

# Organic Vegetable IPM Guide

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Interest in nonchemical pest control has increased over the past several years. To some people, this means the same as “organic farming,” which implies nature’s way. But in this publication, we talk about controlling pests without chemicals, or at least fewer chemicals. This approach does have some limitations. Here are some of them:

1. The problem area needs more personal attention.
2. Nonchemical control is hard work, so it may be better for small areas. This depends on the available labor supply.
3. In some years, you may suffer more damage than you thought you would, including more loss of produce or plants.
4. There are some pests (insects, weeds, or pathogens) for which there is not an effective nonchemical control method available.

When planning a nonchemical control program, keep in mind that the very thing that helps producers/farmers grow a wide range of plants over a long time is also beneficial to insects, weeds, and pathogens: our climate. Mississippi’s climate ranges from semitropical on the Gulf Coast to temperate for the rest of the state. This gives the state a range of 200 to 250 growing days per year. These conditions, along with high humidity, are ideal for the development of a wide range of insects, weeds, and pathogens. For these reasons, be cautious about using information developed in northern states or in the hot, dry climate of the Southwest.

During the planning stages, be careful about information on nonchemical control in popular magazines and newspapers. Writers often report on only a few observations. For example, if a grower reports

having one tomato plant where he successfully used wood ashes to control aphids, question whether aphids would have been a problem without using ashes. Personal experiences are good, but respected tests in your farming area mean more.

Mississippi organic growers who wish to sell their produce with the word “organic” on it must be certified. Commercial growers who wish to be certified as organic should contact the Mississippi Department of Agriculture and Commerce at (601) 359-1100.

For more information on organic resources, see the MSU Extension Service Organic Fruit and Vegetable website at [http://msucares.com/crops/comhort/organic\\_veg\\_fruit.html](http://msucares.com/crops/comhort/organic_veg_fruit.html).

## Fertilizer for Organic Vegetable Production

Organic matter is important to soil structure and, therefore, to the health of a vegetable crop. Here are some advantages of organic matter in the soil:

- Physical condition of the soil is improved.
- It is a source of food for microorganisms, which help to release nutrients.
- Organic matter helps the soil hold minerals, so it reduces the effects of leaching.
- Bacteria growing on organic matter release complex carbohydrates, which help cement soil particles into aggregates.
- Acids released in the decomposition process help release nutrients used in plant growth.
- Water can enter and percolate through the soil better with organic matter present, reducing erosion.
- Root penetration is enhanced.



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- The water-holding capacity of sandy soils is improved.
- Aggregation in heavy soils improves drainage.

The organic matter content of soil varies over time, depending on the amounts added and environmental conditions. In southern latitudes, organic matter breaks down fairly quickly and needs to be added each year to replenish it.

One of the benefits of organic matter is the fertilizer value. While generally low-grade compared to chemical fertilizers, in adequate supply, organic fertilizers can provide enough nutrients for vegetable crops.

One big advantage of organic fertilizers is that nitrogen becomes available to plants gradually through the growing season. This “slow-release” effect is important, because nutrients become available on a continual basis, and the likelihood of fertilizer burn is reduced or eliminated.

**Table 1** shows the typical composition of some organic fertilizers. There is much variation among

samples of these materials, so use the numbers only as a guide. This is especially true of animal manures. Manure nutrient content will vary according to factors such as the feed used, percentage and type of litter or bedding, moisture content, age, and degree of decomposition. With the commercially prepared, bagged manure, some nitrogen content is lost in the drying process.

The main disadvantages of organic fertilizers are supply and cost. Some of the materials may be hard to find commercially. This limited supply often leads to high prices. One other disadvantage is bulk. Since most organic fertilizers are relatively low in nutrient values (e.g., manures tend to be 1 to 4 percent nitrogen), large amounts are needed to obtain enough fertilizer for the crop. While this works well for growers who maintain their own animals or live near farms, it can be challenging for others to find enough manure for their farms. If you have any question about which fertilizers are allowed under organic rules, go to the Organic Materials Review Institute (OMRI) website at <http://www.omri.org>.

**Table 1. Nutrient value of some organic fertilizer materials.**

Organic Material	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Bat guano	10.0	4.0	2.0
Blood, dried	13.0	2.0	1.0
Bone meal, raw	3.0	22.0	—
Bone meal, steamed	1.0	15.0	—
Castor bean meal (pomace)	5.5	2.0	1.0
Cocoa shell meal	2.5	1.0	2.5
Compost	1.5–3.5	0.5–1.0	1.0–2.0
Cottonseed meal	6.0	3.0	1.5
Fish meal (dry)	10.0	6.0	—
Fish scrap (dry)	3.5–12.0	1.0–12.0	0.08–1.6
Garbage tannage (dry)	2.5	2.0	1.0
Granite meal*	0	0	3.0–5.0
Greensand*	0	1.35	4.0–9.5
Kainite*	0	0	12.0
Kelp	0.9	0.5	4.0–13.0
Manure, dairy	0.6–2.1	0.7–1.1	2.4–3.6
Manure, duck	0.6	1.4	0.5
Manure, feedlot	1.0–2.5	0.9–1.6	2.4–3.6
Manure, horse	1.7–3.0	0.7–1.2	1.2–2.2
Manure, poultry	2.0–4.5	4.5–6.0	2.1–2.4
Manure, rabbit	2.4	1.4	0.6
Manure, sheep	3.0–4.0	1.2–1.6	3.0–4.0
Manure, swine	3.0–4.0	0.4–0.6	0.5–1.0
Peanut meal	7.0	1.5	1.2
Rock phosphate*	0	20.0–32.0	0
Sewage sludge	1.5	1.3	0.4
Sewage sludge, activated	6.0	3.0	0.2
Soybean meal	7.0	1.2	1.5
Tankage	7.0	10.0	1.5

\*These materials are natural mineral deposits, not organic materials, but they are commonly used as organic fertilizers.

## Organic Control Practices for Vegetable Diseases

Organic disease management protects plants from many vegetable diseases that commonly occur in Mississippi each season. Organic disease management is based on nonchemical sanitation; cultural, physical, and biological controls; and approved organic chemicals.

Used in an integrated program, these practices reduce populations of fungi, bacteria, nematodes, viruses, and other causes of vegetable diseases. A combination of practices is necessary, since no one practice works for all diseases that threaten a given crop. Some organic disease management practices should be carried out before the crop is planted and others later in the season.

### *Before-You-Plant Practices* Sanitation

**Destroy and bury crop debris.** Many disease microorganisms live through the winter in old plants, cull piles, or plant stubble left in the field. Destroying crop debris is an important sanitation step to reduce the amount of disease inoculum in the production site at the beginning of the season. If you eliminate overwintering sites of fungi, bacteria, viruses, and nematodes, you will reduce disease problems the next season.

As part of an early-season sanitation program, remove and destroy stalks (with root systems, when possible), stems, vines, and other debris as soon as possible after the last harvest. When root-knot nematodes are a problem, destroying old root systems removes thousands of nematodes and eggs from the field site. Do not add debris from diseased plants to compost piles, since temperatures don't always get high enough to kill nematode eggs and other plant-disease microbes.

