

Hoe 522 (CME 134), a New Insect Growth Regulator for Control of the Diamondback Moth

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Abstract

A new insect growth regulator, Hoe 522 (CME-134), was tested in the field in the northern Philippines for the control of diamondback moth, *Plutella xylostella* L which had developed resistance to a large number of insecticides. Hoe 522 was found to be highly effective against diamondback moth populations at all rates from 15 to 105 g AI/ha and performed significantly better than reference products. A flat dose response relationship was recorded in this dosage range. Weekly and ten-day interval sprays gave better control than a spray schedule of 14 days. Under these conditions and high insect infestation levels, rates of 30-45 g AI proved to be more effective than lower dosages. A positive correlation was found between insect control and yield. Application of Hoe-522 resulted in significant yield increase and superior crop quality. Crop tolerance to Hoe 522 was excellent.

Introduction

In southeast Asia the diamondback moth (DBM) *Plutella xylostella* L (Lepidoptera: Yponomeutidae) is a destructive pest of cruciferous crops, especially cabbage, and is a limiting factor for profitable cultivation (Barroga and Morallo-Rejesus 1981, Chuo 1973, Gandhale et al 1982). Continuous vegetable growing and favorable climatic conditions favor high population densities with overlapping of all developmental stages the year round. Only during the rainy season is a decrease in population level to be observed. More than 20 generations per year are reported (Sun et al 1978).

Without insecticide treatment complete crop losses may occur due to DBM attack. Untreated plants normally die during the first two months after transplanting, or survive only long enough to produce few marketable heads or leaves or none at all (Ho 1965, Butani et al 1977).

More intensive use of insecticides has become necessary as the susceptibility of DBM to a number of conventional insecticides has decreased (Liu et al 1981, 1982, Sudderuddin and Kok 1978). To overcome the problem, farmers shorten the spray intervals, increase dose rates, and apply mixtures of different insecticides (Ho et al 1983).

In the last few years, only a limited number of new chemicals have been introduced into the vegetable market of southeast Asia for DBM control. Recently a new experimental product coded Hoe 522 OI 01 (hereafter referred to as Hoe 522) was investigated for its potential to control DBM on cabbage. This product, with internal code CME-134, 1-(3,5-dichloro-2,4-difluorophenyl)-3-(2, 6-difluorobenzoyl)-urea, was discovered in the laboratories of the Celamerck Company, Germany. Properties were described by Becher et al (1983) and Becker (1985).

This paper presents our results concerning the effectiveness of Hoe 522 against DBM on cabbage in the Philippines.

Materials and Methods

Field trials on cabbage, *Brassica oleracea* var *capitata* (cv Grobe King, Scorpio Hybrid, and Green Parade) and leafy cabbage, *Brassica campestris* ssp *chinensis* (cv Black Behi), were conducted in La Trinidad near Baguio during the dry and wet seasons of 1984. Seedlings were raised in a seedbed and transplanted after about three weeks for leafy cabbage or six to nine weeks for cabbage. For protection against early DBM attack and for softrot control, seedlings of leafy cabbage were sprayed at 5 to 15 and 20 days after sowing (DAS) with a tankmix of 500 g AI profenofos and 750 g AI chlorothalonil/ha. For cabbage the same tankmix was applied at 6, 16, 21, 30 and 35 DAS.

Cabbage trials received a basal NPK fertilizer dose of 30 kg/ha at two days after transplanting (DAT), followed by an overall distribution of 200 kg organic fertilizer (Sagana 100)/ha and a handful of chicken manure/plant at 15 DAT. Another 30 kg NPK/ha was applied at 25 DAT during hilling up.

A randomized complete block design with four replicates was used. Plots were 1 m wide and 5 m long with a spacing of 35 cm between plants in the row and 40 cm between rows. Each treatment normally consisted of 39 plants per plot.

The insecticides were applied with a hand-held knapsack sprayer. A hollow cone nozzle was used. The spray volume ranged from 600 up to 800 and 1000 liters/ha, depending on the plant growth; smaller plants received lesser volumes. The first application was made when there was visible feeding by DBM.

Numbers of larvae and pupae were counted on 10 or 15 randomly selected plants/plot at regular intervals according to the spray schedule. Normally the counting was made one day before and one day after the first or subsequent applications. The percent efficacy was calculated on the basis of the number of living larvae in treated and control plots. Feeding damage was assessed as percentage overall damage/plant one day before each application.

