Organic Insect Control for Commercial Vegetable Production

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Controlling insect pests on commercial vegetables organically is a challenging task, 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 insecticide sprays. There are only a few organic insecticides available for use in commercial vegetables and organic insecticides are generally less effective than their non-organic counterparts. Rely on organic insecticides as your primary means of insect control and 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 whole lot more important for organic growers. It is much more difficult to 'spray your way out of trouble' in organic production.

1} Choose crops that have relatively few insect pests. Sweet corn, for fresh market, is a lot easier to grow organically than tomatoes. This does not mean you can not 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 successfully grow organic sweet corn in Mississippi for commercial canning, especially if transgenic seed are not an option.

2}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, armyworm, 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.

3} 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 non-resistant 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 the accompanying table for a partial listing of vegetable varieties with insect tolerance or resistance.

4} Practice crop rotation. Repeatedly growing the same crop in the same field can result in increased insect pressure. Cowpea curculio 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 aid greatly in managing this important pest. Rotating the location of the turnip patch can help reduce numbers of vegetable weevils for similar reasons. Crop rotation is also important in controlling many diseases.

5} 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!

6} Think about where you plant a crop relation to other crops, including crops on neighboring farms. If you are trying to produce organic tomatoes in late summer or early fall, you want 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 surrounded by annual row crops.

7} 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 with disease and weed control.

8} 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 bailing out when insect pressure increases. Then see point 7!

9} Plant into weed free fields and maintain good weed control. Mechanical tillage is the main method of weed control in organic production. Fortunately, 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 also helps control other pests that overwinter in the field in the soil or under crop debris and it also helps reduce the number of in-field fire ant mounds.

10} Know which pests are likely to occur on the crops you are growing and know 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.

11} Use trap crops when feasible. The idea behind trap crops is to plant a crop that is more attractive to the insect pest than the crop you are really interested in. Then the pests go to the trap crop and stay out of your main crop. A border planting of collards can be used as a trap crop for diamondback moths around cabbage. 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. Sunflowers can be

used similarly 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 non-organic 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 non-organic products to be used on the farm.

12} 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 reflectance prevents the insects from recognizing and landing on seedling plants. This is especially helpful in reducing incidence of serious insect vectored diseases, such as tomato spotted wilt virus. In fact, some studies have shown reflective mulches to be more effective in reducing TSWV incidence in tomatoes or peppers, than weekly insecticide sprays. Note that reflective mulches do not provide the same degree of early season soil warming as black mulches, but they do help cool the soil on later crops.

13} 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 vectored diseases. Home gardeners sometimes protect newly set transplants from cutworms with 'cutworm collars', made of wax paper or aluminum foil, that extend about an inch below the soil line and 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 a cutworm prone situation (weeds destroyed less 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 like 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.

14} 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 and/or flies that attack it, as well as fungi, bacteria, and/or 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 because organic insecticides tend to be less detrimental to beneficial insect populations.

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 my 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 and/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 pest(s) you are trying to control; which particular beneficial insects you need to release; when and how to make the releases, and where to purchase healthy, vigorous beneficial insects.

15}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. "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." "I can supply organic tomatoes, but they are more expensive to produce and they will probably have superficial insect damage on some fruit."

16} Grow healthy, vigorous plants. This is a goal of every farmer and gardener, but it is nice to know 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, drought stressed plants, and plants suffering from potassium deficiency are more susceptible to spider mites. On the other hand, excessive nitrogen can make plants more susceptible to spider mites and aphids.

17} 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.

18} Use mating disruption when available and appropriate. The idea behind mating disruption is to flood the field with synthetic pheromone to confuse male moths and reduce their ability to find mates, resulting in many of the female moths laying 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.

19} 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 build up on small plantings.

20} 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(s) 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 and/or maintain control. Comply with the pre-harvest 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, provided 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 used effectively 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.

21} Use 'Integrated Pest Management'. Don't just rely on a single control tactic to control any pest. The more different methods you use the greater your chances for success. Also consider all pests likely to occur in your crop, insects, disease, and weeds, and develop a pest management plan that addresses all of these.

22} 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.

Vegetable Varieties with Tolerance or Resistance to Specific Insect Pests.

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

[1] 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 borer, good control of corn earworm, and suppression of fall armyworm.

[2] A general rule for squash and pumpkin varieties and their susceptibility to squash vine borer 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.

[3] 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), 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, obtaining good spray coverage is especially important when using organic insecticides. Neemix and Aza-Direct are effective against whiteflies and vegetable oils, like Vegol, and soaps, like M-pede, will control spider mites, aphids, and other soft-bodied insects but these products only work 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 most caterpillar pests, as well as thrips and leaf miners. It is produced through commercial culture of a soil-born microbe that produces the toxic metabolites known as spinosad. These metabolites are harvested and formulated into insecticide, so the final product contains no living microbes. Although spinosad is organic, most formulations contain inorganic inert ingredients that disqualify them as 'organic insecticides', but 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 thuringienisis.* Bts are naturally occurring soil bacteria that product 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 thruingienisis* bacteria used to control caterpillar pests. These transgenic crops inherently provide high levels of control of caterpillar pests such as corn earworm and European corn borer. 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, but 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, as well as helping control certain fungal diseases. Products containing "clarified hydrophobic extract of neem" do not contain azadirachtin; they usually contain 70% neem oil. Trilogy 70% Neem Oil is marketed for commercial organic vegetable production, and Monterey 70% Neem Oil is sold for small scale production.

