meadow crop. Careful fall plowing of established stands is important for both winter protection and for reducing the incidence of mint rust and other foliar diseases. "Squirelly" mint, which occurs primarily on peppermint, is caused by the mint bud mite, *Tarsonemus pipermenthae.* Although mints are perennials, older stands may show serious build-ups of disease, insect, and weed problems and should be rotated out every 3 to 4 years.

Fertilizing

pH: Maintain a soil pH of 5.5 to 6.5.

New plantings: Before planting new stolons, apply 40 pounds N per acre, 0 to 100 pounds P_2O_5 per acre, and 0 to 400 pounds K_2O per acre based on soil test results and recommendations from your state. Broadcast the fertilizer and plow it under when preparing the land for the planting furrows.

Topdress with 40 pounds N per acre on muck soils, or 80 pounds N per acre for mineral soils in early June.

Established plantings: Each year before emergence, broadcast or drill in 40 to 60 pounds N per acre, 0 to 50 pounds P_2O_5 per acre and 0 to 150 pounds K_2O per acre if a soil test recommends it.

Topdress with 60 to 90 pounds N per acre after canopy closure. The total amount of N from fertilizer should be 120 to 150 pounds N per acre.

Irrigation significantly increases oil yields on both muck and mineral soils, even in seasons with normal rainfall.

Harvesting

For oil production, maximum yield and quality is reached when 10% of peppermint is in full bloom, or 100% of spearmint is in full bloom. Cut, windrow, and allow to partially dry for 24 to 36 hours before collecting for distillation. The machines for this are similar to hay machines, but the collection into distillation tubs requires a specialized procedure and equipment.

Indiana Mint

Indiana grows the most mint in the Midwest and has a dedicated resource website, titled Indiana Mint Oil Production, within the Purdue web system.

Mint for Oil - Diseases

Reviewed by Petrus Lagenhoven – Aug 2024

Leaf Spot of Mint - Septoria Fungus

Pesticide

chlorothalonil products (chlorothalonil) | *Indiana and Michigan only.* Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2 pt. per acre. Use 54% (720) formulations at 1.38 pt. per acre. Use 82.5% (WDG) formulations at 1.2 lb. per acre. Use 90% (DF) formulations at 1.1 lb. per acre. REI: 12-hour. PHI: 80-day. FRAC M05.

Rust of Multiple Crops - Puccinia Fungus

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day for fresh; 7-day for processed. FRAC 11.

chlorothalonil products (chlorothalonil) | *Indiana and Michigan only.* Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2 pt. per acre. Use 54% (720) formulations at 1.38 pt. per acre. Use 82.5% (WDG) formulations at 1.2 lb. per acre. Use 90% (DF) formulations at 1.1 lb. per acre. REI: 12-hour. PHI: 80-day. FRAC M05.

Headline (pyraclostrobin) | 9-12 fl. oz. per acre. Additional formulations of Headline may be labeled. REI: 12-hour. PHI: 14-day. FRAC 11.

propiconazole products (propiconazole) | 4 fl. oz. per acre. Propimax EC and Tilt are labeled. REI: 12-hour. PHI: 90-day. FRAC 03.

Rally 40WSP (myclobutanil) | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 30-day. FRAC 03.

Wilt of Multiple Crops - Verticillium Fungus

Non-Pesticide

Rotate plantings after no more than 3 or 4 years. Use wilt resistant varieties of peppermint. Native spearmint is resistant.

Mint for Oil - Insects

Reviewed by Laura Ingwell, Elizabeth Long – Sep 2021

Caterpillars

The primary caterpillar pests of mint are loopers, cutworms, and the mint root borer.

Non-Pesticide

The soil-dwelling mint root borer caterpillar can be treated with the commercially-available parasitic nematode, *Steinernema carpocapsae*. Mix the nematodes with water and apply at a rate that deposits 1 - 1.5 billion nematodes per acre.

Pesticide

Avaunt (indoxacarb) | 3.5 oz. per acre. For cutworms, and loopers. REI: 12-hour. PHI: 7-day. IRAC 22A.

Bt (Bacillus thuringiensis) products for caterpillars (Bacillus thuringiensis aizawai strain ABTS-1857, Bacillus thuringiensis aizawai strain GC-91, Bacillus thuringiensis kurstaki strain ABTS-351, Bacillus thuringiensis kurstaki strain EVB-113-19, Bacillus thuringiensis kurstaki strain SA-11) | For armyworms, cutworms, and loopers. Various Bt products (Agree, Biobit, Dipel, Javelin, etc.) are available for control of young caterpillars however, different Bt products can vary in the effectiveness against caterpillars. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Coragen (chlorantraniliprole) | 3.5-7.0 fl. oz. per acre. For armyworms, cutworms, loopers, and mint root borers. REI: 4-hour. PHI: 3-day. IRAC 28.

Entrust SC (spinosad) | For armyworms, cutworms, and loopers. Use 2SC formulations at 4.0-10.0 fl. oz. per acre. Use 80WP formulations at 1.25-3.0 oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 05. *OMRI-listed.*

Intrepid 2F (methoxyfenozide) | 10-16 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 4-hour. PHI: 14-day. IRAC 18.

Lannate LV (methomyl) | 3 pts. per acre. For cutworms, and loopers. REI: 48-hour. PHI: 14-day. IRAC 01A. *RUP.*

Orthene 97 (acephate) | 1 lb. per acre. For cutworms, and loopers. REI: 24-hour. PHI: 14-day. IRAC 01B.

Radiant 1SC (spinetoram) | 4-12 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 4-hour. PHI: 7-day. IRAC 05.

Flea Beetles

Pesticide

Actara (thiamethoxam) | 1.5-3.0 oz. per acre. See pollinator precautions. REI: 12-hour. PHI: 7-day. IRAC 04A.

Lannate LV (methomyl) | 2.25-3 pts. per acre. For best results, apply immediately after harvest on stubble. REI: 48-hour. PHI: 14-day. IRAC 01A. *RUP.*

Malathion 5EC (malathion) | Use 5EC formulations at 1.5 pts. per acre. Use 57EC formulations at 1.0-1.5 pts. per acre. For best results, apply immediately after harvest on stubble. REI: 12-hour. PHI: 7-day. IRAC 01B.

Mites

Squirrelly mint, which occurs primarily on peppermint, is caused by the mint bud mite, *Tarsonemus pipermenthae*. Mite populations spike in hot dry weather. Damage appears as white flecks on leaves, accompanied by webbing. Selective chemistries (e.g. abamectin, bifenazate, etoxazole, cyflumetofen, fenpyroximate, hexythiazox, spiromesifen) that target mites help to preserve natural enemies.

Non-Pesticide

Preserve and encourage natural enemies.

Pesticide

Acramite 50WS (bifenazate) | 0.75-1.5 lbs. per acre. REI: 12-hour. PHI: 7-day. IRAC 20D.

Agri-Mek SC (abamectin) | Use 0.7SC formulations at 1.75-2.5 fl. oz. per acre. Use 0.15EC formulations at 8-12 fl. oz. per acre. REI: 12-hour. PHI: 28-day. IRAC 06. *RUP.*

Dicofol 4E (dicofol) | 1.75-2.5 pts. per acre. REI: 12-hour. PHI: 30-day. IRAC UN.

Portal (fenpyroximate) | 1-2 pts. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A.

Zeal (etoxazole) | 2-4 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 10B.

Mint for Oil - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Before establishing a mint planting, reduce perennial weeds in the area to be planted with systemic broad-spectrum herbicides and/or cultivation. For full-season weed control consider combinations of dormant, in-season, and post-harvest herbicide applications.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Because mint is grown as a short-lived perennial crop, weed management in preceding crops is important to reduce the amount of weed seeds in the soil, and good weed control in the planting year is especially important. Between-row cultivation can be used in the first year before stolons and rhizomes grow into fill in this space. Late winter or early spring cultivation can be used to control winter annual weeds.

Pesticide

Aim EC (carfentrazone) POST | 0.5 to 1.92 fl. oz. per acre Apply before crop emergence to emerged weeds less up to 4 in. tall. Add COC (1% v/v) or NIS (0.25% v/v). REI: 12-hour. PHI: 5-day HRAC 14.

Anthem Flex (carfentrazone, pyroxasulfone) POST PRE | 3.5 fl. oz. per acre. Make a single application over-the-top of dormant peppermint or spearmint. Add COC (1% v/v) or NIS (0.25% v/v). When hard water is used, add spray grade UAN or AMS. Do not use on coarse soil or soil classified as sand. Do not apply to soil with less than 1%

organic matter. Do not apply to newly planted mint. REI: 12-hour. PHI: 5-day. HRAC 14, HRAC 15.

Assure II (quizalofop) POST | 8-12 oz. per acre. Add COC (1% v/v) or NIS (0.25% v/v). Apply to actively growing grass. Do not exceed 2 applications or 24 fl. oz. per acre per season. Applications must be greater than 7 days apart. REI: 12-hour. PHI: 30-day. HRAC 01.

Basagran (bentazon) POST | Use 4L formulations at 1-2 pts. per acre and 5L formulations at 1.2-1.6 pt. per acre. Apply after mint and weeds have emerged. To control yellow nutsedge and Canada thistle, repeat application 7-10 days later. Crop oil will enhance activity. Do not exceed 4 pts. per acre per season. REI: 48-hour. PHI: 20-day. HRAC 06.

Chateau SW (flumioxazin) POST PRE | 2-4 oz. per acre of Chateau SW or 2-4 fl. oz. per acre of Chateau EZ. Apply to established, dormant mint from November 25 to March 1. Do not apply to frozen or snow covered ground. Do not exceed 4 oz. per acre in a single application or more than 8 oz. per acre in a single growing season. Do not make a sequential application of Chateau within 60 days of first application. Applying to nondormant mint may result in unacceptable injury. For improved postemergence control, tank-mix with paraquat and add NIS at 0.5 pt. per 25 gal. of solution (0.25% v/v). Adding a nitrogen source will increase activity. REI: 12-hour. PHI: 80-day. HRAC 14.

clethodim products (clethodim) POST | Use 2EC formulations at 6-16 fl. oz. per acre with COC (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use Select Max at 9-16 fl. oz. per acre to control annual grasses and 12-32 fl. oz. per acre to control perennial grasses. COC (1% v/v) or NIS (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 21-day. HRAC 01.

clopyralid products (clopyralid) POST | 0.33-1.0 pt. per acre. Apply Spur or Stinger (40.9% formulations only) with 4 fl. oz. of NIS per 25 gals. of spray solution. Apply up to 0.5 pt. in spring or up to 1 pt. in fall. Controls mainly composites and nightshade. To control Canada thistle in spring, apply before bud stage. Do not use mint straw, hay, or spent hay for compost or mulch and do not dispose of on land to be rotated to broadleaf crops due to herbicide remaining in mint hay or straw that will injure broadleaf plants. Do not exceed 1 pt. per acre per growing season. REI: 12-hour. PHI: 45-day. HRAC 04.

Command 3ME (clomazone) PRE | 1.3 pts. per acre. Apply in spring before mint starts to grow. Do not apply to emerged mint. Do not exceed 1 application per season. Some whitening of tissue may occur as mint emerges. REI: 12-hour. PHI: 84-day. HRAC 13.

Devrinol DF-XT (napropamide) PRE | 8 lb. per acre. *New plantings:* Apply soon after planting. *Established plantings:* Must be established for at least one growing season. REI: 24-hour. HRAC NC.

glyphosate products (glyphosate) POST | Apply as a spot treatment in a 1-2% solution to actively growing weeds. The sprayed mint crop will be killed. Not all glyphosate formulations are labeled for mint. Apply as a spot treatment to no more than 10% of any acreage but can reapply to the same area at 30-day intervals. Avoid any drift to nontarget crops. REI: 4-hour to 12-hour. PHI: 7-day. HRAC 9.

GoalTender (oxyfluorfen) POST PRE | *Indiana and Michigan only.* 2-3 qt. per acre **Goal 2XL** or 1 pt. per acre **GoalTender**. Use 20-40 gals. of water per acre. Add 0.5 pt. NIS per 25 gal. of solution if emerged weeds are present. Apply to dormant spearmint and peppermint on muck soil (greater than 20% organic matter) before weeds are 4 in. tall. Application to emerged mint will result in severe injury. Not for use on mineral or black sand soils. REI: 24 to 48-hour. HRAC 14.

Moxy 2E (bromoxynil) POST | 1.0-1.5 pts. per acre. Apply in at least 10 gals. water per acre. Apply before weeds have more than 4 leaves, and only on established mint that has been harvested at least one year prior to application. Do not apply to mint growing under stressful conditions, or when air temperatures are, or are expected to be, more than 70 F within 5 days of application. REI: 24-hour. PHI: 70-day. HRAC 06.

paraquat products (paraquat) POST | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Add COC (1% v/v) or NIS (0.25% v/v). Apply to dormant mint when weeds are less than 6 in. tall. Do not exceed 2 applications per year or apply more than 2 pt. per dormant season. Certified applicators must successfully

complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE | 1.5-4.0 pts. per acre. *Established mint only*. Apply 3.8 formulations to dormant mint before mint and weeds start to grow. Use low rate on coarse soils. REI: 24-hour. PHI: 90-day. HRAC 03.

Poast (sethoxydim) POST | 1.0-2.5 pts. per acre. Add COC (1% v/v). Spray on actively growing grass. Do not exceed 5 pt. per acre per season. REI: 12-hour. PHI: 20-day. HRAC 01.

Sinbar WDG (terbacil) POST PRE | As a preemergence application for weeds, apply 1-2 lb. per acre in the spring just after the last cultivation and before mint starts growing. As a postemergence application for weeds, apply 1.0-1.5 lb. per acre in the spring to broadleaf weeds less than 2 inches tall or grasses less than 1 inch tall and before mint starts growing. For postemergence application, add COC (1% v/v) or NIS (0.25% v/v). Do not exceed 2 lb. per acre per season. Discontinue use 1 year before rotating to other crops. REI: 12-hour. PHI: 60-day. HRAC 05.

Spartan 4F (sulfentrazone) PRE | New plantings: 3.3-9.0 fl. oz. per acre. Established plantings: 4.5-12.0 fl. oz. per acre. Renovation: 4 fl. oz. per acre. *New plantings:* Apply after planting before weeds and mint emerge. *Established plantings:* Apply to established mint when it is dormant, in the fall after postharvest cultivation, and/or in the spring after cultivation. *At renovation with special 24c label only:* After cutting and removing mint from the field, apply 4 fl. oz. per acre. Use lower rates on coarse soil with low organic matter. Rainfall or irrigation is required to move herbicide into the soil. Application may injure crop as mint emerges. Application to emerged mint will result in severe injury. Do not exceed 12 fl. oz. per 12-month period. Do not apply to mint grown on sands with less than 1% organic matter. REI: 12-hour. PHI: 92-day for dormant and new planting applications, 55-day for renovation applications. HRAC 14.

Thistrol (MCPB) POST | 1-2 pts. per acre. Apply in spring after mint emerges to suppress broadleaf weeds, or apply in fall to control winter annuals. May injure mint. Oil yields may be reduced if mint is more than 6 inches tall at the time of application. Bindweed suppression is best with spring application when weeds are 6-8 inches long. REI: 24-hour. PHI: 40-day. HRAC 04.

Tough 5EC (pyridate) POST | 24 fl. oz. per acre. Apply before broadleaf weeds reach the 4-leaf stage. Add COC (1% v/v) or NIS (0.25% v/v). Do not exceed 24 fl. oz. per acre in a single application or 48 fl. oz. per acre per year. This product does not provide pre-emergence weed control. May be combined with a grass-selective herbicide. REI: 12-hour. PHI: 49-day. HRAC 06.

trifluralin products (trifluralin) PRE | Apply 1.0-1.5 pt. per acre of 4 lb. per gal. trifluralin to established, dormant or semi-dormant mint, late winter to spring or in the fall after harvest prior to emergence of targeted weed species. Must be incorporated mechanically or by 0.5 in. rainfall or irrigation within 3 days of application. REI: 12-hour. HRAC 03.

Okra - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Liz Maynard – Sep 2024

Crop Description

Okra (*Abelmoschus esculentus*) is a subtropical plant related to hibiscus that is grown for its young green fruit. Okra requires warm weather for best growth. Some varieties have many small spines, similar to vine crops, which can irritate the skin when harvesting. There are also spineless varieties and red-fruiting varieties. Though okra is often listed on pesticide labels along with eggplants, peppers, and tomatoes, they are not a related species and share few pests.

Planting and Spacing

Seed 12 to 18 inches apart in rows 36 inches apart. Seed only after the soil has warmed to 65 F to 70 F for several days. Black plastic mulch with drip irrigation will increase yields. Transplants can be used for early production.

Fertilizing

pH: Maintain a soil pH of 6.0 to 6.5. Okra is very sensitive to low pH soils.

Before planting, apply 40 pounds N per acre, 0 to 200 pounds P_2O_5 per acre, and 0 to 300 pounds K_2O per acre based on soil test results and recommendations from your state.

Sidedress with 40 pounds N per acre after the first harvest.

Harvesting

Okra should be harvested every 2 to 3 days to maintain optimal market size (2- to 4-inch long pods). Frequent harvesting increases overall yield since the plant will reset pods faster. Okra will yield 8,000 to 10,000 pounds per acre. Time from seeding to harvest ranges between 50 to 65 days; transplants can produce pods in 30 to 40 days.

Okra - Diseases

Reviewed by Dan Egel – Aug 2023

Wilt of Multiple Crops - Fusarium Fungus

Non-Pesticide

Use disease-free seed and transplants. Avoid fields with a history of the disease. Rotate to non-solanaceous, non-cucurbit crops for >6 years. Use raised beds and mulch to improve drainage and reduce splashing. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Okra - Insects

Major update by Laura Ingwell, Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Admire Pro (imidacloprid) | 1.3-2.2 fl. oz. per acre foliar application, 7-14 fl. oz. per acre soil application. REI: 12-hour. PHI: 0-day for foliar applications, 21-day for soil applications. IRAC 04A.

Assail 30SG (acetamiprid) | 2.0-4.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Beleaf (flonicamid) | 2.8-4.28 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Malathion 5EC (malathion) | Use 5EC and 57EC formulations at 1.5-1.9 pts. per acre. REI: 12-hour. PHI: 1-day. IRAC 01B.

Movento (spirotetramat) | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 23.

PQZ (pyrifluquinazon) | 2.4-3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 09B.

Pyganic EC 5.0 II (pyrethrins) | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sefina Inscalis (afidopyropen) | 3 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 09D.

Sequoia (sulfoxaflor) | 1.5-2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 04C.

Sivanto 200 (flupyradifurone) | 7-12 fl. oz. per acre foliar application, or 21-28 fl. oz. per acre soil application. REI: 4-hour. PHI: 1-day for foliar application, or 45-day for soil application. IRAC 04D.

Torac (tolfenpyrad) | 17-21 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A, FRAC 39.

Transform WG (sulfoxaflor) | Use Transform WG at 0.75-1.0 oz. per acre. Use Sequoia at 1.5-2 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 04C.

Caterpillars

There are many caterpillar pests of fruiting vegetables, including corn earworm/tomato fruitworm, tomato hornworm, tomato pinworm, European corn borer, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Pesticide

Brigade 2EC (bifenthrin) | For armyworms, fruitworms, and loopers. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for okra. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Bt (Bacillus thuringiensis) products for caterpillars (Bacillus thuringiensis aizawai strain ABTS-1857, Bacillus thuringiensis aizawai strain GC-91, Bacillus thuringiensis kurstaki strain ABTS-351, Bacillus thuringiensis kurstaki strain EVB-113-19, Bacillus thuringiensis kurstaki strain SA-11) | For armyworms, fruitworms, and loopers. Various Bt products (Agree, Biobit, Dipel, Javelin, etc.) are available for control of young caterpillars however, different Bt products can vary in the effectiveness against caterpillars. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Coragen (chlorantraniliprole) | 3.5-7.5 fl. oz. per acre. For armyworms, fruitworms, and loopers. Can be applied as either a foliar application or via drip chemigation. Chemigation will provide up to 30 days of control. REI: 4-hour. PHI: 1-day. IRAC 28.

Entrust SC (spinosad) | For armyworms, fruitworms, and loopers. Use 2SC formulations at 1.5-8.0 fl. oz. per acre. Use 80WP formulations at 0.5-2.5 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) | 7-13.5 fl. oz. per acre. For armyworms, fruitworms, and loopers. REI: 12-hour. PHI: 1-day. IRAC 28.

Harvanta (cyclaniliprole) | 10.9-16.4 fl. oz. per acre. For armyworms, fruitworms, and loopers. Use with adjuvant. REI: 4-hour. PHI: 1-day. IRAC 28.

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. For armyworms, fruitworms, and loopers. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Proclaim (emamectin benzoate) | 2.4-4.8 oz. per acre. For armyworms, fruitworms, and loopers. REI: 12-hour. PHI: 1-day. IRAC 06. *RUP.*

Pyganic EC 5.0 II (pyrethrins) | For armyworms, corn earworms, and fruitworms. *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Radiant 1SC (spinetoram) | 5-10 fl. oz. per acre. For armyworms, fruitworms, and loopers. REI: 4-hour. PHI: 1-day. IRAC 05.

Rimon 0.83EC (novaluron) | 9-12 fl. oz. per acre. For armyworms, fruitworms, and loopers. Apply when majority of population is at egg hatch to second instar. REI: 12-hour. PHI: 1-day. IRAC 15.

Sevin XLR Plus (carbaryl) | 1.0-1.5 qts. per acre. For fruitworms. REI: 12-hour. PHI: 3-day. IRAC 01A.

Japanese Beetle

Japanese beetles emerge in mid June in our region. Traps are not useful in controlling beetles and should be avoided in production areas.

Non-Pesticide

In small plantings, hand removal can be effective.

Pesticide

Brigade 2EC (bifenthrin) | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for okra. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

EverGreen Pro 60-6 (piperonyl butoxide, pyrethrins) | 2-12.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC UN, IRAC 03A.

Malathion 5EC (malathion) | Use 5EC and 57EC formulations at 1.5-1.9 pts. per acre. REI: 12-hour. PHI: 1-day. IRAC 01B.

Pyganic EC 5.0 II (pyrethrins) | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Mites

Mite populations spike in hot dry weather. Damage appears as white flecks on leaves, accompanied by webbing. Selective chemistries (e.g. abamectin, bifenazate, etoxazole, cyflumetofen, fenpyroximate, hexythiazox, spiromesifen) that target mites help to preserve natural enemies.

Non-Pesticide

Preserve and encourage natural enemies.

Pesticide

Acramite 50WS (bifenazate) | 0.75-1.0 lb. per acre. REI: 12-hour. PHI: 3-day. IRAC 20D.

Agri-Mek SC (abamectin) | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15SC formulations at 8-16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 06. *RUP.*

Magister SC (fenazaquin) | 24-36 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 21A, FRAC 39.

Onager Optek (hexythiazox) | 12-24 fl. oz. per acre. REI: 12-hour. PHI: 1-day IRAC 10A.

Portal (fenpyroximate) | 2 pints per acre. REI: 12-hour. PHI: 1-day. IRAC 21A.

Pyganic EC 5.0 II (pyrethrins) | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Zeal (etoxazole) | 2-3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 10B.

Stink Bugs

Pesticide

Brigade 2EC (bifenthrin) | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for okra. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Pyganic EC 5.0 II (pyrethrins) | *Foliar applications*: 4.5-15.6 fl. oz. per acre. *Soil drench applications* (in greenhouses): 0.375 fl. oz. per 1,000 sq. ft. of growing media/soil. REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sevin XLR Plus (carbaryl) | 1.0-1.5 qts. per acre. REI: 12-hour. PHI: 3-day. IRAC 01A.

Okra - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Okra is a warm-season crop that is nearly always started with transplants in Northern climates.

Postemergence herbicides for broadleaf weeds are limited, so it is important to include preemergence herbicides and mechanical control in the weed management plan. There are several herbicides labeled for the control of weeds preemergence, applied before crops are transplanted, or directed between the rows only after transplanting.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. Okra can benefit from the soil warming properties of plastic mulch in addition to the in-row weed control it provides. Materials include landscape cloth/fabric, plastic, and biodegradable plastic. Straw mulch can delay growth by suppressing soil temperatures. Weeds between beds and along the edges of beds can be controlled with a combination of cultivation, mowing, or hand hoeing/pulling. Weeds along the edge of the mulches can be a particular challenge to avoid ripping the mulch. Some fresh market plantings are often small enough to accommodate hand-hoeing or pulling. For larger plantings it may make more sense to mechanically cultivate with tow-able tools between plastic rows or between bare-soil rows.

Pesticide

Aim EC (carfentrazone) POST | 0.5-2.0 fl. oz. per acre. Apply prior to transplanting or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. HRAC 14.

Callisto (mesotrione) POST | PRE | 6 fl. oz. per acre. Band to row middles prior to weed emergence. Leave 1 foot over row or 6 inches on each side of row unsprayed. Do not apply directly over the planted okra row or severe injury may occur. Injury risk is greatest on coarse-textured soils (sand, sandy loam, or loamy sands). A postemergence hooded application can be made at 3 oz. per acre when okra is at least 3 inches tall at time of application. Add 0.25% NIS v/v to spray solution. Avoid any contact with okra plant foliage. Do not exceed 1 application and 6 oz. per acre per year. REI: 12-hour. PHI: 28-day. HRAC 27.

Caparol 4L (prometryn) POST | PRE | 1.5 pts. per acre. Apply as a post-directed spray when okra has 7-9 leaves and weeds are less than 2 inches tall. Do not exceed 3 pts. per acre per year. REI: 12-hour. PHI: 14-day. HRAC 05.

Dual Magnum (s-metolachlor) PRE | 1-2 pts. per acre. *Special 24c label only.* Apply to okra at least 4 inches tall before weeds emerge. Direct the spray to minimize contact with crop foliage, or apply only between crop rows. Do not incorporate. Do not exceed 2 pts. per acre or 1 application per crop per season. REI: 24-hour. PHI: 60-day. HRAC 15.

glyphosate products (glyphosate) POST | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast at least 3 days before transplanting, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. Remove herbicide residue from plastic mulch prior to transplanting. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

Poast (sethoxydim) POST | 1.0-1.5 pts. per acre. Use COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5.5 pts. per acre per season. REI: 12-hour. PHI: 14-day. HRAC 01.

Sandea (halosulfuron) POST | PRE | 0.5-1.0 oz. per acre. Apply between rows of transplanted crop. Use lower rates on coarse soils with low organic matter. Add 0.5-1.0 pt. of NIS per 25 gals. of spray solution if emerged weeds are

present. Avoid contact of the herbicide with the crop. Avoid contact with surface of plastic mulch if present. *Effective against nutsedge.* Do not exceed 2 oz. per acre per 12-month period. REI: 12-hour. PHI: 30-day. HRAC 02.

Sulfen 4SC (sulfentrazone) PRE | 3-12 fl. oz. per acre. Apply prior to transplanting. Do not exceed 12 fl. oz. per acre, and do apply more than 12 fl. oz. per acre per year. Do not apply to sand or soils with less than 1% organic matter. REI: 12-hour. HRAC 14.

trifluralin products (trifluralin) PRE | Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting. Not effective on muck or high organic matter soils. REI: 12-hour. HRAC 03.

Onions and Related Crops - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Ben Phillips – Mar 2022

Crop Description

Garlic (*Allium sativum*): There are two main types of garlic: softneck and hardneck. Hardneck types overwinter better in the Midwest, have a stronger flavor, and are easier to peel. Softneck types have a longer shelf-life, milder flavor, and smaller cloves. Elephant or great headed garlic (*A. ampeloprasum*) is grown like other garlic, but has a milder flavor.

Leek (*A. porrum*): Leeks do not bulb, but form a straight shank of layered leaves that stay white when buried with soil. They can be planted deeply and hilled to increase the length of the shank. There are nonhardy summer-harvested varieties and frost-tolerant fall-harvest varieties.

Onion (*A. cepa* var. *cepa*): Bulb onions include yellow, red, and white-skinned types, and within each of the colors, there are sweet varieties and pungent storage varieties. Bulb onions are categorized as long-day, intermediate-day, or short-day based on the day-length that stimulates bulbing. Long-day varieties grow best in the Midwest. Some intermediate-day onions can also do well in the Midwest. Sweet onions contain more sugar, and do not keep as well as pungent storage onions. Any onion variety can also be used as a green onion, but *A. fistulosum* is a species that is commonly used for bunching that does not make a large bulb.

Shallot (*A. cepa* var. *aggregatum* or *A. ascalonicum*): Shallots form clusters of bulbs and are very winter hardy, like garlic. The torpedo-shaped bulbs are smaller than onions and have a milder flavor.

Planting and Spacing

Garlic: Plant in fall 6 to 8 weeks before ground freezes in rows 12 to 36 inches apart with cloves 3 to 6 inches apart in the row. Plant bulbs 3 to 4 inches deep, with top of clove twice the depth of the clove height. Garlic benefits from 2 to 4 inches of straw mulch applied over winter, which can be left on the rows until harvest. For mechanical cultivation, plant flat side of clove perpendicular to the length of the row; for hand cultivation in dense plantings, plant angled side of clove parallel to the length of the row. Remove flower stalks for maximum yield.

Leek: Seed or transplant outdoors about a month before the frost-free date in rows 14 to 18 inches apart with plants 3 to 4 inches apart in the row. Transplants can be started 10 to 15 weeks before planting. Place transplants 4 to 8 inches deep and backfill soil, or hill throughout the season to maintain a long white shank.

Onion: Seed or transplant outdoors about a month before the frost-free date, or as early as soil can be worked on raised beds with two double rows or wide rows spaced 14 inches apart on top of the bed with 12 seeds per foot, or 3 to 4 transplants per foot. A popular transplanting method on farms that are hand-weeded is to plant onions in groups of four that grow up and out as a clover shape. Transplants may also be planted into plastic-mulch covered beds. When seeding, use 4 pounds per acre of onion seed and consider broadcasting 1 bushel of oats or barley per acre overtop as a nurse crop that can protect young onions from sandblasting and hard frosts. Kill the barley or oats when they are 5 to 6 inches tall with a graminicide. Young onions can withstand several overnight lows in the 23 F to 32 F range, but survivability is less if it is also windy.

Shallots: Seed in the spring like onions with similar row spacing, or transplant bulbs in the fall like garlic with similar row spacings. However, if fall planted, remove mulch in the spring before emergence. Shallot leaves are hollow and are easy to bend and crimp by the movement of straw mulch once they emerge. Transplanting young plants from a greenhouse in the early spring will yield bulbs along the same timeline as garlic.

Fertilizing

pH: Maintain a soil pH of 6.0 to 6.8 on mineral soils, and above 5.2 on muck soils.

Garlic, Shallot–fall-planted: Before planting, apply 25 pounds N per acre, up to 150 pounds P_2O_5 per acre, and up to 100 pounds K_2O per acre based on soil test results and recommendations from your state.

Sidedress in 20- to 40-pound increments of N per acre in 3-week intervals, ending 4 to 6 weeks before harvest. The total amount of N from fertilizer (including starter) and other credits should be 70 to 125 pounds N per acre.

Onion, Leek, Shallot–spring-planted: Before planting, apply 70 pounds N per acre, 0 to 250 pounds P_2O_5 per acre, and 0 to 250 pounds K_2O per acre based on soil test results

and recommendations from your state. Or, broadcast half the N and most of the K_2O before planting, and at planting time band the remaining N, all of the P_2O_5, and up to 20 pounds of K_2O at least 2 inches below and 2 inches to the side of the row. If indicated by soil test, include manganese, copper and zinc in band, or broadcast.

If planting on organic (muck) soils with a pH over 6.0, include 1 pound manganese sulfate per 1,000 feet of row in the starter band (2 pounds actual manganese per acre), and/or apply 1 to 2 pounds manganese sulfate per acre as a foliar spray 2 to 3 times starting 3 weeks after emergence.

Sidedress bulb onions with 90 to 100 pounds N per acre in mid-June or split that amount between early and late June. Sidedress green onions and leeks with 40 to 50 pounds of N per acre when the plants have four true leaves. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer (including starter) and other credits should be 190, 150, or 130 pounds N per acre for bulb onions, leeks, or green onions, respectively, on mineral soils, and 50 pounds less on muck soils.

Harvesting

Garlic and Shallot: Harvest when tops have fallen over and partially dried. Lift from soil and dry protected from sun and rain. After drying, trim roots and remove tops, or leave softneck garlic tops on for braiding.

Onion, bulb: Harvest pungent storage-type bulb onions after tops have naturally fallen over, and tops are dried. To prevent sprouting of bulb onions in storage, use maleic hydrazide (Royal MH-30) according to label directions, when bulbs are fully mature and 50% of tops have fallen over but all tops are still green. Rolling leaves and undercutting several days before harvest can hasten dormancy and improve keeping quality of storage onions. Dig from soil and dry in field or indoors at 75 F to 80 F and 70% to 80% relative humidity. Cut tops about 1 inch from bulb at harvest or after drying, or braid tops and hang onions to dry. Clean dry onions by gently brushing. Time from seeding to harvest ranges from 100 to 125 days for pungent storage types.

Harvest sweet onions at the desired size any time. However, they become more pungent as they go into dormancy, and do not store as well as true storage-types. Time from transplanting to harvest of sweet onions ranges from 60 to 80 days for cipollini or pearl-sized onions, or 90 to 115 days for larger sizes.

Onion, green: Harvest by pulling from soil after bulb base is thicker than a pencil but before bulbing. Optional undercutting can be used to make pulling easier. Remove dirty outer layer from bulb area. Trim roots. Trim tops as needed if allowed by state regulations. Green onions are usually sold in bunches. Harvest small “knob” onions by pulling from soil when bulb has reached desired stage of development, following the same practices as for green onions. Time from seeding to harvest ranges from 60 to 70 days.

Leek: Harvest when stalk is 1 inch or more in diameter. Undercut plants, pull from soil, trim, and bunch. The wide range of maturity times is variety-dependent. Some can withstand heavy freezes and mature late into the fall, while others are not as frost-hardy and mature earlier for summer harvests. Time from seeding to harvest ranges from 70 to 120 days.

Onions and Related Crops - Diseases

Reviewed by Dan Egel, Mary Hausbeck – Aug 2023

Basal Rot of Alliums - Fusarium Fungus

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Avoid fields with a history of the disease and excess water. Rotate to non-host crops for 4 years. Resistant varieties are available. Managing soil insect pests, like Onion Maggot, may reduce disease incidence.

Black Mold of Onions - Aspergillus Fungus

Development is favored by high temperatures. Most losses occur in storage. Pathogen may be seed-borne, however, the pathogen is widespread in many soils.

Non-Pesticide

Garlic, Onion (Dry), Shallot | Store and transport bulbs at temperatures below 59 F and at low humidity to slow growth of the fungus. Avoid injury to bulbs during harvest, handling, and transport. Harvest onions promptly at maturity. Wide temperature fluctuations can cause condensation on the bulbs which promotes the development of black mold.

Bulb Rot of Alliums - Pseudomonas Bacteria

Pesticide

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2.25 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Use disease-free seeds and sets. Practice good greenhouse sanitation of equipment, tools propagation trays/pots, and surfaces. Avoid excess moisture to the transplants in the greenhouse by monitoring irrigation frequency. Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Pesticide

azoxystrobin products (azoxystrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 0.24-0.48 fl. oz. per 1,000 row feet. Use 22.9% formulations at 0.4-0.8 fl. oz. per 1,000 row feet. Use 18.4% formulations at 0.5-1.0 fl. oz. per 1000 row feet. Use 9.6% formulations (Dynasty) for seed treatment at 0.10-0.38 fl. oz. per 100 lbs. of seed. Use 50% formulations (Heritage) on greenhouse transplants only at 0.11-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

mefenoxam/metalaxyl products (mefenoxam) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations (Apron, MetaStar, Ridomil Gold, Ultra Flourish, Subdue Maxx, and Xyler) are labeled. Several formulations are labeled as pre-plant incorporated or surface broadcast and banded applications at various rates between 0.5 pt. and 4 pt. per acre. A 33.3% seed treatment formulation can be used at 0.32-0.64 fl. oz. per 100 lb. of seed. A 22% formulation can be used at 10.9-21.7ml. per 1000 sq. ft. *for transplants grown for retail sale to consumers*. REI: 48-hour. PHI: 0-day. FRAC 04.

Uniform (mefenoxam, azoxystrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 0.34 fl. oz. per 1,000 ft. Make one application per crop season. REI: 0-hour. PHI: 0-day. FRAC 04, FRAC 11.

Downy Mildew of Multiple Crops - Peronospora Oomycete

Cool, wet conditions favor the development of this disease. Can be seedborne or setborne.

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Use disease-free seed and sets. Plant in areas with adequate drainage and air movement to reduce leaf wetness and humidity. Rotate to non-host crop for 3 years. Some resistant varieties of onion are available. Avoid late-season fertilizer applications or overhead irrigation. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Destroy onion cull piles and debris.

Pesticide

Catamaran (potassium phosphite, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 4-7 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallot and garlic; 14-day for green bunching onion and leek. FRAC P07, FRAC M05.

Cymbol Advance (chlorothalonil, cymoxanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 1.6-2.4 pts. per acre. Use lower rates for dry bulb onions and garlic. Other formulations are available such as Ariston. REI: 12-hour. PHI: 7-day for dry bulb onions, and garlic; 14-day for green bunching onions, shallots, leeks. FRAC M05, FRAC 27.

Dexter Max (mancozeb, azoxystrobin) *Garlic, Onion (Dry), Shallot* | 3.2 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03, FRAC 11.

Dexter Xcel (mancozeb, azoxystrobin, tebuconazole) *Onion (Dry)* | 56-72 fl. oz. per acre. REI: See label. PHI: 7-day. FRAC M03, FRAC 11, FRAC 03.

Forum (dimethomorph) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 40.

Gavel 75DF (zoxamide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC 22, FRAC M03.

mancozeb products (mancozeb) *Garlic, Onion (Dry), Shallot* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Omega 500F (fluazinam) *Garlic, Onion (Dry), Shallot* | 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 29.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Garlic, Onion (Dry)* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 7-day. FRAC 49, FRAC M05.

Orondis Ultra (oxathiapiprolin, mandipropamid) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 5.8-8.0 pts. per acre. REI: 4-hour. PHI: 7-day. FRAC 49, FRAC 40.

Reason 500SC (fenamidone) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Revus (mandipropamid) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8 fl. oz. per acre. REI: 4-hour. PHI: 7-day. FRAC 40.

Ridomil Gold Bravo SC (mefenoxam, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2.5 pts. per acre. REI: 48-hour. PHI: 7-day for dry bulb onions, shallots, and garlic; 14-day for green bunching onions and leek. FRAC 04, FRAC M05.

Ridomil Gold Copper (mefenoxam, copper hydroxide) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2 lbs. per acre. REI: 48-hour. PHI: 7-day for green bunching onions, shallots, and leeks; 10-day for dry bulb onions and garlic. FRAC 04, FRAC M01.

