RUTGERS
New Jersey Agricultural Experiment Station

This is a section from the

2022/2023
Mid-Atlantic Commercial Vegetable Production Recommendations

The recommendations are **NOT** for home gardener use.

The **full manual**, containing recommendations specific to New Jersey, can be found on the Rutgers NJAES website in the Publications section: *http://njaes.rutgers.edu/pubs/publication.asp?pid=E001*.

This manual will be revised biennially. **In January 2023, a Critical Update** with important updates to the 2022/2023 manual will be communicated through local Extension Agents and Vegetable Specialists.

The **label** is a legally-binding contract between the user and the manufacturer. The user must follow all rates and restrictions as per label directions. The use of any pesticide inconsistent with the label directions is a violation of federal law.

Cooperating Agencies: Rutgers, The State University of New Jersey, U.S. Department of Agriculture, and County Boards of Commissioners. Rutgers Cooperative Extension, a unit of the Rutgers New Jersey Agricultural Experiment Station, is an equal opportunity program provider and employer.

E. Pest Management

1. How to Improve Pest Management

1.1. Recommendations for More Effective Pest Control

Failure to control a weed, insect, or disease is often blamed on the pesticide when frequently the cause is one of the following: 1. Delaying applications 2. Making applications with insufficient gallonage or with clogged or poorly arranged nozzles, and 3. Selecting the wrong pesticide.

For more effective pest control check the following recommendations:

1. Field Inspection

Frequent scouting (at least twice per week) to determine pest populations will help determine the proper timing of the pesticide applications.

2. Integrated Pest Management (IPM)

Guidelines and information about current pest activity in vegetables are published by Cooperative Extension in weekly IPM newsletters and reports. These publications provide accurate information for the timing of pesticide applications and suggestions for more effective control. To receive these newsletters and reports, contact your state Extension IPM specialist or Extension agent. For example: *http://plant-pest-advisory.rutgers.edu/*.

Use this up-to-date information to decide whether pesticide applications or other management actions are needed. Action thresholds for insects are generally expressed as a count of a given life stage or as a damage level based on a recommended sampling procedure. They are intended to reflect the population size that will cause economic damage and warrants the cost of treatment. Thresholds are listed for a number of crops and pests in chapter F. **Control decisions are also based on the following: a)** economic action threshold level - when the cost of control equals or exceeds potential crop losses attributed to real or potential damage, **b)** field history, **c)** growth stage and vigor of crop, **d)** life stage of the pest, **e)** parasite and predator populations, **f)** pest populations, **g)** resistance to chemicals, **h)** time of the year, **i)** variety, and **j)** weather conditions

To employ an IPM program successfully, basic practices need to be followed. Whether participating in an IPM program, hiring a private consultant, or performing the work yourself, the grower should: **a)** examine fields frequently to determine pest populations and buildup, **b)** apply a control measure only when the economic action threshold level has been reached, and **c)** choose a pesticide that is least harmful to bees, parasites, and predators.

3. Resistance Management

Resistance to pesticides can develop because pests may have natural resistance or develop resistance to a specific pesticide through the intensive or overuse use of that pesticide. In general terms, once resistance develops the pesticide will only kill the susceptible population, leaving only the resistant population to reproduce. Consult the following sections for more information on how to reduce the risk of developing resistance: E 2.5 for herbicides, E 3.2 for insecticides, and E 4.1 for fungicides.

4. Pest Control: Insect and Weed Population Sampling Techniques and Disease Monitoring

Insect Population Sampling Techniques:

a) Shake cloth (ground cloth): Use a standard 3x3 ft shake cloth to assess insect populations. Randomly choose a site without disturbing the plants and carefully unroll the cloth between two rows. Bend the plants over the cloth one row at a time and beat the plants vigorously. Plants are pushed back to their original position and gently shaken to dislodge insects held on stems, leaves, and branches. Count only insects that have landed on the cloth. The number of sampling sites per field will vary with the crop. **b) Sweep net:** Use a standard 15-inch diameter sweep net to assess insect populations. While walking along one row, swing the net from side to side with a pendulum-like motion. The net should be rotated 180 degrees after each sweep and swung through the foliage in the opposite direction. Each pass of the net is counted as one sweep. The number of sweeps per field will vary with the crop. **c) Visual observation:** Examine plants or plant parts (leaves, stems, flowers) for direct counts of insect stages (eggs, larvae, adults), or for the presence of expected injuries. Counts can be taken on individual plants or a prescribed length of row depending on the crop. Quick moving insects are usually counted before less mobile ones.

Weed Population Sampling Techniques:

a) Weed identification: Weed identification is critical for determining a plant's life cycle, emergence patterns, and growth; and in turn, are key for developing a successful weed control program. There are excellent on-line weed guides as well as weed identification books. **b) Growth stage determination:** The ability of weeds to compete with the crop is related to weed and crop size. Weed control by herbicides or mechanical methods is also dependent on weed size. Weed control decisions must be carried out before the crop is affected and before the weed is too large to be controlled. **c) Weed population:** Weed competition for light, water, nutrients, and space is dependent on population and is usually expressed as weeds per feet of row or weeds per square meter. Control measures are needed when the weed population exceeds the maximum tolerable population of that species. Problematic weeds and species prone to developing resistance should be controlled before they produce viable seeds.

Disease Monitoring:

a**)** Fields should be scouted on a regularly based for disease symptoms. b) For many foliar diseases, effective fungicide applications must begin prior to the arrival of the pathogen and be repeated every 7 to 10 days and according to label instructions and weather conditions. Treatment for soil-borne diseases should be done immediately at seeding or transplanting and later in the production season if necessary. If environmental conditions are favorable for disease development, delaying a fungicide application may result in a lack of control. c**)** Predictive disease forecasting systems are available online and timely disease alerts are often published in online Extension publications.

5. Weather Conditions

Consider weather conditions before applying a pesticide. Spray only when wind velocity is less than 10 mph. Dust only when it is perfectly calm. Do not spray plants that are showing signs of moisture stress. Certain pesticides, including biological insecticides and some herbicides, are less ineffective in cool weather. Others do not perform well or may cause crop injury when hot or humid conditions occur. If possible, make applications when good weather conditions prevail.

Rainfall or overhead irrigation can wash pesticide deposits from foliage. Wait at least 48 hours after insecticide or systemic fungicide application and allow contact fungicides to dry on the leaf surface before irrigating. More frequent fungicide applications may be needed during and after periods of heavy rainfall. Provide a minimum rain/irrigation-free period of 1 to 4 hours after most postemergence herbicide applications.

Refer to individual product labels for all application precautions or restrictions.

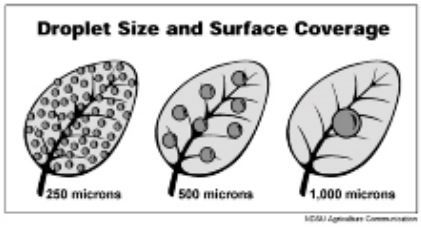
6. Pesticide Coverage of Plants

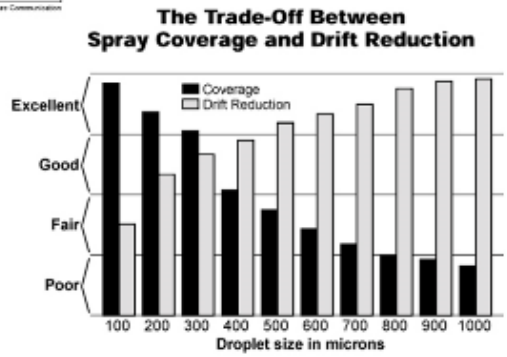
Non-systemic pesticides require more thorough spray droplet coverage than systemic pesticides which move through the plant's vascular system. Several insects (*e.g.*, aphids, mites) and diseases also require thorough spray coverage to obtain adequate control. Better pesticide performance can be accomplished by using adequate spray pressure and appropriately designed nozzles and nozzle arrangements with directed sprays to the surface as well as the underside of leaves.

High gallonage, air assisted sprayers and smaller droplets enhance spray coverage of many fungicides and insecticides (Fig. E-1). The volume of water required for adequate spray coverage increases as plants grow and leaf surface area increases; a minimum of 60 gal/A is recommended on vegetable crops for effective pest control with smaller droplets. As a rule of thumb: spray volumes in excess of 100 gal/A would be considered high-volume applications and spray pressures above 60 psi up to 400 psi would be considered high-pressure applications. **Refer to pesticide labels for specific application instructions. Note that pesticide drift increases with smaller spray droplets** (Fig. E-1). More information is available *at: http://sustainable-farming.rutgers.edu/companion-handouts-for-the-backpack-sprayer-videos/.*

Use one sprayer for herbicides and a different sprayer for fungicides and insecticides. Herbicide sprays should be applied at 15-25 gal/A of spray solution using low pressure (30-45 psi), and a nozzle designed to deliver the appropriate size droplet. Never apply herbicides with a high-pressure sprayer suitable for insecticide or fungicide application because excessive **drift** can result in damage to crops and non-target plants in adjacent areas. On crops that are difficult to wet (*e.g.*, asparagus, cole crops, onions, peppers, and spinach), disease control can be improved with the addition of a spray adjuvant. **However, do not add oil concentrates, surfactants, spreader-stickers, or any other additive unless specified on the label, or the risk of crop injury may be increased.**

Fig. E-1. Droplet Size and Surface Coverage, and Trade-off Between Spray Coverage and Drift Reduction (North Dakota State University).





7. Pesticide Selection

Know the pests to be controlled and choose the recommended pesticide and rate of application (**check the label**). If in doubt, consult your Extension agent. For pests that are extremely difficult to control or for whom resistance is a risk, it is important to alternate labeled pesticides with different modes of action (MoA). In this guide, recommended insecticides are listed with their Insecticide Resistance Action Committee (IRAC) group number, herbicides by their Herbicide Resistance Action Committee (HRAC) group number, and fungicides by their Fungicide Resistance Action Committee (FRAC) code. For example, insecticides are placed in IRAC groups based on common MoA and alternating between insecticides in different IRAC groups is a way of ensuring that different MoA are used on a specific pest. For more assistance, contact your Extension agent.

Caution: Proper application of systemic insecticides is extremely important. Sprays should be directed according to the instructions on the label (which, in general, indicate away from the seed) or crop injury may occur.

Be sure to properly identify disease(s).

8. Pesticide Compatibility

To determine if two pesticides are compatible, use the following "jar test" before tank mixing pesticides or pesticides and fluid fertilizers:

a. Add 1.0 pt of water or fertilizer solution to a clean qt jar, add pesticides in the same proportion as used in the field.

b. To a second clean qt jar, add 1.0 pt of water or fertilizer solution, and add ½ tsp of an adjuvant (such as Compex, Sponto 168D, Uni-Mix, or Unite) to keep the mixture emulsified. After that, add the pesticides to the water-adjuvant or fertilizer solution-adjuvant mixture in the same proportion as used in the field.

c. Close both jars tightly and mix thoroughly by inverting 10 times. Inspect the mixtures immediately and after standing for 30 minutes: If a uniform mix cannot be made, the mixture should not be used. If the mix in either jar remains uniform for 30 minutes, the combination can be used. If the mixture with adjuvant stays mixed and the mixture without adjuvant does not, use the adjuvant in the spray tank. If either mixture separates but readily remixes, constant agitation is required. If non-dispersible oil, sludge, or clumps of solids form, do not use the mixture. **Note**. **For compatibility testing, the pesticide can be added directly or premixed in water first. In actual tank mixing for field application, unless label directions specify otherwise, add pesticides to the water in the tank in this order**: **1)** add, wettable granules or powders; **2)** then add flowables, emulsifiable concentrates, water solubles, and companion surfactants. If tank mixed adjuvants are used, these should be added first to the fluid carrier in the tank. Thoroughly mix each product before adding the next product.

9. Calibration of Application Equipment

Periodic calibrations of sprayers, dusters, and granule distributors are necessary to ensure accurate delivery rates of pesticides per acre. Calibrations are made by measuring the total gal/A of water applied in the case of sprayers, and the total lb/A of dust or granules in the case of dust and granule distributors. The application of too little spray or dust per acre results in inadequate distribution of toxicant over plant surfaces, usually poor control, and the need for additional applications. Application of too much spray or dust per acre is hazardous for the applicator, is frequently injurious to plants (phytotoxic), and could lead to excessive residues if applied close to harvest.

10. Selection of Sprayer Nozzle Tips

The selection of proper sprayer tips for use with various pesticides is very important. Flat fan-spray tips are designed for preemergence and postemergence application of herbicides. These nozzles produce a tapered-edge spray pattern that overlaps for uniform coverage when properly mounted on a boom. Standard flat fan-spray tips are designed to operate at low pressures (30-60 psi) to produce small- to medium-sized droplets that do not have excessive drift. Some flat fan tips (SP) are designed to operate at even lower pressures (15-40 psi) and are generally used for preemergence herbicide applications. Flat fan nozzle tips are available in brass, plastic, ceramic, stainless steel, and hardened stainless steel. Brass nozzles are inexpensive and are satisfactory for spraying liquid pesticide formulations. Brass nozzles are least durable and hardened stainless steel nozzles are most durable and are recommended for wettable powder formulations which are more abrasive than liquid formulations. When using any wettable powder, it is essential to calibrate the sprayer frequently because, as a nozzle wears, the volume of spray material delivered through the nozzle increases.

Flood-type nozzle tips are used for various solutions (*e.g.*, complete fertilizer, liquid N) and sometimes for spraying herbicides onto the soil surface prior to incorporation. They are less suited for spraying postemergence herbicides or for applying fungicides or insecticides to plant foliage. Coverage is often less uniform and complete when flood-type nozzles are used, compared with the coverage obtained with other types of nozzles. Results with postemergence herbicides applied with flood-type nozzles may be satisfactory if certain steps are taken to improve target coverage. Space flood-type nozzles a maximum of 20” apart, rather than the standard 40”. This will result in an overlapping spray pattern. Spray at the maximum pressure recommended for the nozzle. These techniques will improve target coverage with flood-type nozzles and result in satisfactory weed control in most cases.

Full and hollow-cone nozzles deliver circular spray patterns and are used for application of insecticides or fungicides to crops where thorough coverage of the leaf surfaces is extremely important and where spray drift will not cause a problem (see step 6). They are used when higher water volumes and spray pressures are recommended. With cone nozzles, the disk size and the number of holes in the whirl plate affect the output rate. Various combinations of disks and whirl plates can be used to achieve the desired spray coverage.

11. Pesticides and pH

Unsatisfactory results of pesticide applications may be caused by poor application, a bad batch of chemical, pest resistance, and weather conditions. Another possible reason may be the incorrect pH of the mixing water. **Check the pH of the water with a pH meter or ask your Extension agent to test a sample.**

Some materials carry a label cautioning the user against mixing the pesticide with alkaline materials, because the pesticide (in particular organophosphate insecticides) undergoes a chemical reaction known as "alkaline hydrolysis" when mixed with alkaline water (*i.e.*, water with a pH greater than 7). The more alkaline the water, the faster the breakdown rate. In addition to lime sulfur, several other materials provide alkaline conditions, *e.g.*, caustic soda, caustic potash, soda ash, magnesia or dolomitic limestone, and liquid ammonia. **Water sources in agricultural areas can vary in pH from below 3 to greater than 10.**

Many manufacturers provide information on the rate at which their products hydrolyze or break down in water solutions. This rate is expressed as "**half-life**," which is the time it takes for 50% hydrolysis or breakdown to occur. Examples of pesticides that are sensitive to hydrolysis in alkaline water solutions include Counter, Malathion, Dimethoate, Imidan, Lannate, Sevin, and Thimet.

Correction of the alkaline pH: Nutrient buffer sprays are one method; some brand names include: Buffer-X (Kalo Lab), LI-700 Buffer (Hopkins), Mix-Aid (Agway), Nutrient Buffer Sprays (Ortho), Sorba Spray (Leffingwell), Spray-Aide (Miller), and Unite (Hopkins). **Note**: Sprays containing fixed copper fungicides (*e.g.*, Bordeaux mixture, copper oxide, basic copper sulfate, copper hydroxide) should **not** be acidified.

1.2. Calibrating Field Sprayers

Width of Boom The width of boom must be expressed in feet. The boom coverage is equal to the number of nozzles multiplied by the space between two nozzles.

Ground Speed Careful control of ground speed is very important for accurate spray application. Select a gear and throttle setting to maintain constant speed. A speed of 2-3 miles per hour (mph) is desirable. From a "running start," mark off the beginning and end of a 30-second run. The distance traveled (in feet) in this 30-second period divided by 44 will equal the speed in mph. Measure ground speed under field conditions.

Table E-1. Ground Speed Conversion

Tractor speed (mph)	Distance (feet) traveled per minute	Travel time per 500 feet (minutes and seconds)		Tractor speed (mph)	Distance (feet) traveled per minute	Travel time per 500 feet (minutes and seconds)
1.0	88	5 min. and 41 sec		4.5	396	1 min and 16 sec
1.5	132	3 min and 47 sec		5.0	440	1 min and 8 sec
2.0	176	2 min and 50 sec		6.0	528	56 seconds
2.5	220	2 min and 16 sec		7.0	616	49 seconds
3.0	264	1 min and 53 sec		8.0	704	43 seconds
3.5	308	1 min and 37 sec		9.0	792	38 seconds
4.0	352	1 min and 25 sec		10.0	880	34 seconds

Calculating Gallons per Minute Run the sprayer at a certain pressure and catch the discharge from each nozzle for a known length of time. Collect all the discharge and measure the total volume. Divide this volume by the time in minutes to determine discharge in gallons per minute (GPM). Catching the discharge from each nozzle checks the performance of the individual nozzle. When it is not convenient to catch the discharge from each nozzle, a trough may be used to catch the total discharge. Formula For Calculating Sprayer Gallons Per Acre (GPA):

GPA= 5940 x GPM [per nozzle] / MPH x Width [nozzle spacing in inches]

Before Calibrating

1. Thoroughly clean all nozzles, screens, etc., to ensure proper operation.
2. Check to be sure that all nozzles are the same, are made by one manufacturer, and have the same part number.
3. Check the spray patterns of all nozzles for uniformity. Check the volume of delivery by placing similar containers under each nozzle. All containers should fill at the same rate. Replace nozzles that do not have uniform patterns or do not fill containers at the same rate.
4. Select an operating speed. Note the tachometer reading or mark the throttle setting. When spraying, be sure to use the same speed as used for calibrating.
5. Select an operating pressure. Adjust pressure to desired psi while pump is operating at normal speed and water is actually flowing through the nozzles. This pressure should be the same during calibration and field spraying.

Calibration (Jar Method)

Either a special calibration jar or a homemade one can be used. If you buy one, carefully follow the manufacturer's instructions. Take accurate speed and pressure readings and jar measurements; check several times. Keep in mind that you are collecting less than a quart of liquid to measure an application rate of several gallons per acre for many acres. Any 1-quart or larger container, such as a jar or measuring cup, if calibrated in fluid ounces, can easily be used in the following manner:

1. Measure a course on the same type of surface (*e.g.*, sod, plowed) and same type of terrain (*e.g.*, hilly, level) as that to be sprayed, according to nozzle spacing as follows:

Nozzle spacing (in)	16	20	24	28	32	36	40
Course length (ft)	255	204	170	146	127	113	102

2. Time the seconds it takes the sprayer to cover the measured distance at the desired speed. Average several runs.
3. With the sprayer standing still, operate at selected pressure and pump speed. Catch the water from several nozzles for the number of seconds measured in step 2.
4. Determine the average output per nozzle in fluid ounces. The ounces per nozzle equal the gallons per acre applied by one nozzle per spacing.

Calibration (Boom or Airblast Sprayer)

1. Fill sprayer with water.
2. Spray a measured area (width of area covered x distance traveled) at constant speed and pressure selected from manufacturer's information.
3. Measure amount of water necessary to refill tank (gallons used).
4. Multiply gallons used by 43,560 square feet (sq ft) per acre (A) and divide by the number of square feet in area sprayed. This gives gallons per acre (gal/A).
5. Add correct amount of spray material to tank to give the recommended rate per acre.

Example

Assume: 10 gal of water used to spray an area 660 ft long and 20 ft wide,
Tank size-100 gal, Spray material-2 lb formulated product/A

Calculation: (Gal used x 43,560 sq ft/A) / (area sprayed)
= (10 gal x 43,560 sq ft/A) / (660 ft x 20 ft)
= (435,600 gal x sq ft)/A / 1,320 sq ft
= 33 gal/A (all other units cancel out)
Tank capacity 100 gal / 33 gal/A = 3.03 A/tank

1.3. Calibrating Granular Applicators

Sales of granular fertilizer, herbicides, and insecticides for application through granular application equipment have been on the increase. Much of the available equipment was not designed for precision application of granular materials; therefore, extra care must be taken to get the results desired. How well the material is applied is no accident. It will take a conscientious operator, effort, knowledge of equipment, and calibration.

The first step to good application is to be sure the equipment is prepared for operation. Be sure all controls are free and work properly. Check and lubricate moving parts as necessary, remove corrosion, and tighten loose nuts and bolts. Application rates of granular application equipment are affected by several factors: gate openings or settings, ground speed of the applicator, shape and size of granular material, and evenness of the soil surface.

