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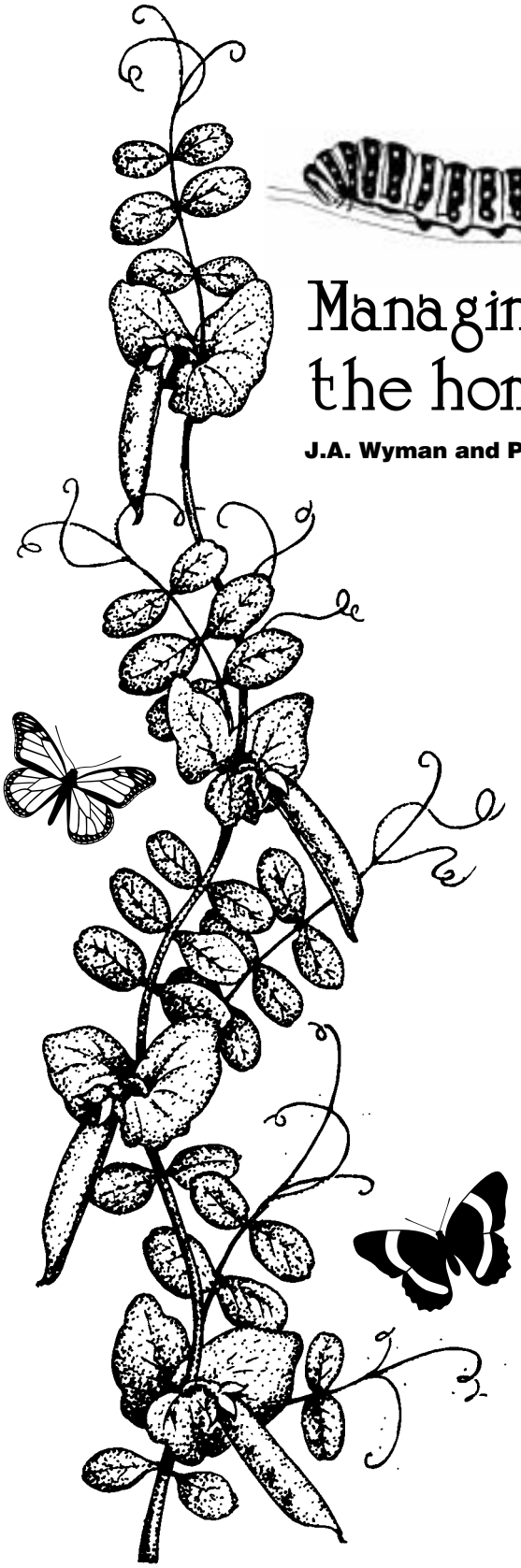
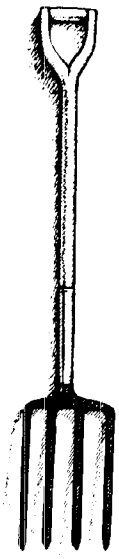


Managing insects in the home vegetable garden

J.A. Wyman and P.J. Pellitteri



Contents

Introduction

Although insects frequently become pests in the home vegetable garden, pest insects represent only a small portion of the total insect fauna. Over 7,000 insect species have been recorded in Wisconsin, but of these less than 100 are garden pests. In fact, many insects are directly beneficial as predators or parasites of pest insects, or as pollinators or decomposers of plant and animal material. The vast majority of insects have no direct impact, either positive or negative, and are important only indirectly as components in food chains.

Control or management of the insects which do become pests can take many directions depending on personal choice and the characteristics of the individual pest. Our objective should not be to eradicate the pest entirely but to manipulate it or the environment in which it lives, so as to maintain populations below levels which cause unacceptable damage.

Proper identification of insect pests is an essential first step in insect management. After an insect is identified, it is possible to examine its life cycle, biology and behavior and identify weak links which can be exploited to reduce its effects. The greater the knowledge of a pest, the greater the number of management options that are available to home gardeners.

This publication contains illustrated keys and detailed narrative to assist in identifying pests. It discusses different styles and types of pest control and suggests a variety of methods. Also included is a seasonal timetable that shows what time of the year specific pests are most active.

Insect pest identification

Insects are members of a group of animals called *Arthropoda* (jointed-feet) this group contains over 75 percent of all described animal species on earth. There are several classes within the arthropods which are not true insects but are closely related. The most common relatives are the *Crustacea* (lobsters, shrimp, crabs), which are primarily aquatic but can be land dwellers (sow bugs). The *Arachnida* are also related, and include two important categories in the home garden, the mites and the spiders. The *Diplopoda* group include centipedes and millipedes. Centipedes are usually predaceous, insect feeders, while the millipedes are plant feeders that usually feed on decaying organic matter.

The insects are the largest group of arthropods and thus are most frequently encountered as pests. An animal can be identified as an insect if you answer yes to all the following characteristics.

Is the body divided into three regions which are specialized for different tasks? (Head with eyes and antennae for sensory perception and mouth parts for feeding, thorax with legs and often wings for locomotion, and the abdomen.)

Does it have three pairs of jointed legs? (These may be reduced or lost in very specialized insects or in some larval insects.)

Does it have one pair of antennae (feelers) located on the head?

Are there two pairs of wings in the adult stage? (These may be highly modified or lost altogether.)

Most insects change from the time they hatch from eggs until they are full grown. This change in form is called metamorphosis. It may be a gradual change, involving little more than an increase in size, to a very dramatic difference between the young and the old.

There are several ways of characterizing the types of metamorphosis, but the most common method is to divide them into incomplete (or simple) and complete metamorphosis.

In the *incomplete metamorphosis,* insects which hatch from eggs are called nymphs. As they feed and grow they shed their skins, or molt. In the winged species, wings first appear as pad-like buds on the nymphs. Each stage between molts is referred to as an instar. There is no prolonged "resting" period before the adult stage is reached. The common orders of insects which have incomplete or simple metamorphosis are listed in the chart accompanying figure 1.

The *complete metamorphosis* involves a very major change in form between the young and the adult. In the winged forms the wings develop internally instead of externally. The typical development involves the egg, larva, pupa and adult. The larvae may go through a number of instars and molts as they grow. The pupae may take several forms; they may be exposed or contained in a capsule-like puparium or in a silken cocoon. Some common orders having this type of development are listed in the chart accompanying figure 1.

To assist identification of common insect pests of vegetable gardens, a pictorial key is included in this publication (see pages 4–7). If you cannot identify an insect, take it to your county Extension office.

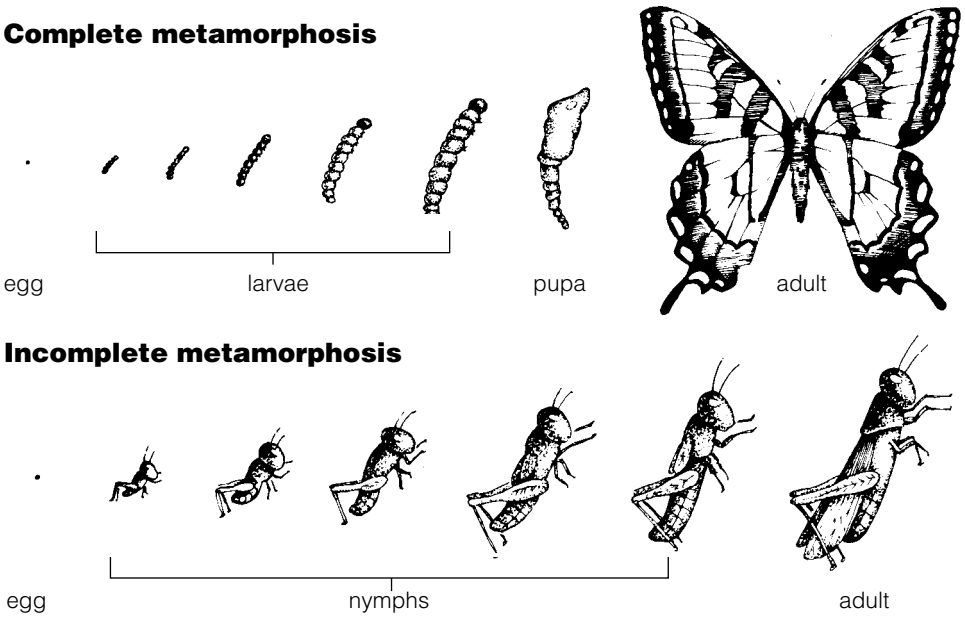
Insects as pests

Insects become pests more frequently than other animals because of the large number of species and their unparalleled ability to increase populations very rapidly. Their reproductive capacity stems from the large number of offspring and from the short life span of the insect. A complete life cycle can be as fast as 7–10 days from egg to adult.