Ridomil Gold MZ WG (mefenoxam, mancozeb) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC 04, FRAC M03.

Viathon (potassium phosphite, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2-3 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC P07, FRAC 03.

Zampro (ametoctradin, dimethomorph) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 45, FRAC 40.

Leaf Blight and Center Rot of Alliums - Pantoea Bacteria

Applying fixed copper products may reduce the spread of these bacterial diseases. For emerged annuals, apply before planting or crop emergence.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may slow the spread of bacterial blights. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2.25 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Leaf Blight and Stalk Rot of Onions - Stemphylium Fungus

Stemphylium causes leaf blight and stalk rot but rarely affects the bulb. Long warm periods with leaf wetness favor disease development. Many growers have local populations of the pathogen that are resistant to strobilurin fungicides (FRAC 11).

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Onion (Dry), Onion (Green)* | 10.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 07.

Cabrio EG (pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8-12 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Fontelis (penthiopyrad) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

Inspire Super (difenoconazole, cyprodinil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day for dry bulb onions, shallots, and garlic; 14-day for green bunching onion and leek. FRAC 03, FRAC 09.

Luna Experience (fluopyram, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Tranquility (fluopyram, pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

Merivon (fluxapyroxad, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 5.5-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Pristine 38WG (boscalid, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 10.5-18.5 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Switch 62.5WG (cyprodinil, fludioxonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 11-14 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Leaf Blight of Alliums - Botrytis Fungus

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Use disease-free seeds and sets. Rotate to non-host crops for 3-4 years. Monitor thrips populations. Prompt destruction of the finished crop and cull piles with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 5.8-9.7 fl. oz. per acre. Use 22.9% formulations at 9.0-15.5 fl. oz. per acre. Use 18.4% formulations at 11.3-19.5 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.11-0.18 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 12 oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.5-4.25 pt. per acre. Use 54% (720) formulations at 1-3 pt. per acre. Use 82.5% (WDG) formulations at 0.9-2.7 lb. per acre. Use 90% (DF) formulations at 1.25-2.5 lb. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallot, and garlic; 14-day for green bunching onion and leek. FRAC M05.

Custodia (azoxystrobin, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 12.9 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 03.

Dexter Max (mancozeb, azoxystrobin) *Garlic, Onion (Dry), Shallot* | 3.2 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03, FRAC 11.

Dexter Xcel (mancozeb, azoxystrobin, tebuconazole) *Onion (Dry)* | 56-72 fl. oz. per acre. REI: See label. PHI: 7-day. FRAC M03, FRAC 11, FRAC 03.

Endura (boscalid) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 6.8 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07.

Fontelis (penthiopyrad) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

Gavel 75DF (zoxamide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC 22, FRAC M03.

Inspire Super (difenoconazole, cyprodinil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day for dry bulb onions, shallots, and garlic; 14-day for green bunching onion and leek. FRAC 03, FRAC 09.

iprodione products (iprodione) *Onion (Dry)* | 1.5 pts. per are. Formulations of iprodione include Nevado and Rovral. See label for tank mix rates. REI: 24-hour. PHI: 14-day. FRAC 02.

Luna Experience (fluopyram, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8-12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Tranquility (fluopyram, pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

mancozeb products (mancozeb) *Garlic, Onion (Dry), Shallot* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Merivon (fluxapyroxad, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Omega 500F (fluazinam) *Garlic, Onion (Dry), Shallot* | 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 29.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Garlic, Onion (Dry)* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 7-day. FRAC 49, FRAC M05.

Pristine 38WG (boscalid, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 14.5-18.5 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2-8 fl. oz. per acre. PropiMax EC and Tilt are labeled. Use 2-4 fl. oz. per acre rate when tank mixing with another effective fungicide. REI: 12-hour. PHI: 14-day for dry bulb onions, shallots, and garlic; 0-day for green bunching onion and leek. FRAC 03.

Quadris Opti (azoxystrobin, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 1.6-3.2 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallots, and garlic; 14-day for green bunching onions and leeks. FRAC 11, FRAC M05.

Quilt (azoxystrobin, propiconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 14-27.5 fl. oz. per acre. REI: 12-hour. PHI: 14-day for dry bulb onions, shallots, and garlic; 0-day for green bunching onions and leeks FRAC 11, FRAC 03.

Ridomil Gold Bravo SC (mefenoxam, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2.5 pts. per acre. REI: 48-hour. PHI: 7-day for dry bulb onions, shallots, and garlic; 14-day for green bunching onions and leek. FRAC 04, FRAC M05.

Scala (pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 18 fl. oz. per acre. Use 9-18 fl. oz. per acre rate when tank mixing with another effective fungicide. REI: 12-hour. PHI: 7-day. FRAC 09.

Switch 62.5WG (cyprodinil, fludioxonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 11-14 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Vangard WG (cyprodinil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 10 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09.

Zing! (zoxamide, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 30 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 22, FRAC M05.

Leaf Blight of Alliums - Xanthomonas Bacteria

Applying fixed copper products may reduce the spread of these bacterial diseases. For emerged annuals, apply before planting or crop emergence.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Garlic, Leek, Onion*

(Dry), Onion (Green), Shallot | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may slow the spread of bacterial blights. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2.25 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Leaf Streak of Alliums - Pseudomonas Bacteria

Applying fixed copper products may reduce the spread of these bacterial diseases. For emerged annuals, apply before planting or crop emergence.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may slow the spread of bacterial blights. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2.25 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Neck Rot of Alliums - Botrytis Fungus

Treatments for Botrytis leaf blight may retard or prevent symptomless spread of Botrytis neck rot in the field prior to harvest.

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Rotate to non-host crop for 3 years. Avoid late-season fertilizer applications or overhead irrigation. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. For dry-bulb crops: windrow plants until neck tissues are dry before topping and storage. Cure rapidly and properly. Artificial drying may be necessary (forced heated air at 93 to 95 F for 5 days).

Pesticide

chlorothalonil products (chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.5-4.25 pt. per acre. Use 54% (720) formulations at 1-3 pt. per acre. Use 82.5% (WDG) formulations at 0.9-2.7 lb. per acre. Use 90% (DF) formulations at 1.25-2.5 lb. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallot, and garlic; 14-day for green bunching onion and leek. FRAC M05.

Dexter Max (mancozeb, azoxystrobin) *Garlic, Onion (Dry), Shallot* | 3.2 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03, FRAC 11.

Dexter Xcel (mancozeb, azoxystrobin, tebuconazole) *Onion (Dry)* | 48-72 fl. oz. per acre. REI: See label. PHI: 7-day. FRAC M03, FRAC 11, FRAC 03.

Fontelis (penthiopyrad) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

Gavel 75DF (zoxamide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC 22, FRAC M03.

iprodione products (iprodione) *Onion (Dry)* | 1.5 pts. per are. Formulations of iprodione include Nevado and Rovral. See label for tank mix rates. REI: 24-hour. PHI: 14-day. FRAC 02.

Luna Experience (fluopyram, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8-12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Tranquility (fluopyram, pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

mancozeb products (mancozeb) *Garlic, Onion (Dry), Shallot* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Merivon (fluxapyroxad, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Omega 500F (fluazinam) *Garlic, Onion (Dry), Shallot* | 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 29.

Pristine 38WG (boscalid, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 14.5-18.5 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 1.6-3.2 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallots, and garlic; 14-day for green bunching onions and leeks. FRAC 11, FRAC M05.

Scala (pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 18 fl. oz. per acre. Use 9-18 fl. oz. per acre rate when tank mixing with another effective fungicide. REI: 12-hour. PHI: 7-day. FRAC 09.

Switch 62.5WG (cyprodinil, fludioxonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 11-14 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Vangard WG (cyprodinil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 10 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09.

Zing! (zoxamide, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 30 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 22, FRAC M05.

Purple Blotch of Alliums - Alternaria Fungus

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Use disease-free seeds and sets. Rotate to non-host crops for 3-4 years. Monitor thrips populations. Prompt destruction of the finished crop and cull piles with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aprovia Top (difenoconazole, benzovindiflupyr) *Onion (Dry), Onion (Green)* | 10.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03, FRAC 07.

azoxystrobin products (azoxystrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-7.8 fl. oz. per acre. Use 22.9% formulations at 6.0-12.0 fl. oz. per acre. Use 18.4% formulations at 7.6-15.1 fl. oz. per acre. Use 50% formulations (Heritage) on greenhouse transplants only at 0.08-0.15 oz. per 1,000 sq. ft. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8-12 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Catamaran (potassium phosphite, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 4-7 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallot and garlic; 14-day for green bunching onion and leek. FRAC P07, FRAC M05.

chlorothalonil products (chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.5-4.25 pt. per acre. Use 54% (720) formulations at 1-3 pt. per acre. Use 82.5% (WDG) formulations at 0.9-2.7 lb. per acre. Use 90% (DF) formulations at 1.25-2.5 lb. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallot, and garlic; 14-day for green bunching onion and leek. FRAC M05.

Custodia (azoxystrobin, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8.6-12.9 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 03.

Cymbol Advance (chlorothalonil, cymoxanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 1.6-2.4 pts. per acre. Use lower rates for dry bulb onions and garlic. Other formulations are available such as Ariston. REI: 12-hour. PHI: 7-day for dry bulb onions, and garlic; 14-day for green bunching onions, shallots, leeks. FRAC M05, FRAC 27.

Dexter Max (mancozeb, azoxystrobin) *Garlic, Onion (Dry), Shallot* | 3.2 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03, FRAC 11.

Dexter Xcel (mancozeb, azoxystrobin, tebuconazole) *Onion (Dry)* | 48-72 fl. oz. per acre. REI: See label. PHI: 7-day. FRAC M03, FRAC 11, FRAC 03.

Fontelis (penthiopyrad) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 07.

Gavel 75DF (zoxamide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC 22, FRAC M03.

Inspire Super (difenoconazole, cyprodinil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day for dry bulb onions, shallots, and

garlic; 14-day for green bunching onion and leek. FRAC 03, FRAC 09.

iprodione products (iprodione) *Onion (Dry)* | 1.5 pts. per are. Formulations of iprodione include Nevado and Rovral. See label for tank mix rates. REI: 24-hour. PHI: 14-day. FRAC 02.

Luna Experience (fluopyram, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8-12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Tranquility (fluopyram, pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

mancozeb products (mancozeb) *Garlic, Onion (Dry), Shallot* | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 1.6-2.4 qt. per acre. Use 75% and 80% formulations at 2-3 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Merivon (fluxapyroxad, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 5.5-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Muscle ADV (chlorothalonil, tebuconazole) *Garlic, Onion (Dry), Shallot* | 1.1-1.6 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC M05, FRAC 03.

Omega 500F (fluazinam) *Garlic, Onion (Dry), Shallot* | 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 29.

Orondis Opti (oxathiapiprolin, chlorothalonil) *Garlic, Onion (Dry)* | 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 7-day. FRAC 49, FRAC M05.

Pristine 38WG (boscalid, pyraclostrobin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 10.5-18.5 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2-8 fl. oz. per acre. PropiMax EC and Tilt are labeled. Use 2-4 fl. oz. per acre rate when tank mixing with another effective fungicide. REI: 12-hour. PHI: 14-day for dry bulb onions, shallots, and garlic; 0-day for green bunching onion and leek. FRAC 03.

Quadris Opti (azoxystrobin, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 1.6-3.2 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb onion, shallots, and garlic; 14-day for green bunching onions and leeks. FRAC 11, FRAC M05.

Quilt (azoxystrobin, propiconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 14-27.5 fl. oz. per acre. REI: 12-hour. PHI: 14-day for dry bulb onions, shallots, and garlic; 0-day for green bunching onions and leeks FRAC 11, FRAC 03.

Reason 500SC (fenamidone) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Ridomil Gold Bravo SC (mefenoxam, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2.5 pts. per acre. REI: 48-hour. PHI: 7-day for dry bulb onions, shallots, and garlic; 14-day for green bunching onions and leek. FRAC 04, FRAC M05.

Scala (pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 18 fl. oz. per acre. Use 9-18 fl. oz. per acre rate when tank mixing with another effective fungicide. REI: 12-hour. PHI: 7-day. FRAC 09.

Switch 62.5WG (cyprodinil, fludioxonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 11-14 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Tanos (famoxadone, cymoxanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 8 oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11, FRAC 27.

tebuconazole products (tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 4-6 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI: 12-hour to 18-day. PHI: 7-day FRAC 03.

Vangard WG (cyprodinil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 10 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09.

Viathon (potassium phosphite, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2-3 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC P07, FRAC 03.

Zing! (zoxamide, chlorothalonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 30 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 22, FRAC M05.

Slippery Skin and Sour Rot of Alliums - Burkholderia Bacteria

Applying fixed copper products may reduce the spread of these bacterial diseases. For emerged annuals, apply before planting or crop emergence.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may slow the spread of bacterial blights. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

ManKocide (copper hydroxide, mancozeb) *Garlic, Onion (Dry), Shallot* | 1.5-2.25 lbs. per acre. REI: 48-hour. PHI: 7-day. FRAC M01, FRAC M03.

Smut of Onion - Urocystis Fungus

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Use disease-free seed and sets. Plant in areas with adequate drainage and air movement to reduce leaf wetness and humidity. Rotate to non-host crop for 3 years. Avoid late-season fertilizer applications or overhead irrigation.

Pesticide

Elixir (mancozeb, chlorothalonil) *Garlic, Onion (Dry), Shallot* | 3-3.6 lbs. per acre. REI: 24-hour. PHI: 7-day. FRAC M03, FRAC M05.

mancozeb products (mancozeb) *Garlic, Onion (Dry), Shallot* | Apply as an in-furrow drench at time of seedling. Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 2.4 qt. per acre. Use 75% and 80% formulations at 3 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

White Rot of Alliums - Stromatinia Fungus

This highly destructive soil pathogen is related to White Mold (*Sclerotinia*), but only infects onions and related species. There are quarantines in effect to slow its spread from region to region.

The fungus infects roots, and then moves to the surface of the bulbs. Inspection of the bulbs will reveal small black pellets that are the overwintering body of the pathogen.

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Wash equipment and footwear between fields to avoid transferring fungal propagules from infested fields.

Pesticide

Custodia (azoxystrobin, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Apply foliar spray at 8.6-12.9 fl. oz. per acre. For dry bulb onion and garlic, one application is also allowed at planting with 32 fl. oz. per acre via in-furrow or chemigation. REI: 12-hour. PHI: 14-day for dry bulb onions, shallots, and garlic; 7-day for green bunching onions and leeks, FRAC 11, FRAC 03.

Fontelis (penthiopyrad) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Apply 1.2-1.6 fl. oz. per 1,000 ft. of row as pre-plant, at-plant in-furrow incorporated, transplant drench or drip irrigation application. Or, use 16-24 fl. oz. as foliar applications REI: 12-hour. PHI: 3-day. FRAC 07.

iprodione products (iprodione) *Garlic* | 4 pts. per acre. Formulations of iprodione include Nevado and Rovral. Use as in-furrow spray preplant. REI: 24-hour. PHI: 7-day. FRAC 02.

Luna Experience (fluopyram, tebuconazole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 12.8 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 03.

Luna Tranquility (fluopyram, pyrimethanil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 27 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

Switch 62.5WG (cyprodinil, fludioxonil) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 11-14 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Topsin 4.5FL (thiophanate-methyl) *Garlic, Onion (Dry)* | Use 4FL formulation or Cercobin at 40 fl. oz. per acre, or 70WSB formulation at 2 lb. per acre. REI: 24-hour to 3-day. PHI: 3-day. FRAC 01.

Onions and Related Crops - Insects

Major update by Marissa Schuh, Ashley Leach – Apr 2025
Reviewed by Raymond Cloyd – Aug 2024

Seed and Root Maggots

Onion maggots are the root maggot of concern in our region. Seed treatments are the best option. Foliar applications of pyrethroids are only partially effective, and require careful timing. Degree day models available to time planting and insecticide application timing.

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Plant after the peak flight and egg-laying window of the first generation of flies looking to lay eggs around 700 GDD base 40. Handle seeds carefully to prevent cracking. Plow winter vegetation under early in the spring and thoroughly cover to limit attractiveness of rotting vegetation to the first generation of flies to lay eggs on. Prompt reduction of crop residues can limit development of populations. Rotate in distance by at least 1 mile from previous year's onions.

Pesticide

Diazinon AG500 (diazinon) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2-4 qts. per acre. Use 50W formulations at 4-8 lbs. per acre as a pre-plant incorporation. Use AG500 formulations at 64-128 fl. oz. per acre as a pre-plant incorporation. Use AG600 formulations at 51-102 fl. oz. per acre as a pre-plant incorporation. Onion maggot exhibit resistance to diazinon. REI: 2 to 4-day. IRAC 01B. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 2.24-4.0 fl. oz. per acre. *For adult control only.* Add COC at 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) *Garlic, Onion (Dry)* | *For adult control only*. Use 25W, 25WP, and 25DF formulations at 9.6-19.2 oz. per acre for dry onion or 9.6-12.8 oz. per acre for garlic. Use 3.2EC formulations at 4-12 fl. oz. per acre for dry onion and 4-8 fl. oz. per acre for garlic. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Seed treatments for insects (various ingredients) *Leek, Onion (Dry), Onion (Green), Shallot* | Rates vary by product, and are often multiple premixed ingredients, such as FarMore FI500. Select seed treatments with ingredients such as clothianidin (Sepresto), thiamethoxam (Cruiser 5FS), imidacloprid (Sepresto), or spinosad (Regard).

Warrior II (lambda-cyhalothrin) *Garlic, Onion (Dry)* | 0.96-1.6 fl. oz. per acre. *For adult control only*. REI: 24-hour. PHI: 14-day. IRAC 03A. *RUP.*

Thrips

Onion and western flower thrips are the species of concern in our area. Thrips populations spike in hot dry weather, and when neighboring small grains or alfalfa is harvested. Damage appears as white flecks on leaves. Thrips transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Selective chemistries (e.g. abamectin, spinetoram, spirotetramat, and spinosad) that target thrips help to preserve natural enemies.

Threshold for making an insecticide application is 1 thrips per leaf for Agri-Mek, Exirel, Minecto Pro, Movento, Lannate LV and 3 thrips per leaf for Radiant.

A suggested treatment schedule starts with two applications of Movento for the first two weekly applications when the thrips population reaches the treatment threshold of 1 thrips per leaf for the first time of the season. Then, rotate products with two sequential weekly applications for each, reserving Radiant for high 3 thrips per leaf thresholds in peak season.

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | A heavy rain or overhead irrigation washes thrips out of plants. Avoid planting near early harvested grain or alfalfa fields. Preserve and encourage natural enemies. Minute pirate bugs, and lacewings are common predators. Some varieties of onion tolerate thrips feeding better than other, with red onions generally suffering more damage than yellow and white onions. Preserve and encourage natural enemies.

Pesticide

Agri-Mek SC (abamectin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 1.75-3.5 fl. oz. per acre. Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15SC formulations at 8-16 fl. oz. per acre. Use at 1 thrips per leaf threshold. Make 2 consecutive applications 7-days apart, then rotate to an insecticide with a different mode of action. Do not use before or after Minecto Pro since it contains the same active ingredient. REI: 12-hour. PHI: 7-day for green onions and leeks, 30-day for dry onions, garlic and shallots. IRAC 06. *RUP.*

Assail 30SG (acetamiprid) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Use 30SG formulations at 5.0-8.0 oz. per

acre. Use 70WP formulations at 2.1-3.4 oz. per acre. Many onion thrips populations have developed resistance to this insecticide, so efficacy will vary. REI: 12-hour. PHI: 7-day. IRAC 04A.

Entrust SC (spinosad) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | Use 2SC formulations at 4.0-8.0 fl. oz. per acre. Use 80WP formulations at 1.25-2.5 oz. per acre. Observe resistance management restrictions. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 13.5-20.5 oz. per acre. Use at 1 thrips per leaf threshold. For suppression only. For best results, use highest rate listed. If thrips populations are high, use Radiant before using Exirel. Tank mix with nonionic surfactant (0.25%-0.5% v/v) for best efficacy. Allow 5 days between applications. Do not make more than 2 consecutive applications before switching to another mode of action. Therefor, do not use in sequence before or after Minecto Pro since it contains the same active ingredient. REI: 12-hour. PHI: 1-day. IRAC 28.

Lannate LV (methomyl) *Onion (Dry), Onion (Green)* | 3 pts. per acre. REI: 48-hour. PHI: 7-day. IRAC 01A. *RUP.*

Minecto Pro (cyantraniliprole, abamectin) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 7.0-10 oz. per acre. Use at 1 thrips per leaf threshold. For suppression only. For best results, use highest rate listed. *Not for rescue treatments*. Tank mix with nonionic surfactant (0.25%-0.5% v/v) for best efficacy. Allow 5 days between applications. Do not make more than 2 consecutive applications before switching to another mode of action. Do not use before or after Exirel or Agri-Mek since these contain the same active ingredients. REI: 12-hour. PHI: 30-day for dry onion, shallots, and garlic.; 7-day for green bunching onion, shallots, and leek IRAC 28, IRAC 06. *RUP.*

Movento (spirotetramat) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 5 oz. per acre. Use in June or July when populations reach the 1 thrips per leaf threshold for the first time of the season. Tank mix with nonionic surfactant (0.25%-0.5% v/v) for best efficacy. Allow 7 days between applications. Do not make more than 2 consecutive applications before switching to another mode of action. REI: 24-hour. PHI: 3-day for dry onion, shallots, and garlic.; 7-day for green bunching onion, shallots, and leek IRAC 23.

Perm-Up 25DF (permethrin) *Garlic, Onion (Dry)* | Use 25W, 25WP, and 25DF formulations at 9.6-19.2 oz. per acre for dry onion or 9.6-12.8 oz. per acre for garlic. Use 3.2EC formulations at 6-12 fl. oz. per acre for dry onion and 6-8 fl. oz. per acre for garlic. Many onion thrips populations have developed resistance to this insecticide, so efficacy may vary. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 6-10 fl. oz. per acre. Use at 3 thrips per leaf threshold. Do not make more than 2 consecutive applications before switching to another mode of action. REI: 4-hour. PHI: 1-day. IRAC 05.

Torac (tolfenpyrad) *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 24 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 21A, FRAC 39.

Warrior II (lambda-cyhalothrin) *Garlic, Onion (Dry)* | 1.28-1.92 fl. oz. per acre. Many onion thrips populations have developed resistance to this insecticide so efficacy may vary. REI: 24-hour. PHI: 14-day. IRAC 03A. *RUP.*

Onions and Related Crops - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Onions and related crops pose challenges for weed control because the narrow leaves and short height of the crop provide little shade to suppress weed growth, and, except for green onions, the crops grow for several months.

Prepare a stale seedbed several weeks in advance of planting, allow weeds to emerge, and kill weeds without bringing new weed seeds to the surface with a burndown herbicide, flame weeder, or very shallow cultivation.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Garlic, Leek, Onion (Dry), Onion (Green), Shallot | Weed control in onions often relies heavily on cultivation and hand weeding for full season weed control. These operations are most efficient when planting arrangement is designed with weed control in mind and is designed to work with available weed control equipment. Specialized weeding equipment for onions includes basket weeders, narrow-bladed hoes, finger weeders, and others. A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. Some growers also use flaming successfully over the top of young onions or garlic, or directed toward the bases of larger plants, even though some crop injury is likely with postemergence flaming. For transplanted sweet onions, plastic mulched beds are commonly used to manage weeds in the row with two or three rows of onions per bed. Black plastic can damage maturing onions in high-light conditions. For this reason, many growers prefer white-on-black plastic with the white side up.

Pesticide

Aim EC (carfentrazone) POST *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 0.5-2 fl. oz. per acre. Apply a minimum of 30 days prior to direct-seeding or with a hooded sprayer as a directed application between crop rows. Add COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. Do not allow spray to contact crop. REI: 12-hour. HRAC 14.

Chateau SW (flumioxazin) PRE *Garlic, Onion (Dry)* | For **garlic:** apply 6 oz. per acre of Chateau SW or 6 fl. oz. per acre of Chateau EZ within 3 days after planting and before garlic emerges. Do not exceed 6 oz. per acre per growing season. For **onion** *in Michigan only*: apply 2 oz. per acre of Chateau SW or 2 fl. oz. per acre of Chateau EZ to transplanted onions between the 2- and 6-leaf stage or to direct-seeded onions between the 3- and 6-leaf stage and prior to weed emergence. Do not exceed 2 oz. per acre per application or 3 oz. per acre per growing season. Will not control emerged weeds. Wait at least 14 days between repeat applications. Do not tank mix with adjuvants or other herbicides. REI: 12-hour. PHI: 45-day for dry bulb onion. HRAC 14.

clethodim products (clethodim) POST *Garlic, Onion (Dry)* | Use 2EC formulations at 6-16 fl. oz. per acre with COC (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use Select Max at 9-16 fl. oz. per acre to control annual grasses and 12-32 fl. oz. per acre to control perennial grasses. Add COC (1% v/v) or NIS (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 45-day. HRAC 01.

Dual Magnum (s-metolachlor) PRE *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | *Special 24c label only.* For **dry onion:** apply 0.67-1.33 pts. per acre prior to weed emergence and when the crop has at least 2 true leaves. A second application may be applied 21 or more days after the first. Do not exceed 1.3 pts. per acre per application and 2.6 pts. per acre per crop and two applications per crop. For **all else:** Apply 0.67-1.33 pts. per acre postemergence starting when the crop has 2 true leaves. Do not exceed 1.3 pts. per acre per season. REI: 24-hour. PHI: 60-day for dry bulb onion; 21-day for all else. HRAC 15.

Fusilade DX (fluazifop-P) POST *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 10-12 fl. oz. per acre. Add COC (1% v/v) or NIS (0.25% v/v). Apply to small actively growing grass. Do not exceed 48 fl. oz. per acre per year. REI: 12-hour. PHI: 45-day for garlic and dry bulb onion (dry), 14-day for green onion and leek. HRAC 01.

glyphosate products (glyphosate) POST *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast before planting, after planting but before crop emergence, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

GoalTender (oxyfluorfen) POST PRE *Garlic, Onion (Dry)* | *Seeded crops*: Broadcast 0.25 pt. per acre GoalTender or 0.5 pt. per acre Goal 2XL after crop has 2 true leaves, or 1 leaf *with special 24c label*. For *transplanted crops*: Broadcast 0.5-1 pt. per acre GoalTender or 1-2 pts. per acre Goal 2XL prior to transplanting (*onion only*), or within 2 days of transplanting. Greenhouse-grown transplants may be sensitive to GoalTender at transplanting. Also works preemergent weeds, and on actively growing postemergent weeds with 2-4 leaves. May cause foliar injury during cool weather. Use lower rate on coarse soils. Do not exceed 1 pt. per acre per season GoalTender or 2 pts. per acre per season Goal 2XL. REI: 24 to 48-hour. PHI: 45-day for onion, 60-day for garlic. HRAC 14.

Moxy 2E (bromoxynil) POST *Garlic, Onion (Dry)* | 1-1.5 pt. per acre for onion or 1.5-2 pt. per acre for garlic. Apply to weeds up to 2 in. tall and 1 in. wide with less than 4 leaves. For **onions:** apply 1.0-1.5 pts. per acre when onions have 2-5 true leaves, using 50-70 gal. of water per acre, or on muck soils east of the Mississippi River only, apply 3-4 days before onions emerge. To minimize onion injury apply after 2 days of sunny weather when onion leaves are dry and temperatures are 70-80 F. For **garlic:** apply 1.5-2.0 pts. per acre after garlic emerges and before it is 12 in. tall, using at least 20 gal. water per acre. REI: 24-hour. PHI: 45-day for onion, 112-day for garlic. HRAC 06.

Nortron SC (ethofumesate) POST PRE *Onion (Dry), Shallot* | 16-32 fl. oz. per acre. Apply preemergence or soon after seeding before weeds germinate. May also be used postemergence. Do not exceed 4 applications or 48 fl. oz. per acre per season on coarse soils and 96 fl. oz. per acre per season on medium and fine soils. May cause temporary leaf fusion. May injure stressed plants. Use on mineral soils only. REI: 12-hour. HRAC 15.

Optogen (bicyclopyrone) POST PRE *Garlic, Onion (Dry), Onion (Green)* | 2.6-3.5 fl. oz. per acre before transplanting or 3.5 fl. oz. per acre after transplanting as a row middle or post-directed application, avoiding contact with crop foliage. If weeds are present, add COC (1% v/v) or NIS (0.25% v/v). Spray grade ammonium sulfate (AMS) may also be added to improve weed control consistency. Apply to weeds less than 2 inches. Do not exceed 1 application per year. Do not exceed 3.5 fl. oz. per acre per year. Do not apply preemergence on mineral soils. REI: 24-hour. PHI: 45-day for garlic and dry onions, 21-day for green onions HRAC 27.

Outlook (dimethenamid-p) PRE *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 12-21 fl. oz. per acre. Apply after crop plants have 2 true leaves. For transplants, apply after transplanting when soil has settled around plants. See label for tank-mix recommendations. REI: 12-hour. PHI: 30-day. HRAC 15.

paraquat products (paraquat) POST *Garlic, Onion (Dry)* | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Add COC (1% v/v) or NIS (0.25% v/v) and apply to emerged weeds less than 6" tall prior to transplanting or after direct-seeding but before crop emergence. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. PHI: 60-day HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | For **garlic:** use 3.8 formulations at 1.5-3.2 pts. per acre or 3.3 formulations at 1.8-3.6 pts. per acre after planting but before crop and weeds emerge, or when garlic has 1-5 true leaves. For **dry bulb onion, and dry shallot:** use 3.8 formulations at 1.5-3.2 pts. per acre (up to 4 pts. on muck) or 3.3 formulations at 1.8-3.6 pts. per acre (up to 4.8 pts. on muck) after planting but before crop and weeds emerge, or when onions have 2-9 true leaves. *In Michigan only: for* mineral soils with more

than 10% organic matter, use similar rates as muck soil applications. For **green onion, leek, and green shallot:** use 3.8 formulations at 2 pts. per acre (*up to 4 pts. Per acre with special 24c label*) after seeding but before crop emerges, or when crop has 2-3 true leaves. The 3.3 formulations are not labeled for green onions or leeks. If both pre and post applications are used, wait 30 days after pre application before making a post application. Only apply pre to muck soils (organic matter greater than 20%) or mineral soils with greater than 3% organic matter. Do not exceed 4 pts. per acre per year. Use low rates on course soils. Heavy rain or excessive irrigation soon after application may cause crop injury. Will not control emerged weeds. REI: 24-hour. PHI: 45-day for dry bulb onion, garlic and dry shallot; 30-day for green onion, leek, and green shallot. HRAC 03.

Poast (sethoxydim) POST *Garlic, Leek, Onion (Dry), Onion (Green), Shallot* | 1-1.5 pt. per acre. Add COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per growing season. REI: 12-hour. PHI: 30-day. HRAC 01.

Prefar 4E (bensulide) PRE *Garlic, Onion (Dry), Shallot* | 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting. Or apply after seeding, before crop emerges and irrigate within 24 hours to incorporate. Mineral soils only. REI: 12-hour. HRAC NC.

Starane Ultra (fluroxypyr) POST *Onion (Dry)* | 5.6 fl. oz. per acre. *Michigan only.* Apply to onions with 2-6 true leaves. Do not exceed 2 applications per season. Controls volunteer potato, chickweed, composites, nightshades, and mustards. REI: 24-hour. PHI: 42-day. HRAC 04.

trifluralin products (trifluralin) PRE *Onion (Dry)* | Use 4EC formulations at 0.75-1.25 pts. per acre. Use 10G formulations at 3.75-6.26 lbs. per acre. Apply at layby as a directed spray between onion rows and incorporate 1-2 inches. Mineral soils only (less than 3.5% organic matter). REI: 12-hour. PHI: 60-day. HRAC 03.

Peas and Beans - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Ben Phillips – Mar 2022

Crop Description

Fresh or Snap Bean (*Phaseolus vulgaris*): These are edible podded beans that are usually green (green beans) or yellow (wax beans), but they also come in red and purple podded varieties as well. They are harvested while pods and seeds are still tender. Older varieties (string beans) had a fibrous "string" the length of the pod that was removed during preparation for eating. Flat-podded Romano beans are also harvested while pods and seeds are tender. Within this category are "vining", "pole", or "runner" beans that need trellising, and "bush" beans that are short and sturdy.

Dry Bean (*Phaseolus vulgaris*): Dry bean refers to a wide variety of beans harvested after the seeds are mature and pods have dried down. Kidney, navy, black turtle, white, and pinto beans are examples. Within this category are "vining", "pole", or "runner" beans that need trellising, and "bush" beans that are short and sturdy.

Lima Bean (*Phaseolus lunatus*): Lima beans represent a different species than fresh beans and dry beans. They can be harvested when completely dry (like dry beans) or as "baby limas" before the seed has matured (similar to the southern pea described below). Some lima bean varieties will readily climb a trellis, but other varieties are more bush-like.

Fresh Pea (*Pisum sativum*): These peas are cool-season crops grown for their immature edible seeds or pods. Snow peas have flattened, tender, edible pods and seeds. Snap peas have edible pods and plump seeds. Shell peas have pods that are too tough to eat and the peas must be removed for eating. Some pea varieties will readily climb a trellis, but other varieties have a sprawling bush-like architecture.

Dry Pea (*Pisum sativum*): These peas are cool-season crops grown for their mature edible seeds, like dry beans. Dry pea varieties are bush-like to facilitate machine harvest.

Southern Pea, Cowpea (*Vigna unguiculata*): These peas are heat-loving crops more commonly grown in southern states, though they can be grown in the north. They include black-eyed peas, cream peas and crowder peas. They are grown for their immature and dried shelled seeds, and are well-accepted in markets where customers are familiar with them. Southern peas have a sprawling bush-like architecture.

Planting and Spacing

Fresh or Snap Bean, Dry Bean, Lima Bean, Southern Pea: Rows 18 to 36 inches apart, 5 to 7 seeds per foot of row for bush types (70 to 100 pounds per acre), or 2 to 3 seeds per foot of row for vining types (35 to 50 pounds per acre). Larger inter-row spacing helps limit white mold development. These warm-season vegetables should be sown after soil temperatures average 60 F and frost danger is past. Sequential plantings of bush snap beans are possible. Vining types will readily climb a trellis of horticultural netting up to 8 feet tall without much training.

Fresh Pea and Dry Pea: Rows 32 to 36 inches apart, 6 to 8 seeds per foot of row for bush types (100 to 150 pounds per acre), or 3 to 4 seeds per foot of rows for vining types (50 to 75 pounds per acre). These cool-season vegetables should be sown in early spring for a spring crop or in mid to late summer for a fall crop. Plants deteriorate quickly in the heat of summer. Vining types will readily climb a trellis of horticultural netting up to 5 feet tall without much training.

Fertilizing

pH: Maintain a soil pH of 6.0 to 6.5.

Before planting, apply 20 to 40 pounds N per acre for peas and 30 to 60 pounds N per acre for beans, 0 to 100 pounds P_2O_5 per acre, and 0 to 100 pounds K_2O per acre based on soil test results and recommendations from your state. Or apply some or all of that amount at planting in bands at least 2 inches below and 2 inches to the side of the row, except the rate of K_2O should not exceed 40 pounds per acre when applied this way because peas and beans are sensitive to injury from fertilizer salts. Reduce the preplant fertilizer by the amount applied in bands at planting.

Beans are prone to zinc and manganese deficiency when pH is over 6.5. Include up to 1 pound of zinc per acre and 2 pounds of manganese per acre in the banded planting time fertilizer. If banding is not possible zinc may be broadcast up to 10 pounds of zinc per acre. Broadcasting manganese is not recommended. Foliar sprays of 0.5 pounds zinc per acre or 1 to 2 pounds manganese per acre can be used if needed.

Sidedressing is not needed for legume crops. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer

(including starter) and other credits should be 40 to 60 pounds per acre.

Harvesting

Fresh or Snap Beans and Fresh Peas: Harvests can take place every few days once plants start producing pods that are of the desirable size. More picking generates more flowers and more pods later. Bush-type beans are commonly machine harvested and sorted with a once-over pass. Time from seeding to harvest ranges from 50 to 60 days for beans, or 60-70 days for peas.

Dry Peas and Dry Beans: Harvests can take place as once-over harvests when pods are dry. Machine harvests should take place before noon when plants are slightly damp to avoid pod shatter. Time from seeding to harvest ranges from 70 to 120 days for beans, or 80 to 100 days for peas.

Southern Peas and Lima Beans: Target harvests for fresh products when the seeds are succulent, and the pods are juicy. When the first beans are ready plants can be hand harvested for fresh product about once per week. A once-over harvest is used for dry seeds. Time from seeding to fresh harvest ranges from 60 to 70 days for southern peas, or 60 to 90 days for lima beans. For dried seeds, time from seeding to harvest can be over 100 days.

Peas and Beans - Diseases

Reviewed by Dan Egel – Aug 2023

Anthracnose of Legumes - Colletotrichum Fungus

Non-Pesticide

Southern Peas/Cowpeas | Use disease-free seed. Rotate to non-host crops for 3 years. Varieties with partial resistance are available, depending on the race of the pathogen. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Beans (Fresh), Peas (Fresh), Southern Peas/Cowpeas* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.25 pt. per acre. Use 54% (720) formulations at 1.38-3 pt. per acre. Use 82.5% (WDG) formulations at 1.25-2.7 lb. per acre. Use 90% (DF) formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 7-day. FRAC M05.

Fontelis (penthiopyrad) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Headline (pyraclostrobin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 6-9 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Omega 500F (fluazinam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 8-13.6 fl. oz. per acre. Do not exceed 27.2 fl. oz. per crop cycle. REI: 12-hour. PHI: 14-day. FRAC 29.

Priaxor (fluxapyroxad, pyraclostrobin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) *Beans (Fresh), Lima Beans, Southern Peas/Cowpeas* | 4 fl. oz. per acre. PropiMax EC and Tilt are labeled. REI: 12-hour. PHI: 7-day. FRAC 03.

Quilt (azoxystrobin, propiconazole) *Beans (Fresh), Southern Peas/Cowpeas* | 10.5-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 03.

Topsin 4.5FL (thiophanate-methyl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Rates depend on formulation and product. Use 4FL formulation or Cercobin at 20-40 fl. oz. per acre, or 70WSB formulation at 1-2 lb. per acre. REI: 24-hour to 3-day. PHI: 14-day. FRAC 01.

Common Bacterial Blight of Beans - Xanthomonas Bacteria

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Plant western-grown, certified disease-free seed. Rotate to non-host crops for 2 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may slow the spread of bacterial blights. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Plant western-grown, certified disease-free seed. Avoid planting in prolonged wet conditions.

