

Growing Organic Vegetables In Iowa



IOWA STATE UNIVERSITY
Extension and Outreach

Introduction

Organic production and consumption has increased in the last 20 years. In 2010, the organic industry grew to over \$28.6 billion. More than 4.1 million acres are in organic production in the U.S. as the industry continues at 10 percent annual growth rate. Consumers purchase organic foods for several reasons, including reduced pesticide residues (organic prohibits the use of synthetic pesticides) and perceived benefits from organic fertilization in terms of nutritional content. Many chefs throughout the world select organic foods for their menus because of the perceived superior taste. In addition, organic consumers strive to support local farmers who rely on environmentally-friendly methods of production that help protect groundwater.

Certified Organic Designation

“Organic” is a term defined by law (Organic Food Production Act, 1990; U.S. Department of Agriculture-National Organic Program, 2004). As of October 2002, anyone selling products labeled as “organic” must be inspected by a third party to ensure compliance with federal USDA rules (see *Fundamentals of Organic Agriculture*, PM 1880).

To sell a product as “organic,” the crop must have been raised on land where synthetic chemicals (any synthetic fertilizers, herbicides, insecticides or fungicides) have not been applied for at least three years prior to harvest. In addition, no genetically-modified organisms (GMOs) or GMO crops are allowed in organic production (e.g., Roundup-Ready® soybeans and Bt-sweet corn®). Other practices specifically disallowed for organic production include use of “biosolids” (sewage sludge) due to concerns with bacterial and heavy metal contamination. Irradiated products also are prohibited. Organic producers who gross less than \$5,000 per year and wish to sell their produce as “organic” are exempt from certification fees but must follow organic standards and register with the Iowa Department of Agriculture and Land Stewardship (see References).



Organic vegetable crops can be planted using mechanical transplanters to aid efficiency.

Many growers have already raised crops “organically” at one time or another—simply by growing plants without the use of synthetic fertilizers or pesticides. Before the invention of synthetic agricultural chemicals around World War II, all crops relied on inherent soil fertility, augmented by manure, kitchen scraps, or nitrogen-fixing leguminous crops, such as alfalfa. Sir Albert Howard (1873-1947) was a pioneer in organic farming techniques that were based on an integration of soil life, plants, animals, and people. He championed the use of crop rotations (alternating crops every year within a given section of land) and compost applications to provide organic matter and replace nitrogen and minerals lost through cropping practices. Others, including J.I. and Robert Rodale, continued Howard’s work in promoting organic methods.

Organic farming is based on the ecological principles of nutrient cycling, biotic regulation of pests, and biodiversity. Inputs used in organic farming are derived from renewable resources in order to preserve our limited supply of non-renewable petroleum, which is the basis for most chemicals used in conventional agriculture. Organic growers rely on materials produced through sunlight, such as plants/plant parts, and manures produced through an animal’s consumption of plants. Recycling of wastes that are potential pollutants, such as animal manure, is a critical component of organic farming.

For commercial organic producers, a third-party certifier inspects annually to assure that no synthetic materials have been used in production. This “audit trail” is verified through farm records, a system that many farmers already embrace, by tracking planting dates, farm sections (crop rotations), and input application rates. Thus, the transition from organic farming to certified organic production should be relatively easy for anyone wishing to market crops as “organic.”

Soil Health and Nutrient Cycling

All organic systems are based on the principle of nutrient cycling. Nutrients in the farm system are in a constant state of cycling. As plants and animals are raised together, their residues are recycled into the soil as fertilizers for the next crop, which may then be used to feed animals and plants in the system. Because livestock are considered part of the organic farm system, many organic producers raise chickens, rabbits, and other small livestock in fenced areas or in movable, pasture-based chicken tractors.

Iowa is an ideal location for livestock operations; growers without livestock should be able to locate manure from nearby farms or livestock operations.



Making or purchasing compost for your soil fertility needs will include assuring that all ingredients meet organic standards (see table 1).

