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CONTROL of CATERPILLARS ATTACKING CABBAGE

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Control of Caterpillars Attacking Cabbage

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THERE ARE SEVERAL different species of caterpillars that infest cabbage and other cole crops in the South.

Those causing major damage are larvae of the cabbage looper, *Trichoplusia ni* (Hubner), imported cabbageworm, *Pieris rapae* (Linne), and the diamondback moth, *Plutella maculipennis* (Curtis). Occasionally, the corn earworm, *Heliothis zea* (Boddie) and cutworms are problems. These caterpillars damage cabbage and other cole crops to the extent that yields of marketable crops and income to southern farmers are reduced in addition to the cost of insect control.

THE CATERPILLARS AND THEIR DAMAGE

The cabbage looper, imported cabbageworm, and larva of the diamondback moth are the most important insect pests of cole crops in Alabama. These caterpillars are shown in Figures 1-3.

Although feeding habits vary somewhat, damage by these three species is quite similar. On cabbage, they usually feed first on the outer leaves. If plants are attacked during early stages of forming heads, the head will be malformed or no head formed at all. In infestations of older plants, the larvae bore into the head and reduce or destroy market value of the product.

CABBAGE LOOPER

The cabbage looper, Figure 1, is usually the most destructive pest of cole crops. It occurs during most of the growing season and is often difficult to control with insecticides. When the larvae become large, it is almost impossible to control them.

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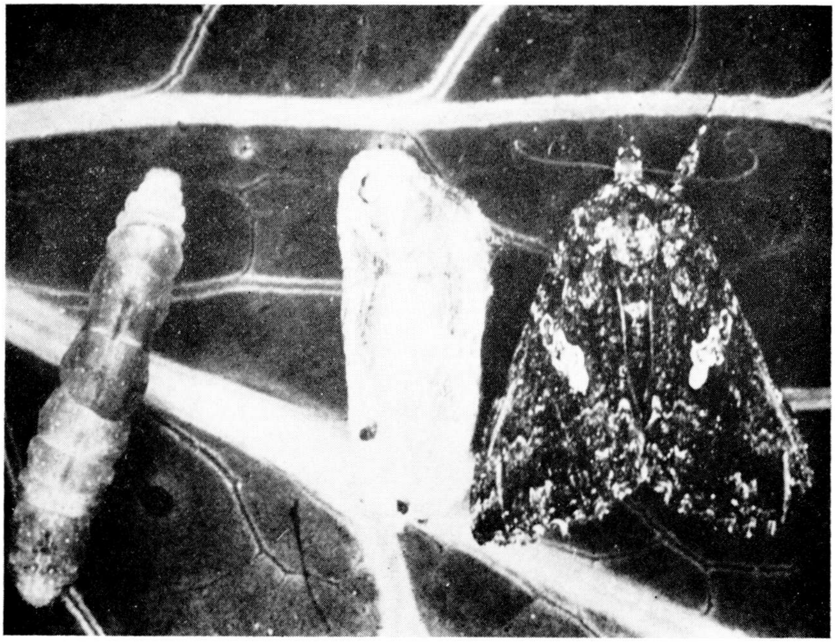

FIG. 1. Cabbage looper larva, pupa, and adult.

The moths are grayish-brown and have a silvery spot near the middle of the front wings that looks like the figure 8. These moths are active at night and are seldom noticed during the day. Their eggs are greenish-white and laid singly, usually on the lower surfaces of the outer leaves of cabbage.

Newly hatched larvae feed on the outer layer of the leaf. Larvae of the cabbage looper make a loop with their body when crawling and are easy to identify. Large loopers are voracious feeders causing serious damage to the mature heads of the plants. These caterpillars are about 1½ inches long when mature and form a brownish-colored pupae that is usually attached to the host plant by a loosely woven cocoon, Figure 1.

Imported Cabbageworm

The imported cabbageworm, often called the common cabbageworm, is a velvety-green caterpillar with a narrow, orange stripe down the middle of the back and a broken, yellowish stripe along each side of the body, Figure 2.