Calibration for Broadcast Applicators (Gravity-Drop or Spinner Applicators)

1. From the label, determine the application rate.
2. From the operators' manual, set dial or feed gate to apply desired rate.
3. On a level surface, fill hopper to a given level and mark this level.
4. Measure test area-length of run will depend on size of equipment. It need not be one long run but can be multiple runs at shorter distances.
5. Apply material to measured area, operating at the speed applicator will travel during application.
6. Weigh amount of material required to refill hopper to the marked level.
7. Determine application rate:

Area covered (A) = number of runs x length of run (ft) x width of application (ft) / 43,560 sq ft/A

Application rate (lb/A) = amount applied (lb to refill hopper) / area covered (A)

Note. Width of application is width of the spreader for drop or gravity spreaders. For spinner applicators, it is the working width (distance between runs). Check operator's manual for recommendations, generally one-half to three-fourths of overall width spread.

Example:

Assume: Rate: 50 lb/A. Test run: 200 ft. Number of runs: 4. Application width: 12 ft. Lbs to refill hopper: 11.5 lb.

Area covered: (4 runs x 200 ft x 12 ft) / 43,560 sq ft/A = 9,600 runs x sq ft / 43,560 sq ft/A = 0.22 A

Application rate: 11.5 lb / 0.22 A = 52.27 lb/A

8. If application rate is not correct, adjust feed gate opening and recheck.

Calibration for Band Applicators

1. From the label, determine application rate.
2. From the operator's manual, determine applicator setting and adjust accordingly.
3. Fill hopper half full.
4. Operate applicator until all units are feeding.
5. Stop applicator; remove feed tubes at hopper.
6. Attach paper or plastic bag over hopper openings.
7. Operate applicator over measured distance at the speed equipment will be operated.
8. Weigh and record amount delivered from each hopper.
   (Be sure all hoppers and all tubes deliver the same amount.)
9. Calculate application rate:
   Area covered in bands (A) = Number of bands x length of run (ft) x band width (ft) / 43,560 sq ft
10. If not correct, readjust and recheck.

Calibration for Changing from Broadcast to Band Application

[Band width (ft) / row spacing (ft)] x broadcast rate (lb/A) = Amount needed (lb/A)

1.4. Pesticide Drift and Misapplication

Serious problems can occur when an unintended pesticide drifts onto your plants or is directly applied due to misapplication or sprayer contamination. Misapplied herbicides, in particular, can result in significant injury to a vegetable crop for which the herbicide is not labeled. For all pesticides that are misapplied or that drift onto unintended crops, you must decide on whether the crop can be sold. To legally sell the produce, there has to be an established tolerance for the particular pesticide(s). Even though a pesticide is not sold for the particular crop, a tolerance may exist. A tolerance is an acceptable level of pesticide allowed based on EPA regulations. If the concentration of the pesticide in your vegetable is above the established tolerance or if there is no tolerance, you have a tainted crop that is illegal to sell. Pesticide residue levels can only be determined by laboratory analysis, contact you state department of agriculture or state extension specialists for an appropriate laboratory. To check for tolerances, go to: *https://www.epa.gov/pesticide-tolerances.*

Tolerances are not the only factor that should be considered in deciding whether or not to sell or consume produce. The U.S. EPA tolerance levels are the best scientific information available, but if your customers have heard of the drift problem, even if residues are below tolerances, selling affected produce may damage your farm's reputation.

Samples for residue analysis must be collected correctly and in a timely manner for it to be useful in the decision-making process. If the harvested part is present, collect that tissue. If fruit are not present, collect samples of recently formed leaves and shoot tips; translocated pesticides will concentrate in those tissues. Ask that fruit samples be collected later to help you in deciding whether or not to sell or consume the fruit. Make sure that samples are collected from the crop plants showing injury and as close as possible to the site of pesticide application.

What will pesticide residue concentrations tell you? Sometimes they may not tell you much. The critical question is: "Are the pesticides absent from the parts you wish to harvest and eat, or are the pesticide concentrations within the tolerances set by the EPA?" But undetectable residues may be due to poor sampling procedure, so care must be taken to ensure the samples were taken from the correct part of the plant, in a timely fashion, and handled properly. Be conservative in how you interpret the residue information.

The scientific literature suggests that acute poisoning effects in humans caused by pesticide residues in vegetables due to drift are very unlikely. Questions about the possible chronic effects (including cancer) from multiple exposures from repeated incidents of pesticide drift along with many other routes of exposure remain the subject of research.

Herbicide drift or herbicides misapplied to a vegetable crop for which the herbicide is not labeled can result in significant visible injury. But misapplication of any pesticide has the same issues.

1.5. Soil Fumigation

In fields that are infested with soil borne plant pathogens, plant parasitic nematodes, or significant weed populations, soil fumigation can help reduce pest populations. Soil fumigants must be applied properly and a dissipation period between fumigant application and planting of the crop is necessary to prevent plant injury. **Labels should be read carefully before deciding whether to use a soil fumigant.**

Nearly all soil fumigants have been re-registered since 2009 resulting in substantial label changes (see also section D.3.3.1 Soil Fumigants). **Labels now include mandatory stipulations on fumigant application including soil tillage, soil temperature, and soil moisture. Labels have specific requirements for plant-back periods that must be adhered to for crop safety. There are also new personal protective equipment mandates as well as site monitoring and management requirements**. Consult your Extension professional for advice regarding your specific needs and assistance with label interpretation. More information on Nematode Control can be found in the following section.

One of the following multipurpose soil fumigants should be used to provide weed, disease, and/or nematode control. Rates are broadcast rates in product/acre:

- allyl isothiocyanate + chloropicrin (Dominus 67:33), 20 gal/A
- allyl isothiocyanate (Dominus), 10-40 gal/A
- chloropicrin, 25-34 gal/A
- dichloropropene + chloropicrin (Pic-Clor 60) (if available), 20-30 gal/A
- dichloropropene + chloropicrin (Pic-Clor 80), 17-34 gal/A
- dichloropropene + chloropicrin (Telone C-17), 11-17 gal/A
- dichloropropene + chloropicrin (Telone C-35), 13-20.5 gal/A
- metam-potassium (K-PAM HL), 30-60 gal/A
- metam-sodium (Vapam HL), 37.5-75 gal/A
- dichloropropene + chloropicrin (Inline), non-perforated plastic 13-30.8 gal/A, perforated 13-84 gal/A (drip-applied)

For nematode control only:

- dichloropropene (Telone II), 9-12 gal/A,
- dichloropropene (Telone EC), 9-18 gal/A (drip-applied)

To determine if it is safe to plant into fumigated soil, collect a soil sample from the treated field (do not go below the treated depth). Place the sample in a glass jar with a screw top lid. Firmly press numerous seeds of a small-seeded vegetable crop (*e.g.*, lettuce or radish) on top of the soil and tighten the lid securely. Repeat the process in another jar with non-fumigated soil to serve as a check. Observe the jars within 1-2 days. If seeds have germinated, it is safe to plant in the field. If seeds have not germinated in the fumigated sample and have germinated in the non-treated sample, then the field is not safe to plant. Rework the field and repeat the process in a few days.

1.6. Nematode Control

Some 100 species of plant-feeding nematodes can seriously damage various crops. Before starting any nematode management procedure, determine what nematodes are present in the soil to find out if action is warranted. If nematode damage is suspected, both soils and roots should be examined to determine if and to what extent nematodes may be involved. Follow the procedures below for proper collection and handling of samples to enable an accurate diagnosis at a Nematode Diagnostic Laboratory.

Soil and Root Samples for Nematode Detection

1. Collecting and Handling

Only a single, composite sample should be collected in each field. If the field is larger than 2 acres, divide the field into 2-acre blocks and collect a composite sample from each block. Label each bag accordingly. This will provide a more accurate assessment of the nematode population and enable more targeted management.

Collect soil and roots from the edges of the affected area(s) in the field. Take a mixture of roots and soil from at least 10 scattered sites, or preferably, under 10 scattered plants in the affected area. Do not take samples from areas where plants are dead. Dig up plants with a shovel and take a small handful of soil and roots from each or use a soil sampling tube (3/4-inch diameter). Combine the individual samples in a bucket to make a composite sample of at least one quart of soil. Mix the soil in the bucket, then place one pint of the mixed soil in a plastic freezer bag and seal it to prevent drying of the soil. Protect bagged samples from high temperatures and freezing which can kill the nematodes.

Take soil samples while the crop is still growing so that areas that are suspected of being affected by nematodes can be identified and sampled, because these areas may be missed in random sampling. In general, samples can be collected from June through November. However, to plan your cropping sequence, it is best to take these survey samples after harvest in the fall *before* any fall tillage and *before* cold weather arrives. This timing is recommended (and especially important for growers who need to monitor root knot nematode populations) because nematode populations are generally highest in the fall. The chance of detecting damaging levels of plant pathogenic nematodes is greatest at that time. The *worst* time to sample to detect root knot nematodes is in late spring just before planting.

Survey samples should be taken at a depth of 8-10 inches, and several inches from the base of the plants, between plants in the row. Do not take samples if the soil is wet. The moisture level should be less than field capacity and there should not be any free water in the plastic bag after adding the sample. Use a soil sampling tube and take 20 to 25 cores per sample in a random pattern in the field. Mix soil cores in a plastic bucket and immediately place a pint of soil in a plastic bag or a nematode soil sample kit purchased from a Nematode Diagnostic Laboratory.

2. Submitting Samples to a Nematode Diagnostic Laboratory

Samples should be sent to the laboratory as soon as possible after collection. If there is any delay, refrigerate samples until shipment. Provide some insulation around the sample(s) during shipment, such as several layers of newspaper, a padded envelope or Styrofoam peanuts. Mark the samples: “For Nematode Analysis” and include the following information **with each sample** (check with the laboratory to see if any additional information is required):

1. Name and address of the grower and of the person submitting the sample
2. Date collected
3. Name of the present crop, the crop to be planted, and history of the affected area
4. Plant and field symptoms

Attach the paper with this information to the **outside** of the bag of soil. Forward the samples to your Extension agent, or directly to the diagnostic laboratory. There is usually a fee for nematode analyses.

Nematode Management Strategies

Plant-parasitic nematodes are difficult to control after they have become established. The best strategy is to use preventive measures, including nematicides, soil fumigants, and/or cultural practices.

1. Chemical Management of Nematodes

Fumigants

Soil fumigation can effectively control plant-feeding nematodes. See section E 1.5. Soil Fumigation above for specific fumigants, rates, and application techniques.

Non-fumigant nematicides

Several non-fumigant nematicides are currently available for selected vegetable commodities. These nematicides are listed in the sections dealing with the vegetables on which they are labeled. Some non-fumigant nematicides are not labeled in all states within the mid-Atlantic region, so consult the label carefully before applying a chemical. These nematicides do not volatilize in the soil as do fumigants. Consequently, these chemicals are effective over a wider range of soil temperature and moisture than are fumigants.

Chemicals registered for use on selected vegetables include:
Contact nematicides: Counter (20CR), Mocap (10G and 6EC), Nimitz (4EC), Velum.
Both contact and systemic nematicide: Vydate L.
Consult the label before applying any of these chemicals.

Factors Affecting the Efficacy of Nematicides

As with any pesticide, the two factors that determine efficacy are **concentration** and **exposure time**. If toxic nematicide concentrations do not come in contact with nematodes for a sufficient period of time, nematode control will be poor. Many factors can reduce the concentration of nematicide available in the soil and/or effectively shorten the time that nematodes are exposed. Good site preparation is extremely important. The soil should be thoroughly tilled several weeks before application to break up clods and encourage decomposition of plant residues. Nematicides can adsorb to organic matter and thus reduce the amount of compound free in the soil. Soil clods can interfere with nematicide distribution and reduce efficacy.

Fumigant nematicides such as Telone or Vapam volatilize and move through the soil as a gas. The movement of a fumigant through the soil is strongly affected by factors such as temperature, moisture, and soil texture. Fumigants tend to move upwards through the soil and will dissipate quickly unless the surface is sealed after treatment. Follow the label to ensure that you are applying the correct dose for your conditions.

Most non-fumigant nematicides such as Vydate are organophosphate or carbamate pesticides, which are potent cholinesterase inhibitors. Nimitz and Velum Prime are in different chemical classes than those mentioned above and kill nematodes via unknown modes of action. All of these compounds are extremely water-soluble, and their redistribution in the soil depends on water movement. Excessive rain or irrigation creates a risk of diluting the nematicide below the level needed to be effective. However, too little water may prevent the nematicide from being distributed effectively in the root zone. Nimitz has an additional concern of being phytotoxic to plants under cold stress; under those conditions, plants grow much slower than those not treated with Nimitz. During warmer periods of the growing season, Nimitz application results in little phytotoxicity to crops.

Organophosphate and carbamate nematicides act relatively slowly. Although high concentrations are lethal, the lower concentrations in soil generally kill by behavior modification. The affected nematodes typically are unable to move, find a host, feed, or find a mate. Eventually they die. If exposure to the nematicide is too short or at a too low concentration, however, these behavioral modifications can be reversed, and the treatment is not effective. Both Nimitz and Velum Prime kill nematodes within the recommended dose ranges.

2. Non-chemical Management of Nematodes

Prevention of spread

Plant-feeding nematodes move only short distances under their own power, *i.e.*, a few inches to a few feet. Nematodes are commonly spread by the movement of infested soil and/or infected plants by human activity. Sanitation and good cultural practices are the best preventive measures against nematodes. Obtain nematode-free transplants from reputable sources. Wash soil from machinery and tools before using them at another location. Nematodes may also be spread by wind, water, soil erosion, and animals.

Crop rotation

Rotation of crops is an effective and widely used cultural practice to reduce nematode populations in the soil. To be most effective, crops that are poor hosts or nonhosts of the target nematodes should be included in the rotation sequence.

Cover crops

Some plants commonly used as cover crops are naturally suppressive to certain nematode species, but no single crop is effective against all nematodes. The cover crop plant may be a nonhost and, therefore, the nematodes starve, their population being reduced as with fallow. Nematodes invade the roots of certain other cover crop plants, but they fail to reproduce. Yet, other “antagonistic” plant species exude chemicals from their roots that are toxic to nematodes, such as marigold and asparagus.

Green manures and soil amendments

In general, the incorporation of large amounts of organic matter into the soil reduces populations of plant-feeding nematodes. The decomposition products of some plants kill nematodes. These include butyric acid released during the decomposition of ryegrass and timothy, and isothiocyanates released during the decomposition of rapeseed and other plants in the genus Brassica. Maximum benefit of these “natural” nematicides is obtained when the plant material is incorporated into the soil as green manure. It is important to consult with a diagnostic lab or extension agent to make sure the treatment is appropriate for the nematode being controlled, as green manure treatments are

not equally effective against all plant- parasitic nematodes. For example, rapeseed is effective against dagger nematodes but not lesion nematodes. Also keep in mind that varieties of the same green manure crop can differ in the amount of toxic chemical components in their cell walls and therefore differ in the amount of toxic byproducts released during decomposition.

For dagger nematode control, two years of rapeseed green manure is desirable, but it may be possible to realize the same benefit by growing two crops of rapeseed within one year. The following timetable is suggested for producing two rotations of rapeseed within one year:

- Prepare seedbed and plant rapeseed by late April or early May (plant only recommended winter rapeseed varieties).
- Turn under green rapeseed by early September. Prepare seedbed and plant second crop by mid-September.
- The second crop should be turned under in late spring after soil temperatures reach 45°F or higher.
- Ideal conditions for incorporating the cover crop are similar to those required for obtaining the maximum benefit from fumigation (*i.e.*, the soil should be above 45°F and moist).
- Alternatively, planting dates may be reversed so that the first planting is in the fall followed by a second crop planted in the spring. This would end the rotation cycle in fall of the following year.

Some rapeseed varieties are more effective at suppressing nematode populations than others, and some varieties will not over-winter (*i.e.*, spring types) or they bloom too early in summer to be useful. The winter varieties 'Dwarf Essex' and 'Humus' work well for both spring and fall planting dates. If planted in the spring, these varieties grow vigorously to crowd out weeds and do not go to seed.

Tips:

- Rapeseed requires a firm, smooth seedbed that is free of weeds, heavy residue, and large clods.
- Seed may be drilled or broadcast. Seed at a depth of 3/8 inch and avoid planting too deep! If seed is broadcast, a cultipacker may be used to cover seed.
- A seeding rate of 7–8 lb/A works well.
- Rapeseed is sensitive to broadleaf herbicide carryover.
- Fall-planted rapeseed should have 8–10 true leaves and a 5-6-inch tap root with a 3/8-inch diameter root neck before the ground freezes.
- Sulfur is necessary for rapeseed to produce nematicidal compounds. Some soils may be deficient in sulfur. A soil test for sulfur may be beneficial.

Keep in mind that some biofumigant crops like rapeseed and sorghum-sudangrass are hosts for nematodes and it is not until incorporated into the soil as green manure that they will suppress nematode populations.

Plant nutrition and general care of the plant

The harmful effects of nematodes on plants can be reduced by providing plants with adequate nutrition, moisture, and protection from stress.

Fallow. Fallow is the practice of keeping land free of vegetation for weeks or months by frequent tilling or applying herbicides. In the absence of a host, nematodes gradually die out; however, eggs of some nematodes may survive for years in the soil. Because fallow may be destructive to soil and the land is out of production during that time, extended periods of fallow are not recommended.

Integrated management practices. Each of the practices mentioned above reduces the soil population of plant-feeding nematodes to varying degrees. Each practice has limitations and the degree of nematode control achieved depends on environmental factors, as well as the particular nematode and crop being considered.

Maximum benefit is realized when several of these practices are employed in an integrated crop management program. Because the host range of different nematode varies, the selection of cover crops, rotation crops, and green manures will be determined by the kinds of nematodes present. No single practice is a "cure-all" for all nematode problems.

2. Weed Control

Effective weed control requires a program that emphasizes prevention and combines crop rotation with mechanical and chemical control methods.

2.1. Postharvest Perennial Weed Control

Weed seed populations in the soil should be kept to a minimum by preventing weeds from producing seed in and around vegetable fields. Destroy all weeds immediately after a crop is harvested. Consider control measures after harvest, but before the first frost, for the following weeds:

1. To suppress or control bitter nightshade, Canada thistle, field bindweed, hemp dogbane, horsenettle, or pokeweed, use a tank mix of 1 qt dicamba plus 1 qt 2,4-D amine. Apply in late summer or early fall to healthy weed foliage for maximum effectiveness (Note. Delay seeding of winter cover crop 3 weeks for each pint per acre of dicamba used). See herbicide labels for optimum treatment time for each weed.
2. To suppress brambles, horseradish (volunteer), horsenettle, milkweed, poison ivy, or sow thistle, tank mix 1.5 lb acid equivalent glyphosate, using one of many labeled glyphosate products, plus 1 pt dicamba (see note above). Use 1 to 2 qt surfactant per 100 gal of spray mixture. Apply in late summer or early fall to healthy weed foliage for maximum effectiveness. See herbicide labels for optimum treatment time for each weed.
3. To control bermudagrass, johnsongrass or quackgrass, apply 0.75 to 1.1 lb acid equivalent glyphosate, using one of many labeled glyphosate products. Delay tillage for 7 to 10 days after application. Apply in late summer or early fall to healthy weed foliage for maximum effectiveness.
4. To control bermudagrass johnsongrass, or quackgrass in crop, apply the maximum labeled rate of Poast, Fusilade, or clethodim (Select, Select Max) early in the season. Repeat applications may be needed for the highest level of control.
5. To control yellow nutsedge foliage and suppress nutlet formation, spray with a labeled glyphosate product after flowers (seed heads) appear, but before foliage dies. Use 1.5 lb acid equivalent glyphosate. Expect only partial control of yellow nutsedge the first year after initiating the program. Plant a crop the following spring with registered herbicides recommended for yellow nutsedge control (see Table E-3). Effective yellow nutsedge control can be achieved by repeating the application for several consecutive years.

2.2. Herbicide Mode of Action: Reducing the Risk of Herbicide Resistance Development

Reducing the risk for developing herbicide-resistant weed populations requires incorporating a number of guidelines in managing your fields. These guidelines include:

1. Spray only when necessary
2. Use alternative methods of control whenever possible such as mechanical cultivation or using cover crops, delayed planting (row crops), mowing (forage crops), and using weed-free crop seeds
3. Rotate crops and their accompanying herbicides' mode of action (HRAC Group Number, see note below)
4. Limit the number of applications of herbicide(s) with the same mode of action in a growing season
5. Use mixtures or sequential herbicide treatments with different modes of action that will control the weeds of concern
6. Scout fields after herbicide application to detect weed escapes or shifts
7. Clean equipment before leaving fields infested with or suspected to have resistant weeds

Note: Classification of Herbicides

A classification of herbicides based on mode of action, was developed to better understand and plan for resistance management. Rotating herbicides with differing modes of action is important for minimizing the risk of developing herbicide-resistant weeds. The system was first developed by the Weed Science Society of America (WSSA) (See: E. James Retzinger and Carol Mallory-Smith. 1997. Classification of Herbicides by Site of Action for Weed Resistance Management Strategies. Weed Technology volume 11, pages 384 to 393).