Many controlling factors in the environment combine to prevent insects from reaching their reproductive potential. These factors can be both biological (parasites, predators, food availability) or physical (rain, frost, pesticides). The biological factors are most important in long-term control of insect numbers, with physical factors exerting short-lived reductions.

Home gardeners should try to manipulate the naturally occurring control factors and add new ones, where appropriate, to maintain insect pest populations at non-damaging levels. The following discussion suggests factors which can be important in pest management.

Figure 1. Metamorphosis of various insects



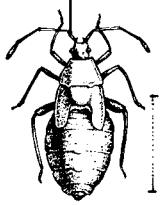
Examples	Orders
Lacewing	Neuroptera
Beetles	Coleoptera
Scorpion fly	Mecoptera
Caddisfly	Trichoptera
Moths, butterflies	Lepidoptera
Flies, mosquitoes	Diptera
Fleas	Siphonaptera
Wasps, bees, ants	Hymenoptera

Examples	Orders
Grasshoppers	Orthoptera
Termites	Isoptera
Booklice	Corrodentia
Thrips	Thysanoptera
True bugs	Hemiptera
Aphids	Homoptera
Earwigs	Dermaptera

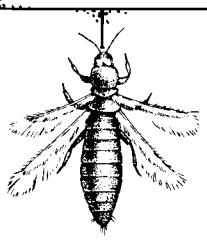
Immature key

Nymphs
Not worm-shaped (without wings)

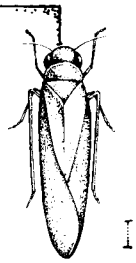
No tail pipe extending from rear of body



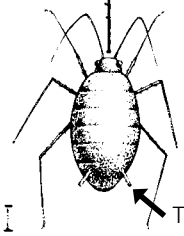
Squash bug and leaf-footed bug
Oblong, greenish brown body, ½ inch long; often has two black spots on abdomen.



Onion thrips
About the size and shape of the exclamation mark "!"; yellow to brown in color.

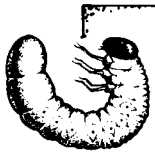


Leafhopper
⅛ inch, green, wedge-shaped nymph. Like adults but smaller.



Plant lice (aphids)
Tail pipes extending from rear of body.

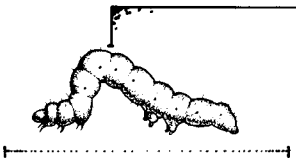
Six true legs (three pairs), prolegs present; caterpillars



White grub
Fat, soft, C-shaped, white grubworms.

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

Hornworms
Red or black horn at rear of body.

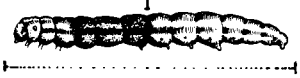


Cabbage looper
Two pairs of prolegs. Light-green larvae up to 1½ inches long, body makes a looping motion while moving.

Diamond moth caterpillar
Three pairs of prolegs. Light green, cigar-shaped larvae less than ¾ inch long.

Four pairs of prolegs

European corn borer
Without cross stripes; not brown at each end; flesh-colored caterpillars up to 1 inch long with small donut-shaped brown spots over the body.



Common stalk borer
Brown and white stripes run lengthwise on body. Yellow head. Bores into stems of many vegetables.

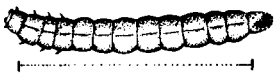
***** Beneficial insect

Worm-shaped larvae

True legs | Prolegs

Six true legs (three pairs), no prolegs

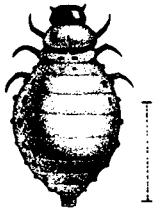
Found in soil



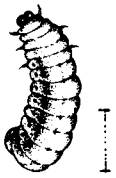
Wireworm
Slender, white or brown, hard-shelled worms.

Found on leaves

Smooth-skinned larvae

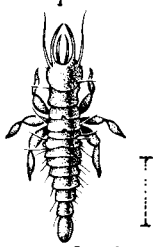


Colorado potato beetle larva
Reddish brown, hump-backed smooth-skinned grubs.

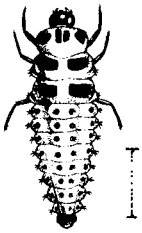


Asparagus beetle
Dark-gray, slug-like larvae with soft, plump, non-hairy skin; black head and legs.

Larval skin with warts or spines



Lacewing*
Spindle-shaped larvae with long sharp pointed jaws.



Lady beetle*
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.

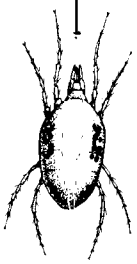
Without cross stripes; not brown at each end; without donut-shaped spots.

Cutworms
Gray, brown, white or black; smooth skinned. Markings indistinct. Curl up in C-shape when disturbed.

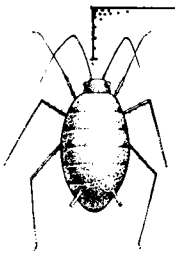
Corn earworm
Light green to nearly black larvae up to 2 inches long with coarse black hairs and alternating light and dark stripes running lengthwise on body.

Imported cabbage worm
Leaf green, velvety-skinned larvae, up to 1¼ inch long.

Adult key

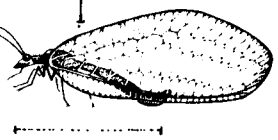


Spider mites
Barely visible—about the size of a period. Adults have eight legs.



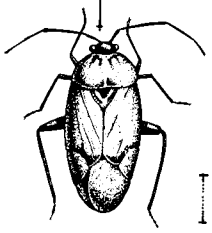
Aphids
1/8–1/10 inch long, small, soft bodied, two tail pipes, usually no wings, pear-shaped bodies.

Wings overlap on back, base of front wing may be leathery; not hard shelled

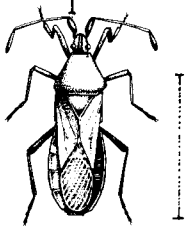


Lacewing*
Front wings entirely membrane-like. Finely netted, held tent-like over body. Green in color. Hair-like antennae.

Leafhopper
1/8 inch long, wedge shaped. Hop when disturbed.

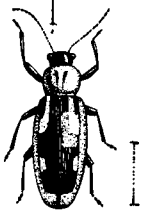


Plant bug
1/4 inch long, actively fly.



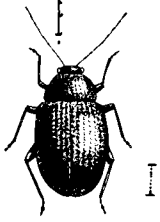
Squash bug
1 inch long, dark brown.

Antennae longer than length of head and thorax

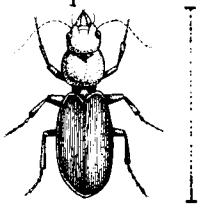


Asparagus beetle
Metallic blue to back, orange to yellow marking.

Usually entirely one color—black, brown, blue or green



Flea beetle
About 1/8–1/4 inch long.



Ground beetle*
1/4 inch or longer.