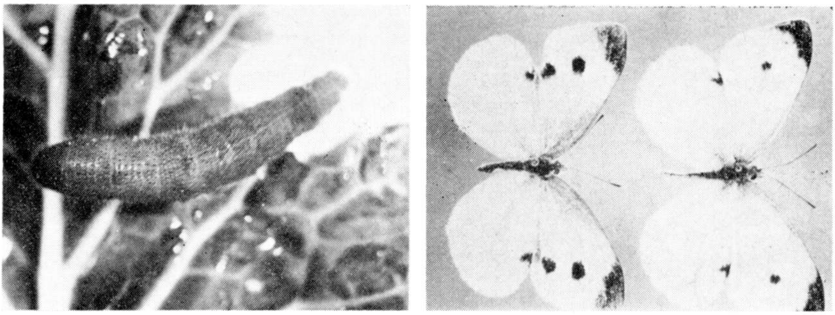

FIG. 2. Imported cabbageworm larva and adults.

The adult is a yellowish-white butterfly with several black spots on the wings, Figure 2. The butterfly has a wingspread of about 2 inches and is often seen flying in and near plantings of cole crops during the day. Yellow, oblong eggs are laid on leaves of the host plant.

Damage caused by the cabbageworm is similar to that of cabbage loopers. However, caterpillars usually feed nearer the center of the plant and may do more damage to the edible part. When mature, larvae are about $1\frac{1}{4}$ inches long and form a light green to tan pupae. These pupae are usually attached to the host plant and are easily recognized by sharp, angular projections in front and along the back.

Diamondback Moth Larvae

Larvae of the diamondback moth are frequent pests of cabbage and other cole crops but are controlled with insecticides more easily than cabbage loopers.

The small grayish moth is about $\frac{1}{3}$ inch long with three diamond-shaped yellow spots where the wings meet down the middle of the back, Figure 3. The minute yellowish-white eggs are deposited singly or in groups of two or three on the host plant. Upon hatching the small greenish larvae begin feeding on the underside of the leaves.

The body is covered with fine erect black hairs and is pointed at one end. When full grown the larvae seldom exceed $\frac{1}{3}$ inch in length, Figure 3. They can usually be distinguished from other small cabbage caterpillars by their habit of wriggling actively when disturbed, often dropping from the plant and hanging by silklike threads.

FIG. 3. Diamonback moth larvae, pupa, and adult.

Pupation occurs on the underside of the leaf. The small pupa is enclosed in a loosely woven, gauze-like cocoon, Figure 3.

Natural Enemies

Caterpillar infestations on cabbage and other cole crops may be appreciably reduced at times by naturally occurring agents such as predators, parasites, and disease. A cabbage looper parasitized by *Copidosoma truncatellum* (Dalm.) is shown in Figure 4. A virus disease affecting cabbage loopers is commonly observed in Alabama. Larvae affected by this disease become sluggish and the body assumes a whitish color. Diseased caterpillars feed sparingly and at death are frequently observed hanging from the host plant by the prolegs. After death, the body becomes black and the integument ruptures easily; the liquified body contents containing millions of virus particles is deposited on the leaves, Figure 5. Other larvae become infected by feeding on contaminated foliage. This disease can drastically reduce looper populations but frequently does not occur until considerable feeding damage has been done.

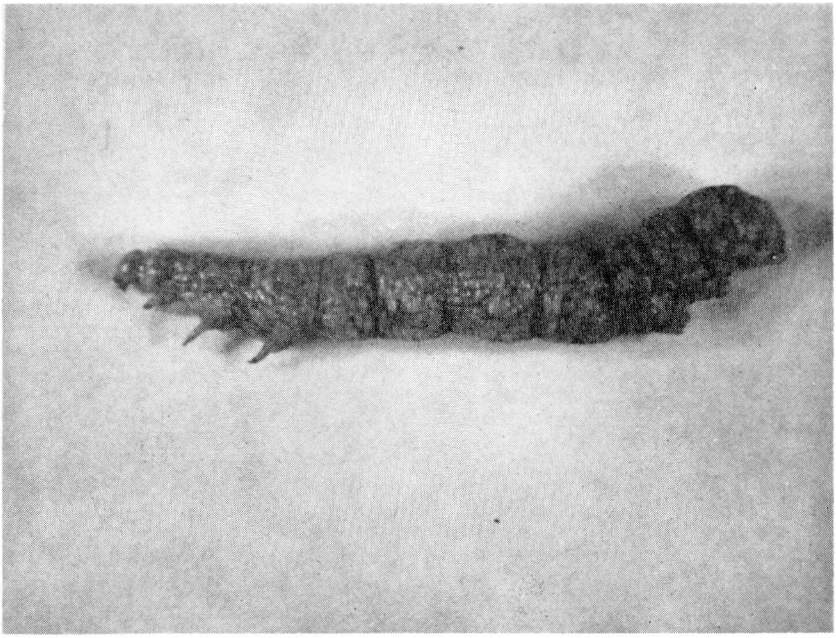

FIG. 4. Parasitized cabbage looper.

