

EVALUATION OF PESTICIDES FOR CONTROLLING THE PEST COMPLEX ON CABBAGE IN THE UPLANDS OF SRI LANKA

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ABSTRACT

Field screening of pesticides conducted at the Agricultural Research Station, Sita Eliya in Maha 1976/77 and Yala 1977 indicated low pest incidence in Yala compared to Maha. In Yala considerable reduction in pesticide use could be effected without affecting the yield significantly.

Though the synthetic pyrethroids permethrin and fenvalerate were superior to the organophosphate and carbamate insecticides, their harmful effects on the natural enemies and rapid development of resistance preclude their being recommended in Sri Lanka. Of the other insecticides chlorpyrifos was the best. Pirimiphos-methyl and methomyl though less effective against the cutworms than methamidophos could be recommended for use against the other pests of cabbage. These three insecticides gave better returns and are less hazardous to mammals than methamidophos.

INTRODUCTION

In Sri Lanka the crucifers such as cabbage, cauliflower, knol khol, Brussels sprouts, radish, turnip and mustard have been traditionally grown in the Up-Country Wet Zone area. In addition to their high economic values in these areas, some are also cultivated in rotation with potatoes, carrots and beet root. A major extent of the cultivation of crucifers in the uplands is in the Nuwara Eliya district, where about three thousand acres are cultivated during each growing season, Maha and Yala.

A wide range of phytophagous arthropods have been reported on the crucifers in the region (Table 1). During the early stages of the crop, damage due to cutworm (which severs the transplanted seedlings at the base) is a major problem. As the plants grow, several species of lepidopterous

insects, including cutworms, feed on the leaves and sometimes on the apical buds. Their feeding may lead to a direct loss in yield or to a reduction in the market value of the crop. In addition to these lepidopterans, other pests like pentatomid bugs, aphids and slugs may also be found feeding on these crucifers. However, other than cutworms or diamond-back moth during certain periods, many of these pests are kept under control by natural enemies (Table 1).

Cultivators normally use insecticides to control these pests. Misuse or overuse of insecticides is common in this region. The use of insecticides, particularly during the late stages of the crop, is at times governed by the prevalent demand for the crop. During periods of high demand, the cultivators harvest and sell the produce without giving due consideration to the insecticide's safety interval.

Methamidophos had been in use from the early nineteen seventies and has come to occupy the status of a panacea for all insect problems in this region. This systemic insecticide with a high mammalian toxicity is a dangerous chemical to use close to harvest as some of these crops are at times eaten raw or cooked lightly. It is thus necessary to select insecticides having low mammalian toxicity as well as a sparing effect on the natural enemies to control economically the pest complex on cabbage.

MATERIALS AND METHODS

Cabbage was selected as the crop to be tested since it harbours almost all the pests of crucifers, is easy to grow and also facilitates pests sampling. Cabbage is also the most extensively grown crucifer. Field experiments were conducted at the Agricultural Research Station, Sita Eliya during Maha 1976/77 and Yala 1977. In Maha the nine insecticides listed below were tested at the rates given along with an untreated control. The experiment was designed as a Randomized Complete Block with four replicates.

<i>Common name</i>	<i>Concentration (a.i.)</i>	<i>Trade name</i>
1. Permethrin	60 ppm	Ambush 25% EC
2. Fenvalerate	500 "	Sumicidin 20% EC
3. Chlorpyrifos	" "	Dursban 20% EC
4. Methamidophos	" "	Tamaron 60% LC
5. Pirimiphos-methyl	" "	Actellic 50% EC
6. Quinalphos	" "	Bayrusil 25% EC
7. Methomyl	" "	Lannate 90% WP
8. Monocrotophos	" "	Azodrin 60% EC
9. Carbofuran	0.675 kg/ha.	Curaterr 3% G

The experiment was repeated in Yala 1977 with the exception that the dosage of fenvalerate was changed to 60 ppm.