Plow under remaining stubble and surface litter at least six inches before planting. This works because as debris decays, the disease microorganisms eventually deteriorate and reduce the amount of fungus and bacterial inoculum that could cause problems in future crops. Plowing to bury debris reduces Southern blight on tomatoes, peppers, and other susceptible vegetables.

**Disinfect plant-support structures.** Some disease-causing microorganisms survive during the off season on stakes, poles, cages, and other plant-support structures. To get rid of these, disinfect tomato stakes and cages by washing to remove soil, then dip or spray with a copper sulfate solution before using the stakes and cages again.

**Use disease-free seeds and transplants.** Clean seeds and transplants are a must in vegetable production. To avoid problems next season, do not save seeds from fields or areas where there are diseases. Examples of seed-borne diseases are anthracnose of

lima beans, mosaic virus of southern peas, bacterial blight of snap beans, black rot of cabbage, and leaf spots of turnip and mustard greens. Buy certified seeds that come from dry regions, such as the western United States, where diseases are less common.

If you produce your own transplants, follow strict guidelines to ensure quality planting material. Sow disease-free seed in a sterile growth medium. If you use growth flats that were used in transplant production, disinfect them with copper sulfate or put them in hot water (at least 180 °F) for 15 to 20 minutes. Buy a steam-sterilized growth medium, or sterilize by baking at 160 °F for one hour. Baking destroys most disease-causing microorganisms.

**Control weeds.** Some insects carry viruses from infected to healthy plants. Destroy perennial weeds (including milkweed, horse nettle, and pokeweed) in and around the field before planting, since these often act as overwintering hosts for harmful viruses. In spring, aphids, thrips, and other insects feed on weeds, pick up virus particles, and carry them to healthy plants.

### Cultural

**Choose a good site.** To reduce chances of damping-off, root rot, and other problems with wet soils, choose a well-drained site. If drainage is a problem, plant on raised beds to promote drainage and faster warming of soil. These conditions encourage faster seed germination and seedling emergence, and young plants are more resistant to seedling disease infection. Also, transplants are less susceptible to root disease problems when you grow them in raised beds.

**Soil test to determine fertility needs.** If you have the soil tested and then fertilize plants according to the test recommendations, the plants are not as likely to have disease problems as are plants that are low in nutrition or don't get a good balance of nutrients. Too much nitrogen is related to some foliage diseases and some seedling diseases of peas, beans, and other vegetables. We don't know how much each nutrient influences disease development, but we do think fertilizers are important in an organic disease management program. Fertilizers may not prevent diseases, but a healthy, well-fertilized plant is less susceptible to disease than one growing in soil lacking required nutrients.

**Soil test to determine presence of parasitic nematodes.** Collecting soil samples for nematode analysis should be a routine part of a vegetable production program. Collect at least 20 cores from six to eight inches deep per 5,000 square feet of production area in fall or winter. Mix this soil thoroughly, and place about one pint in a nematode soil sample bag or in a plastic freezer bag, and seal. Mark the sample number on the collection container, and complete the form that has to go with the samples to the testing lab.

You must properly care for the samples until you send them for analysis. Keep them in a cool place; exposure to temperatures over 100 °F, even for a short time, kills some nematodes. Take the samples to your county Extension office for mailing to the Nematode Laboratory, Box 9655, Mississippi State University. There is a fee for nematode analysis. Expect to receive sample results in about two weeks.

**Rotate crops.** Since some pathogens affect one vegetable crop or group of vegetables but may not affect another, rotating fields to different crops is a good way to control several plant pathogens.

Several vegetables of the same family (such as squash, cucumbers, watermelons, and cantaloupes) may be affected by the same disease, so it is not good to grow plants of the same family in rotation. We suggest at least a three-year rotation for vegetable crops.

**Table 2** lists vegetables susceptible to similar diseases. You can use it as a basis for setting up a rotation program. For example, if you grew tomatoes or peppers this season, switch to vegetables in other groupings for three more years before returning to tomatoes or peppers. *Remember, rotation does not work against all pathogenic microorganisms.*

**Plant at recommended seeding rates.** Dense plantings stay wet longer because of reduced air circulation and poor sunlight. Also, it is more difficult to get good spray coverage.

### Physical

**Use plastic and organic mulch layers.** Plastic mulch is a widely used ground cover in vegetable production. It serves as a barrier between soil and plant

surfaces and reduces the amount of disease inoculum splashed onto foliage, stems, and fruits during rainy periods. The amount of cucumber belly rot and buck-eye rot of tomato may be reduced this way. You can also use organic mulches, such as pine needles, oat straw, bark, composted sawdust, and similar materials, as physical barriers.

Light-reflective mulch materials control several important virus diseases of vegetable crops. Watermelon mosaic virus causes a serious disease in squash. It causes yellow squash to turn green or develop green streaks and also reduces yield. A 30-inch-wide silver-colored mulch (aluminum foil also works) can help control this virus. Light reflected from the mulch surface repels aphids that transmit the virus, reducing the number of virus-infected squash plants. This same control strategy reduces tomato spotted wilt virus-infected tomato and pepper plants. Thrips, which transmit the spotted wilt virus, are also repelled by reflective mulches.

**Consider staking, caging, and trellising.** One of the main reasons for supporting tomatoes and other vegetables by staking, caging, or trellising is to keep plants and fruit off the ground. This reduces losses from fruit rots when fruit touch the ground and from sunburn when fruit are not shaded by foliage.

**Use stem wraps for southern blight control.** You can wrap aluminum foil around the base of the stem of tomato and pepper plants to control southern blight. The stem should be wrapped two inches above the soil line and two inches below the soil surface. The aluminum foil provides a physical barrier to the southern blight fungus.

**Table 2. Grouping of vegetables based on susceptibility to similar diseases.**

Group A	Group B	Group C	Group D	Group E	Group F	Group G
Watermelon	Cabbage	Peppers (all types)	Beets	Beans (all types)	Onions	Sweet corn
Cucumbers	Cauliflower	Tomatoes	Swiss chard	English peas	Shallots	
Squash	Broccoli	Eggplant	Spinach	Snow peas	Garlic	
Cantaloupes	Brussels sprouts	Irish potatoes		Southern peas	Leeks	
Pumpkins	Mustard					
Gourds	Turnips					
	Collards					
	Kohlrabi					

**Try solarization.** This is an excellent nonchemical way to reduce damaging populations of root-knot nematodes. Solarization also controls many soil-borne fungus pathogens, as well as many damaging insects and weeds. The process is most effective for reducing nematode populations in the top eight to ten inches of soil.

Solarization traps the sun's energy in the soil by covering the soil surface with polyethylene tarps. Several procedures must be followed closely to ensure the soil temperature is high enough to control nematodes.

First, the soil should be moist and well tilled before you put down the tarp. Also, you should try solarization during late spring months or, ideally, at the hottest time of the year when the sun is brightest. Normally, four to six weeks is enough time for solarization. Six weeks is the preferred period if you use the technique in the late spring.

Selecting a plastic or polyethylene cover is probably the most important step in the process. The cover must be clear, no more than two millimeters thick, and strong and durable enough to stretch.

