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Organic Vegetable Production

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Introduction

Organic production is a *systems approach*. Although many aspects of vegetable production remain the same in both "organic" and "non-organic" or "conventional" systems, there are differences. The purpose of this bulletin is to discuss the major components of production which differ between the two systems. These components include transplant production, soil fertility management, and insect, disease, and weed management. Information on other aspects of vegetable production may be found in other sources listed at the end of this publication.

"Organic" usually refers to a crop management system that promotes biodiversity, biological cycles, and soil biological activity. Organic production concentrates on natural processes and how to manage them. Other materials and products are additions to, not replacements for, management. It is a total approach. One cannot convert to organic production by substituting an "organic" insecticide or adding manure. The system will fail if this approach is taken.

An organic system takes *time to develop*. It may be achieved in stages, for example by starting with organic soil amendments and other soil improving procedures. Then, try biological control of pests, some companion plants, etc. Eventually, the entire system will be changed. It will take YEARS to convert to a healthy organic system.

The Legal Definition of "Organic" - Federal as well as state regulations govern the use of the term "organic" in the marketplace. Vegetables sold as "organic" must be grown and handled in accordance with these regulations. Operations with more than $5,000 gross annual income from sales of organic products must have their production and handling methods certified by an officially recognized organic certification agency. See *Additional Sources* on page 18.

Production and Markets - Organic produce is usually marketed separately from conventionally grown produce in order to be profitably sold. Because of the amount of management and time invested in developing the system, organic produce should bring a premium price compared with non-organic vegetables. In the Midwest, most organic growers usually cannot compete with the volume produced by non-organic growers. Niche or specialty markets, which require lower volumes, will often pay a premium for organic produce. These markets include CSA's (Community and Supported Agriculture), restaurants, roadside stands, and farmers markets. It is ESSENTIAL to thoroughly investigate markets and develop a marketing plan BEFORE you decide what or how much to grow.

Soil Fertility

Organic production relies on fertile, biologically active soil. Fertile soil has a combination of organic matter, acceptable pH, and a balance of plant nutrients suitable for healthy plant growth. Organic matter is maintained and biological activity is promoted by regular additions of organic material to the soil. Examples of organic material include compost,

Table 1. Nutrient composition of some organic and inorganic materials used as fertilizer in percent.†

Material	N	P_2O_5	K_2O	Relative Availability
Organic Materials				
Alfalfa pellets	3	0.5	3	slow
Dried blood	13	2	0.5	medium/rapid
Bone meal (raw)	2-6	15 - 27	0	slow
Bone meal (steamed)	0.5 - 4	18 - 34	0	slow
Compost	1 - 3	0.5 - 1	1 - 2	slow
Compost (fortified blends)	3 - 5	1 - 2	1 - 2	rapid
Fish emulsion	3 - 5	1 - 2	1 - 2	rapid
Manure (fresh) dairy	0.5	0.2	0.5	medium
horse	0.5	0.2	0.5	medium
poultry	1 - 3	1 - 2	0.5 - 2	medium/rapid
Soybean meal	6 - 7	1 - 2	2	slow/medium
Wood ashes	0	1 - 3	3 - 7	rapid
Minerals				
Colloidal phosphate	0	18 - 25*	0	slow
Granite dust	0	0	3 - 5	very slow
Greensand	0	0	4 - 9	very slow
Rock phosphate	0	20 - 32**		slow
Potassium magnesium sulfate	0	0	21 (11 Mg)	rapid
Epsom salts	0	0	0 (10 Mg)	rapid
Dolomitic lime	0	0	0 (6 -14 Mg)	slow

*3% available
** 2% available
† Adapted from Ferro, D.N., ed., 1998-1999 New England Vegetable Management Guide, Univ. of Conn., Univ. of N.H., Univ. of Maine, Univ. of R.I., Univ. of Mass., Univ. of Vermont. Table 8, p. 18.

manure and cover crops. Proper pH is maintained by applying agricultural lime when necessary based on soil test recommendations. A balance of nutrients in adequate supply is maintained by applying nutrient-rich natural materials to supplement nutrients supplied by soil minerals and organic matter. Some organic fertilizer materials are purchased as processed inputs (i.e. fish emulsions); while others may be produced on-farm (for example a legume green manure crop). Examples of materials used in organic production for supplying nutrients are listed in Table 1. The first column lists the material, and the next three columns describe the nutrient content of the material in terms of a standard N-P_2O_5-K_2O fertilizer analysis.

Some natural materials are not acceptable in organic production or are restricted for use in particular ways. For example, the original national rule states that mined muriate of potash (also known as potassium chloride) may be used only in ways that do not lead to a buildup of chloride in the soil. The use of raw (uncomposted) or aged manure is allowed only when the manure is handled in a way to minimize the risks of contaminating food crops with pathogenic organisms and polluting the environment with nitrogen. Typically this means that raw manure may only be applied to a cover crop or to land from which harvest of edible crops will not take place within 4 to 6 months, and only when the soil is warm enough for biological activity to break down the manure. Many certification programs have a list of approved, restricted, and prohibited materials. These lists should be carefully consulted before applying any material to a field which is to be certified organic. Just because a fertilizer product is advertised or labeled as "organic" or "natural" does not mean it will conform to standards set by the National Organic Program.

How much of a supplemental nutrient to apply should be determined based on prior experience of the farmer, observation of plant growth, knowledge of soil characteristics such as organic matter, cation exchange capacity, phosphorus and potassium supplying ability, and base saturation, knowledge of crop needs and field history, and understanding of the nutrient supplying power of the material to be used. An example of nutrient application rates is provided in Table 2. Overapplication can cause problems in crop production as well as in the environment. When excess nitrogen or phosphorus is applied there is potential for pollution of surface and groundwaters. Heavy applications of manure can easily result in overapplication of these nutrients. A regular soil testing program aids the farmer in understanding soil characteristics and monitoring changes over the years. For further information on soil testing, soil characteristics, crop needs, and use of compost and manure as nutrient sources, see the publications listed at the end of this bulletin.

Nitrogen (N) - In organic production, nitrogen is supplied by soil organic matter and additions of high-nitrogen organic materials to the soil. Soil organic matter can supply roughly 20 lb. nitrogen annually for each 1% soil organic matter. High-nitrogen organic materials such as composted manure, legume green manure crops, and soybean meal release additional nitrogen as they decompose in the soil over a period of months to years.

The release of nitrogen from organic matter of any type requires moisture and warmth, because it depends on microbial activity. If it is too dry or too cold for microbes to be active, then little nitrogen is released. In early spring, the

Table 2. Example of nutrient additions to supply approximately 100 lb. N, 25 lb. P_2O_5, 100 lb. K_2O per acre, in addition to nutrients supplied by soil. This example could represent a field which has no history of manure applications, is relatively low in organic matter, has a relatively high level of soil P, and has a moderate level of available soil K.

		Nutrients Supplied to Crop lb./A		
Nutrient Source	Amount Applied	N	P_2O_5	K_2O
Incorporated rye/hairy vetch green manure		80	0	0
Incorporated potassium magnesium sulfate	476 lb./A; 1 lb./100 sq. ft.	0	0	100
Fish emulsion (3-2-2) in transplant water	500 ppm N; 8 oz./plant	0.9	0.6	0.6
Sidedress blood meal	154 lb./A; 0.35 lb./100 sq. ft.	20	3	0.8
Sidedress bone meal	117 lb./A; 0.27 lb./100 sq. ft.	2	21	0
Approx. Total		103	25	101

soil is usually so cold that nitrogen is not released quickly enough from organic matter for optimal growth of vegetable crops. In that situation, using materials which contain nitrogen in a soluble form will improve crop growth.

Materials listed in Table 1 as having rapid availability have some nitrogen in a soluble form. Since these materials are often more expensive than slowly available materials, they are often side-dressed – applied close to the crop, in a band alongside the row, or around individual plants – instead of broadcast across the entire field.

Phosphorus (P_2O_5) - Phosphorus is supplied as phosphate-containing soil minerals and soil organic matter that gradually breaks down, releasing phosphorus for plant uptake. One of the most important factors in determining the availability of phosphorus to plants is the pH of the soil. In mineral soils, phosphorus is most available when pH is between 6 and 7.

