AGRICULTURAL
GUIDE
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Cabbage pest management

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In Missouri, about 600 acres of cabbage and 200 acres of broccoli, cauliflower, and collards are planted each year. The majority of this acreage is in commercial production in the St. Louis and Bootheel areas. Small truck farms and home gardens produce cabbage and related cole crops throughout the state.

Both spring and fall cabbage crops are grown in Missouri with insects being the major limiting factor for production. Resistant varieties of cabbage eliminate plant diseases, and weeds can be held in check by available herbicides and cultivation. Many home gardeners can live with the damage caused by insect pests but commercial cabbage growers require a management program to control cabbage worms. Aphids, flea beetles, and cutworms may occasionally cause significant damage in commercial cabbage crops. Prior to 1980, most commercial growers depended upon a scheduled spray program to eliminate cabbage worms and aphids. Since 1980, many major cabbage growers have adopted pest management methods for controlling these pests.

Figure 1. A field scout monitors pest and beneficial insect populations.

Pest management philosophy

Pest management integrates all possible methods of controlling pests to maintain pest populations below economically damaging levels. Pest management practitioners attempt to *manage* pests, not to eliminate them entirely. Low pest populations are tolerated and even encouraged because they support beneficial insects and increase the chances of some naturally occurring pest disease epidemics.

Monitoring the crop and insect situation on a regular basis is the key to effective and economically sound pest management. Growers or professional scouts examine crops on a weekly basis to identify pests and beneficial insects, to determine pest development stages, and to assess whether damaging levels of pests are present (Figure 1). Management decisions are based on knowledge, not on guesswork or rigid schedules. Sprays are timed to control pests at their most susceptible stages and to protect beneficial insects.

Following rigid spray schedules without monitoring may waste sprays and fail to provide adequate control of the pests, particularly if susceptible stages are absent. Scheduled spraying may also increase the chance of insects developing pesticide resistance. This has been a problem for Missouri growers attempting to control cabbage-loopers with chemical pesticides. Pest management programs based upon monitoring usually reduce the number of sprays

applied and therefore slow the development of pesticide resistance.

Regular monitoring also enables growers to detect resistance and to modify the program before serious economic losses occur. Thus, an effective pest management program will provide better pest control, will reduce insect losses, will save money by eliminating unnecessary sprays, and will enhance the natural biological controls that contribute to pest suppression. This publication is designed to provide the commercial grower, the home gardener, and professional scout with the information needed to implement an effective pest management program on cabbage.

Characteristics of cabbage pests

Cabbage loopers: Loopers are the major pest on cabbage in Missouri (Figure 2). As many as four generations mature each year. The third and fourth generations cause the most damage in late summer and early fall. Loopers eat large ragged holes in outer leaves and head wrapper leaves. Occasionally, large loopers will penetrate to the base of the head during cool weather and cause significant damage.

Adult loopers are brown moths that fly at night and lay eggs on the underside of the cabbage leaves. The small round white eggs are attached individually or in loose clusters of two to five eggs.

Looper worms range in size from ⅛ inch to nearly 1 and ½ inches when mature. The light green worms often assume a characteristic looping position that distinguishes them from other cabbage worms. The white, thread-covered cocoons can be found on leaves of cabbage plants.

The cabbage looper does not overwinter in Missouri but migrates north each year. This accounts for its late appearance on the spring-planted cabbage. Large loopers are frequently difficult to control with available pesticides and several studies have demonstrated looper resistance to some vegetable crop pesticides.

Imported cabbage worms: Imported cabbage worms are second only to loopers in the amount of damage they cause to cabbage. The larger stages of the imported cabbage worms eat irregular holes in the outer or the wrapper leaves of cabbage heads, whereas the small stages usually feed on the underside of the outer leaves. You can sometimes locate worms by the presence of small green pellets of excrement they produce while feeding.

Imported cabbage worms complete four to five generations each year and are most abundant in the spring and fall. This pest overwinters in the pupal stages on cabbage leaves, other vegetation, or nearby structures (Figure 3).

The familiar white butterfly emerges in spring, mates, and begins laying eggs. Imported cabbage worm adults require sunny days for mating and egg laying. The eggs are shaped like a small cylinder with ridges and a pointed end. After the eggs hatch, the worms grow from about ⅛ inch to 1 and ½ inches while developing to maturity.