Placement of the cover is also important. Stretch it tight and make sure it is in direct contact with the soil surface. Carefully bury the edges of the tarp in the soil at least six inches deep so the wind won't lift the tarp during the solarization period. The tarp should stay in place for four to six weeks. When removing the tarp, be careful not to contaminate the treated area with untreated soil. Remember this at planting, too. You get best results when you prepare beds for planting before solarization and plant immediately after removing the tarp.

### **Biological**

**Take advantage of resistant varieties.** Make every effort to buy disease-resistant or disease-tolerant varieties. Consult lists of recommended varieties, seed catalog variety descriptions, and other sources of information. Unfortunately, resistant or tolerant varieties are not available for many vegetable diseases.

**Use marigolds for nematode control.** Marigolds give off a substance from their roots that is toxic to nematodes, making this plant valuable in nematode control when you plant the marigolds in solid beds. For best results, use one or more of the French marigold varieties (such as Tangerine or Petite Harmony). Space plants 7 inches apart in 7-inch rows.

**Clandosan can control nematodes.** Clandosan 618 has been shown to reduce the number of nematodes over the course of two cropping seasons. But control is sporadic and requires lots of this expensive product.

### **After-Planting Practices**

#### **Sanitation**

**Remove diseased plants or plant parts.** Examine plants at least twice per week for symptoms of disease. Look for leaf spots, wilts, stunting, fruit rots, misshapen leaves, cankers, and stem blights. If you detect only a small amount of disease, removing infected foliage or fruit helps reduce inoculum that may be spread to disease-free foliage and fruit on the same or nearby plants. Remove and destroy badly diseased plants, including the roots, since later treatment of such plants isn't effective. In some cases, you may have to remove surrounding soil. For example, you should remove three or four inches of soil with plants affected by southern blight to ensure removal of the seed-like sclerotia associated with this disease. Do not place diseased plants and plant parts in cull piles. Whenever possible, place this material in landfills or bury it away from production sites.

**Do not use tobacco.** Tobacco products carry tobacco mosaic virus. The virus is easily transmitted to susceptible tomato and pepper varieties. Avoid using tobacco while working with these crops. Workers should wash their hands thoroughly in soap and water after handling tobacco and before working with tobacco mosaic-susceptible plants. Workers may also disinfect hands by dipping them in a dilute solution of skim milk.

**Clean equipment.** Washing the soil off farm equipment before moving it from one field to another may prevent carrying pathogens that are in the soil.

**Cultivate and spray crops when plants are dry.** Delay cultivation and taking spray equipment through the crop until rain or dew has dried on plant surfaces. This reduces the chances of moving bacteria and fungi from diseased to healthy plants.

**Avoid "dirtying" plants during cultivation.** Piling soil around the base of plants creates an environment that favors stem rots and fungus growth. Also, rain may splash bacterial inoculum onto plants.

## Organically Approved Chemicals

The Organic Materials Review Institute (OMRI) is a national non-profit organization that determines which products are suitable for use in organic production. OMRI lists approved products that can be used in USDA certified organic farming systems. Most research has been conducted on sulfur and copper products, and their usage is described in more detail below. **Table 3** provides a partial list of some of the OMRI-approved fungicides on the market and what diseases they prevent.

Alternatives to synthetic products to control vegetable diseases include using fungicides that contain sulfur and copper. Spraying or dusting with sulfur is an old remedy that still works on rusts, powdery mildews, and leaf spots on tomato and other vegetable crops. Mix finely ground sulfur with water at the rate of three ounces per three gallons of water, or dust an even coat over plant surfaces. Rain easily removes sulfur from plants, so you may have to make frequent applications to get adequate disease protection. To avoid plant injury, do not use when temperature is 90 °F or above.

**Make a Bordeaux mixture.** This fungicide can be “homemade” and works on a number of common fungus and bacterial blights and leaf spots on vegetable crops. Combine hydrated lime or any type of finely ground lime with powdered copper sulfate (sometimes referred to as “bluestone”). Both materials should be available at farm and garden supply stores, but you may have to do some checking around.

You can make Bordeaux mixture in several strengths, but the most popular and effective for general field and orchard use is the 4-4-50 formulation. The numbers are the ratio of copper sulfate and lime

in 50 gallons of water. For example, four pounds each of these materials would be combined in 50 gallons of water.

Since this amount is much more than most growers need, the ratio can be reduced to a more useable amount. To prepare a gallon of a 4-4-50 Bordeaux mixture spray, measure out two tablespoons of copper sulfate and three tablespoons of hydrated lime. Mix the lime with a pint of water to make a “milk of lime” suspension. Dissolve the copper sulfate in a pint of water. This may take several minutes. Strain each container of these materials through a cheesecloth filter. This is very important. If cheesecloth isn’t available, use cloth of a similar loose weave. The filtering is necessary to remove small pieces of lime or copper sulfate that won’t dissolve; otherwise, you’ll find these tiny pieces in the end of your garden sprayer tip, clogging up the works! To make the filter, place the cheesecloth loosely over the top of another container and fix securely in place with a string or rubber band.

Add the filtered copper sulfate solution to a one-gallon container. Then add the filtered lime solution. Add enough water (about three quarts) to the container to bring the total volume up to one gallon. You now have one gallon of Bordeaux mixture ready to use. For two gallons, simply double the proportion of materials and prepare as before.

For best results, use your Bordeaux mixture the same day you make it, and keep the sprayer agitated. Don’t add insecticides to the Bordeaux mixture without first checking the insecticide label for possible compatibility problems.

Bordeaux mixture may be used to control early and late blight on tomatoes and Irish potatoes. On leafy greens, this fungicide controls most of the leaf spots that commonly occur on mustard and turnips.

**Table 3. OMRI-approved fungicides\* for vegetables.**

<b>Trade Name</b>	<b>Active Ingredient</b>	<b>Diseases Controlled</b>	<b>Labeled Crops</b>
AgriPhage	Bacteriophage	Bacterial diseases	Tomato, pepper
Root Shield	<i>Trichoderma harzianum</i>	Soil-borne plant diseases	Eggplant, pepper, tomato, leafy vegetables, and cole crops, including greenhouse use
Mycostop	<i>Streptomyces griseoviridis</i>	Seed, root, and stem rots	Any vegetable, including greenhouse use
Serenade	<i>Bacillus subtilis</i>	Bacterial diseases, powdery mildew, gray mold, early blight, fire blight	Any vegetable, including greenhouse use
Contans WG	<i>Coniothyrium minitans</i>	Sclerotinia diseases	Green bean and lima bean, including greenhouse use
Actinovate SP	<i>Streptomyces lydicus</i>	Soil-borne diseases, powdery mildew, Alternaria, and gray mold	Any vegetable, including greenhouse use
SoilGard 12 G	<i>Gliocladium virens</i>	Pythium and Rhizoctonia root diseases	Any vegetable, including greenhouse use
Oxidate	Hydrogen dioxide	Many root and foliar fungal diseases	Any vegetable, including greenhouse use
Trilogy	Neem oil	Foliar fungal diseases	Any vegetable, including greenhouse use

\*This is a partial list of OMRI-approved fungicides that have been the most researched. There are many more products on the market than are presented in this list. Read and follow all label instructions for your crop.