In general, natural controls will not provide sufficient protection to cole crops and little reliance should be placed on them in controlling caterpillars.

CONTROL

Large populations of caterpillars are usually difficult to control. This is especially true of the cabbage looper. This insect is resistant to several insecticides and effective control can be obtained only if applications of an effective insecticide are made before worms become large. In general, use of organic insecticides for control of destructive infestations has yielded erratic results. Favorable control has been obtained with some of the newer organophosphate and carbamate insecticides, but repeated applications were usually necessary. This practice is expensive and often results in a residue problem when crops used for human or domestic animal consumption are involved.

Several alternate, non-insecticidal methods have been used in an attempt to control the cabbage looper. The cabbage looper nuclear-polyhedrosis virus has been applied for looper control in

FIG. 5. Cabbage looper killed by nuclear-polyhedrosis virus disease.

the same manner as a conventional insecticide. This virus has provided inconsistent control because of an inadequate knowledge of this pathogen, the host, and interactions with the environment.

Field Tests

Methods and Materials

A series of small plot field experiments was conducted at various locations in Alabama from 1964 through 1966 to evaluate

FIG. 6. Cabbage plants—one treated for caterpillar control, the other untreated.

the effectiveness of several chemical and microbial insecticides for control of caterpillars on cole crops. In 1964, an experiment was conducted at the North Alabama Horticulture Substation, Cullman. In 1965 and 1966, additional tests were conducted at Cullman, Chilton Area Horticulture Substation, Clanton, and the Auburn Horticulture Farm.

Evaluations were made on spring-planted cabbage. Round Dutch cabbage plants were set 1 foot apart in 44-inch rows from late March to early April of each year. Plantings were fertilized and cultivated according to recommended horticultural procedures. Irrigation was used as needed to produce maximum yields.

In general, plots were 3 rows wide and 25 to 50 feet long. In a few tests, single-row plots were used. All plots were replicated four to five times in a randomized complete block design. The center row in each plot was used as the sample row. Chemical and microbial insecticides in emulsion and/or suspension were applied with a knapsack sprayer at weekly intervals. Volume of finished spray material varied from 10 to 40 gallons per acre; however, 30 gallons were usually applied. Virus suspensions were prepared by grinding diseased larvae in water, counting the number of inclusion bodies (capsules surrounding the virus) and adjusting to desired concentration. Virus rates are expressed as larval equivalents (LE) per acre, i.e., number of particles per large diseased larva, utilizing 10^9 particles per larva as a standard. An emulsifying agent, Pylac, was added to virus suspensions at the recommended rate. Granular insecticides were applied by hand.

Infestation counts were made weekly by recording the number of caterpillars on 2 to 10 plants per plot. Cabbages were harvested one to two times by cutting all firm heads on the sample row in each plot. These heads were counted and examined for insect damage. Heads with one or more feeding holes after removal of the wrapper leaves were considered unmarketable. In 1964, the cabbages from the Cullman experiment were sold to a local dealer and the actual monetary value of each treatment determined.

Infestation counts alone were poor criteria for evaluating effectiveness of insecticidal control. The primary objective of caterpillar control on cabbage is to protect the edible head, and infestation counts represented the number of worms on the entire plant. Many larvae were found on the underside of the outside wrapper leaves, and resulting damage was of little consequence if a given insecticide afforded protection to the cabbage head. Further, it is extremely difficult to direct spray material to the underside of these leaves. Therefore, infestation data were used primarily to assess population pressure, and degree of control was expressed in yields of marketable cabbage.

Results and Discussion

North Alabama Horticulture Substation

1964. Results of the experiment conducted at Cullman are summarized in Table 1. The first worm infestation was encountered May 22 and consisted primarily of diamondback moth larvae and imported cabbageworms. The populations of these decreased rapidly, even in untreated plots, and the cabbage looper became the predominant insect pest until harvest.