* Beneficial insect

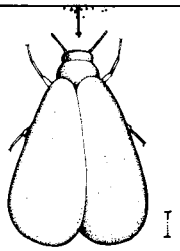
Larger than a period; adults have six legs

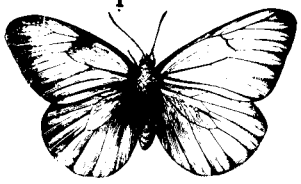
Wings present; no tail pipes

Two pairs of wings present

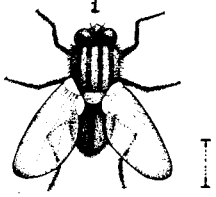
Beetles
Front wings entirely hard shelled, meeting down the middle in straight line.

White fly
Tiny (⅛ inch), moth-like insects. Wings covered with whitish dust. Wings overlap when resting.



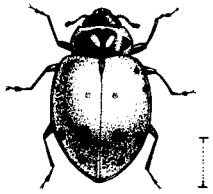


Moths and butterflies
Wing covered with fine powder-like scales. Various sizes.

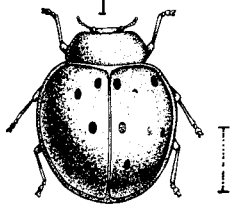


True flies and root maggot adults
Only one pair of wings present.

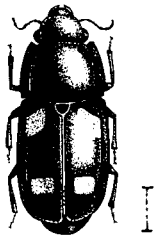
Antennae shorter than length of head and thorax



Lady beetle*
Usually yellow, orange, or red beetles; usually with one or more spots per front wing—but not eight.

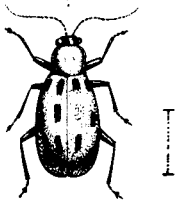


Mexican bean beetle
Yellow to copper brown; eight black spots on each front wing.



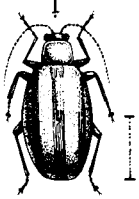
Picnic beetle
Dark brown-black with four orange-yellow spots on back.

Spots or stripes on front wings

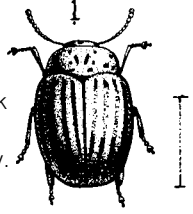


Spotted cucumber beetle
Yellow-green with six black spots on each front wing.

Front wings with stripes



Striped cucumber beetle
Yellow with two black stripes on each front wing, elongate body.



Colorado potato beetle
Yellow with four black stripes on each front wing; fat, round body.

Climate

Insects are cold-blooded and thus drastically affected by temperature extremes. Extreme cold and heat reduce insect numbers. Insect development is slow or non-existent at low temperatures and speeds up at higher temperatures. Although temperature cannot be manipulated, it can serve as a useful guide to the rate at which insects reach damaging levels. With some insects temperature can be used to predict the occurrence of important life stages (see calculating degree days on page 13).

Some pests need humid conditions to thrive (cutworms, slugs) while others may be successful under hot dry conditions (thrips, mites). Rainfall often provides control by washing insects (such as aphids) from plants.

Biological control

Naturally occurring biological controls can play an extremely important role in limiting insect populations. Insect predators including lady beetle larvae and adults, lacewing larvae, predacious sucking bugs (such as the assassin bug) and many others are always present in a vegetable garden. Together with the less obvious parasitic insects they can contribute greatly to a healthy garden. These biological controls frequently prevent pest populations from reaching damaging levels. These effects are seldom spectacular and often go unnoticed. Remember that even when biological controls are functioning effectively there will still be a residual population of pests. Removing all pests, particularly with an insecticide, will disrupt biological control. To promote the natural activities of predators and parasites, use insecticides only when absolutely necessary and as selectively as possible. Introducing parasites and predators by releasing commercially purchased insects such as lady beetle or praying mantis has limited value in Wisconsin.

Naturally occurring insect diseases can be extremely effective in reducing populations. Both fungal and viral diseases are common in some insects. Whenever the conditions are optimal for disease development and a large population of insects occurs at the same time, a disease epidemic usually breaks out. This phenomenon is most often seen in aphids and caterpillars. Unfortunately, it is not easy to manipulate such disease occurrence. However, collecting sick or dying insects and spraying their crushed and diluted body parts on plants is occasionally successful. This approach has no effect unless the insects are infected with a disease. You can identify a diseased population by seeing an increased number of insect carcasses where some of the carcasses are moldy, discolored, or decomposing into liquid tissue.

Cultural control

Cultural control is an area of insect management where gardeners can utilize a wide array of crop management approaches to effectively disrupt or adversely affect insect pests.

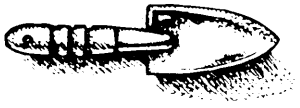
Selection of crops

Crops vary widely in the number of insect pests associated with them. Asparagus, beets, green or wax beans, carrots, peas and tomatoes have relatively few serious insect problems. Cole crops (cabbage, broccoli, brussels sprouts, cauliflower, radish, rutabaga, turnip) and potatoes have many insect pests and are extremely difficult to grow without sustaining some losses. When choosing crop types, also remember to consider plant disease problems. Extension publication *Disease-Resistant Vegetables for the Home Garden* (A3110) will help you select cultivars with resistance to many disease problems.

Timing of planting

Because insect pest development is dependent on temperature, insects are present in damaging numbers for relatively short and predictable periods during the growing season (see the timetable of pest abundance and damage on page 20). By delaying or advancing planting dates, gardeners can frequently avoid periods of high pest activity and drastically reduce damage. Examples of these controls are discussed later under the specific crop sections.

When avoidance of insects is difficult, it is important to keep the time that plants are most susceptible to a minimum. For example, many plants are particularly susceptible to injury in the seed or seedling stages. Gardeners can reduce injury by planting only during good growing conditions, when germination is most rapid, or by using plastic mulches to hasten growth.



Sanitation and clean cultivation

Insect pests can often overwinter in plant debris. Good sanitation and removal of crop residues in the fall reduces or delays infestations the following spring. Working the soil in the fall and spring exposes insects which live or overwinter in the soil and can cause high mortality. Pests such as slugs and cutworms are more of a problem in mulched gardens.

Weed control is important particularly with grassy weeds because several common garden pests (cutworms, grubs, wireworms) are attracted to grasses to lay their eggs.

Crop rotation

The effectiveness of crop rotation in a garden is limited to insects which have only one generation and do not migrate readily. In such cases, rotation can be extremely effective. For example, corn rootworm adults lay eggs only in corn, and these eggs overwinter. If corn is planted in the same spot, the resulting larvae cause damage, but if it is rotated even a short distance from the original site, damage is avoided.

Soil insects which are associated primarily with grass and sod (grubs, wireworms) can be severe problems if the garden is rotated into an area which was previously sod.

Companion planting

Research has demonstrated that plants such as marigolds, basil and nasturtiums do not provide protection when planted next to most vegetables. In fact, they often attract and support many of a garden's common pests. Diversifying a garden by interplanting different plant types can help reduce problems but requires a thorough understanding of the insects which attack each plant. In general, the fewer pests two plants have in common, the better companions they are.

Fertilizer and water

In general, plants which are healthy and growing vigorously are able to contend with higher insect populations than plants which are weak or stressed. Thus, proper amounts of fertilizer and water and good growing practices usually aid in reducing insect damage.

Resistant varieties

Although most vegetable cultivars exhibit differences in resistance to insect attack, these attributes have not been exploited by commercial breeders. Personal experience with varieties can often be used to select the more insect-tolerant cultivars.

Mechanical control

Home vegetable gardens are frequently of small size, so gardeners can physically prevent certain insects from attacking plants or can remove the insects when they are present.

Gardeners can use a number of approaches to prevent insects from attacking plants. Crawling insects such as cutworms can be excluded with a physical barrier such as a tin can around the bases of plants. Paper discs can prevent access to plant bases to control cabbage maggot. Flying insects can be excluded by placing a netting over the plants during periods of intense pest activity. Reflective mulch (aluminum foil or white plastic) effectively repels aphids. Colored traps such as yellow bowls filled with soapy water can attract insects away from plants and drown them. These controls are given as examples. Gardeners often successfully devise new mechanical controls or adapt existing ones to suit individual preferences and situations.