Pesticide

mefenoxam/metalaxyl products (mefenoxam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Apply at planting if Pythium is a significant problem. Several formulations (Apron, MetaStar, Ridomil Gold, Ultra Flourish, and Xyler) are labeled. Several formulations are labeled as pre-plant incorporated or surface broadcast and banded applications at various rates between 0.5 pt. and 4 pt. per acre. A 33.3% seed treatment formulation can be used at 0.16-0.64 fl. oz. per 100 lb. of seed. REI: 48-hour. PHI: 0-day. FRAC 04.

Seed treatments for diseases (various ingredients) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Purchase seed commercially treated with a product such as Apron Maxx, Captan or Thiram.

Gray Mold of Multiple Crops - Botrytis Fungus

Non-Pesticide

Beans (Fresh), Southern Peas/Cowpeas | Avoid fields with a history of the problem. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >6 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Cannonball WG (fludioxonil) *Beans (Fresh), Southern Peas/Cowpeas* | 7 oz. per acre. Do not exceed 28 oz. per year. REI: 12-hour. PHI: 7-day. FRAC 12.

chlorothalonil products (chlorothalonil) *Beans (Fresh), Peas (Fresh), Southern Peas/Cowpeas* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.25 pt. per acre. Use 54% (720) formulations at 1.38-3 pt. per acre. Use 82.5% (WDG) formulations at 1.25-2.7 lb. per acre. Use 90% (DF) formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 7-day. FRAC M05.

Endura (boscalid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 8-11 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07.

Fontelis (penthiopyrad) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

iprodione products (iprodione) *Beans (Fresh), Lima Beans* | 1.5-2 pts. per acre. Formulations of iprodione include Meteor and Rovral. Make up to two applications starting at first flower, and ending no later than peak bloom. REI: 24-hour. FRAC 02.

Omega 500F (fluazinam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 8-13.6 fl. oz. per acre. Do not exceed 27.2 fl. oz. per crop cycle. REI: 12-hour. PHI: 14-day. FRAC 29.

Switch 62.5WG (cyprodinil, fludioxonil) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 11-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Topsin 4.5FL (thiophanate-methyl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Rates depend on formulation and product. Use 4FL formulation or Cercobin at 20-40 fl. oz. per acre, or 70WSB formulation at 1-2 lb. per acre. REI: 24-hour to 3-day. PHI: 14-day. FRAC 01.

Halo Blight of Beans - Pseudomonas Bacteria

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Plant western-grown, certified disease-free seed. Rotate to non-host crops for 2 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Several formulations of copper (Badge, Champ, Kocide) are labelled for use and may slow the spread of bacterial blights. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Nematodes

Non-Pesticide

Beans (Fresh), Lima Beans, Southern Peas/Cowpeas | Collect soil samples for nematodes in the fall and avoid fields with high numbers. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >3 years. Rotation interval depends on the nematode count in soil samples. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue and displace nematodes is an important method to prevent nematode build-up.

Rust of Legumes - Uromyces Fungus

Non-Pesticide

Southern Peas/Cowpeas | Rotate to non-host crops for 3-4 years. Resistant varieties are available,

Pesticide

azoxystrobin products (azoxystrobin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

chlorothalonil products (chlorothalonil) *Beans (Fresh), Peas (Fresh), Southern Peas/Cowpeas* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.0-4.25 pt. per acre. Use 54% (720) formulations at 1.38-3 pt. per acre. Use 82.5% (WDG) formulations at 1.25-2.7 lb. per acre. Use 90% (DF) formulations at 1.1-2.5 lb. per acre. REI: 12-hour. PHI: 7-day. FRAC M05.

Fontelis (penthiopyrad) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Headline (pyraclostrobin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 6-9 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Priaxor (fluxapyroxad, pyraclostrobin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Proline 480SC (prothioconazole) *Southern Peas/Cowpeas* | 5.7 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03.

propiconazole products (propiconazole) *Beans (Fresh), Lima Beans, Southern Peas/Cowpeas* | 4 fl. oz. per acre. PropiMax EC and Tilt are labeled. REI: 12-hour. PHI: 7-day. FRAC 03.

Quilt (azoxystrobin, propiconazole) *Beans (Fresh), Southern Peas/Cowpeas* | 10.5-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 03.

Rally 40WSP (myclobutanil) *Beans (Fresh)* | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 0-day. FRAC 03.

Viruses of Multiple Crops - Multiple Pathogens

Bean Yellow Mosaic Virus (BYMV) overwinters in wild legumes, like sweet clover, and is spread by aphids.

Non-Pesticide

Beans (Fresh), Lima Beans | For **BYMV:** Keep new plantings as far as possible with the previous production area. Eliminating overwintering host plants such as wild sweet clover may reduce infection. Monitor for aphids and avoid broad-spectrum insecticides that might kill natural enemies and flare aphid populations. Some tolerant varieties are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up and transfer back to overwintering wild legumes.

Pesticide

Insecticides *Beans (Fresh), Lima Beans* | For **BYMV:** use aphid-specific insecticides to lower the population without also reducing the population of natural enemies. See insect section.

White Mold (Timber Rot, Drop, Stem Rot) of Multiple Crops - Sclerotinia Fungus

This soil pathogen is long-lived in the soil, and has a wide host range on broadleaved crops and weeds, including beans, vine crops, lettuce, tomatoes, peppers, and cole crops. It goes by other names in other crops, such as Drop, White Mold, Stem Rot, and Timber Rot.

It is more commonly where humidity and temperatures are high. The fungus often infects flowers, which then drop off and infect the stems that they land on. The stems take on a woody appearance and can split open. Inspection of the stems will reveal small black pellets that are the overwintering body of the pathogen.

Non-Pesticide

Beans (Fresh), Southern Peas/Cowpeas | Avoid fields with a history of the problem. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >6 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aproach (picoxystrobin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 8-12 fl. oz. per acre. Suppression. REI: 12-hour. PHI: 14-day. FRAC 11.

Cannonball WG (fludioxonil) *Beans (Fresh), Southern Peas/Cowpeas* | 7 oz. per acre. Do not exceed 28 oz. per year. REI: 12-hour. PHI: 7-day. FRAC 12.

Contans WG (Coniothyrium minitans strain CON/M/91-08) *Beans (Fresh)* | 1-6 lbs. per acre. Apply immediately after harvest or 3-4 months before planting. REI: 4-hour. PHI: 7-day. FRAC BM02. *OMRI-listed.*

Endura (boscalid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 8-11 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07.

Fontelis (penthiopyrad) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

iprodione products (iprodione) *Beans (Fresh), Lima Beans* | 1.5-2 pts. per acre. Formulations of iprodione include Meteor and Rovral. Make up to two applications starting at first flower, and ending no later than peak bloom. REI: 24-hour. FRAC 02.

Omega 500F (fluazinam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 8-13.6 fl. oz. per acre. Do not exceed 27.2 fl. oz. per crop cycle. REI: 12-hour. PHI: 14-day. FRAC 29.

Proline 480SC (prothioconazole) *Southern Peas/Cowpeas* | 5.7 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 03.

Switch 62.5WG (cyprodinil, fludioxonil) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 11-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Topsin 4.5FL (thiophanate-methyl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Rates depend on formulation and product. Use 4FL formulation or Cercobin at 20-40 fl. oz. per acre, or 70WSB formulation at 1-2 lb. per acre. REI: 24-hour to 3-day. PHI: 14-day. FRAC 01.

Wilt of Multiple Crops - Fusarium Fungus

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Avoid fields with a history of the disease. Rotate to non-Legume crops for >6 years. Resistant varieties are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Peas and Beans - Insects

Major update by Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Soybean aphid is the most important species in our region. Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Admire Pro (imidacloprid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 7-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application. IRAC 04A.

Asana XL (esfenvalerate) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.0-2.3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Cruiser 5FS (thiamethoxam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45-days of planting when using seeds treated with a neonicotinoid insecticide. REI: 12-hour. IRAC 04A.

Dimethoate 4EC (dimethoate) *Beans (Fresh), Lima Beans* | Use 2.67EC formulations at 0.5-1.0 pts. per acre on beans. See pollinator precautions. REI: 48-hour. PHI: 0-day. IRAC 01B.

Lannate LV (methomyl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.5-3 pts. per acre. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes. IRAC 01A. *RUP.*

M-Pede (potassium salts of fatty acids) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1-2% by volume. Must contact pest to be effective. To achieve enhanced and residual pest control mix with a labeled companion insecticide. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Movento (spirotetramat) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.0-5.0 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 23.

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Lima Beans* | 8-16 oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 01B.

Sivanto 200 (flupyradifurone) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 7-14 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 04D.

Thimet 20G (phorate) *Beans (Fresh), Lima Beans* | 4.5-7.0 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. REI: 48-hour. PHI: 60-day. IRAC 01B. *RUP.*

Transform WG (sulfoxaflor) *Beans (Fresh), Lima Beans* | 0.75-1.0 oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 04C.

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Bean Leaf Beetle

Warmer winters increase overwintering survival of bean leaf beetles.

A threshold of 1 beetle per foot of row can be used for management. Good spray coverage on the underside of leaves aides in control.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Prompt crop residue destruction and keeping areas around the field neat reduces spots where beetles overwinter. In small plantings, row covers can be effective.

Pesticide

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Cruiser 5FS (thiamethoxam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45-days of planting when using seeds treated with a neonicotinoid insecticide. REI: 12-hour. IRAC 04A.

Dimethoate 4EC (dimethoate) *Beans (Fresh), Lima Beans* | Use 2.67EC formulations at 0.5-1.0 pts. per acre on beans. See pollinator precautions. REI: 48-hour. PHI: 0-day. IRAC 01B.

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Lima Beans* | 8-16 oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 01B.

Sevin XLR Plus (carbaryl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.5-1.0 qts. per acre. Do not use on shelled succulent peas and beans. Edible-pod succulent beans and peas only. REI: 12-hour. PHI: 3-day. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Caterpillars

There are many caterpillar pests of legumes, including European corn borer, corn earworm/tomato fruitworm, alfalfa caterpillars, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Pesticide

Asana XL (esfenvalerate) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 5.8-9.6 fl. oz. per acre. For armyworms, corn borers, cutworms, earworms, and loopers. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) *Southern Peas/Cowpeas* | 0.8-3.2 fl. oz. per acre. For armyworms, corn borers, earworms, and loopers. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | For armyworms, corn borers, cutworms, earworms, and loopers. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.5-7.5 fl. oz. per acre foliar or in-furrow at-planting. For armyworms, corn borers, cutworms, earworms, and loopers. In-furrow sprays must be in the root zone to provide effective control. REI: 4-hour. PHI: 1-day. IRAC 28.

Entrust SC (spinosad) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3-6 oz. per acre. For armyworms, corn borers, earworms, and loopers. Use 2SC formulations at 3.0-6.0 fl. oz. per acre. Use 80WP formulations at 1.0-2.0 oz. per acre. Observe resistance management restrictions. REI: 4-hour. PHI: 3-day. IRAC 05. *OMRI-listed.*

Intrepid 2F (methoxyfenozide) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 4-16 fl. oz. per acre. For armyworms, corn borers, earworms, and loopers. Use lower rates on young plants in early season and higher rates for mid- to late-season applications or heavier infestations. REI: 4-hour. PHI: 7-day. IRAC 18.

Lannate LV (methomyl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.5-3 pts. per acre. For armyworms, corn borers, earworms, and loopers. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 2.72-4.0 fl. oz. for armyworms, corn borers, and earworms. 3.2-4.0 fl. oz. per acre for loopers. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Lima Beans* | 8-16 oz. per acre for cutworms and loopers. 12-16 oz. per acre for armyworms, corn borers and earworms. REI: 24-hour. PHI: 1-day. IRAC 01B.

Radiant 1SC (spinetoram) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3-8 fl. oz. per acre for corn borers. 4-8 fl. oz. per acre for armyworms, earworms, and loopers. REI: 4-hour. PHI: 3-day. IRAC 05.

Sevin XLR Plus (carbaryl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1-1.5 qts. per acre for armyworms, corn borers, and cutworms. 0.5-1.5 qts. per acre for earworms. Do not use on shelled succulent peas and beans. Edible-pod succulent beans and peas only. REI: 12-hour. PHI: 3-day. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. For armyworms, corn borers, cutworms, earworms, and loopers. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Cowpea Curculio Beetle

Pesticide

Baythroid XL (beta-cyfluthrin) *Southern Peas/Cowpeas* | 1.6-2.1 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Sevin XLR Plus (carbaryl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.5-1.5 qts. per acre. Do not use on shelled succulent peas and beans. Edible-pod succulent beans and peas only. REI: 12-hour. PHI: 3-day. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Leafhoppers

Aster leafhopper and potato leafhopper are common in our region and crops. They don’t survive the winter in northern areas, and migrate from southern areas every growing season. A condition known as "hopperburn" is caused by potato leafhopper feeding, and aster yellows is a disease vectored by aster leafhopper feeding. The amount of aster yellows present in any leafhopper population varies by year and location. Some states in the region have programs that test for and track

the percentage of aster leafhoppers that are carrying aster yellows. Leafhoppers can move into vegetable fields when neighboring grain or alfalfa is harvested.

Treatment for potato leafhopper is warranted at the following thresholds.

Seedlings: 0.5 per sweep, or 2 per row foot.

3rd trifoliate: 1 per sweep, or 5 per row foot.

Bud stage: 5 per row foot.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Avoid planting near early harvested grain or alfalfa fields.

Pesticide

Admire Pro (imidacloprid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 7-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application. IRAC 04A.

Asana XL (esfenvalerate) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 30SG formulations at 2.5-5.3 oz. per acre. Use 70WP formulations at 1.0-2.3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Baythroid XL (beta-cyfluthrin) *Southern Peas/Cowpeas* | 0.8-1.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 1.6-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 4-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Cruiser 5FS (thiamethoxam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45-days of planting when using seeds treated with a neonicotinoid insecticide. REI: 12-hour. IRAC 04A.

Dimethoate 4EC (dimethoate) *Beans (Fresh), Lima Beans* | Use 2.67EC formulations at 0.5-1.0 pts. per acre on beans. See pollinator precautions. REI: 48-hour. PHI: 0-day. IRAC 01B.

Lannate LV (methomyl) *Beans (Fresh), Lima Beans, Southern Peas/Cowpeas* | 0.75-3 pts. per acre. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes. IRAC 01A. *RUP.*

M-Pede (potassium salts of fatty acids) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1-2% by volume. Must contact pest to be effective. To achieve enhanced and residual pest control mix with a labeled companion insecticide. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Lima Beans* | 8-16 oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 01B.

Sivanto 200 (flupyradifurone) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 7-14 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 04D.

Thimet 20G (phorate) *Beans (Fresh), Lima Beans* | 4.5-7.0 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. REI: 48-hour. PHI: 60-day. IRAC 01B. *RUP.*

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Mexican Bean Beetle

Early plantings are most susceptible to Mexican Bean Beetle damage.

Treatment for Mexican Bean Beetle is warranted at a threshold of 0.5 beetle per plant.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | In small plantings, row covers can be effective.

Pesticide

Asana XL (esfenvalerate) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 2.9-5.8 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Cruiser 5FS (thiamethoxam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45-days of planting when using seeds treated with a neonicotinoid insecticide. REI: 12-hour. IRAC 04A.

Dimethoate 4EC (dimethoate) *Beans (Fresh), Lima Beans* | Use 2.67EC formulations at 0.5-1.0 pts. per acre on beans. See pollinator precautions. REI: 48-hour. PHI: 0-day. IRAC 01B.

Lannate LV (methomyl) *Beans (Fresh), Lima Beans, Southern Peas/Cowpeas* | 0.75-3 pts. per acre. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Orthene 97 (acephate) *Lima Beans* | 8-16 oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 01B.

Sevin XLR Plus (carbaryl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.5-1.0 qts. per acre. Do not use on shelled succulent peas and beans. Edible-pod succulent beans and peas only. REI: 12-hour. PHI: 3-day. IRAC 01A.

Thimet 20G (phorate) *Beans (Fresh), Lima Beans* | 4.9-9.4 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. REI: 48-hour. PHI: 60-day. IRAC 01B. *RUP.*

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.96-1.6 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Mites

Mite populations spike in hot dry weather. Damage appears as white flecks on leaves, accompanied by webbing. Selective chemistries (e.g. abamectin, bifenazate, etoxazole, cyflumetofen, fenpyroximate, hexythiazox, spiromesifen) that target mites help to preserve natural enemies.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Preserve and encourage natural enemies.

Pesticide

Acramite 50WS (bifenazate) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1-1.5 lbs. per acre. REI: 12-hour. PHI: 3-day. IRAC 20D.

Agri-Mek SC (abamectin) *Beans (Fresh), Lima Beans, Peas (Fresh)* | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15EC formulations at 8-16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 06. *RUP.*

Portal (fenpyroximate) *Beans (Fresh)* | 2 pts. per acre. REI: 12-hour. PHI: 1-day. IRAC 21A.

Pea Weevil Beetle

Pesticide

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Sevin XLR Plus (carbaryl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.5-1.5 qts. per acre. Do not use on shelled succulent peas and beans. Edible-pod succulent beans and peas only. REI: 12-hour. PHI: 3-day. IRAC 01A.

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Seed and Root Maggots

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Plant after the peak flight and egg-laying window of the first generation of flies looking to lay eggs around 360 GDD base 40. Handle seeds carefully to prevent cracking. Plow winter vegetation under early in the spring and thoroughly cover to limit attractiveness of rotting vegetation to the first generation of flies to lay eggs on.

Pesticide

Capture LFR (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.2-0.39 fl. oz. per 1,000 ft. of row. Apply as a 5-7 inch band over the row on the soil surface, open furrow, or in-furrow at planting. REI: 12-hour. IRAC 03A. *RUP.*

Cruiser 5FS (thiamethoxam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45-days of planting when using seeds treated with a neonicotinoid insecticide. REI: 12-hour. IRAC 04A.

Thimet 20G (phorate) *Beans (Fresh), Lima Beans* | 4.5-7.0 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. REI: 48-hour. PHI: 60-day. IRAC 01B. *RUP.*

Stink Bugs

Pesticide

Baythroid XL (beta-cyfluthrin) *Southern Peas/Cowpeas* | 1.6-2.1 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Lannate LV (methomyl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.5-3 pts. per acre. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Sevin XLR Plus (carbaryl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.5-1.5 qts. per acre. Do not use on shelled succulent peas and beans. Edible-pod succulent beans and peas only. REI: 12-hour. PHI: 3-day. IRAC 01A.

Transform WG (sulfoxaflor) *Beans (Fresh), Lima Beans* | 2.25 oz. per acre. *Suppression only.* REI: 24-hour. PHI: 7-day. IRAC 04C.

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Thrips

Thrips populations spike in hot dry weather, and when neighboring small grains or alfalfa is harvested. Damage appears as white flecks on leaves. Thrips transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Selective chemistries (e.g. abamectin, spinetoram, spirotetramat, and spinosad) that target thrips help to preserve natural enemies.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | A heavy rain or overhead irrigation washes thrips out of plants. Avoid planting near early harvested grain or alfalfa fields. Preserve and encourage natural enemies. Minute pirate bugs, and lacewings are common predators.

Pesticide

Admire Pro (imidacloprid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 7-10.5 fl. oz. per acre soil application. REI: 12-hour. PHI: 21-day. IRAC 04A.

Assail 30SG (acetamiprid) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 30SG formulations at 4.5-5.3 oz. per acre. Use 70WP formulations at 1.9-2.3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Brigade 2EC (bifenthrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Entrust SC (spinosad) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2SC formulations at 4.5-6.0 fl. oz. per acre. Use 80WP formulations at 1.0-2.5 oz. per acre. Observe resistance management restrictions. REI: 4-hour. PHI: 3-day. IRAC 05. *OMRI-listed.*

Mustang Maxx (zeta-cypermethrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 5-8 fl. oz. per acre. REI: 4-hour. PHI: 3-day. IRAC 05.

Sevin XLR Plus (carbaryl) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.5-1.5 qts. per acre. Do not use on shelled succulent peas and beans. Edible-pod succulent beans and peas only. REI: 12-hour. PHI: 3-day. IRAC 01A.

Transform WG (sulfoxaflor) *Beans (Fresh), Lima Beans* | 2.25 oz. per acre. *Suppression only.* REI: 24-hour. PHI: 7-day. IRAC 04C.

Warrior II (lambda-cyhalothrin) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Wireworms

Wireworms are long-lived in the soil, and are most common in fields that were previously fallow or in pasture.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | Avoid planting in fields that were recently in grasses.

Pesticide

Cruiser 5FS (thiamethoxam) *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45-days of planting when using seeds treated with a neonicotinoid insecticide. REI: 12-hour. IRAC 04A.

Peas and Beans - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Weed control methods in legumes vary by production system and crop.

For legumes that are no-till, direct-seeded into a killed crop (such as after a rye cover crop, or wheat) growers often use a burndown herbicide with a preemergence herbicide. For legumes direct-seeded into tilled soil, growers often combine one or more preemergence herbicides at planting with one or more cultivations. Sometimes, growers also apply a preemergence herbicide after the last cultivation to improve control of late-emerging weeds. Small, emerged weeds in both systems can be controlled with selective postemergence herbicides and/or shielded applications of nonselective herbicides

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas | A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. Legumes lend themselves to this stale seedbed practice because they are often planted after common weeds have emerged in tilled soil. Uniform and close plant spacing in the row promotes rapid canopy cover, and fresh market growers can keep larger between row spacing clean with between row cultivation tools for hand-pickers or mechanical harvesters. A rolling cultivator on a wide tool-bars offer effective high-speed cultivation.

Pesticide

Aim EC (carfentrazone) POST *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.5-2 fl. oz. per acre. Apply prior to or within 24 hours after seeding, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 inches tall.

Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. HRAC 14.

Assure II (quizalofop) POST *Beans (Fresh), Peas (Fresh)* | 5-12 fl. oz. per acre. Use COC (1% v/v). Apply to actively growing grass. Do not exceed 14 fl. oz. per acre. REI: 12-hour. PHI: 15-day for beans; 30-day for peas HRAC 01.

Basagran (bentazon) POST *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use Basagran 4L at 1.5 to 2.0 pts. per acre, or Basagran 5L at 1.2-1.6 pts. per acre. Apply when weeds are small and after peas have 3 pairs of leaves or first trifoliate leaf of beans is fully expanded. Do not add COC for peas. REI: 48-hour. PHI: 30-day. HRAC 06.

clethodim products (clethodim) POST *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2EC formulations at 6-16 fl. oz. per acre with COC (1% v/v). Use Select Max at 9-32 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v).Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations per acre per season. Do not exceed 64 fl. oz. of Select Max per acre per season. REI: 24-hour. PHI: 21-day. HRAC 01.

Command 3ME (clomazone) PRE *Beans (Fresh), Peas (Fresh)* | 1.3 pts. per acre. For **fresh beans:** apply 0.4-0.67 pt. per acre. For **fresh peas:** apply 1.3 pts. per acre. Broadcast before planting, or after planting before crop emerges. Not effective on muck soil. REI: 12-hour. PHI: 45-day. HRAC 13.

Dual Magnum (s-metolachlor) PRE *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1-2 pts. per acre. For **fresh peas:** apply after seeding before crop emerges. Do not incorporate. For **fresh beans, and southern peas/cowpeas, and lima beans:** apply and incorporate before planting, or apply after seeding but before crop emerges. Can be tank-mixed preplant incorporated with Eptam or trifluralin. Do not use on muck soils. In all cases, use lower rates on coarse soils. Do not use on muck soils. Dual II Magnum contains a safener and may used instead of Dual Magnum to limit crop injury under cool soil conditions. REI: 24-hour. HRAC 15.

Eptam 7E (EPTC) PRE *Beans (Fresh)* | 3.5 pts. per acre. Eptam 7E at 3.5 pts. per acre, or Eptam 20G at 15lbs. per acre. Apply before planting and incorporate immediately, or apply as a directed spray at last cultivation before pods start to form. Check label for sensitive types and varieties. *Green beans on coarse soils*: do not exceed 3.5 pts. per acre (7E) or 15 lbs. per acre (20G). Suppresses nutsedge. REI: 12-hour. HRAC 15.

glyphosate products (glyphosate) POST *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast before or after planting but before crop emerges, or apply up to 0.75 lb. acid equivalent between crop rows with wipers, hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

Optill (imazethapyr, saflufenacil) POST PRE *Peas (Fresh)* | Apply 1.0-1.5 oz per acre preplant, preplant incorporated or preemergence (up to 3 days after planting before cracking). *In Michigan*: do not exceed 1 oz. per acre on sand or loamy sand soils preplant burndown or preemergence. *In Minnesota*: do not apply north of Highway 210. *In Illinois, Iowa, and Minnesota:* a sequential application of Sharpen may be made with a minimum of 30 days between applications. In all cases, some varieties may be injured; check with seed supplier. Plant at least 1/2 inch deep to avoid injury. Do not apply group 14 herbicides within 30 days of planting. REI: 12-hour. HRAC 02, HRAC 14.

paraquat products (paraquat) POST *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation before seeding or after seeding but before crop emergence. Use 4-8 fl. oz. of NIS per 25 gals. of spray solution. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 3.3EC formulations at 1.2-3.6 pts. per

acre. Use 3.8ME formulations at 1.5-3 pts. per acre. Use low rates on coarse soils. Broadcast and incorporate before planting. Not effective on soils with high organic matter. REI: 24-hour. HRAC 03.

Poast (sethoxydim) POST *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 1-2.5 pts. per acre. Use COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4 pts. per acre per season. REI: 12-hour. PHI: 15-day. HRAC 01.

Pursuit (imazethapyr) POST | PRE *Beans (Fresh), Lima Beans, Southern Peas/Cowpeas* | For **fresh beans** *in Illinois, Indiana, Iowa, Michigan, and Minnesota only*: apply and 1.5 fl. oz. per acre and incorporate within 1 week of planting, or apply within 1 day after planting. *In Missouri only*, a postemergence application can be mixed with Basagran after crop has at least one true leaf. Apply before July 31. For **fresh peas, Lima beans, and Southern peas/cowpeas:** apply 3 fl. oz. per acre and incorporate within 1 week of planting, or apply within 3 days after planting before crop emerges, or apply after crop has 1 fully expanded trifoliate leaf or peas or cowpeas are at least three inches tall. *Early postemergence application not allowed on lima beans*. Use 8 oz. of NIS per 25 gals. of spray solution if emerged weeds are present. In all cases, do not apply to fields treated with trifluralin or injury may occur. In Minnesota north of Highway 210 and in Michigan on sandy or sandy loam soils do not exceed 2 fl. oz. per acre. REI: 4-hour. PHI: 30-day. HRAC 02.

Raptor (imazamox) POST *Beans (Fresh), Lima Beans, Peas (Fresh)* | 4 fl. oz. per acre. For **fresh peas**: apply 3 fl. oz. per acre when crop is at least 3 inches tall but prior to 5 nodes before flowering. Must add NIS. May add COC or N fertilizer. If using COC, you must add Basagran or Rezult. For **fresh beans** *in Illinois, Indiana, Iowa, Michigan, and Minnesota*: apply 4 fl. oz. per acre after the first trifoliate is fully expanded and before bloom. Must add NIS. Do not add COC. May add N fertilizer. Must add Basagran or Rezult. For **succulent Lima beans**: apply 4 fl. oz. per acre when first or second trifoliate is fully expanded and before bloom. Must add NIS. Must add Basagran or Rezult. **Notes:** Use COC (1% v/v) or NIS (0.25% v/v), or 2.5 gals. of nitrogen, or 12-15 lbs. ammonium sulfate per 100 gals. of spray solution to improve weed control (but may increase crop injury). Use Basagran at 6-16 fl. oz. per acre or Rezult at 12-24 fl. oz. per acre to minimize crop injury. In all cases, Raptor is most effective on weeds less than 3 inches tall, and the 3 fl. oz. rate is weak on grasses. Using Raptor on fields treated with trifluralin may increase the risk of injury. Do not exceed 1 application per year. REI: 4-hour. PHI: 30-day when tank mixed with Basagran or Rezult. HRAC 02.

Reflex (fomesafen) PRE *Beans (Fresh), Peas (Fresh)* | For **fresh beans:** Reflex is labeled in all states participating in this publication except in Kansas west of Highway 281 and in Minnesota north of Highway 2. It can be used in extreme southeast Missouri (Region 1) at 1.5 pts. per acre year; Indiana, Illinois, and Ohio south of I-70 (Region 2) at 1.5 pts. per acre in alternate years; Indiana, Illinois, and Ohio north of I-70 (Region 3), and the rest of Missouri at 1.25 pts. per acre in alternate years; Kansas east of Highway 281 and Michigan and Minnesota south of I-94 (Region 4) at 1 pt. per acre in alternate years; and in Minnesota south of Highway 2 and north of I-94 (Region 5) at 0.75 pt. per acre in alternate years. Preplant and preemergence applications are labeled for Regions 1, 2, 3, and 4. Postemergence applications are labeled for Regions 1, 2, 3, 4, and 5. Apply postemergence when beans have at least one fully expanded trifoliate leaf, and use NIS, COC, or other additives following label instructions. Do not use liquid nitrogen or ammonium sulfate as an additive. For **fresh peas** *with special 24c label only*: apply 1 pt. per acre in a tank-mix with other herbicides after seeding peas and before emergence. Use only once in 2 years on same soil. 18-month waiting period before planting most other crops. REI: 24-hour. PHI: 30-day. HRAC 14.

Rezult (bentazon, sethoxydim) POST *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | 3.2 pts. per acre. Apply when weeds are small and after peas have 3 pairs of leaves or first trifoliate leaf of beans is fully expanded. An additional application of Basagran is allowed not to exceed 2 pts. per acre, and an additional application of Poast is allowed at 2.9 pts. per acre. REI: 48-hour. PHI: 30-day. HRAC 06, HRAC 01.

Sandea (halosulfuron) POST | PRE *Beans (Fresh), Lima Beans, Southern Peas/Cowpeas* | 0.5-1 oz. per acre. For **Southern peas/cowpeas:** apply 0.5 oz. per acre after planting but prior to soil cracking. Or use up to 1.0 oz. per acre as a directed postemergence application to the row middles when plants have 2-4 trifoliate leaves but before flowering. For **Lima beans and fresh beans:** apply 0.5-1.0 oz. per acre after planting but prior to soil cracking. Or, use 0.5-0.67 oz. per acre for postemergence applications over crop and weeds when plants have 2-4 trifoliate leaves but before flowering, or use up to 1 oz. per acre as a directed postemergence application to row middles with no crop contact. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are

present at time of preemergence application. Use lower rates on coarse soils with low organic matter. Not recommended when temperatures are cool due to potential for crop injury. Do not exceed 1 oz. per acre per crop cycle or 2 oz. per acre per 12-month period. REI: 12-hour. PHI: 30-day. HRAC 02.

Sharpen (saflufenacil) POST | PRE | *Peas (Fresh)* | *In Illinois, Iowa, Michigan, and Minnesota*: apply 0.75 fl. oz. per acre preplant incorporated or preemergence up to 3 days after planting before cracking. Suppresses black nightshade, lambsquarters, pigweed, and velvetleaf. Higher rates in lentils and chickpeas will provide more, but still limited, residual weed control. Plant legumes at least 1/2-inch deep to avoid injury. Do not apply group 14 herbicides within 30 days of planting. REI: 12-hour. HRAC 14.

Spartan Advance (glyphosate, sulfentrazone) POST | PRE | *Lima Beans, Southern Peas/Cowpeas* | 16-57 fl. oz. per acre. Spring-apply early-preplant, preplant-incorporated, or preemergence. Rate depends on soil texture, organic matter, and pH. Do not use on sand soils with less than 1% organic matter or apply after crop emerges. Provide simultaneous burndown of emerged weeds and residual premergence weed control. *Michigan, Minnesota, and Wisconsin only:* a fall application is allowed for control of weeds ahead of winter. REI: 12-hour. PHI: 90-day. HRAC 9, HRAC 14.

Sulfen 4SC (sulfentrazone) PRE *Peas (Fresh)* | Apply 2.25-6 fl. oz. per acre prior to crop emergence. Do not apply in extended periods of dry weather. Do not exceed 6 fl. oz. per acre in a single application. Do not exceed 6 fl. oz. per acre per year. On coarse soils with less than 1.5% organic matter, wait at least 7 days between application and planting. Do not use on sand or soils with less than 1% organic matter. REI: 12-hour. HRAC 14.

Thistrol (MCPB) POST *Peas (Fresh)* | 1-2 qts. per acre. Controls Canada thistle. Apply when peas have 6-12 nodes. Do not apply later than 3 nodes before pea flowering or after pea flower buds appear. Do not apply when peas are stressed or when temperature exceeds 90 F. REI: 24-hour. HRAC 04.

trifluralin products (trifluralin) PRE *Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas* | Use 4E formulations at 1-1.5 pts. per acre for snap beans, lima beans, and peas. Use 10G formulations at 5-7.5 lbs. per acre for snap beans, lima beans, and peas. Broadcast and incorporate 1-2 inches before seeding. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils REI: 12-hour. HRAC 03.

Potato - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Brad Bergefurd – Apr 2022

Crop Description

Potatoes (*Solanum tuberosum*) are a staple food grown from small tubers of a mother plant that is grown by specialized seed-potato producers. The Midwest produces potatoes primarily for table stock and processing into potato chips. Varieties used for chipping are usually brown skinned, white-fleshed, and globe-shaped to facilitate slicing from any direction. Table stock potatoes include 'starchy' (high dry matter) baking varieties and 'waxy' (low dry matter) boiling varieties in numerous skin and flesh color combinations with widely variable sizes and shapes. Starchy varieties include the Russets. Waxy varieties include Norland Reds. Some varieties are intermediate between those two types, for example Yukon Gold.

Scab is an important disease that affects the marketability of table stock potatoes. One way to manage scab is to maintain a soil pH of 5.0 to 5.2. However, low soil pH reduces phosphorus availability, and most rotational crops will not perform well at the low pH. In fields with a history of scab, using scab-resistant varieties is the best option to avoid having to adjust pH to the detriment of rotational crops.

Planting and Spacing

Tuber production: Rows 34 to 36 inches apart. Seed pieces 9 to 11 inches apart in row, depending on variety and intended use. Seed 16 to 18 100-pound bags per acre. Seed piece should be 1-1/2 to 2 ounces. Using B-size certified seed will save cutting labor and reduce tuber-borne diseases.

Seed stock production: Select seed stock from high-yielding hills that are smooth, well-shaped, and free of diseases and insect injury. When possible, obtain certified G1 or G2 (generation) seed stock. Store seed stock in new crates to avoid disease contamination. Seed potatoes should be at least 1-1/2 to 2 ounces in weight. If cutting larger seed potatoes, warm to 45 F before cutting, then sort to remove blind, slab, sliver, ripped, and undersized pieces after cutting. Cure cut stock at 38 F to 40 F, with 85% to 95% humidity in piles less than 6 feet deep, with good air circulation for 6 to 10 days. To supply one acre of seed potatoes, you need roughly 14,000 to 26,000 seed pieces.

Fertilizing

pH: Maintain a soil pH of 5.5 to 6.5.

Before planting, do not fertilize with N or P, but apply 50 to 400 pounds K_2O per acre based on soil test results and recommendations from your state. The most efficient way to spread the remaining fertilizer is with a banded application at planting at least 2 inches below and 2 inches to both sides of the tuber. As a banded starter fertilizer, apply 0 to 30 pounds N per acre, 0 to 150 pounds P_2O_5 per acre, and 0 to 200 pounds K_2O per acre. The rate of K_2O should not exceed 200 pounds per acre when banded.

Manganese may be needed when the soil pH is above 6.5 on mineral soils and above 5.8 on organic soils. Use a soil test to determine the amount of manganese needed. Include the required amount of manganese in the starter fertilizer, or spray the foliage with 1 to 2 pounds of manganese per acre at least twice during active growth. On sandy soils, broadcast 30 pounds or band 15 pounds sulfur per acre.

Sidedress once at emergence and once at hilling or tuber initiation with 50-75 pounds N per acre each time. The second application can be adjusted according to rainfall and a petiole nitrate-N analysis. Use lower end of range for early-maturing varieties. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer and other credits should be 100 to 150 pounds per acre.

Harvesting

"New" potatoes can be dug by hand from the sides of hills for continual harvest for fresh market sale, but they do not keep as well as a mature tuber. New potatoes can also be once-over harvested in sections at a time, but the chain conveyors can blemish the soft skins of these immature tubers.

Storage potato market life can be lengthened by preventing sprouting of potatoes in storage; use maleic hydrazide (Royal MH-30) according to label directions one week after blossoms fall. For varieties and conditions where flowering does not occur, apply four to six weeks before potatoes are mature and ready for harvest. Make only one application. Apply when no rain is expected for 24 hours. Potatoes treated with maleic hydrazide cannot be used for seed because sprouting will be inhibited. Follow label directions.

Storage potatoes benefit from uniform maturation for mechanical harvest. This can be accomplished by killing the

vines with a labeled herbicide. Once vines are down and dried, mechanical harvest can begin with chain-conveyor diggers. The labeled vine-killing herbicides are listed below, along with instructions.

Vine Kill Herbicides

Defol 5 (5L) (sodium chlorate) 4.8 qts. per acre with 10-20 gals. per acre water by ground or 5-10 gals. per acre water by air. Apply 10 days before harvest. Do not apply in extreme heat during the middle of the day. REI: 12-hour. HRAC NC.

paraquat formulations (paraquat) 0.8-1.5 pts. per acre of 2.5L or 0.6-1.3 pt. per acre of 3L in 50-100 gals. of water plus 1 gal. COC or 1-2 pts. nonionic surfactant per 100 gals. spray solution. **Not for potatoes to be stored or used for seed.** Begin applications when leaves begin to turn yellow. Immature potato foliage and drought-stressed potato foliage are tolerant to this product. Maximum 3 pts. of 2.5L or 2.6 pts. of 3L per acre per season. For split applications, use lower rate and wait 5 days between applications. Read label for complete instructions. *3L formulation not for use in Iowa or Missouri*. REI: 24-hour. PHI: 3-day. HRAC 22. *RUP*.

Reglone (2L) (diquat) 1-2 pts. per acre in 20-100 gals. water plus 8-64 fl. oz. nonionic surfactant. A second application can be made if necessary. Allow at least 5 days between applications. REI: 24-hour. PHI: 7-day. HRAC 22.

Rely 280 (2.34L) (glufosinate) 21 fl. oz. per acre. **Not for potatoes to be used for seed.** Do not make more than 1 application. REI: 12-hour. PHI: 9-day. HRAC 10.

Scythe (4.2L) (pelargonic acid) 5% to 10% solution in 75 to 200 gals. spray solution per acre. REI: 12-hour. PHI: 24-hour. HRAC NC.

Potato - Diseases

Reviewed by Dan Egel – Aug 2023

Aster Yellows (Purple-Top Wilt) of Multiple Crops - Phytoplasma Mollicutes

This pathogen is transmitted by leafhoppers. Infection rates can jump when adjacent crops are harvested mid-season, such as alfalfa or wheat.