The influence of these populations was reflected in yield of marketable cabbage, Table 1. Only 36 per cent of the heads harvested from the untreated plots were marketable, and the yield was valued at $126 per acre. Treated plots yielded 47 to 90 per cent marketable heads with a value ranging from $152 to $330

TABLE 1. YIELD AND VALUE OF CABBAGE FOLLOWING TREATMENT FOR CONTROL OF CATERPILLARS, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1964[1]

Treatment	Active per acre	Larvae per plant[2]			Mkt. cabbage	50-lb. bags of mkt. cab/a.	Gross value per acre
		CL	DB	CW			
	Lb.	*No.*	*No.*	*No.*	*Pct.*	*No.*	*Dollars*
Parathion	0.50	1.0	0.2	0.1	90a	189a	$331a
Endosulfan	1.0	1.1	0.2	0.1	86a	186ab	326ab
CL 24055	2.0	2.4	0.3	0.2	73b	165a-c	289a-c
Virus + Thuricide 90T	10 LE + 1 qt.	2.4	0.3	0.2	72b	155a-d	271a-d
Naled	1.0	2.0	0.3	0.2	60b-d	143b-d	250b-d
Parathion[3]	0.50	2.5	0.2	0.2	69bc	142cd	249cd
Virus	10 LE	2.0	0.3	0.2	67bc	142cd	249cd
Malathion	1.5	1.9	0.3	0.2	57bd	132cd	231cd
Naled	2.0	1.6	0.3	0.2	67bc	126cd	221cd
Thuricide 90T	1 qt.	2.4	0.3	0.2	57bd	126cd	221cd
Diazinon	0.5	2.2	0.4	0.3	47de	115d	201d
Phosphamidon	0.5	2.6	0.3	0.3	54cd	110de	193de
Untreated check	0.0	2.0	0.4	0.2	36e	72e	126e

[1] Means followed by the same letter do not differ significantly at the 5 per cent level. Duncans Multiple Range Test.

[2] Seasonal average of cabbage loopers (CL), diamondback moth larvae (DB) and imported cabbageworm (CW).

[3] Applied every 2 weeks, others applied 6 times at weekly interval beginning May 22.

per acre. Plots treated weekly with ½ pound per acre of parathion, or 1 pound per acre of endosulfan, yielded significantly fewer damaged heads, percentage-wise, than other treatments.

All treatments except diazinon afforded significant protection to cabbage from this looper population. Yield of marketable cabbage was increased by all insecticidal treatments except phosphamidon, Table 1. Microbial treatments, Thuricide and the looper virus, were as effective as any of the conventional insecticides except parathion or endosulfan. A high degree of protection resulted from CL 24055, an anti-feeding compound. This material did not act as a contact insecticide or a repellent to either larvae or adults; however, larval feeding was inhibited as shown by the yield of marketable cabbage, Table 1.

1965. Results of the experiment conducted at Cullman in 1965 are summarized in Table 2. Infestation trends were similar to those encountered the previous year. The imported cabbageworm was the dominant species during early-head formation and the cabbage looper was the major insect present during further development and maturity of cabbages. Infestations

TABLE 2. CONTROL OF CATERPILLARS ON CABBAGE, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1965

Treatment	Active per acre	Larvae per plant[1]		Marketable cabbage[2]
		CW	CL	
	Lb.	*No.*	*No.*	*Pct.*
ACy.-EIC[3]	1.0-4.0	0.5	0.4	100.0a
GC 6506	1.0	0.6	0.6	100.0a
Endosulfan + E. Parathion	1.0-0.25	0.3	0.5	99.1ab
Endosulfan	1.0	0.5	1.1	97.6ab
Azodrin	0.5	0.5	1.1	97.1ab
E. Parathion	0.25	0.6	0.8	96.2ab
Naled	2.0	0.3	0.7	95.5ab
Matacil	0.5	0.5	0.6	95.3ab
Carbaryl + Malathion	2.0-1.5	0.5	0.7	94.3ab
Malathion + virus	1.5-10 LE	0.5	0.5	93.1ab
Endosulfan + M. Parathion	0.75-0.37	0.7	0.6	92.4ab
NIA 10242	1.0	0.4	1.2	91.8ab
E. Parathion	0.5	0.5	0.9	91.5ab
Carbaryl	2.0	0.7	1.6	88.4ab
Malathion	1.5	0.5	0.9	85.9ab
Virus	1 LE	0.5	1.3	84.3ab
Virus	10 LE	0.4	0.6	80.9a-c
GS 13005	1.0	0.5	0.7	68.5bc
Untreated check	0.0	0.9	1.4	36.4c

[1] Seasonal average of cabbageworms (CW) and cabbage loopers (CL).