The effectiveness in terms of yield was recorded from the whole plot as total weight of marketable crop. The marketable heads were classified into three groups according to the local practice. Class A heads had no visible damage; class B had slight feeding damage (heads marketable after peeling-off three to four leaves), class C had severe damage (heads only marketable after removal of more than four leaves). For leafy cabbage total yield of all marketable leaves was recorded without further classification. For statistical analysis Duncan's multiple range test was used. Laboratory studies revealed that the DBM population in the experimental area was highly resistant to organo-phosphorus and pyrethroid insecticides.

Results

Trial seasons I and II/1984—Cabbage

Trials were performed during the dry season beginning from March to May 1984 onwards. DBM population density decreased at the end of the trial period due to the beginning of the wet season. Hoe-522 was tested at 30, 60 and 105 g AI/ha. Methamidophos and profenofos were used as reference compounds. Insecticides were applied at seven-day intervals. The results are summarized in Table 1.

Table 1. Efficacy of Hoe 522 against DBM and yield response in head cabbage (trial 1, season I & II)

Insecticides	Rate g AI per ha	Control efficacy ^{bcd}	Marketable heads per four plots ^a		Weight (kg) of heads in grading class		
			Number	Wt (kg)	A	B	C
Hoe 522	30	80.5b	116a	59.1a	45.9	10.2	3.0
Hoe 522	60	85.6bc	119a	61.5a	54.8	6.7	0.0
Hoe 522	105	87.5c	124a	68.2a	58.8	7.5	1.9
Methamidophos	600	38.6a	71b	27.8b	7.4	7.5	12.9
Control	—	81.6	0c	0.0c	0.0	0.0	0.0

^a Means in each vertical column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test. Plot size: 5 sq m. ^b According to Abbott (1925).

^c Average of four replicates and 10 observations. ^d In control plots the data represents actual number of larvae per 10 plants.

At all rates Hoe 522 gave better efficacy than methamidophos. The initial efficacy was low, but one week after application efficacy was considerably better than methamidophos. The maximum control level was reached two weeks after the beginning of application. Differences in efficacy between Hoe 522 application rates were relatively small. There was significant increase in number and weight of the marketable heads in Hoe 522-treated plots compared with methamidophos-treated plots. Cabbage quality, as indicated by the distribution pattern within the three classes, was considerably improved by Hoe 522 treatment. There were no statistically significant differences in yield within the range 30 to 105 g AI/ha of Hoe 522.

Table 2 presents the average efficacy of a second trial with the same rates of Hoe 522 in comparison to profenofos. The highest rate of Hoe 522 gave the best result. Total weight of marketable heads was up to three times higher than in untreated plots and more than twice that of profenofos-treated plots. An overall quality increase was obtained by the treatments. No cabbage heads were graded in class C in Hoe 522 plots whereas in untreated plots all marketable heads were in class C.

Table 2. Efficacy of Hoe 522 against DBM and yield response in head cabbage (trial 2, season I & II)

Insecticides	Rate g AI per ha	Control efficacy ^{abc}	Marketable yield, kg per four plots ^a	Weight (kg) of heads in grading class		
				A	B	C
Hoe 522	30	84.5b	115.8ab	93.1	22.7	0.0
Hoe 522	60	87.8b	101.4b	85.4	16.0	0.0
Hoe 522	105	91.7c	127.0a	107.6	19.4	0.0
Profenofos	500	65.0a	61.7c	27.2	26.3	8.2
Control	—	98.3	41.1	0.0	0.0	41.1

^a Means in each vertical column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test. ^b Average of four replicates and 13 observations. ^c In control plots the data represents actual number of larvae per 10 plants. Plot size 5 sq m.

Trial season III/1984—Leafy cabbage

Trials were conducted during the wet season when DBM population pressure was moderate. Up to three applications were made at weekly intervals. Based on previous results, dosages of Hoe 522 were reduced to 15, 30 and 45 g AI/ha to observe the marginal effective rate.

Efficacy of Hoe-522 was in the range of 70-80%. No rate dependant effect could be observed. The combined application with 1000 g product/ha of *Bacillus thuringiensis* Berliner did not improve the efficacy. Yield increases of up to 20% were found in all treatments including the reference cartap.

A second trial involving leafy cabbage was performed to observe whether an acceptable control level could be maintained with longer spray intervals. Two applications of Hoe 522 were made at 10-day intervals. After the second application, over 80% efficacy was achieved with 30 and 45 g AI/ha. Neither the 15 g treatment nor the reference product increased yield whereas dosages of 30 and 45 g Hoe 522 resulted in increased marketable yield.

In another test, with 15 and 30 g AI/ha Hoe 522 the control of DBM larvae was better than with 250 g/ha diflubenzuron (Figure 1). Control efficacy increased with time after the treatment with Hoe 522.