Raw manure can be used from animals that have not been raised organically but all manure must be incorporated in the soil 4 months before harvest or composted (see Composting section on page 4). Composting at the proper oxygen level, temperature, and humidity should break down all synthetic materials in manure, but if you are concerned about the persistence of antibiotics, hormones, or other synthetic substances fed to animals that have not been raised on organic farms, you may wish to use manure only from organic farms or from a certified organic supplier.

Always ask for a list of ingredients in purchased manure or compost. You may not wish to use a product on your farm if prohibited, synthetic substances have been used in processing or pelletizing it.

Non-manure-based composts also are available, but are generally lower in nitrogen (N) than manure-based compost because they use mostly plant-based ingredients, such as wood chips or straw (see table 1).

Beneficial microorganisms also are critical for recycling nutrients, and are supplied through manure, compost, and cover crops. Compost application rates range from 100 to 150 pounds of nitrogen per acre, depending on crop needs, existing soil fertility, and nitrogen from other sources (cover crops). Because most composts in Iowa range from 1 to 3 percent nitrogen, rates of 6,000 to 12,000 pounds of compost per acre are commonly applied.

Soil Quality and Crop Rotations

Soil quality includes all the physical, biological, and chemical (as in mineral elements, such as nitrogen) components necessary for soil health. Only naturally-occurring materials are allowed in organic production and processing and all applied materials must be recorded in farm records if any produce is sold as “organic.”



By testing your soil, you can estimate the quantity of nitrogen your cover crop provides (shown: hairy vetch and rye).

A crop rotation plan is helpful in protecting against pest problems and maintaining soil health. Horticultural crops should be rotated with a leguminous cover crop at least once every five years. No more than four out of six years should be in row crops, and the same row crop cannot be grown in consecutive years on the same land. Legumes (alfalfa, red clover, berseem clover, hairy vetch) alone, or in combination with small grains (rye, wheat, oats, barley), should be rotated with row crops (corn, soybeans, amaranth, vegetables) to ensure a healthy system.

An example of a seven-year rotation in Iowa would be a (1) hairy vetch/rye cover crop, (2) tomatoes, (3) onions, (4) salad greens, (5) garlic, (6) Austrian winter pea/triticale cover crop, (7) strawberries. The highest nitrogen-demanding crops are followed by crops with lower demands, followed by nitrogen-supplying crops of legumes and small grains. Plants of the *Solonaceae* family (tomatoes, potatoes, eggplant, pepper) should be separated by a minimum of three years to avoid nematode or disease problems from previous *Solonaceae* crops.



Hairy vetch should be plowed down or rolled when 10 to 20 percent of plants are blooming.

Table 1. Composition of typical feedstocks in compost operations.

Material	N	P ₂ O ₅	K ₂ O	C/N
Dairy manure	0.6-2.1	0.7-1.1	2.4-3.6	18
Horse manure	1.7-3.0	0.7-1.2	1.2-2.2	30
Poultry manure	2.0-4.5	4.5-6.0	1.2-2.4	6-16
Sheep manure	3.0-4.0	1.2-1.6	3.0-4.0	16
Swine manure	3.0-4.0	0.4-0.6	0.5-1.0	14
Fish meal	10.0	6.0	-	3.6
Alfalfa hay	2.45	0.50	2.10	16
Wheat straw	0.50	0.15	0.60	127
Apple fruit	0.05	0.02	0.10	40 ¹
Apple leaves	1.00	0.15	0.35	54 ²
Banana peels	0	3.25	41.76	
Beans (pods)	0.25	0.08	0.30	
Coffee grounds	2.08	0.32	0.28	20
Eggshells	1.19	0.38	0.14	
Fish scrapes	6.50	3.75	-	
Potato peels	0	5.18	27.50	19 ³
Wood ashes	0	1.50	7.00	
Sawdust	0.24			440

¹ Includes all fruit wastes (average)² Includes all leaf wastes (average)³ Includes all vegetable wastes (average)

Composting

Composting is the preferred method of fertilization in organic fruit and vegetable production. Composting stabilizes nutrients from manure and raw organic materials (e.g., crop residues, kitchen scraps) and reduces odors and high ammonia levels. Because all operations in compost making must be recorded for the certifying agency, most growers opt to go under the “raw manure” rule and apply their compost 4 months before harvest.