Imported cabbage worms are darker green than loopers and larger imported cabbage worms appear

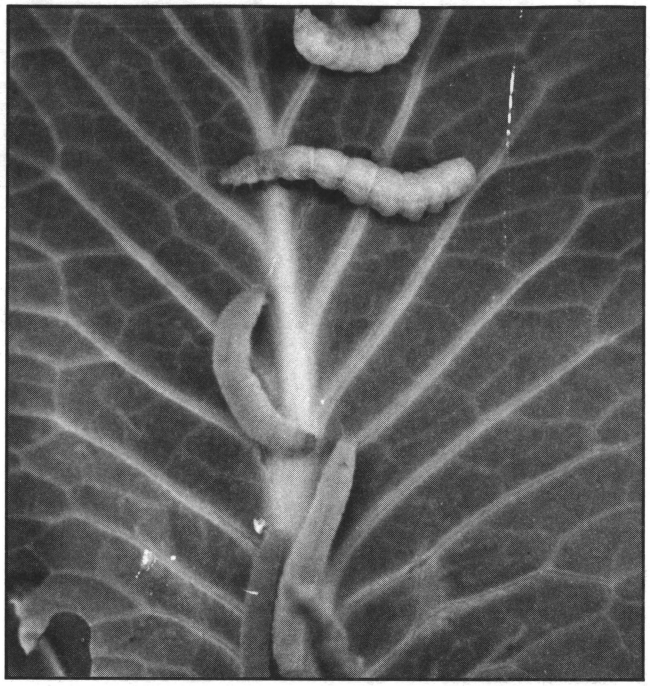

Figure 2. Fifth instar larvae of the cabbage looper (lighter colored worms at the top) and imported cabbage worm (darker colored worms at the bottom).

Figure 3. Imported cabbage worm pupae.

Figure 4. Fourth instar larvae of the diamondback moth.

Figure 5. Green peach aphid colony.

velvety. These large worms may be difficult to control but pesticide resistance has not been detected.

Diamondback moths: The worms of the diamondback moth are smaller and cause less damage to Missouri cabbage than loopers or imported cabbage worms (Figure 4). Feeding damage by the worms is characterized by small shot holes eaten through the leaves. The worms prefer to feed on the underside of leaves or between loose leaves.

The diamondback moth completes five to six generations each year and overwinters as an adult moth. Its eggs are extremely small and are laid on the underside of cabbage leaves. The newly hatched worms are also very small and grow to only ½ inch by maturity. The worms are gray-green, pointed at each end, and are easily recognized by a characteristic avoidance behavior. When disturbed, they rapidly wiggle backwards across the leaf and drop down on a slender, nearly invisible thread. Diamondback moth pupae are about ¼ inch long and are encased in a white, net-like sack.

Diamondback moths are not a serious pest on Missouri cabbage but occasionally cause economic losses in spring cabbage when the crop is not protected. Damage occurs when the small worms attack developing leaves of young plants or newly formed heads.

Aphids: The cabbage aphid and the green peach aphid are small, soft-bodied insects that suck fluids from cabbage leaves (Figure 5). Significant damage occurs only on young transplants or on seedlings developing from seeds sown in the field. The aphids are usually found on the undersides of leaves and large aphid populations can kill or dwarf young cabbage plants. Damage is characterized by curling of young leaves.

Aphids overwinter in the egg stage and hatch in early spring. They mature into wingless "stem mothers" that produce colonies of young aphids without mating. Without effective natural or chemical control, aphid populations can increase rapidly in the spring. Warm weather and beneficial insects usually suppress aphid populations in late spring and summer. However, aphids continue to reproduce throughout the summer and fall and normally complete eight to 10 generations per year in Missouri.

Flea beetle: The cabbage flea beetle and the sinuate striped flea beetle are minor pests of cabbage in Missouri. Occasionally, beetles damage young transplants or plants grown from seed. Flea beetles may attack both spring and fall cabbage crops, but large populations usually only occur in late summer. Flea beetle damage is more severe along field margins. Feeding damage is characterized by small, round shot holes on the whole leaf.

Adult flea beetles overwinter in surrounding vegetation and fence rows, become active in early spring, feed on grasses and weeds, and then move to young plants in the field. The mature beetles lay eggs under the soil surface around the base of young plants. After the eggs hatch, grub-like larvae feed for three to four weeks on plant roots. Succeeding generations move freely between surrounding vegetation and crop plants. When grasses and weeds dry in late

summer, beetles concentrate on transplants and seedlings of the fall crop.

To reduce flea beetle damage, suppress weeds and grasses that support adult populations and plow under the spring planting as soon as possible after harvest.

