Evaluation of Insecticide Usage in the New York Processing-Cabbage Pest Management Program[1]

J. T. ANDALORO,[2] C. W. HOY, K. B. ROSE, AND A. M. SHELTON[3]

IPM Program, Cornell University, New York State Agricultural Experiment Station, Geneva, New York 14456

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ABSTRACT Insecticide usage in the Cornell University Processing (sauerkraut) Cabbage Pest Management Pilot Program was evaluated over the 4-year period from 1978 to 1981. Insecticide load was assessed in terms of dose equivalents. Insecticide efficacy was measured by percent reduction of Lepidoptera and percent reduction of plants infested with onion thrips, *Thrips tabaci* Lindeman. Total insecticide load, in average dose equivalents per field, decreased every year from 1978 to 1980, but increased in 1981. The increase in dose equivalents in 1981 was due to multiple applications of insecticides by growers to suppress high populations of thrips. However, during the 4-year period, most insecticides were applied to control Lepidoptera, and comparing 1981 with 1978, the amount of insecticides used against Lepidoptera decreased by 49%, whereas their effectiveness increased by 54%. These results are attributed to better insecticide selection and improved timing of applications due to development of action thresholds used in conjunction with weekly field scouting. Methamidophos and the pyrethroids consistently provided the most effective control of Lepidoptera. Control of thrips by foliar insecticides was inadequate for present Food and Drug Administration standards.

Insecticides are the most commonly used control strategy for pests of processing cabbage (sauerkraut) in New York. For some insects, such as the cabbage maggot, *Delia radicum* (L.), preventive insecticide treatments may be required as insurance against potential crop loss due to expected infestations. For other pests, such as Lepidoptera in New York, [diamondback moth, *Plutella xylostella* (L.), imported cabbageworm, *Artogeia rapae* (L.), and cabbage looper, *Trichoplusia ni* (Hübner)], preventive treatments and strict insect control are not cost effective (Shelton and Andaloro 1983).

Cornell University's agricultural pest management programs are designed to assist growers in making cost-effective management decisions by monitoring pest populations, utilizing action thresholds, and suggesting specific control strategies. Information collected from commercial fields in these programs provides the opportunity for research and extension to document insecticide usage and evaluate insecticide effectiveness—two integral parts of a total pest management program. The purpose of this report is to assess the impact of Cornell's processing-cabbage integrated pest management (IPM) program on the use of insecticides by growers in Ontario and Yates Counties, N.Y. over the first 4 years of the program.

Materials and Methods

Commercial processing-cabbage fields were scouted weekly during the four growing seasons of 1978 through 1981. The numbers of fields scouted during these years were 12, 16, 33, and 35, respectively. Scouts monitored pests along a V-shaped transect through the field, inspecting 50 plants in 1978, and 40 plants in 1979 and 1980. In 1981, the sample size varied from 11 to 20 plants, based on the variable-intensity sampling procedure described by Hoy et al. (1983). Records of insecticide applications were kept by growers and pest management scouts. Insecticide load was measured by calculating the average total number of dose equivalents (actual rate applied, divided by the Cornell University recommended rate [Tette et al. 1979]) applied per field per season. Dose equivalents provide a common scale of measurement for all insecticides and for all of their formulations. The efficacy of each insecticide was determined by calculating the percent reduction of Lepidoptera and percent reduction of thrips-infested plants after each application. Only applications with pretreatment counts greater than 0.20 larvae per plant or greater than 5% thrips-infested plants were included. Percent reduction for Lepidoptera was calculated by:

$$\frac{\text{no. of larvae pretreatment} - \text{no. of larvae posttreatment}}{\text{no. of larvae pretreatment}} \times 100$$

and for thrips by:

$$\frac{\text{percent plants infested pretreatment} - \text{percent plants infested posttreatment}}{\text{percent plants infested pretreatment}} \times 100$$

Results and Discussion

Insecticide Load

The average total number of dose equivalents per field decreased by 15% from 1978 to 1979 and by 12% from 1979 to 1980 (Fig. 1). However, during 1981, the average total number of dose equivalents per field increased by 25% from the previous year because of severe onion thrips infestations. In all 4 years, more dose equivalents were applied for control of Lepidoptera than for other insects. From 1978 to 1981 the insecticide load

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[2]Present address: DuPont Experiment Station, Biochemicals Research Dept., Wilmington DE 19898.

[3]Dept. of Entomology, NYS Agric. Exp. Stn., Cornell University, Geneva, NY 14456.