Table E-2. Important Herbicide Groups for Commercial Vegetables

In the table below, important herbicide groups for vegetable crops grown in the Mid-Atlantic region are listed with their modes of action. Note that more than one herbicide family may have the same mode of action.

Trade Name	Active Ingredient	HRAC Group	Herbicide Class	Mode of Action
2,4-D	2-4-D	4	Plant growth regulators	IAA-like
Accent Q	nicosulfuron	2	Amino acid biosynthesis	ALS (acetolactate synthase)
Aim	carfentrazone	14	Cell membrane disrupters	PPO (oxidase)
Armezon	topramezone	27	Pigment inhibitors	HPPD (4-hydroxyphenyl-pyruvatedioxygenase)
Assure II	quizalofop	1	Fatty acid (Lipid) biosynthesis inhibitors	ACCase (acetyl coA carboxylase)
Atrazine	atrazine	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Basagran	bentazon	6	Photosynthesis inhibitors (non-mobile)	Photosystem II
Cadet	fluthiacet	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Callisto	mesotrione	27	Pigment inhibitors	HPPD (4-hydroxyphenyl-pyruvatedioxygenase)
Caparol	prometryn	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Chateau	flumioxazin	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Clarity	dicamba	4	Plant growth regulators	IAA-like
Command	clomazone	13	Pigment inhibitors	Diterpenes (carotenoid biosynthesis)
Curbit	ethalfluralin	3	Seedling growth inhibitors (Root)	Microtubule inhibitors
Dacthal	DCPA	3	Seedling growth inhibitors (Root)	Microtubule inhibitors
Devrinol	napropamide	15	Seedling growth inhibitors (Shoot)	Mitosis inhibitor
Dimetric	metribuzin	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Dual Magnum	s-metolachlor	15	Seedling growth inhibitors (Shoot)	Mitosis inhibitor
Eptam	EPTC	8	Seedling growth inhibitors (Shoot)	Lipid synthesis inhibitors
Fusilade	fluazifop	1	Fatty acid (Lipid) biosynthesis inhibitors	ALS (acetolactate synthase)
Glory	metribuzin	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Glyphosate	glyphosate	9	Amino acid biosynthesis	EPSPS-enzyme
Goal	oxyfluorfen	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Goal Tender	oxyfluorfen	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Gramoxone	paraquat	22	Cell membrane disrupters	Photosystem I
Harness	acetochlor	15	Seedling growth inhibitors (Shoot)	Mitosis inhibitor
Impact	topramezone	27	Pigment inhibitors	HPPD (4-hydroxyphenyl-pyruvatedioxygenase)
Karmex	diuron	7	Photosynthesis inhibitors (mobile 2)	Photosystem II
Kerb	pronamide	3	Seedling growth inhibitors (Shoot)	Mitosis inhibitor
Laudis	tembotrione	27	Pigment inhibitors	HPPD (4-hydroxyphenyl-pyruvatedioxygenase)
Liberty	glufosinate	10	Phosphorylated amino acid (N metabolism disrupter)	Glutamine synthetase
Linex	linuron	7	Photosynthesis inhibitors (mobile 2)	Photosystem II
Lorox	linuron	7	Photosynthesis inhibitors (mobile 2)	Photosystem II
Maestro	bromoxynil	6	Photosynthesis inhibitors (non-mobile)	Photosystem II
Matrix	rimsulfuron	2	Amino acid biosynthesis	ALS (acetolactate synthase)
Metribuzin	metribuzin	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Outlook	dimethenamid	15	Seedling growth inhibitors (Shoot)	Mitosis inhibitor
Permit	halosulfuron	2	Amino acid biosynthesis	ALS (acetolactate synthase)
Poast	sethoxydim	1	Fatty acid (Lipid) biosynthesis inhibitors	ALS (acetolactate synthase)
Prefar	bensulide	8	Seedling growth inhibitors (Shoot)	Lipid synthesis inhibitors
Prowl	pendimethalin	3	Seedling growth inhibitors (Root)	Microtubule inhibitors
Prowl H2O	pendimethalin	3	Seedling growth inhibitors (Root)	Microtubule inhibitors

Table E-2. Important Herbicide Groups for Commercial Vegetables - continued next page

Table E-2. Important Herbicide Groups for Commercial Vegetables - continued

Trade Name	Active Ingredient	HRAC Group	Herbicide Class	Mode of Action
Pursuit	imazethapyr	2	Amino acid biosynthesis	ALS (acetolactate synthase)
Raptor	imazamox	2	Amino acid biosynthesis	ALS (acetolactate synthase)
Reflex	fomesafen	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Reglone	diquat	22	Cell membrane disrupters	Photosystem I
Rely	glufosinate	10	Phosphorylated amino acid (N metabolism disrupter)	Glutamine synthetase
Ro-Neet	cycloate	8	Seedling growth inhibitors (Shoot)	Lipid synthesis inhibitors
Roundup	glyphosate	9	Amino acid biosynthesis	EPSPS-enzyme
Sandea	halosulfuron	2	Amino acid biosynthesis	ALS (acetolactate synthase)
Select	clethodim	1	Fatty acid (Lipid) biosynthesis inhibitors	ALS (acetolactate synthase)
Sharpen	saflufenacil	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Shieldex	tolpyralate	27	Pigment inhibitors	HPPD (4-hydroxyphenyl-pyruvatedioxygenase)
Sinbar	terbacil	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Solicam	norflurazon	12	Pigment inhibitors	PDS (carotenoid biosynthesis)
Spin-Aid	phenmedipham	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Sonalan	ethalfluralin	3	Seedling growth inhibitors (Root)	Microtubule inhibitors
Spur	clopyralid	4	Plant growth regulators	IAA-like
Starane Ultra	fluroxypyr	4	Plant growth regulators	IAA-like
Stinger	clopyralid	4	Plant growth regulators	IAA-like
Surpass	acetochlor	15	Seedling growth inhibitors (Shoot)	Mitosis inhibitor
Targa	quizalofop	1	Fatty acid (Lipid) biosynthesis inhibitors	ALS (acetolactate synthase)
Thistrol	MCPB	4	Plant growth regulators	IAA-like
Treflan	trifluralin	3	Seedling growth inhibitors (Root)	Microtubule inhibitors
TriCor	metribuzin	5	Photosynthesis inhibitors (mobile 1)	Photosystem II
Valor	flumioxazin	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Weedar 64	2-4-D	4	Plant growth regulators	IAA-like
Zeus	sulfentrazone	14	Cell membrane disrupters	PPO (protoporphyringogen oxidase)
Zidua	pyroxasulfone	15	Seedling shoot inhibitor	Mitosis inhibitor

2.3. Herbicide Effectiveness on Common Weeds in Vegetables

Notes:

1. Herbicide performance depends on herbicide selection, herbicide rate, weed pressure, weather, soil type, and other factors.
2. The ratings in Table E-3 indicate **ONLY relative effectiveness** in tests conducted by the University of Delaware, University of Maryland, University of Pennsylvania, Rutgers, The State University of New Jersey, and Virginia Polytechnic Institute and State University. **Actual performance may be better or worse than indicated in this table.**
3. **The Herbicide Resistance Action Committee (HRAC) group number** indicates the chemical structure and mode of action of the herbicide.
4. **For field management guidelines aimed at reducing the risk for developing herbicide-resistant weed populations see section E 2.2. Herbicide Mode of Action: Reducing the Risk of Herbicide Resistance Development.**

Table E-3. Herbicide Effectiveness on Common Weeds in Vegetables

Abbreviations: G=good, F=fair, P=poor, N=no control, - =insufficient data.

Herbicide	HRAC Mode of Action Number	Barnyardgrass	Crabgrass, Large	Fall Panicum	Foxtail sp.	Goosegrass	Johnsongrass (Seedlings)	Yellow Nutsedge	Carpetweed	Cocklebur, Common	Galinsoga, Hairy	Jimsonweed	Lambsquarters, Common	Morningglory sp.	Shepherdspurse	Pigweed sp.	Purslane, Common	Ragweed, Common	Smartweed, Pennsylvania	Nightshade, Eastern Black	Velvetleaf
SOIL-APPLIED HERBICIDES (PRE-PLANT INCORPORATED OR PREEMERGENCE)																					
Acetochlor products	**15**	G	F/G	G	G	G	G	F	F	N	-	N	P/F	N	-	F/G	-	P	P	G	P
Atrazine	**5**	F	P/F	P	F	-	P	P/F	G	F/G	G	G	G	G	G	G	G	G	G	G	F
Callisto	**27**	N	F	N	P	N	N	P	-	P/F	G	F	G	F	G	F/G	-	P	-	P	-
Caparol	**5**	F	P/F	P	F	P/F	-	N	G	P	G	P/F	G	P	F	F/G	G	F	F	F	P
Chateau	**14**	P	P	P	P	P	P	P	G	F	G	-	G	F	G	G	G	F	G	G	-
Command	**13**	G	G	G	G	G	G	N	N	N/F	F	G	G	P	F	N/P	G	P/F	G	-	G
Curbit / Sonalan	**3**	F	G	G	-	G	-	N	G	N	N	N	P/F	P	-	F	F/G	N	P	P	P
Dacthal	**3**	F/G	G	F/G	G	F/G	-	N	P	N	N	P	G	N	P	F/G	G	N	N	N	N
Devrinol	**15**	G	G	G	G	G	G	N/P	G	N	F/P	N	F/G	N	-	F/G	G	P/F	P	N	N
Dual Magnum	**15**	G	G	G	G	G	G	F/G[1]	F	N	G	N	P	N	-	G	F/G	N	P	G	P
Eptam	**8**	G	G	G	G	G	G	G	G	P	N	P	F	F	-	G	G	P	P	F/G	F/G
Goal/GoalTender	**14**	P	P	P	P	P	P	P[2]	G[2]	-	G[2]	-	F	-	G	G	G	F	G[2]	G[2]	F[2]
Karmex	**7**	G	F/G	G	G	F/G	N	N	G	-	G	G	G	G	G	G	G	G	G	G	G
Kerb	**3**	G	G	G	G	G	-	N	G	N	P	N	G	-	-	G	G	P	-	-	P
Lorox/Linex	**7**	F	P/F	P	F	P/F	-	N	G	P	G	P/F	G	P	F	G	G	F	G	G	P

*Table E-3. **Herbicide Effectiveness on Common Weeds in Vegetables** - continued next page*

Table E-3. Herbicide Effectiveness on Common Weeds in Vegetables - continued

Herbicide	HRAC Mode of Action Number	Barnyardgrass	Crabgrass, Large	Fall Panicum	Foxtail sp.	Goosegrass	Johnsongrass (Seedlings)	Yellow Nutsedge	Carpetweed	Cocklebur, Common	Galinsoga, Hairy	Jimsonweed	Lambsquarters, Common	Morningglory sp.	Shepherdspurse	Pigweed sp.	Purslane, Common	Ragweed, Common	Smartweed, Pennsylvania	Nightshade, Eastern Black	Velvetleaf
SOIL-APPLIED HERBICIDES (PRE-PLANT INCORPORATED OR PREEMERGENCE) – *continued*																					
Matrix/Solida	**2**	G	F	F	G	-	-	F	-	-	F	-	F	P/F	-	G	G	F	F	P/F	P
Metribuzin	**5**	F	F	F	F	F	-	N	G	F	G	F/G	G	F/P	-	F/G	F	G	G	P	G
Micro-Tech	**15**	G	F/G	G	G	G	G	F	G	N	G	P	P/F	N	G	G	G	N	P	G	P
Outlook	**15**	G	G	G	G	G	P	P/F	-	N	G	N	P	N	-	F/G	G	N	P	F	N
Prefar	**8**	G	G	G	G	F/G	G	N	N	N	N	N	F/G	N	P/F	F	F	N	N	N	N
Prowl/Prowl H2O	**3**	G	G	G	G	-	G	N	G	N	N	N	F/G	P	N	F/G	F/G	N	F	P	G
Pursuit	**2**	P/F	P/F	P/F	P/F	-	N	G	F	-	F	G	F	F	G	G	P	G	F	G	G
Reflex[3]	**14**	P	P	P	P	P	P	N	G	N	G	F/G	P	P	G	E	E	G	P	G	P
Ro-Neet	**8**	G	G	G	G	G	-	N/P	G	N	N	N	F	-	G	G	G	N	-	-	F
Sandea	**2**	N	N	N	N	N	N	F	P	G	G	G	F	F	-	G	F	G	F	N	G
Sinbar	**5**	F	F	-	F	F	-	P	G	-	G	G	G	G	G	P	G	G	G	G	G
Solicam	**12**	G	G	G	G	-	F	F	-	-	-	F	F	P	-	G	G	G	-	-	F
Spartan Charge	**14+14**	P	P	P	P	P	P	P	-	-	-	-	P	P	-	F/G	-	N	P	-	-
Strategy[4]	**3+13**	G	G	G	G	G	G	N	G	N/F	F	G	G	P	F	F	G	F	G	P	G
Treflan	**3**	G	G	G	G	G	G	N	G	N	N	N	F/G	P/F	N	F	G	N	P/F	P	N
Zeus	**14**	P	P/F	P	P	P/F	P	P/F	G	P	-	G	F/G	F/G	F/G	-	G	G	P/F	F	F/G
Zidua	**15**	G	G	G	G	G	P	P	-	N	P	P	F	N	-	G	G	P	P	F/G	P
POSTEMERGENCE																					
2,4-D	**4**	N	N	N	N	N	N	P	G	F/G	P	F	F/G	G	G	G	G	G	F	G	G
Accent Q	**2**	G	P/F	G	G	P	G	P	-	P	-	F	P	F	G	G	P/F	P	F/G	N	P
Aim/Cadet	**14**	N	N	N	N	N	N	N	G	P	-	P	G	F	-	G	-	F	-	G	G
Assure II /Targa	**1**	G	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Atrazine	**5**	F	F	F	F	F	-	G	-	F	G	G	G	G	G	G	G	G	G	G	F/G
Basagran	**6**	N	N	N	N	N	N	F	N	G	F	G	F	P	-	F	F/G	G	G	P	G
Callisto	**27**	N	F	P	P	P	P	F	-	F/G	G	G	G	F	F/G	G	-	P	-	F/G	G
Caparol	**5**	F	P/F	P	F	P/F	-	N	G	P	G	P/F	G	P	F	F/G	G	F	G	G	P

*Table E-3. **Herbicide Effectiveness on Common Weeds in Vegetables** - continued next page*

Table E-3. Herbicide Effectiveness on Common Weeds in Vegetables - continued

Herbicide	HRAC Mode of Action Number	Barnyardgrass	Crabgrass, Large	Fall Panicum	Foxtail sp.	Goosegrass	Johnsongrass (Seedlings)	Yellow Nutsedge	Carpetweed	Cocklebur, Common	Galinsoga, Hairy	Jimsonweed	Lambsquarters, Common	Morningglory sp.	Shepherdspurse	Pigweed sp.	Purslane, Common	Ragweed, Common	Smartweed, Pennsylvania	Nightshade, Eastern Black	Velvetleaf
POSTEMERGENCE – *continued*																					
Clarity/dicamba	**4**	N	N	N	N	N	N	P	G	G	G	G	G	G	G	G	G	G	G	G	G
Fusilade DX	**1**	G	F/G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N
glyphosate products	**9**	G	G	G	G	G	G	F	G	G	G	G	G	F	G	G	G	F	G	G	G
Goal Tender	**14**	P	P	P	P	P	P	P	G	P	G	F	G	F	G	G	G	F	G	G	F
Gramoxone[5]	**22**	F/G	F/G	F/G	G	F/G	-	G	G	G	G	G	F/G	F/G	-	G	F/G	G	P	-	-
Impact/Armezon	**27**	G	G	F/G	G	F	F	-	-	F/G	-	G	G	F	-	G	-	G	G	G	G
Laudis	**27**	G	F/G	P	G	F	G	-	-	F/G	-	G	G	F	-	G	-	F	-	-	-
Liberty	**10**	F/G	F	F/G	F/G	P	F/G	P	G	G/E	G/E	G/E	F/G	G/E	G/E	G	F	G/E	F	G	G
Lorox	**7**	P	P	P	P	P	P	P	G	P/F	F/G	P/F	G	-	G	G	G	G	G	P/F	G
Maestro/Buctril	**6**	P	P	P	P	P	P	P	G	G	G	G	G	G	G	G	F	F	G	G	F
Matrix/Solida	**2**	G	P/F	F/G	G	P	-	F	-	F/G	-	F	F	F	G	G	F/G	P	P/F	P	F
Metribuzin	**5**	P	P	P	P	P	-	P	G	-	G	G	G	P	G	G	G	G	F	P	P/F
Poast	**1**	G	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Pursuit	**2**	F/G	F/G	F/G	F/G	P	F/G	-	G	F	G	F	G	F	P/F	G	G	P/F	-	-	G
Raptor	**2**	P	P	P	P	P	P	P	-	F/G	G	-	F	F	G	G	P/F	P/F	G	G	G
Reflex[3]	**14**	P	P	P	P	P	P	P	G	F	G	G	P	F/G	G	G	-	F	P	F	P
Sandea	**2**	N	N	N	N	N	N	G	P	G	G	G	N	F	-	G	P	G	F	N	G
Select	**1**	G	G	G	G	P	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shieldex	**27**	P/F	F/G	N	F/G	P/F	P	P	-	F/G	-	G	G	F	-	G	-	F	P/F	P	G
Sinate	**10+27**	G	G	F/G	G	F	F	P	G	G/E	G/E	G/E	G	G/E	G/E	G	F	G/E	G	G	G
Sinbar	**5**	F	F	-	F	F	-	P	G	G	G	G	G	G	G	P	G	G	G	G	G
Spin-Aid	**5**	P	P	P	P	P	P	P	-	P	G	G	F	G	G	P/F	G	F/G	-	-	N
Starane Ultra	**4**	N	N	N	N	N	N	N	N	G	-	-	F/G	-	F	G	G	-	F	G	G
Stinger/Spur	**4**	N	N	N	N	N	N	N	N	G	G	P	P	N	N	N	N	G	P	P	P

[1] Control improved with a pre-plant incorporated treatment, [2] Control of this species based on preemergence application; control from pre-plant incorporated treatment slightly reduced.
[3] Reflex ratings based on 1.25 pt/A. Lower rates will result in reduced levels of weed control. [4] Strategy is a repackaged mixture of Command and Curbit. [5] Gramoxone: nonselective herbicide that needs to be applied with shielded application equipment to prevent spray from contacting the crop.

2.4. Crop Rotation Planting Restrictions

Table E-4. Crop Rotation Planting Restrictions: Months After Herbicide Application Until Planting New Crop

This table summarizes the crop rotation planting restrictions after certain herbicide applications have been made. **For example**, if Devrinol was applied to tomatoes, planting sweet corn must be delayed for 12 months after the Devrinol application. **Consult the label** for a different time interval if two or more herbicides were applied in the same season. The label may also mention additional restrictions due to rainfall, soil, pH, geographical region, variety, or application rate. **This table is not a substitute for the label!** Abbreviations: AH=after harvest, B=bioassay of soil recommended before planting, NI=no information, NR=no restrictions, NS=next season, NY=next year, SY=second year following application.