Cutworms: The black cutworm and the variegated cutworm are unpredictable and occasional pests of cabbage. They usually complete three to four generations each year. The adult moths fly at night and lay eggs on the stems and leaves of weeds—particularly curly dock and lambsquarter—in the field or along field margins.

Small cutworms feed on foliage and cause only minor damage to crop plants. Larger cutworms cut entire plants at or just below the soil surface. Black cutworms usually feed at night and are found in small holes in the ground or under clods during the day. Black cutworm damage is usually more common in low-lying fields that are subject to flooding. When gardens or fields are plowed before planting, black cutworms remain in the soil until young transplants or seedlings are available. The most common and severe damage occurs at this time.

The variegated cutworm removes entire leaves from young plants and occasionally feeds in the developing heads of plants. Usually, the whole head is destroyed if it is attacked by a variegated cutworm. Once the worm has penetrated the base of the head, control is extremely difficult.

Common natural enemies of cabbage pests

Lacewings: Both adult and immature lacewings are predators. The adults are about ½ inch long and have light green, lacey wings. Lacewings lay small white eggs that are attached by long slender stalks to leaves or stems. You can easily identify immature lacewings by their large, sickle-shaped jaws. They voraciously feed on aphids, other insects, and insect eggs. One lacewing larva can consume 300 aphids per day.

Syrphids: Syrphids are members of the fly family. They feed heavily on aphid colonies and can rapidly reduce aphid populations in the spring. They are usually more common than lacewings and lady beetles. The medium-sized adult flies, which are not predatory, lay small, white rectangular eggs on leaves and stems of plants near aphid colonies. The larvae are light green maggots that feed by removing the body fluids of aphids. One syrphid larva can eat 200 aphids per day.

Lady beetles: Lady beetle adults and larvae are primarily predators of aphids and insect eggs. One lady beetle can eat 100 aphids per day. In Missouri, the adults overwinter in small clusters in leaf litter or heavily vegatated areas. When spring arrives, these adults invade crops when aphid populations begin to build.

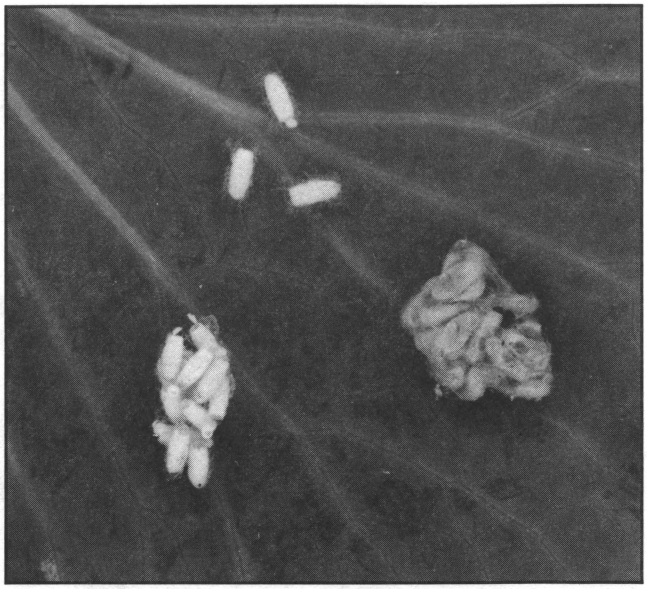

Figure 6. Cocoons from three different species of cabbage worm internal parasites.

After feeding for several days, the adults lay clusters of yellow-orange eggs on leaves and stems of crop plants. The larvae are blue to black with orange or yellow spots. They look like tiny alligators. The black and orange lady beetle pupae look like small horseshoe crabs and are also attached to plant leaves or stems. The adults migrate readily if adequate food is not available. Lady beetle adults collected from overwintering sites and released in crops invariably disperse from the field unless they are caged and provided with adequate food to stimulate egg laying.

Parasites: Several small wasp parasites attack cabbage worms, cutworms, and aphids (Figure 6). Extremely small trichogramma wasps lay their eggs inside the eggs of cabbage loopers, imported cabbage worms, and cutworms. The larvae of the parasite mature inside the host eggs and then emerge as adult wasps.

Several other parasitic wasps also attack the worm stages of loopers, imported cabbage worms, diamondback moths, and cutworms. They lay their eggs inside the bodies of worms. The eggs hatch and the parasites feed on the worms. The larval parasites emerge from the host worm carcasses, spin cocoons, and ultimately emerge as adult wasps that start the cycle again.