Non-Pesticide

Plant only certified seed tubers. Practice clean cultivation. Rogue first infected plants, including tubers.

Pesticide

Insecticides | Use an insecticide to control leafhoppers that transmit the disease. Leafhoppers must be controlled before they feed. See Insect section.

Black Dot of Potatoes - Colletotrichum Fungus

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-12.8 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-25.6 fl. oz. per acre. REI: 4-hour. PHI: 14-day. FRAC 11.

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.1-2.25 pt. per acre. Use 54% (720) formulations at 0.75-1.5 pt. per acre. Use 82.5% (WDG) formulations at 0.7-1.4 lb. per acre. Use 90% (DF) formulations at 0.6-1.25 lb. per acre. REI: 12-hour. PHI: 7-day. FRAC M05.

Headline (pyraclostrobin) | 6-9 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11.

Luna Tranquility (fluopyram, pyrimethanil) | 8-11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

Miravis Prime (pydiflumetofen, fludioxonil) | 9.2-11.4 fl. oz. per acre. Black dot suppression only. Use high rate for white mold. REI: 12-hour. PHI: 14-day. FRAC 07, FRAC 12.

Quadris Opti (azoxystrobin, chlorothalonil) | 1.6 pts. per acre. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC M05.

Revus Top (mandipropamid, difenoconazole) | 5.5-7.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 40, FRAC 03.

Tanos (famoxadone, cymoxanil) | 6-8 oz. per acre. Black dot Disease suppression only. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 27.

Zing! (zoxamide, chlorothalonil) | 24-34 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 22, FRAC M05.

Black Leg of Potatoes - Pectobacterium or Dickeya Bacteria

Non-Pesticide

Use seed pieces certified to be free of disease. Plant in well-drained soil and avoid over-irrigation. Sanitize equipment at planting and at harvest to limit spread.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) | Several formulations of copper (e.g., Badge) products are labelled for use and may slow the spread of bacterial blight. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Double Nickel 55 (Bacillus amyloliquefaciens strain D-747) | 0.125-1 lbs. per acre as a soil drench or 0.25-3 lbs. per acre as a foliar application, according to disease management considerations. REI: 4-hour. PHI: 0-day. FRAC BM02. *OMRI-listed.*

streptomycin products (Streptomycin sulfate) | Use 17% products at 8 oz. per 100 gals of water, or 50% products at 2.7 oz. per 100 gals. of water to maintain a concentration of 100 ppm. Soak seed pieces in solution for several minutes. REI: 12-hour. FRAC 25.

Black Scurf of Potatoes - Rhizoctonia Fungus

Use a fungicide when appropriate.

Non-Pesticide

Plant seed pieces certified to be free of disease. Harvest potatoes as soon after maturity as possible. Rotation to a non-host crop 2-3 years.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 0.24-0.48 fl. oz. per 1,000 row feet. Use 22.9% formulations at 0.4-0.8 fl. oz. per 1,000 row feet. Use 18.4% formulations at 0.5-1.0 fl. oz. per 1000 row feet. Use 9.6% formulations (Dynasty) for seed treatment at 0.10-3.75 fl. oz. per 100 lbs. of seed. REI: 4-hour. FRAC 11.

Moncut (flutolanil) | 0.7-1.1 lbs. per acre of the DF formulation or 16-25 fl. oz. per acre of the SC formulation. REI: 12-hour. FRAC 07.

Dry Rot of Potatoes - Fusarium Fungus

Non-Pesticide

Avoid bruising at harvest. Cure potatoes in storage at 60 F before lowering temperature. Provide adequate ventilation.

Pesticide

mancozeb products (mancozeb) | Seed treatment; dip whole or cut potatoes in solution. Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Always check the label. Use 37% formulations at 1.6-2.5 qt. per acre. Use 75% and 80% formulations at 1.25 lb. per 50 gal. REI: 24-hour. PHI: 3-day in Michigan and Ohio; 14-day in all other states. FRAC M03.

Maxim 4FS (fludioxonil) | 0.08 fl. oz. per 100 lbs. of seed. Seed treatment. Use specific application equipment according to label. REI: 12-hour. FRAC 12.

Maxim MZ (mancozeb, fludioxonil) | 0.5 lbs. per 100 lbs. of seed. Seed treatment. REI: 24-hour. FRAC M03, FRAC 12.

Mertect 340-F (thiabendazole) | 0.42 oz. per 2,000 lbs. of tubers. 0.42 fl. oz. per 2,000 lbs. of tubers. Do not treat seed potatoes after cutting. *Fungicide resistance known* REI: 12-hour. FRAC 01.

Seed treatments for diseases (various ingredients) | Rates of other options otherwise not listed here vary by product, and are often multiple premixed ingredients. Select seed treatments Cruiser Maxx Vibrance Potato (thiamethoxam, difenconazole, sedaxane, fludioxonil); Cruiser Maxx Potato Extreme (thiamethoxam, difenoconazole, fludioxonil); Emesto Silver (penflufen, prothioconazole).

Stadium (azoxystrobin, difenoconazole, fludioxonil) | 1 fl. oz. per 2,000 lbs. of tubers. Postharvest application only; no more than one application to tubers. FRAC 11, FRAC 03, FRAC 12.

Early Blight of Potatoes - Alternaria Fungus

This disease initially causes lesions on lower leaves of the potato plant. After field planting, begin protective fungicide applications on a 7-14 day schedule.

Group 11 Resistance: Strains of the fungus that causes early blight that are resistant to group 11 fungicides have been observed in Indiana and Ohio. Group 11 products labeled for potato and early blight include Cabrio and Quadris. Tank-mix group 11 fungicides with products that have a different mode of action, or alternate group 11 fungicides with fungicides that have a different group number.

Non-Pesticide

Avoid fields with a history of nematodes, Fusarium or Verticillium wilts, droughty, wet, or compacted soils, and other conditions (such as insufficient nitrogen) that might add undue stress to the crop and increase susceptibility to early blight. Varieties with partial resistance are available. Rotate to non-host crops for 2-3 years.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-12.8 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-25.6 fl. oz. per acre. REI: 4-hour. PHI: 14-day. FRAC 11.

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.1-2.25 pt. per acre. Use 54% (720) formulations at 0.75-1.5 pt. per acre. Use 82.5% (WDG) formulations at 0.7-1.4 lb. per acre. Use 90% (DF) formulations at 0.6-1.25 lb. per acre. REI: 12-hour. PHI: 7-day. FRAC M05.

Endura (boscalid) | 3.5-4.5 oz. per acre. REI: 12-hour. PHI: 10-day. FRAC 07.

Gavel 75DF (zoxamide, mancozeb) | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 3-day in Michigan and Ohio; 14-day in all other states. FRAC 22, FRAC M03.

Headline (pyraclostrobin) | 6-9 fl. oz. per acre. REI: 12-hour. PHI: 3-day. FRAC 11.

iprodione products (iprodione) | 1-2 pts. per acre. Formulations of iprodione include Nevado and Rovral. REI: 24-hour. PHI: 14-day. FRAC 02.

Luna Tranquility (fluopyram, pyrimethanil) | 8-11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Always check the label. Use 37% formulations at 0.4-1.6 qt. per acre. Use 75% and 80% at 0.5-2.0 lb. per acre. REI: 24-hour. PHI: 14-day. FRAC M03.

Miravis Prime (pydiflumetofen, fludioxonil) | 9.2-11.4 fl. oz. per acre. Black dot suppression only. Use high rate for white mold. REI: 12-hour. PHI: 14-day. FRAC 07, FRAC 12.

Quadris Opti (azoxystrobin, chlorothalonil) | 1.6 pts. per acre. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC M05.

Revus Top (mandipropamid, difenoconazole) | 5.5-7.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 40, FRAC 03.

Scala (pyrimethanil) | 7 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 09.

Tanos (famoxadone, cymoxanil) | 6 oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 27.

Velum Prime (fluopyram) | 6.5-6.84 fl .oz. per acre. Apply through overhead chemigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 5 days between applications. REI: 12-hour. PHI: 7-day. FRAC 07.

Zing! (zoxamide, chlorothalonil) | 24-34 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 22, FRAC M05.

Late Blight of Potatoes/Tomatoes - Phytophthora Oomycete

This destructive pathogen causes quick plant death and can be identified by large spreading brown stem lesions, velvety white growth on plant surfaces, and large brown leathery spots on green fruits. It is favored by prolonged cool and damp conditions.

The pathogen overwinters on plant residue, including volunteer potatoes and potato cull piles. When it is reported in your region, begin weekly preventive sprays with chlorothalonil and mancozeb for as long as favorable conditions persist. Pay attention to which pathogen strain is

identified. If infections start in a field, the strain US-23 is sensitive to mefenoxam (Ridomil).

Non-Pesticide

The first step to manage this disease is monitoring and destroying cull and volunteer potato emergence in the spring.

Pesticide

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.1-2.25 pt. per acre. Use 54% (720) formulations at 0.75-1.5 pt. per acre. Use 82.5% (WDG) formulations at 0.7-1.4 lb. per acre. Use 90% (DF) formulations at 0.6-1.25 lb. per acre. REI: 12-hour. PHI: 7-day. FRAC M05.

Curzate 60DF (cymoxanil) | 3.2 oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 27.

Gavel 75DF (zoxamide, mancozeb) | 1.5-2 lbs. per acre. REI: 48-hour. PHI: 3-day in Michigan and Ohio; 14-day in all other states. FRAC 22, FRAC M03.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Always check the label. Use 37% formulations at 0.4-1.6 qt. per acre. Use 75% and 80% at 0.5-2.0 lb. per acre. REI: 24-hour. PHI: 14-day. FRAC M03.

Omega 500F (fluazinam) | 5.5 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 29.

Orondis Opti (oxathiapiprolin, chlorothalonil) | 1.75-2.5 pts. per acre. REI: 12-hour. PHI: 7-day. FRAC 49, FRAC M05.

Orondis Ultra (oxathiapiprolin, mandipropamid) | 5.5-8 fl. oz. per acre. REI: 4-hour. PHI: 14-day. FRAC 49, FRAC 40.

Previcur Flex (propamocarb) | 0.7-1.2 pts. per acre. REI: 12-hour. PHI: 14-day. FRAC 28.

Ranman 400SC (cyazofamid) | 1.4-2.75 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 21.

Revus Top (mandipropamid, difenoconazole) | 5.5-7.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 40, FRAC 03.

Tanos (famoxadone, cymoxanil) | 6-8 oz. per acre. Black dot Disease suppression only. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 27.

Zampro (ametoctradin, dimethomorph) | 11-14 fl. oz. per acre. REI: 12-hour. PHI: 4-day. FRAC 45, FRAC 40.

Zing! (zoxamide, chlorothalonil) | 30-34 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 22, FRAC M05.

Nematodes

Potato cyst nematodes are serious pathogens that reduce stands, yield and tuber quality. As sedentary endoparasites, the female body hardens into a cyst that protects its eggs for a decade or so in absence of a host.

Root lesion nematodes form a destructive disease complex with Verticillium, called Potato Early-Die. Both root lesion nematodes and Verticillium can be supported by multiple crops, which makes it difficult to control through rotation.

Non-Pesticide

Collect soil samples for nematodes in the fall and avoid fields with high numbers. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >3 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue and displace nematodes is an important method to prevent nematode build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain nematodes.

Pesticide

K-PAM HL (metam potassium) | 30-60 gals. per acre for K-PAM HL or 30-63.9 gals. per acre for Sectagon K54. Use high rates on muck and lower rates on sands. In the fall, when soil at 6 inches are above 50 F and moist, place K-PAM HL or Sectagon K54 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Nimitz (fluensulfone) | 3.5-7.0 pts. per acre. May be broadcast, banded, or drip-applied in the spring up to 7 days before planting at a depth of 8 inches. Effectiveness is reduced on muck and clay soils REI: 12-hour. IRAC UN.

Telone C-17 (1,3-dichloropropene, chloropicrin) | *Muck soils*: 30 gals. per acre for C-17 formulation and 36 gals. per acre for C-35 formulation. *Mineral soils*: 18-27.5 gals. per acre for C-17 formulation and 21.4-33 gals. per acre for C-35 formulation. In the fall, when soil temperatures at 6 inches are above 50 F and soil is moist, place product about 8 inches

beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing, irrigation, or plastic. Or, in the spring, InLine may be applied through drip irrigation under unperforated plastic beds at 13-20.5 gals. per acre (on mineral soils only). Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 3-5-day. IRAC 8A, FRAC NC, IRAC 08B. *RUP.*

Telone II (1,3-dichloropropene) | *Muck soils*: Use at 25 gals. per acre. *Mineral soils*: Use at 9-12 gals. per acre. In the fall, when soil at 6 inches is above 50 F and moist, place Telone II about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, Telone EC may be applied through drip irrigation under unperforated plastic beds at 9-18 gals. per acre on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 8A, FRAC NC. *RUP.*

VAPAM HL (metam sodium) | 37.5-75 gals. per acre for VAPAM HL, or 30-75 gals. per acre of Sectagon K42. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place VAPAM HL or Sectagon K42 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Velum Prime (fluopyram) | 6.5-6.84 fl .oz. per acre. Apply through overhead chemigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 5 days between applications. REI: 12-hour. PHI: 7-day. FRAC 07.

Vydate C-LV (oxamyl) | 34-68 fl. oz. per acre. Apply as a banded or shank-injected at-plant in-furrow soil treatment incorporated 2-4 inches deep with at least 20 gals. water per acre, or overhead chemigate to deliver rate in 0.5 inch of irrigation water. Do not exceed 8 applications or 306 fl. oz. per acre per season. *In Kansas*, allow 14 days between applications and do not exceed 4 applications or 204 fl. oz. per acre per season. REI: 48-hour. PHI: 7-day. IRAC 01A. *RUP.*

Ring Rot of Potatoes - Clavibacter Bacteria

The ring rot bacterium is easily spread. Although this bacterium will not survive more than 1 year in the soil (and thus can be controlled by crop rotation), a farm with ring rot must conduct a thorough clean-up before bringing in seed for the next crop. The organism can easily survive the winter in crop debris or soil on storage walls; seed cutters, bin pilers, graders, and other handling equipment; tractors, fork lifts and other vehicles; and on burlap sacks, wooden boxes, or other containers. If clean seed potatoes contact any of these contamination sources, the problem can recur.

Non-Pesticide

Use certified disease-free seed. When cutting seed stock, the cutter should be periodically cleaned and disinfected, especially when changing seed lots. The first step is to clean all contaminated surfaces with hot soapy water under pressure or steam to remove all soil and debris. Then apply a disinfectant sanitizer. For more information about sanitation, see *Commercial Greenhouse and Nursery Production: Sanitation for Disease and Pest Management* (Purdue Extension publication HO-250-W), available from the Education Store, www.edustore.purdue.edu.

Scab of Potatoes - Streptomyces Bacteria

Scab is more common on potatoes grown in soils with pH over 5.2.

Non-Pesticide

Avoid fields with a history of nematodes, Fusarium or Verticillium wilts, droughty, wet, or compacted soils, and other conditions (such as insufficient nitrogen) that might add undue stress to the crop and increase susceptibility scab. Acidify soil to a pH between 5.0 and 5.2 with elemental sulfur in the fall prior to planting.

Silver Scurf of Potatoes - Helminthosporium Fungus

Use a fungicide when appropriate.

Non-Pesticide

Plant seed pieces certified to be free of disease. Harvest potatoes as soon after maturity as possible. Rotation to a non-host crop 2-3 years.

Pesticide

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 0.24-0.48 fl. oz. per 1,000 row feet. Use 22.9% formulations at 0.4-

0.8 fl. oz. per 1,000 row feet. Use 18.4% formulations at 0.5-1.0 fl. oz. per 1000 row feet. Use 9.6% formulations (Dynasty) for seed treatment at 0.10-3.75 fl. oz. per 100 lbs. of seed. REI: 4-hour. FRAC 11.

White Mold (Timber Rot, Drop, Stem Rot) of Multiple Crops - Sclerotinia Fungus

This soil pathogen is long-lived in the soil, and has a wide host range on broadleaved crops and weeds, including beans, vine crops, lettuce, tomatoes, peppers, and cole crops. It goes by other names in other crops, such as Drop, White Mold, Stem Rot, and Timber Rot.

It is more commonly where humidity and temperatures are high. The fungus often infects flowers, which then drop off and infect the stems that they land on. But, the pathogen can also infect stem tissue around the root crown. The stems take on a woody appearance and can split open, revealing small black pellets that are the overwintering body of the pathogen.

Non-Pesticide

Avoid fields with a history of the problem. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >6 years. Avoid excess nitrogen. Reduce overhead irrigation if disease is present. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Contans WG (Coniothyrium minitans strain CON/M/91-08) | 1-6 lbs. per acre. Apply immediately after harvest or 3-4 months before planting. REI: 4-hour. FRAC BM02. *OMRI-listed.*

Endura (boscalid) | 5.5-10 oz. per acre. REI: 12-hour. PHI: 10-day. FRAC 07.

iprodione products (iprodione) | 2 pts. per acre. Formulations of iprodione include Nevado and Rovral. REI: 24-hour. PHI: 14-day. FRAC 02.

Luna Tranquility (fluopyram, pyrimethanil) | 11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 09.

Miravis Prime (pydiflumetofen, fludioxonil) | 9.2-11.4 fl. oz. per acre. Black dot suppression only. Use high rate for white mold. REI: 12-hour. PHI: 14-day. FRAC 07, FRAC 12.

Omega 500F (fluazinam) | 5.5-8 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 29.

Topsin M WSB (thiophanate-methyl) | 20-30 fl. oz. per acre. 20-30 fl. oz. per acre for Topsin 4.5FL, 21.8-32.7 fl. oz. per acre for Cercobin, or 1-1.5 lbs. per acre for Topsin M WSB. REI: 24-hour to 3-day. PHI: 21-day PHI. FRAC 01.

Velum Prime (fluopyram) | 6.5-6.84 fl .oz. per acre. Apply through overhead chemigation. Do not exceed 13.7 fl. oz. per acre per season. Allow 5 days between applications. REI: 12-hour. PHI: 7-day. FRAC 07.

Wilt of Multiple Crops - Verticillium Fungus

This pathogen can interact with root lesion nematodes to create a destructive condition known as Potato Early-Die.

Non-Pesticide

Choose potato varieties that have partial resistance to Verticillium wilt. Good weed control also is important in reducing pathogen populations. Employ at least a 2-year rotation with small grains to manage fungus populations in the soil.

Potato - Insects

Major update Zsofia Szendrei, Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) | 3.0 oz. per acre. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Admire Pro (imidacloprid) | *Seed treatment*: 0.17-0.35 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 1.3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications. IRAC 04A.

Asana XL (esfenvalerate) | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) | Use 30SG formulations at 2.5-4.0 oz. per acre. Use 70WP formulations at 1.0-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Athena (bifenthrin, abamectin) | 7-17 fl. oz. per acre. REI: 12-hour. PHI: 21-day. IRAC 03A, IRAC 06. *RUP.*

Belay (clothianidin) | *Seed treatment*: 0.4-0.6 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 2-3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Beleaf (flonicamid) | 2.0-2.8 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 29.

Besiege (chlorantraniliprole, lambda-cyhalothrin) | 6 to 9 fl. oz. per acre REI: 24-hour. IRAC 28, IRAC 03A. *RUP.*

Brigadier (bifenthrin, imidacloprid) | Apply 16.0-25.6 fl. oz. per acre at plant as an in-furrow spray on to the seed pieces or seed potatoes. Apply 3.8-6.14 fl. oz. per acre as a foliar application. REI: 12-hour. PHI: 21-days. IRAC 03A, IRAC 04A. *RUP.*

Dimethoate 4EC (dimethoate) | Use 2.67EC formulations at 0.75-1.5 pt. per acre. Use 4EC, LV-4, and 400 formulations at 0.5-1 pt. per acre. REI: 48-hour. PHI: 0-day. IRAC 01B.

Fulfill (pymetrozine) | 2.75-5.5 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 09B.

Lannate LV (methomyl) | 1.5-3.0 pts. per acre. REI: 48-hour. PHI: 6-day. IRAC 01A. *RUP.*

M-Pede (potassium salts of fatty acids) | 1-2% by volume. Must contact aphids to be effective. Combine with another labeled product for best results. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Movento (spirotetramat) | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 23.

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as a preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. REI: 12-hour. IRAC 04A.

Seed treatments for insects (various ingredients) | Rates of other options otherwise not listed here vary by product, and are often multiple premixed ingredients. Select seed treatments with an insecticide ingredient, such as thiamethoxam (Cruiser 5FS, Cruiser Maxx Vibrance Potato; Cruiser Maxx Potato Extreme).

Sivanto 200 (flupyradifurone) | 7.0-10.5 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 04D.

Thimet 20G (phorate) | *Light or sandy soils*: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches at planting or postemergence. *Heavy or clay soils*: 13.0-17.3 oz. per 1,000 ft. of row at planting but do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. IRAC 01B. *RUP.*

Torac (tolfenpyrad) | 17-21 fl. oz. per acre. See pollination precautions. REI: 12-hour. PHI: 14-day. IRAC 21A, FRAC 39.

Transform WG (sulfoxaflor) | 0.75-1.5 oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 04C.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Vydate C-LV (oxamyl) | 17-34 fl. oz. per acre. REI: 48-hour. PHI: 7-day. IRAC 01A. *RUP.*

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Caterpillars

There are many caterpillar pests of fruiting vegetables, including corn earworm/tomato fruitworm, tomato hornworm, tomato pinworm, European corn borer, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Pesticide

Asana XL (esfenvalerate) | 5.8-9.6 fl. oz. per acre. For corn borers, and cutworms. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) | For corn borers as an ovicide. Use 30SG formulations at 2.5-4.0 oz. per acre. Use 70WP formulations at 1.1-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Athena (bifenthrin, abamectin) | 7-17 fl. oz. per acre. For corn borers, and cutworms. REI: 12-hour. PHI: 21-day. IRAC 03A, IRAC 06. *RUP.*

Avaunt (indoxacarb) | 3.5-6.0 oz. per acre. For corn borers. REI: 12-hour. PHI: 7-day. IRAC 22A.

Baythroid XL (beta-cyfluthrin) | 0.8-2.8 fl. oz. per acre. For corn borers, and cutworms. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) | 3.5-7.5 fl. oz. per acre. For corn borers. REI: 4-hour. PHI: 14-day. IRAC 28.

Diazinon AG500 (diazinon) | 3-4 qts. per acre. For cutworms in *Ohio 24c label only.* Use as a pre-plant incorporation and do not exceed 1 application per season. REI: 2 to 4-day. IRAC 01B. *RUP.*

Endigo ZCX (thiamethoxam, lambda-cyhalothrin) | 3.0-3.5 fl. oz. per acre. For corn borers, and cutworms. REI: 24-hour. PHI: 14-day. IRAC 04A, IRAC 03A. *RUP.*

Entrust SC (spinosad) | For corn borers. Use 2SC formulations at 3.0-10.0 fl. oz. per acre. Use 80WP formulations at 1.0-3.0 oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 05. *OMRI-listed.*

Lannate LV (methomyl) | 1.5 pts. per acre. For cutworms. REI: 48-hour. PHI: 6-day. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 1.28-4.0 fl. oz per acre. For corn borers, and cutworms. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | For corn borers, and cutworms. Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) | 6-8 fl. oz. per acre. For corn borers. REI: 4-hour. PHI: 7-day. IRAC 05.

Rimon 0.83EC (novaluron) | 6-12 fl. oz. per acre. For corn borers. REI: 12-hour. PHI: 14-day. IRAC 15.

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. For corn borers, and cutworms. REI: 12-hour. PHI: 7-day. IRAC 01A.

Tombstone (cyfluthrin) | 0.8-2.8 fl. oz. per acre. For cutworms and loopers. REI: 12-hour. PHI: 12-hour. IRAC 03A. *RUP.*

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. For corn borers. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Warrior II (lambda-cyhalothrin) | 0.96-1.92 For corn borers, and cutworms. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Colorado Potato Beetle

Colorado potato beetles have become resistant to many insecticides. It is recommended that the same insecticide class that was used in the early generation is not used again in the later generation for resistance management. The following insecticides and timings should be considered.

In-furrow at seeding: Admire Pro, Platinum, Cruiser, Verimark.

Early generation beetles and larvae: Agri-Mek, Coragen, Exirel, Torac, Rimon, Radiant, Entrust.

Later generation beetles: Agri-Mek, Coragen, Besiege, Exirel, Avaunt, Torac, Radiant, Entrust, Actara, Endigo ZC.

Insecticidal soaps and horticultural oils are most effective on young larvae, with control rates ranging from 40-70%. These methods are less effective on adult beetles and require frequent reapplication. The biopesticide, spinosad (Entrust), works well against larvae but is not economically feasible in large-scale potato production. The biopesticide, *Beauvaria bassiana* (Botanigard) works well under moist conditions, reducing beetle numbers by up to 50-75%, but is slower acting than chemical insecticides.

Threshold depends on plant growth stage. When plants are small and haven't flowered, treat when beetles have done 20-30% defoliation, when plants are flowering, treat at 5-10% defoliation, when tubers are forming, treat at 30% defoliation.

Non-Pesticide

Crop rotation is effective at disrupting the beetle life cycle, but its efficacy depends on the distance from previous potato plantings. Beetles can migrate from nearby fields, so large rotations or isolating potato fields are more successful. Trap cropping can be effective, especially when combined with targeted insecticide use. Beetles are drawn to early-planted potato, and growers can reduce overall beetle numbers by controlling them on the trap crop. Efficacy depends on the trap crop's placement and management. On smaller scale farms, early handpicking prevents populations from growing, and deep mulching can reduce populations by 50-75% by hindering their movement.

Pesticide

Actara (thiamethoxam) | 3.0 oz. per acre. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Admire Pro (imidacloprid) | *Seed treatment*: 0.17-0.35 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 1.3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications. IRAC 04A.

Agri-Mek SC (abamectin) | Use 0.7SC formulations at 1.75-3.5 fl. oz. per acre. Use 0.15SC formulations at 8-16 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 06. *RUP.*

Asana XL (esfenvalerate) | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) | Use 30SG formulations at 1.5-4.0 oz. per acre. Use 70WP formulations at 0.6-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Athena (bifenthrin, abamectin) | 7-17 fl. oz. per acre. REI: 12-hour. PHI: 21-day. IRAC 03A, IRAC 06. *RUP.*

Avaunt (indoxacarb) | 3.5-6.0 oz. per acre. Control may be enhanced by including a 91% piperonyl butoxide product as a synergist at 4 oz. per ac. REI: 12-hour. PHI: 7-day. IRAC 22A.

Baythroid XL (beta-cyfluthrin) | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) | *Seed treatment*: 0.4-0.6 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 2-3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Besiege (chlorantraniliprole, lambda-cyhalothrin) | 6 to 9 fl. oz. per acre REI: 24-hour. IRAC 28, IRAC 03A. *RUP.*

BotaniGard ES (Beauveria bassiana strain GHA) | 16 to 32 fl. oz. per acre. Effective when used repeatedly early in infestations, and with high moisture from rain or irrigation. REI: 4-hour. IRAC UNF.

Brigadier (bifenthrin, imidacloprid) | Apply 16.0-25.6 fl. oz. per acre at plant as an in-furrow spray on to the seed pieces or seed potatoes. Apply 3.8-6.14 fl. oz. per acre as a foliar application. REI: 12-hour. PHI: 21-days. IRAC 03A, IRAC 04A. *RUP.*

Coragen (chlorantraniliprole) | 3.5-7.5 fl. oz. per acre. REI: 4-hour. PHI: 14-day. IRAC 28.

Endigo ZCX (thiamethoxam, lambda-cyhalothrin) | 3.0-3.5 fl. oz. per acre. REI: 24-hour. PHI: 14-day. IRAC 04A, IRAC 03A. *RUP.*

Entrust SC (spinosad) | Use 2SC formulations at 3.0-10.0 fl. oz. per acre. Use 80WP formulations at 1.0-2.0 oz. per acre. Tolerance/resistance has been observed in Minnesota. Observe resistance management restrictions. REI: 4-hour. PHI: 7-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) | 5.0-13.5 fl. oz. per acre. Do not apply more than twice per generation. REI: 12-hour. PHI: 7-day. IRAC 28.

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Neemix (azadirachtin) | 4-16 fl. oz. per acre. Use on larvae. REI: 4-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as a preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. REI: 12-hour. IRAC 04A.

Radiant 1SC (spinetoram) | 4.5-8 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 05.

Rimon 0.83EC (novaluron) | 6-12 fl. oz. per acre. Only effective on larvae. REI: 12-hour. PHI: 14-day. IRAC 15.

Scorpion 35SL (dinotefuran) | *Soil application*: Use Scorpion 35SL at 11.5-13.25 fl. oz. per acre, or Venom 70SG at 6.5-7.5 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. *Foliar application*: Use Scorpion 35SL at 2.0-2.75 fl. oz. per acre, or Venom 70SG at 1.0-1.5 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day. IRAC 04A.

Seed treatments for insects (various ingredients) | Rates of other options otherwise not listed here vary by product, and are often multiple premixed ingredients. Select seed treatments with an insecticide ingredient, such as thiamethoxam (Cruiser 5FS, Cruiser Maxx Vibrance Potato; Cruiser Maxx Potato Extreme).

Sevin XLR Plus (carbaryl) | 1.0-2.0 qts. per acre. Some Colorado Potato Beetle populations are resistant to carbaryl, so results may vary. REI: 12-hour. PHI: 7-day. IRAC 01A.

Sivanto 200 (flupyradifurone) | 10.5-14.0 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 04D.

Thimet 20G (phorate) | *Light or sandy soils*: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches at planting or postemergence. *Heavy or clay soils*: 13.0-17.3 oz. per 1,000 ft. of row at planting but do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. IRAC 01B. *RUP.*

Tombstone (cyfluthrin) | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 12-hour. IRAC 03A. *RUP.*

Torac (tolfenpyrad) | 14-21 fl. oz. per acre. See pollination precautions. REI: 12-hour. PHI: 14-day. IRAC 21A, FRAC 39.

Trident (Bacillus thuringiensis tenebrionis strain SA-10) | 3-6 qts. per acre.p Effective on small (up to 1/4 inch) larvae only. Use higher rate for mixed sizes or heavier infestations. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Trigard (cyromazine) | 2.66-5.32 oz. per acre. REI: 12-hour. PHI: 17-day. IRAC 17.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Flea Beetles

Pesticide

Actara (thiamethoxam) | 3.0 oz. per acre. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Admire Pro (imidacloprid) | *Seed treatment*: 0.17-0.35 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 1.3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications. IRAC 04A.

Asana XL (esfenvalerate) | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) | Use 30SG formulations at 1.5-2.5 oz. per acre. Use 70WP formulations at 0.6-1.1 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Athena (bifenthrin, abamectin) | 7-17 fl. oz. per acre. REI: 12-hour. PHI: 21-day. IRAC 03A, IRAC 06. *RUP.*

Baythroid XL (beta-cyfluthrin) | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) | *Seed treatment*: 0.4-0.6 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 2-3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Brigadier (bifenthrin, imidacloprid) | Apply 16.0-25.6 fl. oz. per acre at plant as an in-furrow spray on to the seed pieces or seed potatoes. Apply 3.8-6.14 fl. oz. per acre as a foliar application. REI: 12-hour. PHI: 21-days. IRAC 03A, IRAC 04A. *RUP.*

Endigo ZCX (thiamethoxam, lambda-cyhalothrin) | 3.0-3.5 fl. oz. per acre. REI: 24-hour. PHI: 14-day. IRAC 04A, IRAC 03A. *RUP.*

Lannate LV (methomyl) | 1.5 pts. per acre. REI: 48-hour. PHI: 6-day. IRAC 01A. *RUP.*

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as a preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. REI: 12-hour. IRAC 04A.

Scorpion 35SL (dinotefuran) | *Soil application*: Use Scorpion 35SL at 11.5-13.25 fl. oz. per acre, or Venom 70SG at 6.5-7.5 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. *Foliar application*: Use Scorpion 35SL at 2.0-2.75 fl. oz. per acre, or Venom 70SG at 1.0-1.5 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day. IRAC 04A.

Seed treatments for insects (various ingredients) | Rates of other options otherwise not listed here vary by product, and are often multiple premixed ingredients. Select seed treatments with an insecticide ingredient, such as thiamethoxam (Cruiser 5FS, Cruiser Maxx Vibrance Potato; Cruiser Maxx Potato Extreme).

Sevin XLR Plus (carbaryl) | 0.5-1.0 qts. per acre. REI: 12-hour. PHI: 7-day. IRAC 01A.

Thimet 20G (phorate) | *Light or sandy soils*: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches at planting or postemergence. *Heavy or clay soils*: 13.0-17.3 oz. per 1,000 ft. of row at planting but do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. IRAC 01B. *RUP.*

Tombstone (cyfluthrin) | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 12-hour. IRAC 03A. *RUP.*

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Leafhoppers

Aster leafhopper and potato leafhopper are common in our region and crops. They don't survive the winter in northern areas, and migrate from southern areas every growing season. A condition known as "hopperburn" is caused by potato leafhopper feeding, and aster yellows is a disease vectored by aster leafhopper feeding. The amount of aster yellows present in any leafhopper population varies by year and location. Some states in the region have programs that test for and track the percentage of aster leafhoppers that are carrying aster yellows. Leafhoppers can move into vegetable fields when neighboring grain or alfalfa is harvested.

Non-Pesticide

Avoid planting near early grain and alfalfa fields.

Pesticide

Actara (thiamethoxam) | 3.0 oz. per acre. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Admire Pro (imidacloprid) | *Seed treatment*: 0.17-0.35 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 1.3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications. IRAC 04A.

Asana XL (esfenvalerate) | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) | Use 30SG formulations at 1.5-4.0 oz. per acre. Use 70WP formulations at 0.6-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Athena (bifenthrin, abamectin) | 7-17 fl. oz. per acre. REI: 12-hour. PHI: 21-day. IRAC 03A, IRAC 06. *RUP.*

Baythroid XL (beta-cyfluthrin) | 0.8-1.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) | *Seed treatment*: 0.4-0.6 fl. oz. per 100 lbs of seed applied directly to seed pieces. *Soil application*: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. *Foliar application*: 2-3 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Besiege (chlorantraniliprole, lambda-cyhalothrin) | 5 to 8 fl. oz. per acre REI: 24-hour. IRAC 28, IRAC 03A. *RUP.*

Brigadier (bifenthrin, imidacloprid) | Apply 16.0-25.6 fl. oz. per acre at plant as an in-furrow spray on to the seed pieces or seed potatoes. Apply 3.8-6.14 fl. oz. per acre as a foliar application. REI: 12-hour. PHI: 21-days. IRAC 03A, IRAC 04A. *RUP.*

Dimethoate 4EC (dimethoate) | Use 2.67EC formulations at 0.75-1.5 pt. per acre. Use 4EC, LV-4, and 400 formulations at 0.5-1 pt. per acre. REI: 48-hour. PHI: 0-day. IRAC 01B.

Endigo ZCX (thiamethoxam, lambda-cyhalothrin) | 3.0-3.5 fl. oz. per acre. REI: 24-hour. PHI: 14-day. IRAC 04A, IRAC 03A. *RUP.*

Lannate LV (methomyl) | 1.5-3.0 pts. per acre. REI: 48-hour. PHI: 6-day. IRAC 01A. *RUP.*

Malathion 5EC (malathion) | Use 5EC formulations at 2.0 pts. per acre. Use 57EC formulations at 1.0-1.5 pts. per acre. REI: 12-hour. PHI: 0-day. IRAC 01B.

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as a preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. REI: 12-hour. IRAC 04A.

Scorpion 35SL (dinotefuran) | *Soil application*: Use Scorpion 35SL at 11.5-13.25 fl. oz. per acre, or Venom 70SG at 6.5-7.5 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. *Foliar application*: Use Scorpion 35SL at 2.0-2.75 fl. oz. per acre, or Venom 70SG at 1.0-1.5 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day. IRAC 04A.

Seed treatments for insects (various ingredients) | Rates of other options otherwise not listed here vary by product, and are often multiple premixed ingredients. Select seed treatments with an insecticide ingredient, such as thiamethoxam (Cruiser 5FS, Cruiser Maxx Vibrance Potato; Cruiser Maxx Potato Extreme).

Sevin XLR Plus (carbaryl) | 0.5-1.0 qts. per acre. REI: 12-hour. PHI: 7-day. IRAC 01A.

Sivanto 200 (flupyradifurone) | 7.0-10.5 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 04D.

Thimet 20G (phorate) | *Light or sandy soils*: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches at planting or postemergence. *Heavy or clay soils*: 13.0-17.3 oz. per 1,000 ft. of row at planting but do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. IRAC 01B. *RUP.*

Torac (tolfenpyrad) | 14-21 fl. oz. per acre. See pollination precautions. REI: 12-hour. PHI: 14-day. IRAC 21A, FRAC 39.

Transform WG (sulfoxaflor) | 1.5-2.25 oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 04C.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Vydate C-LV (oxamyl) | 17-34 fl. oz. per acre. REI: 48-hour. PHI: 7-day. IRAC 01A. *RUP.*

Warrior II (lambda-cyhalothrin) | 0.96-1.60 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Wireworms

Wireworms are long-lived in the soil, and are most common in fields that were previously fallow or in pasture.

Non-Pesticide

Avoid planting in fields that were recently in grasses.

Pesticide

Admire Pro (imidacloprid) | 0.17-0.35 fl. oz. per 100 lbs of seed Apply directly to seed pieces. See pollinator precautions. REI: 12-hour. IRAC 04A.

Brigade 2EC (bifenthrin) | 9.6-19.2 fl. oz. per acre. Use 2EC formulations at 9.6-19.2 fl. oz. per acre as preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for potatoes. REI: 12-hour. PHI: 21-day. IRAC 03A. *RUP.*

Brigadier (bifenthrin, imidacloprid) | Apply 16.0-25.6 fl. oz. per acre at plant as an in-furrow spray on to the seed pieces or seed potatoes. Apply 3.8-6.14 fl. oz. per acre as a foliar application. REI: 12-hour. PHI: 21-days. IRAC 03A, IRAC 04A. *RUP.*

Capture LFR (bifenthrin) | 12.75-25.5 fl. oz. per acre. Apply as preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. REI: 12-hour. PHI: 21-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as a preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. REI: 12-hour. IRAC 04A.

Regent 4SC (fipronil) | 0.184-0.220 fl. oz. per 1,000 ft. of row. Make one in-furrow application at planting time only. Do not apply in row spacing less than 30 inches. On any row spacing greater than 36 inches, apply no more than 0.220 fl. oz. Do not apply if potato is planted by hand. REI: 0-hour. PHI: 90-day. IRAC 02B. *RUP.*

Seed treatments for insects (various ingredients) | Rates of other options otherwise not listed here vary by product, and are often multiple premixed ingredients. Select seed treatments with an insecticide ingredient, such as thiamethoxam (Cruiser 5FS, Cruiser Maxx Vibrance Potato; Cruiser Maxx Potato Extreme).