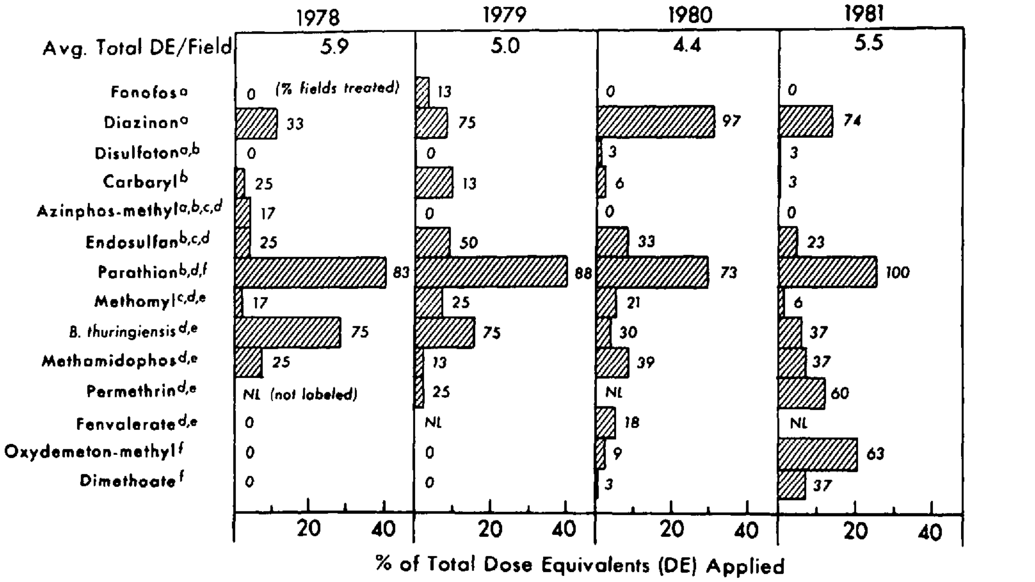

FIG. 1. Insecticide usage by sauerkraut cabbage IPM program participants as measured by dose equivalents. Ontario and Yates Counties, N.Y. (Insecticides applied mainly for control of: [a]cabbage maggot; [b]flea beetles; [c]diamondback moth; [d]imported cabbageworm; [e]cabbage looper; [f]thrips.)

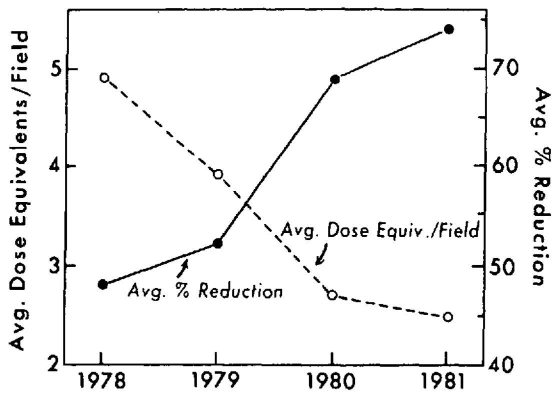

FIG. 2. Efficacy of insecticide treatments for control of Lepidoptera obtained by sauerkraut cabbage IPM program participants. Ontario and Yates Counties, N.Y.

for Lepidoptera decreased from the previous year by 20, 31, and 7%, respectively (Fig. 2). This decrease in the total number of dose equivalents per field for Lepidoptera is partially due to the growers' increased use of treatment thresholds based on larval counts, rather than spraying based on a calendar schedule or in response to visible plant damage.

Parathion was the most commonly-used insecticide over the 4 years and was used against most foliage feeding insects, mainly because of its low cost rather than its effectiveness. However, dose equivalents of parathion decreased over this period as growers became more knowledgeable of the insect species complex in their fields through scouting reports, and thus became more selective of materials for control of specific pests. Two pyrethroids were available through Section 18 permits from 1978 to 1981: permethrin in 1979 and 1981, and fenvalerate in 1978 and 1980. The dose equivalents of the pyrethroids, and their percentage of the total dose equivalents, increased each year over this period because of their availability and effectiveness. The dose equivalents of *Bacillus thuringiensis* (Berliner) decreased by 81% from 1978 to 1981, due to its variable effectiveness against Lepidoptera, as well as the availability of the more effective pyrethroids.

