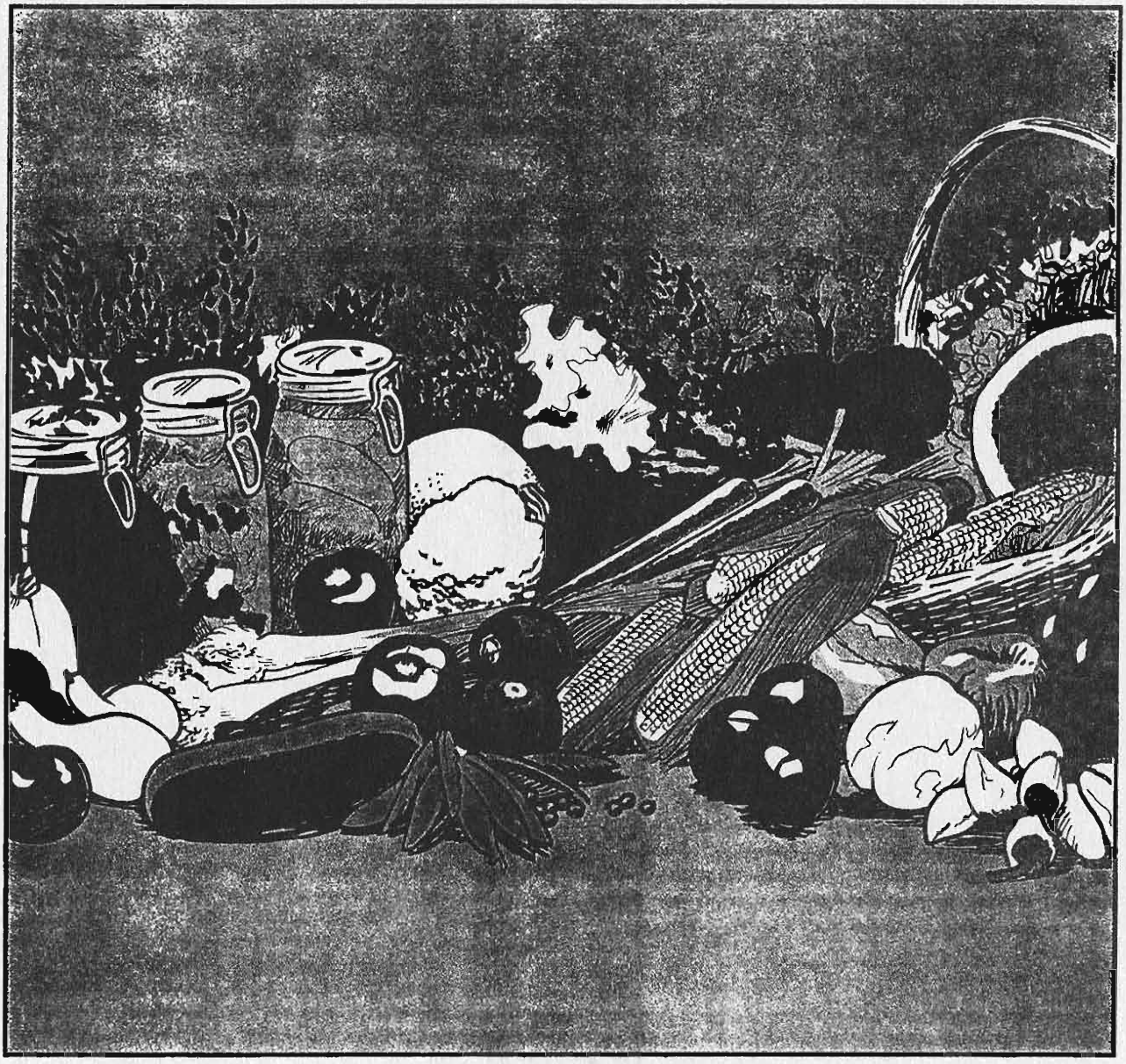
ORGANIC GARDENING *and* PEST CONTROL



Cooperative Extension Service / The University of Georgia College of Agriculture / Athens

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ORGANIC GARDENING and PEST CONTROL

Organic gardeners place emphasis on using natural mineral and organic fertilizers rather than synthetic ones (such as 5-10-15) to build their soil. Likewise they do not use synthetic chemicals (such as Sevin or Maneb) for pest control. Whether you are an organic gardener or just use some of the organic gardening principles, this bulletin will give you a variety of control methods other than the use of synthetic chemicals for insects, diseases and weeds.

Many of the methods described are quite practical for the small garden, but may not be appropriate for those with large areas. Some organic gardeners prefer not to use botanical or mineral pesticides, but these are included for those that do. Select those controls that fit your needs, the size of your plantings and your philosophy of gardening.

You should recognize there will be some limitations to organic gardening:

- It is usually more labor intensive.
- Some damage, often superficial, may need to be accepted.
- It takes more knowledge to be a good organic gardener.

Most organic gardeners believe the satisfaction of producing food without the use of synthetic chemicals more than compensates for any drawbacks.

Good Management Practices

There are many gardening practices that while not aimed directly at controlling a pest, do have an effect. This section covers those good management practices that help prevent or mitigate insects, diseases and weeds. Some general principles of control that relate to insects, diseases and weeds are included.

Healthy Plants

A healthy fast growing plant can better tolerate or outgrow damage from insects and disease, and emerge ahead of weeds. Loose soil to allow rapid root growth, proper nutrients and pH for the crop grown, adequate moisture, correct variety for your area, and a sunny location (unless otherwise required) all relate to rapid growth. Well-drained soil is important because roots and plants that stay wet for long periods encourage disease. Seeds planted too deeply may be slow to germinate. This makes them more susceptible to insect and disease damage before they can emerge and give weeds a head start.

Thomas Jefferson, one of our early agricultural experts, recognized the relationship of healthy plants and insect damage. He stated:

> "I suspect that the insects which have harrassed you have been encouraged by the feebleness of your plants; and that has been produced by the lean state of your soil."

