Suppression of Lepidopterous Larvae in Commercial Sauerkraut Cabbage Fields and Research Plots[1]

C. J. ECKENRODE, J. T. ANDALORO, AND A. M. SHELTON

Department of Entomology, New York State Agricultural Experiment Station, Geneva, New York 14456

ABSTRACT

J. Econ. Entomol. 74: 276–279 (1981)

Parathion and *Bacillus thuringiensis* Berliner were the most frequently used insecticides in commercial sauerkraut cabbage fields by growers in New York for suppression of lepidopterous larvae. Growers also used combinations of chemicals more frequently than expected. Percent reduction of larvae in commercial fields could not be equated with percent control in research plots because untreated controls were not available in commercial plantings. Even when consistent performers (i.e., permethrin and methamidophos) were used, some larvae survived in the research plots and sauerkraut fields.

New York State ranks first in the production of cabbage for sauerkraut, with a 1979 total harvest of 1,377 ha, valued at $2.54 million (Anonymous 1979). Since the return per hectare of processed cabbage is considerably less than that of fresh market cabbage ($1,842 and $8,790, respectively) (Anonymous 1979), sauerkraut growers tend to treat for insect pests less frequently than their fresh market counterparts. Lepidoptera which threaten cabbage in New York early in the season are the imported cabbageworm, *Pieris rapae* (L.) (Pieridae), and the diamondback moth, *Plutella xylostella* (L.) (Yponomeutidae). The cabbage looper, *Trichoplusia ni* (Hübner) (Noctuidae), a migrant from the South, arrives there in late season and can become a major threat along with the early season species which still are present. Green (1972) and Shepard (1973) reported damage thresholds for cabbage based on number of cabbage looper larvae present, whereas Chalfant et al. (1979) reported spray decisions based on feeding damage. These thresholds are unrealistic for sauerkraut cabbage, since a standardized grading system has not been accepted by processors in New York. It is assumed, however, that cabbage grown for sauerkraut can tolerate more peripheral feeding injury than fresh market cabbage because of considerable trimming at harvest and during processing.

Complaints from growers suggest that labeled insecticides applied rather infrequently on sauerkraut fields to suppress lepidopterous larvae do not always perform to the degree of effectiveness indicated in our research trials. This report documents insecticide usage by commercial sauerkraut growers in New York for two growing seasons and compares the efficacy of labeled compounds applied by growers (percent reduction) to the efficacy of the same chemicals in research trials (percent control and percent reduction).

Materials and Methods

Survey of Grower Practices

In 1978, 12 cooperating growers in Ontario and Yates Counties provided seasonal spray records. In 1979, seasonal spray records, either from cooperating growers or from processing companies, documented treatment practices of 26 growers from the same two counties. These surveys do not include applications at planting for suppression of the cabbage maggot, *Hylemya brassicae* (Weidemann), a serious but sporadic pest of roots. They do include treatments for the striped flea beetle, *Phyllotreta striolata* (F.), *P. cruciferae* (Goeze), the cabbage aphid, *Brevicoryne brassicae* (L.), and the onion thrips, *Thrips tabaci* Lindeman, although we do not discuss suppression of these pests here.

Reduction of Lepidopterous Pests in Commercial Fields

Systematic counts were taken during two seasons in commercial sauerkraut fields before and after application by growers of labeled insecticides with spray equipment of their choosing. In 1978, 12 farmers permitted sampling in 12 different fields. Ten random sampling sites per field with five plants per site were selected weekly and examined for larvae. From 1 June until 15 July, all leaves on each plant were examined. Thereafter and until the last count on 1 October, three leaves per plant were chosen randomly from three locations on the plants (bottom, middle, and top).

In 1979, 16 commercial fields were sampled by a different method than the one employed in 1978. Eight sites with five plants per site were sampled twice weekly along a straight line into and out of each field forming an inverted V. All leaves on each plant were examined for larvae for the entire sampling period of 1 June through 1 October. In 1979, some fields were treated by airplanes which provided some comparisons between air and ground application.