[2] Means followed by the same letter are not significantly different at the 5 per cent level. Duncans Multiple Range Test.

[3] Materials were applied 4 times at weekly intervals. The first 2 applications of ACy-EIC were @ 4 pounds per acre.

were less intense than in 1964 although a similar percentage of the heads in the untreated check was damaged. As shown in Table 2, all insecticidal treatments including the looper virus afforded a high degree of control as measured by marketable cabbage.

A high degree of caterpillar control was achieved in this experiment and all materials tested, excluding GS 13005, resulted in protection of 80 per cent or more of the heads.

1966. Insect infestations experienced at Cullman in 1966 did not follow the patterns recorded at this location the two previous years. The imported cabbageworm was the dominant species encountered. Although treatments were purposely delayed, only a light looper infestation developed, but pressure from the cabbageworm was rather intense, Table 3.

Several insecticides provided a significant degree of caterpillar control although only two applications of insecticides were made prior to harvest. As shown in Table 3, plots treated with Azodrin, NIA 10242, endosulfan, Matacil, Thuricide, or Thuricide plus cabbage looper virus at 1 LE yielded significantly fewer damaged cabbage than the untreated plots. Malathion and virus alone and in combination failed to give adequate caterpillar control. This failure was partially a result of the ineffectiveness of malathion against late-instar larvae. Furthermore, the low rate of virus applied and inadequate time for virus incubation undoubtedly limited its effectiveness against the looper population.

TABLE 3. CONTROL OF CATERPILLARS ON CABBAGE, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1966

Treatment[1]	Actual per acre	Larvae per plant[2]		Marketable cabbage[3]
		CW	CL	
	Lb.	*No.*	*No.*	*Pct.*
Azodrin	1.0	0.9	0.8	92.6a
NIA 10242	1.0	1.0	0.4	90.9a
Endosulfan	1.0	1.1	0.4	90.4a
Matacil	1.0	0.9	0.4	88.5a
Thuricide 90TS	1 qt.	1.2	1.1	88.0a
NIA 10242	0.5	0.6	0.6	84.1ab
Thuricide 90TS + virus	1 qt. + 1 LE	1.2	1.1	80.2ab
Virus	1 LE	2.5	0.5	61.8b-d
Malathion + virus	1.5 + 1 LE	1.4	0.4	44.6c-e
Malathion	1.5	2.1	0.5	39.7de
Untreated check	0.0	3.6	0.7	15.1e

[1] Materials applied only two times, 6/8 and 6/15.
[2] Average number of cabbageworms (CW) and cabbage loopers (CL).
[3] Means followed by the same letter are not significantly different at the 5 per cent level. Duncans Multiple Range Test.

Auburn Horticulture Farm

1965. Summarized results on control of caterpillars on cabbage at Auburn in 1965 are given in Table 4. An infestation of imported cabbageworms developed during early-head formation and the cabbage looper was of less importance until about one-half of the heads were mature. The ratio of cabbageworms to loopers was approximately 3:1 in the untreated plots. Damage was heavy in plots receiving no treatment and less than 20 per cent of the cabbages were marketable.

All insecticidal and microbial treatments provided a highly significant degree of control when compared with the untreated check. However, 20 to 30 per cent of the cabbages were damaged in plots receiving the more effective treatments.

Endosulfan plus methyl parathion was the most effective material. Malathion plus virus was superior to either material tested alone. The virus was specific for the looper and malathion was more effective against the cabbageworm than the loopers. This resulted from the spectrum of effectiveness of both materials.

Malathion, carbaryl, or virus alone failed to give an acceptable degree of caterpillar control, although they all reduced head damage below that of the untreated plots. A single application of virus at early-head formation was as effective as weekly treatments.