The strongest characteristic of an organic gardener is care of the soil. This is probably one of the single most important pest control methods. A stressed plant that grows slowly because of soil problems and that has root or leaf loss from pests may not survive.

Rotate Crops

Crop rotation for pest control consists of a planting scheme alternating susceptible and nonsusceptible crops. This is based on the premise that some crops or crops related to it will accumulate certain insects, diseases and nematodes in the soil if planted in the same location year after year. Soil-dwelling insects that are fairly immobile, such as white grubs and wireworms, will prosper if root crops such as sweet potatoes or carrots are planted in the same location; however, rotation with a non-root crop will discourage them. Nematodes can accumulate to damaging numbers when tomatoes or okra are planted in the same location.

Crop rotation can reduce losses to several soil-borne diseases, including bean root rots, clubroot of cabbage, bacterial diseases of tomatoes and various potato diseases.

In rotating crops, try not to plant the same vegetable or a related vegetable in the same location year after year. Groups or related vegetables follow:

cole crops—cabbage, cauliflower, collards, Brussels sprouts, broccoli
solanceous crops—tomato, pepper, eggplant, potato
greens—lettuce, endive, mustard, turnips (tops)
root crops—radishes, turnips, beets, carrots, sweet potatoes
bean, pea
cucurbit crops—cucumbers, gourds, melons, pumpkins, squash

Keeping records and a year by year map of where you plant your vegetables will be important if you plan to practice rotation.

Interplanting and Diversification

Interplanting or intercropping is the growing of more than one crop on a piece of land at the same time. It has been used by tropical and subtropical countries for many years. The advantages are more intensive use of a piece of land; higher crop yields due to planting two crops rather than one in a given area; reduced weed competition due to denser ground cover; better soil conservation due to increased soil cover; conservation of moisture by shading; and more efficient use of soil nutrients. Various studies show insect populations are often reduced through interplanting as compared to planting solid blocks of one crop. Since insects locate their food source by shape of the plant, color and odor, mixing up the plants presumably helps to decrease the attraction and thus the damage.

Some of the old-time favorite groups are planting any of the cucurbits—squash, cucumbers, pumpkins and melons—between corn rows. This helps to shade out weeds. Pole beans planted *after* the corn has emerged use the stalks to climb on. The nitrogen fixing beans provide some nitrogen for the corn.

There are three disadvantages of interplanting:

- It usually takes extra work and planning rather than having single rows of just one crop.
- While the total yield of food for a given piece of land can be higher with interplanting, the size and number of the yield per plant is likely to be smaller due to crowding.
- Prolonged high humidity in close planting may encourage disease.

Since some insects and diseases attack closely-related plants, mix the plants with those not in the same groups. This is called *diversified planting.* It is similar to intercropping. Diversified color, shape and odor of plants help to reduce insect attack. Diversifying reduces soil-borne diseases that can spread from plant to plant where large numbers of the same kind are planted together. For example, mixing cabbage and lettuce would be better than mixing cabbage with cauliflower. Lettuce, onions and carrots can be mixed together. The onion and carrot tops help to shade the tender lettuce in midsummer.

There are many combinations of intercropping and diversified plantings. Experiment on the spacing and combinations that work best for you.

Planting Dates

Sweet corn planted early may avoid the worst of the corn earworm while later plantings will come under much more pressure. On the other hand, delay in planting corn, cabbage and onions until the soil is warm enough to germinate the seeds or to allow rapid root growth. This reduces root maggot damage associated with cold damp weather. Early squash may reach maturity before the squash vine borer does serious damage.

Early planting gives plants a head start on weeds and allows maturing and harvesting before some diseases and insects become more common.

Resistant Varieties

Many vegetables will have a natural resistance to various insects and diseases. Check seed catalogues for varieties available in your area (see Figure 1). Sometimes they will tell you which have some resistance to a pest (see page 5).

Figure 1. Seed Varieties

Vegetable	Variety	Resistance
cabbage	Round Dutch	Cabbage looper, Imported cabbage-worms
collard	Georgia	Striped flea beetle, Harlequin bug
corn (sweet)	Golden security	Corn earworm
cucumbers	Ashley	Pickleworm, spotted cucumber beetle
	Poinsett	Spotted cucumber beetle
kale	Yates	Diamondback moth
peas, southern	Worthmore	Cowpea aphid borne mosaic virus as well as several other viruses, 2 species of root-knot nematode, 3 races of fusarium wilt
potato (sweet)	Centennial Jewel	Sweet potato flea beetle, southern potato wireworm
radish	Cherry Belle	Diamondback moth, Harlequin bug
squash	Early Pacific Straight neck	Pickleworm, stripped cucumber beetle
tomatoes	Bonnie	VFN[1]
	Better Boy	VFN[1]
	monte Carlo	VFN[1]
	Big Set	VFN[1]
watermelon	Crimson Sweet	Pickleworm, spotted cucumber beetle

[1]Verticilluim, Fusarium Wilt, nematode resitant (VFN)

Control Pests When They Are Young

Insects are easier to control when they are young than when they are older. Weeds are easier to uproot by hand or hoe when young than when more extensive root systems develop.

Inspect Garden at Least Twice a Week

If pest problems are detected early, take action before important damage occurs. Randomly check plants in your garden at least twice a week.

Correctly Identify Any Problems

If some of your plants show damage or are doing poorly, it is difficult to take the right action if the problem is not correctly identified. Yellowing of the leaves may be from overwatering rather than disease. Check with your county Extension agent if you are not able to diagnose the problem yourself. Pages 14 through 18 include a key to common insects and diseases you are likely to encounter.

Control Weeds

Keep weeds cut around the garden to help reduce a reservoir for certain insects (such as flea beetles) and plant diseases that spread into the garden. This also helps to reduce a source of weed seeds.