Beauvaria bassiana: *Beauvaria 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; begin treating when pest populations are low. Do not tank mix with fungicides.

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

Parasitic Nematodes: Some nematodes only attack insects and some of these entomopathogenic species of nematodes are formulated and marketed for use in organic crop protection. There are several species, but most are in the genus *Heterorhabditis* or *Steinernema*. Parasitic nematodes are usually used to control soil-dwelling pests, such as cutworms, squash vine borer, 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' only to 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 only contain 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 other pests. 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 insect 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 + pyrethrin. Pyola, a combination of canola oil and pyrethrins, is one example.

Insecticidal Soaps: Insecticidal soaps are potassium salts of fatty acids. They are useful for control of soft-bodied insects such as aphids, spider mites, and whiteflies, but require direct contact to work. Be sure to read and follow label use 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 for control of 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 lbs 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% kaolin clay) that is OMRI approved.

Organic Management and Control Options for Common Vegetable Insects and Mites

Pest	Management and Control Options
Aphids	- Use reflective mulch. - Consider resistant varieties if available, or varieties resistant to important aphid vectored viruses. - Use strong water spray to wash aphids from plants. - Use stylet oil, where appropriate, to help reduce virus transmission. - Destroy crop residue promptly after final harvest. Especially helpful with 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, *Beauvaria bassiana*, 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 mid-summer, 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	- Have field 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 previous fall, 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, *Steinernema scapterisci.*
Leaf miners	- Use floating row covers where appropriate. - Foliar Sprays: Spinosad, neem oil
Bean leaf beetle	- Plant crop after beetles have left overwintering sites and moved to other crops, like soybeans. - Grow varieties with resistance/tolerance to key beetle vectored 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. - 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 Curculio (southern peas)	- Rotate planting location. - Avoid locating successive crops near earlier crops. - Destroy crop residue promptly after final picking. - Foliar Sprays: Pyrethrins, Pyrethrins + rotenone
Vegetable Weevil (turnips & greens)	- Rotate planting location - Avoid locating successive susceptible crops near earlier host crops. - Destroy crop residue promptly after final harvest. - Foliar Sprays: Pyrethrins + rotenone
Sweetpotato Weevil	- Plant only certified weevil-free slips. - Do not transport sweetpotatoes from weevil infested areas to non-infested areas. - Destroy crop residue promptly after harvest.

	- Avoid storing potatoes through the winter, especially in weevil-infested area of state.
Harlequin Bug	- Plant mustard as a trap to protect less favored hosts, but destroy the trap before bugs move to main crop. - Destroy crop debris promptly after harvest. - Foliar Sprays: Rotenone + pyrethrins, insecticidal soap
Wireworms Whitegrubs	- Till field deeply in the previous fall. - Avoid planting recently tilled pastures or fallow fields. - Grow insect resistant sweetpotato varieties.
Squash Bug	- Use floating or hoop-supported row covers to delay infestations. - Destroy crop residue promptly after harvest. - Foliar Sprays: pyrethrins, rotenone + pyrethrins
Stink Bugs Leaffooted Bugs	- Grow early crops. Stink bug populations are highest from mid-summer through fall. - Avoid growing successive crops near earlier crops. - Time vegetable crops to be finished before nearby agricultural crops mature. - Destroy crop residue promptly after final harvest. - Foliar Sprays: Pyrethrins, Pyrethrins + rotenone
Tomato Fruitworm Corn earworm	- Grow an early crop. Fruitworm numbers are highest from mid-summer through fall. - Grow corn varieties with long, tight-fitting shucks. - Foliar Sprays: Spinosad, Bt products, Gem Star (NPV virus).
Armyworms	- Grow early crops. Populations increase as season progresses. - Control weeds, especially pig weeds/amaranth - Foliar Sprays: Spinosad, Bts, Spod-X (for beet armyworms only)
Loopers Diamondback Moth	- Use trap crop of collards to reduce diamondback moth infestation on cabbage and other cole crops. - Foliar Sprays: Spinosad, Bts - Use mating disruption pheromone, for diamondback moth only
Squash vine borer	- Grow resistant varieties when feasible. - Mechanically removing borers from stems may be helpful in small plantings. - Destroy crop residue promptly following last picking. - Foliar Sprays: Spinosad (must control newly hatched larvae before they bore into plant)
Pickleworm, Melonworm	- Grow early crops. Populations are much higher in late season. - Foliar Sprays: Spinosad, Bts
Slugs	- Till weeds and old crop residue before planting. - Iron Phosphate slug bait - 'Beer traps' can be effective in small plantings.
Fire Ant	- Tillage helps reduce number of fire ant mounds in field. - Use granular fire ant baits containing Spinosad. Baits are slow-acting; use preventively. - Apply granular fire ant bait around field borders also.