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
2,4-D[1]	3	1	3	3	3	0.25 –1	1	3	3	3	3	3	1	3	1	1	0.25 –1[1]	3	3	3	3	1
Accent/Accent Q	10[1]	4	10–18[1]	10	10[2]	NR	10	10[2]	10[2]	10[2]	10	10[2]	10[1]	10[2]	4	10–18[1]	0.5	10[2]	10[2]	10[2]	10[2]	4
Acuron	18	4	18	18	18	NR	NR	18	18	18	18	18	10	18	4	10	10	18	18	18	18	4
Acuron Flexi[23]	10	4	18	18	18	NR	NR	18	18	18	18	18	10	18	4	10	10	18	18	18	18	4
Acuron GT	10	4.5	18	18	18	NR	NR	18	18	18	18	18	10	18	4.5	10	10	18	18	18	18	4.5
Afforia (2.5 oz)	4[24]	3	4[24]	3	4[24]	0.5[24]	3	4[24]	4[24]	4[24]	3	4[24]	4[24]	4[25]	3	1	NR [24]	4[24]	1.5	4[24]	4[24]	1[24]
Aim	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Antares Complete	12	4.5	18B	18B	18B	4-10[1]	18B	18B	18B	18B	18B	18B	12	18B	18B	12-18[1]	NR	18B	18	4[9]	18B	4.5
Anthem Flex (5.46 oz)	10	11[25]	11	11	18	NR	NR	18	18	18	11	18	NR	18	11[25]	10[25]	NR	18	18	9	18	4[25]
Anthem Maxx (4.87 oz)	10	11[25]	11	11	18	NR	NR	18	18	18	11	18	1	18	11[25]	10[25]	NR	18	18	9	18	4[25]
Armezon/Impact (0.75 oz)	9	3	9	9	18	NR	NR	18	18	18	9	18	9	18	3	9	9	18	18	18	18	3
Armezon PRO (16–20 fl oz/A)	9	4	9[3]	9[3]	18	NR	NR	18	18	18	9[3]	18	9	18	4	9	9	18	18	18	18	4
Assure II	4	4	4	NR	4	4	4	4	4	4	NR	4	4	4	4	4	NR	4	4	4	4	4
Atrazine	SY	NY	SY	SY	SY	NR	NR	SY	SY	SY	SY	SY	SY	SY	NY	NR	NY	SY	SY	SY	SY	NY
Authority Edge	12	11–18[1]	9	9	18[9]	4	12	18	18	18	9	18	4	18	11–18[1]	10–18[1]	NR[1]	18	18	18	18	4–10[1]
Authority Elite/ BroadAxe XC	12	4.5	12B	12B	2[9]	10	18	12B	12B	12	12B	12B	4	12B	4.5	10	NR	12B	10	4	12B	4.5
Authority First/ Sonic	12	12	12	12	30B	10–18[1]	10–18[1]	30B	30B	30B	9	30B	18	30B	12	12	NR	30B	30[1]	30B	30B	4

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
Authority MTZ	12	4	18	18	18	10	18	18	18	18	18	18	12	18	4	12	NR	18	12	NR[9]	18	4
Authority Supreme	12	11[1]	9	9	18[9]	4	10	18	18	18	9	18	4	18	11[1]	10[1]	NR[1]	18	18	18	18	4[1]
Authority XL	12–18[1]	4	36	36	18	10–18[1]	18	18	36	36	36	36	36	18	4	10–18[1]	NR	36	10–18[1]	12–18[1,9]	18	4
Autumn Super[1]	18B	9	18B	18B	18B	1	9	18	18B	18B	18B	18B	18B	18B	18B	18B	2	18B	18B	18B	18B	3
Axial Bold, Axial Star, Axial XL	3	NR	3	3	1	3	3	3	3	1	3	3	1	3	3	3	3	3	3	3	3	NR
Axiom	12	12	12B	12B	12B	NR	12B	12B	12B	18	12B	12B	1	12B	12	12	NR	12B	12B	12B	12B	0.23–4
Balance Flexx[1]	10[1]	6	18	18	18	NR	6	18	18	18	18	18	6	18	4	6	6	18	12	18	18	4
Basagran	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Basis	10[6]	3	18	10	18	NR	10	10	18	18	10	18	NR	18	3	10[6]	10[6]	18	18	1	18	3
Basis Blend[6,]	10[6]	3	18	10	18	NR	10	10	18	18	10	18	1	18	3	10[6]	10[6]	18	1.5	1	18	3
Beyond	3	9	NR	NR	9	8.5[8]	8.5	9	9	9	NR	9	9	9	4	9	NR	9	9	9	9	3[8]
Bicep products	SY	NY	SY	SY	SY	NR	NY	SY	SY	SY	SY	SY	SY	SY	NY	NR[10]	NY	SY	SY	SY	SY	NY
Boundary	4.5	4.5	12	12	12	4	4	12	12	18	8	12	NR	12	12	12	NR	12	12	12	12	4.5
Buctril/Maestro	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cadet	AH	AH	AH	AH	AH	NR	NR	AH	AH	AH	AH	AH	AH	AH	AH	AH	NR	AH	AH	AH	AH	AH
Callisto	10	4	18	10[1]	18	NR	NR	18	18	18	10[1]	18	10	18	4	NR	10	18	10	18	18	4
Callisto Xtra	10	4	18	10[1]	18	NR	NR	18	18	18	10[1]	18	10	18	4	NR	10	18	10	18	18	4
Canopy[1]	10	4	30	12	18	10	18	18	30	30	12	30	30	18	4	12	NR	30	10[9]	10[9]	18	4
Canopy Blend	10	4	30	18	18	10[26]	18	18	30	30	12	30	30	18	30	18	NR	30	18[9]	10[9]	18	4
Canopy EX	10	4	30	12	18	10[1]	18	18	30	18[1]	12	30	18[1]	18	4	10[1]	0.25[1]	30	10[9]	10[9]	18	4
Caparol	12	12	12	12	5	5	5	12	12	8	5	12	12	12	12	12	12	12	12	12	12	12
Capreno[1]	10-18	10	18	18	18	NR	10	18	18	18	18	18	18	18	18	10	10	18	12	18	18	4
Chaparral	SYB	NY	SYB	SYB	SYB	NY	SYB	SYB	SYB	SYB	SYB	SYB	SYB	SYB	NY	NY	SYB	SYB	SYB	SYB	SYB	NY
Chateau (up to 3 oz)[11]	5[11]	4	12B	4	12B	0.5–1	4	12B	12B	12B	4	12B	5[11]	12B	4	1[1]	NR	12B	2	12B	12B	2
Cimarron Max/ metsulfuron[1]	12[1]	10	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	1

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
Cimarron Plus	4	10	B	B	B	12[1]	B	B	B	B	B	B	B	B	NY B	B	12[1]	B	B	B	B	1
Clarity	4	0.5–1.5[5]	4	4	4	NR	4	4	4	4	4	4	4	4	0.5–1.5[5]	NR	0.5–1[5]	4	4	4	4	0.5–1.5[5]
Classic[1]	12	3	30	9	18	9	18	18	30	30	9	30	30	18	3	9	NR	30	10[9]	10[9]	18	3
Cobra	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Command/Up-stage	12	12	12	9	9	9	9	9	9	12	NR[1]	NR	9	NR[1]	12	9	NR	NR[1]	NR	9[9]	9	12
Corvus	17	9	17B	17	17B	NR	9	17B	17B	17B	17B	17B	17	17B	4	17B[1]	9	17B	12[1]	17B	17B	4
Crossbow[30]	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Curbit	AH	AH	AH	AH	AH	AH	AH	NR	NR	AH	AH	AH	AH	NR	AH	AH	NR	NR	AH	AH	NR	AH
Curtail	10.5–18[1]	1	10.5 B	10.5 B	10.5–18[1]	1	10.5–18[1]	10.5 B	10.5 B	10.5–18[1]	18	10.5 B	18	10.5 B	10.5 B	10.5–18[1]	10.5–18[1]	10.5 B	10.5 B	10.5 B	10.5 B	1
Dacthal	8	8	8	8	AH	8	8	8	AH	AH	8	AH	AH	8	8	8	8	8	8	AH	NR	8
Degree Xtra	SY	SY	SY	SY	SY	NR	NR	SY	SY	SY	SY	SY	SY	SY	SY	NR[10]	NY	SY	NY	SY	SY	AH
Devrinol	12	6	12	12	NR	12	12	12	12	12	12	NR	12	12	6	12	12	12	NR	NR	12	6
DiFlexx	4	2	4	4	4	NR	4	4	4	4	4	4	4	4	4	2	2[1]	4	4	4	4	2
DiFlexx Duo	10	4	18B	10	18B	NR	4	18	18	8/18[27]	10	18B	10	18	4	10	8	18	12	10	18	4
Distinct[1]	1	1	4	4	4	0.25	4	4	4	4	4	4	4	4	1	1	1	4	4	4	4	1
Dual products	4	4.5	NR	NR	2[1]	NR	NR	12	12	2[1]	NR	2	NR	2[1]	4.5	NR[10]	NR	12	NY	2[1]	12	4.5
DuraCor	24B	12	24B	24B	24B	12	12	24B	24B	24B	24B	24B	24B	24B	12	24B	24B	24B	24B	24B	24B	12
Elevore	9	0.5	15B	15B	15B	0.1-0.5[1]	15B	15B	15B	15B	9	15B	24B	15B	0.5	0.5	0.5	15B	15B	15B	15B	0.5
Enlist Duo	NI	NS	NS	NS	NS	0.23–0.5[32]	0.2–0.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	1[32]	NS	NS	NS	NS	NI
Envive	10	4	30	12	18	10	18	18	30	30	12	30	30	18	4	12	NR	30	10[9]	12[9]	18	4
Eptam	NR	AH	AH	NR	AH	AH	AH	AH	AH	AH	AH	AH	NR	AH	AH	AH	AH	AH	AH	AH	AH	AH
Evik	11	3	11	11	11	11	11	11	11	11	11	11	10	11	3	11	11	11	11	11	11	3
Expert	SY	NY	SY	SY	SY	NR	NY	SY	SY	SY	SY	SY	SY	SY	NY	NR[10]	NY	SY	SY	SY	SY	NY
Extreme	4	4	NR	2	18	8.5[8]	18	18	18	40B	NR	18[9]/40B	26	40B	4	18	NR	40B	9.5	18[9]/40B	18	3

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
Facet L	24B	10	10	10	10	10	10	10	10	10	24B	24B	24B	10	10	NR	10	10	24B	24B	10	NR
Fierce/Fierce EZ	10	11–12[1]	11	11	18	0.25–1[1]	18	18	18	18	11	18	4	18	11–12[1]	18	NR	18	12	18	18	1–2[1]
Fierce XLT[1]	18	18	18–30	18–30	18–30	10–18	18–30	18–30	18–30	18–30	18–30	18–30	18–30	18–30	18	18	NR	18–30	18[9]	18[9]	18–30	4
Finesse Cereal and Fallow (0.4 oz)	B	10–16[1]	B	B	B	18	B	B	B	B	B	B	10	B	0–4[1]	4–18[1]	18[14]	B	B	B	B	0–4[1]
FirstRate	9	12	9	9	18	9	18	18	18	18	9	18	18	18	18	9	NR	18	18[15]	18	18	4
Flexstar/Flexstar GT	18	4	4	NR	18	10	10	12	12	18	4	10[9]/12	NR	10	4	18	NR	12	18	10[9]/12	10	4
FulTime/Keystone	15	15	SY	SY	SY	NR	NR	SY	SY	SY	15	SY	15	SY	15	NY	NY	SY	15	SY	SY	15
Fusilade/Fusion	2	2	2	1	2	2	2	2	2	NR	1	1	2	1	2	2	NR	2	2	2	2	2
Glyphosate products	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	1	NR	NR	NR
Goal/GoalTender	2	10	1–2	2	1	10	10	2	2–3[1]	4[1]	2	1[9]	2	2	10	10	0.25	3	2	1[9]	1–2[1]	10
Gramoxone/ paraquat	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
GrazonNext HL	24B	12	24B	24B	24B	12	12	24B	24B	24B	24B	24B	24B	24B	12	24B	24B	24B	24B	24B	24B	12
Grazon P+D	B	2	B	B	B	B	B	B	B	B	B	B	B	B	2	8	B	B	B	B	B	2
Halex GT	10	4.5	18	10[1]	18	NR	NR	18	18	18	10[1]	18	10	18	4.5	NR[10]	10	18	10	18	18	4.5
Harmony Extra SG	1.5	NR	1.5	1.5	1.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0.5	0.25	1.5	1.5	1.5	1.5	NR
Harmony SG	1.5	NR	1.5	1.5	1.5	NR	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	NR	NR	1.5	1.5	1.5	1.5	NR
Harness	9	NS	SY	NS	SY	NR	NR	SY	SY	SY	NS	SY	NS	SY	NS	NR[10]	NS	SY	NS	SY	SY	4
Harness Max	10	NY	18	18	18	NR	18	18	18	18	18	18	18	18	NY	NR[10]	10	18	18	18	18	4
Harness Xtra	SY	SY	SY	SY	SY	NR	NR	SY	SY	SY	SY	SY	SY	SY	SY	NS	NS	SY	SY	SY	SY	SY
Hornet WDG	10.5[1]	4	10.5[1]	18[16]	26B	NR	18[16]	26B	26B	26B	18[16]	26B	18	26B	4	12	10.5	26B	18	26B	26B	4
Huskie	4[1]	0.25	1	9	1	4	1	1	1	9[1]	9	1	9	1	1	0.25	4	1	1	1	1	0.25
Impact Core	9	9	18	18	18	NR	NR	18	18	18	18	18	10	18	9	9	10	18	18	18	18	4
Instigate	18	4	18	10[1]	18	NR	10	18	18	18	10[1]	18	10	18	4	10	10	18	10	18	18	4
Karmex	24	24	24	24	24	NY	24	24	24	24	24	24	24	24	24	NY	24	24	24	24	24	24
Kerb[1]	NR	12	3	3–4	3–6	12	12	3–6	3–6	3–6	3–4	3–6	3	3–6	12	12	3–4	3–6	12	3–6	3–6	12

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
Keystone NXT	SY	15	SY	18	18	NR	NR	18	18	18	SY	18	SY	18	15	NY	NY	18	SY	18	18	15
Laudis	10	4	18	10	18	NR	NR	18	18	8[1]	10	18	10	18	4	10	8	18	12	10	18	4
LeadOff (1.5 oz)	10	3	18	10	18	NR	10	10	18	18	10	18	1	18	3	10	1[1]	18	1.5	1	18	3
Lexar/Lexar EZ	18	NY	18	18	18	NR	NR	18	18	18	18	18	18	18	NY	NR[10][1]	NY	18	18	18	18	NY
Liberty	6	2.3	6	6	2.3	NR	NR	6	6	2.3	6	6	2.3	6	2.3	6	NR	6	6	6	18	2.3
Lightning	9.5	9.5	9.5	9.5	40B	8.5[8]	18	40B	40B	40B	9.5	40B	26	40B	4	18	9	40B	9.5	40B	40B	4
Lorox/Linex	4	12	4	4	4	NR[1]	4	4	4	4	4	4	NR[1]	4	4	NR[1]	NR[1]	4	4	4	4	4
Lumax/Lumax EZ	18	4.5	18	18	18	NR	NR	18	18	18	18	18	18	18	4.5	NR[10][1]	NY	18	18	18	18	4.5
Marvel	18	4	18	NR	18	10	18	18	18	18	10	4[9]	NR	18	4	18	NR	18	18	4[9]	18	4
Matrix	4	12	10	10	12	NR	10	10	18	10	8	12	NR	12	12	18	4	18	18	NR	12	4
Metribuzin products	4	4[1]	18	18	18	4	4	18	18	18	8	18	12	18	18	18	4	18	18	4	18	4[1]
Milestone	24B	12	24B	24B	24B	12	24B	24B	24B	24B	24B	24B	24B	24B	12	24B	24B	24B	24B	24B	24B	12
Optill[1]	4	9.5	4	4	40B	8.5[8]	18	18	40B	40B	4	18	26	40B	4–18	18	0–1	40B	9.5	18	40B	4[8]
Osprey	10	1	10	10	10	3	10	10	10	10	3	10	10	10	10	3	3	10	10	10	10	0.25
Outlook[1]	4–6	4	6–9	6–9	6–9	NR	NR	6–9	6–9	6–9	4	6–9	6–9	6–9	4	NR[10]	NR	6–9	6–9	6–9	6–9	4
Outrider	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	NR
Overdrive	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PastureGard HL	NI	4	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	4
Peak (0.25 oz)[1]	22	NR	22	10	22	1[8]	10	22	22	22	10	22	22	22	NR	1	10	22	10	22	22	NR
Permit	9	2	NI	2	15	1[8]	3	2	9	18	9	10	9	9	2	2	9[1]	9	36	2	9	2
Permit Plus	9	2	NI	2	15	1	3	2	9	18	9	10	9	9	2	2	9[1,14]	9	36	2[9]	9	2
Perpetuo	10	18	11	11	18	NR	8	18	18	18	9–11[1]	18	4	18	18	6–8[1]	NR	18	18	18	18	1–4
Poast	NR	1	NR	NR	NR	1	1[7]	NR	NR	NR	NR	NR	NR	NR	1	1	NR	NR	NR	NR	NR	1
PowerFlex HL	9	9	12	12	12	9	9	12	12	12	9	12	9	12	12	3	3[1]	12	12	12	12	1
Prefar[1]	4	4	4	4	NR	4	4	NR	NR	NR	4	NR	4	NR	4	4	4	NR	4	NR	NR	4
Prefix	18	4.5	4	NR	18	10	10	12	12	18	4	10[9]	1	10	4.5	18	NR	12	18	10[9]	10	4.5

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
Princep 4L	SY	NY	SY	SY	SY	NR	NY	SY	SY	SY	SY	SY	SY	SY	NY	NY	NY[1,7]	SY	SY	SY	SY	NY
Prowl H2O	6[1]	4[1]	NR	NR	NY	NR[1,8]	NR[1,8]	NY	NR	NY	NR	NR[1]	NR[1]	NY	NY	NY	NR	NR	NR[1]	NR[1]	NR	4[1]
Pursuit[1]	4	9.5[1]	NR	2	40B	8.5[8]	18	40B	40B	40B	NR	18[9]	26[1]	40B	4	18	NR	40B	9.5	40B[9]	40B	4
Python	4	4	4	4[1]	26B	NR	18[1]	26B	26B	26B	4	26B	12	26B	4	12	NR	26B	9	26B	26B	4
Raptor	3	9[1]	NR	NR	9	8.5[8]	8.5	9	9	9	NR	9	9[1]	9	4	9	NR	9	9	9	9	3
Realm Q	10	4	18	10[1]	18	NR	10	18	18	18	10[1]	18	10	18	4	10	10	18	10	18	18	4
Reflex	18	4	4	NR	18	10	10	12	12	18	4	10[9]	NR	10	4	18	NR	12	18	10[9]	10	4
Remedy Ultra[30]	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Resicore	10.5[28]	10.5[28]	18	18	18	NR[28]	10.5	18	18	18	18	18	18	18	10.5[28]	10.5[28]	10.5[28]	18	18	18	18	4
Resolve SG (1 oz)	10	9	18	10	18	NR	10	10	18	18	10	18	NR	18	18	10	10[14]	18	18	1	18	3
Resolve Q (1.25 oz)	10	3	18	10	18	NR	10	10	18	18	10	18	NR	18	3	10	2[1]	18	1.5	1	18	3
Resource	1	1	1	1	1	NR	1	1	1	1	1	1	1	1	1	1	NR	1	1	1	1	1
Reviton (2 oz)	5	5	5	5	5	0	5	5	5	5	5	5	5	5	5	5	0.5	5	5	5	5	0
Revulin Q	10[1]	4	18	18	18	NR	10[20]	18	18	18	18	18	10[1]	18	4	10[1]	10	18	18	18	18	4
Ro-Neet	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
Sandea	9	2	36	2	15	1[8]	3	2	9	18	9	10	9	9	2	2	9[1]	9	36	2	9	2
Scepter[1]	18	11	11	11	18	9.5[13]	18	18	18	18	18	18	18	18	18	11	NR	18	9.5	18	18	3
Select/Select Max	NR	1	NR	NR	NR	0.2	1	NR	NR	NR	NR	NR	NR	NR	1	1	NR	NR	1	NR	NR	1
Sentrallas	4	NR	4	4	4	NR	4	4	4	4	4	4	4	4	4	NR	4[1]	4	4	4	4	NR
Sequence	4	4.5	NR	NR	NY	NR	NI	NI	NI	NI	NR	NY	NY	NI	4.5	NR	NR	NI	NY	6[1]	NI	4.5
Sharpen (1 oz)[1]	4	NR	4	4	4	NR	0.5	4	4	4	NR	4	4	4	NR	NR	0–1	4	4	4	4	NR
Shieldex	9	3	9	9	9	NR	NR	9	9	12	9	12	9	9	3	9	9	9	12	9	9	3
Sierra[1]	24	9	24	24	24	11	24	24	24	24	11	24	9	24	24	24	9[14]	24	24	24	24	NR
Sinate	9	3	18	9–18[1]	18	NR	NR	18	18	18	9–18[1]	18	9	18	3	9	9	18	18	18	18	3
Sinbar	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Solicam	16	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	1.5–16[1]	24B	24B	24B	24B	24B

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
Sonalan	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	NR	AH	AH	AH	AH	AH
Spartan	12	4	NR	12B	NR	10	18	12B	12B	12B	12B	12B	12B	12B	4	10[1]	NR	12B	NR	NR[9]	12B	4
Spartan Charge	12	4	12B[1]	12B	NR[9]	4	12	12B	12B	12B	12B	12B	4	12B	4	10[1]	NR	12B	NR	NR[9]	12B	4
Spin-Aid	AH	4	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	4	AH	AH	AH	AH	AH	AH	4
Spirit	18	3	18	10	10	1[8]	8	18	18	18	10	18	10	18	3	10	10	18	10	10	18	3
Spur	10.5	NR	10.5 B	10.5 B	NR	NR	NR	10.5 – 18B	10.5 – 18B	10.5	18B	10.5 B	18B	10.5 – 18B	10.5 B	10.5	10.5 –18	10.5 B	10.5 B	10.5 B	10.5 – 18B	NR
Starane Ultra	4	NR	4	4	4	NR	NR	4	4	4	4	4	4	4	NR	NR	4[31]	4	4	4	4	NR
Status	1[5]	1[5]	4	4	4	0.25	4	4	4	4	4	4	4	4	1[5]	1[5]	1[5]	4	4	4	4	1[5]
Steadfast Q	10[1]	4	10–18	10	18	NR	10[20]	10–18	10–18	10–18	10	10–18	10[1]	10–18	4	10–18	0.5	10–18	10–18	10–18	10–18	4
Stinger	10.5	NR	18B	18B	NR	NR	NR	18B	18B	10.5	18B	18B	18B	18B	NR	10.5	10.5[1]	18B	18B	18B	18B	NR
Storm	3.3	1.5	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	1.5	3.3	NR	3.3	3.3	3.3	3.3	1.5
Stout	10[1]	4	18	10	18	NR	10[20]	18	18	18	10	18	10[1]	18	4	10	0.5	18	18	18	18	4
SureStart/TripleFLEX	NY[1]	NY	26B	26B	26B	NR	18[1]	26B	26B	26B	NY	26B	18	26B	NY	12	NY[1]	26B	18	26B	26B	4
Surpass NXT	9	NY	NY	NY	NI	NR	NR	NI	NI	NI	NY	NI	NY	NI	NY	NR[10]	NY	NI	NY	NY	NI	4
Surveil	10	30B	9	9	30B	9	18	30B	30B	30B	9	30B	18	30B	30B	9	NR	30B	10[21]	30B	30B	3
Synchrony XP[1]	12	3	30	9	18	9	18	18	30	30	9	30	30	18	3	9	NR	30	9[9]	9[9]	18	3
Targa	4	NR	4	NR	4	4	4	4	4	4	NR	4	4	4	4	4	NR	4	4	4	4	NR
Tavium	6	4.5	6	6	6	NR	NR	12	12	6	6	6	6	6	4.5	6	1[1]	12	NY	6	12	4.5
Treflan	NR	NR	NR	NR	NR	12–14[33]	12–14[33]	5	5	5	NR	NR[9]	NR	5	NR	12–14[33]	NR	5	5	NR	5	NR
Trivence	10	4	30	30	18	10[1]	18	18	30	30	12	30	30	18	30	18	NR	30	18[9]	12[9]	18	4
Ultra Blazer	3.3	1.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	1.3	3.3	NR	3.3	3.3	3.3	3.3	1.3
Valor SX/Valor EZ (up to 3 oz)	5[11]	4	6–12B	4	6–12B	0.5–1[1]	4	6–12B	6–12B	6–12B	4	6–12B	5[11]	6–12B	4	1	NR	12	2[11]	6–12B	6–12B	2[11]
Valor XLT[22]	12	4	18	12	18	10	18	18	18	18	12	18	18	18	4	10	NR	18	10[9]	12–18[9]	18[1]	4
Varisto	3	9[29]	NR	NR	9	8.5[29]	8.5	18	9	9	NR	9	9[29]	9	4	9	NR	9	9	9	9	3[29]
Verdict	7	4	7	7	7	NR	4	7	7	7	4	7	7	7	4	NR	NR	7	7	7	7	4