**Table 4. Vegetables and their resistance or tolerance to one or more important diseases and nematode pests.**

<b>Vegetable and Variety</b>	<b>Disease or Nematode</b>
Beans, bush snap Atlantic Derby Gator Green Topcrop	Common bean mosaic virus Common bean mosaic virus Common bean mosaic virus Common bean mosaic virus
Beans, pole snap Alabama No. 1	Root-knot nematode
Beans, bush lima Nemagreen	Root-knot nematodes
Corn, sweet Guardian Merit	Common smut Common smut
Cucumber, pickling type Calypso Carolina Green Spear 14	Tolerant to angular leaf spot, one or more races of cucumber mosaic virus, downy mildew, powdery mildew, and anthracnose; resistant to scab
Cucumber, slicing type Poinsett 76  Sweet Slice	Tolerant to one or more races of downy mildew, powdery mildew, angular leaf spot, and anthracnose; resistant to scab Tolerant to powdery mildew, cucumber mosaic virus, water melon mosaic virus - strain 2, and zucchini yellow mosaic virus
Pepper, sweet Emerald Giant Jupiter Keystone Resistant Giant	Tolerant to tobacco mosaic virus Tolerant to tobacco mosaic virus Resistant to tobacco mosaic virus
Southern pea Magnolia (blackeye) Mississippi Pinkeye (pinkeye) Mississippi Purple (brown crowder) Mississippi Silver (brown crowder) Pinkeye Purple Hull - BVR (pinkeye)	Tolerant to blackeye cowpea mosaic virus and related viruses; resistant to root-knot nematodes and Fusarium wilt Tolerant to blackeye cowpea mosaic virus and related viruses
Squash, summer yellow mosaic virus	Tolerant to watermelon mosaic virus - strain 2 and zucchini
Sweetpotato Beauregard	Tolerant to soil rot; susceptible to root-knot nematodes
Tomato, indeterminate (long season) Better Boy VFN hybrid  Park's Whopper VFNT hybrid Super Fantastic VF hybrid	Resistant to Verticillium and Fusarium wilts and root-knot nematode Same as Better Boy but also resistant to tobacco mosaic virus
Tomato, determinate (short season) Celebrity VFNT hybrid Cherry Grande VF hybrid Floramerica VF hybrid Mountain Pride VF hybrid Mountain Spring VF hybrid Sunny VF hybrid Super Fantastic VF hybrid President VFNT	Same as Park's Whopper Resistant to Verticillium and Fusarium wilts Resistant to Verticillium and Fusarium wilts Resistant to Verticillium and Fusarium wilts Resistant to Verticillium and Fusarium wilts Resistant to Verticillium and Fusarium wilts Resistant to Verticillium and Fusarium wilts Resistant to Verticillium and Fusarium wilts Resistant to Verticillium and Fusarium wilts, root-knot nematode, and tobacco mosaic virus



## Organic Insect Control for Commercial Vegetable Production

Controlling insect pests on commercial vegetables organically is difficult, especially in the South, but it is not impossible. The key to success is to choose your crops and planting times wisely and rely more on non-insecticidal management methods than on insecticide sprays. There are only a few organic insecticides available for use in commercial vegetables, and organic insecticides are generally less effective than their nonorganic counterparts. If you rely on organic insecticides as your primary means of insect control, you will spend a lot of time and money spraying and may still have disappointing results.

Following are some of the more important non-insecticidal management tools. These tools are available to both conventional and organic vegetable producers, but they are a lot more important for organic growers. It is much more difficult to “spray your way out of trouble” in organic production.

**Choose crops that have relatively few insect pests.** Sweet corn for fresh market is a lot easier to grow organically than tomatoes are. This does not mean you cannot grow tomatoes organically, but it does take more planning, management, effort, and luck. Sweet corn for commercial canning is a different situation altogether. Because of the extremely low tolerance for caterpillar contamination, it is probably not possible to grow organic sweet corn successfully in Mississippi for commercial canning, especially if transgenic seed is not an option.

**Grow crops at a time of year when the insect pests they do have are least abundant.** Usually, early-planted crops experience less insect pressure than late-planted crops, but this is not always the case. Most vegetable insect pests have several generations per year, with populations increasing each generation. By late summer and fall, populations of pests like stink bugs, whiteflies, and tomato fruitworms can be extremely high. If you have large acreages of agricultural crops growing nearby that generate large numbers of pests, such as stink bugs, loopers, armyworms, or tomato fruitworms, time planting of susceptible vegetable crops so that they will be harvested before the agricultural crops mature and insects begin leaving the fields in search of other hosts. There are some situations where it is helpful to delay planting until overwintered pests have left their overwintering sites and moved to other crops. This is true for bean leaf beetles on beans and peas and for cucumber beetles on melons and squash.

**When possible, choose varieties that are resistant to key pests.** Sometimes choosing a variety that is resistant to a particular disease can aid in insect management, as well. For example, thrips control is less important on tomatoes resistant to tomato spotted wilt

virus than on nonresistant varieties. Of course, there are no resistant varieties for many pests, and varieties that are resistant don't always have other traits needed to produce a marketable, profitable crop. Consider the big picture when choosing varieties. See **Table 4** for a partial listing of vegetable varieties with insect tolerance or resistance.

**Practice crop rotation.** Repeatedly growing the same crop in the same field can result in increased insect pressure. Cowpea curculios on southern peas is a good example. This pest overwinters as an adult in crop residue and nearby ground litter and rarely flies. Rotating the pea patch to a different location each year can help manage this important pest. Likewise, rotating the location of the turnip patch can help reduce numbers of vegetable weevils. Crop rotation is also important in controlling many diseases.

**Avoid growing successive plantings of the same crop near each other, especially if the crop is attacked by serious insect pests that have multiple generations per year.** For example, if you grow three successive plantings of organic peas in close proximity, each planted two or three weeks apart, there will probably be a lot of stink bugs in that last planting!

**Think about where you plant a crop in relation to other crops, including crops on neighboring farms.** If you are trying to produce organic tomatoes in late summer or early fall, locate them as far as possible from crops such as corn, sorghum, soybeans, or peas that generate large numbers of stink bugs and tomato fruitworms. A tomato patch surrounded by timber will probably have less stink bug and tomato fruitworm pressure than a patch near annual row crops.

**Destroy old crop residue as soon as possible after the final harvest.** This is an extremely important insect management tool! It destroys large numbers of immature insect pests before they have a chance to become adults and move to nearby crops, destroys adult insects before they have a chance to lay eggs or enter overwintering sites, removes the crop as a breeding site for future generations of pests, and destroys overwintering pests. Prompt crop destruction also helps control disease and weeds.

**Know when to quit on a crop.** Because pest populations usually increase as a crop ages, fruit produced earlier in a crop's growth cycle are more likely to be blemish-free and pest-free than fruit produced later. Depending on the overall situation, it may be worth growing a crop just to get those few early weeks of production and then stopping when insect pressure increases. Then, remember to destroy old crop residue promptly!