A small wasp also attacks the pupal stage of the imported cabbage worm (Figure 7). It deposits numerous wasp eggs in the pupa and several adult parasites emerge after two or more weeks, depending on temperature. The egg, larval, and pupal parasites of cabbage worms and cutworms contribute significantly to suppressing worm populations. They

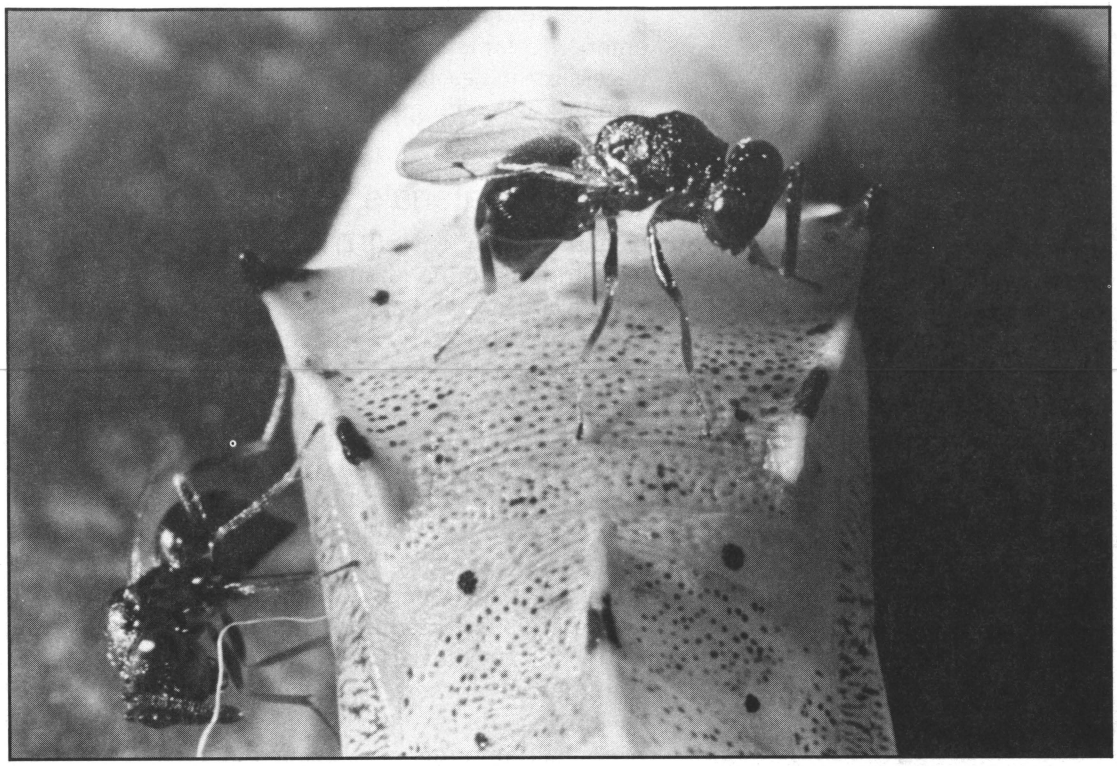

Figure 7. Adult pupal parasites of the imported cabbage worm.

prevent economic losses when allowed to survive in the crop system.

Small wasps also heavily parasitize aphids. The wasps sting the aphids and deposit eggs inside the aphid. Aphid mummies form when the worms of the parasites mature and the outer surfaces of the aphid bodies harden and turn black or tan. After maturing, the adult parasites emerge from small holes in the mummies. The presence of numerous aphid mummies in aphid colonies usually indicates the parasites will prevent economic losses by suppressing the pest population.

Virus: Cabbage loopers and imported cabbage worms occasionally suffer virus disease epidemics that decimate the population (Figure 8). The virus particles that initiate the disease overwinter in the soil or on plant residues. Tillage, wind, and rain spread the virus particles to growing cabbage plants where worms eat them. The virus infection develops inside the worm, and when the worm dies, it rapidly liquifies and spreads virus particles over the leaf. Worms, moths, and other insects spread the virus particles throughout the crop. Virus epidemics can be initiated only if sufficient worms are available to reproduce and spread the virus.