Trade Name	Alfalfa	Barley, Winter	Bean, Lima	Bean, Snap	Cabbage	Corn, Field	Corn, Sweet	Cucumber	Muskmelon	Onion	Peas	Pepper	Potato, White	Pumpkin	Rye, Winter	Sorghum, Grain	Soybean	Squash	Tobacco	Tomato	Watermelon	Wheat, Winter
Vida	1	1 day	1 day	1 day	1 day	NR	1	1 day	1 day	1 day	1 day	1 day	NR	1 day	1 day	1 day	NR	1 day	1	1 day	1 day	NR
Warrant	9	NY	NY	NY	NI	NR	NY	NI	NI	NI	SY	NI	NY	NI	NY	NR[10]	NR	NI	NY	NI	NI	4
Warrant Ultra	18	4	NY	NY	NI	10	12	NI	NI	NI	10	NI	NI	NI	4	18	NR	NI	NI	NI	NI	4
XtendiMax[1]	4	1	4	4	4	NR	4	4	4	4	4	4	4	4	1	0.5[1]	1	4	4	4	4	1
Yukon	9	2	NI	2	15	1[8]	3	9	9	18	9	10	9	9	2	2	9[1]	9	NI	2[9]	9	2
Zeus XC	12	4	12B	12B	NR[9]	10	18	12B	12B	12B	12B	12B	12B	12B	4	10[1]	NR	12B	NR	NR[9]	12B	4
Zidua/ Zidua SC (3 oz or 5 fl oz)[1]	10	11[1]	11	11	18	NR	NR	18	18	18	11[1]	18	4	18	11[1]	10	NR	18	18	18	18	4[1]
Zone Defense	12	4	4[34]	12	4[34]	10	18	12	4[34]	12	4[34]	12	4[34]	12	4	10	NR	12	1	4[9,34]	4[34]	4

AH = after harvest,
B = bioassay of soil recommended before planting,
NI = no information,
NR = no restrictions,
NS = next season,
NY = next year,
SY = second year following application.

The information listed in this rotation restriction table is our interpretation of label statements. Consult the label if two or more of these materials are applied during the same season. Herbicide labels are constantly changing; therefore, this list is not a substitute for the most recent herbicide label.

[1] Read the label for additional restrictions due to application rate, timing, geographical region, rainfall, soil pH, tillage, variety, or supplemental labeling.

[2] 18 months with a soil pH > 6.5. At rates greater than 2.1 oz/A, a rotation interval of 30 months and a successful field bioassay are required.

[3] Rotation interval for lima bean is 18 months if Armezon PRO is applied at greater than 20 fl oz/A. Rotation interval for pea and snap bean is extended to 18 months if Armezon PRO is applied at greater than 25 fl oz/A.

[4] Cotton may be planted after 12 months where Authority Elite/BroadAxe was applied at rates less than 36 oz/A, Authority MTZ DF at rates less than 17 oz/A, or Authority First/Sonic at rates less than 5 oz/A and the following conditions are met: medium and fine soils, pH < 7.2, and rainfall or irrigation must exceed 15 inches after herbicide application and prior to planting cotton.

[5] Following application of Clarity and a minimum of 1 inch of rainfall or overhead irrigation, a waiting interval of 21 days is required per 8 fl oz/A applied prior to planting cotton, 30 days per pint restriction for soybean, and 20 days per pint restriction for small grains. If less than 1 inch or rainfall or irrigation is received after application and Status is applied at greater than 5 oz/A, the rotation interval is 4 months.

[6] If Basis rate is 0.33 to 0.5 oz/A or Basis Blend rate is 1.25 oz/A, alfalfa, sorghum, pea = 18 months; soybean, snap bean = 10 months; STS soybean = 1 month; spring oat = 9 months; if Basis rate is greater than 0.5 oz/A or Basis Blend rate is 2.5oz/A, cotton = 10 months and 18 months if greater than and less than 15 inches of rainfall or irrigation occur after application and prior to planting, respectively; STS soybean = 4 months; if Basis rate is 0.33 oz/A or Basis Blend rate is 0.825, soybean = 0.5 month.

[7] NR for Poast Protected corn hybrids.

[8] NR for IMI (IR/IT) or Clearfield (CL) varieties.

[9] Transplanted.

[10] Use safener with seed.

[11] Cotton may be planted no-till or strip-till after 14 or 21 days when applied at 1 oz/A or 1.5 to 2 oz/A, respectively. For winter wheat, at rates up to 2 oz/A, the rotation interval is 7 days for no-till or minimum-till wheat and 30 days for conventional-till wheat. At least 1 inch of rainfall/irrigation must occur between application and cotton, field corn, grain sorghum, tobacco, or wheat planting, or crop injury may occur. For alfalfa, clover, potato, and spring oats the rotation interval is 5 months if the soil is tilled prior to planting or 10 months if no tillage is preformed prior to planting. At lower rates of Valor/Rowel/Chateau, rotation interval for many crops are reduced. Chateau may be applied to potato following hilling at a rate of 1.5oz/A. Consult labels for more specific information.

[12] Command may be applied preemergence to cotton only if Di-Syston or Thimet insecticides are applied in furrow with the seed at planting.

[13] Corn hybrids that are classified as IMI-corn or as tolerant (IT) or resistant (IR) may be planted in the spring of the year following regardless of rainfall or time interval from chemical treatment to corn planting. Rotation interval varies by tillage type and use rate. Consult the label for specific rotation intervals.

[14] Rotation interval is shorter for STS soybean.

[15] Transplanted tobacco = 10 months if ≤ 0.3 oz/A.

[16] If Hornet WDG rate is < 4 oz/A, snap beans, peas, and some varieties of sweet corn = 10.5 months.

[17] If no more than 2 lb ai applied the previous year.

[18] Regardless of tillage, be sure to plant corn at least 1.5 inches deep and completely cover with soil.

[19] Cotton may be planted 9.5 months following Pursuit if all of the following criteria are met: Pursuit is applied to peanuts only; soil texture is sandy loam or loamy sand only; and greater than 16 inches of rainfall/irrigation is received following application of Pursuit through October of the application year.

[20] The rotation interval for the sweet corn varieties ‘Merit’, ‘Carnival’, and ‘Sweet Success’ is 15 months.

[21] Transplanted tobacco may be planted 10 months after application of 2.1 oz/A of Surveil. Tobacco in seeded nurseries may be planted 18 months after application of 2.1 oz/A of Surveil and following a successful field bioassay. At rates greater than 2.1 oz/A, a rotation interval of 30 months and a successful field bioassay are required.

[22] Rotation intervals based on soil pH less than 7.0. In Pennsylvania, rotation interval for clover, lima bean, muskmelon, onion, pepper, spring oat, squash, and white potato is 18, 30, 30, 30, 30, 30, 30, and 30 months, respectively. Consult seed corn agronomist regarding inbred sensitivity to Valor XLT/Rowel FX prior to planting inbred seed corn lines.

[23] If applied after June 1, rotating to crops other than corn (all types) may result in crop injury.

[24] For Bolt or non-Bolt soybean and minimum- or no-till field corn, if Afforia is used on coarse textured soils, such as sands and loamy sands, or on high-pH soils (>7.9), extend time to planting by 7 additional days. For minimum- or no-till wheat in the states of DE, MD, NJ, or VA, Afforia may be applied at a minimum 7 days before planting. Do not us on Durum wheat and do not irrigate between emergence and spike. Wheat must be planted at least 1 inch deep. Do no graze until wheat has reached 5 inches in height. For conventional-till field corn, grain sorghum, cotton, and wheat, at least 1 inch of rainfall/irrigation must occur between application and planting, or crop injury may occur. For alfalfa, cabbage, clover, cucumber, lima bean, muskmelon, onion, pepper, pumpkin, spring oat, squash, sweet corn, tobacco, tomato, watermelon, and white potato, the rotation interval is 4 months if the soil is tilled prior to planting. If no tillage is performed prior to planting these crops, the rotation interval is extended to 8 months.

[25] Rotation interval for spring oat, or winter barley at 5.7 oz/A or greater rates is extended to 18 months. For winter wheat, at 5.7 oz/A or greater rates, the rotation interval is extended to 6 months.

[26] Seed corn inbred lines vary in sensitivity to herbicides; therefore, users should seek advice from seed corn agronomist regarding inbred sensitivity to Canopy Blend prior to planting inbred seed corn.

[27] For onion, the rotation interval for irrigated and non-irrigated is 8 and 18 months, respectively.

[28] For corn, if the original corn crop is lost, do not make a second application. Injury may occur to soybean planted the year following application on soils having a calcareous subsurface layer if products containing atrazine were used at rates greater than 0.75 lb/ai atrazine per acre in tank mixtures and/or sequentially with Resicore. If Resicore is applied after June 1, rotating to crops other than corn or grain sorghum the next spring may result in crop injury.

[29] NR for Clearfield corn (field and seed). For wheat, planting non-Clearfield cultivars in areas receiving less than 10 inches of precipitation from time of application up until wheat planting may result in wheat injury. Injury potential increases if less than normal precipitation occurs in the 2 months just after Varisto application. For barley, the rotation interval at pH > 6.2 and > 18 inches of rainfall/irrigation, pH < 6.2 and < 18 inches of rainfall/irrigation and with moldboard plowing, and pH < 6.2 and < 18 inches rainfall/irrigation and without moldboard plowing is 9, 9, and 18 months, respectively. For potato, the rotation interval at pH > 6.2 and > 18 inches of rainfall/irrigation and pH < 6.2 and < 18 inches of rainfall/irrigation is 9 and 18 months, respectively.

[30] Rotation information is unknown for this product. Contact manufacturer for recommendations.

[31] In Delaware and Virginia, a Special Local Needs Label 24(c) has approved a 3-month plant-back restriction for soybean after an application to winter wheat.

[32] NR for Enlist varieties.

[33] In areas receiving 20 inches of rainfall or irrigation; 12 months after a spring application or 14 months after a fall application of Treflan 4L or 4EC. Labelled for these crops or after crop plants have emerged.

[34] Rotation is 8 months in no-till.

2.5. Prepackaged Herbicide Mixtures

Table E-5. Prepackaged Herbicide Mixtures and the Components of the Mixtures Available for Various Vegetable Crops

Trade Name	Components (ai/gal or lb)	HRAC Mode of Action Number	If You Apply (per acre)	You Have Applied (ai per acre)	Equivalent to a Tank Mixture of These Products (per acre)
Acuron 3.44SC	2.14 lb s-metolachlor	15	2.5 qt	1.34 lb s-metolachlor	1.4 pt Dual II Magnum 7.64E
	0.24 lb mesotrione	27		0.15 lb mesotrione	4.8 fl oz Callisto 4SC
	0.06 lb bicyclopyrone	27		0.038 lb bicyclopyrone	0.038 lb bicyclopyrone
	1 lb atrazine	5		0.625 lb atrazine	0.625 qt Atrazine 4L
Acuron Flexi 3.26SC	2.86 lb s-metolachlor	15	2 qt	1.43 lb s-metolachlor	1.5 pt Dual II Magnum 7.64E
	0.32 lb mesotrione	27		0.16 lb mesotrione	5.12 fl oz Callisto 4SC
	0.08 lb bicyclopyrone	27		0.04 lb bicyclopyrone	0.04 lb bicyclopyrone
Anthem Flex 4SE	3.733 lb pyroxasulfone	15	4.0 fl oz	0.117 lb pyroxasulfone	3.5 fl oz Zidua 4.17SC
	0.267 lb carfentrazone	14		0.008 lb carfentrazone	0.54 fl oz Aim 2EC
Armezon PRO 5.35 EC	0.1 lb topramezone	27	24 fl oz	0.017 lb topramezone	0.76 fl oz Armezon 2.8SC
	5.25 lb dimethenamid	15		0.84 lb dimethenamid	18 fl oz Outlook 6E
Authority Elite 7SE	0.7 lb sulfentrazone	14	25 fl oz	0.13 lb sulfentrazone	4.2 fl oz Zeus 4L OR 5.3 fl oz Spartan Charge 3.5EC
	6.3 lb s-metolachlor	15		1.23 lb s-metolachlor	1.29 pt Dual Magnum 7.62E
Bicep II Magnum 5.5L	2.4 lb s-metolachlor	15	2.1 qt	1.26 lb s-metolachlor	1.33 pt Dual II Magnum 7.64E
	3.1 lb atrazine	5		1.63 lb atrazine	1.63 qt Atrazine 4L
BroadAxe XC 7SE	0.7 lb sulfentrazone	14	25 fl oz	0.13 lb sulfentrazone	4.2 fl oz Zeus 4L OR 5.3 fl oz Spartan Charge 3.5EC
	6.3 lb s-metolachlor	15		1.23 lb s-metolachlor	1.29 pt Dual Magnum 7.62E
Degree Xtra 4.04ME	2.7 lb acetochlor	15	3 qt	2.03 lb acetochlor	4.3 pt Degree 3.8ME
	1.34 lb atrazine	5		1 lb atrazine	1 qt Atrazine 4L
Harness Xtra 5.6L	0.74 lb dimethenamid	15	2.5 qt	1.94 lb acetochlor	2.21 pt Harness 7E
	1.44 lb atrazine	5		1.56 lb atrazine	1.56 qt Atrazine 4L
Keystone NXT 5.6SE	3.1 lb acetochlor	15	2.5 qt	1.94 lb acetochlor	2.22 pt Surpass NXT 7E
	2.5 lb atrazine	5		1.57 lb atrazine	3.15 pt Atrazine 4L
Lexar EZ 3.7SC	1.74 lb s-metolachlor	15	3 qt	1.3 lb s-metolachlor	1.36 pt Dual II Magnum 7.64E
	0.224 lb mesotrione	27		0.168 lb mesotrione	5.36 oz Callisto 4SC
	1.74 lb atrazine	5		1.3 lb atrazine	1.3 qt Atrazine 4L

Table E-5. Prepackaged Herbicide Mixtures - continued next page

Table E-5. Prepackaged Herbicide Mixtures - continued

Trade Name	Components (ai/gal or lb)	HRAC Mode of Action Number	If You Apply (per acre)	You Have Applied (ai per acre)	Equivalent to a Tank Mixture of These Products (per acre)
Lumax EZ 3.6SC	2.49 lb s-metolachlor	15	2.7 qt	1.67 lb s-metolachlor	1.75 pt Dual II Magnum 7.64E
	0.249 lb mesotrione	27		0.168 lb mesotrione	5.36 oz Callisto 4SC
	0.935 lb atrazine	5		0.625 lb atrazine	0.625 qt Atrazine 4L
Revulin Q 51.2WDG	0.144 lb nicosulfuron	2	4 oz	0.036 lb nicosulfuron	1.1 oz Accent Q WG
	0.368 lb mesotrione	27		0.094 lb mesotrione	3 fl oz Callisto 4SC
Sinate 2.57SL	2.47 lb glufosinate	10	28 fl oz	0.54 lb glufosinate	30 fl oz Liberty 2.34L
	0.1 lb topramezone	27		0.022 lb topramezone	1 fl oz Impact 2.8SC
Spartan Charge 3.5EC	3.15 lb sulfentrazone	14	3.5 fl oz	0.09 lb sulfentrazone	2.8 fl oz Zeus 4L
	0.35 lb carfentrazone	14		0.01 lb carfentrazone	0.6 fl oz Aim 2EC
Strategy 2.1SC	1.6 lb ethalfluralin	3	3 pt	0.61 lb ethalfluralin	26 fl oz Curbit 3EC
	0.5 lb clomazone	13		0.19 lb clomazone	8 fl oz Command 3ME
Varisto 4.187SL	4 lb bentazon	6	21 fl oz	0.65 lb bentazon	21 fl oz Basagran 4L
	0.187 imazamox	2		0.03 lb imzamox	4 fl oz Raptor 1L
Verdict 5.57EC	5 lb dimethenamid	15	13 fl oz	0.5 lb dimethenamid	11 fl oz Outlook 6EC
	0.57 lb saflufenacil	14		0.058 lb saflufenacil	2.6 fl oz Sharpen 2.85L
Zemax 3.67SC	3.34 lb s-metolachlor	15	2 qt	1.67 lb s-metolachlor	1.75 pt Dual II Magnum 7.64E
	0.33 lb mesotrione	27		0.165 lb mesotrione	5.36 fl oz Callisto 4SC

3. Insect Control

3.1. Soil Pests - Detection and Control

Cutworms

Several cutworm species can damage vegetables. Cutworm larvae (caterpillars) chew leaves, sever stalks and stems, and also may chew tubers, roots, spears, or fruit, rendering them unmarketable. Most cutworm larvae are night feeders and hide during the day, *e.g.*, under sod clumps, stones, or decaying vegetation. During periods of drought, low-lying areas in fields are more subject to cutworm damage than other areas, presumably because of more desirable conditions.

For cutworm adults (moths), Weedy or minimum-tillage fields are especially attractive overwintering and egg-laying sites for cutworm adults. Cutworm adults can also lay eggs on transplants in greenhouses that are lighted at night, as the moths are attracted to light. Eggs and larvae may be transferred with transplants to the field.

Control. Where cutworms are suspected, a broadcast spray of a pyrethroid insecticide on no-till crop residue or broadcast incorporation of an insecticide treatment into the soil may be necessary just before planting (see individual crops for labeled insecticides). For organic producers, Seduce bait (OMRI listed) is labeled for cutworm control. **Always consult the label for rates and restrictions.**

Even if a broadcast treatment is used, fields should be scouted for cutworm damage within a week of planting or plant emergence. If cutworms are actively cutting plants, a post-planting contact treatment may be necessary. The following procedures may help improve control when a contact insecticide treatment is used:

1. Direct sprays at the base of the plants where cutworms are actively feeding.
2. Increase the amount of water used to at least 30 gal/A, especially in dry weather.
3. Spray between midnight and 5 a.m. when cutworms are most active.
4. Cultivate after insecticide application to improve contact with cutworms, especially in dry weather.

Garden Centipedes (Symphylans)

Garden centipedes are arthropods that are related to insects. They feed on germinating seed and fibrous roots of many crops and non-crop plants, including practically all vegetable species, and on decaying plant material. They are often associated with moist, fine textured heavier soils and typically establish in spots or field edges. Crops planted into those areas are often damaged because the symphylans are continuously grazing on the fibrous roots. Spinach acts as very good host for this pest. Rotation does not appear to be an effective control.

Detection. The first symptom is an area or patch of poorly developing plants, similar to other root problems. Check the soil in these areas so that treatment can be made before planting the next crop, as there is no practical post-planting control. A common practice is to flag off the spot and treat that area with soil insecticides in the following fall or spring. Soil solarization has not been an effective control. Symphylans can probably be transported in soil on field equipment. Dig up the soil and look for small, slender (smaller than 0.25 inch) white centipede-like animals that move quickly and try to avoid light. Another sampling method is to drop soil into a bucket of water. Symphylans will float to the top. Symphylans have beaded antennae and 12 pairs of legs on 14 body segments. Do not confuse symphylans with true centipedes (that eat other arthropods and are considered beneficial). Centipedes are not white and have large mandibles. Note: Dry or cold (under 45°F/7°C) soil will reveal few, if any, symphylans.