Thimet 20G (phorate) | *Light or sandy soils*: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches at planting or postemergence. *Heavy or clay soils*: 13.0-17.3 oz. per 1,000 ft. of row at planting but do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. IRAC 01B. *RUP.*

Potato - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

A relatively large number of herbicides are labeled for use on potatoes, and there are many opportunities to apply them because the hilling process recreates a preemergent crop situation by burying crop leaves and protecting them from soil surface sprays.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Potato cultural practices offer several good opportunities to control weeds, beginning with the period between planting and emergence (when early-emerging weeds can be killed by flaming), and continuing through the hilling process (when weeds can be buried or cultivated out). Some organic farmers also use flaming after potatoes emerge because some injury to the potato foliage early in the season can be tolerated. Rolling cultivators on wide tool-bars offer effective high-speed cultivation between rows and can also hill.

Pesticide

Aim EC (carfentrazone) POST | 0.5-2 fl. oz. per acre. Apply prior to or within 24 hours of planting, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. HRAC 14.

Anthem Flex (carfentrazone, pyroxasulfone) POST

PRE | 3.5-6.0 fl. oz. per acre. Apply as a broadcast spray to the soil surface after planting, drag-off, or hilling. Ensure that a minimum of 2 inches of soil cover the vegetative portion of the potato plants. Use lower rates on coarse soils. Do not exceed 6 fl. oz. per acre in a single application or more than 9.12 fl. oz. per acre per year. Do not apply to soil with less than 1% organic matter. REI: 12-hour. PHI: 0-day. HRAC 14, HRAC 15.

Chateau SW (flumioxazin) PRE | 1.5 oz. per acre of Chateau SW or 1.5 fl. oz. per acre of Chateau EZ. *Minnesota only.* Apply to potatoes after hilling. A minimum of 2 inches of soil must cover vegetative plant parts when applied to avoid injury. Provides suppression of lambsquarters, nightshades, pigweeds, wild mustard, and wild radish. Tank-mixes recommended to improve efficacy. REI: 12-hour. HRAC 14.

clethodim products (clethodim) POST | Use 2EC formulations at 6-16 fl. oz. per acre with COC (1% v/v). Use Select Max at 9-32 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v).Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max per acre per season. REI: 24-hour. PHI: 30-day. HRAC 01.

Dual Magnum (s-metolachlor) PRE | 1-2 pts. per acre. Dual Magnum or Dual II Magnum at 1-2 pts. per acre. Use lower rates on coarse soils. Apply and incorporate before planting, or apply after planting before weeds emerge. May also be applied at 1.67 pts. per acre after hilling. Dual Magnum might delay maturity and/or reduce yield of Superior and other early maturing varieties if cold, wet soil conditions occur after treatment. Dual Magnum can be tank-mixed with Lorox, Sencor, Prowl or Eptam. See labels. Do not exceed 3.6 pts. per acre. REI: 24-hour. PHI: 60-day if applied before drag-off, or 40-day if applied at lay-by. HRAC 15.

Eptam 7E (EPTC) PRE | Eptam 7E at 3.5-7 pts. per acre, or Eptam 20G at 15-20 lbs. per acre. Apply before planting, after drag-off, or as directed spray at lay-by. Incorporate immediately. On muck soils, supplement with linuron or metribuzin products applied before crop emerges and after drag-off. The Superior variety may be sensitive. Suppresses nutsedge. REI: 12-hour. PHI: 45-day. HRAC 15.

glyphosate products (glyphosate) POST | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast before planting, after planting before ground cracks, or apply between crop rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

League (imazosulfuron) POST PRE | 4.0-6.4 oz. per acre. Apply after planting crop and before crop emerges, or immediately after hilling. Or use 3.2 oz. per acre and after at least 21 days make a second application of 3.2 oz. per acre to control emerged weeds less than 3 inches tall. Or use 3.2-4 oz. per acre after crop emerges and before weeds are 3 inches tall; combine this with other measures to achieve satisfactory control. When emerged weeds are present use a Valent-recommended surfactant. Use the high rate in fields with a known history of nutsedge. Do not exceed two applications and 6.4 oz. per acre per year. REI: 12-hour. PHI: 45-day. HRAC 02.

Lorox DF (linuron) POST PRE | Use 50DF formulations at 1.5-3 lbs. per acre. Use 4L formulations at 1.5-4 pts. per acre. Also controls small, emerged weeds. Apply after planting but before crop emergence, when weeds are less than 2 inches tall. Seed pieces must be planted at least 2 inches deep. Do not use on sand, loamy sand, or soils with less than 1% organic matter. REI: 24-hour to 8-day. HRAC 05.

Matrix SG (rimsulfuron) POST PRE | 1-1.5 oz. per acre. Typically combined with full-labeled rates of metribuzin to improve spectrum of broadleaf control. Use 0.5 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply after planting before crop emerges, at hilling, drag-off, or reservoir tillage, to a clean, newly prepared seedbed. Apply post when weeds are less than 1 inch tall. Avoid using adjuvants when potatoes are under heat stress. Do not exceed 2.5 oz. per acre per year. REI: 4-hour. PHI: 30-day. HRAC 02.

metribuzin products (metribuzin) POST PRE | Use 4F formulations at 0.5-2 pts. per acre, or 75DF

formulations at 0.33-1.32 lbs. per acre. Not for early-maturing or red-skinned varieties. Apply after planting before crop emerges, or apply up to 1 pt. of metribuzin 4F (1.32 lbs. of 75DF formulations) after emergence. Check label for sensitive varieties. Avoid spraying when potatoes are 12-15 inches tall. Do not apply within 3 days of cool, wet, or cloudy weather, or crop injury may occur. Do not apply within 1 day of other pesticide applications. Do not exceed 2 pts. of 4F formulations or 1.32 lbs. of 75DF formulations per acre per year. REI: 12-hour. PHI: 60-day. HRAC 05.

Outlook (dimethenamid-p) PRE | 12-21 fl. oz. per acre. Apply after planting or drag-off and before weeds emerge. In cold and wet conditions potatoes may emerge slowly or be stunted. May be tank-mixed with a number of other potato herbicides. REI: 12-hour. PHI: 40-day. HRAC 15.

paraquat products (paraquat) POST | 1-2 pts. per acre. Use 1-2 pt. per acre of 2SL formulation or 0.7-1.3 pt. per acre of 3SL formulation. Use COC (1% v/v) or NIS (0.25% v/v). Apply before planting, or after planting but before ground cracks. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE | Use 3.8 formulations at 1.5-3 pts. per acre. Use 3.3EC formulations at 1.2-3.6 pts. per acre. Use low rates on coarse soils. Broadcast after planting but before emergence or drag-off, or after potatoes have fully emerged before potatoes are 6 inches tall. May be incorporated. Not effective on muck soils. Do not apply postemergence to stressed potatoes. REI: 24-hour. HRAC 03.

Poast (sethoxydim) POST | 1.0-2.5 pts. per acre. Use COC (1% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. REI: 12-hour. PHI: 30-day. HRAC 01.

Reflex (fomesafen) PRE | 1 pt. per acre. Broadcast after planting and before potatoes emerge. When using on any variety for the first time, first determine whether the variety is tolerant to this herbicide. May be tank-mixed with other preemergence herbicides. May not be used on the same land the following year. Alfalfa and most vegetables should not be planted for 18 months. REI: 24-hour. PHI: 70-day. HRAC 14.

trifluralin products (trifluralin) PRE | 0.5-1 lb. a.i. per acre. Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Broadcast and incorporate 1-2 inches after planting but before emergence, immediately after drag-off, or after potatoes have fully emerged. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour. HRAC 03.

Tripzin ZC (pendimethalin, metribuzin) POST PRE | 31-62 fl. oz. per acre. before potatoes are 6 inches tall. May be incorporated. Not effective on muck soils. Do not apply postemergence to red-skinned varieties or to stressed plants. REI: 24-hour. HRAC 03, HRAC 05.

Zidua SC (pyroxasulfone) PRE | 2.5-3.25 fl. oz. per acre. Apply after planting and before potatoes emerge. Use with another herbicide. Some varieties may be sensitive to Zidua. REI: 12-hour. HRAC 15.

Rhubarb - Horticulture

Major update by Ben Phillips – Apr 2022
Reviewed by Liz Maynard – Sep 2024

Crop Description

Rhubarb (*Rheum x rhabarbarum*) is a perennial plant in the Buckwheat family, Polygonaceae. The cultivated species is of unknown European origin, but most commercial varieties were probably hybridized at some point and cloned from root cuttings for generations. Variety names have been lost, confused, and rebranded over the years. There are only a handful of varieties that can be sourced in the United States, and the varieties commonly grown commercially in the Midwest are Canada Red, Crimson, MacDonald, Ruby, Sutton, Valentine, and Victoria – all red-stalked varieties. All varieties produce more green stalks later in summer, and some varieties only produce green stalks. But, pink and red-stalked varieties picked at peak color are more popular at market.

A combination of breeding efforts in the early 1900's to reduce flower stalk production and a naturally sporadic flowering period, has resulted in a bottleneck of reliable seed-production and an industry focused more on cloning through dormant root crown division. Seeds that are replanted will have a mixture of characteristics. However, Victoria flowers readily, is commonly available from seed, and produces a similar mixture of green and red-stalked plants from seed in subsequent generations.

After 2 years of unharvested growth, plants can begin to be annually harvested in the field for 3 to 8 productive years. Alternatively, after 3 years of unharvested growth, plants can be dug in late fall or early winter and stored in dark indoor facilities where they are sprouted early for a lucrative late winter and early spring harvest, after which the roots are exhausted and discarded. Victoria is the most reliable forcing variety, and the most widely available in the United States, although several other forcing varieties are maintained commercially in England.

New root cuttings can be purchased, or old plantings can be dug and split into 5 to 10 individual crowns with 2 to 3 buds each for replanting in a new area. This digging and splitting process is commonly performed in the winter when root crowns are dormant.

The split crowns are a marketable product themselves during spring plant sale season with flowers and other vegetable transplants. The crowns can be stored in refrigerated crates with high humidity like other edible root crops and asparagus crowns, or planted in pots for vegetative plant sale.

Planting and Spacing

For commercial crown production, seeds of rhubarb may be planted in field plantings or in pots, grown for one year before selling. However, this is uncommon due to the unreliable characteristics of rhubarb seeds, and the slow growth of plants in their first year.

For commercial stalk production, we recommend using only healthy root crowns having preferably 2 or 3 buds. Plant in rows 5 to 6 feet apart. Set crowns 3 feet apart in shallow furrows so crowns will be 2 inches below surface. Infertile soil, extreme heat or cold, drought, or long days that expose plants to too much light may cause bolting, and older plants bolt more. Break off flower stalks to maintain a strong root system year after year. A productive planting can be maintained for 3 to 8 years.

For forcing, crowns are placed in a dark room with about 1 square foot per crown on an open dirt floor, or in apple crates, and a few inches of soil is piled around each crown. Plants can be held dormant with temperatures below 40 F.

Some growers are experimenting with plasticulture production of rhubarb in the field for an early market that overlaps with indoor forced production in early spring. Rhubarb is frost tolerant down to 25 F.

Fertilizing

pH: Maintain a soil pH of 6.2 to 6.8.

New plantings: Before planting, apply 50 pounds N per acre, 0 to 150 pounds P_2O_5 per acre, and 0 to 200 pounds K_2O per acre based on soil test results and recommendations from your state. Apply an additional 25 pounds P_2O_5 per acre directly in furrows when setting crowns. Sidedress with 50 pounds N per acre after growth starts in the spring.

Established plantings: Each year before emergence, apply 50 pounds N per acre by broadcasting and incorporate by lightly tilling. After harvests conclude, apply 30 pounds N per acre. The total amount of N from fertilizer should be 80 pounds N per acre. No P_2O_5 is necessary if adequate fertilization was achieved prior to planting. Every fourth year apply up to 120 pounds K_2O per acre if a soil test recommends it.

Harvesting

By year 3, one can begin harvesting in the spring, or wait until the late fall to dig and force over the winter. Harvest field rhubarb for no longer than 4 weeks in year 3. Harvest for about 8 to 10 weeks after year 3. Do not remove more than 2/3 of the developed stalks from any plant at one time.

Rhubarb that is placed indoors for forcing is sprouted by wetting the soil around the crowns and maintaining a temperature between 50 and 65 F. The plants then produce many bright pink stalks for about 1 month and are usually picked 2 times per week. Forced plants produce about half as many stalks as field plants.

After forcing, crowns are generally too weak to produce well again in the following year, and are usually discarded for new, smaller root crown cuttings that are easier to transport and plant than the large 3-year old forced crowns. But, the forced crowns can also be split into smaller crowns and replanted to build strength for another 3 years.

Rhubarb - Diseases

Reviewed by Dan Egel – Aug 2023

Leaf Spot of Rhubarb - Ascochyta Fungus

Non-Pesticide

Fertilize in the fall for growth in the spring. Improves rapid, strong plant growth and uniform establishment, and enhances competitiveness. Remove older yellowed leaves or leaves with lesions in the fall.

Phytophthora Blight of Multiple Crops - Phytophthora Oomycete

Non-Pesticide

Use disease-free plants. Plant only on well-drained soil.

Rhubarb - Insects

Reviewed by Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Pesticide

Actara (thiamethoxam) | 1.5-3.0 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. Applied at soil as band or chemigation through drip. REI: 12-hour. PHI: 45-day. IRAC 04A.

Assail 30SG (acetamiprid) | Use 30SG formulations at 2.0-4.0 oz. per acre. Use 70WP formulations at 0.8-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre of 2.13SC formulation. 4.8-6.4 oz. per acre of 50WDG formulation. *Foliar applications*: 3-4 fl. oz. per acre of 2.13SC formulation. 1.6-2.1 oz. per acre of 50WDG formulation. See bee warning on label. REI: 12-hour. PHI: 7-day. IRAC 04A.

Beleaf (flonicamid) | 2-2.8 oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 29.

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Fulfill (pymetrozine) | 2.75 oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 09B.

Perm-Up 25DF (permethrin) | 3.2-12.8 oz. per acre. Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations

as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) | 4.5-15.6 fl. oz. per acre foliar application, or 0.375 fl. oz. per 1,000 sq. ft. growing media for soil drench application (in greenhouse). REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sivanto 200 (flupyradifurone) | 7.0-14.0 fl. oz. per acre. Use Sivanto 200SL and Sivanto Prime at 7-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 04D.

Caterpillars

There are many minor caterpillar pests of rhubarb, including corn earworm/tomato fruitworm, tomato hornworm, European corn borer, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Non-Pesticide

Remove curly dock weeds from fields and field edges. Curly dock is the normal host for common stalk borer caterpillars that feed on rhubarb.

Pesticide

Baythroid XL (beta-cyfluthrin) | 1.6-3.2 fl. oz. per acre. For armyworms, cutworms, loopers, corn earworm, and European corn borer. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Caterpillars include armyworms, cutworms and loopers. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) | 3.5-7.5 fl. oz. per acre. For armyworms and loopers. Can be applied through soil or foliar applications. REI: 4-hour. PHI: 1-day. IRAC 28.

Entrust SC (spinosad) | For armyworms and loopers. Use 2SC formulations at 3.0-8.0 fl. oz. per acre. Use 80WP formulations at 0.5-2.5 oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Exirel (cyantraniliprole) | 7-17 fl. oz. per acre. For armyworms, corn earworm, and loopers. REI: 12-hour. PHI: 1-day. IRAC 28.

Intrepid 2F (methoxyfenozide) | 4-10 fl. oz. per acre. For armyworms, and loopers. REI: 4-hour. PHI: 1-day. IRAC 18.

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre Caterpillars include armyworm, cutworm, cabbageworm and loopers. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | 3.2-12.8 oz. per acre. For armyworms, cutworms, corn earworm, and loopers. Use 25W, 25WP or 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 2-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) | 5-10 fl. oz. per acre. For armyworms, corn earworm, and loopers. REI: 4-hour. PHI: 1-day. IRAC 05.

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. For armyworms. REI: 12-hour. PHI: 14-day. IRAC 01A.

Flea Beetles

Pesticide

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre of 2.13SC formulation. 4.8-6.4 oz. per acre of 50WDG formulation. *Foliar applications*: 3-4 fl. oz. per acre of 2.13SC formulation. 1.6-2.1 oz. per acre of 50WDG formulation. See bee warning on label. REI: 12-hour. PHI: 7-day. IRAC 04A.

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Leafhoppers

Pesticide

Actara (thiamethoxam) | 1.5-3.0 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. Applied at soil as band or chemigation through drip. REI: 12-hour. PHI: 45-day. IRAC 04A.

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre of 2.13SC formulation. 4.8-6.4 oz. per acre of 50WDG

formulation. *Foliar applications*: 3-4 fl. oz. per acre of 2.13SC formulation. 1.6-2.1 oz. per acre of 50WDG formulation. See bee warning on label. REI: 12-hour. PHI: 7-day. IRAC 04A.

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Sivanto 200 (flupyradifurone) | 7.0-14.0 fl. oz. per acre. Use Sivanto 200SL and Sivanto Prime at 7-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 04D.

Rhubarb Curculio Beetle

The adult weevils overwinter in margins near the rhubarb planting. They emerge in spring and can be easily picked off of the leaves they are resting on, due to their large size. Weevil populations survive on weed hosts, such as dock, thistle and sunflower. Managing these plants in relation to the rhubarb crop is especially important. Eggs laid in rhubarb do not survive, they are crushed by the growing plant tissue.

There are no registered insecticides that will give adequate control.

Non-Pesticide

Remove weed hosts (dock, thistle, and sunflower) from fields and field edges.

Stink Bugs

Pesticide

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Pyganic EC 5.0 II (pyrethrins) | 4.5-15.6 fl. oz. per acre foliar application, or 0.375 fl. oz. per 1,000 sq. ft. growing media for soil drench application (in greenhouse). REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Whiteflies

Pesticide

Actara (thiamethoxam) | 3.0-5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) | 4.4-10.5 fl. oz. per acre. Applied at soil as band or chemigation through drip. REI: 12-hour. PHI: 45-day. IRAC 04A.

Assail 30SG (acetamiprid) | Use 30SG formulations at 3.0-4.0 oz. per acre. Use 70WP formulations at 1.1-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations at 2.1-6.4 fl. oz. per acre. Use 10DF, 10WP, or 10WSB formulations at 5.3-16 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations as a soil treatment at 5-11 fl. oz. per acre. Use 75SG formulations as a soil treatment at 1.66-3.67 oz. per acre. REI: 12-hour. PHI: 30-day. IRAC 04A.

Pyganic EC 5.0 II (pyrethrins) | 4.5-15.6 fl. oz. per acre foliar application, or 0.375 fl. oz. per 1,000 sq. ft. growing media for soil drench application (in greenhouse). REI: 12-hour. PHI: 0-day. IRAC 03A. *OMRI-listed.*

Sivanto 200 (flupyradifurone) | 7.0-14.0 fl. oz. per acre. Use Sivanto 200SL and Sivanto Prime at 7-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day. IRAC 04D.

Rhubarb - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Before establishing a rhubarb planting, reduce perennial weeds in the area to be planted with systemic broad-spectrum herbicides.

Herbicides that control broadleaves must be applied while rhubarb is dormant or with shielded equipment between the row, as stated on the label. Herbicides that kill only emerged grasses may be applied over the top of rhubarb plants.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Good weed control in the planting year is especially important. Multivators, tines, rolling cultivators, flame weeders work well before emergence of rhubarb, but it is important to avoid damaging crowns when cultivating. Cultivate row-middles and hand-hoe after emergence. Once established and before spring growth, harrow bed thoroughly but carefully to avoid injuring the crowns. During the growing season, cultivate row-middles and hand hoe to keep the planting clean. Following the first light freeze in fall, mulch with 3-4 inches of straw around plants, but not on crowns. If additional mulch is needed in the spring, apply before hot, dry weather. Add more mulch during summer (if needed) to control weeds and retain moisture.

Pesticide

Aim EC (carfentrazone) POST | 0.5-2.0 fl. oz. per acre. Apply a minimum of 1 day prior to transplanting, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Add COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 in. tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. HRAC 14.

Callisto (mesotrione) PRE | 6 fl. oz. per acre. Apply to dormant, established rhubarb. Applying after growth begins will cause crop stunting and bleaching. If weeds are emerged, add COC (1% v/v) or NIS (0.25% v/v). Has residual activity to control weeds that have not emerged. Do not exceed 6 fl. oz. per acre per year, or 1 application per year. REI: 12-hour. PHI: 21-day. HRAC 27.

Caparol 4L (prometryn) POST PRE | 2-4 pts. per acre. Apply to dormant, established rhubarb before leaves emerge in spring. Use low rate on light soils. If weeds are present, add COC (1% v/v) or NIS (0.25% v/v). REI: 12-hour. PHI: 40-day. HRAC 05.

Casoron 4G (dichlobenil) PRE | 50 lb. per acre. Apply before rhubarb emerges in early spring. Broadcast on soil, and thoroughly incorporate granules by watering in. REI: 12-hour. HRAC 29.

clethodim products (clethodim) POST | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season. Use Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Do not exceed 64 fl. oz. of Select Max per acre per season. Use low rates for annual grasses and high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 30-day. HRAC 01.

Command 3ME (clomazone) PRE | 2 qt. per acre. Apply to dormant rhubarb prior to leaf emergence. Do not exceed one application per crop per year. REI: 12-hour. HRAC 13.

Dual Magnum (s-metolachlor) PRE | 0.67-1.33 pts. per acre. Apply in spring before rhubarb and weeds emerge. Do not exceed one application and 1.33 pts. per acre per year. REI: 24-hour. PHI: 62-day. HRAC 15.

Fusilade DX (fluazifop-P) POST | 10-16 fl. oz. per acre. Add COC (1% v/v) or NIS (0.25% v/v). Apply to small actively growing grass. Do not exceed 32 fl. oz. per acre per year. REI: 12-hour. PHI: 14-day. HRAC 01.

glyphosate products (glyphosate) POST | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast before plants emerge, or apply between rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour to 12-hour. PHI: 14-day. HRAC 9.

Kerb SC (pronamide) POST | PRE | 2.5-5 pt. per acre. *Special 24c label only:* apply to dormant plants after frost has killed leaves in fall. Suppresses quackgrass. Do not apply to rhubarb the year of planting. Include glyphosate with application for better weed control. REI: 24-hour. PHI: 38-day. HRAC 03. *RUP.*

Lorox DF (linuron) POST | PRE | 2-3 lbs. per acre. Apply broadcast to dormant rhubarb in the spring before leaves emerge. REI: 24-hour to 8-day. HRAC 05.

paraquat products (paraquat) POST | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Add COC (1% v/v) or NIS (0.25% v/v). Apply during the dormant season before buds begin to grow. Do not exceed 2 applications per year. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

Poast (sethoxydim) POST | 1-1.5 pts. per acre. Add COC (1% v/v). Spray on actively growing grass. Do not exceed 3 pt. per acre per growing season. REI: 12-hour. PHI: 15-day in Illinois, Indiana, Michigan, and Minnesota; 30-day in other states. HRAC 01.

QuinStar 4L (quinclorac) POST | 12.6 fl. oz. per acre. Apply as a foliar spray to control Canada thistle and field bindweed. Can make a second application 30 days after the first. Do not exceed 25.2 fl. oz. per acre per year. REI: 12-hour. PHI: 30-day. HRAC 04.

Sandea (halosulfuron) POST | PRE | 0.5-1.0 oz. per acre. Apply to dormant rhubarb in the spring. If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). May cause crop stunting. Use low rate to determine crop safety under field conditions. Controls yellow nutsedge. Does not control grass. REI: 12-hour. PHI: 60-day. HRAC 02.

Root Crops - Horticulture

Major update by Ben Phillips, Liz Maynard – Dec 2020
Reviewed by Ben Phillips – Mar 2022

Crop Description

Most root crops are biennial plants that do not normally flower within a typical production season unless they are under stress. They come from a few different plant groups and species. Most are amenable to direct seeding before last frost, and some can be transplanted. Some are short season crops that offer double-cropping opportunities, while others are some of the longest season vegetable crops grown in an annual production system.

It is important to know the botanical relationships of root crops because similar pests will go to related plants. Root crops come from at least five botanical families. Within those family groups you can expect similar pests. In this guide we try to provide some precision to this. *However, when using pesticides, you must abide by the EPA Crop Groupings on pesticide labels.*

Amaranthaceae, the Pigweed family, contains Beets classified as "root and tuber vegetables" in EPA Crop Group 1. The pests of plants in this family are shared with Spinach and Swiss chard (EPA Crop group 4) in the Leafy Greens and Herbs chapter.

Apiaceae, the Carrot family, contains Carrots, Celeriac, and Parsnips classified as "root and tuber vegetables" in EPA Crop Group 1. But this family also includes Celery, Cilantro, Coriander, Dill, Fennel, Florence Fennel, and Parsley (EPA Crop Groups 4 and 19). The pests of plants in this family are shared with the Celery, and Leafy Vegetables and Herbs chapters.

Brassicaceae, the Mustard family, contains Horseradish, Radish, Rutabaga, and Turnip classified as "root and tuber vegetables" in EPA Crop Group 1. But, this family also includes cole crop and mustard-type plants (EPA Crop Groups 4 and 5). The pests of plants in this family are shared with the Cole Crops and Brassica Leafy Greens, and Leafy Vegetables and Herbs chapters.

Convolvulaceae, the Morning glory family, contains Sweet Potato classified as a "root and tuber vegetable" in EPA Crop Group 1. Please refer to the Sweet Potato Chapter.

Solanaceae, the Nightshade family, contains Potato classified as a "root and tuber vegetable" in EPA Crop Group 1. Please refer to the Potato Chapter.

Planting, Spacing, and Harvesting

Beet
Sugar beets, table beets, and Swiss chard are all the same species (*Beta vulgaris*) bred for different purposes. Table beets come in red, striped, white, and gold. They are typically round, but there are some longer shaped beets that are utilized for slicing and pickling. Most beet varieties are multigerm types that grow multiple plants from one seedball. There are monogerm beet varieties, such as Solo and Moneta.

Beets can be direct-seeded in rows 18 to 24 inches apart. Plant 6 to 12 seeds per foot of row, depending on sprout count and desired size. Seed 8 to 10 pounds per acre for bunching. Mechanical harvesters are common for beets, lifting them from their tops, or digging them with an undercutting chain conveyor. Some growers choose monogerm varieties for more reliable sizing in a one-pass harvest with machines. Other growers choose multigerm varieties and hand-harvest large "bully" beets first, allowing small "runts" to size up for later harvests. Time from seeding to harvest ranges from 50 to 60 days.

Carrot and Parsnip
Carrots (*Daucus carota*) and parsnips (*Pastinaca sativa*) have similar production systems. There are five broad types of carrot varieties. Chantenay carrot types have short, girthy, sometimes globe shaped roots that do well in heavy soils. Danvers carrot types are typically diced processing carrots and are thinner, longer, and more cone shaped than Chantenays and require the longest time to maturity. Imperator carrot types are good fresh market carrots that have long and slender roots with a higher sugar content; they require loose and deep soils. Nantes carrot types are good multi-market carrots for processing and fresh market with a more cylindrical root than Danvers, but girthier than Imperators, and an earlier maturation time than Imperators or Danvers. These four types all include orange, yellow, red, purple, and white varieties. The parsnip is a white-rooted plant related to carrots. Parsnip varieties differ in their size and time to harvest, but most are shaped like Danvers carrots.

Carrots and parsnips can be direct-seeded in single rows 16 to 30 inches apart, or in three-row beds with 10 to 12 inches between rows and 36 inches between beds, center to center. Plant 20 to 30 per foot for slicing/fresh market; 10 to 20 plants per foot for dicing. Seed 2 to 4 pounds per acre.

Both mechanical and hand harvest is common and starts when roots are of suitable size for the market between August and November. Undercutting chain-conveyor harvesters are more likely to break roots than top-puller harvesters. Time from seeding to harvest ranges from 60 days for baby carrots to 120 days for parsnips and full-size Danvers type carrots. Parsnips can be harvested up to freeze-up and continued as soon as soils can be worked in the spring.

Celeriac
This type of celery (*Apium graveolens* var. *rapaceum*) has been bred as a root crop with low-growing bushy foliage and a large, bearded, globe-shaped hypocotyl/root structure with a celery flavor.

Start as transplants 8 to 10 weeks before planting, and plant in early spring before last frost date. Transplant in rows 24 to 30 inches apart with plants 6 to 8 inches apart in row. For an acre of transplanted celeriac, you will need 2 to 4 ounces of seed to start in the greenhouse.

The full flavor is only reached after first frost. Time from transplanting to harvest ranges from 80 to 90 days. From seeding in cell trays, add 20 days.

Horseradish
This perennial Brassica (*Armoracia rusticana*) is grown commercially in Illinois and Wisconsin as an annual crop from cloned root "sets" cut from harvested roots in nurseries, like garlic, potato, or rhubarb. The roots are not eaten raw, but grated as a spice for condiments and flavoring. Type I varieties produce large smooth roots and are highly resistant to turnip mosaic virus and white rust. Type III varieties produce large roots but are highly susceptible to those two diseases. Type II varieties produce large roots with bark-like exterior, with intermediate resistance to those two diseases. Numbered commercial varieties are maintained by a small breeding effort supported directly by the largest growers of the commodity.

Plant root sets in early spring before last frost date. Sets should be 1/2 to 3/4 inches in diameter and 10 to 16 inches long. Root set ends that were closest to the plant (thicker end) and the ends that were farthest from the plant (thinner end) have to be planted thick end to thin end along the row, with the thick ends elevated about 2 inches higher than the thin end. This is accomplished by first scooping divots in rows 36 inches apart and 12 to 24 inches apart in-row. Then lay roots by hand into the divots with the thin end in the deepest part. That is roughly 10,000 sets per acre. Cover the roots with a disc-hiller to a depth of 5 to 8 inches.

Horseradish plants put the most size on their roots in the late summer and fall. Mechanical harvests with an undercutting chain conveyor take place in November until freeze-up and continues as soon as soils can be worked in the spring. Time from transplanting to harvest ranges from 200 to 250 days.

Radish, Rutabaga, and Turnip
The roots of these Brassica plants are strong to mildly-flavored and come in diverse size, colors, and shapes. For all of these crops, the flavor is sweeter or milder when roots reach marketable size in cool conditions.

Radishes (*Raphanus sativus*) come in globe-shaped bright red varieties that are the most common in United States markets, but market opportunities exist for the torpedo-shaped varieties, as well as for white, black, yellow, green, pink and deep red varieties. Most have white internal flesh, but some have pink internal flesh. Radishes become pungent during hot weather. They can be direct-seeded in single rows 16 to 30 inches apart, or in three-row beds with 10 to 12 inches between rows and 36 inches between beds, center to center. Plant 12 to 15 per foot of row. Seed 10 to 15 pounds per acre.

Rutabagas (*Brassica napus* supsp. *rapifera*) are the largest and mildest-flavored of these root crops. They are commonly white or yellow skinned with white internal flesh. Some develop a pink, purple, or green blush on the shoulders of the root when exposed to the sun. They can be direct-seeded in single rows 24 to 30 inches apart. Plant 3 to 4 seeds per foot of row. Seed 1 to 2 pounds per acre.

Turnip roots (*Brassica rapa* subsp. *rapa*) are larger than a radish, but smaller than a rutabaga, with a flavor that is an intermediate intensity between radish and rutabaga. The variety options are similar in appearance to rutabaga. They can be direct-seeded in single rows 14 to 18 inches apart. Plant 2 to 3 inches apart in row. Seed 1 to 2 pounds per acre.

Both mechanical and hand harvest is common and starts when roots are of suitable size for the market. Time from seeding to harvest ranges from 30 to 60 days for radishes and turnips, or 80 to 100 days for rutabagas.

Fertilizing

pH: Maintain a soil pH of 6.0 to 6.8. For beets, maintain a soil pH of 6.5 to 7.0.

Before planting, apply 60 pounds N per acre, 0 to 160 pounds P_2O_5 per acre, and 0 to 200 pounds K_2O per acre based on soil test results and recommendations from your state.

For beets grown on sandy soils, light-colored silt and clay loams, and alkaline, dark-colored soils apply boron at 2.5 to 5 pounds per acre applied over the row at planting. Do not let

boron contact seed. Beans, peas and cucurbits are sensitive to boron so use caution if these crops will follow beets, especially in the same season.

For carrots grown on muck soil with a pH greater than 6.0, apply 6 pounds of manganese sulfate per acre applied over the row at planting, or in a starter band.

For horseradish, add 1 to 2-1/2 pounds per acre boron and 15 to 25 pounds per acre sulfur with the initial N–P–K broadcast application. An optional sidedress application of 50 to 75 lb/acre N can be made 8 to 12 weeks after planting, but overapplication of nitrogen reduces root quality.

For most other root crops, sidedress with 30 to 60 pounds N per acre 4 to 6 weeks after planting. Most radishes mature quickly and do not require sidedressing. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer (including starter) and other credits should be 50 (radish), 90 (turnip), 100 (beets, fresh market carrots, horseradish, parsnip, rutabaga), 120 (processing carrots), or 150 (celeriac) pounds N per acre on mineral soils, and 50 pounds less on muck soils.

Root Crops - Diseases

Reviewed by Dan Egel – Aug 2023

Aster Yellows (Purple-Top Wilt) of Multiple Crops - Phytoplasma Mollicutes

This pathogen is transmitted by leafhoppers. Infection rates can jump when adjacent crops are harvested mid-season, such as alfalfa or wheat.

Non-Pesticide

Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip | Use disease-free seed. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 20 minutes for carrot, rutabaga and turnip, 122 F for 15 minutes for radish, or 118 F for 30 minutes for celeriac. There are some varieties of carrot that tolerate aster yellows more than others. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Destroying perennial weed hosts near high-value crops can reduce inoculum that is transmitted by leafhoppers.

Pesticide

Insecticides *Beet, Carrot, Celeriac, Parsnip* | Use an insecticide to control leafhoppers that transmit the disease. Leafhoppers must be controlled before they feed. See Insect section.

Brittle Root of Horseradish - Spiroplasma Bacteria

This pathogen is transmitted by leafhoppers. The symptoms include inward curling and yellowing of leaves, stunting of new growth, and an eventual collapse of the foliar portion of the plant. Root tissue becomes tan to black and they become easy to snap off.

Pesticide

Insecticides *Horseradish* | For **TuMV:** maintain an aphid management program. See Insects section. For **Brittle Root:** maintain a leafhopper management program. See Insects section.

Cavity Spot of Carrots - Pythium Oomycete

Cavity spot can affect root quality and yield.

Pesticide

mefenoxam/metalaxyl products (mefenoxam) *Carrot* | Several formulations (Apron, MetaStar, Ridomil Gold, Ultra Flourish, and Xyler) are labeled. Several formulations are labeled as pre-plant incorporated or surface broadcast and banded applications at various rates between 0.5 pt. and 8 pt. per acre. For post-emergence control, begin applications 28 days after planting as broadcast sprays, or 40 days after planting for banded sprays. A 33.3% seed treatment formulation can be used at 0.085-0.64 fl. oz. per 100 lb. of seed. REI: 48-hour. PHI: 7-day. FRAC 04.

Presidio (fluopicolide) *Carrot* | 4 fl. oz. per acre. Labeled for in-furrow applications. Use 5-10 gallons of water per acre. REI: 12-hour. PHI: 7-day FRAC 43.

Ranman 400SC (cyazofamid) *Carrot* | 6 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 21.

Reason 500SC (fenamidone) *Carrot* | 8.2 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 11.

Ridomil Gold Bravo SC (mefenoxam, chlorothalonil) *Carrot* | 1.5-2.5 pts. per acre. REI: 48-hour. PHI: 7-day. FRAC 04, FRAC M05.

Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens

Non-Pesticide

Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Avoid excess moisture to young plants by monitoring irrigation frequency. Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Pesticide

Presidio (fluopicolide) *Carrot* | 4 fl. oz. per acre. Labeled for in-furrow applications. Use 5-10 gallons of water per acre. REI: 12-hour. PHI: 7-day FRAC 43.

Reason 500SC (fenamidone) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.45 fl. oz. per 1000 ft. row. Pythium damping-off only. REI: 12-hour. PHI: 14-day. FRAC 11.

Uniform (mefenoxam, azoxystrobin) *Beet, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.34 fl. oz. per acre per 1,000 ft. of row. Make one application per crop season. For damping-off caused by Pythium or Rhizoctonia spp. REI: 0-hour. PHI: 0-day. FRAC 04, FRAC 11.

Internal Root Discoloration of Horseradish - Fusarium and Verticillium Fungi

This long-lived complex of soil pathogens reduce marketability by discoloring roots to a black color.

Non-Pesticide

Horseradish | Use disease-free root stocks generated from tissue-culture. Hot water seed treatment may reduce this disease in root clones. Use temperatures and times of 115 F for 10 minutes. Control volunteer horseradish in rotation years.

Leaf Blight of Carrots - Xanthomonas Bacteria

Copper products that are labeled for Cercospora may be helpful; however, bacteria may become resistant to copper products. Early bacterial leaf blight symptoms may mimic Alternaria leaf spot.

Bacteria may occur on seed and can survive on carrot debris in soil. Bacteria spread within a field by rain or overhead irrigation. Under dry conditions, low levels of bacterial leaf blight may not result in significant crop loss. Under hot and wet conditions, high levels of bacterial blight may develop and lead to premature defoliation and an inability to harvest the roots via a mechanical harvester.

Non-Pesticide

Carrot | Use disease-free seed. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 20 minutes for carrot. Rotate to non-host crops for 2 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

copper products (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) *Carrot* | Several formulations of copper (Badge, Champ, Kocide) products are labelled for use and may slow the spread of bacterial blight. See label for directions. REI: 4 to 48-hour. PHI: 0-day. FRAC M01. *OMRI-listed.*

Leaf Blight of Root Crops - Alternaria Fungus

Scout fields to initiate a spray program when foliar blights are first detected (trace of disease). TOM-CAST with 15 disease severity values (DSVs) can help carrot farmers time their fungicide applications for control of foliar blights. See Disease Forecasting Systems for details. Cercospora leaf spot is sometimes known as early blight. Alternaria leaf blight is sometimes known as late blight.