Mulch

Mulching reduces moisture loss, weed emergence and certain diseases coming from the soil that causes fruit rot when vegetables rest on bare ground. The latter is especially effective with tomatoes and melons (but tying these vegetables off the ground is even better). One disadvantage is that mulch may serve as harborage for some pests—such as snails and slugs, squash bugs and crickets.

Select Appropriate Control Measures

Once a pest problem is identified, review options as to what is appropriate for you. For example, suppose that Colorado potato beetles are noted in your potato patch. Do nothing if only a few are present; however, if control is needed you can hand pick the larvae and adults from the leaves or spray with rotenone. Weeds between the tomato plants can be ignored if they're small, pulled, hoed or mulch-added. A successful organic gardener should know the various options available for a particular pest problem and which is most appropriate to apply, and when.

Destroy Old Plants After Harvest

Plants left in the garden provide shelter for such insects as Mexican bean beetle, squash bug, imported cabbage worm, diamondback moth, European corn borer, corn earworm, harlequin bug, cowpea curculio and others. As soon as a crop is harvested, plow or spade under the stalks, debris and any mulch used. This allows for early rotting to improve the soil and removes a major source of over-wintering insects and disease organisms.

If you do not plow or spade under, remove plants for compost. If you do not remove the old plants after harvest, be sure to do so in a fall plowing or spading. This not only removes the harborage but helps to reduce soil insects. If the ground slopes and is subject to soil erosion, the disadvantages

of fall plowing may be greater than the advantages.

In the spring, it is usually best to turn or spade organic matter and weeds into the soil three to four weeks before replanting. The harm comes when certain microorganisms that increase in the soil as part of the natural decay process also cause damage to the planted crop. As the organic matter decays the potential for this problem diminishes.

Insect Control

Hand Picking and Foot Stomping

Remove beetles or caterpillars by hand and drop them into a container of water. A thin layer of kerosene or oil may be added to the water to kill them. Japanese beetles (pick in early morning when not active), Mexican bean beetles, squash bugs and cabbage worms are examples of insects easily picked (see Figure 2). Recognize the egg masses of pests and either crush them or remove them with a part of the leaf.

Squash bugs harbor under the leaves and in the lower portions of the squash plant by day. Lift the plant, shake it and stomp the bugs underneath.

Figure 2. Hand Picking

Barriers

Transplants such as tomato, pepper and eggplant can be wrapped with a 4 x 4 inch strip of aluminum foil to prevent cutworm damage. Wrap the stem area between the roots and leaves with foil and plant so that two inches of foil-wrapped stem are below the soil and two inches above the soil (see Figure 7, page 10).

Screen cones or a mesh netting over early spring cabbage will prevent the cabbage maggot fly from laying its eggs at the base of the plant. Similar barriers over cole crops will prevent cabbage worms.

Companion Plants

The premise is that certain plants (mainly herbs) will repel insects. There are many combinations in the organic gardening literature, such as:

- interplant tomatoes with basil to repel tomato hornworms.
- interplant cucumbers with radishes or nasturtiums to control cucumber beetles.
- or interplant eggplant with catnip to repel flea beetles (see Figure 3).

Figure 3. Experimental Comparison Planting—Broccoli and Catnip at Rodale's Organic Research Farm, Emmaus, Pennsylvania

Most research reports which determine the value of companion plants have been negative, possibly due to the design of some of the studies. The University of California found that when anise, nasturtium, marigold or catnip were alternated with cabbages they produced no reduction of cabbage worms as compared to the control. When these herbs were planted on all four sides of a cabbage plant, there was a significant reduction in insect numbers below those on the control. However, any beneficial effects of companion plants were negated by a substantial reduction in cabbage yields. In Virginia similar results were found with French marigolds to reduce Mexican bean beetles in beans. Yield reduction was probably caused by competition for sunlight, soil moisture and nutrients. Spacing of plants is obviously critical. Another disadvantage is the amount of garden space taken by the mainly inedible (herbs) companion plants.

Under the title of companion plants, there are listings in the literature of various vegetables that can be grown side by side and have mutual benefit. For example, green beans reportedly deter the chief pest of potatoes—the Colorado potato beetle—while potatoes repel the Mexican bean beetle, a

major pest of beans. Tomatoes reportedly repel the asparagus beetle, and asparagus helps reduce the nematodes which are a pest of tomatoes. There are many others.

In a related area, there is some evidence that planting flowers among the vegetables will attract beneficial wasps seeking the nectar. Decreased pest damage has been associated with this.

Water Sprays

A forceful stream of water, as from a garden hose, can syringe aphids or spider mites from foliage. This will need to be repeated since many (but not all) will return. Do not use on soft tender plants that may break unless you give them some support with your hand.

Bug Juices

If you find a dead cabbage looper hanging from a leaf and it is discolored and liquefying, it probably died from a polyhedrosis virus (see Figure 4). The caterpillar can be placed in a blender with about a cup of water, liquified, strained through a cloth and the liquid further diluted. You would have enough virus to spray and infect about an acre of cabbage loopers. Applying *Bacillus thuringiensis* would be quicker and easier.

According to some gardeners, grinding up an offending bug in a blender and spraying the "juices" over the corp will help take control of that species.

The chances of finding a bug with a disease organism adequate for control is very uncertain. While other factors may be involved and because the method is considered undependable, it is not recommended.

Figure 4. Dead Cabbage Looper with Polyhedrosis Virus

Traps

A wide variety of traps are available for catching various pests. For example:

Slugs and snails are attracted to stale beer in a shallow pan (such as a pie tin) set into the ground. They end up drowning in the brew. The beer soon gets foul and must be replaced every few days.

Whiteflies are attracted to the color yellow (same shade as on a traffic sign) (see Figure 5). When colored stakes, wooden panels or jugs are coated with a sticky material—STP or a motor oil—large numbers of whiteflies will get stuck on it. Old Prestone jugs will do. Wrap the object with a clear plastic-like Saran Wrap before putting on the oil with a brush (it makes clean-up much easier). Prepared traps are available in garden shops under the brands "Ortho Sticky Whitefly Trap", "Flying Insect Attack" and others. While this method of trapping has been commercially used for monitoring and less seldom for control in greenhouses, there is little evidence it will give adequate control outside. For best results, set traps out at frequent intervals (such as between each plant) and at the first sign of whiteflies. This trap is based on sight, so you are only attracting those whiteflies in the immediate vicinity of it.