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Cabbage variety A-S Cross was used in these experiments. The plants were raised in nurseries and transplanted in the field after 1—1½ months at a spacing of 50×40 cm². Plot size was 3×4m², with a 1m unplanted border between plots and between replicates. Other agronomic practices were followed in accordance with the recommendations of the Department of Agriculture.

Five insecticidal applications were given at fortnightly intervals from the date of transplanting. Data on the following were collected from all the plants excluding those from the border rows of each plot :

1. Number of dead cutworms (>2cm) at 24 and 48 hours after the first two applications of the insecticides.
2. Number of cut-stems at 48 hours after the first application of the insecticides.
3. Visual estimate of damage to the top leaves, based on a scale of 1 to 5 (1= <10%, 2=11—20%, 3=21—30%, 4=31—40%, 5=>40%), at 1 week after the application of the insecticides.
4. Yield—Weight of marketable heads.
5. Gross income minus cost of insecticidal treatments was calculated from:— (a) Gross income per hectare based on the marketable yield per treatment and the average market price of cabbage which was 55ct per kg., and (b) Cost of insecticidal treatments.

Data that gave coefficients of variation below 30% for counts and below 15% for yield are presented.

RESULTS AND DISCUSSION

Effect on cutworm mortality. The performance of the insecticides in causing mortality to cutworms is shown in Table 2 for the 1st count for Maha 1976/77. The synthetic pyrethroid permethrin was significantly superior to all other insecticides tested. This was followed by fenvalerate and chlorpyrifos which were significantly superior to methamidophos. There were no significant differences between pirimiphos-methyl, methomyl, quinalphos and monocrotophos, although they were better than carbofuran and the untreated control.

The number of dead cutworms obtained for the 2nd count was low and variable. This should be expected as after the 1st application of insecticides a good proportion of the cutworms that are in the soil would be eliminated. Under laboratory conditions the eggs of *A. ipsilon* (the dominant species of cutworm in the area) took about a week to hatch (De Silva 1962). To reach over 2 cm in length (about 4th instar, the stage which severs the plants) it would take another 2—3 weeks. Hence, new migrants into the area as well as a few escapees and resistant individuals from the 1st spray would constitute the population that would be exposed to the 2nd spray. Their differential distribution in the field as well as susceptibilities to the insecticides tested may account for the high variation in the 2nd count. In Yala the number of dead cutworms obtained for the two counts was low and variable.

Effect on cut-stem incidence. The effect of the insecticides in reducing cut-stem incidence caused by cutworm feeding is shown in Table 3 for Maha 1976/77. All insecticides except carbofuran were significantly superior to the untreated control in reducing cut-stem incidence. There were no significant differences between the first four insecticides permethrin, fenvalerate, chlorpyrifos and quinalphos. However, permethrin and fenvalerate were superior to pirimiphos-methyl, monocrotophos, methomyl and methamidophos in reducing cut-stem incidence.

The application of carbofuran as granules to the soil had no effect in causing mortality to cutworms (Table 2) or reducing cut-stem incidence (Table 3). Forty eight hours after transplanting this systemic insecticide may not have been absorbed in sufficient amounts to cause any effect. With granular systemic insecticides the cutworm will have to feed on the plants before succumbing to the poison. It may be that contact-poison type insecticides are more effective in preventing damage by cutworms during the early stages of the transplanted crop. This was illustrated by the good performance of the pyrethroids and chlorpyrifos which are essentially contact and stomach poisons. The number of cut-stems obtained was low and variable, during Yala.

Effect on leaf damage. When leaf damage estimates were analysed they gave high coefficients of variation for Maha as well as Yala. However in Maha, plots receiving the pyrethroids and chlorpyrifos were observed to have less leaf damage than those receiving the other treatments. The variation in leaf

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damage estimates may be due to a complex of insects feeding on cabbage with each having a different pattern of field distribution. The diamond-back moth is the major leaf-eating pest of cabbage in the upland areas (Fernando 1964).