When to treat. For spring soil samples, control is generally warranted if there are more than 2 symphylans per shovelful on average. For September or October soil samples, on average 4 or 5 per shovelful warrants treatment before the next crop. Insecticides are generally applied before spring planting, and fumigant treatments are usually made in the fall. Effectiveness of soil-applied insecticides decreases if soil temperatures are below 55°F (13°C).

Grubs

Grubs are the larvae of various beetles and can be soil pests in most vegetable crops. Serious problems have occurred in potatoes, sweet potatoes, beans, corn, spinach, and strawberries. Grubs feed on the roots and underground parts of the plant from one to several inches below the soil surface. The plants may yellow and wilt, which causes a patchy growth in fields where plants are dead or dying. If injured plants are pulled up, the roots will show feeding damage, and usually the curve-bodied grub can be found in the soil. Adult beetles lay eggs in the soil during the summer. As the soil cools in the fall, grubs move deeper into the soil and return to the surface the following spring. Depending on the insect, grubs may take 1-3 years to become adults and may cause problems year after year.

Control. Grub damage is usually associated with grassy or weedy fields. Clean fields may help prevent serious grub damage. Problems may occur in crops planted to fields that were previously sod.

Maggots

Three species of maggots (seedcorn maggot, cabbage maggot, and onion maggot) attack either the seed or roots of vegetables during the growing season. The biology is similar for these species, although the crops they feed on are often different. The adult of the maggot (a fly) fluctuates in abundance in different areas in different years. Since it is impossible to determine when and where maggots will attack and since nothing can be done once the injury is noted, preventive controls are good insurance before planting if you have previously had maggot problems.

Seed Maggots: A seed attacked by seed maggots usually fails to sprout or, if it does, it is weak or sickly. Newly transplanted plants are also susceptible to maggots that tunnel up through the stem causing the plant to wilt. Injury is most severe in wet, cold springs and on land rich in organic matter or with recent organic matter incorporation

Control. Control may be achieved using commercially applied seed treatments containing either clothianidin (Poncho 600), imidacloprid (Gaucho 600), or thiamethoxam (Cruiser 5FS, or Farmore DI-400). The level of control will depend on soil type, soil moisture, crop, weather conditions, and other factors. Refer to each specific crop section of this manual for listing of labeled seed treatments. **Do NOT use treated seed for food or feed**

Root Maggots: Plant roots become riddled with maggot tunnels, and underground fleshy parts soon become rotten. Above ground, plants appear off-color, wilt, and seldom reach full growth. Transplant water treatments, in-furrow treatments, pre-plant broadcast, and postplant treatments may be recommended depending on the crop. Refer to insecticide labels for labeled materials.

Nematodes

See section E 1.6. Nematode Control.

Slugs

Slugs are closely related to snails. All slugs require damp or humid surroundings for development and will avoid the drying effects of sun and wind. During the day, slugs seek shelter under protective debris and mulch. This is why weed control is a useful deterrent to any slug problem. Slugs are particularly problematic in no-till or minimal till farming systems. Look for slime trails in the morning. Shelter traps, such as square foot shingle or cardboard segments can be used to detect slugs.

Control. Metaldehyde (*e.g.*, Deadline M-Ps Mini-Pellets) is an effective slug-control chemical, and numerous commercial preparations are available at farm supply centers. Iron phosphate containing products (ex Sluggo, Ferroxx AQ, Iron Fist [OMRI listed]) are also labeled for slug control on a number of crops.

Read the label for crops and use rates, as not all products are labeled for all crops!

Wireworms

Wireworms are the larval stage of click beetles. Some species can remain in the soil as a larvae for multiple years. They injure vegetable crops by killing seeds or seedlings and tunneling and scarring tubers, roots, bulbs, and low-growing vegetable fruit in contact with soil.

Detection. Injury to young plants or tubers frequently is sufficient evidence to warrant future control measures. Since there is no effective post-planting rescue treatment, the following methods are useful to detect the presence of wireworms before planting:

Method 1: A technique using baits has been developed for evaluating wireworm potential before planting. The bait stations should be established 2-3 weeks before the anticipated planting date. Fields where small grain or grasses have been grown the preceding 2 or 3 years are the best candidates for bait stations. Since wireworm infestations are often localized within a field, it will be necessary to place the bait stations randomly throughout the field. One bait station per acre is desirable. Place 2 bait stations at the highest elevation in a field, 2 on a slope, and 2 in the lowest area. Follow this procedure for baiting:

1. Mix 1 cup of untreated wheat or rolled oats and 1 cup of untreated shelled corn at each station
2. Bury the bait about 2” deep (if buried too deeply the grain will rot). Cover the ground over each bait station with an 18” square of black plastic. The plastic collects solar heat and speeds germination of the corn and wheat, enticing overwintering wireworms to respond.
3. Mark each station with a flag or stake.
4. Dig up the bait stations after 10-14 days and count the number of wireworms. For best results wait until the

germinating grain has emerged before digging. Look for slender, reddish-brown insects that are ¼-1" long.

Method 2: Be sure the soil temperature at the 6-inch depth ranges between 45-85°F (7-29°C) and that soil moisture is equivalent to that desired for planting.

1. Collect soil samples from 20 scattered sites per acre. Each sample should be about 12" deep and 6" in diameter. Sample sites should be near plant crowns.
2. Sift soil and count wireworms.

Control. If you find an average of 1 wireworm per bait station (Method 1) or if you find 5 or more wireworms in 20 soil samples (Method 2), a labeled soil insecticide should be used. Wireworm infestations tend to concentrate in some locations. Hence several wireworms may be found in one bait station and none in others. It may be possible to limit treatment to areas of the field with the largest concentration. **See individual crops for labeled insecticides.**

When to apply. Insecticides can be applied either in the spring or fall when the soil temperature at the 6-inch depth is at least 50°F (10°C) and soil moisture is equivalent to that desired for planting. Frequently, the insecticide is applied immediately before planting. Consider fall treatment if an early spring planting is planned.

3.2. Insecticide Mode of Action: Reducing the Risk of Insecticide Resistance Development

Resistance to insecticides develops because intensive pesticide use kills the susceptible individuals in a population, leaving only the surviving resistant ones to reproduce. Adopting the practices outlined below will help reduce the development of pest resistance.

a. Crop rotation to a nonhost crop reduces the need for pesticide treatment and, thus, reduces the ratio of resistant to susceptible individuals in the breeding population.
b. Spot treatment is an important practice. Early season insects are often concentrated in areas near their overwintering sites. Spot treating these areas, rather than the entire field, will reduce the resistance problem at a reduced cost.
c. Control efforts should be concentrated on the early stages of development, which are often easier to kill.
d. Do not overspray. Attempts to destroy every pest in the field by multiple applications or by using rates higher than labeled rates often eliminate the susceptible but not the resistant pests. **The way pesticides are used affects the development of resistance.** Insecticides within a specific chemical group usually share a common target site within the pest, and thus share a common Mode of Action (MoA). Resistance often develops based on a genetic modification of this target site. When this happens, the compound usually loses its pesticidal activity. Because all insecticides within the chemical grouping share a common MoA, there is a high risk that this resistance will automatically confer cross-resistance to all the compounds in that group. The MoA classification provides a guide to the selection of insecticides for an insecticide resistance management strategy. The MoA classification was developed and is endorsed by the Insecticide Resistance Action Committee (IRAC) to insure growers can effectively alternate insecticides with different modes of action. More information can be found at: *http://www.irac-online.org/documents/moa-classification/?ext=pdf*. In Table E-6 below, insecticides are listed with their MoA classification (IRAC Group). In crop specific sections, insecticides are organized by mode of action only, not by efficacy or recommendation.

3.3. Insect Pest and Mite Control for Greenhouse Production

Adequate ventilation is critical for greenhouse pesticide use. Follow the re-entry intervals (REI) listed on the labels for worker safety. Always read and fully understand the label before applying any pesticide.

Applications of insecticides in **high tunnels** may be considered equivalent to a greenhouse, depending on the state's definition of "high tunnel". Check with your state's pesticide regulatory agency for an interpretation concerning use of pesticides in high tunnels.

Yellow and blue sticky traps are very effective in catching winged aphids, leafminers, thrips, whiteflies, fungus gnats and shore flies. Traps can be hung vertically just above the plant canopy as well as the growing medium surface or near doors and side vents, or other areas where insects may enter or exit the greenhouse. It is suggested that at least 1 trap be used per 1,000 sq ft.

See Table E-6. Insecticides and Miticides Labeled for Use on Greenhouse Vegetables on the following pages

Table E-6. Insecticides and Miticides Specifically Labeled for Use on Greenhouse Vegetables

Pesticides are listed in alphabetical order by Active Ingredient. The IRAC number refers to the Mode of Action, see section E 3.2. "Insecticide Mode of Action: Reducing the Risk of Insecticide Resistance Development"

IRAC Group	Active Ingredient Product Name(s)	Target Pests	Labeled Crops	PHI (d)	REI (h)	Comments
6	**abamectin** Agri-Mek SC	Spider mites, russet mites, leafminers, pinworms	Tomatoes only (not for transplants)	1	12	Use a minimum of 20 gal/A
20B	**acequinocyl** Kanemite 15SC, Shuttle O	Two spotted spider mites, broad mites	Fruiting vegetables	1	12	Use at least 100-gal water/A 2 applications per year No surfactant or adjuvant use
4A	**acetamiprid** TriStar 30SG	Aphids, leafhoppers, mealybugs, caterpillars, plant bugs, whiteflies, fungus gnat larvae, thrips, beetles, leafminers	Leafy vegetables, fruiting vegetables, cole crops, cucurbits, onions and bulb vegetables, strawberries (non-bearing)	7	12	**For vegetables grown as transplants only, except for peppers and strawberry.** Treat small area to test for phytotoxicity first.
18b	**azadirachtin** Azatin XL, Azatrol EC, Neemix, Ornazin, Azahar, Aza-Direct	Immature stages of whiteflies, aphids, and other listed insects; fungus gnat larvae (as soil drench)	Most vegetables including fruiting vegetables and cucurbits, herbs, spices, and others	0	4 or 12 check label	Botanical insect growth regulator (some products OMRI listed). Can be applied via chemigation. Spray water pH should be between 5.5 and 6.5. REI 12 for Neemix and Ornazin
11	***Bacillus thuringiensis*** var ***aizawai*** XenTari, Agree	Armyworms, beet armyworm, cabbage looper, tomato fruitworm	Most vegetables including fruiting vegetables and cucurbits, herbs, spices, and others	0	4	Lepidopteran larvae only - most effective against early instars.
11	***Bacillus thuringiensis*** var ***israelensis*** Gnatrol	Fungus gnats (larvae only)	All vegetables	0	4	Drench. Repeat applications may be needed.
11A	***Bacillus thuringiensis*** var ***kurstaki*** Dipel, Javelin, Deliver, Biobit	Armyworms, beet armyworm, cabbage looper, tomato fruitworm,	Most vegetables including fruiting vegetables and cucurbits, herbs, spices, and others	0	4	Lepidopteran larvae only - most effective against early instars.
n/a	***Beauveria bassiana*** strain GHA Mycotrol O (OMRI listed) BotaniGard ES, BotaniGard WP	Aphids, thrips, whiteflies, certain other pests	All vegetables, herbs, spices, and others	0	4	Slow acting, fungus infects insects. Repeat applications at 5-10-day intervals may be needed. Note storage and other restrictions. **Do not use BotaniGard ES on tomatoes**.
25	**bifenazate** Floramite SC	Spider mites, clover mites	Tomatoes	3	12	No more than 2 applications per crop per season for tomatoes that are greater than 1" in diameter at maturity. Maintain spray water pH 5.5-6.5. **Do not use an adjuvant**.
16	**buprofezin** Talus 40SC	Leafhoppers, mealybugs, whiteflies	Tomatoes	1	12	Insect growth regulator for immature stages only. Maximum 2 applications per season at least 5 d apart. Will reduce egg viability.

Table E-6. Insecticides and Miticides Specifically Labeled for Use on Greenhouse Vegetables – continued next page

Table E-6. Insecticides and Miticides Specifically Labeled for Use on Greenhouse Vegetables - continued

IRAC Group	**Active Ingredient** Product Name(s)	**Target Pests**	**Labeled Crops**	**PHI (d)**	**REI (h)**	**Comments**
13	**chlorfenapyr** Pylon	Caterpillars, spider mites (*Tetrany-chus* spp.), broad mites, western flower, and melon thrips	Fruiting vegetables	0	12	**Do not** use on tomato varieties with mature fruit less than 1 inch in diameter. No more than 3 applications per crop.
28	**cyantraniliprole** Exirel	Thrips, Whitefly	Tomato, eggplant, peppers, cucumbers	1 (0 for cucumber)	12	For whitefly add effective adjuvant. Only suppresses thrips
28 + 6	**cyantraniliprole + abamectin** Minecto Pro	Leafminer, spider mites, tomato russet mite, tomato psyllid, whitefly, pinworm	Tomatoes	1	12	Tomatoes only. Foliar feeding thrips suppression only. Thorough coverage is essential to obtain best results.
17	**cyromazine** Citation	Leafminers, fungus gnats, shore flies	Only for vegetable transplant production grown for consumers	7	12	**Do not** apply within 7 d of shipping to market. No more than 6 applications per crop
4A	**dinotefuran** Safari 20 SG	Aphids, leafminers, mealybugs, whiteflies	Cucurbits, fruiting vegetables, head and stem brassicas, leafy vegetables	1 or 7	12	One application/crop. For vegetable transplants only. May be applied via a chemigation system. PHI 7 for leafy vegetables, PHI 1 for all other.
10B	**etoxazole** TetraSan 5WDG	Spider Mites	Tomatoes only	1	12	**Do not** make more than 2 applications per season. **Do not** use with an adjuvant.
21A	**fenpyroximate** Akari	Two spotted spider mites, tomato russet mites (suppresses whiteflies)	Cucumbers, Tomatoes, Peppers	7	12	One application per growing season. **Do not** use adjuvants.
29	**flonicamid** Beleaf 50 SG	aphids, plant bugs, GH whitefly	Cucumbers	0	12	Allow a minimum of 7-days between applications. Whitefly suppression only
4D	**flupyradifurone** Altus 1.67 SL	Aphids, whiteflies, chili thrips, squash bug, psyllids, leaf hoppers	Cucumbers, Lettuce, Tomatoes, Peppers, Many vegetable transplants	1-all but Pepper-3	4	**Do not make more than 1 (one) application to transplants per season**
10A	**hexythiazox** Onager miticide 1EC	Two spotted spider mites, European red mites	Tomatoes	1	12	**Do not** make more than 1 (one) application per year
4A	**imidacloprid** Marathon	Aphids, fungus gnat larvae, leafhoppers, whiteflies	Cole crops, collards, kale, kohlrabi, lettuce, mustard greens, pepper, tomato, eggplant.	-	12	**Use on vegetable plants intended for resale only**. May be applied via a chemigation system.
4A	**imidacloprid** Admire PRO	Aphids, whiteflies	Tomato and cucumber only in production greenhouses.	0	12	**Only** for plants growing in field soil, potting media or mixes. **Do not** apply to plants growing hydroponically or in rock wool, perlite or other soil-less mix. May be applied as drench or chemigation system. Label notes possible repellent effect on bumble bees and some beneficials (*Orius* sp.)

Table E-6. Insecticides and Miticides Specifically Labeled for Use on Greenhouse Vegetables – continued next page

Table E-6. Insecticides and Miticides Specifically Labeled for Use on Greenhouse Vegetables - continued

IRAC Group	Active Ingredient Product Name(s)	Target Pests	Labeled Crops	PHI (d)	REI (h)	Comments
n/a	**iron phosphate** Sluggo-AG, Escar-Go	Slugs and snails	All vegetables	0	0	OMRI listed. Bait; scatter around plants or perimeter of plantings.
1B	**malathion** Gowan Malathion 8F	Japanese beetles, thrips, onion maggots	Succulent beans, cucumbers, eggplant, lettuce, green and bulb onions, sweet corn, tomatoes (crops vary depending on label)	1 to 7	12	See label for specific crops. May be applied through a chemigation system.
n/a	**paraffinic oils** Sunspray Ultra-fine SuffOil-X	Aphids, two spotted spider mites, leafminers, thrips, whitefly	Tomato, pepper, lettuce, cucurbits, radish, squash, herbs, spices	1	4	**Do not** exceed 4 applications a growing season. Allow 2 w between applications.
n/a	**potassium salts of fatty acids** insecticidal soap M-Pede	Aphids; leafminer; spider, broad and russet mites; thrips; whiteflies; plant bugs; leafhopper; Powdery Mildew (cucumber only)	Many vegetables (see label for specifics), herbs, spices	0	12	Works well on whiteflies, mites and aphids if coverage is good but has no residual control. Note label cautions about application frequency, water quality and tank mixing. OMRI listed
3a	**pyrethrins** Pyrenone Crop Spray, Pyronyl Crop Spray, PyGanic, Pyrethrum PT	All	All vegetables, herbs, spices	0	12	Pyrenone and Pyronyl include PBO synergist; PyGanic is OMRI listed.
21	**pyridaben** Sanmite	Two spotted spider mite, whiteflies, leafhoppers, European red mite, some aphid species, broad mite	Tomatoes (PHI 2) and Cucumbers (PHI 1)	1 or 2	12	Only 2 applications per crop per year. Allow 30 days between sequential applications.
7c	**pyriproxyfen** Distance	Whiteflies, aphids, fungus gnats, shoreflies	Fruiting vegetables (except non-bell peppers)	1	12	Insect growth regulator. **Do not** use on tomato varieties with mature fruit less than 1 inch in diameter. Spray, sprench or drench.
n/a	**rosemary oil + peppermint oil** Ecotec	Aphids, beetles, mites, thrips, plant bugs, others	Many vegetables, herbs, spices	0	0	OMRI listed. Can be applied in drip for soil pests.
23	**spirotetramat** Kontos	Aphids, leafhoppers, mealybugs, psyllids, spider mites, spittlebugs, whiteflies	Vegetable transplants only (see label for list)	-	24	Apply as drench or via an irrigation system to plants in containers. Not for use in vegetable production.
4a	**thiamethoxam** Flagship 25WG	Whiteflies, leafhoppers, Colorado potato beetle, stinkbugs	Fruiting vegetables and cucurbits	-	12	**ONLY** use for vegetable transplants intended for resale

3.4. Insect Pest and Mite Control for Chemigation

Table E-7. Insecticides with Labels for Chemigation
Note: Read and understand all chemigation instructions on the label before use on any crop!

Drip/trickle Systems	
azadirachtin (Aza-Direct or OLF)	flupyradifurone (Sivanto Prime)
chlorantraniliprole (Coragen, Vantacor)	imidacloprid (Admire PRO or OLF)
clothianidin (Belay)	malathion (Malathion 8 Aquamul)
cyantraniliprole (Verimark)	oxamyl (Vydate)
diazinon (Diazinon)	rosemary oil + peppermint oil (Ecotec)
dimethoate (Dimate)	thiamethoxam (Platinum)
dinotefuran (Venom)	thiamethoxam + chlorantraniliprole (Durivo)
Overhead and Sprinkler Systems	
abamectin (Agri-Mek **onion only**)	lambda-cyhalothrin (Warrior II)
acetamiprid (Assail 30SG)	lambda-cyhalothrin + chlorantraniliprole (**potato only**)
afidopyropen (Versys and Sefina)	(Voliam Xpress)
azadirachtin (Aza-Direct or OLF)	lambda-cyhalothrin + thiamethoxam (Endigo ZC)
Bacillus thuringiensis (DiPel, XenTari)	malathion (Malathion 8 Aquamul)
beta-cyfluthrin (Baythroid XL)	methomyl (**green/bulb onions, potatoes only**) (Lannate LV)
bifenthrin (Capture or OLF)	novaluron (**potatoes only**) (Rimon)
bifenthrin + imidacloprid (Brigadier)	permethrin (Pounce or OLF)
carbaryl (Sevin or OLF)	propargite (**sweet corn, potatoes only**) (Comite)
chlorantraniliprole (Coragen, Vantacor)	pymetrozine (**potato only**) (Fulfill)
clothianidin (Belay)	pyrifluquinazon (PQZ)
cryolite (Kryocide)	pyrethrins (PyGanic)
cyclaniliprole (Harvanta)	spinetoram (Radiant)
cyfluthrin (Renounce, Tombstone or OLF)	spinosad (Entrust, SpinTor)
deltamethrin (Battalion)	spinosad + gamma-cyhalothrin (**corn only**) (Consero)
diazinon (Diazinon)	spiromesifen (Oberon)
dimethoate (Dimate or OLF)	spirotetramat (Movento)
dinotefuran (Venom)	sulfoxaflor (Closer SC, **potato only**)
esfenvalerate (Asana)	thiamethoxam (Platinum, **potato only**) (Actara 25WDG)
flonicamid (Beleaf)	thiamethoxam + chlorantraniliprole (**potato only**)
flupyradifurone (Sivanto Prime)	(Voliam Flexi)
gamma-cyhalothrin (Proaxis)	thiamethoxam + lambda-cyhalothrin (Endigo ZC)
imidacloprid (Admire PRO or OLF)	tolfenpyrad (Torac)
imidacloprid + beta-cyfluthrin (Leverage 2.7)	zeta-cypermethrin (Mustang Maxx)
indoxacarb (Avaunt, Avaunt eVo)	zeta-cypermethrin + bifenthrin (Hero)

4. Disease Control

4.1. Fungicide Mode of Action: Reducing the Risk of Fungicide Resistance Development

Pathogens may develop resistance to fungicides because of increased selection pressure with the intensive use of high-risk fungicides. High-risk fungicides may only kill susceptible individuals within a given population, while allowing resistant individuals to continue to reproduce and cause more disease. Use the practices outlined below to help reduce the chances for fungicide resistance development.

a. Long and proper crop rotations with non-host crops will help break disease cycles and decrease the need for or overuse of specific fungicides. This is especially important for controlling soil-borne pathogens.

b. Do NOT apply a fungicide at a higher or lower than recommended labeled rate.

c. Fungicides are organized according to Fungicide Resistance Action Codes (FRAC codes), based on chemical structure (see Table E-8) and Mode of Action (MoA). Fungicides within a given FRAC code control pathogens in a similar manner and share the same risk for fungicide resistance development. Table E-10 lists commonly used fungicides and their FRAC codes.

d. Some fungicides are referred to as **high-risk fungicides because of their very specific MoA's and high risk for resistance development**, for example, the DMI's (FRAC code 3) and the QoI's (FRAC code 11). Fungicides in high-risk codes (**in bold in Table E-8 and in crop sections in chapter F**) should be rotated and tank-mixed with broad spectrum, protectant fungicides to delay or reduce the potential for resistance development. All high-risk fungicides have seasonal application restrictions which should be followed precisely.

e. Rotate as many fungicides from different FRAC codes as possible during the production season.

f. If you feel control with a high-risk fungicide is no longer effective, stop using it and switch to fungicides with other MoA (*i.e.*, fungicides with other FRAC codes).