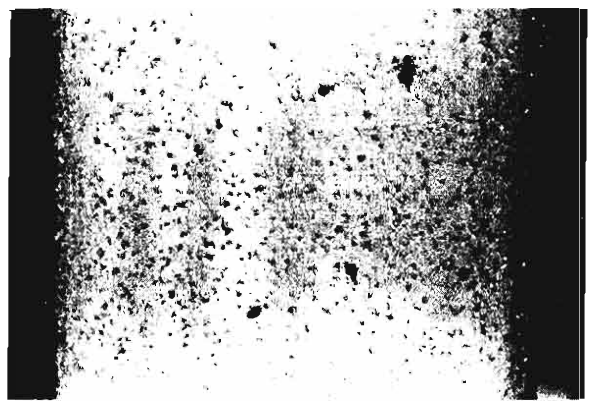


Figure 5. Whiteflies Stuck on Yellow Trap

Japanese beetle traps are available in many garden shops. A sex pheromone and sometimes fermenting fruit are used as baits. Since both baits are based on scent, large numbers of beetles will fly long distances to come to the trap. While many beetles will be lured, they unfortunately do not all go into the trap. Many will linger to feed on the foliage in your garden, so you could easily have more damage with the trap than without it. Since control is questionable, the trap is not recommended.

There is little or no evidence light traps designed for outside use (patio bug zappers) that electrocute flying insects have any value in controlling garden pests.

Beneficial Insects

The best friend of the organic gardener is the many species of lady beetles, tiny wasps and others that feed on various garden pests. One lady beetle will eat several hundred aphids. Note how many will be in the whorl of sweet corn. Lady beetles will feed on the eggs of the corn earworm.

Lady beetles, various wasps and praying mantid eggs can be purchased to "augment" the beneficials in your garden; however, this is not recommended. When released they soon disperse leaving you with questionable benefit for the expense. The convergent lady beetle, the same species collected in California for sale, is very common in the South.

Squash Vine Borer

The squash vine borer feeds inside the base of the squash plant and is often the cause of its rapid decline and death. When sawdust-like deposits are seen at the base (or the base is soft to the touch), there is probably one or more borers inside. Early planting helps to avoid the borer and allow a good squash harvest before serious damage. Dusting or spraying the base of the plant with rotenone twice a week from first bloom until harvest will help prevent this pest. Injecting about 5cc of *Bacillus thuringiensis (B.t.)* with a hypodermic syringe and 23 gauge needle into the base of the plant every two weeks appears to be successful. Protection from sunlight which degrades *B.t.* seems to prolong its activity within the plant.

When a plant has been found to be infested, make a vertical slit over the soft place, open the stalk and remove any borers. Mounding soil up to cover the wound helps encourage new roots and gives support to the weakened stalk. This "radical surgery" is practical only if you have a few plants and most of your harvesting is ahead of you.

Corn Earworm

A squirt of mineral oil from an eye dropper into the tip of an ear is often reported as good control of the corn earworm. Do not inject the oil until the silk turns brown or fertilization of the kernels may not take place. Since the corn earworm feeds mainly at the tip of the ear, the simplest control is to do nothing and just cut off the end of the ear at harvest time.

Insecticides

Insecticides that are acceptable to most organic gardeners are those made from plants (the botanicals), minerals, soaps and microbials. Some of these, such as rotenone and pyrethrins, will kill beneficials, so use only when needed. Those readily available in most garden shops are: rotenone, pyrethrin, nicotine sulfate (not recommended), insecticidal soap, *Bacillus thuringiensis* (*B.t.*) and sulfur.

Use insecticides only for the vegetables listed on the label.

Rotenone is extracted from the roots of *Derris* plants in Asia and cuberoots from South America. This rather powerful general garden insecticide is highly toxic to fish and moderately toxic to mammals. It is a slow-acting insecticide, it does leave a residue, but its effectiveness is lost within a week due to degrading by sunlight. Rotenone dusts and wettable powders work well on various beetles, sucking insects *and* many beneficials.

Pyrethrins are extracted from the flowers of a species of *Chrysanthemum* from Kenya and Ecuador. Pyrethrins provide a very rapid knockdown of beetles, caterpillars and various sucking insects. Death is soon, or not at all. Spray pyrethrins directly on the pest insect since it degrades very rapidly and leaves little or no residue. It will kill adult lady beetles, is expensive, but has a very low mammalian toxicity.

Ryania is the powdered stems and roots of a South American plant, *Ryania speciosa.* It is an alkaloid that is toxic to some selective caterpillars. It is not readily available and is not labeled for use on vegetables (but is on fruit). Mammalian toxicity is very low.

Sabadilla is obtained from the seed of a lily-like plant native to Central and South America. It is reported effective in controlling cabbageworms, squash bug, harlequin bug and others. While it has a very low mammalian toxicity, as a dust it is reported to be very irritating to the throat and eyes and can cause violent seizures of sneezing. Wear a respirator during application. Sabadilla is toxic to honey bees and breaks down rapidly in sunlight. It is expensive and not readily available.

Nicotine sulfate is a tobacco extract sold under the brand name of "Black Leaf 40". It is highly toxic to mammals and is almost the only pesticide readily available in garden shops with the signal words "Danger", "Poison" and the skull and cross bones. It can be used for various sucking insects, is labeled on a wide variety of vegetables, and degrades rapidly after application. It is not recommended by the Extension service for home gardeners because of its toxicity.

Insecticidal Soaps of various formations have been used since the early 1800s to control soft-bodied pests such as aphids, spider mites and whiteflies. Commercial brands of insecticidal soaps

are commonly available. Applications more frequent than once a week are needed for maximum effectiveness, but some damage (such as loss of weight in cabbage) may occur from frequent use. There is little or no damage to beneficials.