Lepidoptera Control

The average effectiveness for insecticides used against the three major Lepidoptera during 1978 to 1981, as measured by percent reduction, is depicted in Table 1. All insecticides provided at least 63% control of imported cabbageworm, whereas the range in control of other Lepidoptera was much more variable. Methomyl, endosulfan, permethrin, fenvalerate, and methamidophos reduced imported cabbageworm, diamondback moth, and cabbage looper larvae more effectively than did other materials reported in this survey. Parathion was the least effective in controlling diamondback moth populations. Among the three lepidopteran species, *B. thuringiensis* performed best against imported cabbageworm, though it still provided less control than did most other insecticides, and gave very little reduction of cabbage looper larvae. In 1981, oxydemeton-methyl and dimethoate were used in combination sprays with other materials to control thrips on cabbage. These partially systemic insecticides are not known to effectively control lepidopteran populations, however, when added to permethrin, parathion, and methamidophos they appeared to enhance effectiveness.

Table 1. Effectiveness of insecticides on lepidopterous larvae in processing-cabbage fields in Ontario and Yates Counties, N.Y., 1978 through 1981

Insecticide[a]	Range of rates (kg of AI/ha)	Mean % reduction[b]		
		Imported Cabbageworm	Diamondback moth	Cabbage looper
B. t.	0.56–1.12	72 (12)[c]	47 (18)	17 (20)
Endosulfan	0.65–0.84	81 (3)	96 (3)	—
Fenvalerate	0.22	75 (6)	—[d]	58 (8)
Methamidophos	0.56–1.12	91 (25)	93 (23)	61 (17)
Methomyl	0.25–0.50	73 (5)	58 (6)	40 (3)
Parathion	0.28–0.84	80 (47)	40 (39)	23 (7)
Permethrin	0.06–0.12	95 (7)	96 (4)	49 (11)
B.t. + Parathion	0.56–1.12 and 0.56–0.84	90 (12)	42 (10)	12 (11)
B.t. + Permethrin	0.28–1.12 and 0.06–0.11	63 (4)	75 (5)	40 (6)
B.t. + Methomyl	1.0 + 0.76	95 (3)	73 (5)	33 (5)
Methamidophos + oxydemeton-methyl	1.12 + 0.71	100 (5)	99 (6)	99 (6)
Parathion + dimethoate	0.56 + 0.56	84 (3)	—	—
Parathion + endosulfan	0.56–0.84 + 0.65–0.84	81 (13)	77 (10)	—
Parathion + oxydemeton-methyl	0.28–1.12 + 0.43–0.71	66 (8)	49 (8)	—
Parathion + methomyl	0.56 + 0.50	98 (4)	90 (4)	—
Parathion + permethrin	0.56 + 0.12	96 (4)	96 (3)	81 (4)
Permethrin + dimethoate	0.12 + 0.56	91 (6)	100 (4)	88 (5)

[a]*B.t.* = *B. thuringiensis*.
[b]See text.
[c]Number in parentheses indicates total number of observations during 1978 through 1982.
[d]—· Pest not present at time of sampling, or less than three observations were made.
[e]Refers to formulation (15.97 × 10^9 IU/kg).

Table 2. Effectiveness of insecticides on thrips in processing-cabbage fields in Ontario and Yates Counties, N.Y. 1980–1981

Insecticide	Range of rates (kg of AI/ha)	% Applications post-heading	Mean % reduction in plants infested[a]	
			1 wk posttreatment	2 wk posttreatment
Oxydemeton-methyl	0.56–0.71	55	67 (11)[b]	33 (11)[c]
Dimethoate	0.56	50	67 (6)	36 (5)
Parathion	0.56	13	78 (16)	51 (16)
Methamidophos	0.56–1.12	100	100 (6)	69 (4)
Permethrin	0.06–0.12	100	27 (4)	33 (3)
Endosulfan	0.65–0.84	25	60 (4)	—
Parathion + oxydemeton-methyl	0.28–1.12 and 0.43–0.71	36	68 (14)	58 (13)
Parathion + dimethoate	0.56 and 0.56	0	77 (5)	60 (5)
Parathion + methamidophos	0.28–1.12 and 0.56–1.12	17	90 (6)	65 (6)
Parathion + permethrin	0.56 and 0.12	100	100 (4)	—
Parathion + endosulfan	0.56–0.84 and 0.65–0.84	33	97 (6)	61 (6)
Mean			77.3	57.6

[a]See text.
[b]Number in parentheses indicates the total number of observations during 1980 and 1981.
[c]—· Less than three observations were made.

The data in Table 1 indicate that chemicals used singly against the cabbage looper and diamondback moth were generally not very effective; e.g., the most effective chemical used singly against the cabbage looper achieved only a 61% reduction. However, this interpretation may be misleading, since no untreated plots were available for comparison as is the case in research plots. Since these data were computed from pre- and posttreatment counts to acquire a percent reduction and not compared with an untreated control population in which pest populations are allowed to build, pest control appears to be less effective.