Effect on yield. The effect of the insecticides in reducing damage by a complex of pests feeding on cabbage and thereby producing better yields per hectare is shown in Table 4. In Maha all insecticides tested were significantly superior to the untreated control. There were no significant differences in yield between fenvalerate, permethrin, chlorpyrifos, quinalphos, methomyl, pirimiphos-methyl and methamidophos, although, the first three were significantly superior to carbofuran and monocrotophos.

In Yala the differences in yield amongst the insecticides as well as against the untreated control were not significant. The order of performance of the insecticides in the mean yield for Maha and Yala was similar to that of Maha. The mean yield of fenvalerate, permethrin, chlorpyrifos, quinalphos, methomyl and pirimiphos-methyl was higher than that for methamidophos.

Effect on cost / benefit. The benefits accruing due to money spent on different insecticidal treatments are shown in Table 5. In Maha all insecticides gave a better return than the untreated control. The best treatment, permethrin, gave Rs. 7,683 more per hectare than the untreated control. In Yala the control was better than some of the insecticides namely methomyl, monocrotophos and carbofuran. The best treatment, fenvalerate, gave only Rs. 1,270 more per hectare than the control.

For Maha and Yala the mean returns due to treatments were greater with permethrin, chlorpyrifos, pirimiphos-methyl and methomyl than methamidophos. The low mean returns from the fenvalerate treatment were mainly due to the money spent on the high dosage that was used in Maha.

Seasonal differences in pest incidence. In Yala the number of dead cutworms, cut-stem and leaf damage incidence was low compared to Maha. In addition there were no significant differences in yield in Yala between the treated and untreated plots, indicating low pest incidence and damage. Jesudasan and Yogaratnam (in press) have shown that the diamond-back moth reaches a population peak in late-March which drops to very low levels between

mid-May and mid-September, due mainly to adverse weather conditions such as high wind velocities and high rainfall during this period. It is possible that these same climatic factors may be keeping down the incidence of the other pests as well in Yala. A considerable saving could thus be effected in reducing the number of insecticidal applications during Yala without significantly affecting the yield (Table 4) and net returns (Table 5). Also, pesticide screening experiments, timed to coincide with the high pest population levels during March—April, may yield more realistic comparisons.

Pesticide recommendation based on above results. Synthetic pyrethroids and pirimiphos-methyl are less hazardous to mammals than all other insecticides (Anonymous 1983a). Of the other chemicals that were more effective than methamidophos, the dermal toxicities of chlorpyrifos and methomyl are low. They are thus safer than methamidophos. Methomyl in addition has very short persistence of 4—7 days on plants. It can thus be used closer to harvest.

The major limitations of chemical control are secondary pest outbreak, pest resurgence, toxicity to non-target organisms and insect resistance. All insecticides suffer to some degree one or more of these limitations. The organophosphates and carbamates have been used on a wide range of agricultural crops and their major limitations are fairly well known. The synthetic pyrethroids are of recent origin and their application is limited to a few crops. However, there is increasing evidence to suggest that these pyrethroids also have some major drawbacks.

Several workers (Balasubramaniam *et al.* 1980, Chari 1980, Hoyt *et al.* 1978, Kathane 1980, Penman and Chapman 1980, Rote *et al.* 1980) have reported flare-up of sucking pests like aphids, mites or jassids on cotton or on apples after the application of synthetic pyrethroids. The gradual build-up of mites on potatoes in the Jaffna area (Mr. C. W. Wijeratnam, pers. comm.) and mites and jassids on potatoes in the Eastern Region could be due to the increased use of pyrethroids in these areas. Though pyrethroids are recommended only against the onion caterpillar, *Spodoptera exigua* (Hb.) in Jaffna (Anonymous 1983b), it is common knowledge that they are being used in several other crop / pest situations. Resurgence of the brown planthopper (BHP) *Nilaparvata lugens* (Stal.) with pyrethroids had been reported by Heinrichs and Mochida (1983). If these pyrethroids are introduced to the rice eco-system in Sri Lanka they can further complicate the BPH problem.