1966. The populations of cabbage caterpillars were dissimilar in 1966 to those encountered the previous year. The cabbage

TABLE 4. CONTROL OF CATERPILLARS ON CABBAGE, HORTICULTURE FARM, AUBURN, ALABAMA, 1965

Treatment	Active per acre	Larvae per plant[1]		Marketable cabbage[2]
		CW	CL	
	Lb.	*No.*	*No.*	*Pct.*
Endosulfan + M. Parathion	1.0 + 0.5	0.2	0.4	80.5a
Malathion + virus	1.5 + 1 LE	0.4	0.3	72.2ab
Malathion + virus	1.5 + 10 LE	0.4	0.6	71.1a-c
Malathion	1.5	0.1	0.5	51.0b-d
Virus	10 LE	0.9	0.3	46.7cd
Virus[3]	10 LE	1.0	0.8	46.0d
Carbaryl	2.0	0.3	0.6	42.7d
Untreated check	0.0	1.8	0.6	18.5e

[1] Seasonal average number cabbageworms (CW) and cabbage loopers (CL).

[2] Means followed by the same letter do not differ significantly at the 5 per cent level. Duncans Multiple Range Test.

[3] This material applied only once on May 19, others applied 5 times from May 19 to June 14.

looper appeared earlier and was present throughout head formation. Infestation data from the untreated check showed a ratio of loopers to cabbageworms of approximately 2:1.

As shown in Table 5, all materials applied as foliar sprays reduced caterpillar damage when compared with the untreated check. Plots treated with endosulfan, 1.0 pound per acre; GC 6506, 0.5 pound per acre; Thuricide plus virus, 1 qt. and 100 LE per acre; or Matacil, 0.5 pound per acre, yielded 95 to 100 per cent marketable cabbages. Treatments with the virus at 100 LE per acre afforded a high degree of crop protection; however, the virus applied in combination with malathion was no more effective than malathion alone. As in the previous year, one application of the virus at early-head formation was as effective as weekly applications. NIA 10242 applied as a sidedress in a granular formulation appeared to offer promise in caterpillar control. Other granular systemic insecticides failed to give any significant degree of control.

TABLE 5. CONTROL OF CATERPILLARS ON CABBAGE, HORTICULTURE FARM, AUBURN, ALABAMA, 1966

Treatment	Active per acre	Method of applications[1]	Marketable cabbage[2]
	Lb.		*Pct.*
Endosulfan	1.0	Spray	100.a
GC 6506	0.5	Spray	100.0a
Azodrin	0.75	Spray	98.2ab
Thuricide 90TS + Virus	1 qt. + 100 LE	Spray	95.9ab
Matacil	0.5	Spray	95.7a-c
Malathion	1.5	Spray	88.7b-f
Malathion + Virus	1.5 + 100 LE	Spray	88.6b-f
GS 10128	1.0	Spray	75.4c-e
Virus	100 LE	Spray	74.8d-h
GS 10133	1.0	Spray	74.3e-h
Virus[3]	100 LE	Spray	62.5f-j
NIA 10242	2.0	Sidedress	62.1g-j
NIA 10242	1.0	Sidedress	52.0h-k
Thimet	1.0	Sidedress	34.6k-q
NIA 10242	0.5	Sidedress	27.9k-s
Bay. 37289	1.0	Sidedress	24.3n-s
Thimet	0.5	Sidedress	21.4i-s
DiSyston	1.0	Sidedress	16.0o-s
Cygon	1.0	Sidedress	13.9q-s
DiSyston	0.5	Sidedress	11.3r-s
UC 21149	1.0	Sidedress	10.6p-e
UC 21149	0.5	Sidedress	6.5s
Untreated check	0.0		20.4m-s

[1] Sprays applied 5 times from May 27 to June 23; granular materials as sidedress, May 8.
[2] Means followed by the same letter are not significantly different at the 5 per cent level.
[3] Applied once, May 27.

Chilton Area Horticulture Substation

1965. The cabbage looper was the dominant species of importance in this experiment, Table 6. Population density of the looper averaged approximately three caterpillars per plant and the cabbageworm was observed only occasionally.

The influence of this population pressure is reflected in the low percentage of marketable cabbage in the untreated plots. Only 19 per cent of these were marketable, Table 6. All insecticidal and microbial treatments reduced caterpillar damage. American Cyanimid EIC was the most effective material tested in this experiment; however, it was applied at a high rate of 4 pounds per acre for the first three applications. Parathion, Matacil, endosulfan, or malathion plus virus protected 70 per cent or more of the heads. Virus alone and in combination with malathion was more effective than malathion alone. This apparently resulted from a high degree of looper control with the virus, whereas, malathion was relatively ineffective against this caterpillar.