When insects are on plants, gardeners can physically remove and destroy them. This hands-on approach is most effective with large, easily detected pests such as hornworms and Colorado potato beetles. Using an insect net to catch and remove day-flying insects like the imported cabbage worm or the squash vine borer can also reduce egg laying.

Pest exclusion

Because Wisconsin has extremely harsh winters, insects must hibernate in the state or migrate in from states with milder climates each year. For this reason, most insect infestations do not become severe until well into the growing season. Commercially purchased transplants, however, are produced in greenhouses or southern states where insects are active year-round and may be infested when purchased. Careful inspection of transplants and removal of pests can effectively prevent early buildups of pests on these plants.

Chemical control

Insecticides represent an artificial means of reducing insect populations. They have the advantage of being relatively simple to use and quick to reduce populations which are at damaging levels. Gardeners should use insecticides as only one part of a carefully designed management strategy. In this way, the benefits of such materials can be realized and the adverse impacts on other natural factors can be avoided.

Types of formulations

Many different insecticidal products are available commercially, but these represent relatively few active ingredients which are formulated into many different products. The most common formulations are:

Emulsifiable concentrates (EC)—These insecticides are purchased as liquids which are not soluble in water but form a white emulsion when mixed with water. They must be diluted with water prior to application.

Wettable powders (WP)—These are dry formulations (finely divided powders) where the insecticide is mixed with inert material which easily disperses in water to form a suspension. They must be diluted before application, and occasional agitation is recommended to ensure that the suspension remains evenly mixed.

Dusts—Dusts are dry formulations with small percentages (2–5 percent) of insecticides mixed with inert dust. They are applied dry without dilution.

Baits—These are dry insecticide formulations mixed with a material which is attractive to pests as a food (bran, apple pomace) and formed into pellets. Baits are sprinkled on the soil and must be eaten by pests to be effective.

Types of insecticides

Insecticides can be manufactured chemically or can be extracted from certain plants. The most common insecticides available for home garden use are:

Botanical insecticides (extracted from plants)

Ryania, Rotenone: Derived from the roots of tropical plants and need to be ingested to act as stomach poisons. These are normally used against chewing insects.

Pyrethrin: Derived from the flowers of certain chrysanthemum plants. Pyrethrin causes rapid paralysis and apparent death, but insects may subsequently recover. It is used primarily as a fly spray additive or against soft-bodied insects. Mixtures with piperonyl butoxide provide greater control.

Nicotine: Derived from the tobacco plant and is effective against some soft-bodied insects.

Manufactured insecticides

Carbaryl (Sevin): A widely used insecticide with several trade names. Effective on beetles and some caterpillars but does not kill aphids. Persistent on plants for 4–5 days. Available as liquid, dust, wettable powder and baits.

Malathion: Moderately effective on a wide range of insects. Persistent on plants for 2–3 days. Available as liquid, dust and wettable powder.

Diazinon: Moderately effective on a wide range of insects and can be applied to the soil. Persistent for 4–5 days. Available as wettable powder, liquid and granular.

Methoxychlor: A longer lasting material used primarily on chewing insects.

Inorganic insecticides

Oils and soaps: Both oils and mild soap (1–2 percent by volume) or detergent solutions will kill insects. Oils and soaps kill only insects contacted with the spray and have little residual effect. Many oils will burn certain tissues if applied to actively growing plants. Some soaps have greater insecticidal activity than others and specific “insecticidal soaps” are now available which are very effective against soft-bodied insects such as aphids, scales and mealybugs. Pure unscented soaps

are less likely to burn. If you are not familiar with these treatments, test spray a small number of plant leaves and allow 2–3 days for signs of burning. Summer oils can be used during the growing season.

Microbial insecticides

Bacillus thuringiensis (Bt) (Dipel, Thuricide): This type of insecticide is a bacterium derived from a microbe and is the only product available for home garden use. Marketed under several trade names, this product is actually a formulation of bacterial spores which contain a toxin. Bt is a stomach poison which causes gut paralysis when consumed by certain insects. Its action is extremely specific, being effective only against true caterpillars (lepidopterous larvae). A different strain can be used to control beetles such as the Colorado potato beetle. It is extremely safe for other organisms.

Miscellaneous products

Various products such as salt, red and black pepper, garlic and flour have been reported to kill insects or discourage feeding. There is no scientific evidence to support these claims and their use should be approached with caution. Insects have markedly different sensory perception systems from humans and do not respond to the same things. In nature there are numerous insects which feed on plants which produce pepper, garlic and other noxious odors. For example, the insects attracted to cabbage are attracted to mustard oils which humans utilize for tear gas.

Insecticide toxicity

Insecticides which are registered for use in home vegetable gardens need to be used properly. Materials which are classified as "slightly toxic" will bear a "CAUTION" statement on the label. Those which are "moderately toxic" bear a "WARNING," and those which are "highly toxic" will bear a "DANGER" statement and will also be identified by a skull and crossbones symbol on the label. As a measure of relative toxicity to humans it is estimated that the following doses would need to be ingested to cause death in an average 160-pound adult:

- slightly toxic—1 pint to 1 quart
- moderately toxic—1 ounce to 1 pint
- highly toxic—1 drop to 1 ounce

Table 1 compares the relative toxicities of insecticides registered for home garden use. For comparative purposes, table salt (LD_{50}—3,750 mg/kg) and aspirin (LD_{50}—1,750 mg/kg) would be classified as "slightly toxic" if used as insecticides.

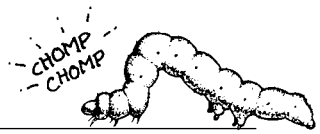


Table 1. Relative toxicities of insecticides registered for home garden use

Common name	Trade name	Oral LD_{50}, rat[a] (mg/kg)	Mammalian toxicity
Carbaryl	Sevin	650	Moderate
Diazinon	Diazinon, Spectracide	108	High
Malathion	Malathion	1375	Moderate
Methoxychlor	Marlate, Methoxychlor	5000	Low
Nicotine	Various trade names	83	High
Rotenone	Rotenone	75	High
Bacillus thuringiensis	Thuricide, Dipel, M-One	4000	Low
Pyrethrin	Various names in combination with other insecticides.	1870	Moderate

[1] LD_{50} is a term used to describe the toxicity of a pesticide to various test animals. The oral LD_{50} for rats is the amount of pesticide in mg/kg of body weight required to kill 50 percent of a test population of rats when taken orally. These values should be used only as comparative values to indicate the relative degree of toxicity since they can vary among test animals.

Insecticide application

Most garden insecticides are applied to the foliage as liquid sprays. Dust and granular formulations are the exception. To prepare a spray, use the amounts listed in table 2 of insecticides to each gallon of water. Mix only enough for the plants which require treatment, and use the mixture as soon as possible after mixing.

Table 2. Insecticide spray mixes

Insecticide[a]	Rate/gallon of water
carbaryl (Sevin) 50% WP	2 tablespoons
diazinon (Spectracide) 25% WP	2 tablespoons
diazinon (Spectracide) 25% LC	2 teaspoons
malathion 25% WP	4 tablespoons
malathion 50–57% LC	2 teaspoons
methoxychlor 50% WP	2 tablespoons
methoxychlor EC	2 tablespoons
rotenone 5% WP	4 tablespoons

[a] **WP**=wettable powder, **LC**=liquid concentrate, **EC**=emulsifiable concentrate

Some insecticides are available in small packages as dusts. Apply a light coating of dust at the rate of 1 ounce per 50 feet of row.

Complete plant coverage of upper and lower leaf surfaces is important. This is because many insecticides must contact the insects or be eaten by them to provide control. On plants which are extremely hairy or waxy, adding a drop of household detergent per gallon will improve coverage.