Composting is a controlled process where nitrogen-containing materials (manure, yard/kitchen waste) are mixed with a carbon-containing source (corn stalks/cobs, straw, wood chips) to produce a substance preferably in a carbon-to-nitrogen ratio (C:N) of 25–30 to 1 (see table 1 for examples). A general rule of thumb in making compost is to use 4 parts carbon-containing materials to 1 part nitrogen-containing materials. Oxygen is supplied to the beneficial microorganisms through turning of the compost pile.

Many methods of composting are available—from simple piles to bins, barrels, or drums, to expensive machines, such as hydraulic windrow-turners. All systems operate on the same principle of providing sufficient heat to kill harmful microorganisms and weed seeds, but retaining beneficial organisms that help convert ammonia to the preferred form of nitrate-nitrogen.

A minimal size of 3 ft. x 3 ft. x 3 ft. is required to obtain adequate heating. The compost mixture must reach a

temperature of 140°F for at least three days during the composting process to adequately decompose organic materials and kill plant pathogens and weed seeds.

Adequate moisture and temperature are required for proper composting (strive for 45 to 50 percent moisture). If compost piles reach ideal temperatures and moisture conditions, and are routinely turned when temperatures reach 140°F, a finished compost (with the look and smell of soil) can be obtained in 6 to 8 weeks.

Other composting systems include vermicomposting (using earthworms in “beds” or “towers” to decompose manure and other wastes), in-vessel digesters, and anaerobic systems.

Other Soil Amendments and Foliar Treatments

Soil testing is essential to determine which, if any, amendments are needed and in what amounts. Iowa State University and private labs in the Midwest can analyze your soils.

Although compost contains the majority of necessary nutrients, many other soil amendments are available to add nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), and other nutrients to soil and plants. For example, lime (calcium carbonate) is a common amendment to raise soil pH to the preferred neutral status of 6.5 to 7. Gypsum adds both calcium and sulfur. Rock phosphate can be used to add phosphorus.

Several foliar nutritional treatments are available for organic farmers, including Earth Juice™ and many fish emulsion products. These products can be used alone or in combination with soil amendments. Compost tea is another foliar spray that provides some nutrition and also has been used for powdery mildew and other diseases.

Pest Management Strategies

Preventative practices are the cornerstone of organic pest management. Prevention starts with planting the most insect- and disease-resistant varieties. Other cultural, physical, and biological controls include using fabric row covers, trapping or hand-picking beetles, attracting natural enemies, or using organic-compliant insecticides. Pesticides are applied only in emergencies and must be justified to your certification agency.

Insect pests are less prone to colonize healthy plants that contain the proper balance of nitrogen, phosphorus, and potassium than plants in a stressed situation. Thus, soil health is critical in helping prevent pest problems because many leaf-feeding insects prefer plants with high concentrations of free amino acids that may be present in plant tissues containing high amounts of nitrogen.

Companion Planting

Many farming books encourage the planting of certain plants with others in order to increase yields or prevent pest attack. The majority of these plans are based on grower-experience and are often site-specific. Some growers have experienced reduced infestations of squash pests when squash is planted with corn, for example. This system is referred to as the “Three Sisters” (corn, beans, and squash) planted by Native Americans. The theory behind this strategy is that the presence of the other plants “masks” the squash from squash pest species. Other tactics include planting mint around brassicas (broccoli and cabbage family) to repel the cabbage butterfly and reduce egg-laying. Marigolds, which exude a nematode-repelling chemical called thiopene, often are planted with tomatoes to help manage root-knot nematode.