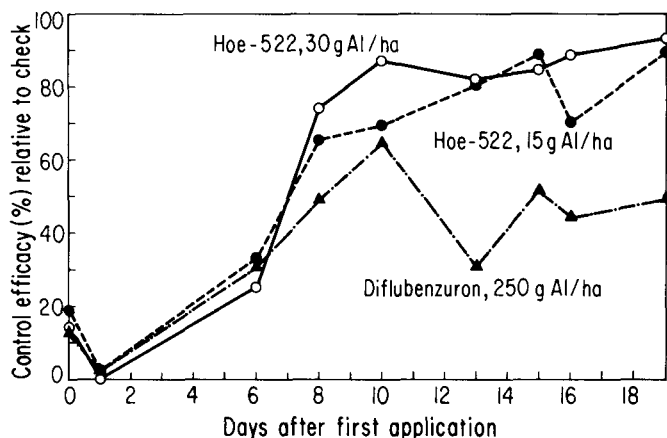


Figure 1.
Efficacy of Hoe 522 against
DBM on leafy cabbage

Trial Season IV/1984—Cabbage

Figure 2 presents results from larval counts after Hoe 522 application at seven-day intervals. Eight sprays were applied to head cabbage. During this dry period the population pressure of DBM increased remarkably. In untreated plots more than 400 larvae/10 plants were counted. Even under these conditions the application of Hoe-522 gave a high level of DBM control with efficacy of more than 90%. This level was reached at two weeks after the first application. Differences in efficacy between 15 and 45 g AI/ha were small. Only the 45 g rate showed significantly different efficacy from the low rates. The yield response data are given in Table 3. An increase of marketable head weight was observed with increasing dosage rates. Minor fluctuations were noticed at 30 g AI/ha dosage rate. In the 37.5 and 45 g AI/ha plots the head quality was best.

The application interval for Hoe 522 was further extended to 10 days. Figure 3 shows the results of the 15 and 45 g treatments in comparison to cartap 500 g AI/ha which was applied at seven-day intervals. The 90% efficacy level was achieved three weeks after the first application of Hoe 522. The differences between the rates were more pronounced here than at a seven-day interval spray schedule. The activity of the reference compound decreased during the trial period. The dose response curve for Hoe 522 between 15 to 45 g AI/ha was relatively flat; similar observation were made by Becher et al (1983). The highest yields were recorded in the 37.5 and 45 g plots (Figure 4).

In a 14-day interval spray schedule, and at an extremely high infestation level, the performance was reduced and differences between the rates became more pronounced.

The 45 g treatment gave a significantly better control than the lowest dosage of 15 g. The yield data (Table 4) show that even under these conditions all Hoe 522 rates increased total weight of marketable heads from four to eight times in comparison with untreated plots. A relatively high number of class C cabbage heads were harvested. In all trials crop tolerance to Hoe 522 was excellent.

Preliminary results from residue trials in head cabbage showed that after seven weekly-sprays of 60 g AI/ha Hoe 522, and with the last treatment 10 days before harvest, no residues could be detected in the marketable heads at harvest. Further data will be available later.

Table 3. Yield response of head cabbage to Hoe 522 treatment for DBM control (trial season IV)

Hoe 522 rate, g AI/ha	Marketable yield kg per 4 plots ^{ab}	Head weight kg per head	Distribution (%) of heads in grading class		
			A	B	C
15.0	126ab	0.86	65	33	2
22.5	131ab	0.87	67	28	5
30.0	122b	0.90	69	29	2
37.5	136ab	0.93	88	12	0
45.0	144a	0.97	76	24	0
Control	9c	0.38	0	0	100

^a Means in vertical column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test. ^b Plot size: 5 sq m.

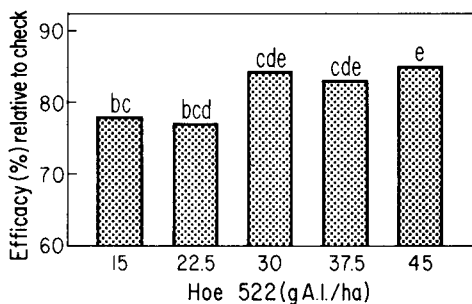


Figure 2. Efficacy of Hoe 522 against DBM on cabbage. Mean separation by Duncan's multiple range test, $p = 0.05$