Bacillus thuringiensis (*B.t.*) (Dipel. Thuricide and others) is a bacterial spore with an endotoxin that when ingested by various caterpillars causes them to stop feeding (usually within an hour) and die within a few days. *B.t.* is effective for controlling cabbage worms, tomato fruitworm, tomato hornworm and others. It is more effective when the caterpillars are young. It gives good protection for cabbage against cabbage worms when applied once a week from leaf cupping until harvest. *B.t.* is harmless to mammals and beneficial insects, but it does break down in sunlight within a few days.

Bacillus popilliae (Doom, Japidemic and others) causes a milky spore disease in Japanese beetle larvae in lawns. Once established the disease will maintain itself for many years in the soil, but it has no effect on adult beetles that fly-in from untreated areas or on white grubs other than the Japanese beetle.

Diatomaceous earth is composed of finely ground skeletons of fossil diatoms. Its sharp edges scratch the waxy layer of soft bodied insects and they reportedly eventually die from dehydration. While this material is frequently listed in organic gardening literature, it is not readily available and there are no registered uses for it on vegetables.

Sulfur may be used as a dust or spray for control of mites on various vegetables. It is readily available, but high summer temperatures may cause plant damage.

Disease and Nematode Control

Western Grown Seed

Numerous diseases may be introduced to the garden site by infected seed. Common diseases such as anthracnose of lima bean and bacterial leafspot of tomato and pepper can be carried on seeds if they are produced in areas where the diseases occur.

Purchase a good high quality seed from a western source. Seed produced in the arid West are free of diseases that cause major problems in Georgia because of the environmental conditions. Most Eastern seed companies produce their seed stocks out west because of freedom from disease.

The Georgia Department of Agriculture checks seed lots upon request from seed companies that wish to sell certified seeds. The certification program covers tomatoes, peppers, cabbage and collards. If the seeds are contaminated with disease causing fungi and or bacteria, the seeds cannot be used for the production of certified transplants.

Certified Transplants

Purchase transplants which have been certified by the Georgia Department of Agriculture to be free of pathogens. Such transplants are identified by a certification label in or on every container of transplants (see Figure 6). Since serious diseases may be introduced to the garden site by contaminated transplants, use only high quality disease free transplants.

Figure 6. Certified Plants

Barriers and Repellents

Southern stem blight of tomato, pepper and eggplant is a common disease in home gardens because of the lack of rotation and the fact that most garden plants are susceptible to the disease. Another reason this disease is prevalent in gardens is that most gardeners lack the ability to turn the soil deeply. This fungus is an oxygen-loving fungus (it attacks the host at or just below the soil line). Deep turning will reduce southern stem blight.

There is an excellent control for this disease for the above mentioned crops. Aluminum foil can be wrapped around the base of the stem so that two inches of foil are above the soil line and two inches extend below the soil surface. The aluminum foil provides a physical barrier to the fungus. Be careful not to move soil above the aluminum foil during hoeing or cultivating or the disease can enter at that point. The aluminum foil technique has proven very successful for the control of Southern stem blight (see Figure 7).

Watermelon mosaic virus causes a serious disease in squash. The virus causes yellow squash to turn green or develop green streaks. Mosaic disease also causes a reduction in yield. Some

success has been obtained in preventing this disease by using 30 inch wide reflective plastic mulching (aluminum foil can also be used). Reflective mulch is a material used to reflect sunlight. The disease is transmitted to the squash plants by aphids (commonly known as plant lice). The reflective barrier wards off the aphids thus preventing disease transmission.

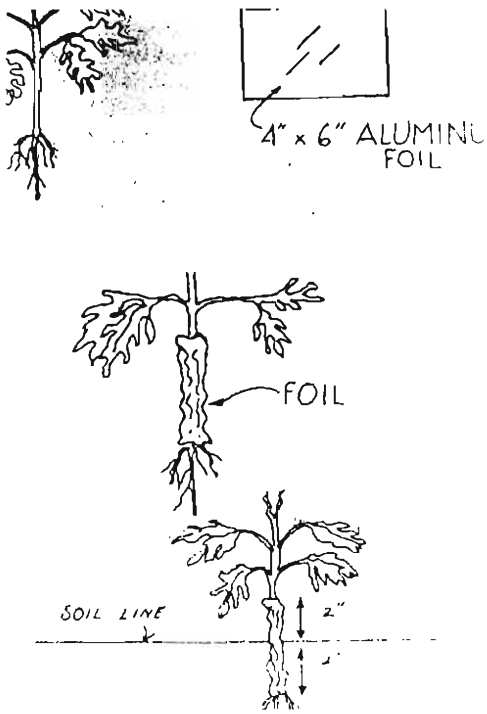


Figure 7. Aluminum Foil Protection for Southern Stem Blight and Cutworms

Water Management

It is often necessary to apply supplemental water to the garden as a form of irrigation. Knowing when and how to apply the water will aid in disease prevention. Furrow and drip irrigation are by far the best methods of applying water. This method prevents the foliage from becoming wet. It takes from twelve to fourteen hours of free water on the foliage of a plant before the disease causing organism can germinate and get into the leaf. Keeping the foliage dry can greatly reduce the incidence of disease. Wet foliage is beautiful, but it provides the best avenue for disease development.

If overhead irrigation is necessary, then timing of application can reduce the chance of disease. The ideal time to water the garden is when the foliage is already wet. If the garden is watered very early in the morning, turn off the water by sunrise to allow the plants to dry quickly. The second best time to water using overhead irrigation is after the plants have dried in the morning (making sure that the water is turned off in time for the plants to dry before night). Breaking the wet cycle will not allow enough time for the disease spore to germinate, thus preventing disease development.

Nematodes

Root-knot nematodes cause the number one disease problem in home gardens. Nematodes thrive in warm, moist, sandy soils (see Figure 8). Most garden plants are susceptible to root-knot nematodes and they provide a good food base needed for growth and development of the nematodes. Several cultural practices may be used to reduce nematode populations. Rotation is one.