Many soils which have received manure or synthetic applications over a number of years contain relatively high levels of soil phosphorus. In soils which have not been so fertilized, phosphorus levels may be low. Rock powders such as colloidal phosphate and rock phosphate can be applied to build up the phosphorus-supplying power of a soil over time. However, these products become available to plants very slowly, and cannot be relied upon to supply adequate phosphorus to a crop the year of application when soil levels of phosphorus are low. They are more efficiently used by incorporating into a compost-making operation where the compost process will make them more available to plants.

Organic fertilizer materials and manure also contain phosphorus, which is made available as the materials decompose in the soil. Bone meal has a relatively high concentration of available phosphorus compared to other organic fertilizers, and poultry manure has a higher concentration of phosphorus than other manures (see Table 1).

As with nitrogen, when cool temperatures limit decomposition of organic matter in the early spring, phosphorus may not be readily available to vegetable crops. This problem is compounded because root growth is slow when temperatures are low. Even in soils which have high levels of phosphorus, it can be helpful to sidedress with a material high in available phosphorus early in the season.

Potassium (K) - Potassium becomes available to plants by the gradual breakdown of soil minerals and clays. Rock powders such as granite dust and greensand contain 1-7% potash (K_2O) but they break down very slowly and are of little fertilizer value. Potassium magnesium sulfate (langbeinite) and potassium sulfate provide K in a readily-available form. These materials both supply sulfur and the former supplies magnesium, both essential plant nutrients. Compost and manure are other sources of readily-available K.

Secondary Nutrients - Calcium, magnesium, and sulfur are often in adequate supply in the soil. If the pH is in the desired range, calcium levels usually are adequate. The most common calcium source is agricultural limestone, which also raises the soil pH. Magnesium is supplied by break down of soil minerals. If soil tests or plant response suggest a deficiency, it can be supplied from sulfate of potash magnesia, magnesium sulfate (epsom salts), or, if an increase in soil pH is desirable, dolomitic lime. Sulfur becomes available as organic matter decomposes and as soil minerals break down. Subsoils often contain higher levels of sulfur which can be tapped into by growing deep-rooted crops or cover crops. When soil levels of sulfur are inadequate, potassium magnesium sulfate, potassium sulfate, or magnesium sulfate are good sources.

Micronutrients - Mineral nutrients required in smaller amounts than those mentioned in preceding paragraphs are usually in adequate supply when the soil pH is at the desired level. These include manganese, iron, copper, zinc, boron, and molybdenum. If a deficiency is suspected, it is important to have it accurately diagnosed before taking corrective measures. Metal chelates or sulfates, borax, and sodium molybdate are used to correct deficiencies when necessary.

Cover Crops - Important components of soil fertility management in organic production are rotations which include cover crops and/or sod-forming crops. Cover crops are planted for the primary purpose of improving and maintaining soil fertility. Typically they are in the field for less than a year, and often grow during periods when the land would otherwise be left fallow. Sod-forming crops, such as a legume/grass pasture, may grow for several years or more, and may have uses in addition to the soil-building function. Both types of crops add organic matter to the soil, improv-

Cover crops help improve soil fertility and reduce weed growth. In this photo, oilseed rape, bare ground, and winter rye (l to r) are compared.

ing soil fertility. Not only the aboveground portions of the crop, but also the entire root mass is new organic matter which stimulates microbial activity leading to improved soil structure, nutrient-holding capacity, water infiltration, and water-holding capacity. Planted in the late summer or fall, they protect the soil from erosion and leaching of nutrients during winter and early spring.

Legume cover and sod crops, in addition to adding organic matter, add nitrogen to soil. The nitrogen is absorbed from the air by symbiotic bacteria living in the roots of the legume crop, and is transformed by the bacteria into forms usable by plants. Non-legume cover crops do not add plant nutrients to the soil, but they can help to redistribute them from deeper soil. Deep-rooted cover or sod crops can take up nutrients below the root zone of shallow-rooted cash crops, and recycle them into the plow layer when the cover or sod crop is tilled under. Some cover crops, such as winter rye, contain compounds which suppress weed seed germination and growth.

Cover crops may be planted at any time during the year. A late summer or fall seeding is common for winter cover crops such as winter rye, or winter rye/hairy vetch mixture, or spring oats. Spring or summer-planted annual cover crops include sudangrass, sorghum sudangrass, and buckwheat. Buckwheat is particularly useful for areas which are uncropped for short periods of time, since it establishes quickly and can go from seed to seed in less than 8 weeks. Yellow-blossom sweet clover, a deep-rooting biennial, is often planted in spring or summer and left to grow until the following spring. Cover crops may be overseeded or interseeded while a cash crop is still in the ground, if care is taken to provide a good seed bed and moisture. This is often done at the final cultivation.

Species mixtures are often recommended over single-species cover crops or sod crops because the mixtures tend to use resources more fully and provide a more diverse habitat. Except in situations where a legume would not establish well, or where the nitrogen-fixing power of legumes is not desired, at least one legume and one non-legume are recommended.

Some growers establish a sod-forming crop between rows of a cash crop, forming a living mulch which provides soil-improving benefits without taking land totally out of vegetable production. The sod-crop typically must be carefully managed to limit competition with the cash crop for nutrients and water. For example, the low-growing Dutch white clover can be seeded between rows of a tomato crop several weeks after transplanting. Periodic mowing can be used to control its growth. This system has worked best when irrigation is available and the sod crop grows only in a strip between cash crop rows, with an uncropped area between the sod and the cash crop.

Seeds and Transplants

Seeds and transplants should be produced using organic methods. Greenhouse grown transplants are usually grown in a peat- or compost-based growing medium. Some growers use commercially available products, while others mix their own. Many commercial products contain synthetic fertilizers and/or synthetic wetting agents that are not allowed by national organic standards; these should be avoided. Growers who mix their own growing medium usually experiment with different recipes over several years to develop one that works well for them. A sample recipe is provided below. If composted materials are used, it is important that they be fully composted, because incompletely composted materials will continue to compost and may temporarily deplete nitrogen in the growing medium. Whether the growing medium is purchased or mixed on the farm, it is wise to have it tested for pH, soluble salts content (also called electrical conductivity), and major nutrients (N, P, K, Ca, Mg) before seeding. This service is provided by commercial soil testing labs as well as many companies that produce growing media. The Greenhouse Media Analysis Lab of Purdue University also tests greenhouse media (see below).

The media samples should be representative of the crop or problem you wish to analyze. The sample should be collected from top to bottom of the growing container so the entire root zone is included. At least a cup of medium is needed for a proper analysis. The samples should be mailed in a plastic bag. New media should be wetted to field or container capacity before mailing. Contact the Media Analysis Lab for details.

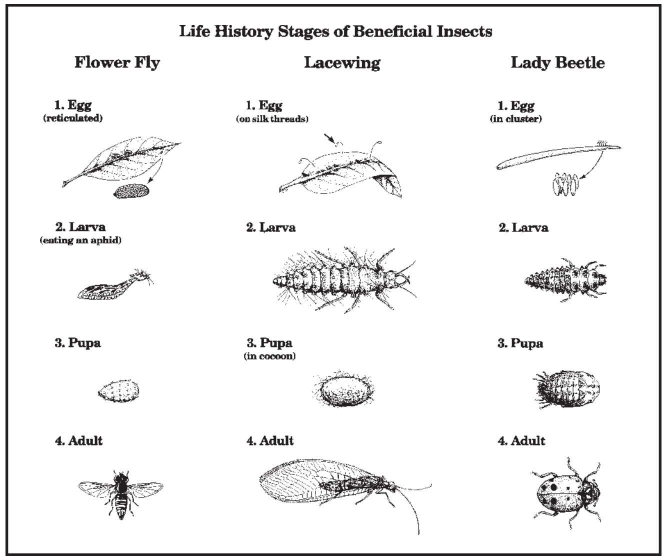

Figure 1. Common Natural Enemies

Purdue Greenhouse Media Analysis Lab
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Transplants will usually require fertilization after a couple of weeks. Observations of plant growth combined with knowledge of nutrients available in the growing medium before planting, and nutrients available in applied materials should be the growers' guide to fertilizing transplants. We have had success with weekly applications of fish emulsion (analysis 3-2-2) at a rate of 250 to 500 ppm N (2 to 4 tablespoons/gallon), applied to the growing medium with the irrigation water. Other practices include using magnesium sulfate or extracts of plant compost or seaweed.

Keeping transplants healthy requires attention to the greenhouse physical environment (light, temperature, air quality, and humidity), growing medium (moisture content, pH, nutrient status), and sanitation. Refer to Purdue Extension Publication BP-61 for more details.