Non-Pesticide

Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Use disease-free seed. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 20 minutes for carrot, rutabaga and turnip, 122 F for 15 minutes for radish, or 118 F for 30 minutes for celeriac. Rotate to non-host crops for 2 years. Varieties with partial resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-12.8 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-25.6 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 8-12 oz. per acre. REI: 12-hour. PHI: 0-day FRAC 11.

chlorothalonil products (chlorothalonil) *Carrot, Horseradish, Parsnip* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.25-2.75 pt. per acre. Use 54% (720) formulations at 1.5-2.0 pt. per acre. Use 82.5% (WDG) formulations at 1.4-1.8 lb. per acre. Use 90% (DF) formulations at 1.25-1.6 lb. per acre. REI: 12-hour. PHI: 0-day for carrot; 10-day for parsnip; 14-day for horseradish. FRAC M05.

Endura (boscalid) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 4.5 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Flint Extra (trifloxystrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Rutabaga, Turnip* | 2.0-2.9 oz. per acre. Use Gem 500 SC and Flint (50%) formulation at same rate. REI: 12-hour. PHI: 7-day. FRAC 11.

Fontelis (penthiopyrad) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

iprodione products (iprodione) *Carrot* | 1-2 pts per acre. Formulations of iprodione include Nevado and Rovral. REI: 24-hour. PHI: 0-day. FRAC 02.

Luna Sensation (fluopyram, trifloxystrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 7.6 fl. oz. per acre. High rate only allowed on carrots. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Merivon (fluxapyroxad, pyraclostrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Alternaria at 4-5.5 fl. oz. per acre. Cercospora at 5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Omega 500F (fluazinam) *Carrot* | 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 29.

Pristine 38WG (boscalid, pyraclostrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 8.0-10.5 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) *Carrot* | 4 fl. oz. per acre. PropiMax EC and Tilt are labeled. See label for tank mix rates. REI: 12-hour. PHI: 14-day. FRAC 03.

Quadris Opti (azoxystrobin, chlorothalonil) *Carrot* | 2.4 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Carrot* | 12-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 03.

Quilt (azoxystrobin, propiconazole) *Carrot* | 14 oz. per acre. Late blight suppression only. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Switch 62.5WG (cyprodinil, fludioxonil) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 11-14 oz. per acre. Do not exceed 2 applications to radish. REI: 12-hour. PHI: 7-day. FRAC 09, FRAC 12.

Leaf Spot of Root Crops - Cercospora Fungus

Scout fields to initiate a spray program when foliar blights are first detected (trace of disease). TOM-CAST with 15 disease severity values (DSVs) can help carrot farmers time their fungicide applications for control of foliar blights. See Disease Forecasting Systems for details. Cercospora leaf spot is sometimes known as early blight. Alternaria leaf blight is sometimes known as late blight.

Non-Pesticide

Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Use disease-free seed. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 20 minutes for carrot, rutabaga and turnip, 122 F for 15 minutes for radish, or 118 F for 30 minutes for celeriac. Rotate to non-host crops for 2 years. Varieties with partial resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

azoxystrobin products (azoxystrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Heritage, Quadris, Satori). Use 34.3% formulations at 3.9-12.8 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-25.6 fl. oz. per acre. REI: 4-hour. PHI: 0-day. FRAC 11.

Cabrio EG (pyraclostrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 8-12 oz. per acre. REI: 12-hour. PHI: 0-day FRAC 11.

chlorothalonil products (chlorothalonil) *Carrot, Horseradish, Parsnip* | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 2.25-2.75 pt. per acre. Use 54% (720) formulations at 1.5-2.0 pt. per acre. Use 82.5% (WDG) formulations at 1.4-1.8 lb. per acre. Use 90% (DF) formulations at 1.25-1.6 lb. per acre. REI: 12-hour. PHI: 0-day for carrot; 10-day for parsnip; 14-day for horseradish. FRAC M05.

Flint Extra (trifloxystrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Rutabaga, Turnip* | 2.0-2.9 oz. per acre. Use Gem 500 SC and Flint (50%) formulation at same rate. REI: 12-hour. PHI: 7-day. FRAC 11.

Fontelis (penthiopyrad) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Merivon (fluxapyroxad, pyraclostrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Alternaria at 4-5.5 fl. oz. per acre. Cercospora at 5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Pristine 38WG (boscalid, pyraclostrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 8.0-10.5 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07, FRAC 11.

Quadris Opti (azoxystrobin, chlorothalonil) *Carrot* | 2.4 pts. per acre. REI: 12-hour. PHI: 0-day. FRAC 11, FRAC M05.

Quadris Top (azoxystrobin, difenoconazole) *Carrot* | 12-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 03.

Quilt (azoxystrobin, propiconazole) *Carrot* | 14 oz. per acre. Late blight suppression only. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

tebuconazole products (tebuconazole) *Beet* | 3.0-7.2 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Nematodes

Northern root knot nematode (NRKN) has a wide host range, including most broadleaf crops and weeds, but seem to have a disproportionate effect on carrots resulting in large yield losses if uncontrolled. Carrot cyst nematodes (CCN) are also found throughout the region and only feed on carrots. Sugar Beet Cyst Nematode (SBCN) will infect beets, radishes, rutabagas, and turnips.

Non-Pesticide

Beet, Carrot, Horseradish, Radish, Rutabaga, Turnip | Collect soil samples for nematodes in the fall and avoid fields with high numbers. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue and displace nematodes is an important method to prevent nematode build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain nematodes. For **NRKN:** rotate to a non-broadleaf crop, such as grass grains or sweet corn for >3 years. For **SBCN:** a late-summer, or early-fall cover crop of 'Defender',

'Concorde', or 'Control' radishes are effective trap crops for SBCN.

Pesticide

K-PAM HL (metam potassium) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 30-62 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place K-PAM HL or Sectagon K54 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Telone C-17 (1,3-dichloropropene, chloropicrin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Muck soils*: Use C-17 formulation at 27.4-30 gals. per acre, and C-35 formulation at 33-36 gals. per acre. *Mineral soils*: Use C-17 formulation at 10.8-17.1 gals. per acre, and C-35 formulation at 13-20.5 gals per acre. In the fall, when soil at 6 inches is above 50 F and moist, place Telone C-17 or C-35 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing, irrigation, or plastic. Or, in the spring, InLine may be applied through drip irrigation under unperforated plastic beds at 13-20.5 gals. per acre on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 3-5-day. IRAC 8A, FRAC NC, IRAC 08B. *RUP.*

Telone II (1,3-dichloropropene) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Muck soils*: Use at 25 gals. per acre. *Mineral soils*: Use at 9-12 gals. per acre. In the spring or fall, when soil at 6 inches is above 50 F and moist, place Telone II about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, Telone EC may be applied through drip irrigation under unperforated plastic beds at 9-18 gals. per acre on mineral soils only. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 8A, FRAC NC. *RUP.*

VAPAM HL (metam sodium) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 37.5-75 gals. per acre. Use high rates on muck, and lower rates on sands. In the fall, when soil at 6 inches is above 50 F and moist, place VAPAM HL or Sectagon K42 about 8 inches beneath the surface through shank-injectors, or broadcast sprayers directly in front of tillage tools to bury it. Seal with soil packing or irrigation. Or, in the spring, it can be applied through drip irrigation under unperforated plastic beds. Before planting, allow product to dissipate for 1 week for every 10 gals. per acre plus 1 more week. REI: 5-day. IRAC 08F, HRAC NC, FRAC NC. *RUP.*

Vydate L (oxamyl) *Carrot* | 1-2 gal. per acre. Apply as a banded or shank-injected pre-plant, at-plant in-furrow or directed post-plant soil treatment with at least 20 gals. water per acre incorporated 2-4 inches deep by water or mechanical means, or overhead chemigate before crop emergence to deliver in 0.5 inch of irrigation water. Allow 14 days between applications. *IA, IL, KS, MN, and MO* use low rate only and do not exceed 4 applications or 2.5 gals. per acre per season. *IN, MI, OH* use high rate and do not exceed 8 applications or 8 gals. per acre per season. REI: 48-hour. PHI: 14-day. IRAC 01A. *RUP.*

Viruses of Multiple Crops - Multiple Pathogens

Turnip Mosaic Virus is transmitted by multiple species of aphids. In horseradish the pathogen can increase with each growing season as root clones are propagated.

Non-Pesticide

Horseradish | For **TuMV:** start new plantings with virus-free root stocks generated from tissue-culture.

Pesticide

Insecticides *Horseradish* | For **TuMV:** maintain an aphid management program. See Insects section. For **Brittle Root:** maintain a leafhopper management program. See Insects section.

White Mold (Timber Rot, Drop, Stem Rot) of Multiple Crops - Sclerotinia Fungus

This soil pathogen is long-lived in the soil, and has a wide host range on broadleaved crops and weeds, including beans, vine crops, lettuce, tomatoes, peppers, and cole crops. It goes by other names in other crops, such as Drop, White Mold, Stem Rot, and Timber Rot.

It is more commonly found where humidity and temperatures are high. The fungus often infects flowers, which then drop off and infect the stems that they land on. The stems take on a woody appearance and can split open. On root crops, the pathogen infects the root crown and stem, which makes the leaves drop and rot. Inspection of the stems will reveal small black pellets that are the overwintering body of the pathogen.

Non-Pesticide

Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Avoid fields with a history of the problem. Rotate to a non-broadleaf crop, such as grass grains or sweet corn for >6 years. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up. Anaerobic soil disinfestation (ASD) is an effective sterilization method for greenhouse and high tunnel soils that contain this pathogen.

Pesticide

Endura (boscalid) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 7.8 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Fontelis (penthiopyrad) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 07.

Luna Sensation (fluopyram, trifloxystrobin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 7.6 fl. oz. per acre. High rate only allowed on carrots. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Omega 500F (fluazinam) *Carrot* | 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 29.

White Rust of Multiple Crops - Albugo Oomycete

Non-Pesticide

Horseradish, Radish, Rutabaga, Turnip | Use disease-free seed and transplants. Hot water seed treatment may reduce this seedborne disease. Use temperatures and times of 122 F for 20 minutes for rutabaga and turnip, 122 F for 15 minutes for radish. Rotate to non-host crops for 2 years. Varieties with partial resistance are available. Brassica weeds like shepherd's purse, yellow rocket, and wild mustard can host the pathogen and should be managed. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Cabrio EG (pyraclostrobin) *Horseradish, Radish, Rutabaga, Turnip* | 8-16 oz. per acre. REI: 12-hour. PHI: 0-day. FRAC 11.

Ridomil Gold Copper (mefenoxam, copper hydroxide) *Radish* | Use as a foliar spray. REI: 48-hour. PHI: 7-day. FRAC 04, FRAC M01.

Root Crops - Insects

Major update by Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.31-0.74 fl. oz. per 1,000 ft. of row. Apply as chemigation through drip, as an in-furrow spray, shanked in to seed trench, or as a narrow banded spray over eventual row within 14 days of planting. Do not apply more than once per season. REI: 12-hour. PHI: 21-day. IRAC 04A.

Beleaf (flonicamid) *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* | 2.0-2.8 oz. per acre. Use lower rate for building populations and use higher rate for greater populations or dense foliage. REI: 12-hour. PHI: 3-day IRAC 29.

Brigade 2EC (bifenthrin) *Beet* | Use 2EC formulation at 5.1-6.4 fl. oz. per acre. Use 10DF, 10 WP, or 10WSB formulations at 12.8-16.0 oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Use 2EC formulation at 5.1-6.4 fl. oz. per acre. Use 10DF, 10 WP, or 10WSB formulations at 12.8-16.0 oz. per acre. REI: 12-hour. PHI: 21-day. IRAC 03A. *RUP.*

Lannate LV (methomyl) *Horseradish* | 1.5 pts. per acre. Ground application only. REI: 48-hour. PHI: 65-day. IRAC 01A. *RUP.*

M-Pede (potassium salts of fatty acids) *Beet, Carrot, Horseradish, Parsnip, Radish, Rutabaga* | 1-2% by volume. Must contact aphids to be effective. REI: 12-hour. PHI: 0-day. IRAC UN, FRAC NC. *OMRI-listed.*

Malathion 5EC (malathion) *Beet, Carrot, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Use 5EC formulations at 1.5-2.0 pts. per acre on beets, carrots, parsnips and horseradish; 1.5 pts. per acre on radishes and rutabagas; or 1.0-2.0 pts. per acre on turnips. Use 57EC formulations at 1.5-2.0 pts. per acre on beets, carrots, and parsnips; 1.0-1.6 pts. per acre on radish and rutabagas; or 1.0-2.0 pts. per acre on horseradish and turnips. REI: 12-hour on beet, rutabaga, turnip and 24-hour on carrot, horseradish, parsnip. REI: 12-hour. PHI: 7-day. IRAC 01B.

Neemix (azadirachtin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 5-7 fl. oz. per acre. Suppression of nymphs and adult feeding deterrence. REI: 4-hour. PHI: 0-day. IRAC UN. *OMRI-listed.*

Platinum 2SC (thiamethoxam) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Use 2SC formulations as a soil treatment at 5.0-12.0 fl. oz. per acre on beet, carrot, parsnip, rutabaga, and turnip or 5.0-6.5 fl. oz. per acre on radish. Use 75SG formulations as a soil treatment at 1.7-4.0 oz. per acre on beet, carrot, parsnip, rutabaga, and turnip or 1.7-2.2 fl. oz. per acre on radish. REI: 12-hour. IRAC 04A.

Sivanto 200 (flupyradifurone) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 7.0-14 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 04D.

Carrot Weevil Beetle

Prior to transplanting, use carrot-baited monitoring traps to determine level of carrot weevil pressure in the field. Begin insecticide applications in the spring when plants have 3-true leaves (petioles) and direct applications at the base of the plant where adult weevils are active.

Non-Pesticide

Carrot, Parsley | Use crop rotation to reduce buildup of carrot weevil populations. Disk crop residue at the end of the growing season to eliminate food resources and reduce overwintering survival of life stages remaining in the field.

Pesticide

Asana XL (esfenvalerate) *Carrot* | 9.6 fl. oz. per acre. Begin treatment when weevils become active. Thorough spray coverage of crown area is essential. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) *Carrot, Parsley* | For carrot, use 2.8 fl. oz. per acre. For parsley, use 2.4-3.2 fl. oz. per acre. Do not harvest tops for human consumption. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Vydate L (oxamyl) *Carrot* | 2-4 pts. per acre. Apply as a soil-directed spray with at least 20 gals. water per acre, incorporated 2-4 inches deep by water or mechanical means. *IN, MI, OH* do not exceed 8 applications per season. REI: 48-hour. PHI: 14-day. IRAC 01A. *RUP.*

Caterpillars

Cutworms are the most important caterpillar pest of root crop in our region. Other foliage-feeding caterpillars include loopers and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Treatment is warranted when 25% of plants are infested.

Pesticide

Asana XL (esfenvalerate) *Carrot* | 5.8-9.6 fl. oz. per acre. For cutworms. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) *Carrot, Radish* | 1.6-2.8 fl. oz. per acre. For cutworms. Do not harvest tops for human consumption. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | For armyworms, cabbageworms, and cutworms. Use 2EC formulation at 5.1-6.4 fl. oz. per acre. Use 10DF, 10 WP, or 10WSB formulations at 12.8-16.0 oz. per acre. REI: 12-hour. PHI: 1-day for beet. 21-day for carrot, celeriac, parsnip, radish, rutabaga and turnip. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 3.5-7.5 fl. oz. per acre. For armyworms. REI: 4-hour. PHI: 1-day. IRAC 28.

Diazinon AG500 (diazinon) *Beet, Carrot, Radish* | For cutwoms. Use 50W formulations at 4-8 lbs. per acre as a pre-plant incorporation. Use AG500 formulations at 2-4 lbs. per acre for radish and beet, 4 lbs. per acre for carrot as a pre-plant incorporation. Use AG600 formulations at 51-102 fl. oz. per acre as a pre-plant incorporation. REI: 2 to 4-day. PHI: 14-day. IRAC 01B. *RUP.*

Entrust SC (spinosad) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | For armyworms, borers, and loopers. Use 2SC formulations at 3.0-6.0 fl. oz. per acre on carrot, horseradish, parsnip, radish, rutabaga, turnip and 3.0-10 fl. oz per acre on beets. Use 80WP formulations at 1.0-3.0 oz. per acre. REI: 4-hour. PHI: 3-day. IRAC 05. *OMRI-listed.*

Lannate LV (methomyl) *Beet, Carrot* | For cutworms. Use 1.5 pts. per acre for beets. Use 0.75-1.5 pts. per acre for carrots. REI: 48-hour. PHI: 0-day for beet roots, 10-day for beet tops, 1-day for carrot. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 1.28-4.0 fl. oz. per acre. For cutworms. Leaves cannot be used for food or feed. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 6-8 fl. oz. per acre. For armyworms. REI: 4-hour. PHI: 3-day for carrot, parsnip. radish, rutabaga, and turnip; 7-day for beet. IRAC 05.

Sevin XLR Plus (carbaryl) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 1-2 qts. per acre. For armyworms, and cutworms. REI: 12-hour. PHI: 7-day. IRAC 01A.

Flea Beetles

Pesticide

Actara (thiamethoxam) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Asana XL (esfenvalerate) *Radish, Turnip* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) *Carrot, Radish* | 1.6-2.8 fl. oz. per acre. Do not harvest tops for human consumption. REI: 12-hour. PHI: 0-day IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Beet* | Use 2EC formulation at 5.1-6.4 fl. oz. per acre. Use 10DF, 10 WP, or 10WSB formulations at 12.8-16.0 oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) *Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Use 2EC formulation at 5.1-6.4 fl. oz. per acre. Use 10DF, 10 WP, or 10WSB

formulations at 12.8-16.0 oz. per acre. REI: 12-hour. PHI: 21-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Use 2SC formulations as a soil treatment at 5.0-12.0 fl. oz. per acre on beet, carrot, parsnip, rutabaga, and turnip or 5.0-6.5 fl. oz. per acre on radish. Use 75SG formulations as a soil treatment at 1.7-4.0 oz. per acre on beet, carrot, parsnip, rutabaga, and turnip or 1.7-2.2 fl. oz. per acre on radish. REI: 12-hour. IRAC 04A.

Sevin XLR Plus (carbaryl) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.5-1 qts. per acre. REI: 12-hour. PHI: 7-day. IRAC 01A.

Leafhoppers

Aster leafhopper is a migratory species that affects carrots and beets, and are a concern because they vector aster yellows. The amount of aster yellows present in any leafhopper population varies by year and location. Some states in the region have programs that test for and track the percentage of aster leafhoppers that are carrying aster yellows. Aster leafhoppers can move into vegetable fields when neighboring wheat or alfalfa is harvested.

Management efforts can be stopped 2-3 weeks before harvest, as plants that are infected during that time will be harvested before symptoms manifest.

For susceptible varieties of carrots, a threshold of 20 leafhoppers per 100 sweeps can be used.

Non-Pesticide

Carrot | Avoid planting near early harvested grain or alfalfa fields. There are some varieties of carrots that tolerate aster yellows more than others.

Pesticide

Actara (thiamethoxam) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 1.5-3.0 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Admire Pro (imidacloprid) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.31-0.74 fl. oz. per 1,000 ft. of row. Apply as chemigation through drip, as an in-furrow spray, shanked in to seed trench, or as a narrow banded spray over eventual row within 14 days of planting. Do not apply more than once per season. REI: 12-hour. PHI: 21-day. IRAC 04A.

Asana XL (esfenvalerate) *Carrot* | 5.8-9.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) *Carrot, Radish* | 1.6-2.8 fl. oz. per acre. Do not harvest tops for human consumption. REI: 12-hour. PHI: 0-day IRAC 03A. *RUP.*

Lannate LV (methomyl) *Carrot* | 1.5-3.0 pts. per acre. REI: 48-hour. PHI: 1-day. IRAC 01A. *RUP.*

Platinum 2SC (thiamethoxam) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Use 2SC formulations as a soil treatment at 5.0-12.0 fl. oz. per acre on beet, carrot, parsnip, rutabaga, and turnip or 5.0-6.5 fl. oz. per acre on radish. Use 75SG formulations as a soil treatment at 1.7-4.0 oz. per acre on beet, carrot, parsnip, rutabaga, and turnip or 1.7-2.2 fl. oz. per acre on radish. REI: 12-hour. IRAC 04A.

Sevin XLR Plus (carbaryl) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.5-1 qts. per acre. REI: 12-hour. PHI: 7-day. IRAC 01A.

Sivanto 200 (flupyradifurone) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 7.0-14 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 04D.

Seed and Root Maggots

Cabbage maggot is the main root maggot of radish, rutabaga, and turnip. Cabbage maggot causes the biggest problems during cool, wet springs when plants are growing slowly. Egg-laying adults are attracted to the smell of decaying organic matter, and are attracted to fields where green manures, cover crops, and weeds have been recently killed. Foliar applications of pyrethroids are only partially effective, and require careful timing. Degree day models exist for states across the region, and can be used to time management actions.

Non-Pesticide

Radish, Rutabaga, Turnip | Plant after the peak flight and egg-laying window of the first generation of flies looking to lay eggs around 700 GDD base 40. Handle seeds carefully to prevent cracking. Plow winter vegetation under early in the spring and thoroughly cover to limit attractiveness of rotting vegetation to the first generation of flies to lay eggs on. Row covers can be effective in small plantings.

Pesticide

Diazinon AG500 (diazinon) *Rutabaga* | Use 50W formulations at 4-6 lbs. per acre as a pre-plant incorporation. Use AG500 formulations at 2-4 lbs. per acre as a pre-plant incorporation. Use AG600 formulations at 51-102 fl. oz. per acre as a pre-plant incorporation. REI: 2 to 4-day. PHI: 14-day. IRAC 01B. *RUP.*

Mustang Maxx (zeta-cypermethrin) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 3.2-4.0 fl. oz. per acre. Apply weekly, broadcast applications starting at fly emergence and continuing through the activity period, typically 6 applications. Leaves cannot be used for food or feed. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Root Crops - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Herbicides are not widely labeled across the many root crops. Instead, herbicides are labeled based on the root crop plant families. For example, beets have several herbicides that can be applied over the top of the crop that would damage any other root crop.

Prepare a stale seedbed several weeks in advance of planting, allow weeds to emerge, and kill weeds without bringing new weed seeds to the surface with a burndown herbicide, flame weeder, or very shallow cultivation. In fields with lower weed pressure, it may be possible to plant into some emerged weeds, and then use an approved burndown herbicide prior to crop emergence to control emerged weeds. For crops like carrots and parsnips that take a long time to emerge, a burndown application made just prior to crop emergence is especially useful, but it can also pay off for faster-emerging species like radishes or beets.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip | Weed control in root crops often relies heavily on cultivation and hand-weeding for full season weed control. These operations are most efficient when planting arrangement is designed with weed control in mind and is designed to work with available weed control equipment. Specialized weeding equipment for root crops includes basket weeders, narrow-bladed hoes, finger weeders, and others. Prepare a stale seedbed with flaming or very shallow cultivation, instead of herbicides.

Pesticide

Aim EC (carfentrazone) POST *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.5-2.0 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less

than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. HRAC 14.

Caparol 4L (prometryn) POST | PRE *Carrot, Celeriac* | Use lower rates on sandy soils. For **carrot**: Apply 2-4 pts. per acre preemergence and/or postemergence through the 6-leaf stage of carrot development. Do not exceed 8 pts. per acre per year. For transplanted **celeriac**: Make a single application of 1.6-4 pts. per acre after crop the crop has 6-8 leaves. REI: 12-hour. PHI: 30-day for carrot, 60-day for celeriac. HRAC 05.

clethodim products (clethodim) POST *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | Use 2EC formulations at 6-8 fl. oz. per acre with COC (1% v/v). Use Select Max at 9-16 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. Use lower rates for annual grasses, the higher rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max per acre per season. REI: 24-hour. PHI: 15-day for radish, 30-day for beet, carrot, celeriac, horseradish, parsnip, rutabaga, and turnip. HRAC 01.

clopyralid products (clopyralid) POST *Beet, Turnip* | 4-8 fl. oz. per acre. Apply Spur or Stinger (40.9% formulations only). Beets must have 2-8 true leaves. Controls primarily composites and nightshade. Do not exceed 8 fl. oz. per acre per crop for beet. Do not exceed 1 application per crop for turnip. REI: 12-hour. PHI: 30-day. HRAC 04.

Dual Magnum (s-metolachlor) PRE *Beet, Carrot, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | For **carrot** *with special 24c label*: apply 0.5-1.33 pts. per acre after planting but before carrots emerge, or 0.67-1.33 pts. per acre after carrots have 3-5 true leaves. Increase rates to 1.33-2.0 pts. per acre on muck soils. Do not apply both pre- and postemergence. Only the postemergence application is allowed in Ohio. For **beet, parsnip, radish, rutabaga, and turnip** *with special 24c label*: 0.67-1.0 pt. per acre before planting with or without incorporation, or apply after seeding before crop emerges. Risk of crop injury is generally greater with preplant incorporated applications and on coarse-textured soils with less than 1.5% organic matter. Increase rate to 1.33 pts. per acre on muck soils. Do not exceed 1.3 pts. per acre per crop or 1 application per crop. For **horseradish** in all states: Apply after planting but before weeds emerge. Do not exceed 1 application per crop. REI: 24-hour. PHI: 64-day for carrot. HRAC 15.

Fusilade DX (fluazifop-P) POST *Carrot* | 10-12 fl. oz. per acre. Use COC (1% v/v) or NIS (0.25% v/v). Spray on actively growing grass. REI: 12-hour. PHI: 45-day. HRAC 01.

glyphosate products (glyphosate) POST *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast before seeding, or apply between crop rows with wipers or hooded or shielded sprayers. Use lower rate for annuals and higher rates for perennials. For carrot and rutabaga only wipers may be used over top of crop, see label. See label for suggested application volume and adjuvants. REI: 4-hour to 12-hour. PHI: 14-day for foliar applications directed between rows, 7-day for wiper applications on carrot only. HRAC 9.

GoalTender (oxyfluorfen) POST | PRE *Horseradish* | 1 pt. per acre for GoalTender 4SC, or 2 pts. per acre for Goal 2XL. Apply after planting but prior to crop emergence. REI: 24 to 48-hour. HRAC 14.

Lorox DF (linuron) POST | PRE *Carrot, Celeriac, Horseradish, Parsnip* | Use low rate on coarse soils and higher rate on heavy soils and muck. Do not use on sand, loamy sand, or soils with less than 1% organic matter. For **carrot**: *In Minnesota only*, apply 1-2 lbs. per acre after planting but before carrots emerge. *In Michigan and Ohio only*, apply 1-3 lbs. per acre per acre after planting but before carrots emerge. Do not exceed 4 lbs. per acre per season. *In all states*, an additional application of 1.5-3 lbs. per acre can be made after carrots seedlings they are 3 inches tall. For **celeriac**: Make a single application of up to 3 lbs. per acre as a broadcast spray after celeriac has been transplanted and established, but before celeriac is 8 inches tall. Do not add surfactants, nitrogen (or other fertilizers), or other pesticides to the spray mix. For **horseradish**: Make a single application of up to 3 lbs. per acre as a broadcast spray after planting or during dormancy, but before leaves emerge in spring. After planting, allow rainfall or irrigation of at least 0.5 inch prior to application. For **parsnip**: Make a single application of 1.5-3 lbs. per acre as a broadcast spray after planting but prior to

crop emergence. Plant at least 0.5 inch deep. REI: 24-hour to 8-day. PHI: 14-day for carrot, 60-day for celeriac. HRAC 05.

metribuzin products (metribuzin) POST | PRE

Carrot | Apply 0.5 pts. per acre for 4F, 0.33 lbs. per acre for 75DF. Broadcast after carrots have 5-6 true leaves and when weeds are less than 1 inch tall or across. Do not apply within 3 days of cool, cloudy weather or other pesticide application, or when temperature is above 85 F. Do not exceed 1 application per season if carrots are rotated with onions; otherwise do not exceed 1 pt. of 4F products per acre per season, or 0.66 lb. of 75DF products per acre per season. REI: 12-hour. PHI: 60-day. HRAC 05.

Nortron SC (ethofumesate) POST | PRE *Beet* |

Apply 60 fl. oz. per acre at (or soon after) seeding and before weed seeds germinate, 5.25 fl. oz. per acre. when beets have 2-4 true leaves, or 10.5 fl. oz. per acre when beets have 6-8 true leaves. May cause temporary leaf fusion. May injure stressed plants. Use on mineral soils only. Do not exceed 96 fl. oz. per acre per season. REI: 12-hour. HRAC 15.

Optogen (bicyclopyrone) POST | PRE

Horseradish | For **horseradish**: 2.6-3.5 fl. oz. per acre after transplanting but at least 3 days prior to crop emergence or 3.5 fl. oz. per acre after transplanting as a row middle or post-directed application, avoiding contact with crop foliage. If weeds are present, add COC (1% v/v) or NIS (0.25% v/v). Spray grade ammonium sulfate (AMS) may also be added to improve weed control consistency. Apply to weeds less than 2 inches. Do not apply prior to transplanting. Do not exceed 1 application per year. Do not exceed 3.5 fl. oz. per acre per year. REI: 24-hour. PHI: 30-day. HRAC 27.

Outlook (dimethenamid-p) PRE *Horseradish* |

12-21 fl. oz. per acre. Apply from 2-leaf stage to 8-leaf stage of horseradish. Cold, wet conditions at application may stunt horseradish. Will not control emerged weeds. REI: 12-hour. PHI: 40-day. HRAC 15.

paraquat products (paraquat) POST *Carrot, Turnip* | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Use COC (1% v/v) or NIS (0.25% v/v). Apply before or after seeding but before crop emerges. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE

Carrot | Apply 3.8 lb. per gallon formulations at 2 pts. per acre within 2 days after seeding and before crop and weeds emerge. Or apply at layby as a directed spray between rows. Do not allow spray to contact carrot plants. Will not control emerged weeds. Do not exceed 2 pts. per acre per season. REI: 24-hour. PHI: 60-day. HRAC 03.

Poast (sethoxydim) POST *Beet, Carrot, Horseradish, Parsnip, Radish, Rutabaga, Turnip* | 1.0-1.5 pts. per acre. Use COC (1% v/v). Spray on actively growing grass. Do not exceed 2.5 pts. per acre per season for parsnip, radish, rutabaga, and turnip or 5 pts. per acre per season for beet, carrot, and horseradish. REI: 12-hour. PHI: 14-day for parsnip, radish, rutabaga, and turnip, 30-day for carrot, and 60-day for beet and horseradish. HRAC 01.

Ro-Neet (cycloate) PRE *Beet* | 0.5-0.67 gals. per acre. Apply before planting and incorporate immediately. Use on mineral soils only. REI: 48-hour. HRAC 15.

Spartan 4F (sulfentrazone) PRE *Horseradish* | 2.25-8.0 fl. oz. per acre Broadcast in the spring before planting or after planting but at least 5 days before crop emergence; or band into row middles after crop emergence. Applications made in the spring shortly before planting may be incorporated, but do not incorporate at other times. Rainfall or irrigation is required to move herbicide into the soil when not incorporated. Do not broadcast if sprouts are close to soil surface, or over top of emerged crop. Do not use on sandy soils with less than 1% organic matter. Do not exceed 8 fl. oz. of Spartan 4F per 12-month period. REI: 12-hour. HRAC 14.

Spartan Charge (carfentrazone, sulfentrazone) POST | PRE *Horseradish* | 2.9-10.2 fl. oz. per acre Broadcast in the spring before planting or after planting but at least 5 days before crop emergence; or band into row middles after crop emergence. Applications made in the spring shortly before planting may be incorporated, but do not incorporate at other times. Rainfall or irrigation is required to move herbicide into the soil when not incorporated. Do not broadcast if sprouts are close to soil surface, or over top of emerged crop. Do not use on sandy soils with less than 1% organic matter. Do not exceed 10.2 fl. oz. of Spartan Charge per 12-month period. REI: 12-hour. HRAC 14.

Spin-Aid (phenmedipham) POST *Beet* | 1.5-3 pts. per acre in 10-20 gals. of water. Apply to beets with at least 4 true leaves to avoid injury. Do not apply if beets are stressed. Do not exceed 3 applications. Does not control pigweed. REI: 12-hour. PHI: 60-day. HRAC 05. *RUP.*

Sulfen 4SC (sulfentrazone) PRE *Turnip* | 8 fl. oz. per acre. Make one application after emergence 40-60 days before harvest. Do not make more than one application per year. Do not apply more than 8 fl. oz. per acre or per 12-month period. Do not use on sand or soils with less than 1% organic matter. REI: 12-hour. HRAC 14.

trifluralin products (trifluralin) PRE *Carrot, Radish* | 0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. Use 10G formulations at 5-7.5 lbs. per acre. Apply and incorporate 1-2 inches before planting. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. Not effective on muck or high organic matter soils. REI: 12-hour. HRAC 03.

UpBeet (triflusulfuron) POST *Beet* | 0.5 oz. per acre. Apply postemergence when beets have 2-4 and 4-6 leaves to control velvetleaf and mustards. Suppresses lambsquarters, pigweed, nightshade, ragweed, smartweed, and wild buckwheat. Add 8 fl. oz. NIS per 25 gals. spray solution. Do not exceed 1.5 oz. per acre per season. REI: 4-hour. PHI: 30-day. HRAC 02.

Sweet Corn - Horticulture

Major update by Ben Phillips, Liz Maynard, Bill Tracy – Oct 2020
Reviewed by Liz Maynard and Dan Fillius – Sep 2024

Crop Description

Sweet corn (*Zea mays* subsp. *mays*) originates from a wild relative in Central America. Sweet corn is usually described by color (yellow, bicolor, or white) and by the major gene names that make it sweet. Despite the many marketing terms and trademarked names, sweet corn can be categorized into five major types.

The original sweet corn (called standard, sugary, or *su*) contains the su1 genetic variant that makes it sweet instead of starchy like field corn. Sugary sweet corn is grown today primarily for processing and specialized markets.

A second type of sweet corn (called sugar-enhanced, sugary enhancer, EH, or *se*) contains the *se1* genetic variant in addition to *su1*. The combination increases sugar content and makes the kernels more tender. Heterozygous se corn has one copy of the *se1* mutation and homozygous se corn has two copies of the *se1* mutation, increasing its effect. Sugar-enhanced sweet corn is grown primarily for direct retail sales and local wholesale markets.

A third type of sweet corn (called supersweet, ultrasweet, extra sweet, or shrunken-2) contains the *sh2* genetic variation. This type typically has a higher sugar content than *su* corn, and the sugar content does not decline rapidly after picking, so it remains sweet for several days after harvest. Kernels typically are not as tender as *se* corn. Shrunken-2 (sh2) types are grown for retail sales, local fresh markets, and wholesale shipping markets.

Many of the newest sweet corn varieties combine the *sh2* (or similar genes) with *se* and/or *su* genetics. Sugar-enhanced sweet corn that also includes *sh2* (or similar) genes is called synergistic, and may be abbreviated as *sesh2,* syn, or sy corn. Current synergistic varieties are typically very sweet and very tender. Shrunken-2 sweet corn varieties with genetics increasing tenderness and flavor are categorized as augmented or improved supersweet or sh2, sometimes abbreviated shA or sh aug. These varieties are typically extremely sweet and tender. Many of these varieties have performed well in midwestern trials and receive top ratings for eating quality. A variant of the *sh2* gene called *sh2-i* is becoming available in the market. This variant leads to plumper seeds, which may improve germination in unfavorable conditions. It also increases the compounds that give sweet corn kernels a creamy texture, which is associated with improved eating quality. The new types are often identified by trademarked brand names.

Sweet corn varieties commonly have some resistance to major diseases. Varieties with resistance to certain insects, and/or glyphosate or glufosinate herbicides are also available.

Planting and Spacing

Common spacing is 30 to 40 inches apart between rows. Plant early varieties 8 to 10 inches apart in the row, late varieties 9 to 12 inches apart in the row. Seed 10 to 15 pounds per acre.

Sweet corn flavor is affected by pollen source. Isolate all sweet corns from all other non-sweet corns, including dent (field), flint (Indian), flour, and popcorn by 250 feet or by a 14-day difference in tasseling dates. Likewise, supersweet (sh2) and augmented (shA) sweet corn varieties must be isolated from sugary (su), sugar-enhanced (se) and synergistic (syn) types. If not isolated, kernels of both varieties will be starchy instead of sweet. Refer to the table below for isolation requirements or check with your seed supplier.

To maintain color purity, isolate white corn from yellow or bi-color corn. Pollen from yellow or bi-color corn will cause some yellow kernels in white varieties. Pollen from yellow corn will lead to extra yellow kernels in bi-color varieties. Pollen from white corn will not affect the color of yellow or bi-color varieties.

Table of Sweet Corn Isolation Requirements

Type	Isolate from
Sugary (su)	sh2, shA
Sugar-enhanced (se)	sh2, shA
Synergistic (se x sh2 = syn)	sh2, shA
Shrunken-2 (sh2)	su, se, syn
Augmented (su x sh2 = shA or sh aug)	su, se, syn

Plastic mulch and/or transplants are used by some growers on the first plantings to achieve a 7-to-14-day earlier harvest of sweet corn. Two corn rows can be placed on one mulch strip. Whenever clear plastic is used, it is important to plan for weed management under the plastic; herbicides like atrazine, and s-metolachlor can be used. With IRT mulch weeds are less of a problem under the plastic. Increasing in-row spacing with plastic mulch increases the chances of ripening tiller ears.

One method is to direct-seed corn in a shallow trench over which clear plastic is applied just after seeding. The clear plastic warms soil and air, speeding emergence and seedling growth. Monitoring temperature and sunshine is important

because on warm sunny days it can get too hot under the plastic. When temperatures are going to routinely exceed 86 F under the plastic, the plastic should be opened or removed. It can be cut down the row along the center and allowed to open up so corn is exposed.

Another method is to apply clear or infrared transmitting (IRT) mulch to the soil on 5 or 6-ft. centers, and direct-seed or transplant 2- to 3-week-old plants from 72 to 98 cell trays through the mulch.

Conventional seed treatments permit successful direct-seeding of sweet corn in the first fieldwork window of the season. Corn spikes may not emerge for 3 weeks, but the seed treatment prevents rotting and typically ensures a first harvest near July 4th in Iowa. This timeline has been observed with varieties demonstrating high vigor across all sweetness levels, including sh2. For these early plantings it is important to choose varieties known to have good emergence in cool soil.

Fertilizing

pH: Maintain the soil pH between 6.0 and 6.5.

Before planting, apply 40 to 60 pounds N per acre, 0 to 100 pounds P_2O_5 per acre, and 0 to 150 pounds K_2O per acre based on soil test results and recommendations from your state. For early plantings, apply a starter fertilizer at planting 2 inches below and 2 inches to the side of the seed, but do not exceed 80 to 100 pounds of N plus K_2O per acre. On irrigated sandy soils reduce N to 10 to 20 pounds per acre and apply in a band of starter fertilizer. On sandy soils, broadcast 30 pounds or band 15 pounds of sulfur per acre.