Figure 8. Nematode Injury

Crop removal immediately following the last harvest will remove thousands of nematodes and eggs from the garden site. Destroy any plants showing signs of root-knot injury and do not incorporate into the compost pile because research has shown some nematode eggs survive the decomposition process. This means that the nematodes are reintroduced to the garden site by infested compost. The use of organic matter reduces nematode populations. Plants grown in soils containing a high organic matter may escape devastating injury because of a reduced nematode population.

Marigolds have been used to reduce root-knot nematodes. The French Marigold *(Tagetes patula)* has been the most effective variety for nematode suppression.

Some gardeners have reported success using marigolds around the garden, alternated in the drill, or even planted in the same hole. However, research has shown no reduction in nematode numbers or injury when marigolds are used in these ways. The only effective way to use marigolds is in broadcast planting where no other root systems are available (see Figure 9). At the end of the sea-

son, plow up, and the planted area will be relatively free of most nematodes the following year.

Similar results may be obtained by fallowing (tilling the land without sowing it) the area. Either way the nematodes are starved. Fallowing is more effective when the soil is tilled frequently especially during the hot dry months. Repeated discing brings nematodes to the surface at which time they are killed by the hot drying sun. Remember that cultural practices reduce nematode populations; however, they may not be reduced below a level of economic damage. Repeated cultivation may cause soil erosion.

Figure 9. Solid Planting of Marigolds for Nematode Control

Remove Diseased Plants

Remove diseased plants to greatly reduce the inoculum level and to prevent the spread of disease to healthy plants. Once a disease has become established, it is difficult to gain any degree of control without the use of chemicals.

Sterilize Seeding Soil

Sterilize soil used for production of transplants. A quick and easy method is to place the soil in the oven and bake it at 160 degrees for one hour. Baking will destroy most disease causing organisms. If clean seed are planted in sterilized soil, expect a disease-free transplant.

Fungicides

Sulfur is about the only naturally occurring compound which has good fungicidal activity. Sulfur is an effective fungicide for diseases like rust on snap beans. It also has activity against powdery mildew.

Weed Control

Man's struggle to control weeds began with the earliest attempts to cultivate plants and continues today. Weeds and crops have the same basic requirements and compete for nutrients, water, light and growing space. Since a weed is sometimes considered a desirable plant, the true definition of a weed is; a plant growing where it is not desired, or a plant growing out of place.

Effective weed control strategies are dependent upon weed identification and the understanding of their life cycles. Weeds are grouped on the basis of similiar life cycles into annuals, biennials and perennials. Annual weeds complete their life cycle in one year and reproduce only by seeds. Annuals are subdivided into summer annuals and winter annuals. Summer annuals germinate in the spring, grow during the summer and die in the fall. Winter annuals germinate in the fall, grow during the winter and die in late spring. Biennials require two years to complete their life cycle. The first year biennials produce leaves and store food in the roots. The second year biennials produce a flowering stalk, set seed and die. Perennial plants live for more than two years. Perennial weeds can reproduce by seeds (sexual reproduction) or by vegetative structures (asexual reproduction) such as stolons, rhizomes, corms, bulbs, tubers and roots. Vegetative reproduction contributes to the difficulty of controlling perennial weeds.

Once the proper weed identification is made, the next step is to select the most cost effective, **non-chemical** control method. No single approach is total, but may require integrated non-chemical control methods.

There are various non-chemical optional approaches to the proper control of weeds in gardens. These are discussed in detail as follows.

Land Selection

Do not attempt to plant a garden on land with a history of heavy weed infestation, especially perennial weeds such a nutsedge or bermudagrass. If the choice of land area is not an option and you must plant on land with a history of troublesome weeds, then hand weed or deep turn the soil. If the area is hand weeded, remove all visible plant materials and compost for future use as a mulch. Then, break soil at least twelve inches deep by use of a hand fork or tractor-mounted cultivator, and form a smooth seedbed. If plant materials were not removed and soil was deep turned, leave plant materials buried for at least two months to allow proper decay before forming seedbed.

Seedbed Preparation

Before planting crop, prepare a smooth seedbed. Remove all stubble and rocks. If possible prepare soil at least three months in advance of planting crop. This will allow enough time for much of the troublesome weed seeds in the first two to three inches of the soil surface to germinate and to be killed by light cultivation before planting crop.

Hand Hoeing

If your garden area is small and you enjoy the pleasure of hoeing weeds for the exercise, then this method is cheap and very effective. If you choose to hand hoe, hoe the weeds when they are small. If weeds are annuals or biennials, then regrowth from existing weeds will not occur and it will not be necessary to remove hoed-out weeds from crops. If weeds are perennials such as nutsedge and bermudagrass, the regrowth from underground plant parts will occur. Also the reestablishment from non-removed, above-ground plant parts will occur in the case of bermudagrass. When hand hoeing is selected as the only source of weed control, several hoeings will be necessary (at least once per two weeks under good moisture conditions).

Mechanical Cultivation

Mechanical cultivation uses tractor mounted cultivators, rototiller and hand-pushed or horse-pulled cultivators (see Figure 10). This method of weed control must be planned ahead of planting the crop.

Figure 10. Mechanical Cultivation

in order for mechanical cultivation to fit into a weed control operation, space plant beds to allow easy movement of tractors and cultivators. Space rows evenly and straight. Land should be level and not too sloped. The growth habit of the crop should be such that roots and vines of crop will not be in the path of cultivators. If mechanical cultivation is used, it will require supplemental hand hoeing or hand pulling of weeds to remove weeds from within the crop rows.

Mulching

Mulching is probably one of the most effective and least total time consuming approaches to weed control in gardens. There are various types of mulches available which may be divided into ***organic mulch*** and ***inorganic mulch.*** Organic mulches are of plant origin such as straw, leaves, paper, compost, tree bark and sawdust. Inorganic mulches are of inorganic origin such as plastics and other petroleum by-products.