**Plant into weed-free fields and maintain good weed control.** Mechanical tillage is the main method of weed control in organic production. It also helps control insect pests such as cutworms, false chinch

bugs, vegetable weevils, spider mites, slugs, and crickets that often begin developing on weeds growing in the field before planting and then move to seedling vegetables. Avoid these early insect problems by planting into a weed-free field. For cutworm control, till the field to destroy all weeds and cover crops at least three weeks before planting. Thorough tilling helps control insect pests that overwinter in the soil or under crop debris. It also helps reduce the number of in-field fire ant mounds.

**Know which pests are likely to occur on the crops you are growing and understand the biology of these pests.** Often you can use your knowledge of a pest's biology to help manage that pest. Know how to identify insect pests and be able to distinguish between insects that are pests and those that are not. See Extension Publication 2347 *Insect Pests of the Home Vegetable Garden* for information on identification and biology of common vegetable pests.

**Use trap crops when feasible.** Trap crops are crops planted to attract pests away from the main crop. Around cabbage, border plantings of collards can trap diamondback moths. Trap crops can also work for stink bugs, leaffooted bugs, and bean leaf beetles. Plant some southern peas near your tomato patch, and most of the stink bugs will go to the peas. Similarly, sunflowers can be used as a trap crop for leaffooted bugs.

But there is an important pitfall to using trap crops: you have to be able to kill the pests that are attracted to the trap crop before they move to the main crop. Otherwise, you have a nursery crop! The problem is there are no really effective organic insecticides to control stink bugs and leaffooted bugs. You will have to use conventional insecticides like Baythroid, ProAxis, or Mustang Max. Depending on the organic production goals for your particular farm, this may or may not present a problem. Potentially, you could use a trap crop of southern peas to help keep stink bug numbers down in your organic tomato patch, spray the peas with an effective nonorganic stink bug treatment, and sell organic tomatoes and conventionally grown peas. But this will not work if your organic certification program does not allow any nonorganic products to be used on the farm.

**Use metalized reflective plastic mulches to reduce early season infestations of pests such as thrips, aphids, and whiteflies.** Research has shown that reflective mulches can greatly reduce the number of thrips and aphids attracted to seedling crops. The increased light reflection prevents the insects from recognizing and landing on seedling plants. This is especially helpful in reducing incidence of serious insect-vector diseases, such as tomato spotted wilt virus. In fact, some studies have shown reflective mulches to be more effective than weekly insecticide sprays for reducing TSWV incidence in tomatoes or

peppers. Reflective mulches do not provide the same degree of early season soil warming as black mulches do, but they do help cool the soil on later crops.

**Use physical exclusion methods when feasible.** Physical exclusion methods are not available for most crops, but there are some specific situations where they may be useful. One is in the production of seedling transplants. Transplants grown in a "bug-tight" greenhouse, in isolation from other plants, are more likely to be free of insects and insect-vector diseases. Home gardeners sometimes protect newly set transplants from cutworms with "cutworm collars." Cutworm collars are made of wax paper or aluminum foil and extend from about one inch below the soil line to two to three inches above. This is usually too labor-intensive for commercial production but may still be worthwhile if you have to plant into fields where weeds were destroyed fewer than three weeks before planting.

Some growers use floating or hoop-supported spun-bond fabric row covers for early frost protection and to help protect against early-season pests such as cucumber beetles on melons or squash. Row covers are costly and labor-intensive to install, but they are an effective way to protect many vegetable crops from early pest infestations. Agribon Row Covers and Dewitts Row Covers are examples of floating row covers available in commercial quantities.

**Rely on naturally occurring biological control.** This is our most important means of controlling insect pests, and it is much more important to organic growers than to conventional growers. Pest insect populations are normally kept in check by naturally occurring populations of the three Ps: predators, parasites, and pathogens. For any given insect pest, there are usually many different species of predators that feed on that pest; several species of parasitic wasps or flies that attack it; and fungi, bacteria, and viruses that cause fatal diseases. Collectively, these naturally occurring beneficial organisms are our most important defense against pest insects. Without this free natural control, the pests would definitely have the advantage.

Still, it is normal for there to be more pests than predators and parasites—there are usually more rabbits than foxes. When severe pest outbreaks occur, it is usually because the pest population has gotten ahead of the beneficials. The beneficials will usually eventually catch up and bring the pest population under control, but this does not always happen in time to prevent excessive damage.

What can you do to take advantage of this free natural insect control? The main thing is to try to avoid messing it up! Insecticide applications kill more than just the target pests; they also kill beneficial insect predators and parasites. This can trigger outbreaks of other pests, or allow the population of the target pest to rebound to even higher levels. Don't spray unless

you are sure you really need to spray. On the other hand, don't let concern over preserving beneficials prevent you from spraying when you really need to. When you do have to spray, try to choose an insecticide that works well on the target pest but has minimal impact on beneficial insects. Organic growers usually benefit much more from biological control than conventional growers do because organic insecticides tend to harm beneficial insect populations less.

Growing a diversity of plants, especially plants with large numbers of blooms, can also promote beneficial insects. Many adult predators and parasites rely on nectar from blooming plants as food. Some organic producers maintain "nursery strips," planted with a variety of plants that bloom at various times, to provide habitat and nectar sources for beneficial insects. Just be sure to avoid using plants that are a host to a major pest of one of the crops you are growing.

What about buying and releasing beneficial insects into your crop? Artificial releases of laboratory-reared parasites and predators can work quite well in enclosed greenhouse situations where the environment is carefully controlled, but such releases are usually less successful in annual outdoor crops. The released insects either fly away, die because they are not adapted to the environment, or fail to find suitable hosts because the timing is wrong. This does not mean that there are no situations where artificial releases of predators or parasites will work outdoors. There are special cases where such releases can be helpful. Success with artificial releases in outdoor annual crops requires knowing exactly which pests you are trying to control; which beneficial insects you need to release; when and how to make the releases; and where to purchase healthy, vigorous beneficial insects.

**Educate your market.** Organically produced vegetables usually cost more to produce and have more insect blemishes and infestations than conventionally produced vegetables. Consumers who purchase organic vegetables usually understand this, but it is still wise to be sure the customer understands what they are buying. Explanations such as the following can be helpful: "This is organic sweet corn. Most ears are probably going to have some caterpillar damage, or even live caterpillars, at the end of the ear." Or: "I can supply organic tomatoes, but they are more expensive to produce and they will probably have superficial insect damage on some fruit."

**Grow healthy, vigorous plants.** This is a goal of every farmer and gardener, but it also helps with insect control. Healthy plants are less susceptible to insect attack and better able to tolerate low to moderate insect infestations and still produce. For example, plants stressed by drought or potassium deficiency are more susceptible to spider mites. On the other hand, excessive nitrogen can make plants more susceptible to spider mites and aphids.

**Monitor pest populations.** Good scouting can help assess effectiveness of non-insecticide management tactics and better time insecticide treatments. Scout crops at least once or twice weekly by making a special trip through the crop specifically to check for insects and diseases. Know what pests are present and how abundant they are. Use a hand lens to check for small pests like thrips and spider mites. Use pheromone traps and other survey tools as appropriate for the particular pests you need to monitor. Yellow sticky traps can help monitor pests like thrips and whiteflies. Pheromone traps are available for moths of many caterpillar pests and a few other types of pests.