Sampling

Sampling is the key to an effective cabbage pest management program. Examine crops at least once each week to assess beneficial insect activity and to determine whether economically damaging numbers of pests are present. Fields planted on different dates, with different cabbage varieties, or separated by more than 1,000 feet should be sampled separately. You can get the necessary population information for both pests and beneficial insects by individually examining 20 plants from each sample field. Figure 9 shows the best way to select plants. Examine the tops and bottoms of leaves and the head area carefully for worms, aphids, flea beetles, beneficial insects, and signs of virus. Look closely for small worms on new leaves of young plants or on developing heads. Record the field location, cabbage variety, sample date, and insect abundance on each plant for each species on a tally sheet. An efficient record keeping system can assist decision making on control efforts and can serve as a reference for modifying or improving the pest management program.

Treatment guidelines

Table 1 gives numerical treatment guidelines for cabbage worms and aphids. Damage by flea beetles and cutworms is sporadic and specific guidelines are unavailable. The numbers in this table are guidelines you can adapt to local growing conditions and your preference. After several years under a cabbage pest management program, crops can usually tolerate slightly higher numbers of worms and aphids because beneficial insect activity has increased.

Base the decision to treat for cabbage worms on the size of the worms and their locations on the plant. To prevent economic losses, it is crucially important

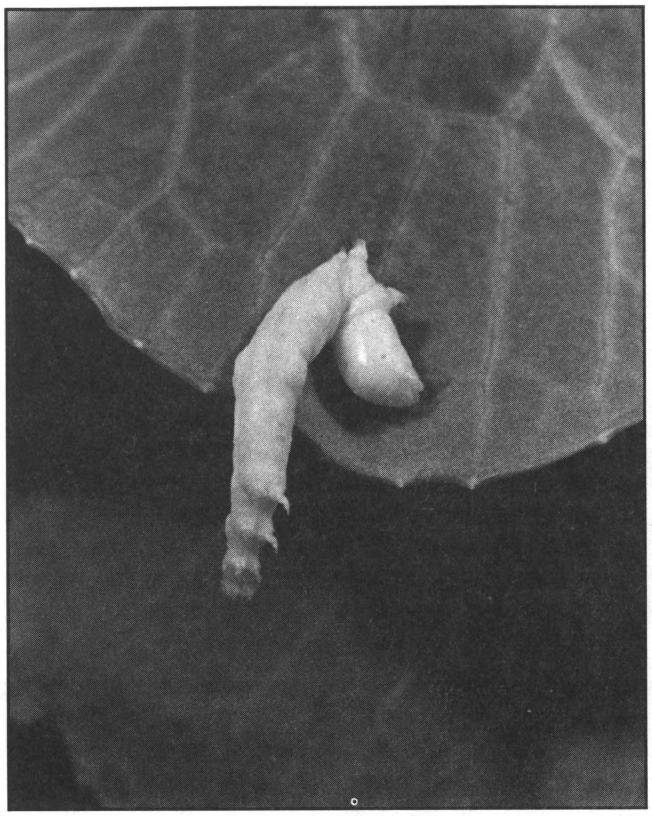

Figure 8. Cabbage looper infected with virus disease.

to protect the head area of the cabbage plant. Worms of any size in the head area can cause significant damage. Moderate numbers of worms attacking the outer leaves cause little damage to plants and may actually enhance natural control by providing food for beneficial insects and by occasionally initiating virus epidemics. However, if cool weather occurs, large and medium size worms may move into the head area and cause significant economic losses. If cool weather does occur and the most recent sample shows more than one large or medium size worm per plant, reexamine the field immediately. If you find more than 0.1 worms per plant in the head area, you need to treat.

The presence of eggs does not indicate a need for treatment. Beneficial insects and adverse weather often are effective in eliminating eggs and newly hatched larvae. However, if you see more than six eggs of the cabbage worm and looper per plant, recount in four days (after the eggs have hatched) to determine whether the small worm treatment guidelines are being exceeded.

Aphids generally harm only small cabbage plants. Beyond the eight-leaf stage, plants usually outgrow aphid damage. Mature, healthy cabbage plants also tolerate large numbers of flea beetles. Flea beetles occasionally damage smaller plants (one- to eight-leaf stage). However, small plants can usually tolerate from five to 10 flea beetles per plant. The most severe flea beetle damage occurs in late summer on newly emerged plants sown from seed. Treatment may be necessary if flea beetles are destroying a significant number of seedlings.

Control materials and methods

Bacillus thuringiensis (BT) is a bacterial pesticide toxic to a limited number of insect pests, non-toxic to most beneficial insects, and completely safe for man. When used properly, BT is very effective for controlling cabbage loopers, imported cabbage worms, and diamondback moths.