Biological control is a predominant factor in all organic farms. Nearly every insect pest in Iowa has a “natural enemy” or beneficial organism (predator, parasite, or pathogen) that helps manage that particular pest. Farmers rely on beneficial insects (ladybeetles and spiders, for example) to prey on pests such as aphids and caterpillars, or they employ physical, preventive measures, such as fabric row covers. Because our extended winter weather kills many insects, most organic farmers in the Midwest have not needed insecticides for managing pests. Damaged plant parts can be removed prior to selling or eating produce, as many organic farmers expect to “donate” some of their leaves or fruit to the insects and diseases that are part of the ecosystem.

Even when organic-compliant insecticides are sprayed on the farm, beneficial organisms also may be harmed, so the first rule of pest management is to prevent insect pests through the following methods:

- Plant resistant or tolerant crop varieties, such as the VFN series (*Verticillium*, *Fusarium* and *Nematode resistant cultivars*);
- Plant under proper conditions (when the soil is adequately warmed and all danger of frost has passed);
- Harvest in a timely manner; and
- Practice good sanitation by collecting and destroying infected plants.

Insect pests are either soft-bodied (easily crushed) insects, such as aphids, mites, and lepidopteran larvae (caterpillars), or hard-bodied (hard, exterior wings protect insect body) insects, such as beetles or true bugs (e.g., squash

bugs). Organic-compliant insecticides are most effective on soft-bodied insects. Because beetles are hard-bodied insects, effective management often requires multiple applications of organic-complaint insecticides.

Organic insecticides that are derived from plants are called botanical insecticides. Other approved insecticides are derived from mineral sources and operate on the principles of repellency and irritation.

Biological insecticides include microorganisms that are harmful or competitive with pests, for example, *Bacillus thuringiensis* or *Bt*. This naturally-occurring bacterium is found in soil. For commercial production, bacteria are multiplied in vats, with harvested spores dried to a powder that can be applied to crop plants. This bacterial toxin is not harmful to humans but is a stomach poison when consumed by lepidopteran larvae (caterpillars). Many *Bt* formulations are available but certified organic growers must read the label carefully; any *Bt* with petroleum carriers or other synthetic materials would be disallowed in organic production. A *Bt* that is effective against Colorado potato beetle larvae (immature stage) is called *Bacillus thuringiensis tenebionis* or *Btt*. A new biological control, *Bacillus subtilis*, is a bacterial preparation that has been used against bacterial blight disease in tomatoes and for soybean rust in Florida. This bacteria competes with fungi that causes the disease and in certain cases, disease has been reduced.

Most of these materials may require multiple applications, and even then, will not result in the “100% knockdown” obtained with synthetic chemicals. Most insecticides are repellent in nature (insects decrease feeding or avoid colonization through chemical or visual cues). Some, such as neem, also are insect growth-limiting. Some insecticides available for organic growers are listed in table 2.



Organic strawberries should be grown on straw-mulched beds to help prevent disease and keep produce clean.

Table 2. Insecticides used in organic production in the Midwest.¹

Common Name	Type	Use ²
Neem Scientific Name: <i>Azadiracta indica</i>	Botanical insecticide (seeds primarily, but also leaves, pods, and other parts)	Soft-bodied and some hard-bodied insects; neem oil used for downy and powdery mildew control; do not apply when bees are active in the area
Pyrethrum	Botanical insecticide: flower petals	Soft-bodied and some hard-bodied insects
Sadadilla	Botanical insecticide from roots	Leafhoppers, caterpillars, and thrips; do not apply when bees are active in the area
Ryania	Botanical insecticide from roots	Codling moth, thrips, and European corn borer
Rotenone	Botanical insecticide roots	Restricted insecticide (reports of human illness associated with use)
<i>Bt</i>	Natural bacteria <i>Bacillus thuringiensis</i>	Caterpillars (<i>Bt kurstaki</i>), Colorado potato beetle (<i>Bt tenebrionis</i>), and black flies (<i>Bt israeliensis</i>)
Granulosis virus	Naturally occurring microbial insecticide	Codling moth
Soaps	Fatty acids derived from plant sources	Mites, aphids, and mealybugs; check if organic-compliant—no synthetic oils
Vegetable oils	Insecticide derived from several seed oils	Scale insects, aphids, and mites
Surround™	Naturally mined mineral (kaolin clay)	Soft-bodied and hard-bodied insects
Sulfur	Naturally mined mineral	Mites; disease control for mildew and other diseases; use caution when applying (may be phytotoxic and cause respiratory problems)
Lime sulfur	Mixture of naturally mined minerals	Mites; disease control for mildew and other diseases; use caution when applying (may be phytotoxic and cause respiratory problems)

¹ From University of California-Davis: *Pests of the Farm and Small Farm*, Pub. No. 3332.