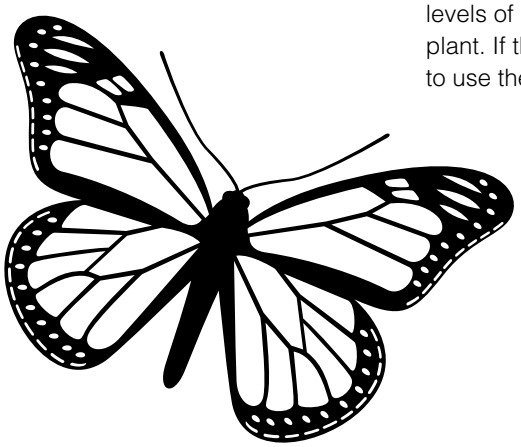
Guidelines for insecticide use

Always consider the following when using insecticides:

Correct timing and treatment thresholds—Insects infest plants at definite times and should only be treated when present in threatening numbers. Individual gardeners should make judgments as to how much insect damage they are prepared to tolerate. Often by tolerating minimal damage, which can easily be trimmed or discarded, the need for insecticides is greatly reduced and natural controls build up to regulate the pest population.

Protection of beneficial insects—By definition insecticides kill insects; indiscriminate use will harm the pollinators, predators and parasites which keep a garden healthy.

Safety—Insecticides are relatively safe to use when properly handled, and only relatively nontoxic materials are registered for home garden use. Nevertheless, all chemicals can be toxic if used improperly. Always read product labels thoroughly, and follow directions exactly. It is illegal to change containers for pesticides. Pesticides should be stored in a locked cabinet out of the reach of children. Check the label for pre-harvest periods after treatment. Pre-harvest periods define how long you must wait to harvest the vegetable to ensure that there are not toxic levels of residue of the insecticide left on the plant. If the crop is not on the label, it is illegal to use the product on that particular vegetable.



Development of insect management strategies

Two schools of thought are most commonly encountered in insect management in the home garden. One school has relied primarily on insecticide use, while the other—the organic approach—has shunned all insecticide use except that which is considered "organic" in nature. Another approach is integrated pest management (IPM). With IPM, all possible approaches to insect management are utilized in a unified strategy to maintain insect populations at nondamaging levels, while avoiding adverse environmental effects.

In the following section, the major insect pests of garden vegetables are discussed together with various control approaches. From this, gardeners should be able to design an insect management strategy tailored to suit individual preferences. The pest keys (pages 4–7) enable each insect to be identified, and the timetable (page 20) indicates the time and duration of probable infestations.

Calculating degree days

Temperature plays an important role in controlling the rate of development of crop plants and insects. Cold weather slows development while warm weather accelerates it. To monitor crop development and predict pest behavior, you can use a system that takes into account the accumulation of heat with passing time. This system is based on degree days (DD).

A degree day (DD) is a unit of measure that occurs for each degree above a base temperature during a 24-hour period. The base temperature is the temperature below which there is no plant or insect development. Specific insects have specific base temperatures. To monitor plant and insect development using degree days, you will need a maximum/minimum thermometer to obtain the daily high and low temperatures. Begin calculating degree day accumulations on March 1 using the following equations:

(daily high[a] + daily low[b]) ÷ 2 = daily average temperature

daily average temperature – base temperature = 24-hour degree day accumulation

[a]Use 86°F if the high temperature for the day is more than 86°F.

[b]Substitute the base temperature if the daily low is less than the base temperature.

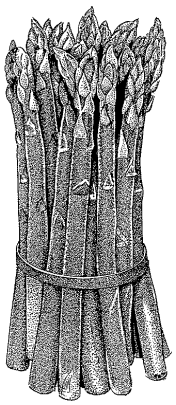
Example: First-generation cabbage maggot emergence peaks at 300 degree days. This pest has a base temperature of 43°F. If the high for one day was 66°F and the low was 44°F, calculating the degree days would look like this:

(66 + 44) ÷ 2 = 55 (daily average temperature)

55 – 43 = 12 (degree day accumulation)

Record the degree days for each day and continue adding them together. When the total nears 300 degree days, take steps to prevent plant damage.

Insect management on vegetable crops



Asparagus

Asparagus beetles and aphids are two types of insects that attack asparagus. Both do most of their damage in the spring.

Adult **asparagus beetles** are ¼-inch long and may be orange with black spots, or have yellowish squares on a dark green background. Larvae are plump grayish worms with black heads. Activity begins in spring as the plants emerge. Both adults and larvae chew on the shoots and foliage, but some damage can be tolerated. Eggs are cigar-shaped and black and often are placed on the foliage in rows. Destruction of crop residues and trash eliminates adult overwintering sites, and adults can be hand picked early in spring before egg laying. Carbaryl, rotenone or malathion may be used if damage is severe.

Asparagus aphids damage young shoots, stunt growth and cause parts of the plant to take on a bushy rosette appearance. Normally only one or two plants in a patch are affected. Soapy water or malathion can be used as a spot treatment.

Beans (green, wax, broad, lima)

Beans are a very good choice for people who prefer to grow vegetables without chemicals, because most insect pest damage can be tolerated without treatment.

Seedcorn maggot is by far the most serious pest to all beans. The white legless maggot burrows into the seed or seedling, causing very poor seed germination and emergence, and/or stems without leaves (snake heads). The adult is a small grayish fly which looks identical to the cabbage maggot. This insect overwinters in the pupal stage in the soil and becomes active early in the spring. Heaviest plant damage occurs during cool damp weather, in heavy organic soils and after peak adult flights. There are five generations per year, but most severe damage occurs in May and June. Peak activity of each generation can be predicted using degree days (200, 600 and 1000 degree days with a base temperature of 39°F for first, second and third generations, respectively). But since damage is severe for each of the first three generations, it is seldom possible to avoid activity periods. Yellow pans (their bright color attracts insects) filled with water and placed in the garden are helpful in monitoring and reducing adult numbers. Damage can be reduced by planting seeds during good germinating weather, using seed treated with insecticide or sowing seed in higher than normal numbers. Planting seeds too early or directly into rich organic matter, like manure, frequently increases problems with this insect. Other crops attacked include peas, corn, all vine crops and crucifers, but beans are the preferred host.

Black bean aphids may cluster on the undersides of succulent leaves, and large populations can cause yellowish foliage and poor growth. Both winged and wingless forms of this dark black aphid will be found on the plant. In general aphids are susceptible to many diseases and are frequently controlled by beneficial insects. Soapy sprays or malathion can be used if high populations are observed.

Flea beetles can cause occasional problems when plants first emerge by chewing numerous small holes in the leaves. Established plants can tolerate such feeding. Flea beetles will be most severe in weedy gardens. If a problem does exist, cover the plants with cheesecloth or spray them with carbaryl.

Potato leafhoppers are an annual pest of the foliage of bean plants. Adults are ⅛-inch, wedge-shaped, bright green insects which fly off plants before gardeners can observe them. Nymphs hide on the undersides of the leaves and move sideways when disturbed. They feed by inserting needle-like mouth parts into the plant and extracting plant sap. Their saliva causes the plant to become stunted and the outer margins of the leaves to turn yellow or brown. This damage is called “hopperburn” and is often mistaken for a disease. There are no effective natural enemies of this insect. Potato leafhoppers are frequently found in large numbers in alfalfa. Gardens close to alfalfa fields are often inundated when the alfalfa is cut. Hairy-leafed bean varieties have some resistance. Leafhopper feeding may reduce yields, but the average gardener can tolerate this damage.

Beets and spinach

Spinach leafminers are very small flies. They lay their eggs inside the leaves of a number of vegetables (spinach is particularly susceptible), where their small maggots develop within the leaf tissue. Numerous tan or white trails or blotches appear on the leaves, and gardeners may see small, pepper-like fecal pellets inside the leafmines. To control this pest, remove and destroy infested leaves and weeds at the first sign of activity. Sprays are largely ineffective because insecticides have long harvest restrictions and pest activity often coincides with maturation of the crop. Sprays will not kill larvae already in the leaves.