**Use mating disruption when available and appropriate.** The goal of mating disruption is to confuse male moths and reduce their ability to find mates by flooding the field with synthetic pheromone. As a result, many of the female moths lay unfertilized eggs. Mating disruption pheromones are species specific and are available for only a few vegetable insect pests. CheckMate TPW and CheckMate DBM are commercially available products that work against tomato pinworm and diamondback moth, respectively. Note that while the TPW lure is OMRI-approved, the DBM lure is not.

**Use mechanical controls where feasible.** Some organic growers use specially designed vacuums or blowers to remove insects from plants. A forceful spray of water can be used to dislodge pests such as aphids. Though too labor-intensive for large-scale use, hand-picking insects and egg masses can help delay pest population buildup on small plantings.

**Use organic insecticides when necessary.** Sometimes you have to use insecticides to avoid excessive crop damage. Scout regularly and begin treating before pests reach damaging levels. Choose approved organic insecticides that are effective against the pest or pests you are trying to control. Use rates that are adequate but not excessive. Apply sprays in a manner that achieves thorough coverage, especially to undersides of leaves. Target treatments against the most susceptible pest stage. For example, when treating caterpillar pests, target small, newly hatched caterpillars. Retreat at appropriate intervals when necessary to obtain or maintain control. Comply with the preharvest interval for the specific insecticide and crop.

Be aware of the limitations of organic insecticides. Organic insecticides vary greatly in relative efficacy against various pests. Spinosad and Bts are effective against most caterpillar pests if they are applied when caterpillars are small, but they don't work at all on stink bugs and most beetles. If good spray coverage is achieved, products like azadirachtin, botanical and horticultural oils, and insecticidal soaps can be effective against aphids and whiteflies. There are no highly effective organic insecticides for most beetles and stink

bugs, but products like pyrethrins and rotenone + pyrethrins can provide limited, short-term control.

**Use integrated pest management.** Don't rely on a single control tactic to control any pest. The more different methods you use, the greater your chances for success. Consider all pests likely to occur in your crop, including insects, diseases, and weeds, and develop a pest management plan that addresses all of these.

**Keep records, keep learning, and use what you learn in the next crop.** Every farm situation is different. By keeping records, you can learn which pests are particular problems on your farm and at what time of year they are most abundant. You can also learn which pests are least likely to cause problems and what management tactics work best for you.

**Table 5. Vegetable varieties with tolerance or resistance to specific insect pests.**

Vegetable	Variety	Insect Tolerance
Broccoli	De Cicco	Striped flea beetle
Cabbage	Early Globe Red Acre Round Dutch	Cabbage looper, imported cabbageworm Cabbage looper, imported cabbageworm Cabbage looper, imported cabbageworm
Chinese cabbage	Michihli	Diamondback moth
Collard	Georgia	Striped flea beetle, Harlequin bug
Corn	Merit Golden Security {Transgenic Bt varieties} <sup>1</sup>	Corn earworm (good shuck extension) Corn earworm European corn borer, corn earworm
Cucumber	Poinsett Ashley	Spotted cucumber beetle Pickleworm, spotted cucumber beetle
Kale	Yates	Diamondback moth
Mustard	Florida Broadleaf	Diamondback moth, striped flea beetle
Radish	Cherry Belle White Icicle	Diamondback moth, Harlequin bug Harlequin bug
Rutabaga	American Purple Top	Diamondback moth, striped flea beetle
Squash	Early Prolific (SN) Straight Neck White Bush Scallop Zucchini	Pickleworm, striped cucumber beetle Pickleworm, striped cucumber beetle Pickleworm, striped cucumber beetle Striped cucumber beetle, squash vine borer <sup>2</sup>
Sweetpotato	Centennial Jewel Beauregard	Sweetpotato flea beetle, southern potato wireworm Sweetpotato flea beetle, southern potato wireworm Soil insects (except susceptible to flea beetles)
Tomato	TSWV-resistant varieties <sup>3</sup>	TSWV is vectored by thrips. Thrips control is less important on TSWV-resistant varieties.
Turnip	Seven	Diamondback moth, striped flea beetle
Watermelon	Crimson Sweet	Pickleworm, spotted cucumber beetle

<sup>1</sup> Transgenic Bt sweet corn varieties are not approved for certified organic production. Because of their cost and the licensing and resistance management practices required for their use, they are only suitable for large-scale commercial production. Use transgenic Bt varieties only if you are sure they are acceptable for your particular market. These varieties provide excellent control of European corn borers, good control of corn earworms, and suppression of fall armyworms.

<sup>2</sup> A general rule for squash and pumpkin varieties and their susceptibility to squash vine borers is that *Cucurbita moschata* and *C. mixta* species are more susceptible than *C. pepos species*, and *C. maxima* species are less susceptible than *C. pepos*. Within the *C. pepos*, zucchinis tend to be less susceptible than yellow summer squash.

<sup>3</sup> Tomato varieties resistant to tomato spotted wilt virus (TSWV) include Amelia VR, Bella Rose, BHN 640, BHN 602, Quincy, Taladega, Crista, Muriel (roma), BHN 685 (roma), and Picus (roma).

## **Organic Insecticides for Commercial Vegetable Production**

Following is a listing and brief review of many of the insecticides currently approved for organic vegetable production. Note that some of these active ingredients are also sold as formulations that are not approved for organic production. For example, Spintor is a liquid formulation of spinosad that is widely used in commercial vegetable production, but Spintor contains inert ingredients that are not organic. Entrust also contains spinosad, but Entrust is a wettable powder formulation that is specially formulated for organic production.

Also note some of these products are extremely target specific. Spod-X is only active against beet armyworms! Other products, such as Pyganic, have activity against a wide range of insect pests, but only provide very short-term control and are generally much less effective than conventional inorganic insecticides. Consequently, sprays may need to be applied more frequently than with conventional insecticides. Because most organic insect control products only work by direct contact, good spray coverage is especially important when using organic insecticides. Neemix and Aza-Direct are effective against whiteflies. Vegetable oils, such as Vegol, and soaps, such as M-pede, will control spider mites, aphids, and other soft-bodied insects. All these products work only on pests they contact.

Always read the product label at least twice, once before you buy it and again just before you use it. Be sure the product is suitable for your organic production goals. Follow label directions.

**Spinosad:** Spinosad is a biopesticide that is very effective against thrips, leaf miners, and most caterpillar pests. It is produced through commercial culture of a soil-borne microbe that makes the toxic metabolites known as spinosad. These metabolites are harvested and formulated into insecticide, so the final product contains no living microbes. Spinosad is organic, but most formulations contain inorganic inert ingredients that disqualify them as “organic insecticides.” Some products are formulated to comply with organic guidelines. Entrust is an organic formulation of spinosad formulated for commercial use. Justice and Greenlight Fire Ant Bait with Conserve are granular baits containing spinosad that are approved for fire ant control in organic crops.

**Bts:** “Bt” stands for *Bacillus thuringiensis*. Bts are naturally occurring soil bacteria that produce toxins that have insecticidal activity. There are many different strains of Bts. Some only control caterpillar pests (*Bt kurstaki* and *Bt aizawai*), while others only work on mosquito larvae (*Bt israelensis*) or beetles (*Bt tenebrionis*). Bts are generally slow-acting and have to be eaten by the caterpillar in order to work, but they are useful

organic insecticides when used properly. Javelin, Dipel, Delfin, Deliver, Biobit, and Agree are examples of Bt products used in commercial organic vegetable production. Because of their relatively slow activity, Bts are best used when caterpillars are small.