Sidedress with 30 to 60 pounds N per acre when plants are 5 to 10 inches tall. On irrigated sandy soils, apply two sidedressings of approximately 40 pounds N per acre each: one when 4 to 5 inches tall (4^{th} to 5^{th} leaf), and the other at 10 inches tall (10^{th} to 12^{th} leaf).

Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer (including starter) and other credits should be 100 to 120 pounds per acre.

Harvesting

Sweet corn is harvested when the kernels plump up and flavor is good. Normally sweet corn will be ready to harvest 18-21 days after 50% of the plants have. Sugary and sugar-enhanced varieties should be harvested promptly when they are ready to reduce starchy buildup in the kernels. Synergistic, supersweet and augmented supersweet varieties can be harvested over a slightly longer period. Hand picking is common, but there are single-row and multi-row mechanical harvester options. With mechanical harvest hand labor hand labor is delayed, not fully eliminated, since sorting is required to cull out unmarketable crop that the mechanical harvester has picked.

Sweet Corn - Diseases

Reviewed by Dan Egel – Aug 2023

Anthracnose of Corn - Colletotrichum Fungus

Non-Pesticide

Rotate to non-host crops for 1-3 years. Varieties with resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aproach (picoxystrobin) | 3-12 fl. oz. per acre. Use 3-6 fl. oz rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. REI: 12-hour. PHI: 7-day. FRAC 11.

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 7-day. FRAC 11.

Elatus (azoxystrobin, benzovindiflupyr) | 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 07.

Headline (pyraclostrobin) | 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Headline AMP (pyraclostrobin, metconazole) | 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day. FRAC 11, FRAC 03.

Priaxor (fluxapyroxad, pyraclostrobin) | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

Quilt (azoxystrobin, propiconazole) | 10.5-14.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Stratego (propiconazole, trifloxystrobin) | 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 03, FRAC 11.

Goss' Wilt of Corn - Clavibacter Bacteria

This pathogen primarily infects leaves that have been wounded by wind, sandblasting, hail, and insect feeding. It overwinters on plant residue on the soil surface.

Non-Pesticide

Rotate to non-host crops for at least 1 year. Use disease-free seed and resistant varieties. Control grassy weeds that are also hosts to the pathogen. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Northern Corn Leaf Blight of Corn - Exserohilum or Helminthosporium Fungus

Non-Pesticide

Rotate to non-host crops for at least 1 year. Varieties with resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aproach (picoxystrobin) | 3-12 fl. oz. per acre. Use 3-6 fl. oz rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. REI: 12-hour. PHI: 7-day. FRAC 11.

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 7-day. FRAC 11.

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.1-2.75 pt. per acre. Use 54% (720) formulations at 0.75-2.0 pt. per acre. Use 82.5% (WDG) formulations at 0.7-1.8 lb. per acre. Use 90% (DF) formulations at 1.25-1.6 lb. per acre. REI: 12-hour. PHI: 14-day. FRAC M05.

Elatus (azoxystrobin, benzovindiflupyr) | 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 07.

Headline (pyraclostrobin) | 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Headline AMP (pyraclostrobin, metconazole) | 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day. FRAC 11, FRAC 03.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate,

Penncozeb). Use 37% formulations at 0.8-1.2 qt. per acre. Use 75% and 80% at 1.0-1.5 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

Priaxor (fluxapyroxad, pyraclostrobin) | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) | 2-4 fl. oz. per acre. PropiMax EC and Tilt are labeled. REI: 12-hour. PHI: 14-day. FRAC 03.

Quilt (azoxystrobin, propiconazole) | 7-14 fl. oz. per acre. Use lower rate for early season applications and increase rate with disease pressure. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Stratego (propiconazole, trifloxystrobin) | 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 03, FRAC 11.

tebuconazole products (tebuconazole) | 4-6 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI is longer than the PHI, and pickers may require PPE if timing is not planned. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Northern Corn Leaf Spot of Corn - Bipolaris Fungus

Non-Pesticide

Rotate to non-host crops for at least 1 year. Varieties with resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aproach (picoxystrobin) | 3-12 fl. oz. per acre. Use 3-6 fl. oz rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. REI: 12-hour. PHI: 7-day. FRAC 11.

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 7-day. FRAC 11.

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.1-2.75 pt. per acre. Use 54% (720) formulations at 0.75-2.0 pt. per acre. Use 82.5% (WDG) formulations at 0.7-1.8 lb. per acre. Use 90% (DF) formulations at 1.25-1.6 lb. per acre. REI: 12-hour. PHI: 14-day. FRAC M05.

Elatus (azoxystrobin, benzovindiflupyr) | 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 07.

Headline (pyraclostrobin) | 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Headline AMP (pyraclostrobin, metconazole) | 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day. FRAC 11, FRAC 03.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.8-1.2 qt. per acre. Use 75% and 80% at 1.0-1.5 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

Priaxor (fluxapyroxad, pyraclostrobin) | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) | 2-4 fl. oz. per acre. PropiMax EC and Tilt are labeled. REI: 12-hour. PHI: 14-day. FRAC 03.

Quilt (azoxystrobin, propiconazole) | 7-14 fl. oz. per acre. Use lower rate for early season applications and increase rate with disease pressure. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Stratego (propiconazole, trifloxystrobin) | 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 03, FRAC 11.

tebuconazole products (tebuconazole) | 4-6 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI is longer than the PHI, and pickers may require PPE if timing is not planned. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Rust of Multiple Crops - Puccinia Fungus

This pathogen can severely reduce yields of grain corn late in the season through defoliation of the plant, but because sweet corn is harvested long before maturity they are less impacted. If rust shows up before tassel then it is worth spraying for in sweet corn to keep healthy leaves until harvest.

Non-Pesticide

Plant resistant hybrids. Sweet corn hybrid resistance to rust will depend on the hybrid's particular Rp-resistant gene, its

general (background) resistance, and the race(s) of the rust prevalent in the planting.

Pesticide

Aproach (picoxystrobin) | 3-12 fl. oz. per acre. Use 3-6 fl. oz rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. REI: 12-hour. PHI: 7-day. FRAC 11.

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 7-day. FRAC 11.

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus, Initiate). Use 38.5% (Zn) formulations at 1.1-2.75 pt. per acre. Use 54% (720) formulations at 0.75-2.0 pt. per acre. Use 82.5% (WDG) formulations at 0.7-1.8 lb. per acre. Use 90% (DF) formulations at 1.25-1.6 lb. per acre. REI: 12-hour. PHI: 14-day. FRAC M05.

Elatus (azoxystrobin, benzovindiflupyr) | 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 07.

Headline (pyraclostrobin) | 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Headline AMP (pyraclostrobin, metconazole) | 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day. FRAC 11, FRAC 03.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.8-1.2 qt. per acre. Use 75% and 80% at 1.0-1.5 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

Priaxor (fluxapyroxad, pyraclostrobin) | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) | 2-4 fl. oz. per acre. PropiMax EC and Tilt are labeled. REI: 12-hour. PHI: 14-day. FRAC 03.

Quilt (azoxystrobin, propiconazole) | 10.5-14.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Stratego (propiconazole, trifloxystrobin) | 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 03, FRAC 11.

tebuconazole products (tebuconazole) | 4-6 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI is longer than the PHI, and pickers may require PPE if timing is not planned. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Smut of Corn - Ustilago Fungus

This pathogen is common at low levels, but it can be worse when roots and stalks are damaged from close cultivation that nips the roots, wind lodging and wind sandblasting, or in times of drought stress. When under drought stress, tasseling and silking do not line up. Tassels come first and silks last longer than usual because they are not getting pollinated. This provides an entry for the fungus into the ears. Flowering patterns and response to environmental stress are unique to each variety. Planting field position in relation to prevailing winds, timing and variety are likely factors for disease occurrence.

Non-Pesticide

Some hybrids tend to have fewer infections. Use past experience to choose successful hybrids. Avoid mechanical damage to corn plant. Avoid plant stresses that affect pollen production and silk emergence.

Southern Corn Leaf Blight of Corn - Bipolaris Fungus

Non-Pesticide

Rotate to non-host crops for at least 1 year. Varieties with resistance are available. Prompt destruction of the finished crop with tillage to rapidly breakdown tissue is an important method to prevent disease build-up.

Pesticide

Aproach (picoxystrobin) | 3-12 fl. oz. per acre. Use 3-6 fl. oz rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. REI: 12-hour. PHI: 7-day. FRAC 11.

azoxystrobin products (azoxystrobin) | Several formulations are labeled at various rates (Acadia LFC, AZteroid FC 3.3, Dexter SC, Quadris, Satori). Use 34.3% formulations at 3.9-9.7 fl. oz. per acre. Use 22.9% formulations at 6.0-15.5 fl. oz. per acre. Use 18.4% formulations at 7.6-19.5 fl. oz. per acre. REI: 4-hour. PHI: 7-day. FRAC 11.

chlorothalonil products (chlorothalonil) | Several formulations are labeled at various rates (Bravo, Echo, Equus,

Initiate). Use 38.5% (Zn) formulations at 1.1-2.75 pt. per acre. Use 54% (720) formulations at 0.75-2.0 pt. per acre. Use 82.5% (WDG) formulations at 0.7-1.8 lb. per acre. Use 90% (DF) formulations at 1.25-1.6 lb. per acre. REI: 12-hour. PHI: 14-day. FRAC M05.

Elatus (azoxystrobin, benzovindiflupyr) | 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11, FRAC 07.

Headline (pyraclostrobin) | 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 11.

Headline AMP (pyraclostrobin, metconazole) | 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day. FRAC 11, FRAC 03.

mancozeb products (mancozeb) | Several formulations are labeled at various rates (Dithane, Koverall, Manzate, Penncozeb). Use 37% formulations at 0.8-1.2 qt. per acre. Use 75% and 80% at 1.0-1.5 lb. per acre. REI: 24-hour. PHI: 7-day. FRAC M03.

Priaxor (fluxapyroxad, pyraclostrobin) | 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day. FRAC 07, FRAC 11.

propiconazole products (propiconazole) | 2-4 fl. oz. per acre. PropiMax EC and Tilt are labeled. REI: 12-hour. PHI: 14-day. FRAC 03.

Quilt (azoxystrobin, propiconazole) | 7-14 fl. oz. per acre. Use lower rate for early season applications and increase rate with disease pressure. REI: 12-hour. PHI: 14-day. FRAC 11, FRAC 03.

Stratego (propiconazole, trifloxystrobin) | 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day. FRAC 03, FRAC 11.

tebuconazole products (tebuconazole) | 4-6 fl. oz. per acre. There are many 38.7% formulations (Monsoon, Onset, Toledo, Vibe) that use the same rate. REI is longer than the PHI, and pickers may require PPE if timing is not planned. REI: 12-hour to 18-day. PHI: 7-day. FRAC 03.

Stewart's Wilt of Corn - Pantoea Bacteria

This bacterial disease is spread by overwintered flea beetles in the spring time. If the plants become infected at the seedling stage, they become severely stunted and have white striping on the leaves and internal browning of stem tissue. Infections after the seedling stage will cause leaf blight and are generally not as economically severe as seedling infections. Early infection of seedling plants can lead to total yield loss in some plantings. Severity of the disease is directly related to overwintering survival of the flea beetle, and beetle survival depends directly on temperature. See insect section.

Non-Pesticide

Plant wilt-resistant, or partially resistant hybrids. Monitor overwintering flea beetle population.

Pesticide

Insecticides | Use an insecticide or seed treatment to control the flea beetles that transmit Stewart's wilt. Insecticide treatments are more likely to be necessary in season following a mild winter and when using susceptible varieties.

Viruses of Multiple Crops - Multiple Pathogens

Non-Pesticide

Virus diseases include maize dwarf mosaic, chlorotic dwarf, wheat streak mosaic. Plant resistant or partially resistant varieties. Control Johnson grass and volunteer wheat.

Sweet Corn - Insects

Major Update by Marissa Schuh, Laura Ingwell, Ashley Leach – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Heavy corn leaf aphid infestations are often limited to early-season plantings that develop on late whorl to early tassel sweet corn. Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Asana XL (esfenvalerate) | 2.9-9.6 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) | Use 30SG formulations at 2.1-2.9 oz. per acre. Use 70WP formulations at 0.9-1.2 oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 04A.

Capture LFR (bifenthrin) | 2.8-8.5 fl. oz. per acre. Apply as a foliar spray. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Lannate LV (methomyl) | 0.75 - 1.5 pts. per acre. Some varieties are susceptible to methomyl injury; determine crop safety before full scale spraying. REI: 48-hour. PHI: 0-day for ears, 3-day for forage. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.8-4.0 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Caterpillars

The main caterpillar species seen in sweet corn are European corn borer, western bean cutworm, and corn earworm. All species can co-occur in a sweet corn field during some parts of the year.

European corn borer (ECB) is less common in our region than it was 20 years ago. Eggs are laid on leaves, usually on the undersides, in the region of the ear. Larvae feed on the leaves and later may migrate to the ears (if present). Corn borers can be controlled by spraying during the late whorl, tasseling, and silking stages. The migrating larvae should contact a lethal dose of insecticide while moving to the ear zone.

Western bean cutworm (WBC) is present in the southern and eastern portions of our region. Eggs are laid on the top surface of leaves on corn that is in pre-tassel. They have one generation per year from mid-July to early August. Sweet corn that has well-developed ears during flight is less likely to be infested; however, tillers (suckers) that have not tasseled may be attractive for egg-laying.

Corn earworm (CEW) does not overwinter in our region, and travels to the region on weather fronts. There is consistent corn earworm pressure starting in August. Eggs are laid directly on green silks. The larvae that hatch from those eggs will follow the silks down into the tips of the ears. Corn earworms must be controlled by directing sprays at the silks, such as using drop nozzles, so larvae will immediately contact the insecticide after hatching, prior to being protected once they enter the ear.

Fall armyworm (FAW) does not overwinter in our region and isn't seen every year. Eggs are laid on corn leaves, and newly emerged larvae consume large quantities of foliage as they rapidly grow. FAW will feed on all stages and parts of the plant, but the pre-tassel whorl is preferred. Caterpillars can directly penetrate husks and damage ears.

All moths can be monitored with pheromone traps. When moths are being caught in traps, it means they are mating and laying eggs in the crop.

ECB: treatment is justified when more than 10 moths per night are caught in traps while corn is in late whorl stage or when 20% or more of the plants show larval feeding. One application during the late whorl stage, followed by additional treatments every five days up until seven days of harvest, usually provides adequate control. Do not treat separately for European corn borer and corn earworm.

WBC: treatment is justified when moths are being caught in pheromone traps or larval damage is present when corn is in late whorl stage.

CEW: treatment is justified when moths are being caught in traps while green silks are present. In general, the higher the moth catches, the shorter the interval between sprays. If fewer than 5 moths are being caught per night, a five-day spray interval should be adequate. As moth catches approach 50 to 100 per night, a two- to three-day spray interval would be more appropriate. If no field corn in the area is silking, moths will lay eggs primarily on silking sweet corn. In this situation,

use a threshold of 1-3 moths per trap per night. Stop treating for corn earworms when 90% of the silks are brown. Resistance to pyrethroids have been documented in the region, check for state level guidance. Do not treat separately for European corn borer and corn earworm.

FAW: treatment is justified when moths are being caught in pheromone traps or larval damage is present when corn is in late whorl stage.

Non-Pesticide

Plant early maturing varieties of sweet corn to avoid late season caterpillar pressure.

Pesticide

Asana XL (esfenvalerate) | 2.9-9.6 fl. oz. per acre. Caterpillars include cutworms, corn borers, and earworms. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Baythroid XL (beta-cyfluthrin) | 0.8-2.8 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Besiege (chlorantraniliprole, lambda-cyhalothrin) | 6-10 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 24-hour. PHI: 1-day. IRAC 28, IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | For armyworms, and cutworms use 2EC formulations at 0.3 fl. oz. per 1,000 linear ft. of row in a minimum of 3 gals. of finished spray as a 5- to 7-inch band over an open seed furrow (T-band). For armyworms, corn borers, cutworms, and earworms, use 2EC formulations as a foliar application at 2.1-6.4 fl. oz. per acre. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 30-day for soil applications, 1-day for foliar applications. IRAC 03A. *RUP.*

Bt (Bacillus thuringiensis) products for caterpillars (Bacillus thuringiensis aizawai strain ABTS-1857, Bacillus thuringiensis aizawai strain GC-91, Bacillus thuringiensis kurstaki strain ABTS-351, Bacillus thuringiensis kurstaki strain EVB-113-19, Bacillus thuringiensis kurstaki strain SA-11) | For earworms. Various Bt products (Agree, Biobit, Dipel, Javelin, etc.) are available for control of young caterpillars however, different Bt products can vary in the effectiveness against caterpillars. Apply early and often directly to silks and mix with horticultural oil. REI: 4-hour. PHI: 0-day. IRAC 11A. *OMRI-listed.*

Bt (Bacillus thuringiensis) varieties (Cry1Ab, Cry2Ab, Cry1A.105, Vip3A) | There are four Bt proteins bred into sweet corn for control of armyworms, corn borers, earworms, and cutworms. Cry1Ab is effective on European corn borer but has never been effective on western bean cutworm. It is moderately effective on fall armyworm and corn earworm. Field corn with this single trait is not marketed for control of corn earworm or fall armyworm, but sweet corn still is. To slow down counter-resistance in pest populations the field corn market is moving away from single-trait varieties. Syngenta Attribute I Series sweet corn has this trait. Cry2Ab2 is always paired with Cry1A.105 and is effective on European corn borer and fall armyworm. It is moderately effective on western bean cutworm, and in some places is no longer effective on corn earworm. There are reports of corn earworm resistance in North Carolina field corn, and sweet corn in Maryland. Seminis Performance Series has these traits. Vip3A is the only effective protein on corn earworm, western bean cutworm, and fall armyworm. Syngenta Attribute II and Attribute Plus series corn has both Vip3A and Cry1Ab traits. IRAC 11A.

Capture LFR (bifenthrin) | For armyworms, corn borers, cutworms, and earworms. Apply to soil as pre-plant or pre-emergent application at 0.2-0.78 fl. oz. per acre per 1,000 linear ft. row at planting, or as a foliar spray at 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Coragen (chlorantraniliprole) | 3.5-7.5 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 4-hour. PHI: 1-day. IRAC 28.

Entrust SC (spinosad) | For armyworms, corn borers, cutworms, and earworms. Use 2SC formulations at 1.5-6.0 fl. oz. per acre. Use 80WP formulations at 0.5-2.0 oz. per acre. Observe resistance management restrictions. REI: 4-hour. PHI: 1-day. IRAC 05. *OMRI-listed.*

Ethos XB (bifenthrin, Bacillus amyloliquefaciens strain D-747) | 0.2 to 0.98 fl. oz per 1,000 linear feet of row. For armyworm and cutworm caterpillars. Apply as a 5 to 7 inch band over an open furrow, or in-furrow with the seed. REI: 12-hour. IRAC 03A, FRAC BM02. *RUP.*

Force CS (tefluthrin) | For cutworms. Apply Force Evo (2.1CS) at 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force 6.5G at 1.8-2.3 oz. per 1,000 linear ft. of row. Apply Force 3G at 3-4 oz. per 1,000 linear ft. of row. Apply Force 10G HL at 1.25-1.5 oz. per 1,000 linear ft. or row. Apply at planting. Do not exceed 1 application per crop. REI: 48-hour. IRAC 03A. *RUP.*

Helicovex (Helicoverpa armigera nucleopolyhedrovirus strain BV-0003) | 0.5-2.5 fl. oz. per acre. For corn earworm only. Apply 0.5-1.5 fl. oz. per acre every 3 days during silking. REI: 4-hour. PHI: 0-day. IRAC 31. *OMRI-listed.*

Lannate LV (methomyl) | 0.75 - 1.5 pts. per acre. For armyworms, corn borers, cutworms, and earworms. Has ovidical properties. Some varieties are susceptible to methomyl injury, determine crop safety before full scale spraying. REI: 48-hour. PHI: 0-day for ears, 3-day for forage. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.8-4.0 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | For armyworms, corn borers, cutworms, and earworms. Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. Control is poor when temperatures are above 90 F. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) | 3-6 fl. oz. per acre. For armyworms, corn borers, Western bean cutworms, and earworms. REI: 4-hour. PHI: 1-day for ears. 3-day for forage. IRAC 05.

Sevin XLR Plus (carbaryl) | 2 qts. per acre. For armyworms, corn borers, earworms and Western bean cutworm only. Machine harvest only. REI: 12-hour. PHI: 2-day for ears. 14-day for forage. IRAC 01A.

Warrior II (lambda-cyhalothrin) | For armyworms, corn borers, cutworms, and earworms apply foliar applications at 1.28-1.92 fl. oz. per acre. For cutworm caterpillars and corn rootworm larvae apply a soil application at 0.33 fl. oz. per 1,000 ft. of row. Apply in furrow or as a 5- to 7-inch band. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Corn Rootworm Beetles

If few or no rootworm beetles were present in the field in the previous year, or you grew sweet corn in a field the previous year and followed a regular spray schedule during silking, there is little chance of a damaging infestation.

Corn rootworm adults may prevent pollination by feeding on green silks. Treat when silks are being clipped.

Pesticide

Assail 30SG (acetamiprid) | Use 30SG formulations at 4.0-5.3 oz. per acre. Use 70WP formulations at 1.7-2.3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Baythroid XL (beta-cyfluthrin) | 0.8-2.8 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Besiege (chlorantraniliprole, lambda-cyhalothrin) | 6-10 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 28, IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations as a foliar application at 2.1-6.4 fl. oz. per acre. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Corn Rootworm Larvae

If few or no rootworm beetles were present in the field in the previous year, or you grew sweet corn in a field the previous year and followed a regular spray schedule during silking, there is little chance of a damaging infestation.

Corn rootworm adults may prevent pollination by feeding on green silks. Treat when silks are being clipped.

Pesticide

Aztec 4.67G (tebupirimphos, cyfluthrin) | Use 4.67G formulations at 3.0 oz. per 1,000 linear ft. of row, or HC formulations at 1.5 oz. per 1,000 ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. IRAC 01B, IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | Use 2EC formulations at 0.3 fl. oz. per 1,000 linear ft. of row in a minimum of 3 gals. of finished spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 30-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) | 0.39-0.98 fl. oz. per 1,000 linear ft. of row. Apply at planting in furrow or a T-band. REI: 12-hour. IRAC 03A. *RUP.*

Counter 20G (terbufos) | 4.5-6.0 oz. per 1,000 linear ft. or row. Available as Lock 'N Load, SmartBox, and SmartCartridge. REI: 48-hour. IRAC 01B. *RUP.*

Ethos XB (bifenthrin, Bacillus amyloliquefaciens strain D-747) | 0.49 to 0.98 fl. oz. per 1,000 square feet Apply as a 5 to 7 inch band over an open furrow, or in-furrow with the seed. REI: 12-hour. IRAC 03A, FRAC BM02. *RUP.*

Force CS (tefluthrin) | 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force Evo (2.1CS) at 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force 6.5G at 1.8-2.3 oz. per 1,000 linear ft. of row. Apply Force 3G at 4-5 oz. per 1,000 liner ft. of row. Apply Force 10G at 1.25-1.5 oz. per 1,000 linear ft. or row. Apply at planting. Do not exceed 1 application per crop. REI: 48-hour. IRAC 03A. *RUP.*

Mocap 15G (ethoprop) | 8 oz. per 1,000 linear ft. of row. Apply in band over closed seed furrow and incorporate with tines or drag chains. Do not place in the furrow or in direct contact with the seed. Do not exceed 1 application per crop per year. REI: 48-hour. IRAC 01B. *RUP.*

Thimet 20G (phorate) | 4.5-6 oz. per 1,000 linear ft. of row. Place in a 7-inch band over the row behind the planter shoe and in front of or behind the press wheel and lightly incorporate. REI: 48-hour. IRAC 01B. *RUP.*

Warrior II (lambda-cyhalothrin) | For armyworms, corn borers, cutworms, and earworms apply foliar applications at 1.28-1.92 fl. oz. per acre. For cutworm caterpillars and corn rootworm larvae apply a soil application at 0.33 fl. oz. per 1,000 ft. of row. Apply in furrow or as a 5- to 7-inch band. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Flea Beetles

Corn flea beetle is the main species in sweet corn, and is more common in southern portions of the region. Populations are bigger after a mild winter. This species vectors Stewart's wilt. In sweet corn that is taller than 6 inches, yield losses from direct feeding are minimal.

Non-Pesticide

Plant varieties that are resistant to Stewart's wilt.

Pesticide

Asana XL (esfenvalerate) | 2.9-9.6 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Assail 30SG (acetamiprid) | Use 30SG formulations at 4.0-5.3 oz. per acre. Use 70WP formulations at 1.7-2.3 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Baythroid XL (beta-cyfluthrin) | 0.8-2.8 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Besiege (chlorantraniliprole, lambda-cyhalothrin) | 6-10 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 28, IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations as a foliar application at 2.1-6.4 fl. oz. per acre. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) | 2.8-8.5 fl. oz. per acre. Apply as a foliar spray. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Lannate LV (methomyl) | 0.75 - 1.5 pts. per acre. Some varieties are susceptible to methomyl injury; determine crop safety before full scale spraying. REI: 48-hour. PHI: 0-day for ears, 3-day for forage. IRAC 01A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 2.24-4.0 fl. oz. per acre. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP.*

Perm-Up 25DF (permethrin) | Use 25W, 25WP, and 25DF formulations at 6.4-12.8 oz. per acre. Use 3.2EC formulations at 4-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Seed treatments for insects (various ingredients) | Rates vary by product, and are often multiple premixed ingredients. Select seed treatments with ingredients such as clothianidin (Poncho), thiamethoxam (Cruiser 5FS), or imidacloprid (Gaucho).

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. Machine harvest only. REI: 12-hour. PHI: 2-day. IRAC 01A.

Thimet 20G (phorate) | 4.5-6 oz. per 1,000 linear ft. of row. Place in a 7-inch band over the row behind the planter shoe and in front of or behind the press wheel and lightly incorporate. REI: 48-hour. IRAC 01B. *RUP.*

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP.*

Seed and Root Maggots

Seedcorn maggot is the root maggot of concern in our region. This pest is a problem during cool, wet springs when plants are growing slowly. Egg-laying adults are attracted to the smell of decaying organic matter, and fields where green manures, cover crops, and weeds have been recently killed are at greater risk. Degree day models can be used to time

planting and management actions. Seed treatments are available. Warm, dry weather reduces risk of damage.

Non-Pesticide

Plant after the peak flight and egg-laying window of the first generation of flies looking to lay eggs around 360 GDD base 40. Handle seeds carefully to prevent cracking. Plow winter vegetation under early in the spring and thoroughly cover to limit attractiveness of rotting vegetation to the first generation of flies to lay eggs on.

Pesticide

Aztec 4.67G (tebupirimphos, cyfluthrin) | Use 4.67G formulations at 3.0 oz. per 1,000 linear ft. of row, or HC formulations at 1.5 oz. per 1,000 ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. IRAC 01B, IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | Use 2EC formulations at 0.3 fl. oz. per 1,000 linear ft. of row in a minimum of 3 gals. of finished spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 30-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) | 0.2-0.78 fl. oz. per 1,000 linear bed ft. of row. Apply at planting in furrow or a T-band. REI: 12-hour. IRAC 03A. *RUP.*

Counter 20G (terbufos) | 4.5-6.0 oz. per 1,000 linear ft. or row. Available as Lock 'N Load, SmartBox, and SmartCartridge. REI: 48-hour. IRAC 01B. *RUP.*

Ethos XB (bifenthrin, Bacillus amyloliquefaciens strain D-747) | 0.2 to 0.98 fl. oz per 1,000 linear feet of row. Apply as a 5 to 7 inch band over an open furrow, or in-furrow with the seed. REI: 12-hour. IRAC 03A, FRAC BM02. *RUP.*

Force CS (tefluthrin) | 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force Evo (2.1CS) at 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force 6.5G at 1.8-2.3 oz. per 1,000 linear ft. of row. Apply Force 3G at 4-5 oz. per 1,000 liner ft. of row. Apply Force 10G at 1.25-1.5 oz. per 1,000 linear ft. or row. Apply at planting. Do not exceed 1 application per crop. REI: 48-hour. IRAC 03A. *RUP.*

Seed treatments for insects (various ingredients) | Rates vary by product, and are often multiple premixed ingredients. Select seed treatments with ingredients such as clothianidin (Poncho), thiamethoxam (Cruiser 5FS), or imidacloprid (Gaucho).

Thimet 20G (phorate) | 4.5-6 oz. per 1,000 linear ft. of row. Place in a 7-inch band over the row behind the planter shoe and in front of or behind the press wheel and lightly incorporate. REI: 48-hour. IRAC 01B. *RUP.*

Seedcorn Beetles

Non-Pesticide

If you have a history of this pest, delay planting to starve beetles.

Pesticide

Aztec 4.67G (tebupirimphos, cyfluthrin) | Use 4.67G formulations at 3.0 oz. per 1,000 linear ft. of row, or HC formulations at 1.5 oz. per 1,000 ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. IRAC 01B, IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | Use 2EC formulations at 0.3 fl. oz. per 1,000 linear ft. of row in a minimum of 3 gals. of finished spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 30-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) | 0.2-0.78 fl. oz. per 1,000 linear bed ft. of row. Apply at planting in furrow or a T-band. REI: 12-hour. IRAC 03A. *RUP.*

Counter 20G (terbufos) | 4.5-6.0 oz. per 1,000 linear ft. or row. Available as Lock 'N Load, SmartBox, and SmartCartridge. REI: 48-hour. IRAC 01B. *RUP.*

Force CS (tefluthrin) | 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force Evo (2.1CS) at 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force 6.5G at 1.8-2.3 oz. per 1,000 linear ft. of row. Apply Force 3G at 4-5 oz. per 1,000 liner ft. of row. Apply Force 10G at 1.25-1.5 oz. per 1,000 linear ft. or row. Apply at planting. Do not exceed 1 application per crop. REI: 48-hour. IRAC 03A. *RUP.*

Seed treatments for insects (various ingredients) | Rates vary by product, and are often multiple premixed ingredients. Select seed treatments with ingredients such as clothianidin (Poncho), thiamethoxam (Cruiser 5FS), or imidacloprid (Gaucho).

Thimet 20G (phorate) | 4.5-6 oz. per 1,000 linear ft. of row. Place in a 7-inch band over the row behind the planter shoe

and in front of or behind the press wheel and lightly incorporate. REI: 48-hour. IRAC 01B. *RUP*.

Stink Bugs

Pesticide

Baythroid XL (beta-cyfluthrin) | 0.8-2.8 fl. oz. per acre. For armyworms, corn borers, cutworms, and earworms. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP*.

Besiege (chlorantraniliprole, lambda-cyhalothrin) | 6-10 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 28, IRAC 03A. *RUP*.

Brigade 2EC (bifenthrin) | 2.1-6.4 fl. oz. per acre. Use 2EC formulations as a foliar application at 2.1-6.4 fl. oz. per acre. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP*.

Capture LFR (bifenthrin) | 2.8-8.5 fl. oz. per acre. Apply as a foliar spray. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP*.

Hero (bifenthrin, zeta-cypermethrin) | 4.0-10.3 fl. oz. per acre. Do not exceed 27.39 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. IRAC 03A. *RUP*.

Lannate LV (methomyl) | 1.5 pts. per acre. Some varieties are susceptible to methomyl injury, determine crop safety before full scale spraying. REI: 48-hour. PHI: 0-day for ears, 3-day for forage. IRAC 01A. *RUP*.

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 1-day. IRAC 03A. *RUP*.

Wireworms

Wireworms are long-lived in the soil, and are most common in fields that were previously fallow or in pasture.

Non-Pesticide

Avoid planting in fields that were recently in grasses.

Pesticide

Aztec 4.67G (tebupirimphos, cyfluthrin) | Use 4.67G formulations at 3.0 oz. per 1,000 linear ft. of row, or HC formulations at 1.5 oz. per 1,000 ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. IRAC 01B, IRAC 03A. *RUP*.

Brigade 2EC (bifenthrin) | Use 2EC formulations at 0.3 fl. oz. per 1,000 linear ft. of row in a minimum of 3 gals. of finished spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet corn. REI: 12-hour. PHI: 30-day. IRAC 03A. *RUP*.

Capture LFR (bifenthrin) | 0.2-0.78 fl. oz. per 1,000 linear bed ft. of row. Apply at planting in furrow or a T-band. REI: 12-hour. IRAC 03A. *RUP*.

Counter 20G (terbufos) | 4.5-6.0 oz. per 1,000 linear ft. or row. Available as Lock 'N Load, SmartBox, and SmartCartridge. REI: 48-hour. IRAC 01B. *RUP*.

Force CS (tefluthrin) | 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force Evo (2.1CS) at 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply Force 6.5G at 1.8-2.3 oz. per 1,000 linear ft. of row. Apply Force 3G at 4-5 oz. per 1,000 liner ft. of row. Apply Force 10G at 1.25-1.5 oz. per 1,000 linear ft. or row. Apply at planting. Do not exceed 1 application per crop. REI: 48-hour. IRAC 03A. *RUP*.

Mocap 15G (ethoprop) | 8 oz. per 1,000 linear ft. of row. Apply in band over closed seed furrow and incorporate with tines or drag chains. Do not place in the furrow or in direct contact with the seed. Do not exceed 1 application per crop per year. REI: 48-hour. IRAC 01B. *RUP*.

Seed treatments for insects (various ingredients) | Rates vary by product, and are often multiple premixed ingredients. Select seed treatments with ingredients such as clothianidin (Poncho), thiamethoxam (Cruiser 5FS), or imidacloprid (Gaucho).

Thimet 20G (phorate) | 4.5-6 oz. per 1,000 linear ft. of row. Place in a 7-inch band over the row behind the planter shoe and in front of or behind the press wheel and lightly incorporate. REI: 48-hour. IRAC 01B. *RUP*.

Sweet Corn - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

Weed control methods in sweet corn vary by production system and variety.

For sweet corn that is no-till, direct-seeded into a killed crop (such as after a rye cover crop, or wheat) growers often use a burndown herbicide with a preemergence herbicide. For sweet corn direct-seeded into tilled soil, growers often combine one or more preemergence herbicides at planting with one or more cultivations. Sometimes, growers also apply a preemergence herbicide after the last cultivation to improve control of late-emerging weeds. Small, emerged weeds in both systems can be controlled with selective postemergence herbicides and/or shielded applications of nonselective herbicides.

For early sweet corn direct-seeded under vented plastic row cover, some herbicides are applied before laying the plastic to prevent germinating weeds along with the early corn. But, without good incorporation or irrigation for activation these rows will usually need extensive clean up after the row-cover comes off.

There are sweet corn varieties that are tolerant of glyphosate (RoundUp-Ready), glufosinate (Liberty-Link), or sethoxydim (Poast-Protected) applications over-the-top of the crop. Confirm the herbicide tolerance traits of your sweet corn before making an over-the-top herbicide application.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. Later plantings of sweet corn lend themselves to this stale seedbed practice because they are often planted after common weeds have emerged in tilled soil. Uniform and close plant spacing in the row promotes rapid canopy cover, and fresh market growers can keep larger between-row spacing clean with between-row cultivation tools for hand-pickers or mechanical harvesters. Rolling cultivators on wide tool-bars offer effective, high-speed between-row cultivation.

Pesticide

2,4-D amine products (2,4-D) POST | 4L amine formulations at 0.5-1.5 pts. per acre. Use lower rates on annual weeds and higher rates on perennial weeds in the bud stage. Use drop nozzles if corn is more than 8 inches tall. Do not apply to open whorls or from 2 week before tasseling through harvest. Avoid drift onto other vegetable crops. Can cause severe injury to some varieties. REI: 48-hour. PHI: 45-day. HRAC 04.

Accent Q (nicosulfuron) POST | 0.45-0.90 oz. per acre. Use COC (1% v/v) or NIS (0.25% v/v). Apply broadcast or with drop nozzles on corn up to 12 inches tall or up through 5 leaf collars. For corn 12-18 inches tall use drop nozzles. Do not apply to corn more than 18 inches tall or showing 6 leaf collars or more. Cultivars differ in sensitivity to this herbicide; get information on cultivars prior to use. Not recommended for use on corn previously treated with Counter or Thimet insecticides. REI: 4-hour. HRAC 02.

acetochlor + atrazine products (acetochlor, atrazine) PRE | Apply 2.2-3.4 qts. per acre Breakfree ATZ, 1.6 to 3 qts. per acre Breakfree ATZ Light or Keystone LA, 2.9-3.7 qts. per acre Degree Xtra, 2.5-5 qts. per acre FulTime, 1.8-3.3 qts. per acre Harness Xtra, 1.4-3 qts. per acre Harness Extra 5.6L, or 2.2-3.4 qts. per acre Keystone. Do not apply postemergence. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting before sweet corn emerges. Do not apply to light textured soils specified in the label where ground water is at 30 ft. or less. REI: 12-hour. HRAC 15, HRAC 05. *RUP.*

acetochlor products (acetochlor) PRE | Apply 1.5-3 pts. per acre for Harness 7E, 1.5-3.75 pts. per acre for Surpass 6.4EC, or 2-3 pts. per acre TopNotch 3.2M. Do not apply postemergence. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting but before sweet corn emerges. May be mixed with atrazine or simazine. See label for details. Do not apply to light textured soils specified in the label where ground water is at 30 ft. or less. REI: 12-hour. HRAC 15.

Acuron (atrazine, mesotrione, s-metolachlor, bicyclopyrone) PRE | 2.5 qts. per acre on soil with less than 3% organic matter; 3 qts. per acre on soil with more than 3% organic matter. For control of most broadleaf and grass weeds. Control may be reduced on soils with >10% organic matter. Do not apply after sweet corn has emerged or severe crop injury may occur. 18-month replant restriction for all crops except corn types (no restrictions); small grains (4 months); dry beans, potato, and soybean (10 months). Contains atrazine so state restrictions for atrazine apply. REI: 24-hour. PHI: 45-day for grazing or forage feeding, 60-day for forage harvest. HRAC 05, HRAC 27, HRAC 15. *RUP.*

Aim EC (carfentrazone) POST | 0.5-2.0 fl. oz. per acre. Apply to actively growing weeds up to 4 in. tall from prior to planting up to V-14 stage. To reduce injury, use drop nozzles to make applications in corn from V8-V14 stages or apply with a hooded-sprayer to minimize application to the whorl. Add 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Do not exceed 2 fl. oz. per acre per season. For burndown applications, consider tank-mixing with an additional broad-spectrum herbicide such as glyphosate. REI: 12-hour. HRAC 14.