Control and Reduction of Lepidopterous Pests in Research Trials

Research trials were conducted on the Robbins Vegetable Research Farm located near Geneva, N.Y., in Ontario County in 1979. Four replications of treatments and untreated controls consisting of two 15.2-m rows of cabbage, bordered on either side by two rows of sweet corn to minimize spray drift, were arranged in a randomized complete block design. The five commonly used commercial insecticide treatments tested were parathion, methamidophos, methomyl, parathion in combination with endosulfan, and *Bacillus thuringiensis* Berliner. A sixth treatment, permethrin, was also evaluated for efficacy, since it was used in New York on

[1] Approved by the Director of the N.Y. Agric. Exp. Stn. for publication as journal paper No. 3314. Received for publication 1 August 1980.

0022-0493/81/0302-7604$02.00/0

some cabbage in 1979 under an emergency use (section 18) permit for control of cabbage loopers late in the season. These materials, and others included in the test but not mentioned here, were applied by a tractor-mounted, two-row sprayer (three nozzles per row) delivering 279 liters/ha at 3.46 kg/cm^2 pressure.

Treatments were applied on 20 and 28 August, 4 and 11 September, and 5 October with evaluations taken 3 to 4 days before and after each application. Three plants per plot were randomly selected; all leaves were removed, and all lepidopterous larvae of the three species mentioned above were counted. In the research trials, two methods of evaluating performance were utilized. In the first, all five application dates were included.

$$\% \text{ control} = 1 - \frac{\text{no. of larvae posttreatment}}{\text{no. of larva in untreated controls}} \times 100 \qquad (1)$$

In the second, only application dates with pretreatment counts of <1 larva per treatment were included.

$$\% \text{ reduction} = \frac{\text{no. of larvae pretreatment} - \text{no. of larvae posttreatment}}{\text{no. of larvae pretreatment}} \times 100 \qquad (2)$$

These are two fundamentally different ways of evaluating insecticide effectiveness with the former method (percent control) more suitable in carefully controlled research trials and the latter (percent reduction) more suited to evaluation of efficacy in large commercial fields where no untreated control is available.

Results and Discussion

Survey of Grower Practices

Table 1 presents information about grower practices which has heretofore been unknown to us. In both years, parathion and *B. thuringiensis* preparations were the most frequently used insecticides. In addition, both chemicals were used in combination with each other, or with other materials, much more than we had previously suspected. Apparently, some growers combine materials based on their own experiences or because of advice from sources other than extension recommendations. The occasional use of insecticides not emphasized in official state recommendations for control of lepidopterous pests (i.e., diazinon, carbaryl, dimethoate, azinphosmethyl) was attributed to attempts to suppress other pests such as flea beetles, cabbage aphid, and onion thrips. Much more endosulfan was used in 1979 than in 1978 (Table 1). This apparent increase may have resulted because more than twice as many growers were sampled in 1979 then in 1978. Methamidophos, a most effective broad-spectrum insecticide, was not used as heavily as we anticipated, probably because the legal interval from application to harvest is 35 days. Davis et al. (1974), however, showed that cabbage treated with methamidophos can be grown in New York and safely harvested within 1 week after the last application,

Table 1.—Survey of various insecticides used by commercial sauerkraut growers for control of foliage pests in Yates and Ontario Counties, N.Y.

Year	Insecticide[a]	Rate (kg of AI/ha)	No. of growers using insecticide	No. of applications	
				Avg/grower	Total
1978[b]	Parathion	0.46	10	2.1	21
	Bt	0.46–0.92[d]	7	1.9	13
	Methamidophos	0.46	3	2.3	7
	Diazinon	0.46	3	1.7	5
	Azinphosmethyl	0.46	2	1.5	3
	Bt + methomyl	0.46[d] + 0.83	2	1.5	3
	Parathion + endosulfan	0.46 + 0.46	2	1.5	3
	Parathion + Bt	0.46 + 0.46[d]	2	1.0	2
	Carbaryl	0.46 + 0.69	2	1.0	2
	Carbaryl + Bt	0.46 + 0.46[c]	1	1.0	1
	Endosulfan	0.69	1	1.0	1
	Parathion + diazinon	0.46 + 0.46	1	1.0	1
1979[c]	Parathion	0.46	18	1.5	37
	Bt	0.92[d]	12	1.5	16
	Endosulfan	0.46–0.69	10	1.3	13
	Parathion + Bt	0.46 + 0.92[d]	8	1.0	8
	Parathion + endosulfan	0.46 + 0.46	4	1.8	7
	Methamidophos	0.92	5	1.2	7
	Permethrin	0.09	6	1.0	6
	Diazinon	0.46	2	2.0	4
	Methomyl	0.83	1	1.0	2
	Parathion + methomyl	0.46 + 0.83	2	1.0	2
	Carbaryl	0.92	1	2.0	2
	Parathion + carbaryl	0.46 + 0.92	1	1.0	1
	Dimethoate	0.46	1	1.0	1