Organic mulches may be applied to a weed-free soil surface prior to direct seeding or transplanting of crop (see Figure 11). It may also be applied after crop emergence, but before weeds emerge. If weeds emerge they become more difficult to control by mulching. Mulching with a material whether it be leaves, straw or bark, should be done with care. The mulch should be spread evenly over the surface of the soil and should not consist of too large particles. Place at least one-half inch thick over the soil to prevent light penetration. Mulching materials should be free of weed seeds, insects, diseases and chemicals; therefore know the source of the mulch material.

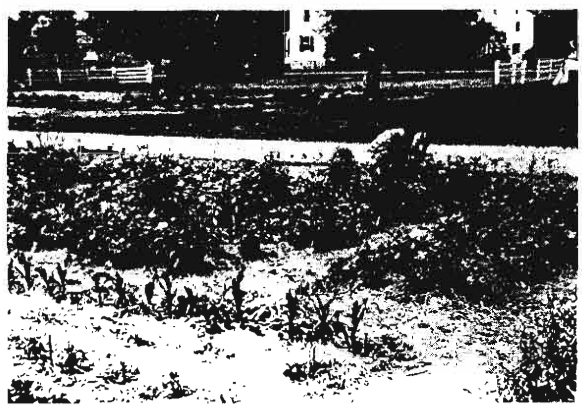


Figure 11. Organic Mulch

Mulch materials should be heavy enough or densely packed so that it will not be easily displaced by wind and water. Mulch materials of paper, sawdust and tree bark are usually free of weeds, disease and insects. Sawdust, however, may contain excessive amounts of tree sap or wood binding glue (found in sawdust from boards such as presswood and plywood). To prevent problems, know the source of the sawdust.

A major advantage of organic over inorganic mulches is that they add organic matter to the soil.

Inorganic mulch of black plastic is the most widely used ground cover in commercial production (see Figure 12). Some clear plastic mulch is used, but is not desirable since it allows the penetration of sunlight, which warms up the soil and encourages weed growth.

Figure 12. Inorganic Mulch

Mulching with black plastic is excellent and simple, but could be somewhat expensive and an obstacle to soil moisture penetration. If cost is not a negative factor, then irrigation problems are easily solved.

At the completion of seedbed preparation, cover individual beds with black plastic and secure edges with soil. If an under-plastic irrigation system is planned, the irrigation tubing must be put in place before laying the plastic. Once the plastic is laid and edges secured, punch holes in plastic at desirable spacing and plant crop by direct seeding or transplanting. Holes normally range from two to four inches in diameter. After the planting process is completed, make sure that enough moisture is supplied to each individual plant by means of underplastic irrigation, sprinkler, irrigation or rain. If some weeds such as nutsedge penetrates the plastic, pull them by hand or overlay the area with another layer of plastic.

Summary

Plan your weed control strategies prior to planting the crop of choice. Each crop may require a different control method and will be greatly influenced by the weed species present. Therefore, properly identify weeds, prepare soil and plant crops in a pattern to effectively allow easy weed control.

Identification of Insects on Vegetables

This section is intended as additional assistance in identifying common insects found on vegetables. There are two pictorial keys (pages 15-16).

If the insect you wish to identify does not fit the keys, it is probably not on it, and you will need additional assistance from your county Extension agent.

How to Use the Pictorial Keys

To use the keys, start at the top of the page, read the choices (usually only two), select the choice that best fits your insect, and follow the line to the next choice until the identification is made. Pictures accompany most choices to help you make the identification. In some cases, the identification can be made with the first choice.

Pictorial Key of Common Adult Insects on Vegetables

In this key the first choice would be to determine if the adult is smaller than a period at the end of a sentence or is larger than a period. If it is smaller, it is a spider mite. If it is larger, it is something else and you drop down to the next choice. If the insect has "tail pipes," it is an aphid; if not, you drop down to four choices based on the wings. Continue this process until the insect fits the key.

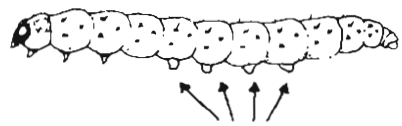
Pictorial Key of Common Immature Insect Pests on Vegetables

In this key the first choice would be to determine if the immature insect is worm shaped or not. If it is, drop down to three choices. These three choices are based on the presence or absence of true legs and prolegs. This process is continued until the insect fits the key.

Definition of Terms Used in the Keys

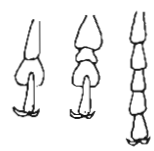
Nymph — a young insect; most differ from an adult by not yet having developed wings.

Prolegs — unsegmented fleshly abdominal legs of caterpillars which serve the purpose of a leg. There may be none, 2,3, or 4 pairs of prolegs present.

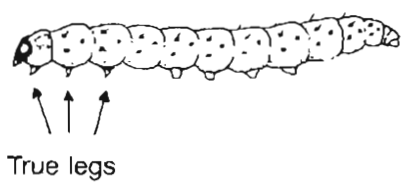


Tail pipes — short blunt horns (2) or rounded projections (cornicles) on the rear end of aphids.

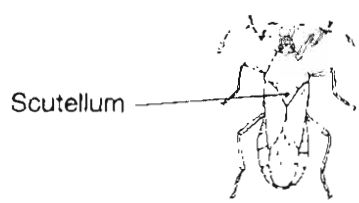
Tarsi — equivalent to the foot in man; the end of the leg consisting of 3-5 segments with the last having a claw.