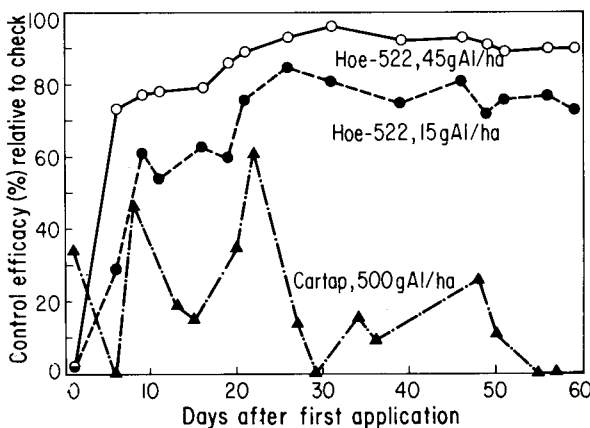


Figure 3. Comparison of efficacy of Hoe 522 and cartap against DBM

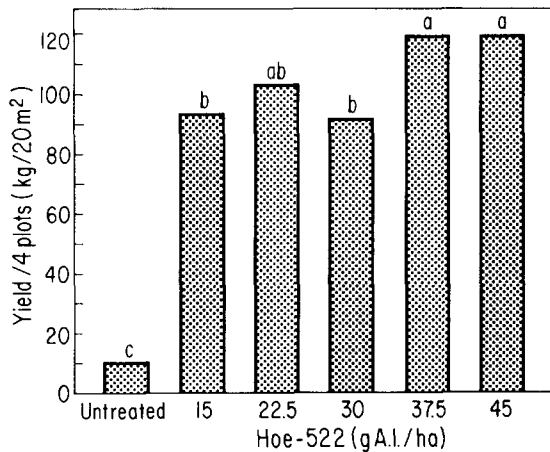


Figure 4. Influence of application of Hoe 522 for DBM control on the yield of cabbage. Mean separation by Duncan's multiple range test, $p=0.05$

Table 4. Influence of Hoe 522 treatment on the yield and quality of cabbage

Hoe 522 rate g AI/ha	Marketable yield per four plots ^{ab}		Distribution (%) of heads in grading class		
	absolute kg	relative %	A	B	C
15.0	53.10b	450	4	41	55
22.5	77.85a	660	35	38	27
30.0	84.50a	716	23	48	29
37.5	85.65a	726	42	39	19
45.0	94.05a	797	37	43	20
Control	11.80c	100	0	87	13

^a Means in each vertical column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test. ^b Plot size: 5 sq m.

Discussion

Hoe 522 has shown very high efficacy for control of insecticide-resistant DBM populations at rates ranging from 15 to 105 g AI/ha. Even the lowest rate of 15 g AI/ha had some effect on DBM and might be sufficient to control the pest under conditions of low infestation. The highest rate of 105 g AI/ha had the best biological effect. There were no significant differences in yield in the range of 30 to 105 g AI/ha.

Population density and spray interval each had a more pronounced influence on the performance of Hoe 522. Under high population pressure, even at a seven-day spray schedule, efficacy differences between rates were more prominent.

The same tendency was observed when the spray interval was extended to 14 days. Under these conditions the low rates gave insufficient control. At a 14-day spray interval, yield increase and quality of cabbage was lower than with a seven- or ten-day interval despite the well known long residual effect of IGR compounds (Becher et al 1983, Hammann and Sirrenberg 1980). Apart from high population pressure, therefore, some other factors might be involved.

It is well known that benzoyl urea compounds mainly act as larvicides after oral uptake of the chemicals (Mulder and Gijswijt 1983). Consequently a spray deposit on the plant is necessary to obtain sufficient uptake of active material. Especially during periods of rapid growth, a dilution may occur if the spray interval is too long.

Furthermore new plant growth may be unprotected for a longer time. Short interval treatments may thus minimize the risk to unprotected plant parts.

In common with other IGR compounds, Hoe 522 exhibits delayed initial activity. Our findings showed that, dependent on spray interval, peak activity was reached two or three weeks after the first application. Magallona and Velasco (1980) stated that shortly after transplanting some damage may be tolerated without negative influence on yield. Limon (1982) reported that the most susceptible growth stage of cabbage occurs two to four weeks after transplanting. Therefore, rapid initial activity is not critical at this stage. Moreover it is general practice to start treatment soon after transplanting so that high activity of Hoe 522 will coincide with the fast growing stage of the host plant and result in required control.

Conclusions

In achieving optimum DBM control, rates of 15-105 g AI/ha Hoe 522 were superior to reference products. A flat dose response curve was observed for these Hoe522 rates. Even under severe population pressure Hoe522 at 30-45 g AI/ha effectively controlled DBM and achieved considerable increase in yield. An application interval of seven to ten days gave better control than a spray schedule of 14 days. Crops showed excellent tolerance to Hoe 522. No residues could be detected in marketable heads. Hoe 522 has proven its outstanding efficacy for the control insecticide-resistant DBM populations and is a valuable alternative for cabbage crop protection.

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