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Pyrethroids are also extremely toxic to bees and other pollinators as well as to certain parasites and predators. In addition, they are extremely toxic to fresh water fish (Nishizawa 1971, Toobey *et al.* 1975). Keiding (1977) first monitored a rapid development of resistance in houseflies exposed to intensive control with pyrethroids. (Liu *et al.* 1981) have found several cases of pyrethroid resistance in the diamond-back moth in Taiwan where these chemicals were recommended for its control on crucifers since 1976. A case of cross resistance between organophosphates and pyrethroids was recorded in *Myzus persicae* (Sulz.). Resistance has also been reported in several other insects. The mechanism and inheritance of pyrethroid resistance in the housefly involves a recessive *kdr* gene which is thought to lower the sensitivity of the nerve to DDT. Flies that have homozygous *kdr* genes also show resistance to pyrethroids. The *kdr* gene confers resistance to all pyrethroids so far known. On the pessimistic side the intense use of pyrethroids could lead to the appearance of *kdr*-type resistance which would confer cross resistance. And thus all pyrethroids will become ineffective (Shono 1985). The possibility of the development of *kdr*-type resistance is a major obstacle to recommending these otherwise ideal agricultural insecticides for use against the pest complex on crucifers in the upland areas. If these pyrethroids are freely available in the market, the farmers, impressed by their performance against the caterpillar pests, would tend to use them as a panacea for all insect problems. Inquiries conducted at the major retail outlets for pesticides in the Nuwara Eliya District revealed that the synthetic pyrethroids, permethrin and fenvalerate, were the most preferred insecticides in 1983.

Chlorpyrifos, pirimiphos-methyl and methomyl are more effective and safer than methamidophos and these could be recommended for use against the pests of cabbage. Since the number of effective insecticides is limited care should be taken to prolong the useful life of these chemicals.

CONCLUSIONS

1. In Maha insecticidal application produced significant yield differences from the untreated control. These differences were not significant in Yala indicating low pest incidence. Considerable reduction in pesticide use could be effected in Yala without significantly affecting the yield and net returns.

2. The synthetic pyrethroids permethrin and fenvalerate were more effective than the organophosphates and carbamates in controlling the pest complex on cabbage. They are however not recommended for use in the uplands of Sri Lanka due to their possible harmful effects on the natural enemies of the pests as well as the development of *Kdr*-type resistance.
3. Chlorpyrifos could be recommended for the control of cutworms and other pests of cabbage. Pirimiphos-methyl and methomyl, though less effective in causing mortality to cutworms than methamidophos, could be recommended for use against the other pests of cabbage. Methomyl could be used close to harvest as it has a very short persistence.

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Table 1. Common arthropod pests of crucifers and their parasites and predators in the uplands of Sri Lanka