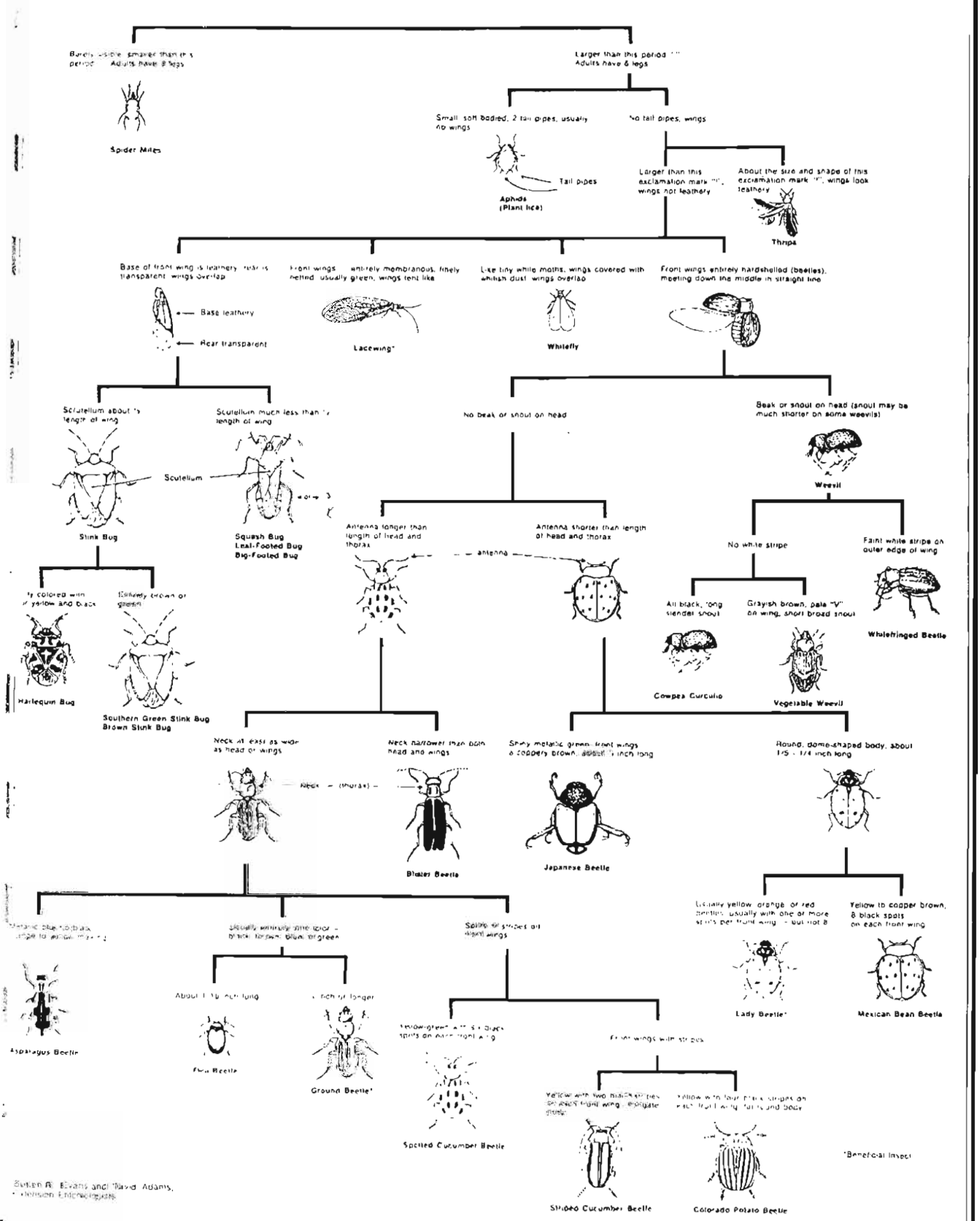
True legs — segmented legs (6) located directly behind the head.



Scutellum — a triangular part of a bug located between the base of the wings.



Pictorial Key of Common Adult Insects on Vegetables



William R. Evans and David Adams,
Extension Entomologists

Pictorial Key to Common Immature Insects on Vegetables

Not worm shaped larvae

Worm shaped larvae

True legs

Prolegs

No tail pipes extending from rear of body

Tail pipes extending from rear of body

Tail pipes

Aphids (Plant lice)

Larger than this exclamation mark shield-shaped brown or green bugs often with orange or black markings disagreeable odor

Stink Bug

Larger than this exclamation mark oblong body greenish brown often with two black spots on abdomen

Squash Bug and Leaf-Footed Bug

Thrips

About the size and shape of this exclamation mark yellow to brown in color

6 true legs (3 pair) prolegs present caterpillars

6 true legs (3 pair) no prolegs

No true legs no prolegs

Found in soil

Found on leaves

Slender, white or brown hard-shelled worms

Wireworm

Fat, soft, C-shaped white grubworms

White Grub

Not transparent body twice as long as wide, head brown

Cowpea Curculio

Not transparent body twice as long as wide, head end distinguished by brown mouthparts

Whitefringed Beetle

Almost transparent, body four times as long as wide mouthparts not visible

Root Maggot

Green, brown or black larvae without horn at rear of body

Have a black horn at rear of body

Hornworm

Smooth-skinned larvae

Larval skin with warts or spines

Reddish brown hump-backed smooth-skinned grubs

Colorado Potato Beetle Larva

Dark gray, slug-like larva with soft, plump, moisture skin, black head and legs

Asparagus Beetle

Spindle shaped larvae with long, sharp pointed jaws

Lacewing*

Carrot shaped flattened, gradually tapering body with a warty back, does not have long sharp-pointed jaws, colored with patches of blue, black and orange

Lady Beetle*

Yellow spiny larvae

Mexican Bean Beetle Larva

2 pairs of prolegs light green larvae up to 1½ inches long, body makes a looping motion while moving

Cabbage Looper

3 pairs of prolegs light green, cigar-shaped, strike less than ½ inch long

Diamondback Moth Caterpillar

4 pairs of prolegs

No Stripes

Stripes

Pale green with small dark shaped spots over the body

European Corn Borer

Potato Tuberworm

Pickleworm

Corn Earworm (tomato fruitworm)

Imported Cabbage Worm

Fall Armyworm

Lesser Cornstalk Borer

*Beneficial insect

Source: Adams and Dutton, [illegible] Extension Entomologists