**Transgenic Bt Crops:** Some varieties of sweet corn have been biologically engineered to produce toxins found in some of the *Bacillus thuringiensis* bacteria used to control caterpillar pests. These transgenic crops inherently provide high levels of control of caterpillar pests such as corn earworms and European corn borers. Be aware, however, that these transgenic crops are not approved for certified organic production. Use transgenic varieties only if you are sure they are suitable for your market.

**Azadirachtin:** Azadirachtin is a natural insect-growth disruptor derived from the seed of the neem tree. It is especially effective against sucking insect pests, such as whiteflies and aphids. Because it is a growth disruptor, it is slow-acting and must be applied when low populations of immature pests are present. Neemix, Aza-Direct, and Azatrol are examples of azadirachtin products labeled for commercial organic vegetable production. Azadirachtin is one of the better options for organic control of whiteflies.

**Neem Oil:** Neem oil, obtained from the seed of the neem tree, controls soft-bodied insects such as aphids, whiteflies, and mites. It also helps control certain fungal diseases. Products containing “clarified hydrophobic extract of neem” do not contain azadirachtin; they usually contain 70 percent neem oil. Trilogy 70 percent neem oil is marketed for commercial organic vegetable production, and Monterey 70 percent neem oil is sold for small-scale production.

**Beauveria bassiana:** *Beauveria bassiana* is a fungal disease that infects certain insect pests, especially whiteflies, thrips, aphids, mealybugs, and certain beetles and caterpillars. It is marketed for organic crop production under the brand names Mycotrol-O, BotaniGard, and Naturalis L. These products are slow-acting, so begin treatments when pest populations are low. Do not tank-mix with fungicides.

**Viruses:** Virus diseases of insects attack only very specific species. A few insect viruses are formulated and sold commercially. Spod-X LC is a sprayable formulation containing polyhedra of a viral disease that attacks only beet armyworms. Gemstar LC is a similar product that controls only corn earworms/tomato fruitworms and tobacco budworms. Proper pest identification and spray timing are critical when using these products.

**Parasitic Nematodes:** Some nematodes attack only insects, and some of these species of nematodes are formulated and marketed for use in organic crop protection. There are several species, but most are *Heterorhabditis* or *Steinernema* species. Parasitic nematodes are usually used to control soil-dwelling pests

such as cutworms, squash vine borers, mole crickets, and white grubs. Do your homework before purchasing parasitic nematodes. Be sure that the species you purchase is active on the pest you need to control, and be sure you know how to handle and apply the nematodes properly.

**Pyrethrin:** Pyrethrin, also known as pyrethrum, is a natural extract from the flowers of the pyrethrum daisy. Pyrethrin is a broad-spectrum insecticide that affects most insect pests through contact activity. However, it is short-lived, and many pests may be “knocked down” but recover later. Inorganic synergists, such as pipronyl butoxide (PBO), are often mixed with pyrethrin to enhance activity. Although the addition of PBO greatly enhances short-term control, it does not greatly increase residual control. Pyrethrin products that contain the inorganic synergist PBO cannot be considered organic. Pyganic is an example of a totally organic formulation of pyrethrin. This product can be used to control a wide range of insect pests, but repeated treatments may be necessary because it only provides very short-term control.

**Rotenone + Pyrethrin:** Rotenone is an older botanical insecticide that is effective against aphids, stink bugs, beetles, and other pests, but it is difficult to find products that contain only rotenone. Pyrellin is a commercial insecticide that contains a combination of rotenone and pyrethrins. Pyrellin is labeled for use on commercial vegetables to control pests such as stink bugs, squash bugs, cucumber beetles, vegetable weevils, and others. Note that Pyrellin is not currently approved by OMRI (Organic Materials Review Institute).

**Plant Extract Products:** Several companies market, or are developing, products based on extracts from various plants for insect control. Quite a few companies market “garlic spray” products that have pest repellent properties. Garlic Barrier is one example. Be aware that such products may not be approved for certified organic production. Cinnamite is a commercial miticide based on extracts from cinnamon oil. It is not currently OMRI-approved and can be phytotoxic to tomatoes and certain other plants.

**Iron Phosphate:** Several companies make slug baits that contain iron phosphate and are approved for organic production. Sluggo is an example of an iron phosphate-based slug bait. This product is only useful to control snails and slugs.

**Horticultural Oils:** Petroleum-based horticultural oils are useful for control of soft-bodied pests such as aphids, spider mites, and whiteflies. However, most petroleum-based horticultural oils are not approved for organic production. Although the oils themselves are classified as organic, many of the secondary ingredients added as emulsifiers are inorganic. Only a few

companies formulate petroleum oils using organic emulsifiers. BVA Spray 10 and Organic JMS Stylet-Oil are two examples. Stylet oil is most often used to help prevent sucking insects like aphids from transmitting certain virus diseases. Stylet oil does not necessarily kill insects. Instead, it forms a fine coat on the leaf and cleans the virus particles off the insects’ mouthparts as they feed, preventing them from getting into the plant.

**Vegetable Oils and Fish Oils:** There are a number of organic oils made from various plant seed or fish extracts. These are effective against soft-bodied insects such as aphids, mites, and whiteflies. Golden Pest Spray Oil is an example of an oil derived from soybeans. Vegol Year-Round Spray Oil is derived from canola seed, and Organocide is a combination of fish oil and sesame oil. Such oils may or may not be approved for certified organic production. Some products contain a combination of vegetable oil and pyrethrins. Pyola, a combination of canola oil and pyrethrins, is one example.

**Insecticidal Soaps:** Insecticidal soaps are potassium salts of fatty acids. They help control soft-bodied insects such as aphids, spider mites, and whiteflies, but they require direct contact to work. Be sure to read and follow label directions; insecticidal soaps can cause foliage injury. Be aware that chain length has a big effect on the phytotoxicity of fatty acids. Some short-chain fatty acids are actually used as herbicides. This is one reason it is not a good idea to use commercial soaps as insecticides. Another good reason is that they are not labeled for use as insecticides. If you want to use soaps to control insect pests, stick with labeled insecticidal soaps. M-Pede and Safer Insect Killing Soap Concentrate are two examples.

**Sulfur:** Elemental sulfur has long been used to control spider mites and certain plant diseases and is approved for organic production. Organic gardeners primarily use microfine sulfur dust formulated for application as a liquid spray. Sulfur can cause skin and eye irritation and can cause plant injury if improperly used, especially if applied in combination with oils, or if applied within several weeks of an oil treatment. Thiolux, Microsul, and Sulfur DF are examples.

**Kaolin Clay:** Finely ground kaolin clay is sometimes applied to crops to help reduce heat stress or prevent sunburn on fruit of crops like tomatoes and peppers. It is applied as a foliar spray at relatively high rates, around 25 pounds per acre, and dries to form a fine coating of clay particles that reflect sunlight. This coating of clay also helps suppress feeding by certain insect pests, such as cucumber beetles, flea beetles, thrips, and grasshoppers. Surround WP is one example of a commercially available product (95 percent kaolin clay) that is OMRI-approved.