² Because registrations and formulations change routinely, check with state and federal labels before using any insecticides. Your certification agency and OMRI (Organic Material Review Institute) can provide status for use in organic operations.

Materials that can accumulate in the soil and may lead to toxic levels, such as copper fungicides, are considered restricted materials in organic production. The use of all insecticides or fungicides should be justified through monitoring for insect/plant pathogen numbers and determining economic damage thresholds. If there are low populations of insect pests or disease, the use of pesticides will not be warranted.

Read all pesticide labels carefully for instructions. The label is considered a legal document and violation of label directions can result in damage to plants, people, and the environment. Consult with your certification agency or the Organic Materials Review Institute (OMRI) before applying any materials to assure organic approval if you sell your product as organic. Applying prohibited materials can result in a one- to three-year loss of certification, depending upon the material applied and the extent of spread.

Disease Management Strategies

Planting resistant or tolerant varieties and rotating crops every year is the first line of defense for plant diseases.

Downy mildew (*Pseudoperonospora cubensis*) and powdery mildew can be found on cucurbit plants in the Midwest. Symptoms first appear as pale green spots on the upper leaf surface that become angular lesions. A whitish-gray “downy” mildew-looking mass soon covers the lower surface of the leaves. Stunted growth, reduction in yield, defoliation, and eventual death of the plant may result.

Products that are available for disease management in organic vegetable production include *Bacillus subtilis* (a biological control agent formulated as Serenade™), a hydrogen peroxide-based product, and baking soda products (formulated as Armicarb 100™ or FirstStep™). The efficacy of these products has not been tested in Iowa.

Compost teas also have been reported to help manage diseases in research at Michigan State University, but information from Iowa is limited. It is believed that compost teas contain antagonistic or competitive biological control agents, such as *Bacillus subtilis* and *Trichoderma* sp., which may decrease harmful microorganisms.

Bacterial wilt is a disease transmitted by the cucumber beetle. Symptoms include a rapid wilting of the plant and a slimy exudate from plant stems upon cutting. Bacterial wilt is controlled by preventing or reducing beetle populations through row covers or organic-compliant spray treatments.

EXAMPLE: Pest Management for Organic Squash Production

General comments: Squash and other cucurbit crops require more intensive management than most crops, such as lettuce and kale. Squash is considered a medium-feeder—it requires more nitrogen than lettuce and greens but less than tomatoes and sweet corn. In Iowa State University trials, organic squash yields were not increased with the addition of compost in very fertile soils but adding compost to more sandy soils can increase yields.

Predominant pests: Squash bug has been the predominant pest in Iowa State University organic squash trials. Cucumber beetles and squash vine borers also can cause problems in certain years.

Squash bug (*Anasa tristis*) can be a very destructive cucurbit pest in Iowa. Adults are about 5/8 inch long at maturity, grayish-brown or yellowish-brown, flat-backed, with the edges of the orange/orange-brown abdomen protruding from beneath the wings at rest. The nymphs (the immature forms without wings that are normally seen in the farm) are primarily all gray and feed in groups. Eggs are usually seen as bright bronze elliptical-shaped clusters of 7 to 20 eggs laid under the leaf in the angles formed by two leaf veins.

Scout for overwintered adults as soon as plants emerge and for eggs beginning in mid-June. There is one generation per year in Iowa, with five nymphal stages. Scout for adults and nymphs on top and under leaves and on the soil surface around plants.