Green peach aphids (small, ⅛-inch, greenish aphids) may build to large populations on the undersides of the leaves. They can stunt the plant's growth or cause it to wilt. The lush growth of spinach and beets makes spray coverage difficult, but forceful streams of water, a mild soap solution or malathion can be used if populations are very high. Late-season populations are often controlled by naturally occurring fungal diseases.

Carrots, celery and lettuce

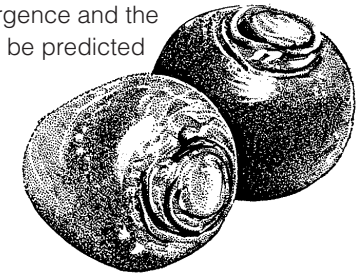
Aster leafhoppers carry a disease called aster yellows, which is the main problem for these crops. Infestation in May and June results from leafhoppers migrating into Wisconsin, but because of its migration pattern, the severity of the disease varies yearly. Well over 100 species of flowers, weeds and vegetables are attacked. Once symptoms (stunting, yellowing, or distorted growth) appear, gardeners should pull up and destroy infested plants to slow the spread of the disease. Some varieties of carrots such as 'Scarlet Nantes' and 'Gold King' are more tolerant of the disease.

Crucifers (broccoli, cauliflower, cabbage, brussels sprouts, radish, rutabaga, turnip)

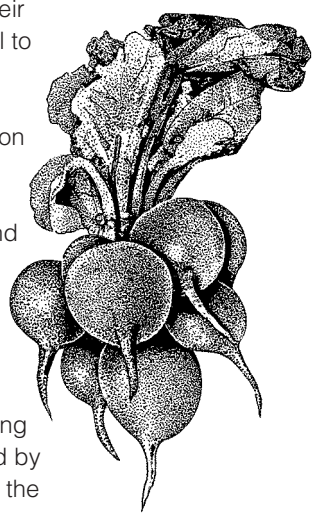
Crucifers include a wide range of closely related vegetable species, all of which are extremely susceptible to insect attack and generally have the same complex of insects.

Cabbage maggot is the first insect to attack these crops. The adult cabbage maggot is a small gray fly which lays its eggs at the base of crop plants in the cabbage family. The small cylindrical and white eggs hatch into legless white maggots which feed on the roots. Seedling plants can be killed rapidly, while transplants tend to wilt and die slowly. Root crucifers such as radish and turnip show surface tunneling which is often accompanied by soft rots.

The cabbage maggot has three generations in Wisconsin. The first emergence of adults from overwintering pupae is the largest and most damaging. This emergence and the egg laying peak may be predicted accurately by accumulating the degree days (see sidebar). Cabbage maggots do not develop below 43°F (base temperature), and their development above 43°F is directly proportional to temperature, (the warmer it gets the faster cabbage maggots will develop).



Chemical controls require either soil application of diazinon to seed furrows or transplant drenches. However, these treatments are often not effective since they last for only 4–5 days and need to be applied when the adults are actively laying eggs.



Knowledge of the emergence enables growers to avoid planting during this time, thus avoiding damage. If planting is necessary, then diazinon soil treatment should be effective. During this time the adult maggot can also be excluded by placing a netting over the plants or surrounding the base with a protective collar.

Flea beetles are frequently a pest of early plantings. These small, shiny black beetles, which jump when approached, chew small circular holes in the leaves. This damage is insignificant on large plants, but young seedlings can be rapidly killed. Usually, beetles are present for only a short time and can be excluded with netting or controlled with a carbaryl spray.

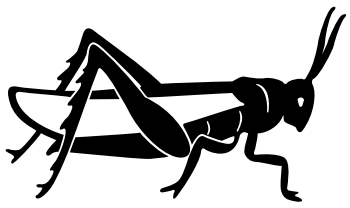
Caterpillars (lepidopterous larvae) which chew holes in the leaves and heads of leafy crucifers pose the greatest insect problem. Three caterpillars are present in Wisconsin: the diamondback moth, the imported cabbageworm and the cabbage looper. The diamondback moth and imported cabbageworm overwinter in Wisconsin as pupae and are the first to appear on crucifers with a larval generation in June. Diamondback moth adults are small nocturnal moths with a distinctive diamond pattern on the wings but are rarely seen by the gardener. Larvae are small (½ inch), cigar-shaped green caterpillars which wiggle rapidly when touched. Their feeding damage is usually not severe enough to warrant treatment. In the absence of pesticides this pest is heavily parasitized, and numbers do not exceed damaging levels.

Imported cabbageworms are day-flying white butterflies which lay cigar-shaped yellow eggs on the undersides of leaves. Adult flights are easily detected. Gardeners can remove eggs on small plants by hand. Seven to ten days after the eggs are laid, small velvety-green caterpillars begin feeding on the leaves. These increase to over 1 inch in length and cause considerable damage if large numbers are present. Two damaging larval generations normally occur, with the first in June and the second in July and August.

Cabbage loopers do not overwinter in Wisconsin. The adults are mottled brown nocturnal moths with white hourglass markings on the wings who migrate into the state in June. The small, round white eggs are easily detected on the undersides of leaves. The larvae are light green and characteristically move by looping the body. They reach 1½ inches in length and cause considerable feeding injury. Second generation larval infestations occur in late August and September and are most severe.

Bacillus thuringiensis sprays are an effective control of imported cabbageworm and cabbage looper since Bt is very specific and does not affect helpful parasites. Sprays are most effective if timed to coincide with the presence of small larvae. These periods can be expected to occur 1–2 weeks after egg laying and before damage is severe. *Bacillus thuringiensis* is less effective against larger caterpillars.

Two aphid species attack crucifers. The **green peach aphid** is a small, light green aphid which may reach large numbers on the older leaves of leafy crucifers. Gardeners can treat these with soapy water or malathion, but they cause little damage and may be left to natural control by parasites and predators. The **cabbage aphid** is a gray aphid which lives in closely packed groups and secretes a copious gray wax. Heavy infestations cause leaf distortion and can prevent head formation. Early detection and removal with soap or malathion sprays are most effective. Both the green peach aphid and cabbage aphid can infest the heads of broccoli and the sprouts of brussels sprouts, where they are extremely difficult to remove. Treat these plants prior to head formation if aphid populations are heavy.



Onions

Onion maggots are small whitish larvae found in the bulbs of onions. The adult is a grayish fly which resembles the cabbage maggot. This insect is extremely difficult to control with the options available to the home gardener. To prevent increasing problems, gardeners occasionally need to rotate out of plants in the onion family.

Thrips are small 1/25-inch insects which cause whitish scratches and brownish blotches on the leaves. They are often associated with weedy gardens and are more severe in hot dry summers. Damage is superficial and can often be tolerated. When populations are very high, diazinon can be used as a spray treatment. The insect hides under leaf sheaths, and sprays must be applied with enough water to ensure penetration to these areas. Two or three treatments may be needed.

Peas

Peas are normally an early-season crop which has few insect problems. **Seedcorn maggots** may reduce plant stands during poor germinating weather and can be controlled as described under beans.

Three species of **aphid** can be found on peas. Although they transmit virus diseases, aphids normally do not need to be controlled in the home garden. However, gardeners can use soapy water or malathion if populations become extremely large.

Peppers

Green peach aphids are a common pest of peppers and often infest transplants as they come from the greenhouse. Large numbers of these greenish aphids will cluster on the undersides of leaves, causing a sticky, shiny sap-like residue called honeydew which accumulates on lower leaves. A black sooty mold fungus frequently flourishes on the honeydew, and its presence indicates high aphid populations. Growth may be distorted, and the plant may wilt. Green peach aphids are subject to a number of natural control factors. Gardeners also can control them with soapy water, malathion or diazinon.