**Table 6. Insect management options for organic vegetable production.**

<b>Pest</b>	<b>Management and Control Options</b>
Aphids	Use reflective mulch. If they are available, consider varieties resistant to aphids or to important aphid-vectoring viruses. Use a strong water spray to wash aphids from plants. Where appropriate, use stylet oil to help reduce virus transmission. Destroy crop residue promptly after final harvest. This is especially helpful for root aphids. Foliar sprays: azadirachtin, neem oil, oil sprays, insecticidal soaps
Whiteflies	Grow transplants in isolation from other plants. Use reflective mulch. Avoid growing whitefly-susceptible crops near greenhouses or nurseries. Destroy crop residue promptly after final harvest. Foliar sprays: azadirachtin, <i>Beauveria bassiana</i> , neem oil, insecticidal soaps
Thrips	Grow tomato varieties resistant to tomato spotted wilt virus. Use reflective mulch. Promptly remove tomato spotted wilt virus-infected plants. Avoid mowing or tilling field borders and adjacent fallow fields after transplants are set. Foliar sprays: spinosad, azadirachtin, neem oil, insecticidal soaps, pyrethrins
Spider mites	Plant into a weed-free field. Avoid mowing field borders after midsummer or during drought. Avoid potassium deficiency, drought stress, or excessive nitrogen. Avoid water stress. Mist leaves with water spray to encourage outbreak of natural fungal disease. Foliar sprays: neem oil, oil sprays, insecticidal soaps, sulfur
Cutworms	Be sure field is tilled and free of all weeds and cover crops at least three weeks before planting. Use "cutworm collars" when planting small numbers of transplants into cutworm-prone situations.
Seed corn maggots Root maggots	Work manure and other organic fertilizers into the soil in the fall before you plan to plant, or well before planting. Till field at least four weeks before planting to allow weeds and cover crops time to decompose.
Mole crickets	Preventive treatment with parasitic nematodes <i>Steinernema scapterisci</i> .
Leaf miners	Use floating row covers where appropriate. Foliar sprays: spinosad, neem oil
Bean leaf beetles	Plant crop after beetles have left overwintering sites and moved to other crops, such as soybeans. Grow varieties with resistance or tolerance to key beetle-vectoring virus diseases. Foliar sprays: pyrethrins, rotenone + pyrethrins
Flea beetles	Maintain good weed control. Many weeds, especially solanaceous weeds, are hosts to flea beetles. Destroy crop residue promptly following harvest. Grow insect-resistant sweetpotato varieties. Parasitic nematodes can help control larvae in soil. Foliar sprays: pyrethrins, rotenone + pyrethrins, insecticidal soap
Colorado potato beetles	Avoid planting Irish potatoes following another solanaceous crop. Mulching with straw can help reduce populations. Destroy crop residue promptly following harvest. Foliar sprays: spinosad (target larvae), rotenone + pyrethrins
Blister beetles	These insects often occur in clusters. Dislodge from plants and crush them. Foliar sprays: pyrethrins, rotenone + pyrethrins
Cucumber beetles	Avoid early planting to avoid the heavy early flush of overwintered beetles. Use floating or hoop-supported row covers to protect young plants. Foliar sprays: pyrethrins, rotenone + pyrethrins
Cowpea curculios (southern peas)	Rotate planting locations. Avoid locating successive crops near earlier crops. Destroy crop residue promptly after final picking. Foliar sprays: pyrethrins, rotenone + pyrethrins

Vegetable weevils (turnips & greens)	<p>Rotate planting location.</p> <p>Avoid locating successive susceptible crops near earlier host crops.</p> <p>Destroy crop residue promptly after final harvest.</p> <p>Foliar sprays: rotenone + pyrethrins</p>
Sweetpotato weevils	<p>Plant only certified weevil-free slips.</p> <p>Do not transport sweetpotatoes from weevil-infested areas to noninfested areas.</p> <p>Destroy crop residue promptly after harvest.</p> <p>Avoid storing potatoes through the winter, especially in weevil-infested areas of the state.</p>
Harlequin bugs	<p>Plant mustard as a trap to protect less favored hosts, but destroy the trap before bugs move to main crop.</p> <p>Destroy crop debris promptly after harvest.</p> <p>Foliar sprays: rotenone + pyrethrins, insecticidal soap</p>
Wireworms Whitegrubs	<p>Till field deeply in the previous fall.</p> <p>Avoid planting recently tilled pastures or fallow fields.</p> <p>Grow insect-resistant sweetpotato varieties.</p>
Squash bugs	<p>Use floating or hoop-supported row covers to delay infestations.</p> <p>Destroy crop residue promptly after harvest.</p> <p>Foliar sprays: pyrethrins, rotenone + pyrethrins</p>
Stink bugs Leaffooted bugs	<p>Grow early crops. Stink bug populations are highest from midsummer through fall.</p> <p>Avoid growing successive crops near earlier crops.</p> <p>Time vegetable crops to be finished before nearby agricultural crops mature.</p> <p>Destroy crop residue promptly after final harvest.</p> <p>Foliar sprays: pyrethrins, rotenone + pyrethrins</p>
Tomato fruitworms Corn earworms	<p>Grow an early crop. Fruitworm numbers are highest from midsummer through fall.</p> <p>Grow corn varieties with long, tight-fitting shucks.</p> <p>Foliar sprays: spinosad, Bts, Gem Star (NPV virus).</p>
Armyworms	<p>Grow early crops. Populations increase as season progresses.</p> <p>Control weeds, especially pig weeds and amaranth.</p> <p>Foliar sprays: spinosad, Bts, Spod-X (for beet armyworms only)</p>
Loopers Diamondback moths	<p>Use trap crop of collards to reduce diamondback moth infestation on cabbage and other cole crops.</p> <p>Use mating disruption pheromone (for diamondback moths only).</p> <p>Foliar sprays: spinosad, Bts</p>
Squash vine borers	<p>Grow resistant varieties when feasible.</p> <p>Mechanically removing borers from stems may be helpful in small plantings.</p> <p>Destroy crop residue promptly following last picking.</p> <p>Foliar sprays: spinosad (to control newly hatched larvae before they bore into plant)</p>
Pickleworms Melonworms	<p>Grow early crops. Populations are much higher in late season.</p> <p>Foliar sprays: spinosad, Bts</p>
Slugs	<p>Till weeds and old crop residue before planting.</p> <p>Use iron phosphate slug bait.</p> <p>“Beer traps” can be effective in small plantings.</p>
Fire ants	<p>Tillage helps reduce number of fire ant mounds in field.</p> <p>Use granular fire ant baits containing spinosad. Baits are slow-acting; use preventively.</p> <p>Apply granular fire ant bait around field borders, too.</p>

The information given here is for educational purposes only. References to commercial products, trade names, or suppliers are made with the understanding that no endorsement is implied and that no discrimination against other products or suppliers is intended.

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Publication 2036

Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Published in furtherance of Acts of Congress, May 8 and June 30, 1914. GARY B. JACKSON, Director. (POD-06-13)



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