The key to effective control is treating before worms become too large. Weekly sampling determines the growth stage of cabbage worms and enables you to treat before worms are longer than ½ inch. Good spray coverage is also necessary because BT is a stomach poison that worms must eat. Pay particular attention to adequately covering undersides of leaves where smaller worms feed. Commercial stickers and wetting agents enhance coverage and the effectiveness of BT. You can also use small amounts of soap or detergent as wetting and sticking agents, but they should be tested carefully for toxicity to plants.

The most common brand names of BT are Thuricide® and Dipel®. You can purchase both as liquids or wettable powders. They remain effective for several years when stored under moderate temperatures.

In Missouri, elimination of weeds in the Cruciferae family—for example, pepper grass, shepherd's purse, penny cress, and winter cress—also helps reduce the diamondback moth population.

You can control aphids and flea beetles by properly timing sprays of pyrethrum. You need adequate coverage and stickers or wetting agents for this botanically derived pesticide. Pyrethrum has low toxicity to man, but is extremely toxic to many beneficial insects, so use it only when and where necessary.

Cutworms are usually difficult to control. Home growers can use individual collars around young plants or can replant when excessive cutting has occurred. Commercial growers should avoid planting in low-lying fields that have chronic cutworm problems. Early spring and fall tillage destroy weeds and reduce egg laying in the field, but cutworm damage may occur along field margins. Generally, black cutworms destroy fewer plants in reduced-tillage systems that leave alternative food sources in the field during the growing season.

If cultural control methods do not prevent cutworm damage, contact your local extension agent for information on recommended pesticides. Keep in mind that most chemical pesticides are extremely toxic to beneficial insects and should be used only when necessary.

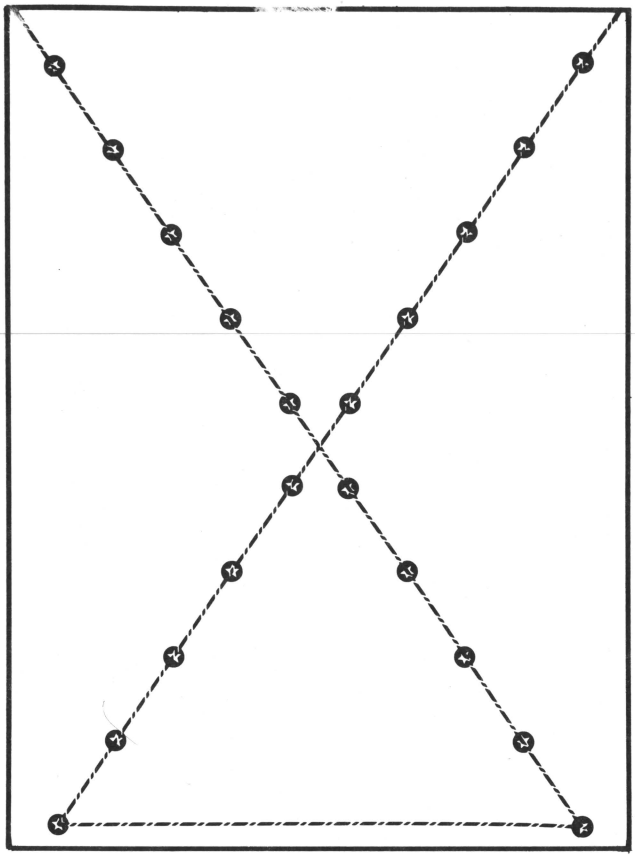

Figure 9. Twenty-plant sampling method for pest and beneficial insects in cabbage.

Table 1. Treatment guidelines for cabbage worms and aphids

Worm size and location	Treat if the number of worms or aphids exceeds the number below
—Any size worm on the head or on the leaves immediately surrounding the head.	.1 worm/plant (2 worms/20 plants)
—Worms on young transplants up to the eight-leaf stage:	
Large worms (>½″)	.3 worms/plant (6 worms/20 plants)
Medium worms (¼″-½″)	1.0 worms/plant (20 worms/20 plants)
Small worms (<¼″)	2.0 worms/plant (40 worms/20 plants)
—Worms on the outer leaves:	
Large worms (>½″)	1.0 worms/plant (20 worms/20 plants)
Medium worms (¼″-½″)	3.0 worms/plant (60 worms/20 plants)
Small worms (<¼″)	6.0 worms/plant (120 worms/20 plants)
—Aphids on transplants up to the eight-leaf stage:	6 aphids/plant (120 aphids/20 plants)

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