1966. Caterpillar infestations in this experiment were similar to those encountered at the same location in 1965. Treatment was purposely delayed to permit a heavy looper population to develop, and the average number of loopers was 5.4 per plant in the untreated check plots, Table 7. Cabbageworms were present throughout the experiment but were of lesser impor-

TABLE 6. CONTROL OF CATERPILLARS ON CABBAGE, CHILTON AREA HORTICULTURE SUBSTATION, CLANTON, ALABAMA, 1965

Treatment[1]	Active per acre	Looper larvae per plant	Marketable cabbage[2]
	Lb.	*No.*	*Pct.*
ACy-EIC	1.0-4.0	1.0	99.1a
Malathion + Virus	1.5 + 10 LE	3.1	86.3b
Endosulfan	1.0	2.4	77.5b
Matacil	1.0	2.4	76.0b
Parathion	0.5	3.0	71.3bc
Virus	10 LE	3.0	68.6bc
Matacil	0.5	3.6	67.8bc
GS 13005	1.0	3.1	50.7cd
Carbaryl	2.0	3.3	48.2cd
GS 13005	0.5	3.9	41.8d
Malathion	1.5	2.8	39.6d
Untreated check	0.0	3.1	17.3e

[1] Materials applied 4 times from June 3 to June 23, ACy-EIC applied at 4 pounds per acre June 3 and June 9.

[2] Means followed by the same letter are not significantly different at the 5 per cent level. Duncan's Multiple Range Test.

tance. The ratio of loopers to cabbageworms was greater than 5:1.

The impact of this population pressure was reflected in the yield of marketable cabbage. The untreated plants were virtually destroyed – only 3.5 per cent were marketable, Table 7. Most of the materials tested failed to give an acceptable degree of control. Azodrin at 1 pound per acre was the only material that afforded adequate protection to cabbage against this heavy looper population.

Data from this experiment serve to demonstrate the importance of starting a control program before heavy populations of caterpillars become established. This is especially important if loopers are the predominant pest. Mode of action of the virus is such that control of an established population cannot be achieved before crop damage occurs.

TABLE 7. CONTROL OF CATERPILLARS ON CABBAGE, CHILTON AREA HORTICULTURE SUBSTATION, CLANTON, ALABAMA, 1966

Treatment[1]	Active per acre	Larvae per plant[2]		Marketable cabbage[3]
		CW	CL	
	Lb.	*No.*	*No.*	*Pct.*
Azodrin	1.0	0.4	2.5	90.0a
Endosulfan	1.0	0.8	2.9	67.5a-c
Carbaryl	2.0	0.4	3.3	64.0a-d
Thuricide 90TS	1 qt.	0.4	6.6	60.6a-d
Matacil	0.75	0.4	5.5	59.3a-d
Thuricide 90TS + virus	1 qt. + 1 LE	0.6	3.1	58.7a-d
GC 6506	0.5	0.3	3.6	52.3a-e
Hercules 9326[4]	0.2-2.0	0.4	4.3	38.5b-h
GS 13005	1.0	0.4	3.4	30.0c-i
SD 8447	1.0	0.3	4.6	28.4d-j
Virus	1 LE	1.3	3.9	26.1e-j
Malathion	1.5	0.5	4.0	16.4f-j
GS 10128	1.0	0.7	7.0	12.9h-j
Malathion + virus	1.5 + 1 LE	0.5	5.8	10.1g-j
GS 10133	1.0	0.3	4.2	7.8i-j
Untreated check	0.0	1.0	5.4	3.5j

[1] Materials applied 3 times, June 6-June 20.
[2] Av. number of cabbageworms (CW) and cabbage loopers (CL).
[3] Means followed by the same letter are not significantly different at the 5 per cent level. Duncan's Multiple Range Test.
[4] First 2 applications made at 0.2 pound per acre.

Three-Year Summary

Seven small-plot field experiments were conducted at three locations in which 25 chemical and microbial insecticides were evaluated for effectiveness against caterpillars attacking cabbage. Several of these materials were tested at various rates and in various combinations. Both foliar and granular treatments were tested. Emphasis was placed on evaluation of the cabbage looper nuclear-polyhedrosis virus at various rates alone and in combination with malathion.