Potting Mix Recipe

1 part peat, 1 part compost, 1 part vermiculite or perlite per 25 gallons finished product, mix in 1.5 cups each of superfine dolomitic, blood meal, bone meal and greensand.

Safety

The safety of the applicator is just as important with the application of organically approved pesticides as it is with conventional pesticides. Organic pesticides, although they may be the result of natural processes, can be health hazards if used improperly. Research the chemicals you plan to use carefully for possible health hazards. Read the label of each product carefully and follow the precautions listed there. Always wear the protective clothing called for in the label. Double check the calibration to make certain the proper amount is applied.

Insect Management

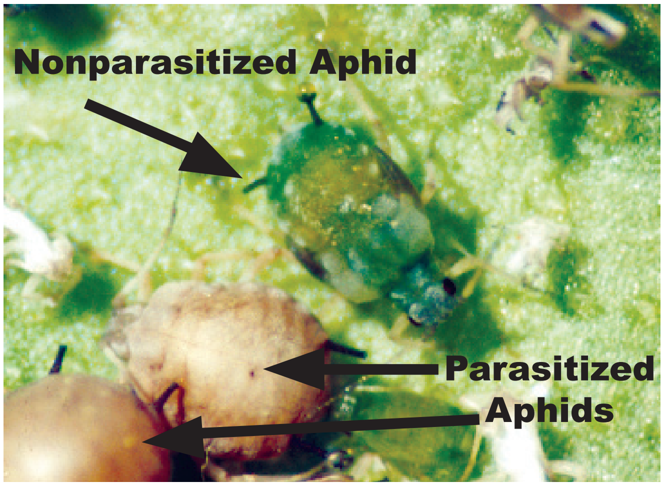
In organic systems, insect pests are managed preventively rather than curatively. The idea is to alter the system so that pests do not find the plants, are controlled by natural enemies, or their damage is kept to a minimum. Insect management is also dependent upon having a healthy organic system. This includes a proper balance of nutrients in the soil and in the plant. Plants that are vigorous have a much better ability to withstand damage caused by insects and disease. Healthy soil and plants, therefore, are the best defense. Table 3 (at the end of this publication) gives information on pests and which of the following management systems might work best in their control.

This section describes the general principles of insect pest management in organic production. For more information regarding the efficiency of specific practices, refer to Table 3.

Biological Control - In organic systems, much of the "control" of insect pests is by natural enemies. These natural enemies can be broken into two major categories: predators and parasitoids. Predators catch and eat their prey much like wolves or other carnivores. There are several predator species commonly found in gardens (Figure 1). Lady beetles are oval and usually red, orange, or yellow with black spots. Lady beetle eggs, laid in groups of 5-20, are oblong and orangish/yellow. Eggs are almost always laid near some prey, so that when the eggs hatch, larvae will have a food source. Larvae are alligator-shaped and are black with yellow or orange spots. Lacewings are green or brown and have iridescent eyes of green or gold. Their wings have many veins and, as their name implies, appear lacey. Immatures are alligator-shaped and have long sickle-like mouthparts that they use to impale their prey and suck out juices. Lacewing eggs are laid near prey and on the ends of silk threads. Another common predator is the syrphid fly (flower fly). The adult syrphid has two wings and therefore is a fly, but resembles a bee with its black and gold stripes. The immature is a maggot, which feeds on aphids and other soft-bodied insects. The adult is called a "flower" or "hover fly" and it feeds on nectar and pollen. Other less commonly seen predators are minute pirate bugs, big-eyed bugs, assassin bugs, certain stinkbugs, spiders, and soldier beetles.

Some predators spend most of their time on the ground, and climb plants at night to search for prey. The most common of these are the carabids or ground beetles. These are dark-colored, sometimes shiny iridescent beetles that run rapidly along the ground when disturbed. The adults eat many types of things, which is a benefit because these predators will be present even if there are few pests. The immatures of carabid and staphylinid (another group of predators found in the soil) beetles are predaceous and feed almost exclusively on other insects such as caterpillars. Other predators found in the soil are centipedes, and wolf, garden, and jumping spiders.

The other group of natural enemies is parasitoids (or parasites). These are adult insects that usually do not eat their prey, instead they lay their eggs on or in the host (insect) such as a caterpillar, and when the eggs hatch, immatures use the host as food. Some parasitoids are very specific in selection, while others are more general. Many parasitoids are relatively small wasps that will be seldom seen, but the results can be detected if one knows what to look for. For instance, parasitic wasps often attack aphids and other sucking insects resulting in mummified prey. A parasitized aphid will be about two times its normal size and be brownish-tan. The parasitized aphid will not move. If there is no hole in the parasitized aphid, the wasp is still inside. The immature wasp completes its development within the mummified aphid, until it emerges, leaving a hole in the parasitized pest. If mummified aphids are present on a leaf that is infested with aphids, no action should be taken.



If mummified aphids are present on a leaf with aphids, no action should be taken.

Tachinid flies are another group of common parasitoids. These flies look like large houseflies and lay their white, oval eggs on the backs of caterpillars and other pests. The eggs hatch and the fly larvae enter and kill the caterpillar.

John Obermeyer

The white, oval eggs on the back of this caterpillar are signs of a tachinid fly parasitoid.

Two other types of natural enemies are birds and bats. Birds will eat a variety of pests and some beneficial insects too, as will bats. Attracting birds to your farm is possible, but a large scale (larger than just a vegetable field) is usually necessary – see Farmscaping (p. 8). Bats can be encouraged to roost nearby by putting up bat houses or being sure not to disturb a nearby colony.

In the field it should NOT be necessary to purchase these various biocontrol agents. All of these natural enemies are quite common in the Midwest. A grower just needs to know how to invite and keep these biocontrol agents in their system. If they are not present in your field, it could mean that environmental conditions are not conducive to their presence and purchasing them would not help, as once they were released they would leave the area. Purchase of biocontrol agents does however, make good sense in greenhouse situations where the beneficial insects can be contained.

Since many adult predators and parasitoids feed on nectar and pollen, it is essential to have these resources nearby. A variety of plants will be more effective than a single species. An example would be several types of clover (red, crimson, sweet, white, etc.) along with more traditional flowers like marigolds, zinnias, etc. The objective is to have a continuous nectar and pollen source throughout the season. The closer these flowering plants are to the vegetables the more often the vegetable plants will be searched by the parasitoids or predators. In addition to natural enemies, flowering plants will attract a wide variety of pollinators such as honeybees, bumble bees, wasps, and butterflies.

Creating a diverse environment of flowers and vegetables favors parasitoids, predators, and insect diseases over pests.

Organic mulch, such as straw and grass clippings not only acts as a weed barrier, but as it decays, the mulch becomes a haven for soil predators such as carabid and staphylinid beetles, spiders, and centipedes. Therefore, mulching should be encouraged in the field whenever possible, but not too early in the year when the soil is cold and damp. This could lead to additional pest problems. Wait until the soil warms to approximately 70°F at a 4 inch depth before mulching. With nectar/pollen sources and mulch available throughout the growing season, natural enemies should be present in numbers sufficient to handle most potential pest problems.

Another biocontrol is insect diseases (**or microbial controls**). There are fungi, viruses, bacteria, and nematodes that attack insects and help keep their populations under control. Moist conditions are usually necessary for most of these to work, especially fungal pathogens. Insect populations often need to be at fairly high numbers (numbers too high to be tolerated in the field) before the diseases spread efficiently. There are a few commercial products that contain these microbial organisms. These products will be discussed in the "organic insecticides" section. In very dry years, the pathogens will not work as well as they should and there could be an explosion of some pests like grasshoppers or hornworms.

Companion Planting (Intercropping) - In natural systems (especially old field) there is always a variety of plant species. However, in the vegetable garden we abandon this companion planting scheme and make our vegetables mini-monocultures. There has been much said and written about the insect repellent properties of certain plant combinations, but there is little experimental evidence demonstrating their efficiency. For example, marigolds are supposed to have many insect repellent properties, but in our studies, we found no difference in the number of pests on cabbage or tomatoes when marigolds were present vs. when they were not. The key to mixing plants is usually NOT the repelling action per se, but the plants contrasting "desirability" to the pest. In a complex system where plants are mixed, insect pests spend a great deal of time moving from plant to plant looking for the right one instead of eating. When they are moving, the pests are much more vulnerable to natural enemies and diseases. Companion plantings should be chosen so they 1) will not interfere with one another's growth and 2) are from different groups so that the pest cannot utilize both of the plant types present. For example, flea beetles can feed on many members of the solanaceae family, so peppers or tomatoes would be poor companion plants. Herbs make good companion plants, as most insects do not like their taste. Beans (dry or snap) would also work as a companion plant with eggplant.