Damage: Squash bugs feed by sucking plant leaf sap and causing a wilting of the plant from the feeding point forward. Fruit can be damaged if populations are allowed to increase during the season. Young plants and plants at the initial flowering stage are particularly vulnerable.



Spotted and striped cucumber beetles can spread bacterial wilt in cucurbits.

Cucumber beetles that bother squash include the striped cucumber beetle—*Acalymma vittatum* (Fabricius) and the immature spotted cucumber beetle—*Diabrotica undecimpunctata howardi* Barber (also known as the Southern corn rootworm that migrates from the south into Iowa cornfields every year). Cucumber beetles have two generations; the first appears in early spring and the second appears in July and August.

Scout for yellow-orange eggs at the base of plants or in soil cracks near the plants. The larvae (immature form) are tiny, white, grub-like worms in the soil that feed on plant roots.

Damage: Only in the case of severe infestations is larval feeding a concern. The most important consideration for the cucumber beetle management is the transmission of bacterial wilt by the beetle. Jack-o-lantern pumpkins and some squashes are rarely susceptible to this disease. Hubbard and butternut squash, however, are susceptible to bacterial wilt. In Iowa State University organic squash trials, the incidence of bacterial wilt was very low but can be a concern in years of heavy beetle numbers.

Squash vine borer (*Melittia satyriniformis*) adults are members of the moth and butterfly order of insects (Lepidoptera) in a sub-category called clear wing moths which resemble wasps. The moth's body is red with black bands, and its hind wings are transparent and fringed by reddish-brown hairs. Adults usually fly in the daytime and can be seen laying eggs at the base of the plant, or on leaf petioles and stems. Adults emerge when squash plants are blooming from over-wintering pupae (resting forms in the soil). This period usually follows squash bug and cucumber beetle emergence.

Scout for small disk-shaped, reddish-brown eggs or sawdust-like frass (fecal pellets and chewed plant parts) at the base of the plant.

Damage: Once eggs hatch and larvae tunnel into plant, squash plants will begin to wilt—a symptom that can be confused with bacterial blight.



Ornamental and edible hard squashes and gourds can be grown using organic techniques.

Strategies for handling squash bug, cucumber beetle, and squash vine borer

Prevention through use of row covers: Row covers are used in managing all squash pests: squash bugs, squash vine borers, and cucumber beetles.

In research at Iowa State University, cucumber beetles and squash bugs were more successfully managed with floating row covers compared to the use of a clay-based insecticide (Surround®) or interplanting squash with an insectary plant (buckwheat) to attract natural enemies.

Row covers are available in many weaves and sizes. Pre-cut rolls are best for small farms but commercial rolls that can be cut to grower's specific row shape are more cost-effective for larger operations. Row covers should be placed over the squash crop as soon as plants are established (approximately 6 inches in height). If feasible, row covers can be removed for a few hours each day once flowers are opening in order to allow pollination to occur. Other systems have bee boxes at the end of row-covered tunnels that allow the bees entrance without the labor of removing and replacing row covers each day.

Row covers can be placed on wooden or metal frames over squash beds, or placed as floating covers directly on squash plants. There may be some deformation of squash leaves from direct contact, but yields are not affected. At a certain point (when fruit set appears complete), row covers can be removed permanently.



White, spun fabric row covers (shown on the ground-on the right-lifted off the hoops that keep it off plants) help protect crops from beetles (cucurbits) and caterpillars (brassic) until crops are large enough to withstand damage from insect pests.

Prevention through the use of pheromone traps: These traps emit a chemical that disrupts the mating ability of the adult squash vine borer moth and leads to lower insect populations. Hanging squash vine borer pheromone traps around the field should help in managing SVB pests.



Pheromone traps can be used to catch and monitor squash vine borer adult moths.