The mean number of cabbage loopers in untreated plots ranged from 0.6 to 5.4 per plant in the seven experiments. The imported cabbageworm was present in all experiments and population levels ranged from a mean of 0.1 to 3.6 worms per plant. The impact of these populations was reflected in the damage to untreated plots. Yield of marketable cabbage was reduced 63 to 96.5 per cent where the crop was not protected. Larvae of the diamondback moth were occasionally observed but were of no significance in most experiments.

Two to six weekly applications of one or more chemical or microbial insecticides or both reduced insect damage. Effective insecticides resulted in protection of 70 to 100 per cent of the treated crop. In general, the degree of protection, expressed as per cent marketable cabbage, was directly related to population pressure and number and timing of applications. Of the materials most extensively tested, endosulfan, 1.0 pound per acre or parathion 0.5 to 1.0 pound per acre, consistently afforded a high degree of control. These materials were considered as standards for comparing effectiveness of others. Chemical insecticides found to be generally as effective as the standards included Azodrin, General Chemical 6506, and Matacil. Niagara 10242 appeared to offer promise both as a foliar treatment and when applied in a granular formulation as a sidedress.

Results with two microbial agents, Thuricide and the looper virus, were encouraging. Thuricide at one quart per acre was generally as effective as the standards when applied alone or in combination with the virus. Plots treated with virus alone yielded fewer damaged cabbages than the untreated plots in all experiments. However, the degree of control obtained with virus treatments was not considered economically acceptable in most tests. This is not surprising inasmuch as both cabbage loopers and imported cabbageworms were present in the plantings, and the virus is effective only against the looper. The virus applied in combination with malathion was as effective as the standard conventional insecticide when applications were initiated at early head formation. Further, a combination of virus and malathion was usually superior to either material applied alone. This was a result of the spectrum of activity of these materials.

The looper virus was effective at 1, 10, and 100 LE per acre. One application of 10 or 100 LE per acre at early-head formation appeared to be as effective as weekly application. The residual effectiveness apparently resulted from a cyclic infection and inoculum liberation in a restricted area.

It was concluded from these experiments that utilization of the virus as an insecticide is restricted by its host specificity. However, the virus can be of significant value when used in combination with an effective broad spectrum insecticide. The virus is slower in producing death than an effective chemical, but has merit in its safety. To ensure crop protection, applications must be made sufficiently early before crop maturity and before a heavy looper population becomes established because of the time required for the virus to establish a lethal infection. It is usually advisable to approach insect control in general on cole crops on a preventative basis.

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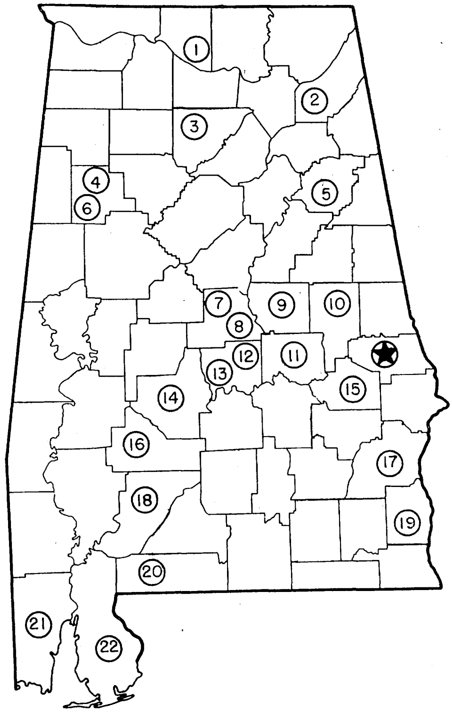
AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Alexandria Experiment Field, Alexandria.
6. Forestry Unit, Fayette County.
7. Thorsby Foundation Seed Stocks Farm, Thorsby.
8. Chilton Area Horticulture Substation, Clanton.
9. Forestry Unit, Coosa County.
10. Piedmont Substation, Camp Hill.
11. Plant Breeding Unit, Tallassee.
12. Forestry Unit, Autauga County.
13. Prattville Experiment Field, Prattville.
14. Black Belt Substation, Marion Junction.
15. Tuskegee Experiment Field, Tuskegee.
16. Lower Coastal Plain Substation, Camden.
17. Forestry Unit, Barbour County.
18. Monroeville Experiment Field, Monroeville.
19. Wiregrass Substation, Headland.
20. Brewton Experiment Field, Brewton.
21. Ornamental Horticulture Field Station, Spring Hill.
22. Gulf Coast Substation, Fairhope.