Farmscaping - Just as you can mix plants in your vegetable field you can also plan your entire farm for positive interactions of plants. For example, to attract birds to your farm grow a border (or an area of your farm) that has fruiting trees and shrubs in it. The larger the area the better, but even a narrow border will help. A portion of the farm may be left to a natural area of diverse plants that flower at different times, have different growth patterns, and different light needs. Another possibility would be to plant native Midwestern plants (example of some natives: *Ascelepias tuberosa* L butterfly milkweed, *Echinacea purpurea* Monench. – purple coneflower, *Helianthus tuberosu*s L – Jerusalem artichoke, etc.) around the farm. When compared with bedding plants, native plants attract more natural enemies and require less care.

Organic mulches help control weeds and provide an excellent habitat for soil predators.

Timing of Plantings - Sometimes pests will cycle, peaking at certain times of the summer or be present at only one time. Knowing when this occurs can allow you to plant earlier or later to avoid pests. For example, the adult seed corn maggot lays eggs in cool, moist soil, so by delaying planting until the soil warms you could avoid the problem entirely. Sweet corn has greater numbers of corn earworms the later it is planted in the season. Peppers rarely have worm damage (mostly due to European corn borer) until late in the season (late August or September).

Trap crops - These crops are used to lure a particular pest away from a more important crop. The trap crop is usually considered expendable and is usually destroyed once it is heavily infested. If it does not become heavily infested and retains most of the pests that visit it, then it can be left in the field. An example would be using Hubbard Squash to attract squash vine borer and striped cucumber beetle away from watermelon, pumpkin, or cantaloupe plantings. Corn (sweet or field) before silking will attract European cornborer from plantings of pepper and earworms (fruitworms) from tomatoes**.**

Sticky traps, which attract and trap insects, are an example of mechanical control.

Mechanical Controls **-** These include barriers and physical controls. A mechanical barrier is anything that physically prevents the pest from reaching the crop. The most common barrier is row cover. The most common row cover is REMAY®, which is spun-bound polyester; another material is cheesecloth. The barrier can be laid directly on plants or supported above plants with wire or other supports. Other barriers could include plastic or metal cylinders (e.g., metal soup cans with the top and bottom removed, plastic milk jugs with bottom cut out) surrounding small plants to protect them from cutworm or armyworm feeding. As an example, the first 12 inches of the base of pumpkin or squash plants could be wrapped with aluminum foil or an old stocking to stop squash vineborers from laying eggs in this area. Copper strips around plants (like strawberries) can stop slugs or snails from crossing over the strip. When slugs touch the copper strip they receive a small shock which keeps them from moving any further. Traps also are types of barriers that attract insects to them and then hold them. Sticky cards, usually yellow, can be placed in a row to collect flies or moths. Removal of pests by picking them off by hand or any other method (e.g., strong water spray) or by removing the entire infested plant from the field is one of the oldest and most basic of insect controls. This can work well on a few plants, but it takes time, patience, and perseverance, and when there are a lot of plants this method is not cost effective.

Cultural Controls **-** These include those already discussed such as trap crops, inter-planting a companion crop, using organic or non-organic mulches, proper fertilization and watering. By using **rotation** of crops, following one crop that is not closely related to another (e.g., corn or legumes following tomatoes or crucifers) growers can disrupt disease and insect life cycles. **Sanitation** includes cleaning up, tilling under or composting crops that have been harvested for the last time to stop insect pests from building their population. Broccoli or cauliflower should be removed completely once harvest is over to stop cabbage worms from using the plants as a nursery. Destroy all potatoes and volunteers after harvest to cut down on Colorado potato beetle food sources before they go into hibernation.

When these biological or cultural controls do not work, and at times they won't, then the grower has to make more immediate management decisions to stop the pest. This is when organic pesticides may be used.

Organic Pesticides are products usually made from plants that control insects by killing, repelling, or disrupting their life cycle. Because of differences in certifying agencies, it is best to check on the status of the following "organic pesticides" to see if they are allowed, restricted, or prohibited for use in your organic system. Some organic products may contain unacceptable additions to them so that even though the active ingredient is allowed the other chemicals are not. **Check labels and your certifying agency before using.**

There are several types of organic pesticides available to the organic grower.

Bacillus thuringiensis ***(***Bt) is a soil bacterium that when ingested destroys the stomach of certain insects (caterpillars, immature Colorado potato beetles, mosquito larvae, and maggots). Insects quickly stop feeding but take a few days to die. There are several types (subspecies) of Bt – *Bt kurstaki*, *Bt aizawai* (trade names: Agree, Biobit, Design, Foray, Dipel, Javelin, Thuricide, Xen Tari), that work well on many caterpillars, loopers, hornworms, and bagworms. *Bt israelensis* (Bactimos, Gnatrol, Vectobac) is effective against fly larvae such as mosquitoes and fungus gnats; *Bt tenebrionis* (Novador) is most effective against small Colorado potato beetle larvae. Bt products work best on small larvae and ONLY on those that are chewing. Sucking insects such as aphids and plant bugs are NOT affected by Bt. Larvae need to feed on the plant somewhat to ingest enough Bt to die. Bt will last only a few days on plant leaves and will need to be applied 2-3 times over an 8 day period for best control. Bt is one of the most effective organic insecticides. Most certifying agencies will not allow liquid forms of Bt containing xylene or petroleum distillates. Bt will not harm predators, parasitoids, or mammals. We have had very good success with Bt for certain pests (See Table 3).

Pyrethrums are found in chrysanthemum flowers. Pyrethrums are essentially nontoxic to mammals and are fast acting in insects. As with Rotenone, pyrethrums are highly unstable in light, moisture or air and therefore, do not last very long on plants, (1-2 days). Pyrethrum acts on contact on a broad spectrum of insects, which includes predators and parasitoids. In our studies, it had moderate success in controlling pests (Table 3).

Rotenone (Derris, cube, timbo) is derived usually from tropical plants (*Derris malaccenis* and *elliptica*), although a native weed (devils shoestring – *Tephrosia virginiana*) also contains some rotenone. It is usually sold as a powder, but there are some liquid formulations. Be careful not to buy any rotenone that has been adulterated with synthetic chemicals (Piperonyl Butoxide (PBO) is not allowed by most organic certification agencies). Rotenone acts as a stomach or contact poison on a broad spectrum of insects, including predators and parasitoids too. It is very toxic to fish. In our studies, it had moderate success in controlling some pests (See Table 3). As with pyrethrums, rotenone products are relatively unstable.

Insecticidal Soaps (Ringers, M-pede, Safer's Soap) are potassium salts of fatty acids that work by dehydrating insects by breaking down the waterproof covering on their bodies. It works best on soft-bodied insects such as aphids and mealy bugs, and also mites. In our studies, it had little overall success in controlling pests in the field, but can work fairly well if only a few plants are moderately infested with aphids. However, it does not work well on mites (See Table 3).

Diatomaceous earth is composed of microscopic organisms (diatoms) that are made of silica (these organisms are no longer alive). Because they have hard pointy bodies, diatoms abrade the outer covering of an insect's exoskeleton and cause the insect to dehydrate and die. Diatomaceous earth works best on soft-bodied insects. It is difficult to get the material to the pests, as most soft-bodied insects are on the underside of leaves. We have had little success with this product under field conditions.

Azadirachtin (Margosan-O, Neemix, Azatin) is the active ingredient from the neem tree. It can act as a repellent (although in our studies, we have seen little evidence of this) and a growth regulator. Small larvae should be targeted. In our studies, neem has worked well when applied for control of small worms or small sucking insects. For best control, applications need to be made every three days. Neem does not work well on adults or large larvae (large caterpillars).

Entomophagous nematodes (*Steinernema riobravis, S. carpocapsae*) (Biovector) are soil nematodes that attack and kill soil insects (e.g., grubs, borers, etc.). Good timing of these nematodes is essential if they are to work. They can be some-what effective, but environmental conditions, stage of pest, initial infestation rate, etc. will affect how well they work.

