This is a section from the

2020/2021 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 2021, a **critical update** with important updates to the 2020/2021 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 Chosen Freeholders. 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 until pests become too large or too numerous, 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

Keep abreast of the pest situation and buildup in your fields. Frequent examinations (at least twice per week) help determine the proper timing of the next application. Do not apply controls simply because your neighbor does.

2. Integrated Pest Management (IPM)

Guidelines and information about current pest activity in vegetables are published 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, or subscribe online at: *http://plant-pest-advisory.rutgers.edu/*.

Pest control programs use prevention, biological, physical, cultural, and chemical methods in an integrated approach. Field scouts collect pest population data. **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 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 parasites and predators.

3. Resistance Management

Resistance to pesticides develops because pest organisms have genetic resistance to a pesticide and intensive use of that pesticide kills the susceptible individuals in a population, leaving only resistant ones 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.

<u>Weed Population Sampling Techniques</u>:

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.

<u>Disease Monitoring</u>:

a) Determining the crop growth stage: Disease control is primarily obtained by applying protective fungicides on a regular schedule. For many diseases, fungicide application must begin at a certain growth stage and be repeated every 7 to 10 days and according to label instructions. If environmental conditions are favorable for disease development, delaying a spray program will result in a lack of control if the disease has progressed too far. **b) Observing symptoms on plants:** For diseases that do not spread rapidly, fields should be scouted regularly. When the first disease symptoms are noticed, a fungicide should be applied and repeated every 7 to 10 days and according to label instructions. **c) Daily collection of weather conditions in the field:** Predictive systems are available for a few diseases. Temperature, rainfall, relative humidity, and duration of leaf wetness are monitored, and the timing of fungicide application is determined by applying a mathematical model.

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.

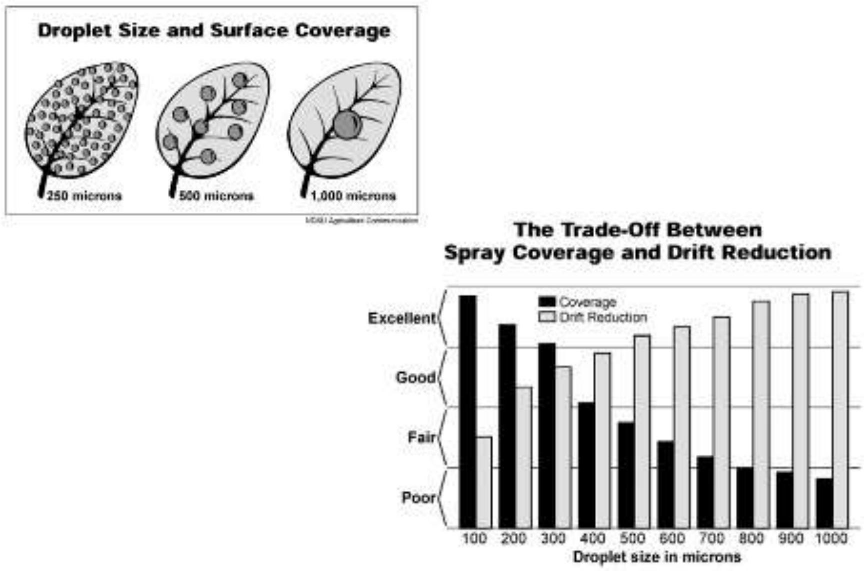
6. Pesticide Coverage of Plants

Non-systemic pesticides require more thorough spray droplet coverage than systemic pesticides which move through the plant's vascular system. A number of 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. The herbicide choice should be based on weed species or cropping systems; see Table E-2 for a listing of herbicide effectiveness on common weeds in vegetables.

For insects that are extremely difficult to control or for whom resistance is a risk, it is important to alternate labeled insecticides with different modes of action (MoA). In this guide, recommended insecticides are listed with their Insecticide Resistance Action Committee (IRAC) group number. Insecticides are placed in IRAC groups based on common MoA and alternating between insecticides in different IRAC groups is a way of insuring that different MoA are used on a specific pest. Be alert for a possible aphid or mite buildup following the application of certain insecticides such as synthetic pyrethroids (IRAC 3A). 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). Many fungicides control only certain diseases and provide no control of others.

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 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 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 nondispersible 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 make a decision 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.

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

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).

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-11. Selected Fungicides and Bactericides Labeled for Greenhouse Use - continued

Fungicide	Target Diseases	Labeled Crops	Comments
Propamocarb Hydrochloride (Previcur Flex, Bayer Crop Science) REI=12 h.	*Pythium* root rot and damping off	Tomatoes, leaf lettuce, cucurbits and peppers	See label for specific usage instructions.
Pyraclastrobin plus Boscalid (Pageant Intrinsic, BASF Corp) REI=12 h.	*Botrytis* grey 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
Pyrimethanil (Scala, Bayer Crop Science) REI=12 h.	Early blight and gray mold, Botrytis	Tomatoes and greenhouse grown cucumber	Use in well-ventilated houses only and ventilate two hours after application.
Reynoutria sachalinensis (Regalia, Marrone Bio Innovations) REI=4 h.	Many diseases including powdery mildew	Cucurbits, bulb vegetables, Fruiting vegetables and others	**OMRI listed[1].**
Streptomyces lydicus (Actinovate, Novozymes BioAg, Inc.) REI=1 h.	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	**OMRI listed[1]**. May be applied to soil or foliage through mist systems or sprayer.
Streptomycin Sulfate (Agri-mycin 17, Nufarm Americas, Inc.) REI=12 h.	Bacterial spot, bacterial speck	Tomatoes and peppers grown for transplant	Repeated applications can result in resistant bacteria. Do not apply through any irrigation system.
Sulfur (Microthiol Disperss, United Phosphorus, Inc.) REI=24 h.	Powdery mildew	Crucifers, cucurbits, peppers and tomatoes	**OMRI listed[1]**. Crops grown in greenhouses may be more sensitive to sulfur injury, so the lowest label rate should be tried initially. Do not use within two weeks of an oil spray treatment.
Thiophanate-methyl (3336 WP, Cleary Chemicals LLC) REI=12 h	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.
Trichoderma harzianum (PlantShield, Rootshield, Bioworks, Inc.) REI=4 h.	*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.
***Trichoderma virens* GL-21** (formerly known as Gliocladium virens) (SoilGard 12G, Certis USA LLC) REI=0 h.	Damping off and root rot, pathogens *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.

[1]The National Organic Program (NOP) maintains a list of products that are approved for use in organic production. In addition the Organic Materials Review Institute (**OMRI**) maintains a brand name list of products that approved for use. Some fungicides that are approved for use in organic production have been reviewed by the Environmental Protection Agency (EPA) for NOP compliance and will have a three-leaf logo and the words “for organic production” on the label.