Anthem (pyroxasulfone, fluthiacet-methyl) POST | PRE | 2.5-6.5 fl. oz. per acre. Apply 4-13 fl. oz. of Anthem or 2-6.5 fl. oz. Anthem Maxx per acre. Adjust rate based on soil organic matter and texture, and pre or postemergence use, see label. Preplant surface applications are not recommended for sweet corn. Apply post from crop emergence through V4 growth stage. Add COC/MSO (1% v/v) or NIS (0.25% v/v) for best activity. Before applying to corn, confirm that your line has Anthem tolerance with your seed company or supplier to avoid injury to sensitive lines. Avoid postemergence application when crop foliage is wet or prior to or after a rain because a crop injury can occur. However, the crop will recover. Do not apply if crop is under stress and do not irrigate within 4 hours of a postemergence application. REI: 12-hour. PHI: 40-day. HRAC 15, HRAC 14.

Anthem ATZ (atrazine, pyroxasulfone, fluthiacet-methyl) POST | PRE | 1.5-4 pts. per acre. Adjust rate based on soil organic matter and texture, and pre or postemergence use, see label. Preplant surface applications are not recommended for sweet corn. Apply post from crop emergence through V4 growth stage. Add COC/MSU (1% v/v) or NIS (0.25% v/v).. Before applying to corn, confirm that your line has Anthem selectivity with your seed company or supplier to avoid injury to sensitive lines. Avoid postemergence application when crop foliage is wet or prior to or after a rain because a crop response can occur. However, the crop will recover. Do not apply if crop is under stress and do not irrigate within 4 hours of a postemergence application. REI: 12-hour. PHI: 45-day. HRAC 05, HRAC 15, HRAC 14. *RUP.*

Anthem Flex (carfentrazone, pyroxasulfone) POST | PRE | *Preplant or pre-emergence:* Apply 2.75-7.3 fl. oz. per acre from 14 days preplant to spike stage corn. *After corn emergence:* Apply 2.25-6.4 fl. oz. per acre through the V-4 stage. Use higher rates on finer textured soil and soil with greater organic matter. Within each soil texture-organic matter category, use a higher rate on soils with high-residue or higher weed pressure. See label for maximum rates per application and year based on soil texture. Do not apply on coarse textured soil or medium-textured soil with less than 2% organic matter. REI: 12-hour. PHI: 3-day. HRAC 14, HRAC 15.

atrazine products (atrazine) POST | PRE | Apply 4L formulations at 1-2 qts. per acre and 90W formulations at 1.1-2.2 lbs. per acre. To control small, emerged broadleaves, include COC (1% v/v). Apply before planting and incorporate, after planting but before corn emerges, or after emergence but before corn is 12 inches tall. Many atrazine products are available. See labels for details. REI: 12-hour. HRAC 05. *RUP.*

Basagran (bentazon) POST | Use 4L formulations at 1.5-2 pt. per acre and 5L formulations at 1.2 to 1.6 pts. per acre. Add COC (1% v/v). Apply to small weeds. Also controls nutsedge. Do not apply to corn that is stressed because injury may result. Combine with atrazine to broaden weed control spectrum. Do not exceed 2 lbs. of bentazon per acre, per season. REI: 48-hour. HRAC 06.

Cadet (fluthiacet-methyl) POST | 0.6-0.9 fl. oz. per acre. ***For processing sweet corn only***. Apply from preplant until corn reaches 48 inches tall, but before tasseling. Controls velvetleaf and several other broadleaves. May be tank-mixed with labeled postemergence herbicides. Add COC (1% v/v) or NIS (0.25% v/v). Do not exceed 1.25 fl. oz. per acre per year. REI: 12-hour. PHI: 40-day. HRAC 14.

Callisto (mesotrione) POST | PRE | 6-7.7 fl. oz. per acre preemergence, 3 fl. oz. per acre postemergence. Some varieties may be severely injured. If weeds are present, add

COC (1% v/v) or NIS (0.25% v/v). Do not add UAN or AMS when applying to emerged sweet corn. Adding atrazine at 0.25-0.5 lb. of a.i. per acre for post applications, or 0.75 lb. a.i. per acre for pre applications will improve weed control. Note organophosphate insecticide precautions. Do not exceed 0.24 lb. mesotrione per acre per year (7.7 fl. oz. Callisto) from all sources. REI: 12-hour. PHI: 45-day. HRAC 27.

Callisto Xtra (mesotrione, atrazine) POST | 20-24 fl. oz. per acre. Apply with COC (1% v/v) or NIS (0.25% v/v). Apply after corn emerges and before corn is 12 inches tall. Also controls large crabgrass. Cultivars differ in sensitivity to this herbicide; get information on cultivars prior to use. Do not use on corn previously treated with Counter insecticide, or within 7 days of treatment with any organophosphate or carbamate insecticide. Do not exceed one application per year. REI: 12-hour. PHI: 45-day. HRAC 27, HRAC 05. *RUP.*

clopyralid products (clopyralid) POST | Use Spur (40.9%) at 0.33-0.66 pts per acre on fresh or processing sweet corn. Use Stinger (40.9%) at 0.33-0.66 pts per acre on processing sweet corn. Use Stinger HL (60.22%) on at 0.2-0.4 pts per acre on processing sweet corn. Spray on actively growing weeds before corn is 18 inches tall. Controls composites and nightshade. Wait 21 days between applications. Do not exceed 0.66 pts. per acre of 3 lbs. per gal. formulations or 0.4 pts. per acre of 5 lbs. per gal. formulations. REI: 12-hour. PHI: 30-day for ears, 60-day for stover. HRAC 04.

dimethenamid-p plus atrazine products (dimethenamid-p, atrazine) PRE | Apply Commit ATZ at 2.5-4.6 pts. per acre, Commit ATZ Lite at 2.0 to 3.5 pts. per acre, or Guardsman Max at 2.5-4.6 pts. per acre. Use low rates on coarse soils with low organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 12 inches tall. Rates may be reduced if corn will be cultivated or full-season control is not needed. If multiple applications are made, do not exceed maximum rate per acre per year. REI: 12-hour. PHI: 50-day. HRAC 15, HRAC 05. *RUP.*

Double Header (acetochlor, mesotrione) PRE | 1.4-2.4 qt. per acre. Apply to the soil surface up to 28 days prior to planting or after planting but before crop emergence or apply and incorporate 2 inches deep within 14 days prior to planting. Use lower rates for coarse textured soil and soils with low organic matter. Although other acetochlor + mesotrione products are available, not all are registered for use in sweet corn. See labels. REI: 12-hour. PHI: 45-day. HRAC 15, HRAC 27.

Dual Magnum (s-metolachlor) PRE | 1-2 pts. per acre. Use lower rate on coarse soils. Apply before planting and incorporate, or apply after planting but before corn emerges. May also be applied as a directed spray between rows when corn is 5-40 inches tall. Incorporate to control nutsedge. May be mixed with atrazine, see label for details. Do not exceed 3.9 pts. per acre per year. Dual II Magnum contains a safener and may used instead of Dual Magnum to limit crop injury under cool soil conditions. REI: 24-hour. PHI: 30-day. HRAC 15.

glyphosate products (glyphosate) POST | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast before or after planting but before crop emerges, or apply up to 0.75 lb. acid equivalent between crop rows with wipers, hooded or shielded sprayers after corn is 12 inches tall. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. For **RoundUp-Ready sweet corn only** - will kill other varieties: postemergence applications may be made over-the-top of corn through the 8 leaf-collar stage (V-8) or until corn is 30 inches tall. Drop nozzles are recommended if corn is more than 24 inches tall, and must be used if corn is more than 30 inches tall to prevent spraying into whorls. Do not apply to corn more than 30 inches tall or if it has reached the reproductive stage. See product label for maximum use rates. REI: 4-hour to 12-hour. PHI: 7-day. HRAC 9.

Impact (topramezone) POST | 0.5-2 fl. oz. per acre. Add MSO or high surfactant methylated oil concentrate (HSMOC) and urea ammonium nitrate (UAN) or spray grade ammonium sulfate (AMS). See label for additive rates. REI: 12-hour. PHI: 45-day. HRAC 27.

Laudis (tembotrione) POST | 3 oz. per acre. Apply with MSO (1% v/v) plus 8.5 lbs. of AMS per 100 gals. of spray solution. COC is less efficacious than MSO but can be used instead of MSO when broadleaves are the main target and conditions for control are excellent. Tank-mixing with atrazine will improve efficacy and spectrum of weed species controlled. REI: 12-hour. PHI: 45-day. HRAC 27.

Lexar EZ (s-metolachlor, atrazine, mesotrione) PRE | Use Lexar EZ at 3 or 3.5 qts. per acre or Lumax EZ at 2.7 or 3.25 qts. per acre. Use the lower rate on soils with organic matter less than 3% and the higher rate on soils with organic matter greater than 3%. Apply up to 14 days before planting or apply after planting but before corn emerges. Can be combined with glyphosate or paraquat products to control emerged weeds. REI: 24-hour. PHI: 60-day. HRAC 15, HRAC 05, HRAC 27. *RUP.*

Liberty 280 SL (glufosinate) POST | Apply 29-43 fl. oz. per acre as a burndown application prior to planting. For **Liberty-Link sweet corn varieties only** - will kill other varieties: apply 22 fl. oz. per acre postemergence. Do not exceed 2 postemergence applications per season. Applications must be at least 7 days apart. Add AMS at 3 lb. per acre. Also available as Interline herbicide. REI: 12-hour. PHI: 50-day. HRAC 10.

Outlook (dimethenamid-p) PRE | 12-21 fl. oz. per acre. Use lower rate on coarse soils low in organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 12 inches tall. Apply preemergence for best activity. Do not exceed 21 fl. oz. of Commit or 24 fl. oz. of Outlook per acre per year. REI: 12-hour. PHI: 50-day. HRAC 15.

paraquat products (paraquat) POST | Use 2-4 pt. per acre of 2SL formulation or 1.3-2.7 pt. per acre of 3SL formulation. Add COC (1% v/v) or NIS (0.25% v/v). Apply before or after seeding but before crop emerges. Or apply after crop emergence and use a hooded or shielded sprayers to prevent spray from contacting crop. Or wait until corn is more than 10 inches tall and apply between rows using directed spray that reaches no higher than 3 inches up the corn stalk. Corn plants contacted by spray may be injured or killed. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

pendimethalin products (pendimethalin) PRE | Apply 3.3 lb. per gallon formulations at 1.8-4.8 pts. per acre and 3.8 lb. a.i. per gallon formulations at 2-4 pts. per acre. Use low rates on coarse soils with low organic matter. Apply after planting but before corn emerges, or after emergence until corn is 20-24 in. tall or shows 8 leaf collars. Plant corn at least 1.5 inches deep and make sure seed is well covered. Use drop nozzles and directed spray for post applications, if necessary, to get spray to soil. Do not exceed one application per season. REI: 24-hour. HRAC 03.

Poast (sethoxydim) POST | 0.75-1.5 pt. per acre. ***Poast Protected sweet corn varieties only*** - will kill other varieties. Add COC/MSO (1% v/v). UAN or AMS are optional, see label. Allow at least 10 days between repeated applications. Do not exceed 3 pt. per acre per growing season. Poast Plus may be used instead at 1.5-2.25 pt. per acre, not to exceed 4.5 pt. per acre per growing season. REI: 12-hour. PHI: 30-day. HRAC 01.

Revulin Q (nicosulfuron, mesotrione) POST | 3.4 to 4.0 oz. per acre. Use with NIS after emergence until 12 inches tall or 5 leaf-collar stage. Use drop nozzles for corn between 12 and 18 inches tall. Do not apply to sweet corn taller than 18 inches or at 6 leaf-collar stage or later. Do not use AMS or UAN adjuvants. Because of the adjuvant restrictions, better results will be obtained when applied to smaller weeds. Can use COC (1% v/v) under dry conditions to improve weed control, but may increase crop injury. Possible hybrid sensitivity. REI: 12-hour. PHI: 45-day. HRAC 02, HRAC 27.

s-metolachlor plus atrazine products (atrazine, s-metolachlor) PRE | Apply Bicep II Magnum, Bicep II Magnum FC, Cinch ATZ, and Charger Max ATZ at 1.3-2.6 qts. per acre OR apply Bicep Lite II Magnum, Cinch ATZ Lite, or Charger Max ATZ Lite at 0.9-2.2 qts. per acre. Use low rates on coarse soils with low organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 5 inches tall. REI: 24-hour. PHI: 30-day. HRAC 05, HRAC 15. *RUP.*

Sandea (halosulfuron) POST | PRE | 2/3-1 oz. per acre. Apply over-the-top or with drop nozzles from the spike through layby stages. Has some soil residual activity. A second application of 2/3 oz. per acre may be made only with drop nozzles aimed to avoid application into whorls. Do not exceed 2 applications per 12-month period. Additional halosulfuron products are available. See labels for details. REI: 12-hour. PHI: 30-day. HRAC 02.

Shieldex (tolpyralate) POST | 1-1.35 fl. oz. per acre. Apply as a broadcast spray over corn when weeds are small. Apply to corn up to 20 inches tall and showing no more than 6 leaf collars. Use higher rate for larger weeds. Add COC

(1% v/v) or NIS (0.25% v/v). Do not exceed 2 applications per year or 2.7 fl. oz. per acre per year. REI: 12-hour. PHI: 35-day. HRAC 27.

Sinate (topramezone, glufosinate) POST | 21 fl. oz. per acre. Apply to LibertyLink sweetcorn only from emergence to V6 stage of growth. Do not apply more than once per year. Add COC/MSO (1% v/v) or HSMOC (0.5% v/v) and spray grade ammonium sulfate (AMS). See label for additive rates. REI: 12-hour. PHI: 50-day for ears, 55-day for stover. HRAC 27, HRAC 10.

Starane Ultra (fluroxypyr) POST | 0.4 pt. per acre. Apply broadcast or as a directed spray to corn that has up to 4 fully exposed leaf collars. Use directed spray when corn is beyond the 4-leaf collar stage. For volunteer potato, can apply preplant to emerged potato followed by a second application postemergence to emerged potato. REI: 24-hour. PHI: 31-day. HRAC 04.

Zidua SC (pyroxasulfone) PRE | 1.75-6.5 fl. oz. per acre of SC formulations, 1.0-4.0 oz. per acre of WDG formulation. Apply before or after planting and before crop emergence, or at spiking up to V4 (4 leaf collars visible). May be incorporated. Will not control emerged weeds. May be tank-mixed or applied sequentially with many other products. Seed at least 1 inch deep. REI: 12-hour. PHI: 37-day. HRAC 15.

Sweet Potato - Horticulture

Major update by Ben Phillips, Liz Maynard – Oct 2020
Reviewed by Brad Bergefurd – Apr 2022

Crop Description

Sweet potatoes (*Ipomoea batatas*) are of tropical origin and are related to morning glories. They can perform well in the Midwest too. The varieties that are easiest to get, and that perform well in the Midwest are listed below. Some varieties need up to 140 frost free days to mature. Sweet potatoes can make for a productive hoophouse crop, and in this way the longer maturing varieties can also be grown. Asian sweet potato varieties are starchier than more commonly grown varieties, and often are white or purple fleshed, instead of orange. In the table below, FW = Fusarium wilt resistant, SRKN = Southern root knot nematode resistant, SSR = Streptomyces soil rot resistant, * = varieties that performed well in midwestern trials.

Variety Name	Description
*Beauregard	Red skin, orange flesh, vine type, 90-100 days. FW, SSR.
*Carolina Ruby	Red skin, orange flesh, vine type, 95-100 days. FW.
*Centennial	Orange skin, orange flesh, vine type, 100 days. FW.
*Covington	Red skin, orange flesh, bush type, 95-105 days. FW, SRKN, SSR.
Evangeline	Red skin, orange flesh, vine type, 100 days. FW, SRKN, SSR.
Hernandez	Orange skin, orange flesh, vine type, 120 days. FW, SRKN, SSR.
Georgia Jets	Orange skin, orange flesh, vine type, 120 days. FW, SRKN, SSR.
Molokai Purple	Purple skin, purple flesh, vine type, 120 days. Starchy.
Murasaki	Purple skin, white flesh, bush type, 120 days. Starchy. FW, SRKN, SSR.
O-Henry	White skin, white flesh, vine type, 90-100 days. Starchy. FW, SSR.
Okinawan Purple	Beige skin, purple flesh, vine type, 140 days. Starchy.
Porto Rico	Orange skin, orange flesh, bush type, 100 days. FW.
Vardaman	Red skin, orange flesh, bush type, 100 days. FW.
White Bonita	White skin, white flesh, vine type, 110-115 days. SRKN.
*Red Japanese	Purple skin, purple flesh, vine type, 110 days. Starchy. FW.

Planting and Spacing

Root production: Water wheel and finger-style transplanters work well for mechanically planting sweet potato slips. Common spacing is 1 foot apart in the row, with rows 3 to 4 feet apart, depending upon the cultivating and harvesting equipment used. 14,520 slips per acre are required at the 1 foot by 3 feet spacing, while 10,890 are needed at the 1 foot by 4 feet spacing. Transplant only strong, stocky slips. Yields can be increased up to 100 bushels per acre by using strong transplants. It is common for the tops to wither after transplanting until they root. Transplanting with water is important to improve their rooting recovery time. Slips may be transplanted into beds covered with plastic mulch; the warmed soil will enhance growth and mulch will help with control.

Slip/cutting production: Select seed stock from high-yielding hills that are smooth, well-shaped, and free of diseases (scurf, internal cork, wilt, black rot) and insect injury. When possible, obtain certified G1 or G2 (generation) seed stock. Store seed stock in new crates to avoid disease contamination. Seed potatoes should be at least 1-1/2 inches in diameter. One bushel of small- to medium-sized roots should produce 500 to 800 sprouts in 10 to 15 square feet of bed area (one cut).

Slip/cutting production should be in movable protected systems (low or high tunnels) for early planting in the field to maximize production season. Before bedding, seed stock should be pre-sprouted at 85 F and 90% relative humidity for 3 to 4 weeks until the sprouts are 1 to 1-1/2 inch. Treat seed stock before planting with Mertect 340F to protect roots from soil-borne diseases. Bed the seed stock in clean land that has not been planted with sweet potato for 4 years. Optimal temperature for growth is 75 F to 85 F. Remove tunnels 7 days prior to planting to harden the slips.

Fertilizing

pH: Maintain the soil pH above 5.0.

Before planting, apply 30 pounds N per acre, 0 to 75 pounds P_2O_5 per acre, and 0 to 250 pounds K_2O per acre based on soil test results and recommendations from your state. Set the slips with a starter solution at the rate of 1 cup (8 fl. oz.) per plant.

Sidedress with 30 to 50 pounds N per acre three to four weeks after transplanting on irrigated sands. Finer textured soils usually do not need sidedressing. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3% organic matter. The total amount of N from fertilizer (including starter) and other credits should be 80 pounds per acre or less.

Harvesting

The last month or so of production is when sweet potato roots put on all their size. Thin, long roots indicate that they are still bulking up. Harvests can begin when roots reach a desired size but should be finished before regular freezing temperatures begin. Tops can freeze off without damaging roots right away, but the decomposing tops can eventually lead to rots in the roots. As soil temperatures go below 65 F tuber growth stops.

Remove vines by cutting with a rotary mower 5 to 7 days before harvest to toughen the skin. Plowing out and hand-collecting sweet potatoes is a common harvest method because their thin skins are easily damaged from chain-diggers. Dig only those potatoes that can be picked up immediately. Potatoes will sunburn if left in direct sunlight for more than an hour. To prevent skinning and bruising use cotton gloves when placing potatoes in crates. Field grading is important. Overnight temperatures below 55 F can chill any dug sweet potatoes that were not collected and cause internal breakdown in storage.

Flavor improves and sweetens a few weeks after digging. Uncured sweet potatoes will last 3 to 6 months in storage. To cure them for 6- to 12-month storage, immediately place them at 80 to 85 F and 85% to 95% humidity for 4 to 7 days. After curing, the temperature may be gradually dropped to 58 F. Hold this temperature until potatoes are marketed or used for producing slips.

Sweet Potato - Diseases

Reviewed by Dan Egel – Aug 2023

Black Rot of Sweet Potatoes - Ceratocystis Fungus

Non-Pesticide

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising. Cure and store only healthy, blemish-free tubers, and maintain proper storage temperatures.

Pesticide

Mertect 340-F (thiabendazole) | 8 fl. oz. per 7.5 gal. of water. One application only. REI: 12-hour. PHI: 0-day. FRAC 01.

Foot Rot of Sweet Potatoes - Plenodomus Fungus

Non-Pesticide

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising. Cure and store only healthy, blemish-free tubers, and maintain proper storage temperatures.

Pesticide

Mertect 340-F (thiabendazole) | 8 fl. oz. per 7.5 gal. of water. One application only. REI: 12-hour. PHI: 0-day. FRAC 01.

Scurf of Sweet Potatoes - Monilochaetes Fungus

Non-Pesticide

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising. Cure and store only healthy, blemish-free tubers, and maintain proper storage temperatures.

Pesticide

Botran 75W (dichloro-nitroaniline) | Use as seed potato dip or plant bed spray. REI: 12-hour. PHI: 0-day. FRAC 14.

Mertect 340-F (thiabendazole) | 8 fl. oz. per 7.5 gal. of water. One application only. REI: 12-hour. PHI: 0-day. FRAC 01.

Storage Rots of Sweet Potato

Non-Pesticide

Prevent bruising. Cure and store only healthy, blemish-free tubers, and maintain proper storage temperatures.

Wilt of Multiple Crops - Fusarium Fungus

Non-Pesticide

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising. Cure and store only healthy, blemish-free tubers, and maintain proper storage temperatures.

Sweet Potato - Insects

Major update by Marissa Schuh, Ashley Leach – Apr 2025

Aphids

Aphid populations tend to spike during periods of hot weather and when plants have excess nitrogen. Aphids transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Scout the upper and lower surface of leaves and look for shed skins or honey dew. Selective chemistries (e.g. flonicamid, pymetrozine) that target piercing-sucking insects help to preserve natural enemies.

Non-Pesticide

Preserve and encourage natural enemies. Aphid mummies indicate the presence of parasitoids. Predatory fly larvae, lady beetles, minute pirate bugs, and lacewings are common predators.

Pesticide

Actara (thiamethoxam) | 3.0 oz. per acre. Control may require two applications. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Admire Pro (imidacloprid) | 1.2 fl. oz. per acre foliar application, 4.4-10.5 fl. oz. per acre or 0.26 fl. oz. per 1,000 ft. of row soil application. Do not exceed 10.5 fl. oz. or 1 application per acre per season. REI: 12-hour. PHI: 7-day for foliar applications, or 125-day for soil applications. IRAC 04A.

Assail 30SG (acetamiprid) | Use 30SG formulations at 2.5-4.0 oz. per acre. Use 70WP formulations at 1.0-1.7 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Baythroid XL (beta-cyfluthrin) | 2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 2-3 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A.

Beleaf (flonicamid) | 2.0-2.8 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 29.

Fulfill (pymetrozine) | 2.75-5.50 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 09B.

Movento (spirotetramat) | 4-5 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 23.

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as an in-furrow spray during planting. REI: 12-hour. IRAC 04A.

Sivanto 200 (flupyradifurone) | 7.0-10.5 fl. oz. per acre. Apply at planting or as foliar spray. REI: 4-hour. PHI: 7-day. IRAC 04D.

Transform WG (sulfoxaflor) | 0.75-1.0 oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 04C.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Caterpillars

Armyworms are an occasional pest, especially in the southern part of our region.

Pesticide

Avaunt (indoxacarb) | 2.5-6.0 oz. per acre. For loopers. REI: 12-hour. PHI: 7-day. IRAC 22A.

Baythroid XL (beta-cyfluthrin) | 0.8-2.8 fl. oz. per acre. For cutworms, and loopers. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Endigo ZCX (thiamethoxam, lambda-cyhalothrin) | 3.0-3.5 fl. oz. per acre. REI: 24-hour. IRAC 04A, IRAC 03A. *RUP.*

Entrust SC (spinosad) | For armyworms, and loopers. Use 2SC formulations at 4.5-10.0 fl. oz. per acre. Use 80WP formulations at 1.5-3.0 oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 05. *OMRI-listed.*

Mustang Maxx (zeta-cypermethrin) | 1.28-4.0 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Radiant 1SC (spinetoram) | 6.0-8.0 fl. oz. per acre. For armyworms, and loopers. REI: 4-hour. PHI: 7-day. IRAC 05.

Rimon 0.83EC (novaluron) | 6-12 fl. oz. per acre. For armyworms, and loopers. REI: 12-hour. PHI: 14-day. IRAC 15.

Sevin XLR Plus (carbaryl) | 1-2 qts. per acre. For armyworms and cutworms. REI: 12-hour. PHI: 7-day. IRAC 01A.

Tombstone (cyfluthrin) | 0.8-2.8 fl. oz. per acre. For cutworms and loopers. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. For armyworms and loopers. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Warrior II (lambda-cyhalothrin) | 0.96-1.92 fl. oz. per acre. For armyworms, cutworms, and loopers. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Cucumber Beetles

Spotted cucumber beetle is the most common species in sweet potato. Adults feed on foliage and larvae in the soil feed on roots.

Pesticide

Assail 30SG (acetamiprid) | Use 30SG formulations at 1.5-4.0 oz. per acre. Use 70WP formulations at 0.6-1.7 oz. per acre. REI: 12-hour. PHI: 7-day IRAC 04A.

Baythroid XL (beta-cyfluthrin) | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Brigade 2EC (bifenthrin) | Use 2EC formulations at 2.1-6.4 fl. oz. per acre as a foliar spray. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet potatoes. REI: 12-hour. PHI: 21-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) | Apply as a foliar spray at 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: 21-day, IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Flea Beetles

Pesticide

Actara (thiamethoxam) | 3.0 oz. per acre. Control may require two applications. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Admire Pro (imidacloprid) | 1.2 fl. oz. per acre foliar application, 4.4-10.5 fl. oz. per acre or 0.26 fl. oz. per 1,000 ft. of row soil application. Do not exceed 10.5 fl. oz. or 1 application per acre per season. REI: 12-hour. PHI: 7-day for foliar applications, or 125-day for soil applications. IRAC 04A.

Assail 30SG (acetamiprid) | Use 30SG formulations at 1.5-2.5 oz. per acre. Use 70WP formulations at 0.6-1.1 oz. per acre. REI: 12-hour. PHI: 7-day. IRAC 04A.

Baythroid XL (beta-cyfluthrin) | 1.6-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 2-3 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A.

Brigade 2EC (bifenthrin) | Use 2EC formulations at 2.1-6.4 fl. oz. per acre as a foliar spray. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet potatoes. REI: 12-hour. PHI: 21-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) | Apply at planting at 12.75-25.5 fl. oz. per acre, or apply as a foliar spray at 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: 21-day, IRAC 03A. *RUP.*

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as an in-furrow spray during planting. REI: 12-hour. IRAC 04A.

Scorpion 35SL (dinotefuran) | *Soil application*: Use Scorpion 35SL at 11.5-13.25 fl. oz. per acre, or Venom 70SG at 6.5-7.5 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. *Foliar application*: Use Scorpion 35SL at 2.0-2.75 fl. oz. per acre, or Venom 70SG at 1.0-1.5 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day. IRAC 04A.

Sevin XLR Plus (carbaryl) | 0.5-1.0 qts. per acre. REI: 12-hour. PHI: 7-day. IRAC 01A.

Tombstone (cyfluthrin) | 0.8-1.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Leafhoppers

Aster leafhopper and potato leafhopper are common in our region and crops. They don’t survive the winter in northern areas, and migrate from southern areas every growing season. A condition known as "hopperburn" is caused by potato leafhopper feeding, and aster yellows is a disease vectored by aster leafhopper feeding. The amount of aster yellows present in any leafhopper population varies by year and location. Some states in the region have programs that test for and track the percentage of aster leafhoppers that are carrying aster yellows. Leafhoppers can move into vegetable fields when neighboring grain or alfalfa is harvested.

Non-Pesticide

Avoid planting near early harvested grain or alfalfa fields.

Pesticide

Actara (thiamethoxam) | 3.0 oz. per acre. Control may require two applications. See pollinator precautions. REI: 12-hour. PHI: 14-day. IRAC 04A.

Admire Pro (imidacloprid) | 1.2 fl. oz. per acre foliar application, 4.4-10.5 fl. oz. per acre or 0.26 fl. oz. per 1,000 ft. of row soil application. Do not exceed 10.5 fl. oz. or 1 application per acre per season. REI: 12-hour. PHI: 7-day for foliar applications, or 125-day for soil applications. IRAC 04A.

Assail 30SG (acetamiprid) | Use 30SG formulations at 1.5-4.0 oz. per acre. Use 70WP formulations at 0.6-1.7 oz. per acre. REI: 12-hour. PHI: 7-day IRAC 04A.

Baythroid XL (beta-cyfluthrin) | 0.8-1.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Belay (clothianidin) | *Soil applications*: 9-12 fl. oz. per acre. *Foliar applications*: 2-3 fl. oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A.

Malathion 5EC (malathion) | Use 5EC and 57EC formulations at 1.5-2.5 pts. per acre. REI: 12-hour. PHI: 0-3-day. IRAC 01B.

Mustang Maxx (zeta-cypermethrin) | 3.2-4.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as an in-furrow spray during planting. REI: 12-hour. IRAC 04A.

Scorpion 35SL (dinotefuran) | *Soil application*: Use Scorpion 35SL at 11.5-13.25 fl. oz. per acre, or Venom 70SG at 6.5-7.5 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. *Foliar application*: Use Scorpion 35SL at 2.0-2.75 fl. oz. per acre, or Venom 70SG at 1.0-1.5 fl. oz. per acre applied to foliage. See pollinator precautions. REI: 12-hour. PHI: 7-day. IRAC 04A.

Sivanto 200 (flupyradifurone) | 7.0-10.5 fl. oz. per acre. Apply at planting or as foliar spray. REI: 4-hour. PHI: 7-day. IRAC 04D.

Tombstone (cyfluthrin) | 0.8-1.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day. IRAC 03A. *RUP.*

Transform WG (sulfoxaflor) | 0.75-1.0 oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 04C.

Voliam Flexi (thiamethoxam, chlorantraniliprole) | 4 oz. per acre. REI: 12-hour. PHI: 14-day. IRAC 04A, IRAC 28.

Warrior II (lambda-cyhalothrin) | 0.96-1.60 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Thrips

Thrips populations spike in hot dry weather, and when neighboring small grains or alfalfa is harvested. Damage appears as white flecks on leaves. Thrips transmit viral diseases. Treatment will not reverse the symptoms of viruses, but will limit further spread. Selective chemistries (e.g. abamectin, spinetoram, spirotetramat, and spinosad) that target thrips help to preserve natural enemies.

Non-Pesticide

A heavy rain or overhead irrigation washes thrips out of plants. Avoid planting near early harvested grain or alfalfa fields. Preserve and encourage natural enemies. Minute pirate bugs, and lacewings are common predators.

Pesticide

Admire Pro (imidacloprid) | In-furrow spray or side dress 4.4-10.5 fl. oz. per acre or 0.31-0.74 fl. oz. per 1,000 ft. of row. Allowed 1 application per acre per season. REI: 12-hour. PHI: 125-day. IRAC 04A.

Entrust SC (spinosad) | Use 2SC formulations at 4.5-10.0 fl. oz. per acre. Use 80WP formulations at 1.5-3.0 oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 05. *OMRI-listed.*

Radiant 1SC (spinetoram) | 6.0-8.0 fl. oz. per acre. REI: 4-hour. PHI: 7-day. IRAC 05.

Warrior II (lambda-cyhalothrin) | 1.28-1.92 fl. oz. per acre. REI: 24-hour. PHI: 7-day. IRAC 03A. *RUP.*

Wireworms

Wireworms are long-lived in the soil, and are most common in fields that were previously fallow or in pasture.

Non-Pesticide

Avoid planting in fields that were recently in grasses or have a recent history of wireworm damage.

Pesticide

Brigade 2EC (bifenthrin) | 9.6-19.2 fl. oz. per acre. Use 2EC formulations at 9.6-19.2 fl. oz. per acre as a preplant-incorporated broadcast, directed bed spray, or T-band spray into the planting furrow. Do not use 10DF, 10WP, or 10WSB formulations as they are not labeled for sweet potatoes. REI: 12-hour. PHI: 21-day. IRAC 03A. *RUP.*

Capture LFR (bifenthrin) | Apply at planting at 12.75-25.5 fl. oz. per acre, or apply as a foliar spray at 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: 21-day, IRAC 03A. *RUP.*

Platinum 2SC (thiamethoxam) | Use 2SC formulations at 5-8 fl. oz. per acre or 75SG formulations at 1.66-2.67 oz. per acre as an in-furrow spray during planting. REI: 12-hour. IRAC 04A.

Sweet Potato - Weeds

Reviewed by Stephen Meyers, Ram Yadav, Chris Galbraith – Feb 2025

All Weeds

The critical period for weed control in sweet potato is between 2-6 weeks after transplanting. Maintaining the crop weed-free during this period of time allows the vines to close canopy and compete better with weeds later in the season.

Herbicide choices are limited, especially for postemergence control of broadleaf weeds. For this reason, it is important to include pre-emergence herbicides and mechanical control in the weed management plan.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For a banded treatment, reduce amounts according to the portion of acre treated.

Non-Pesticide

A stale seedbed can be prepared prior to transplanting with flame weeding or very shallow cultivation to control emerged weeds, instead of herbicides. The more quickly vines cover the soil surface, the better they will suppress late-emerging weeds. In-row plant spacing can be decreased to close canopy more quickly. However, this practice can delay storage root bulking later in the growing season. Sweet potatoes can benefit from the soil warming properties of plastic mulch in addition to the in-row weed control it provides. Materials include landscape cloth/fabric, plastic, and biodegradeable plastic. Straw mulch can delay growth by suppressing soil temperatures. Weeds between rows and along the edges of beds can be controlled with a combination of cultivation, mowing, or hand-hoeing/pulling. Weeds along the edge of the mulches can be a particular challenge to avoid ripping the mulch. Some fresh market plantings are often small enough to accommodate some hand hoeing or pulling. For larger plantings it may make more sense to mechanically cultivate with tow-able tools between plastic rows or between bare-soil rows. In bare-soil production, rolling cultivators on wide tool-bars offer effective high-speed cultivation between rows and can also hill before row closure from vines.

Pesticide

Aim EC (carfentrazone) POST | 0.5-2 fl. oz. per acre. Apply as a burndown application prior to transplanting or apply with a hooded sprayer as a directed application between crop rows. Add COC (1% v/v) or NIS (0.25% v/v). Weeds must be actively growing and less than 4 in. tall. Do not allow spray to contact crop. Do not exceed 11.6 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. HRAC 14.

Chateau SW (flumioxazin) PRE | 2-3 oz. per acre of SW formulations, or 2-3 fl. oz. per acre of EZ formulations. Apply to prepared planting beds prior to transplanting. Do not use on greenhouse-grown transplants, or on transplants harvested more than 2 days before transplanting. Do not use on varieties other than Beauregard unless you have tested for phytotoxicity under your conditions. Provides suppression of many grass weeds. REI: 12-hour. HRAC 14.

clethodim products (clethodim) POST | Use 2EC formulations at 6-16 fl. oz. per acre with COC (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use Select Max at 9-32 fl. oz. per acre with COC (1% v/v) or NIS (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Use low rates for annual grasses and high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 30-day. HRAC 01.

Command 3ME (clomazone) PRE | 1.4-4.0 pt. per acre. Use a lower rate on coarse textured soils. Apply in a single application immediately after transplanting and before weeds emerge. When used alone, may not adequately control pigweed species and does not control carpetweed. REI: 12-hour. PHI: 95-day for rates up to 3.3 pt. per acre, 125-day for rates over 3.3 pt. per acre. HRAC 13.

Devrinol DF-XT (napropamide) PRE | 2-4 lbs. per acre. Apply immediately after transplanting. If rain does not occur within 24 hours, incorporate shallowly or irrigate with 0.5 inch of water. REI: 24-hour. HRAC NC.

Dual Magnum (s-metolachlor) PRE | 1.0-1.3 pts. per acre. *Special 24c label only.* Apply after transplanting but before weeds emerge. Do not incorporate into soil. Close transplant trenches before application. Dual Magnum applied shortly after transplanting and followed by moderate to heavy rainfall or irrigation can result in reduced yields and

misshapen storage roots. Crop safety is improved by 10-14 days after transplanting when Dual Magnum can be used as a layby application prior to canopy closure. REI: 24-hour. PHI: 60-day. HRAC 15.

Fusilade DX (fluazifop-P) POST | 10-12 fl. oz. per acre. Add COC (1% v/v) or NIS (0.25% v/v). Apply to actively growing grass. Do not exceed 4 applications or 48 fl. oz. per acre per season. REI: 12-hour. PHI: 14-day. HRAC 01.

glyphosate products (glyphosate) POST | 0.375-3.75 lbs. acid equivalent (ae) per acre. Divide lb. acid equivalent (ae) per acre target rate by lb. ae per gal and then multiply by 4. For example, for RoundUp ULTRA at the high rate, (3.75 lb. ae per acre / 3 lb. ae per gal) * 4 = 5 qt. per acre of actual product. Broadcast before planting, or apply between crop rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. REI: 4-hour to 12-hour. PHI: 14-day for foliar applications directed between rows, 7-day for wiper applications. HRAC 9.

Optogen (bicyclopyrone) POST | PRE | 2.6-3.5 fl. oz. per acre. Apply to prepared planting beds prior to transplanting or apply to row middles after transplanting. When applied to row middles, use a hooded or shielded sprayer to minimize crop injury. When weeds are present, add COC (1% v/v) or NIS (0.25% v/v). Use 3.5 fl. oz. per acre on medium and fine-textured soil and 2.6 fl. oz. per acre on coarse-textured soil. Do not make more than 1 application per crop per year. Do not apply more than 3.5 fl. oz. per acre per year. Do not apply to sweet potatoes grown on sand or loamy sand with <1% organic matter. Do not apply to greenhouse-grown transplants. REI: 24-hour. PHI: 60-day. HRAC 27.

paraquat products (paraquat) POST | 1-2 pt. of 2 lb. per gal. formulation. Use 1-2 pt. per acre of 2SL formulation or 0.7-1.3 pt. per acre of 3SL formulation. Add COC (1% v/v) or NIS (0.25% v/v) and apply to emerged weeds less than 6" tall prior to transplanting. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 12 to 24-hour. HRAC 22. *RUP.*

Notes

THIS ANNUALLY-REVISED GUIDE IS A COLLABORATION OF LAND-GRANT UNIVERSITIES FROM EIGHT STATES AND IS A SUMMARY OF CURRENTLY SUGGESTED FERTILITY, HORTICULTURAL, AND PEST MANAGEMENT TECHNIQUES AND TOOLS FOR COMMERCIAL VEGETABLE GROWERS.

THIS GUIDE PROVIDES CONTACT AND VEGETABLE PRODUCTION INFORMATION THAT IS VALID FOR THE CURRENT YEAR IN ILLINOIS, INDIANA, IOWA, KANSAS, MICHIGAN, MINNESOTA, MISSOURI, AND OHIO