Beauveria bassiana (Bb) is a fungus that attacks insects. As an insecticide, it has been concentrated so that it can be sprayed on insects to induce infection. It works best on young immatures – small caterpillars or nymphs under humid (> 70% relative humidity) conditions. It does not work well on adults or large immatures.

Suffocating oils or horticultural oils are used either when plants are dormant (dormant oils), or when plants are actively growing (summer oils). They are usually used on woody plants for control of aphids, mites, whiteflies, and thrips. Under some circumstances, oils can burn foliage such as on cloudy, humid days. Plant-based oils are best; petroleum oils are restricted by most certifying agencies. Be sure to check before using.

There are several plant extracts used to repel insects (such as hot pepper wax, garlic spray, citrus oil, etc.). Our studies and others have found they work poorly if at all, and we generally do not recommend them.

Disease Management

Diseases can be very difficult to control in organic systems. Once a disease is present and the environmental conditions favor disease, there is little an organic grower can do. Therefore it is best to be proactive. The following items are important to understanding Table 4 on plant disease management.

The tomato leaves shown are heavily infected with the disease early blight. Organic growers have limited resources to combat heavy infections, therefore preventative steps such as crop rotation and tillage are critical to prevent severe disease outbreaks.

Crop Rotation - Many disease-causing microorganisms (**pathogens**) can survive in plant debris. When one plants a specific crop year after year in the same soil, the pathogens can build up to high levels. Crop rotation allows the plant debris to decay and the associated pathogens to die out. If pathogens survive in the soil itself, crop rotations will have to be longer. Growers should rotate from the crop in question to a crop in another family. For example, after growing tomatoes, one should avoid tomatoes, potatoes, peppers, and eggplants for the length of the rotation. Whether crop rotation is effective or not and the length of crop rotation required are listed under each crop/disease combination. If the table lists two years, plant a different crop for two years before planting the original crop again (Table 4).

Tillage - Decay of plant debris can be hastened by tilling the debris into the soil. The sooner the plant debris is buried, the sooner decay starts and the pathogens die out. Therefore, it is often wise to till a field in the fall. The deeper the debris is buried, the better. Moldboard plowing may be advisable.

To avoid soil erosion, a cover crop can be planted over the winter. Alternatively, some growers may want to remove plant debris and compost it. In such cases it is critical to remove roots as well as tops and make sure the compost becomes hot enough to kill the plant pathogens that may be present. Whether tillage is likely to be effective or not is listed under each crop/disease combination (Table 4). As a general rule, composting will not be effective unless plant parts can no longer be recognized.

Resistant Varieties are an organic grower's best friend. If at all possible, use resistant varieties to avoid disease problems in the first place. Some varieties are listed as partially resistant or tolerant. Whereas resistant varieties show very few symptoms of the disease, **partially resistant varieties** may show symptoms, but yield is unaffected. Growers should note that some varieties are resistant to only certain races of a pathogen. Find out what races of a pathogen are in your area by asking your seed representative or Purdue Extension educator. Unfortunately, resistant varieties are not available for all situations. In addition, varieties that are resistant may lack desirable horticultural characteristics or consumer preference. The availability of resistant varieties is listed under each crop/disease combination (Table 4).

Saving Seed - It may be tempting to save seed from your favorite varieties for use in future years. All vegetable growers should realize, however, that there are certain dangers to saving seed. Many diseases can be seed borne. This means that a disease that was present in the plant can be carried in the seed and thus may cause disease problems when planted. In addition to plant disease problems, saved seed may not have the characteristics of the original variety. Saving vegetable seeds requires special skills and equipment.

Other Remedies - Organic growers may spray certain substances as a treatment for plant disease. Such treatments are targeted at foliar diseases and are ineffective in controlling root diseases. Depending on the organic certification process, such chemicals may include copper, bicarbonate salts, and polymer films. Copper and polymer films leave some residue on the leaves and therefore may be used as a preventative treatment. These chemicals should be applied on a weekly basis during the time diseases threaten. Salts of bicarbonate, however, cannot be used as a preventative treatment. Substances such as ammonium or sodium or potassium bicarbonate may have a toxic activity on fungi existing on the leaf. A concentration of one of these bicarbonate substances at 0.5% (weight to volume) or less should not have any phytotoxic effects.

Weed Management

Organic growers manage weeds using a combination of methods. The mix of weed species in a field changes in response to the cropping practices used over a period of years; the weed species and types most adapted to the practices in use will increase in number, and those poorly adapted will decrease. As organic practices are adopted, the mix of weed species will probably change; weeds that were difficult to control will become manageable, and weeds hardly noticed before will become the problem weeds. The more diverse the weed management program, the better chance that no weed will be well-adapted to it.

Attention to timing is critical for successful weed management. In most cases, the smaller the weed, the easier it is to control. Some cultivation tools work well only on very small weeds, others can kill larger weeds as well. The timing of control in relation to crop growth is also important. Most vegetable crops show little yield loss if kept weed-free from 3 to 6 weeks after planting. Those weeds that emerge soon after the crop is planted are likely to reduce yield. Make controlling such weeds a priority. Late-emerging weeds may need to be controlled to prevent additions of seed to the soil, to ease harvest operations, or for appearance. Strategies, practices, and technologies which aid in weed control are included below.

These watermelon varieties differ in susceptibility to Fusarium wilt. Organic growers should choose resistant/tolerant varieties whenever possible.

Prevention - Minimize weed seed additions to the soil. Weed seeds can live for many years in the soil, but some buried seeds die or are eaten every year. If the addition of weed seeds can be avoided, the number of viable weed seeds decreases and it will be easier to control the remaining weeds. This really can make a difference. Weeds that have escaped early season weed control measures and are about to flower, or have flowered, should be killed and, if they have flowered, removed from the field to prevent maturation and dispersal of the seed back into the field. Weeds can also be brought into a field in manure, compost, hay, straw, animal feed, and other material. Whenever you apply something to a field, make an effort to learn whether there are weed seeds present, and evaluate benefits of the material versus potential for causing a weed problem.

Cover Cropping - Plant cover crops to compete with weeds. A fallow field grown up to weeds is a source of weed seed for itself and the rest of the farm. A cover crop instead of a fallow, will reduce weed growth by competing for light and nutrients, thereby reducing weed seed production.

Flame Weeding - A hot flame passed quickly over small broadleaf weeds provides a one-time kill of emerged seedlings. Equipment designed for field use can be purchased. Flame weeding can be performed after planting but before crop emergence, to kill weeds that germinate before the crop. This is particularly useful in crops which take a long time to emerge, such as carrots. After crop emergence, directed flaming can be used to selectively kill small weeds in certain crops such as sweet corn, onions, and potatoes.

An advantage to flame weeding over cultivation is that it does not disturb the soil, and so does not stimulate germination of additional dormant weed seeds.

Stale Seedbed - A stale seedbed is prepared several weeks to months prior to crop seeding, weeds are allowed to emerge, and they are killed while still small by very shallow cultivation, flame weeding, or other non-selective method. Depending on the length of time before planting, one or more flushes of weeds may emerge and be killed between seedbed preparation and planting. The final kill should occur as close to the planting date as possible. This technique reduces the number of weeds that germinate after the crop is planted. Its success depends on the weed spectrum and the timing of planting. It has proven useful in reducing populations of summer annual broadleaves such as lambsquarters and pigweed.

Cultivation is an important part of weed control.

Cultivation - Cultivate using mechanical and hand tools designed for the particular crop and weed stage. For more information on cultivating equipment, see the resources listed at the end of this publication.

Crop Rotation - Rotate crops and planting dates to disrupt weed life cycles. Summer annual weeds such as pigweed and nightshade will do best in crops which are planted about the same time as these weeds normally germinate, such as the warm season crops of peppers, tomatoes, etc. Winter annual weeds such as shepherdspurse and pepperweed will thrive in crops planted in late summer or fall. Perennial weeds such as Canada thistle or bindweed are well-adapted to perennial crops, such as a sod crop, or untilled fields, such as no-till operations. Organic growers can plan rotations so that a weed species favored in one year will not be favored in another year.