Table E-8. FRAC Codes and Corresponding Chemical Groups for Commonly Used Fungicides

FRAC Code*	Chemical Group		FRAC Code*	Chemical Group
P01	Salicylic Acid Pathway		12	phenylpyrroles
P05	Extract of *Reynoutria sachalinensis*		**13**	aryloxyquinoline
P07	phosphonates; fosetyl-Al		14	aromatic hydrocarbons
M01	inorganic copper		17	hydroxylanilide
M02	inorganic sulfur		21	quinone outside inhibitor (QiI)
M03	dithiocarbamate		22	benzamides (toluamides)
M04	phthalimide		27	cyanoacetamideoxime
M05	chloronitrile		28	carbamates
1	benzimidazole		29	dinitroanilines
2	dicarboximide		39	quinazoline
3	triazole		40	carboxylic acid amides
4	phenylamide		43	benzamides (acylpicolides) quinazoline
7	carboxamide		45	triazolo-pyrimidylamine carboxylic acid amides
9	anilino-pyridines		49	piperidinyl-thiazole-isoxazolines
11	quinone inside inhibitor (QoI)		50	benzophenone triazolo-pyrimidylamine

*** FRAC Code in bold for fungicides with high risk for resistance development**

4.2. How Biofungicides Work

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Biofungicides are formulations of living organisms that are used to control the activity of plant pathogenic fungi and bacteria. The concept of biofungicides is based upon observations of natural processes where beneficial microorganisms, usually isolated from soil, hinder the activity of plant pathogens. Biocontrol microorganisms are free-living fungi, bacteria, or actinomycetes that are active in root, soil, and foliar environments. These microorganisms produce a wide range of antibiotic substances, parasitize other fungi, compete with other fungi,

and induce localized or systemic resistance in plants. The use of composts and suppressive growing medium, which both contain living microorganisms, to mitigate disease is another example of this disease management option.

- **Rhizosphere Competence** - The most successful of the strains of biocontrol microorganisms exhibit rhizosphere competence, the ability to colonize and grow in association with plant roots. They can colonize entire root surfaces for several months. Here they effectively compete with plant pathogens for nutrients, infection sites, and space. Competition for glucose in the soil is involved in disease suppression. Biofungicide organisms also metabolize seed and root exudates that normally stimulate pathogen germination or zoospore attraction.
- **Parasitism** - Parasitism, the ability of species to attack and consume plant pathogens, has been well studied. Mycoparasitism of biocontrol microorganisms includes directed growth, contact and binding, coiling of hyphae around the host fungus, penetration, and degradation. Production of cell wall degrading enzymes is almost always part of the process.
- **Antibiosis** - Antibiosis occurs when one microorganism produces molecules that directly affect other organisms negatively by toxicity or growth inhibition. These compounds are called antibiotics and are commonly produced by a wide range of soil dwelling microorganisms in the course of their growth. A familiar antibiotic, streptomycin, is produced by *Streptomyces* species which are classified as actinomycetes or filamentous bacteria.
- **Inducing Metabolic Changes** - An important mechanism of biocontrol microorganisms is the ability to induce metabolic changes in plants that increase their resistance to a wide range of plant pathogenic fungi and bacteria. Systemic Acquired Resistance (SAR) improves the plant response to pathogen attack by priming the production of plant defense compounds. This capacity to induce resistance to a wide range of diseases in a variety of plants appears to be widespread. Enhanced resistance is systemic because disease resistance occurs at sites distance from the location of the biocontrol microorganisms.
- **Plant Growth Promotion** - A final way in which these organisms act is through plant growth promotion. Beneficial root-colonizing microorganisms promote plant growth and productivity. Many resistance-inducing fungi and bacteria promote both root and shoot growth in the absence of plant pathogens. When applied to growing media or as a seed treatment, some biofungicides can increase root development and improve drought resistance in some plants. Improvements in plant growth result from effects on soil microflora and direct effects on the plant. Biofungicides can also improve nutrient uptake (copper, phosphorous, iron, and manganese).

In the greenhouse industry, biofungicides are applied preventively to growth media or as a seed treatment for root and crown disease control and can be as effective as chemical fungicides. Biofungicides used for foliar disease management must be applied preventatively. Biofungicides are generally safer for growers, can be more persistent, and are sometimes less expensive than conventional fungicides.

The most effective uses of biofungicides are as a preventive treatment in growing media or as a seed treatment. They should be mixed into the growing media prior to planting or applied as a drench immediately after transplanting, making sure that the entire soil volume is treated. For foliar applications, the biofungicides must be in place before pathogen infection as their action is purely protective. They must be reapplied frequently both to protect new growth and to ensure that effective populations of the microorganisms are present. Because biofungicides consist of living organisms, they may have different storage, shelf life, and handling requirements than conventional fungicides. Most biofungicides have short reentry intervals (0-4 hours).

4.3. Disease Control in Seeds, Plant Growing Mix and Plant Beds

Seed Treatment

Seed treatment is essential to control seed-borne diseases in many transplanted crops. Failure to treat seed properly could lead to diseases in the plant bed that will reduce plant stands, or that are carried into the field at transplanting. Crop failure could result. Seed treatment is especially important for asparagus, broccoli, Brussels sprouts, cabbage, cauliflower, collards, eggplant, kale, kohlrabi, peppers, radish, and tomato.

Heat treatment of seeds is a non-chemical alternative to conventional chlorine treatments with the additional benefit of killing pathogens that may be found within the seed coat (*e.g.*, bacterial canker organism of tomatoes). Seed heat-treatment follows a strict time and temperature protocol and is best done with thermostatically controlled

water baths. Two baths are required: one for pre-heating and a second for the effective pathogen killing temperature. The initial pre-heat treatment is 10 minutes at 100ºF (38ºC). The effective temperature treatment and time in the second bath differ between crops; protocols for several important crops are listed in Table E-9.

Immediately after removal from the second bath, seeds should be rinsed with cool water to stop the heating process and dried on screen or paper. Seeds may be re-dusted with fungicide if desired. Pelleted seed is not recommended for heat treatment. Heat treat only seed that will be used during the current season. See crop sections for specific seed treatment recommendations.

Table E-9. Effective Seed Treatment Temperature Protocols (2nd Bath) for Pathogen Eradication

Crop	Water Temperature		Minutes
	°F	°C	
Brussels sprouts, eggplant, spinach, cabbage, tomato	122	50	25
Broccoli, cauliflower, carrot, collard, kale, kohlrabi, rutabaga, turnip	122	50	20
Mustard, cress, radish	122	50	15
Pepper	125	51	30
Lettuce, celery, celeriac	118	48	30

Disease Control in Plant Growing Mix

For the best control of all soil-borne diseases, use the plant-growing mix described in Table R-4 or R-5. If this is not possible, use soil steaming or fumigation as described below.

Disease Control in Plant Beds

Preplant: Soil steaming is the only practice that ensures complete sterilization of soil. A temperature of 180°F (82°C) must be maintained throughout the entire mass of soil for a period of 30 minutes. **Soil fumigation** is also used to control disease. The following materials are suitable for small lots of soil:
- chloropicrin and metam-sodium (Vapam HL), see label for rates and instructions.

For larger areas, such as plant beds or seed beds, the following materials are suitable (see label for rates and instructions):
- chloropicrin
- metam-sodium (Vapam HL)
- Potassium N-methyldithiocarbamate (K-Pam HL)

Consul the Fumigation section in this chapter (section E 1.5.) for additional recommendations.
Note: The use of soil fumigants has become severely limited because of new restrictions. Check with your local county agricultural agent.

Pre-and post-seeding treatments in transplant and greenhouse production: See crop sections for seed treatment options and Table E-11. below for a list of selected fungicides for use in greenhouse production.

Nematode Control

See section E 1.6. Nematode Control.

4.4. Fungicides Registered for Vegetables

See Table E-10 "Commonly Used Fungicides Registered for Vegetables" on the following pages

Note:
- **Table E-10 is not all inclusive; crop sections in chapter F Commodity Recommendations may include additional recommendations.**
- **Crop sections in chapter F should be consulted to ensure efficacy on specific pathogens.**
- **Guidelines for preventing fungicide resistance development can be found in section E 4.1. "Fungicide Mode of Action: Reducing the Risk of Fungicide Resistance Development."**

Table E-10. Commonly Used Fungicides Registered for Vegetables

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days (See also Table E-11. Selected Fungicides Labeled for Greenhouse Use).

Fungicides / FRAC Code(s) / Crop	**Actigard** (acibenzolar-S-methyl)	**Aliette** (fosetyl A1)	**Aproach** (picoxystrobin)	**Aprovia Top** (difenoconazole + benzovindiflupyr)	**Ariston** (chlorothalonil + cymoxanil)	**azoxystrobin**	**Cabrio** (pyraclostrobin)	**Cannonball** (fludioxonil)	**Catamaran** (chlorothalonil + phosphite)	**chlorothalonil**[a]	**Curzate** (cymoxanil)	**Dexter Max** (azoxystrobin + mancozeb)	**Elatus** (azoxystrobin + benzovindiflupyr)
FRAC Code(s)	P01	33	11	3+ 7	M05 + 27	11	11	12	M05+ P07	M05	27	11 + M03	11+ 7
Asparagus		X110				X100				X190		X180	
Beans, Snap			X14	X14		X		X7		X7			
Beans, Lima			X14	X14		X		X7		X14			
Beets						X	X						
Broccoli	X7	X3				X	X			X7			
Carrots						X	X			X			
Celery		X3				X	X	X		X7			
Chinese Cabbage	X7	X3				X	X			X7			
Cole Crops	X7	X3				X	X			X7			
Cucumbers	X	X		X	X3	X1	X			X	X3		
Eggplants				X		X	X			X3			
Garlic	X7					X	X7	X7		X7			
Greens, Mustard	X7	X3				X	X						
Greens, Turnip	X7					X							
Horseradish						X	X			X14			
Leeks						X	X7	X7		X14			
Lettuce	X7	X3				X	X	X			X3		
Muskmelons	X	X		X	X3	X1	X	X14		X	X3		
Okra				X		X				X3			
Onions, Dry	X7	X7				X	X7	X7		X14			
Onions, Green		X7				X	X7	X7		X14			
Parsley		X				X	X	X					
Parsnips						X	X			X10			
Peas				X14		X							
Peppers	X14			X		X	X			X3			
Potatoes						X14				X7	X14		X14
Pumpkin/Winter Squash	X	X		X	X3	X1	X			X	X3		
Radish						X	X						
Spinach	X7	X3				X	X	X			X1		
Squash, Summer	X	X		X	X3	X1	X			X	X3		
Strawberries	X	X				X	X						
Sweet Corn			X7			X7				X14		X7	
Sweet Potatoes				X14		X							
Tomatoes	X14	X14		X		X	X		X0/4	X	X3		
Watermelon	X	X		X	X3	X1	X	X14		X	X3		

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-10. - continued next page.

Table E-10. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days (See also Table E-11. Selected Fungicides Labeled for Greenhouse Use).

Fungicides / Crop	**Elumin** (ethaboxam)	**Endura** (boscalid)	**Fixed copper**[a]	**Flint Extra** (trifloxystrobin)	**Fontelis** (penthiopyrad)	**Forum** (dimethomorph)	**Gatten** (flutianil)	**Gavel** (zoxamide + mancozeb)	**Gem** (trifloxystrobin)	**Headline** (pyraclostrobin)	**Headline AMP** (pyraclostrobin+metconazole)	**Inspire Super** (difenoconazole + cyprodonil)	**iprodione**
FRAC Code(s)	22	7	M01	11	7	40	U13	22 + M03	11	11	11 + 3	3+ 9	2
Asparagus													
Beans, Snap		X7	X		X					X7			X[e]
Beans, Lima		X7	X		X	X7				X7			X[e]
Beets			X	X7	X				X7				
Broccoli		X	X		X	X7						X7	X
Carrots		X	X		X				X7				X
Celery		X	X		X3	X7			X7				
Chinese Cabbage		X	X		X	X7						X7	
Cole Crops		X14	X		X	X7						X7	
Cucumbers	X2	X	X		X1	X5	X	X5				X7	
Eggplants		X	X		X	X5			X3			X	
Garlic		X7	X		X3	X5		X7				X7	X
Greens, Mustard		X14	X		X	X7						X7	
Greens, Turnip			X		X	X7						X7	
Horseradish		X			X				X7				
Leeks		X7	X		X3	X5						X7	
Lettuce		X14	X		X3	X7							X14
Muskmelons	X2	X	X		X1	X5	X	X5				X7	
Okra			X		X								
Onions, Dry		X7	X		X3	X5		X7				X7	X7
Onions, Green		X7	X		X3	X5		X7				X14	
Parsley		X14	X		X3	X7							
Parsnips				X7					X7				
Peas		X21	X		X					X7			
Peppers		X	X		X	X5			X3			X	
Potatoes		X10	X	X7		X5		X14[d]	X7	X3			X14
Pumpkin/Winter Squash	X2	X	X		X1	X5		X5				X7	
Radish					X								
Spinach			X		X3	X7							
Squash, Summer	X2	X	X		X1	X5	X	X5				X7	
Strawberries			X	X	X								X[e]
Sweet Corn			X							X7	X7		
Sweet Potatoes	X2	X10								X3			
Tomatoes		X	X		X	X5		X5	X3			X	
Watermelon	X2	X	X		X1	X5		X5				X7	

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-10. - continued next page.

Table E-10. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days (See also Table E-11. Selected Fungicides Labeled for Greenhouse Use).

Fungicides / Crop	**Luna Experience** (fluopyram + tebuconazole)	**Luna Sensation** (fluopyram + trifloxystrobin)	**Luna Tranquility** (fluopyram + pyrimethanil)	**Magister** (fenazaquin)	**mancozeb**	**ManKocide** (mancozeb + copper hydroxide)	**Merivon** (fluxapyroxad + pyraclostrobin)	**metalaxyl**	**Miravis Neo** (propiconazole + pydiflumetofen + azoxystrobin)	**Miravis Prime** (pydiflumetofen + fludioxonil)	**Omega** (fluazinam)	**Orondis Gold** (oxathiapiprolin + mefenoxam)	**Orondis Opti** (oxathiapiprolin + chlorothalonil)	**Orondis Ultra** (oxathiapiprolin + mandipropamid)
FRAC Code(s)	7 + 3	7 + 11	7 + 9	39	M03	M03+ M01	7 + 11	4	3+ 7 + 11	7 + 12	29	49 + 4	49 + M05	49 + 40
Asparagus					X180			X				X[e]		
Beans, Snap								X			X14			
Beans, Lima								X	X14		X30			
Beets			X7				X7	X		X7				
Broccoli								X			X50			
Carrots		X7					X7	X		X7	X7			
Celery							X1	X		X7				
Chinese Cabbage								X			X20			
Cole Crops								X			X20		X[e]	X[e]
Cucumbers	X7			X3	X5		X	X		X1			X[e]	X[e]
Eggplants								X		X0	X30	X[e]		
Garlic					X7		X7	X			X7			X[e]
Greens, Mustard										X7	X20			X[e]
Greens, Turnip										X7	X20			X[e]
Horseradish							X7	X		X7				
Leeks	X7		X7				X7	X					X[e]	
Lettuce							X1	X		X0	X30	X[e]		X
Muskmelons	X7	X		X3	X5		X	X		X1	X30		X[e]	X
Okra											X30			
Onions, Dry			X7		X7	X5	X7	X			X7		X[e]	
Onions, Green			X7			X5	X7	X					X[e]	
Parsley							X1	X		X7		X[e]		
Parsnips		X7	X7				X7	X						
Peas								X						
Peppers								X			X30	X[e]		
Potatoes			X7		X14[d]			X			X14		X[e]	X
Pumpkin/Winter Squash	X7			X3			X	X		X1		X[e]	X[e]	X
Radish			X7				X7	X						
Spinach							X1	X		X		X[e]		
Squash, Summer	X7			X3	X5		X	X		X1		X[e]	X[e]	X
Strawberries		X	X7				X			X0		X[e]		
Sweet Corn					X7				X14					
Sweet Potatoes								X						
Tomatoes					X5	X5		X					X[e]	X
Watermelon	X7	X		X3	X5		X	X		X1	X30		X[e]	X

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-10. - continued next page

Table E-10. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days (See also Table E-11. Selected Fungicides Labeled for Greenhouse Use).

Fungicides / FRAC Code(s) / Crop	**phosphonates**[a]	**Polyram** (metiram)	**Presidio** (fluopicolide)	**Previcur Flex** (propamocarb)	**Priaxor** (fluxapyroxad + pyraclostrobin)	**Pristine** (pyraclostrobin + boscalid)	**Procure** (triflumizole)	**Proline** (prothioconazole)	**propiconazole**	**Quadris Opti** (azoxystrobin + chlorothalonil)	**Quadris Top** (difenoconazole + azoxystrobin)	**Quash** (metconazole)	**Quilt Xcel** (propiconazole + azoxystrobin)
FRAC Code(s)	P07	M03	43	28	7 + 11	11 + 7	3	3	3	11 + M05	3 + 11	3	3 + 11
Asparagus													
Beans, Snap	X				X7				X7				X7
Beans, Lima	X				X7				X7	X14			X7
Beets			X7						X14				
Broccoli	X		X2		X3		X1				X1		
Carrots			X7			X			X14	X	X7		X14
Celery	X		X2			X			X14	X7			X14
Chinese Cabbage	X		X2		X3		X1				X1		
Cole Crops	X		X2		X3		X1				X1		
Cucumbers	X		X2	X2		X	X	X7		X1	X1		
Eggplants	X		X2		X						X		
Garlic	X					X7			X14	X7	X7		X14
Greens, Mustard	X		X2		X3		X1				X1		
Greens, Turnip	X				X3		X1				X1		
Horseradish			X7										
Leeks	X					X7			X14	X14	X7		X
Lettuce	X		X2	X2			X						
Muskmelons	X		X2	X2		X	X	X7		X1	X1		
Okra													
Onions, Dry	X					X7			X14	X7	X7		X14
Onions, Green	X					X7			X14	X14	X7		X
Parsley	X		X2				X		X14				
Parsnips			X7										
Peas	X				X7			X7					
Peppers	X		X2	X5	X						X		
Potatoes	X	X14		X14	X7					X14	X14	X1	
Pumpkin/Winter Squash	X		X2	X2		X	X	X7		X1	X1		
Radish			X7										
Spinach	X		X2										
Squash, Summer	X		X2	X2		X	X	X7		X1	X1		
Strawberries						X	X1		X		X		X
Sweet Corn					X7				X14				X14
Sweet Potatoes			X7								X14	X1	
Tomatoes	X		X2	X5	X					X	X		
Watermelon	X		X2	X2		X	X	X7		X1	X1		

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-10. - continued next page.

Table E-10. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days (See also Table E-11. Selected Fungicides Labeled for Greenhouse Use).