From 1978 to 1981, the average dose equivalents per field applied against Lepidoptera decreased by 49%, whereas the effectiveness (average percent reduction) for all materials against Lepidoptera increased in 1981 by 54% over that in 1978 (Fig. 2). This increase in insecticide efficiency is attributed to improved selection and timing of insecticide treatments, based on field monitoring of insect populations and interpretive information. Field monitoring information included population densities for each of the three Lepidoptera, thus alerting the grower to select the most effective material for the species complex present in individual fields. This emphasis on selection also resulted in a decrease in the application of insecticide combinations, hence a decrease in the average total number of dose equivalents per field. Timing of insecticide treatments was improved by the development of action thresholds and their use by growers. In 1978, no specific thresholds were recommended. In 1979, treatment decisions were recommended by the Cornell Cabbage IPM Advisory Committee, a group comprised of research, extension, and industry personnel. Treatment levels varied, but averaged 2.0 lepidopteran larvae (of any size or species) per plant. Based on 1979 observations and tests, higher threshold levels were developed and used in 1980. These levels were further refined for 1981 and 1982 (Andaloro et al. 1983). The use of these increasingly higher thresholds by growers resulted in progressively fewer insecticide treatments, and thus lowered the number of dose equivalents per field (Fig. 2).

No instances of grade or yield loss due to Lepidoptera were noted in any of the 4 years of the program in either commercial fields or research plots. These results are consistent with those presented by Shelton and Andaloro (1982) for 1979 and 1980. Therefore, the thresholds used were not too high for the populations and growing conditions experienced in New York over the past 4 years. However, they could have been too low, hence requiring more sprays than may have been necessary to prevent economic damage. Whereas a complete analysis of insecticide efficiency must include considerations of insecticide cost and both actual and potential monetary loss due to Lepidoptera, the present analysis shows a marked improvement in the efficiency of insecticide usage due to field scouting, action thresholds, and more careful selection of insecticides.

Thrips Control

Thrips infestations of cabbage reached damaging levels in 1980 and 1981. In 1980, several loads of processing cabbage from Ontario County were rejected by processors due to thrips infestations. Because no specific defect action level (level of contaminant rendering product unacceptable) for thrips had been set by the Food and Drug Administration (FDA), the processor was concerned about discretionary seizure by the FDA for any thrips contamination (Shelton et al. 1982). In 1981, thrips were commonly found in fields and, in reaction to previous rejections, growers applied more insecticides than in previous years. The thrips infestation explains the increased use of oxydemeton-methyl and dimethoate in 1980 and 1981 as compared with 1978 to 1979 (Fig. 1). Both chemicals were applied explicitly for thrips control, but achieved only a 67% reduction in heads infested 1 week posttreatment and less than a 36% reduction 2 weeks posttreatment in commercial fields (Table 2). Methamidophos alone was found to be 100% effective, whereas parathion, the most commonly used insecticide, reduced infested heads by 78%. These results, obtained from intact plant counts, differed from those of other research tests (Shelton and Wilsey 1981), in which plants were dissected. In the latter study, dimethoate, oxydemeton-methyl), parathion, and methamidophos gave 90, 87, 85, and 66% control, respectively, 4 days posttreatment. Though the overall average reduction in plants infested with thrips in commercial fields 1 week posttreatment appears adequate (77%) in these tests, this interpretation of control is misleading because of three factors. First, detection of thrips on intact plants can be difficult due to their small size and tendency to seek sheltered areas on the plant, i.e., within the apical meristem of young plants and within the head of older plants. Second, because thrips are parthenogenic and reproduce rapidly, inaccurate field counts can lead to miscalculation of a thrips population increase. Last, once thrips infest a plant within the head, they are sheltered from foliar insecticides. The combination of these factors make it imperative that thrips infestations are accurately estimated and effective control strategies are developed. The performance of topically applied insecticides on commercial fields for control of thrips varied widely at the individual treatment level. Several important variables that may affect the effectiveness of insecticides are the crop stage at which the treatment was applied, the cabbage variety (Shelton et al. 1983), and the rate of thrips immigration into cabbage fields. Given the apparent difficulty of controlling thrips on cabbage with topically applied insecticides, the combined tactics of resistant varieties, systemic insecticides, placement of cabbage fields to reduce immigration of thrips, and a reasonable defect action level will be a much more effective strategy for controlling thrips in processing cabbage in the future.

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