Flea beetles may cause small shot holes in the leaves. This damage is insignificant on all but the smallest plants. If needed, carbaryl or rotenone can be used.

European corn borers can be a pest of peppers. Egg masses are laid on the leaves in August, and the dirty white caterpillars with dark heads can be found burrowing in the fruits which often rot after infestation. This insect is only active for short periods of time, and the injured areas are easily cut out of damaged peppers. Because of this, chemical control is not suggested.

Potatoes

Potatoes are one of the most difficult crops to grow in the home garden on an economical basis. Much of the insect damage is subtle but often responsible for killing vines 3–4 weeks early, substantially reducing yields. The insect pests of potatoes are hard to monitor and often missed by the average gardener.

Potato leafhoppers are small (⅛ inch), wedge-shaped, bright green insects which migrate into the state every spring. Their saliva is toxic to the plant and causes the leaf edges to curl, turn yellow and eventually brown, and die. This "hopperburn" is the most commonly missed insect injury in the Wisconsin garden. There are no good cultural controls, and the potato leafhopper is without effective natural enemies. To control, spray with carbaryl or malathion at the first sign of hopperburn. In severe years, more than one treatment may be necessary. This insect builds to large numbers in alfalfa, and large infestations can occur following the first cutting of alfalfa.

Potato flea beetles are small blackish insects which cause numerous ⅛-inch holes in potato leaves. This damage is insignificant on established plants and can be ignored.

Two species of **aphids** attack potatoes. The **potato aphid** is a large (⅛ inch), green or red aphid seen on the succulent new growth of the plant. The **green peach aphid** is a smaller greenish aphid most often seen on the lower leaves. They both are responsible for spreading virus diseases. These aphids rarely need control unless plants are grown for seed stock or infestations are exceedingly heavy. Because many of the viruses are carried in the tubers, plant only certified seed stock, and do not replant home-grown tubers.

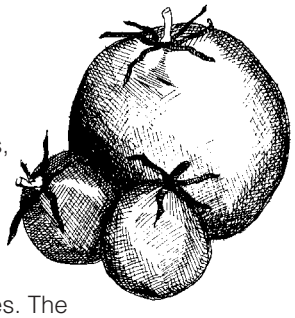
Colorado potato beetles are the most distinctive pest of potatoes. Both the yellow and black striped adults and the brick-red humped larvae feed on the foliage. They normally feed on new growth and damage can be severe. Adults overwinter and move to emerging potatoes early in the spring (May). The adults lay bright yellow egg masses, and larvae feed for several weeks in the summer before pupating in the soil. Emerging adults then continue feeding throughout the season until no vines remain. Gardeners can successfully hand pick them to achieve control. Colorado potato beetle is highly resistant to most garden insecticides. Use the beetle strain of Bt (M-One) or plant resistant (genetically engineered) potatoes. See Extension bulletin *Colorado Potato Beetle* (A3678) for more information.

Sweet corn

Early-planted sweet corn normally has few serious problems. This is because most of the corn pests do not become abundant until mid-August. Always rotate sweet corn plantings within the garden to prevent **corn rootworm** larval problems.

A number of caterpillars can attack the ear tips. The adults are night-flying moths which first appear in late June. The **European corn borer**, the **corn earworm** and the **fall armyworm** are all more common in late-planted corn. They usually lay their eggs on leaves or in the developing corn silks. Because the damaged portion of the ear is so easily removed, treatment is rarely justified. Gardeners can spray carbaryl while the silks are still green.

Seedcorn maggots can reduce the stand if corn is planted during cool germinating weather. For control of this pest, see the discussion in this section regarding beans.



Tomatoes

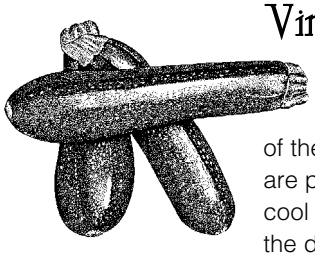
A variety of **aphids** may affect tomatoes. However, plants can tolerate large numbers, and natural enemies will eventually control their populations. In extreme cases, gardeners may use a forceful stream of water, soapy water or malathion for control.

Two caterpillars can be found on tomatoes. The **tomato fruitworm** is a brownish to green caterpillar which bores into ripening fruit. It is a late-season pest (late August–September) which rarely needs treatment because the infested fruits are easily detected and discarded.

The **tomato hornworm** is a very large greenish worm (up to 3 inches) with a spine on the posterior end and white side stripes. The larva feeds on both foliage and fruit, and because each larva eats three to four times its weight in food daily, the damage appears dramatic. The adult stage of this insect is a grayish hawk moth which is often mistaken for a hummingbird as it feeds on flowers. Because of its large size and small numbers, gardeners can get effective control by hand picking and destroying the larvae.

Whiteflies are tropical insects which do not survive Wisconsin winters but often accompany greenhouse-grown transplants. Populations will build throughout the summer so that clouds of ⅛-inch adults fly up when the plants are disturbed. The nymphs (immature insects) are scale-like creatures found on the undersides of leaves. This is a very difficult insect to control, but tomatoes can tolerate large numbers of these insects. A minimum of three insecticidal treatments at 5-day intervals must be used to achieve control. Diazinon or insecticidal soap can be used. If one treatment is missed, the program must be started again from the beginning. Thorough coverage on the undersides of the leaves is needed.

Vine crops (cucumbers, melons, pumpkins, squash)



Seedcorn maggots will attack the seeds of all of the vine crops. Damage is most severe when plants are planted before the recommended date or during cool springs. For control, see the information listed in the discussion of beans in this section.

The **squash bug** (an occasional pest) is a 1-inch, dark brown insect which becomes active as plants emerge. It sucks the plant juices and causes wilting. Because insects are usually present in small numbers, they can be hand picked. Soapy water or carbaryl treatment also provides some control.

Striped or **spotted cucumber beetles** are ¼-inch, yellow-green beetles which become active in very early spring. Adults feed on developing fruit and foliage and, more importantly, transmit bacteria which cause wilt disease. Small numbers of beetles can devastate a planting if they carry the disease, and they must be controlled before the disease appears. Hand pick and destroy adults, or treat plants with rotenone or carbaryl as seedlings emerge and beetle activity is noted. In the fall, adults of these beetles can chew holes in the developing fruit.

Melon aphids occasionally build up on the undersides of leaves. They are 1/10-inch blackish insects which may cause stunting or wilting of the plant. Malathion or soapy water may be used as needed.

Squash vine borers are a very serious and hard-to-control problem of summer and winter squash. Plants begin wilting in late July, and gardeners may find plump whitish caterpillars burrowing in the vines. There is only one generation per year and the moth overwinters as a pupa in the soil. Gardeners must start control procedures before injury is noted. In most of the state, adults begin to lay eggs during the last week of June. Adults are 1-inch, orange and green, day-flying moths. Eggs are brown, button-shaped and 1/16 inch in diameter and are most often found at the base of the plant. Gardeners may remove the eggs by hand, cover the plants with cheesecloth or net and destroy the adults. Apply carbaryl to plant bases as a weekly spray for the 3-week egg laying period. Other treatments, especially dusts, tend to provide insufficient coverage. Cucumbers are highly resistant to borer attack, while summer squashes are very susceptible.

General pests

The following insects are potential problems on a wide variety of vegetables.

Common stalk borer

Common stalk borers lay their eggs in grassy weeds in September. From late May through July the brown and white striped caterpillars migrate into the garden and burrow into the stems of tomatoes, potatoes, beans and other thick-stemmed plants. Once inside the stem, the insect cannot be controlled. Fall grass control or mowing will prevent egg laying and is the best control method for common stalk borer.