Mulching - Mulch is a material covering the soil surface. To control weeds, the mulch must block nearly all the light that reaches the soil, so that weeds which emerge underneath the mulch do not have enough light to survive. Non-degradable black plastic mulch and wavelength selective mulches are acceptable in some organic programs, provided the mulch is completely removed from the field at the end of the season. Mulches of organic material such as straw, paper, newspaper, and cardboard, or killed cover crop, are effective if they block sufficient light. Using mulch in combination with no-till planting of vegetables into undisturbed soil has looked promising in a number of trials. For example, people are experimenting with no-till planting into a killed winter rye cover crop. In addition to controlling weeds, plastic and organic mulches influence other aspects of the system. Black mulch, and to a greater extent, Infra Red Transmitting (IRT) mulch, increase soil temperature, which speeds growth of warm season crops, leading to earlier and sometimes higher total yield. Organic mulches typically decrease the soil temperature. This lower temperature can delay warm season crops, if mulches are applied before the soil has warmed up. It can also provide a better environment for cool season crops during the summer months. Organic mulches which have a high carbon to nitrogen ratio such as straw, paper, or cardboard, may reduce the amount of nitrogen available to the plant as they begin to decompose. Additions of nitrogen-rich organic fertilizers may be needed to overcome this problem. Mulches provide additional benefits, including keeping the crop clean, reducing loss of soil moisture to evaporation, and (if organic) adding organic matter to the soil.

Mowing - Mowing can reduce competition and seed production. Most weeds will regrow after mowing and so repeated mowing is necessary to be most effective. As with any practice, weeds species adapted to mowing will increase in number if it is practiced repeatedly over a number of years.

Living Mulches - See the soil fertility section for a discussion of living mulches. Once established, a living mulch can compete with weeds and reduce weed seed production. An unmanaged living mulch can have much the same effect on a crop as weeds, competing for light, water, and nutrients, and reducing yield.

Biological Diversity - Encourage biological activity to reduce weed seed survival. Weed seeds are eaten by a variety of soil organisms, attacked by microbes, and eaten by insects, rodents and birds. The more biological activity in the soil and environment, the fewer weed seeds will be left to germinate. Practices such as adding organic matter to the soil, using organic mulches, rotating crops, planting a variety of crops, and cultivating diversity along field edges all promote biological activity.

ORGANIC INSECT MANAGEMENT

Table 3. This table will help in making decisions on how best to control some of the more common pests in organic vegetables. Pick a procedure that works best in your management system.

				Possible Management Procedures[5]					
Vegetable[1]	Pest[2]	When[3] Present	Damage[4] Type	Biocontrol	Mechanical Control	Timing	Cultural	Organic Pesticides	Comments
Asparagus	Asparagus* Beetle (Common)	May - Aug	Feeding on ferns by larvae, eggs laid in spear heads.	Parasitic Wasp important as are ladybugs.	Pick off eggs & larvae.	Not very effective	Clean cultivation around ferns.	Neem has some effect on larvae, but not adults.	Be sure it is the common asp. beetle - blue & brown with cream-colored spots. IT IS A PEST! The spotted asp. beetle is orange with black spots and is usually **NOT** a PEST!
	Asparagus Aphids	July - Aug	Worse in new plantings, injects toxin causing witch's broom.	Not very effective	Not very effective	Not very effective	Pick most spears in spring - spears left will propagate aphids.	Insecticidal Soaps	
	Plant Bugs	July - Aug	Injects toxin into plant causing die back - tip wilts and dies - mature fern not affected.	Not very effective	Not very effective	Not very effective	Eliminate weeds around the field that harbor plant bugs.	Not very effective	
Crucifers Broccoli Brussel Sprouts Cabbage Cauliflower Collards Kale Kohlrabi Radish Turnip	Root Maggots	Apr through mid-June	Tunnels into root and stem.	Not very effective	Row cover	Later planting	Plow under residue.	Not effective	Later plantings may not be feasible. Must consider root maggots with earlier planting.
	Flea Beetles	Apr - June	Shot-hole feeding on leaves by adults on small plants.	Not very effective	Row cover	Earlier planting	Remove weeds, interplant tomatoes, plow residue.	Not very effective	
	Cabbage Worms* (imported cabbage worm, diamond-back moth, cabbage looper)	Apr - Sept	Small and large holes in leaves can defoliate any size plants	Very important, but usually not enough to completely control.	Row cover Pick off larvae.	Earlier planting	Plow under residue.	Bt very effective, Neem and Bt work well if used early.	
	Aphids, Thrips (sporadic pests)	Apr - Sept	Sucks plant juices, can kill small plants, rasping leaf surface.	High amounts, usually enough to control aphids.	Not very effective	Not very effective	Cover crop between rows. Do NOT plant near grains!	Soaps (if used early).	
Cucurbits Cantaloupe Cucumber Gourds Muskmelon Pumpkin Squash -summer -winter -acorn Watermelon	Root Maggots	Apr - early May	Tunnels into root & stem.	Not very effective	Row cover until mid-May.	Later planting (mid-May or mid-June)	Plow under organic matter or manure 3-4 weeks before planting.	Not very effective	Cucumber & muskmelon are very susceptible to bacterial wilt. Squash & pumpkin are somewhat susceptible to bacterial wilt up to 4-leaf stage, while watermelon is almost immune. Must rotate squash & pump-kin at least 1/2 mi. away from any other squash crop from previous year.
	Cucumber Beetles*	Apr - May	Feeding on leaves. Transmits bacterial wilt.	Not very effective	Row cover until flowering	Later plant-ing of muskmelon & cucumber.	Trap crops possible.	Not very effective	
	Aphids & Mites	Apr - Aug July - Sept	Aphids suck juices & leave sticky honey dew behind. Mites cause yellowing between veins.	Very important, look for mummified aphids, ladybugs, lacewings, and syrphids	Not very effective	Not very effective	Do not allow plants to become water stressed, high humidity helps keep pests down.	Very few work well. Possibly insecticidal soaps.	

ORGANIC INSECT MANAGEMENT

Table 3. (Continued)

				Possible Management Procedures[5]					
Vegetable[1]	Pest[2]	When[3] Present	Damage[4] Type	Biocontrol	Mechanical Control	Timing	Cultural	Organic Pesticides	Comments
Cucurbits	Squash Vine Borer* (Pumpkin & Squash)	June - Aug	Boring into stem causing wilting symptoms.	Somewhat important but not enough.	Splitting & burying stems is not effective - most eggs laid at base of plant.	Later planting in early June will help.	ROTATION is BEST! Trap crops of Hubbard squash will attract SVB from plants.	Bt or Neem at base of plant 3 weeks after planting - repeat every 5 days for 3 weeks.	Protect the base of the plant for several weeks.
Leafy Crops -Lettuces Romain Leaf Red Endive Escarole Radicchio Spinach Swiss Chard	Leafhoppers	May - Aug	Leaf sucking - Transmits Yellows disease.	Not effective	Row cover, traps	Not effective	Eliminate any crops that act as a host after Yellows disease.	Not effective	Leafhoppers are usually not a pest, but can be if numbers get large enough.
	Caterpillars	May - Sept	Leaf feeding.	Important	Row cover	Not very effective	Compost or plow under crop when done.	Bt effective	
	Aphids	Apr - Aug	Sucking plant juice, honeydew.	Important, but in cool weather biocontrol agents can't keep up with aphid population.	Row cover	Not very effective	Use of reflective mulch - keeps aphids from landing.	Insecticidal soaps somewhat effective.	
Legumes Broad bean Field Pea Lima Bean Pea Pod-edible peas Snap Bean Sweet Pea	Potato Leafhopper	June - Aug	Sucking, veins & leaves turn yellow & curl. Hopperburn is worst in seedling.	Not very effective	Not very effective	Early planting. Plant be-fore leaf-hoppers in large numbers.	Not very effective	Rotenone or Pyrethrin	Hopperburn is caused when leafhoppers inject toxins into plant. When present, Bean leaf beetle and Mexican bean beetle can devastate a planting. Before flowering, you need 50% defoliation before yield loss. After flowering, you need 15-20% defoliation before yield loss.
	Bean Leaf* and Blister Beetle	May - mid July	Chew small and large holes in leaves.	Somewhat	Pick off	Not very effective	Not very effective	Same as above.	
	Earworm	June - Aug	Chew large holes in leaves.	Important	Pick off	Not very effective	Plant corn nearby to lure ECB & earworm away.	Bt & Neem on young larvae.	
	Mexican Beetle	June - Aug	Lacey defoliation on underside of leaves.	Important	Pick off	Avoid early plantings.	Not very effective	Not very effective	
	Looper (Caterpillar)	June - Sept	Feeding on leaves and pods.	Important	Pick off	Not very effective	Little effect	Bt, Neem, and Bb	
	Stinkbug	May - Sept	Sucking juices from the plant.	Not very effective	Not very effective	Not very effective	Not very effective	Not very effective	
	European Corn Borer	May - Sept	Leaf feeding, bore into stem or beans.	Not very effective	Not very effective	Not very effective	Not very effective	Rotenone, Pyrethrin	
	Pea Aphid	June - Aug	Sucking plant juice honeydew production.	Very Important (esp. fungal diseases)	Not very effective	Not very effective	Not very effective	Not very effective	