Attracting natural enemies: The beneficial insect, *Trichopoda pennipes*, is a fly that parasitizes the squash bug by laying eggs on the bug's body. The larvae (maggots) that emerge from the eggs feed internally on the squash bug's hemolymph (fluids) until the bug's death ensues. Look for the fly's tiny white eggs on the squash bug and allow that bug to remain in the farm. Flies that emerge from the parasitized squash bug will then continue the cycle of biotic regulation by attacking other squash bugs in the field. Adult flies feed on nectar that can be supplied through flowering plants (also known as insectary plants), such as buckwheat and sweet alyssum. Oftentimes, however, the population of parasitic flies is inadequate to manage squash bugs below economic damage levels.

Two beneficial insects, a robber fly and a ground beetle, are generalist predators that can prey on squash vine borer (SVB). A parasitic wasp also attacks SVB eggs and parasitic nematodes can prey on SVB. Beneficial flies and wasps feed on nectar that can be supplied through flowering insectary plants such as buckwheat and sweet alyssum. Ground beetles prefer mulched areas. Beneficial nematodes can be purchased for distribution in the field. There is no guarantee, however, when



Squash bug (L) and the natural enemy (R), a parasitic fly, whose eggs are visible on the back of a parasitized bug.

augmenting natural populations of beneficial insects with purchased natural enemies. Conservation of natural enemies by providing nesting and flowering sites is always the best practice.

Planting techniques: Planting squash after June may help plants escape the arrival of the first squash bugs although the insects may eventually locate and colonize later plantings.

Late planting or staggered plantings also are used to escape SVB populations, or to allow adequate plant populations in the event of SVB attack of one planting. Sustaining vigorous plant growth (through compost applications and irrigation) is essential to maintaining plants that can tolerate SVB injury.

Varietal selection also is important—squash bugs prefer squash and pumpkins over zucchinis. Squash vine borers prefer winter squash, followed by summer squash, zucchini, and pumpkins, with cucumbers and melons the least preferred. Of the winter squashes, butternut is the most tolerant cultivar, and the hubbard types are the most susceptible.

Trapping: Squash bugs can be trapped under boards in the fields where they tend to congregate. Another option is to plant an early trap crop of squash or pumpkins where the bugs can be trapped and then vacuumed or handpicked from the underside of the boards or managed with an organic-compliant insecticide before the main crop is planted.

Planting an early crop of squash or zucchini also may help manage SVB. When the trap crop is colonized by SVB larvae, it can be treated with one of the approved insecticides or plowed under to destroy the insects.

Physical control: Physically removing the SVB larvae from the stem of the plant is a labor-intensive method employed by small-scale growers. Using a knife or Exacto® blade, growers slit the stem at the base of the plant and kill the larvae inside the stem. Many growers cover the injured area with moist soil to encourage new rooting and re-growth, however, this method is not always effective.

Sanitation: Removing debris that may harbor squash bugs or eggs can help reduce populations. Insects or eggs can be hand-picked from plants and crushed (between the board and a hand trowel, for example) or vacuumed (mini-vacs or commercial D-Vac® machines work well).

Vines should be destroyed as soon as possible following harvest to prevent further development of SVB larvae inside squash plants. Tillage and incorporating through plowing will destroy cocoons (resting stages of the SVB moth).

Economic thresholds and organic-compliant pesticides: The economic damage threshold for squash bugs is one egg mass on each monitored plant. If all previously described methods have been used and you continue to find extensive egg masses, consider using organic-compliant insecticides (see table 2). Although these plant and mineral-based insecticides are less damaging to natural enemies than synthetic insecticides, some harmful effects may occur with extensive use.

Research at Iowa State University did not perceive any benefits from the use of clay-based insecticide for squash bugs because of our inability to cover plant undersides where squash bugs clustered. Other botanical insecticides that have been tested for general insect pest control include neem (from the plant *Azadirachta indica*), garlic, and pyrethrum (from daisy plants). These insecticides are generally more successfully used against soft-bodied insects, such as aphids and mites. Detailed information about these insecticides can be found in the ATTRA (Appropriate Technology Transfer for Rural Areas, a USDA-supported organization that serves as a clearinghouse for organic and sustainable agriculture information) publication (see References).