Common name	Scientific name	Parasite / Predator	Source
I. Cutworms	1. <i>Agrotis ipsilon</i> (Huf.)	a. <i>Ichneumon</i> sp.	Jesudasan (1978)
		b. Unidentified ichneumonid	" "
	2. <i>Agrotis segetum</i> (D. & S.)		
II. Leaf-eating caterpillars	3. <i>Peridroma saucia</i> (Hb.)		
	1. <i>Plutella xylostella</i> (L.)	a. <i>Apanteles plutellae</i> (Kurdj.)	De Silva (1960)
		b. <i>Anilastus</i> sp.	" "
		c. <i>Thyraeella collaris</i> (Grav)	Jesudasan (1978)
		d. <i>Diadegma eucrophaga</i> (Horst.)	" "
		e. <i>Platycheirus</i> sp.	" "
	2. <i>Plusia orichalcea</i> (Daub)	a. <i>Apanteles ruficrus</i> (Hal)	De Silva (1961)
	3. <i>Plusia eriosoma</i> (F)	b. <i>Copidosoma</i> sp.	" "
	4. <i>Crociodolomia binotalis</i>	a. <i>A. ruficrus</i>	" "
		b. <i>Sarcophaga peregrina</i> R.	" "
		c. <i>Winthermia diversa</i> Mall.	" "
		d. <i>Sturmia inconspicuoides</i> Bar.	" "
	5. <i>Hellula undais</i>		
	6. <i>Prodenia litura</i> F.	a. <i>A. ruficrus</i>	De Silva (1961)
		b. <i>Actia monticola</i> Mall.	" "
III. Pentatomid bug	<i>Bagrada picta</i> F.	a. <i>Cydnocoris crocatus</i> St.	" "
		b. <i>Sarcophaga albiceps</i> Meig.	" "
		c. <i>Sarcophaga kempii</i> Snr. White	" "
IV. Aphids	<i>Myzus persicae</i> Sulz.	a. <i>Aphidius</i> sp.	Jesudasan (1978)
		b. <i>Aphidencyrus</i> sp.	" "

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**Table 2. Cumulative number of dead cutworms upto 48 hours after treatments,
Maha 1976 / 77**

<i>Insecticide</i>	<i>Mean number of dead cutworms</i> $y = \sqrt{x + 0.02}$
Permethrin	2.74
Fenvalerate	2.23
Chlorpyrifos	2.08
Methamidophos	1.71
Pirimiphos-methyl	1.08
Methomyl	0.94
Quinalphos	0.78
Monocrotophos	0.78
Carbofuran	0.14
Control	0.14
L. S. D., at 5%	0.30
Coefficient of variation	5.11%

**Table 3. Number of seedlings severed by cutworms at 48 hours after treatments,
Maha 1976 / 77**

<i>Insecticide</i>	<i>Mean number of seedlings severed</i> $y = \sqrt{x + 0.05}$
Permethrin	0.63
Fenvalerate	0.93
Chlorpyrifos	1.13
Quinalphos	1.13
Pirimiphos-methyl	1.37
Monocrotophos	1.63
Methomyl	1.65
Methamidophos	1.71
Carbofuran	2.43
Control	2.60
L. S. D., at 5%	0.65
Coefficient of variation	26.9%

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Table 4. Yield of marketable heads of cabbage in kg / ha

<i>Insecticide</i>	<i>Maha 1976/77</i>	<i>Yala 1977</i>	<i>Mean</i>
Fenvalerate	48,523	44,533	46,528
Permethrin	48,148	44,748	46,448
Chlorpyrifos	47,708	43,470	45,589
Quinalphos	45,335	42,295	43,815
Methomyl	44,748	41,565	43,157
Pirimiphos-methyl	44,165	41,983	43,074
Methamidophos	42,498	41,874	42,186
Carbofuran	40,248	40,948	40,598
Monocrotophos	39,773	38,865	39,319
Control	30,832	39,041	34,937
L. S. D., at 5%	7,183	n. s.	
Coefficient of variation	11.5 %	8.73 %	

Table 5. Gross income per hectare minus cost insecticidal treatments (in rupees)

<i>Insecticide</i>	<i>Maha 1976/77</i>	<i>Yala 1977</i>	<i>Mean</i>
Permethrin	24,646	22,581	23,613.50
Chlorpyrifos	24,587	21,757	23,172.00
Pirimiphos-methyl	23,675	21,976	22,825.50
Methomyl	23,547	21,396	22,471.50
Methamidophos	22,836	21,993	22,414.50
Quinalphos	23,461	21,289	22,375.00
Carbofuran	21,751	21,636	21,693.50
Fenvalerate	20,431	22,743	21,587.00
Monocrotophos	21,092	20,095	20,593.50
Control	16,958	21,473	19,215.50