[a] Bt, *B. thuringiensis*.
[b] Twelve growers cooperating.
[c] Twenty-six growers cooperating.
[d] Refers to formulation (15.97 × 10^9 IU/kg).

providing the outer leaves are trimmed from the marketable portion of the heads. In the mechanical harvest of sauerkraut cabbage, 10 to 12 outer leaves are left in the field as refuse, whereas substantial additional trimming occurs in the processing plant.

Limited use of permethrin was noted in 1979 after approval of a section 18 permit in New York for that material. Six growers out of 26 used one application for late-season control of the cabbage looper.

Reduction of Lepidopterous Pests in Commercial Fields

Generally in commercial fields, most of the insecticides provided better reduction of larvae of the imported cabbageworm than of the diamondback moth or cabbage looper (Table 2). Methamidophos, ground applications of *B. thuringiensis* in 1979, and methomyl reduced imported cabbageworms and diamondback moth larvae more effectively than other materials mentioned in this survey. In 1979, parathion gave better percent reduction of imported cabbageworms than in 1978. Ground applications of parathion in 1979 appeared to suppress imported cabbageworms more effectively than air applications, but because of differing numbers of observations in this study, no statistical comparisons were used. There were far fewer observations on cabbage looper, the most serious threat to cabbage in New York, because this pest is not usually observed here in large numbers until late summer or early fall. The only insecticides which provided close to 50% reduction of cabbage loopers were permethrin and methamidophos in 1979.

The data in Table 2 suggest that most of the materials used by growers were not performing adequately, particularly for suppression of cabbage loopers and, in some cases, of diamondback moth larvae. However, this may be misleading because no untreated plants were available for comparison as is the case in research plots; thus, performance data in Table 2 were computed from pre- and posttreatment counts. In commercial fields in New York, lepidopterous pests seldom build up to the levels that they do in untreated research plots. Spray schedules in commercial fields tend to suppress, but not eliminate, larval populations, whereas populations in the untreated research plots tend to cycle to higher levels (nine or more per plant), particularly late in the growing season. In spite of the method for evaluating efficacy in commercial fields, which suggests a mediocre performance by many insecticides, it is still surprising that methamidophos and permethrin provided less than 50% reduction of cabbage loopers.

Control and Reduction of Lepidopterous Pests in Research Trials

Table 3 presents counts from research plots computed two different ways. Percent reduction (where untreated plots were not used, as in commercial fields) suggests less suppression of larvae of imported cabbageworms and diamondback moths, especially with methomyl, parathion, and *B. thuringiensis* than when percent control was computed by using untreated plots where larval populations continued to increase throughout the season. The percent control data indicate that parathion and *B. thuringiensis* did not provide satisfactory control of cabbage loopers (less than 60%), and no material, including permethrin and methamidophos, which are consistent performers in most research trials (Bowman 1979, Halfhill 1979, etc.) provided even 50% reduction of this pest in either research trials or commercial fields (Tables 2 and 3).

It would appear from this information that in plots or fields treated periodically with insecticides labeled for use on this crop, a small but persistent residual population of cabbage loopers survived from one application date until the next. The same situation may also have occurred, but to a lesser extent, with diamondback moth larvae. With the exception of looper suppression, methamidophos, and parathion in combination with endosulfan, provided effective control and reduction.

Table 2.—Effectiveness of insecticides on larval pests in commercial sauerkraut fields in Yates and Ontario Counties, N.Y.