ORGANIC INSECT MANAGEMENT

Table 3. (Continued)

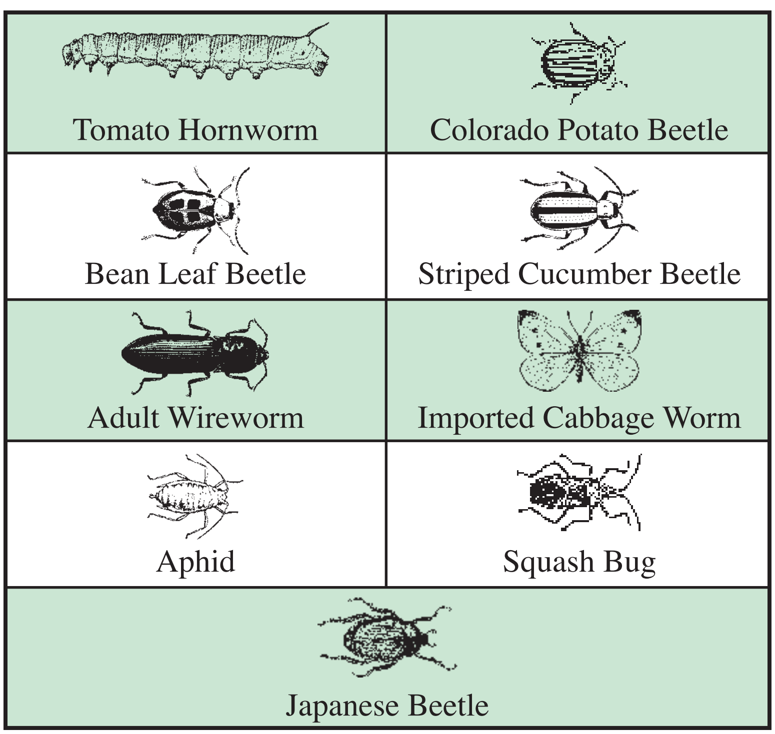
				Possible Management Procedures[5]					
Vegetable[1]	Pest[2]	When[3] Present	Damage[4] Type	Biocontrol	Mechanical Control	Timing	Cultural	Organic Pesticides	Comments
Onions Sweet Dry Bulb	Onion Maggot	May - Sept	Maggots feed on bulbs. Adults are attracted to damaged onions.	Somewhat - but at times not enough.	Row cover	Not very effective	Eliminate volunteer and harvested onion. Rotation helps reduce number of maggots next year.	Not very effective	
	Thrips	June - Aug	Leaf feeding - white or silvery blotches on leaves.	Not very effective	Row cover	Not very effective	Heavy watering of plants.	Rotenone & Pyrthrins - somewhat effective.	
Root Crops Carrots Beets	Aster Leaf-hopper	May - Aug	Spreads aster-yellow disease	Not effective	Row cover	Not very effective	Some resistant cultivars. If virus is a problem, do not grow other cross-susceptib-le vegetables.	Not very effective	Other crops susceptible to aster yellows are lettuce and onion.
	Carrot Weevil	May - July	Larvae feeding on carrots.	Not effective	Row cover	Not very effective	Move planting to later in year and/or rotate crops.	Not very effective	Leaf miners not much of a problem in Indiana.
	Leaf Miners	May - July	Leaf blotches & leaf feeding.	Some	Row cover	Not very effective	None	Neem will help repel adult.	
Solanaceae	Hornworm Fruitworm Cutworm Tomato	May - Aug	Feeding on foliage and in/on fruit.	Important in limiting damage.	Barrier around base of plant for cutworm.	Not very effective	Not very effective	Bt - when feeding on foliage.	Worms must feed on plants to ingest Bt - will consume some fruit. Bt is only effective on small larvae - it will NOT control large larvae.
Pepper - bell - chilli	European Cornborer (pepper, potato)	July - Aug	Feeding on pepper.	Not effective	Row cover	Earlier plantings	Plant corn near, but not next to, peppers.	Possibly Bt	
Potato	Colorado Potato Beetle (Potato, some tomato)	Apr - July	Defoliation of potato, tomato plants.	Helpful in control of larvae, but not adults.	Pick off	Trap crop	Mulching with straw will attract ground predators.	Bt	Use an earlier planting of potatoes to attract CPB away from main planting.
Tomato	Aphids & Mites	June - Aug	Sucking plant juices & yellowing of foliage.	Very Important - usually keeps them as minor pests.	Not very effective	Not very effective	Same as above	Not very effective	
Tomatillo	Potato Leafhoppers (Potato, some tomato)	June - Aug	Sucking plant juices & yellowing of foliage.	Not very effective	Not very effective	Earlier plantings	Plow under right after potato harvest.	Not very effective - can try soaps.	Flea beetles can be severe on eggplant, but plants can take heavy feeding after they are 3-4 weeks old.
Eggplant	Flea Beetle (eggplant, tomato)	May - Aug	Small round holes in foliage, can defoliate plant.	Not very effective	Row cover - MOST effective control for eggplant.	Plant eggplant when beetle population is low.	Not very effective	Not very effective	

ORGANIC INSECT MANAGEMENT

Table 3. (Continued)

				Possible Management Procedures[5]					
Vegetable[1]	Pest[2]	When[3]	Damage[4] Type	Biocontrol	Mechanical Control	Timing	Cultural	Organic Pesticides	Comments
Sweet Corn	European Corn Borer	May - Aug	Bore into stalk and then into ear.	While there is bio-control for all these caterpillars - it is not enough, especially later in the season.	Not very effective	Early planting	Monitor pest with black light trap or pheromone traps. If caught and silks are green - damage potential is great.	Bt will give suitable control but there must be thorough coverage for small larve.	Apply Bt for ECB control when larvae are small and when tassels push.
	Earworm	July - Sept	Feed on ear tip.	Not very effective	Not very effective	Early planting	Monitor with pheromone traps.	Bt & oil injected into silks - one drop of Bt: oil at a 1:20 mix.	For earworms - must wait till silks are 4 days old before applying Bt and vegetable oil. If oil is applied too soon, it will interfere with pollination.
	Fall Armyworm	Aug - Sept	Feed on foliage and ear tip.	Not very effective	Not very effective	Early planting	Monitor with pheromone traps.	Bt	
	Flea Beetles	Apr - May	Feed by eating leaf material in short streaks - carries Stewart's Wilt	Not very effective	Not very effective	Not very effective	Most effective: Resistent varieties to Stewart's Wilt.	None	

[1]This table represents many of the vegetables grown in gardens and most of the pests we see in the Midwest. If a vegetable you grow or a pest you have is not in this table, try to match it with something in a similar group.
[2]The most important pest within each crop grouping is marked with an asterick.
[3]This column represents when the pest could be present for this crop.
[4]Gives a general descripton of the type of damage each pest does.
[5]Each of the control procedures is explained in more detail in the text and represent possible controls - some will work better in certain situations than others.



These line drawings represent insect pests common to vegetable production in Indiana. More information on these and other pests can be found in the Purdue Extension publication E-65.

ORGANIC DISEASE MANAGEMENT

Table 4. Vegetable diseases important to Indiana are listed by crop. Note that some pathogens have races. The reaction of a particular race of fungus or bacterium will depend on the cultivar or variety grown. Rotation refers to the number of years that the field should be planted to a different crop.