Weed Management Strategies

Weed management is a critical component of organic vegetable production for transitioning and certified organic growers. If vegetable crops are planted in rows of sufficient width, row cultivators (either front-mounted or rear-mounted) can be used to kill weeds between rows. Crops, such as strawberries and tomatoes, should be mulched to prevent weed infestations. While plastic mulch is allowed in organic production (provided it is removed after each season to avoid degradation in the soil), many organic vegetable farmers use alternatives, such as straw and natural fiber mulches. In trials at ISU, organic squash crops were cultivated while small, and mulched with alfalfa hay after vines extended beyond the row.



The roller/crimper crushes a cover crop planted in the previous fall. Seeds can be directly planted or drilled into the flattened mulch.



Row cultivators can be used for weed management between rows when crops are small and there is sufficient width between rows.

Cover crops also are under investigation for their efficacy in weed management on organic farms. Successful production of organic corn, soybean, tomatoes, pumpkins, and strawberries has been achieved with rolled cover crops in Pennsylvania and Michigan. Trials at ISU have shown that rolled or crushed cover crops can provide a season-long mulch for organic tomatoes.

Cover crops are planted in the fall, then rolled and killed in the spring with a goal of having a dense cover crop-mulch capable of suppressing weeds so that additional weed control is unnecessary. The roller consists of a large steel cylinder (10.5 ft wide x 16 in. diameter) front-mounted on the tractor and filled with water to provide 2,000 pounds of weight. Steel blades are welded in a chevron pattern to crimp and mechanically kill the fall-planted cover crops. Afterwards, vegetable crops are planted into the flattened cover crop, using no-till drilling of seeds, high-residue transplanter, or hand-transplanting.

No-till roller research in Iowa

The Rodale Institute (Kutztown, PA) provided a no-till roller/crimper to ISU and four other Midwest universities. Two seasons of research with the no-till roller at the ISU Neely-Kinyon Farm in Greenfield demonstrated excellent tomato yields with reduced weed pressure. Cover crops (rye and hairy vetch or winter wheat and Austrian winter pea) were planted in September-October and then killed in late May when the rye/wheat was headed out and the vetch/peas were at 20 percent bloom. Twenty days later, 6-inch 'Roma' tomato seedlings were transplanted into the dried mulch. Transplants were side-dressed with 0.5 pounds of organic compost per plant at the time of transplanting. Harvests began in August and lasted until frost. Weed pressure was half that of tilled plots because of the season-long mulch from the rolled cover crops. Disease pressure also was reduced because the mulch helps prevent some splashing of disease spores. Research will continue on no-till organic production of corn, soybean, and tomatoes.

Marketing and Economic Strategies

Organic vegetable production is a management-intensive system that can pay economic dividends but also requires continuous monitoring for insects and diseases and a rapid response when economic threshold levels are met. Crop rotation provides much protection against insect, weed, and disease problems but selection of resistant or tolerant varieties, and timely harvests also are critical.

The most common approach for marketing organic vegetables in Iowa includes farmers' markets and Community Supported Agriculture farms. Restaurant and institutional food service purchasing also has become more popular in the last five years.

For detailed marketing information, see *Using Organic Agriculture and Sustainable Crops and Livestock in the Local Food Systems* (PM 1995) at <https://store.extension.iastate.edu/>

Knowing the economical outcomes of your operation is critical for your success. Keeping track of all expenses and revenue is a tedious but necessary part of determining which crops are aiding or hurting your bottom line.



Farmers' markets provide an excellent venue for selling local, organic produce.



Organic produce is preferred by The Chefs' Collaborative that promotes local and organic food.

References

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Iowa Department of Agriculture & Land Stewardship (IDALS) Organic Certification and Organic Standards, Des Moines, IA. www.iowaagriculture.gov/AgDiversification/organicCertification.asp

Iowa State University Organic Agriculture <http://extension.agron.iastate.edu/organicag/> (See especially "Research and education" for research reports on organic squash, sweet corn, and broccoli production and "Resources" for information on organic seeds and supplies.)

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