Year	Insecticide[a]	Rate (kg of AI/ha)	Mean % reduction[b]: Imported cabbageworm	Diamondback moth	Cabbage looper
1978	Methamidophos	0.92	90 (5)[c]	100 (3)	26 (3)
	Methomyl + Bt	0.83 + 0.46[e]	88 (1)	59 (3)	25 (3)
	Parathion + endosulfan	0.46 + 0.69	60 (3)	50 (2)	—[d]
	Bt	0.46–0.92[e]	55 (7)	41 (9)	26 (9)
	Parathion + Bt	0.46 + 0.46–0.92[e]	50 (2)	22 (3)	0 (2)
	Parathion	0.46	42 (7)	33 (6)	—
1979	Methamidophos	0.92	95 (3)	97 (3)	46 (3)
	Methomyl	0.83	86 (2)	78 (2)	0 (1)
	Bt (ground)	0.46–0.92[e]	85 (3)	83 (3)	0 (1)
	Bt (air)	0.92[e]	82 (2)	0 (2)	0 (2)
	Parathion + Bt	0.46 + 0.92[e]	86 (2)	78 (2)	0 (1)
	Permethrin	0.09	100 (2)	—	47 (4)
	Parathion (ground)	0.46	86 (9)	33 (9)	9 (1)
	Parathion (air)	0.46	64 (6)	37 (6)	0 (2)

[a] Bt, *B. thuringiensis*.
[b] See text.
[c] Number in parentheses indicates number of observations per season.
[d] —, Pest not present at time of sampling.
[e] Refers to formulation (15.97 × 10^9 IU/kg).

Table 3.—Effectiveness of selected insecticides on cabbage larval pests in research plots in Geneva, N.Y. 1979

			Mean %		
Method[a]	Insecticide[b]	Rate (kg of AI/ha)	Imported cabbageworm	Diamondback moth	Cabbage looper
Control	Permethrin	0.09	98.6	94.1	86.3
	Parathion + endosulfan	0.46 + 0.69	96.9	100.0	77.2
	Methamidophos	0.92	96.2	100.0	89.7
	Methomyl	0.83	94.2	97.6	75.0
	Parathion	0.46	92.6	93.2	40.1
	Bt	0.92[c]	75.5	92.9	57.1
Reduction	Permethrin	0.09	97 (3)[d]	93 (2)	44 (3)
	Parathion + endosulfan	0.46 + 0.69	81 (4)	100 (1)	7 (3)
	Methamidophos	0.92	84 (4)	100 (1)	37 (3)
	Methomyl	0.83	59 (5)	89 (2)	24 (3)
	Parathion	0.46	43 (5)	57 (3)	26 (3)
	Bt	0.92[c]	47 (4)	71 (3)	15 (3)

[a] See text.
[b] Bt, *B. thuringiensis*.
[c] Refers to formulation (15.97×10^9 IU/kg).
[d] Number in parentheses indicates number of observations per season.

Cabbage grown for sauerkraut is not sprayed on a regular schedule as is fresh market cabbage, and sauerkraut growers in New York tend to treat only after populations increase to ca. three larvae per plant. We conclude that it is risky to attempt to compare research findings directly with efficacy in commercial fields where untreated checks are not available. We are concerned that none of the registered compounds which our growers rely on provide adequate percent reduction of cabbage loopers. Sauerkraut growers need an insecticide which, when infrequently sprayed, will effectively suppress all three lepidopterous pests, especially cabbage loopers, which might very well increase beyond control if large migrations occur earlier than usual. With such a compound and a standardized grading system for sauerkraut, a workable damage threshold would be easier to develop.

Acknowledgment

We thank L. Pedersen and the New York State Vegetable IPM Program, which assisted us in obtaining information on commercial practices.

REFERENCES CITED

Anonymous. 1979. Vegetables: 1978 annual summary acreage, yield, production and value. Crop Reporting Board, USDA. Washington, D.C. 83 pp.

Bowman, J. S. 1979. Control of worms on cabbage, 1978. Insecticide Acaricide Tests 4: 49–50.

Chalfant, R. B., W. H. Denton, D. J. Schuster, and R. B. Workman. 1979. Management of cabbage caterpillars in Florida and Georgia by using visual damage thresholds. J. Econ. Entomol. 72: 411–413.

Davis, A. C., J. B. Bourke, and R. J. Kuhr. 1974. Disappearance of monitor residues from cole crops. Ibid. 67: 766–768.

Green, G. L. 1972. Economic damage thresholds and spray interval for cabbage looper control on cabbage. Ibid. 65: 205–208.

Halfhill, J. E. 1979. Control of cabbage looper and diamondback moth larvae on summer cabbage, 1978. Insecticide Acaricide Tests 4: 53.

Shepard, M. 1973. A sequential sampling plan for treatment decisions on the cabbage looper on cabbage. Environ. Entomol. 2: 901–903.