Cutworms

Cutworms are the larval stage or caterpillar of night-flying moths. They are whitish gray to brown worms, ranging from ½ to 2 inches long. They feed almost exclusively at night and hide in the soil during the day. All cutworms curl to a characteristic tight ball when exposed, making them easy to identify. Most cutworms cut plants off at or slightly below the soil surface, making recent transplants especially susceptible. Eventually, plants become too thick and tough for cutworms to feed. Adult females are attracted to tall grasses for egg laying, and cutworm numbers tend to be higher in weedy gardens or gardens bordered by weeds.

To prevent cutworm damage on valuable transplants, place small paper cups or tin cans with the bottoms removed at least 1½ inches into the soil around the base of each plant. Commercial cutworm baits containing carbaryl are available but must be used before damage begins.

The variegated cutworm climbs susceptible plants and feeds on foliage. The larger stages do most of the damage, but because they pupate in 7–10 days, it is usually too late to treat after noticing damage. Earlier treatments with carbaryl or Bt are partially effective.

Picnic beetles (sap beetles)

Picnic beetles are ¼-inch, dark brown to black beetles with four distinct yellowish orange spots on their backs. They do not damage fruit directly but are attracted to overly ripe or damaged fruits or vegetables. Melons, tomatoes, strawberries and raspberries are commonly infested. Because these beetles migrate into the garden and are attracted to fermenting fruit and vegetables, the first step in controlling picnic beetles is to remove and destroy overly ripe fruit. In most cases, spraying is ineffective. Beetles will continue to migrate into the garden and delays in harvesting ripe fruit and vegetables due to the waiting period after spraying will increase problems. Place a mixture of one-half water, one-half dark corn syrup, one cake of yeast, and spoonful of vinegar in a container outside the garden. It will attract, trap, and drown adult picnic beetles.

Plant bugs

Plant bugs are ¼-inch, tan to dark brown oval insects with piercing sucking mouthparts. They attack more than 50 different economic crops but are most damaging to strawberries, peppers and snap beans in the home garden. Feeding by this insect causes poor fruit set, and distorted gnarled fruit due to the toxic saliva they inject into the plant. Populations are greatest in rural gardens. This is a highly mobile insect which overwinters in debris left in the field. Large numbers of adult plant bugs migrate out of alfalfa fields when hay is cut. To control plant bugs, remove weeds and debris to prevent overwintering. In problem areas, sprays of malathion or carbaryl can be used as flower buds start to form.

Slugs

Slugs are closely related to snails and can be common pests in gardens, especially during wet seasons. Slugs feed at night and are especially troublesome on tomatoes, strawberries and low-lying plants. Reducing daytime hiding places such as boards, rubbish, unused pots and rocks will help. Placing pie tins baited with a beer and water mixture at ground level will attract and drown slugs. Chemical baits containing metaldehyde are also available for slug control. See Extension publication *General Plant Disorder: Slugs* (A3186) for more information on slugs and their control.

White grubs

The white grub, which is the larval stage of the June bug, has up to a 3-year life cycle. Because the adults lay eggs in grassy sodded areas, only newly established gardens (1–3 years old) and weedy gardens have significant problems. The characteristic C-shaped grubs feed on the roots of most plants. They are most damaging to root crops such as carrots or potatoes. Tilling the soil to expose the larvae during the spring and fall helps reduce numbers. Granular insecticides such as diazinon can be worked in the soil before planting in areas where damage is expected. Established gardens should have few problems.

Wireworms

The wireworm is the larval stage of the click beetle and, like the white grub, lays eggs in grassy areas. Wireworms are also troublesome in low, poorly drained areas. Weed control is the best preventative measure. Control procedures for white grubs will also control wireworms.

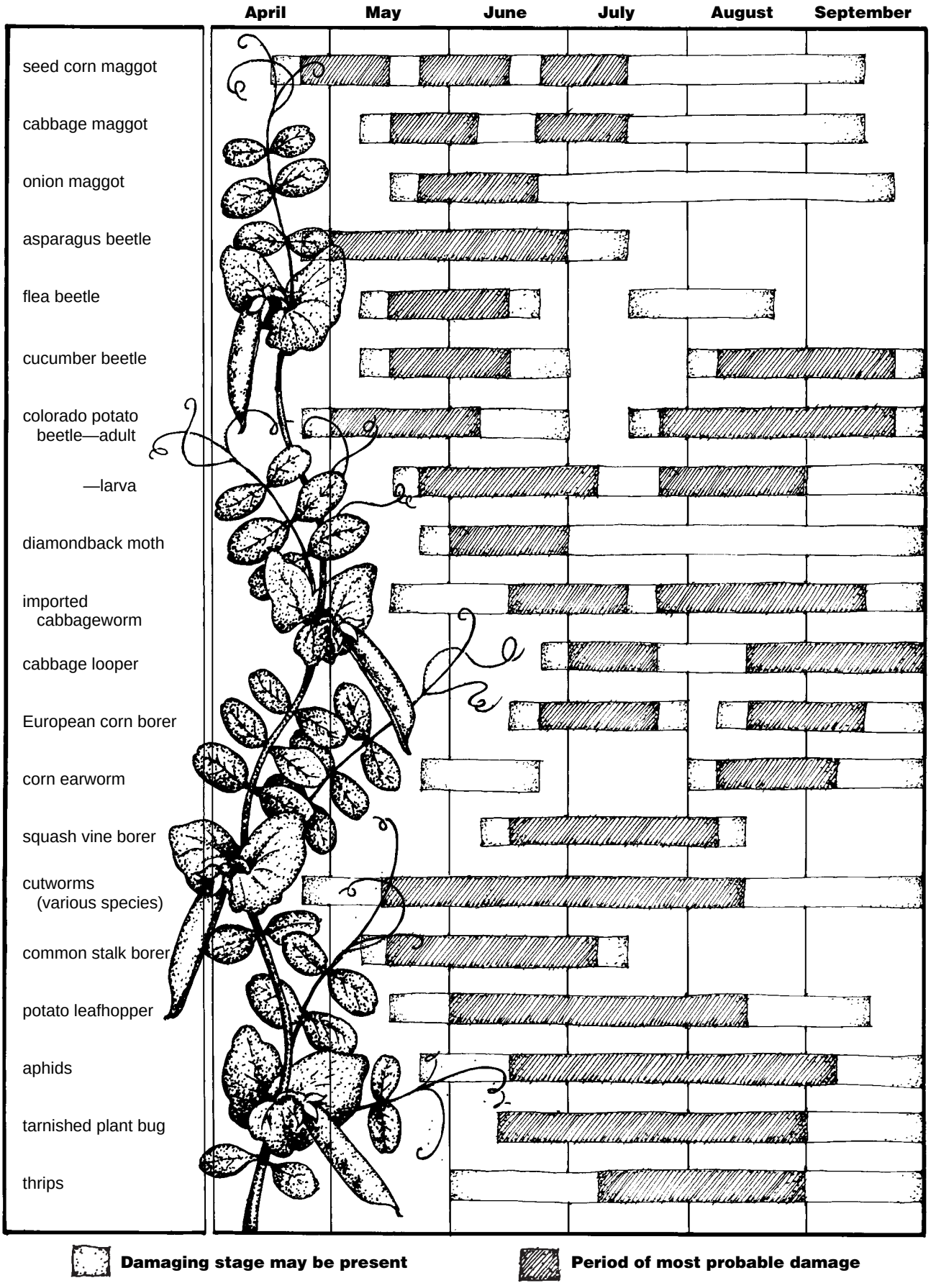
Further reading

Organic Gardening Magazine

Common Sense Pest Control

References to pesticide products in this publication are for your convenience are not an endorsement or criticism of one product over other similar products. You are responsible for using pesticides according to the manufacturer's current label directions. Follow directions exactly to protect the environment and people from pesticide exposure. Failure to do so violates the law.

Timetable of pest abundance and damage



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