			Management Options			
Crop	Disease	Tillage	Seedborne	Rotation	Resistance	Comments
Cabbage	Alternaria Leaf Spot	XXX†	Yes	3-4 yrs.	No	
	Black Rot	XXX	Yes	2-3 yrs.	Yes	
	Yellows	XX	Yes	Long‡	Yes	Fusarium fungus survives in soil.
Carrot	Bacterial Blight	XXX	Yes	2-3 yrs.	No	
	Alternaria Leaf Blight	XXX	Yes	2 yrs.	Yes	
Cucumber	Angular Leaf Spot	XXX	Yes	1-2 yrs.	Yes	
	Anthracnose	XXX	Yes	1-2 yrs.	Yes	
	Bacterial Wilt	X	No	-------	No	Spread by cucumber beetles.
	Scab	XXX	Yes	3+ yrs.	Yes	Likes cool (<70º F), wet weather.
Muskmelon	Alternaria Leaf Blight	XXX	No	1-2 yrs.	No	
	Anthracnose	XXX	Yes	1-2 yrs.	No	
	Bacterial Wilt	X	No	------	No	Spread by cucumber beetles.
	Gummy Stem Blight	XXX	Yes	1-2 yrs.	No	Also affects pumpkin, watermelon.
	Powdery Mildew	X	No	------	Yes	
	Root Knot	XX	No	Long	No	
Pepper	TMV	X	No	2 yrs.	Yes	Mechanical transmission.
	PVY	X	No	2 yrs.	Yes	Aphid transmission (reflective mulch).
	TEV	X	No	2 yrs.	Yes	
	Phytophthora	XX	Yes	2-3 yrs.	Yes	Resistance to some races.
	Bacterial Spot	XXX	Yes	1-2 yrs.	Yes	
Potato	Early Blight	XXX	No	3-4 yrs.	Partial	More disease on early maturing cultivars.
	Late Blight	XXX	Yes	2-3 yrs.	Partial	Survives on cull piles and volunteers.
Pumpkin	Virus Diseases (several)	X	No	------	No	Aphids spread virus. All cucurbits affected. Control w/planting date & reflective mulch.
	Black Rot	XXX	Yes	2-3 yrs.	No	Same as GSB on muskmelon, watermelon.
	Powdery Mildew	X	No	------	Yes	Some new cultivars with partial resistance.
Snap Bean	Rhizoctonia Root Rot	XXX	No	------	No	Deep plow residue.
Sweet Corn	Stewart's Wilt	X	Yes	------	Yes	Spreads & survives in flea beetles.

ORGANIC DISEASE MANAGEMENT

Table 4. Continued.

			Management Options			
Crop	Disease	Tillage	Seedborne	Rotation	Resistance	Comments
Tomato	Early Blight	XXX	No	3-4 yrs.	Partial	Some resistance to stem canker.
	Septoria	XXX	No	2-3 yrs.	None	
	Fusarium Crown Rot	XX	No	Long	No	
	Bacterial Spot	XXX	Yes	2-3 yrs.	None	
	Speck	XXX	Yes	1 yr.	Yes	
	Canker	XXX	Yes	3-4 yrs.	No	
	Verticillium	XX	No	Long	Yes	
	TMV	X	No	2 yrs.	Yes	Can be spread by contact.
	Fusarium	XX	Yes	Long	Yes	Check races for resistance.
	Root Knot	XX	No	Long	Yes	
	Anthracnose	XXX	Yes	2-3 yrs.	Partial	Stake and mulch.
Vegetables (ALL)	Damping-off	X	No	------	No	Manage with warm soils, sanitation.
Watermelon	Anthracnose	XXX	Yes	1-2 yrs.	No	
	Gummy Stem Blight	XXX	Yes	2-3 yrs.	No	Also affects muskmelon and pumpkin.
	Root Knot	XX	No	Long	No	
	Fusarium	XX	Yes	Long	Partial	
Broadleaf Vegetables esp. tomato potato carrot	Sclerotinia aka "timber rot"	XX	No	with grasses 3-4 yrs.	No	Possible managment by flooding 23-45 days.

† XXX=tillage is an important control; XX=tillage is of limited help; X=tillage has little effect.
‡ Long=rotations are not generally effective unless longer than 5 or 6 years.

Additional Sources of Information on Organic Vegetable Production:

Books

Great Garden Formulas: The Ultimate Book of Mix-it-Yourself Concoctions for Your Garden. Rodale Press. Book Readers' Service, 33 East Minor St., Emmaus, PA 18098. <www.rodalepress.com>

The New Organic Grower, by E. Coleman. Chelsea Green Publishing, Chelsea, VT. <www.chelseagreen.com>

Pests of the Garden & Small Farm: A Grower's Guide to Using Less Pesticide, by M. L. Flint. Pub. 3332, Division of Agriculture & Natural Resources, Univ. of California, 6701 San Pablo Ave., Oakland, CA 94608-1239. <www.ucpress.edu>

Rodale's Successful Organic Gardening: Controlling Pests & Diseases. Rodale Press, Book Readers' Service, 33 East Minor St., Emmaus, PA 18098. <www.rodalepress.com>

Sustainable Vegetable Production from Startup to Market, by V. Grubinger. NRAES-104. Natural Resource, Agriculture & Engineering Service, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. <www.nraes.org>

Vegetable Insect Management with Emphasis on the Midwest, by R. Foster and B. Flood. Meister Publishing Company, Willoughby, OH. <http://meisterpro.com/mpn/>
(Not written for organic production, but includes alternative methods of control for pests.)

Purdue University Extension Publications

E-21 Managing Insects in the Home Vegetable Garden

E-30-W Cucurbit Insect Management

E-65 Vegetable Insect Identification

E-74 Flea Beetles

E-95 Managing Striped Cucumber Beetle Populations on Cantaloupe and Watermelon

E-96 Managing Insect Pests of Potato

E-97 Management of Insect Pests on Fresh Market Tomatoes

E-98 Managing Insects in Commercially Grown Sweet Corn

E-99 Managing Insect Pests of Commercially Grown Cole Crops

BP-61 Preventing Seedling Diseases in the Greenhouse

ID-56 Midwest Vegetable Production Guide for Commercial Growers

ID-101 Animal Manure as a Plant Nutrient Resource

WQ-16 Land Application of Manure

AY-277 Calculating Manure and Manure Nutrient Application Rates

AY-281 Soil Sampling for P, K, and Lime Recommendations

Many of these are available on the Web at <http://www.ces.purdue.edu/extmedia>

Also, single copies of these can be obtained through Purdue Media Distribution Center, 1-888-EXT-INFO.

Other Extension Publications

Cultivation Equipment. IPM Fact Sheet 102FSNCT, Cornell Cooperative Extension, Resource Center, 7 Business and Technology Park, Ithaca, NY 14850. (607) 255-2080. <http://www.cce.cornell.edu/publications/catalog.html>

Information on the Internet

Sites at Land Grant Universities

Univ. of California, Davis
<vric.ucdavis.edu/selectnewtopic.organic.htm>

Univ. of Wisconsin: Healthy Farms, Healthy Profits
<www.bse.wisc.edu/hfhp>

Federal and State Government Sites

Appropriate Technology Transfer for Rural Areas (ATTRA)
<http://attra.ncat.org>
Many publications about organic growing online.

National Organic Program
<http://www.ams.usda.gov/nop >
This site has the National Organic Rule (standards) online.

Indiana Organic Certification Standards
<http://www.IN.gov/oca/other/organic_rule.html>

Indiana Organic Certification Accreditation Law
<http://www.IN.gov/legislative/ic/code/title15/ar4/ch12.html>

Commercial Sites

Organic Gardening
<http://www.organicgardening.com>

The Natural Gardening Co.
<http://www.naturalgardening.com>

Organic Trade Association
<http://www.ota.com>

Individuals and Organizations

Hoosier Organic Marketing Education
<http://members.iquest.net/~cvof/home/homeinfo.htm>

Noah's Ark – An Organic Growers Homepage
<www.rain.org/~sals/my.html>

Organic Ag Info
<http://www.organicaginfo.org>

Organic Consumers Association
<http://organicconsumers.org/>

Organic Materials Review Institute
<http://www.omri.org>

The Organic Vegetable Gardening Guru
<http://members.aol.com/ovgguru/ovgguru.html>

Rodale Institute
<http://www.rodaleinstitute.org>

Sustainable Earth
<http://www.sustainableearth.net>

Organic Certification - Educational Organizations

Hoosier Organic Marketing Education
8364 S. State Road 39
Clayton, IN 46118
Phone: (317) 539-4317
E-mail: cvof@iquest.net
<http://members.iquest.net/~cvof/home/homeinfo.htm>

Organic Certification - Certifying Agents

Indiana Certified Organic
8364 S. State Road 39
Clayton, IN 46118
Phone: (317) 539-4317

Ohio Ecological Food and Farm Association
9665 Kline Road
West Salem, OH 44287-9562
Phone: (419) 853-4060
E-mail: organic@oeffa.com

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