Fungicides / Crop	**Quintec** (quinoxyfen)	**Rally** (myclobutanil)	**Ranman** (cyazofamid)	**Reason** (fenamidone)	**Revus** (mandipropamid)	**Revus Top** (mandipropamid + difenoconazole)	**Rhyme (flutriafol)**	**Ridomil Gold**, **Ultra Flourish** (mefenoxam)	**Ridomil Gold Bravo** (mefenoxam + chlorothalonil)	**Ridomil Gold Copper** (mefenoxam + copper)	**Ridomil Gold MZ** (mefenoxam + mancozeb)	**Scala** (pyrimethanil)	**Stratego** (propiconazole + trifloxystrobin)
FRAC Code(s)	13	3	21	11	40	3 + 40	3	4	4+ M05	4+ M01	4+ M03	9	3 + 11
Asparagus		X180						X					
Beans, Snap		X	X	X3	X1			X[b]		X7			
Beans, Lima			X	X3				X[b]		X3			
Beets				X14				X					
Broccoli			X	X2	X1			X[b]	X7				
Carrots			X14	X14				X[b]	X7	X7			
Celery				X2	X1		X7	X					
Chinese Cabbage			X	X2	X1			X[b]	X7				
Cole Crops			X	X2	X1			X	X7				
Cucumbers		X	X	X14	X		X	X	X	X5	X5		
Eggplants	X3	X	X	X14	X			X					
Garlic				X7	X7			X[a]	X7	X10	X7	X7	
Greens, Mustard			X	X2	X1			X[b]					
Greens, Turnip			X	X2	X1			X[b]					
Horseradish				X14				X[a]					
Leeks				X7	X7			X	X14	X10	X7	X7	
Lettuce	X1	X3	X	X2	X1		X7	X[a]					
Muskmelons	X3	X	X	X14	X		X	X	X	X5	X5		
Okra		X	X	X14	X								
Onions, Dry				X7	X7			X	X7	X10	X7	X7	
Onions, Green				X7	X7			X	X14	X7		X7	
Parsley			X	X2	X1		X7	X					
Parsnips				X14				X					
Peas								X[b]					
Peppers	X3	X	X	X14	X			X		X7			
Potatoes			X7	X14		X14		X	X14	X14	X14	X7	
Pumpkin/Winter Squash	X3	X	X	X14	X		X	X	X	X5			
Radish				X14				X		X7			
Spinach			X	X2	X1			X		X3			
Squash, Summer		X	X	X14	X		X	X	X	X5	X5		
Strawberries	X1	X						X				X1	
Sweet Corn													X14
Sweet Potatoes			X7	X14				X				X7	
Tomatoes	X3	X	X	X14		X1		X	X5	X14	X5	X1	
Watermelon	X3	X	X	X14	X		X	X	X	X5	X5		

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-10. - continued next page.

Table E-10. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days (See also Table E-11. Selected Fungicides Labeled for Greenhouse Use).

Fungicides	**Sulfur** [c,e]	**Switch** (cyprodinil + fludioxonil)	**Tanos** (famoxadone + cymoxanil)	**tebuconazole**	**Terraclor** (PCNB)	**thiophanate-methyl**	**Tilt (propiconazole)**	**Top Guard EQ (flutriafol + azoxystrobin)**	**Torino** (cyflufenamid)	**Uniform** (mefenoxam + azoxystrobin) [e]	**Vivando** (metrafenone)	**Zampro** (ametoctradin + dimethomorph)	**Zing!** (zoxamide + chlorothalonil)
FRAC Code(s) / **Crop**	M02	9 + 12	11 + 27	3	14	1	3	3 + 11	U06	4 + 11	50	45+ 40	22+ M05
Asparagus	X			X180									
Beans, Snap	X	X7		X14	X14	X14				X			
Beans, Lima	X	X7		X14	X14	X14				X			
Beets	X	X7		X7			X14			X			
Broccoli	X	X7		X7	X							X	
Carrots	X	X7											
Celery	X	X				X7				X		X	
Chinese Cabbage		X7		X7	X					X		X	
Cole Crops	X	X7		X7	X					X		X	
Cucumbers	X	X1	X3	X7		X1		X1	X	X	X	X	X
Eggplants	X	X		X7							X	X4	
Garlic	X	X7	X3	X7	X	X[a]				X		X	X7
Greens, Mustard	X	X7		X7						X		X	
Greens, Turnip	X	X7		X7									
Horseradish	X	X7											
Leeks		X7	X3	X7						X		X	
Lettuce	X	X	X1							X		X	
Muskmelons	X	X1	X3	X7		X1		X1	X	X	X	X	X
Okra	X	X		X3							X		
Onions, Dry	X	X7	X3	X7		X[a]				X		X	X7
Onions, Green	X	X7	X3	X7		X[a]				X		X	
Parsley		X7	X1					X7		X		X	
Parsnips	X	X7											
Peas	X									X			
Peppers	X	X	X3	X7	X			X			X	X4	
Potatoes	X	X7	X			X21						X4	X7
Pumpkin/Winter Squash	X	X1	X3	X7		X1			X	X	X	X	X
Radish	X	X7					X14			X			
Spinach	X	X	X1							X		X	
Squash, Summer	X	X1	X3	X7		X1			X	X	X	X	X
Strawberries	X	X				X1	X		X				
Sweet Corn				X7									
Sweet Potatoes	X	X7			X					X			
Tomatoes	X	X	X3	X7	X			X			X	X4	X5
Watermelon		X1	X3	X7		X1		X1	X	X	X	X	X

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

4.5. Disease Control for Greenhouse Production

Table E-11. Selected Fungicides Labeled for Greenhouse Use

Fungicides are listed in alphabetical order within FRAC code.
BM 02 = Biological; M0x = Protectant Fungicide; P0x = Plant Defense Inducer; NC = not classified by FRAC; # = FRAC code(s)
Note: Some states define pesticide applications in high tunnels as greenhouse applications, others define them as field applications. Check with your extension educator or state department of agriculture for correct application. If any information in this table is inconsistent with the label, follow the label.

Fungicide	Active Ingredient(s)	FRAC Code	OMRI Listed	Target Diseases/Pathogens	Labeled Crops	Comments
Actinovate (Novozymes BioAg, Inc.)	*Streptomyces lydicus*	BM 02	**Yes**	Damping off and root rot, pathogens *Pythium*, *Rhizoctonia*, *Phytophthora*, *Verticillium,* and foliar diseases including Downy and Powdery Mildew and *Alternaria* and *Botrytis*	Greenhouse vegetables and herb crops	May be applied to soil or foliage through mist systems or sprayer.
Bio-Tam (SePRO)	*Trichoderma asperellum* + *Trichoderma gamsii*	BM 02	**Yes**	Damping off and root rot, pathogens *Pythium*, *Rhizoctonia*, *Phytophthora*, and *Verticillium*	For cole crops, cucurbits, fruiting vegetables and leafy vegetables, onions, and herbs	See label for specific rates.
Cease, Serenade ASO, Subtilex NG	*Bacillus subtilis* (various) - see label*s*	BM 02	**Yes**	For suppression of soilborne and foliar diseases including damping off, Root Rot and Early Blight	Many vegetables including fruiting and leafy vegetables, cucurbits, cole crops and herbs	May be used in hydroponic and soilless production systems. Most effective when used preventatively.
Contans (Sipcam Agro)	*Coniothyrium minitans*	BM 02	**Yes**	*Sclerotinia sclerotiorum*, *S. minor*	Many vegetables including leafy vegetables, brassicas, legumes, fruiting vegetables and bulb vegetables. Do not use on tomato.	Contains a beneficial fungus. Do not allow to stand overnight following mixture. Acts as a preventative.
Howler (AgBiome Innovations)	*Pseudomonas chlororaphis* strain AFS009	BM 02	**Yes**	For suppression of *Rhizoctonia*, *Pythium*, *Fusarium*, *Phytophthora*, *Sclerotinia*, *Colletotrichum* and *Botrytis*	Cucurbits fruiting vegetables, herbs, leafy vegetables, cole crops	May be used in hydroponic and soilless production systems. Most effective when used preventatively.
Lifegard WG (Certis USA)	*Bacillus mycoides* isolate J	BM 02	**Yes**	Downy Mildew, Powdery Mildew, Leaf Spots	Brassica head and stem vegetables, cucurbits, fruiting vegetables	Transplants can be treated in the greenhouse prior to transplanting.
RootShield, RootShield + (Bioworks, Inc.)	*Trichoderma harzianum*	BM 02	**Yes**	*Pythium*, *Rhizoctonia*, and *Fusarium*. When applied as a foliar spray, suppresses *Botrytis* and Powdery Mildew.	Greenhouse vegetables	Contains a beneficial fungus. Avoid applications of fungicides at least one week before or after application. Acts as a preventative. Will not cure diseased plants.
SoilGard 12G (Certis USA)	*Trichoderma virens* GL-21 (formerly known as *Gliocladium virens*)	BM 02	**Yes**	Damping off and root rot caused by *Pythium* and *Rhizoctonia*	Food crop plants in greenhouse	Has preventative activity only, will not cure already diseased plants. Allow treated soil to incubate for one day prior to planting for best results. Do not use other soil fungicides at time of incorporation.

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued next page

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued

Fungicide	Active Ingredient(s)	FRAC Code	OMRI Listed	Target Diseases/Pathogens	Labeled Crops	Comments
Sonata (Bayer Crop Science LP)	*Bacillus pumilus*	BM 02	**No**	Early Blight, Late Blight, Downy Mildew, Powdery Mildew	Many vegetables including brassicas, cucurbits, bulb, fruiting, and leafy vegetables and root and tuber crops	Preventative biological fungicide. Can be used in organic production.
Stargus, Double Nickel	*Bacillus amyloliquefaciens* (various) - see labels	BM 02	**Yes**	Bacterial Blight, Bacterial Spot, Late Blight, Grey Mold, Downy Mildew, and other diseases	Cucurbits, tomatoes, peppers, leafy vegetables, and other greenhouse-grown vegetables	Can be used as a soil drench for soilborne diseases or as a foliar spray. Apply prior to disease infection.
Badge SC, Badge X2 (Gowan)	copper hydroxide + copper oxychloride	M01	**No**	Leaf Spots, Bacterial Leaf Spot, and others	Tomato, pepper, eggplant, and cucumber	See label for rates, restrictions, and application timing. Phytotoxicity may occur.
Camelot O, Cueva	copper octanoate	M01	**Yes**	Leaf Spots, Bacterial Leaf Spot, and others	Cucurbits, tomatoes, peppers, and others	See labels for specific rates and usage instructions. Phytotoxicity may occur.
Cuprofix Ultra 40 Disperss (United Phosphorus, Inc.)	basic copper sulfate	M01	**No**	Many diseases including Angular Leaf Spot, Downy Mildew, *Alternaria* blight, *Anthracnose*, Bacterial Blight, etc.	Vegetables including cucumbers, eggplant, peppers, tomatoes, and others	Crops grown in the greenhouse may be more sensitive to copper injury so end user should determine plant sensitivity.
Kocide 2000-O, Kocide 3000-O, Nu-Cop 50DF, Champ WG, ChampION++	copper hydroxide	M01	**Yes**	Leaf Spots, *Anthracnose* and Bacterial Spots, and others	See labels for specific crops	See labels for specific usage instructions. Phytotoxicity may occur.
Magna-Bon CS 2005 (Magna-Bon II, LLC)	copper sulfur pentahydrate	M01	**Yes**	Many diseases including Angular Leaf Spot, Downy Mildew. *Alternaria* blight, *Anthracnose*, Bacterial Blight, etc.	Vegetables including cucurbits, eggplant, peppers, tomatoes and others	Crops grown in the greenhouse may be more sensitive to copper injury so end user should determine plant sensitivity.
Nordox (Brandt Consolidated)	cuprous oxide	M01	**No**	Bacterial Spot and Speck, *Alternaria* leaf spot, *Anthracnose*, Early and Late Blight, etc.	Eggplant, pepper, and tomato	See label for specific usage instructions.
Microthiol Disperss (United Phosphorus, Inc.)	sulfur (S)	M02	**Yes**	Powdery Mildew	Crucifers, cucurbits, peppers and tomatoes	Crops grown in greenhouses may be more sensitive to S injury, so the lowest label rate should be tried initially. Do not use within two weeks of an oil spray treatment.
Dithane M45 (Corteva Agriscience US)	mancozeb	M03	**No**	Seed treatment for damping-off, Seedling Blight, Seed Rots	Tomato	Broad-spectrum protectant fungicide.
Actigard (Syngenta Crop Protection)	acibenzolar-s-methyl	P01	**No**	Angular Leaf Spot, Bacterial Fruit Blotch, Bacterial Leaf Spot, Downy Mildew, Powdery Mildew, Scab	Summer squash production only	See label for rates, restrictions, and application timing. Phytotoxicity may occur.
Regalia, Regalia CG (Marrone Bio Innovations)	*Reynoutria sachalinensis*	P05	**Yes**	Many diseases including Powdery Mildew	Cucurbits, bulb vegetables, fruiting vegetables and others	See label for crops, application methods

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued next page

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued

Fungicide	Active Ingredient(s)	FRAC Code	OMRI Listed	Target Diseases/Pathogens	Labeled Crops	Comments
K-Phite (Plant Food Systems) **Prophyt** (Helena Chemical Co.)	phosphorous acids - mono and di-potassium salts	P07	**No**	Root Rots, damping off, Downy Mildew	Cucurbit, fruiting vegetable, and leafy vegetable crops	See label for pre-plant seedling tray application instructions.
DeBug Tres, Debug Turbo (Agro Logistic Systems, Inc.)	azadirachtin + neem oil	NC	**Yes**	Nematodes. *Sclerotinia sclerotiorum* and *S. rolfsii* diseases	Cucurbits, fruiting vegetables and others (see label)	See labels for specific rates and usage instructions.
Majestene Bionematicide (Marrone Bio Innovations)	*Burkholderia* spp.	NC	**Yes**	Root-Knot, Lesion, Sting, Stunt, Ring and other nematodes	Brassica, bulb, cucurbit, fruiting and leafy vegetables	Take soil samples prior to planting to assess nematode populations.
Milstop SP (BioWorks, Inc.), **Kaligreen** (OAT Agrio Co.), **Carb-O-Nator** (Certis USA)	potassium bicarbonate	NC	**Yes**	Powdery Mildew and others	Many vegetables including cabbage, cucumber, eggplant, broccoli, cauliflower, lettuce, peppers, tomatoes, and squash	Works by contact. Potassium bicarbonate disrupts the potassium ion balance in the fungus cell, causing the cell walls to collapse.
M-Pede (Gowan Company)	potassium salts of fatty acids	NC	**Yes**	Powdery Mildew	Cucurbits, fruiting, leafy, root and tuber vegetables and others	Contact fungicide. See label for details.
Oxidate 2.0, Oxidate 5.0 (Bio-Safe Systems LLC)	hydrogen dioxide, peroxyacetic acid	NC	**Yes**	*Anthracnose*, Downy Mildew, Powdery Mildew, *Pythium* Root Rot, and other diseases	Many vegetables including cole crops, cucurbit, leafy vegetables, peppers, and tomatoes	Strong oxidizing agent. Contact, oxidizing sanitizer.
Surround WP (Tessenderlo Kerley, Inc.)	kaolin	NC	**Yes**	Powdery Mildew	Cucurbit and other vegetables	Product forms a white clay film on leaves and fruit. Reduces sunburn and heat stress.
Ultra-Pure Oil (BASF Corp)	mineral oil	NC	**No**	Powdery Mildew, insect pests (see label)	Cucurbits, melons, squash, tomatoes, oriental vegetables, and others	Application should be made when disease is first noticed. See label for information on plant safety. Use lower label rates in the greenhouse.
3336 WP (Cleary Chemicals, LLC)	thiophanate-methyl	1	**No**	*Anthracnose*, Gray Mold, *Sclerotinia*, Gummy Stem Blight, Powdery Mildew, and others	Dry and succulent beans, and cucurbits for transplant.	Caution: Some populations of the pathogens that cause gummy stem blight, grey mold and powdery mildew, are resistant to thiophanate-methyl.
Procure 480SC (UPL NA Inc)	triflumizole	3	**No**	Powdery Mildew, *Alternaria* Leaf Spot	Butterhead lettuce only	See label for specific instructions.
Terraguard (Arysta Lifescience North America, LLC)	triflumizole	3	**No**	Powdery Mildew	Greenhouse tomato and cucumber production, including transplants	See label for specific instructions.
Fontelis (Corteva Agriscience US)	penthiopyrad	7	**No**	Many diseases, including Gummy Stem Blight, *Sclerotinia* Stem Rot, Leaf Spots, Powdery Mildew and *Anthracnose*	Tomatoes, eggplant, peppers, and edible peel cucurbits	See label for specific usage instructions.

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued next page

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued

Fungicide	Active Ingredient(s)	FRAC Code	OMRI Listed	Target Diseases/Pathogens	Labeled Crops	Comments
Scala SC (Bayer CropScience)	pyrimethanil	9	**No**	Early Blight and Gray Mold, *Botrytis*	Tomatoes and greenhouse grown cucumber	Use in well-ventilated houses only and ventilate two hours after application.
Heritage, Quadris, A-frame, Dynasty, Satori and others	azoxystrobin	11	**No**	*Rhizoctonia*, Leaf Spots and others	Brassica, cucurbit, fruiting vegetables and others	Vegetable and herb plants grown for transplanting
Reason (Bayer/Gowan)	fenamidone	11	**No**	Basil Downy Mildew	Basil only	See label for specific instructions.
Emblem, Spirato GHN (Nufarm Americas, Inc.)	fludioxonil	12	**No**	*Alternaria* Leaf Blight, *Cercospora* Leaf Spot, Gummy Stem Blight, Powdery Mildew, Early Blight, Gray Mold, *Septoria* Leaf Spot, and *Sclerotinia* Rot	Brassica (cole) crops, cucurbits, tomatoes and other fruiting vegetables, leafy greens	Good coverage is essential for disease control. Use good resistance management practices (see label for crop use and rates.
Terraclor 400 (Amvac Chemical Corp.)	pentachloro-nitrobenzene (PCNB)	14	**No**	Root and Stem Rot, damping off (*Rhizoctonia solani*, *Pellicularia filamentosa*)	Vegetable bedding plants. Limited to container-grown broccoli, Brussels sprouts, cabbage, cauliflower, peppers, and tomatoes.	Apply as a soil drench in nursery and greenhouse to seedlings grown in containers prior to transplanting. See label for additional information.
Decree (Arysta LifeScience)	fenhexamid	17	**No**	*Botrytis*	Tomatoes, cucumber, pepper, lettuce, and eggplant	Protectant fungicide with some plant back restrictions. See label for details.
Affirm WDG (Nufarm Americas, Inc.)	polyoxin D zinc salt	19	**No**	Powdery Mildew, Leaf Spots, *Botrytis*	For cucurbits, fruiting vegetables, herbs, and strawberry transplant production only	NOT for field use or production of edible commodities
Ranman (FMC Corp.)	cyazofamid	21	**No**	*Pythium* damping-off, Basil Downy Mildew	Tomato greenhouse transplant production and basil	Drench transplant tray with fungicide at planting or up until one week before transplant. See label for additional details.
Segway O (OHP Inc.)	cyazofamid	21	**No**	Basil Downy Mildew, *Pythium,* damping-off, *Phytophthora capsica, Phytophthora* Blight	Greenhouse herbs, tomato, and pepper production	See label for specific instructions.
Agri-Mycin 50 (Nufarm Americas, Inc.)	streptomycin sulfate	25	**No**	Bacterial Leaf Spot, Bacterial Speck	Tomatoes and peppers grown for transplant only	Repeated applications can result in resistant bacteria. Do not apply through any irrigation system.
Previcur Flex (Bayer CropScience)	propamocarb hydrochloride	28	**No**	*Pythium* Root Rot and damping off	Tomatoes, leaf lettuce, cucurbits, and peppers	See label for specific instructions.
Micora (Syngenta Crop Protection, LLC)	mandipropamid	40	**No**	Downy Mildews, Blue Mold, Late Blight, and suppression of *Phytophthora* blight	Some vegetables and basil grown for transplant and retail sale to customers	Registered for closed greenhouses with permanent flooring on transplants for re-sale to consumers.
Revus (Syngenta Crop Protection)	mandipropamid	40	**No**	Late Blight only	Tomato production only	See label for rates, restrictions, and application timing.

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued next page

Table E-11. Selected Fungicides Labeled for Greenhouse Use - continued

Fungicide	Active Ingredient(s)	FRAC Code	OMRI Listed	Target Diseases/Pathogens	Labeled Crops	Comments
Inspire Super (Syngenta Crop Protection	difenoconazole + cyprodinil	3 + 9	**No**	*Alternaria* Leaf Spot, *Anthracnose*, *Cercospora* Leaf Spot, Gummy Stem Blight, Powdery Mildew	Cucumber production only	See label for rates and application timing.
Luna Tranquility (Bayer CropScience)	fluopyram + pyrimethanil	7 + 9	**No**	Early Blight, Gray Leaf Spot, Gray Mold, *Alternaria*, Powdery Mildew	Tomato and strawberry only	See label for rates, restrictions, and application timing.
Mural (Syngenta Crop Protection LLC)	benzovindiflupyr + azoxystrobin	7 + 11	**No**	Powdery Mildew, Leaf Mold, Leaf Spots and others.	Tomatoes, cucurbits	Vegetable plants for re-sale to consumers. Do not make more than two applications per crop.
Pageant Intrinsic (BASF Corp)	boscalid + pyraclostrobin	7 + 11	**No**	Gray Mold	Transplant and greenhouse-grown tomatoes, cucurbits, and leafy greens	Pageant Intrinsic is also labeled for greenhouse use on transplants grown for the home consumer market
Orondis Ultra (Syngenta Crop Protection LLC)	oxathiapiprolin + mandipropamid	49 + 40	**No**	Late Blight and Buckeye Rot	Tomato production only	See label for rates, restrictions, and application timing.