Philipp. Ent. 2(4): 297-305

FIELD EVALUATION OF DIPEL IN COMPARISON WITH OTHER COMMERCIAL BACILLUS THURINGIENSIS AND CHEMICAL INSECTICIDES AGAINST PLUTELLA XYLOSTELLA (L.) AND OTHER INSECT PESTS OF CABBAGE[1]

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Cabbage production in the Philippines is highly dependent on chemical insecticides for pest control. The frequent and regular use of chemical insecticides however has brought about a number of problems namely: development of insect resistance, toxic residues and the destructive effects on non-target but beneficial organisms. This situation has necessitated the search for other non-chemical materials for pest control with the hope of an effective and safe method of insect pest control.

This work was conducted to evaluate the effectiveness of Dipel and in comparison with other preparations of *Bacillus thuringiensis* and other chemical insecticides against the diamond-back moth and other insect pests of cabbage.

The experiment was conducted at the Central Experiment Station, U.P. College of Agriculture during the dry season, 1972.

MATERIALS AND METHODS

The study was conducted on a 800-square-meter experimental lot using a randomized complete block design replicated four times. Plots were prepared the usual way by plowing and harrowing followed by making deep furrows with raised ridges 75 centimeters apart and 40 meters long. Five-week old cabbage seedlings were transplanted to the furrow ridges 30 cms apart on January 24, 1972. Excluding the boarder, there were 5 rows per replicate with 44 plants per treatment. A space of 1.5 meters between each replicate was left unplanted. Twelve treatments were used. Hybrid cabbage (kk), the heat tolerant variety imported from Japan was used in the study.

The bacterial insecticides, (Dipel, Biotrol and Thuricide) and chemicals and the various treatments used in this experiment are shown in Table 1.

Spraying was done weekly from transplanting until the 10th week except for treatment 6 which was sprayed every other week.

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[1] Contribution No. 63; This project was funded by Abbot-Dipel Research Grant. Received for publication October 1972.

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TABLE 1. **Treatments used in the field of evaluation of Dipel, Biotrol, and Abate + Malathion combination in comparison with standard insecticides used in the control of the diamond-back moth,** Plutella xylostella **Linnaeus and other insect pests affecting cabbage. UPCA, Dry season, 1972.**

Treatment Number	Chemical Used	Total kilogram a. i. /hectare	Application* Frequency of
1	Dipel	0.1	Weekly
2	Dipel	0.3	"
3	Dipel	0.5	"
4	Dipel	0.5 + .5 sticker Shell Tenac	"
5	Dipel	1.0	"
6	Dipel	2.0	Every other week
7	Bayrusil 25EC	0.5	Weekly
8	Abate 500E + Malathion 57EC	(.75 + .75) = 1.5	"
9	Phosdrin 3E	0.5	"
10	Biotrol 25WP	3.0	"
11	Thuricide 90 TS	0.5	"
12	Control	0	—

* All treatments were applied a day after transplanting until 2 weeks before harvest.

Observation and data collection relating to the insect pest present, their relative abundance in each treatment and the damage they caused to the plant were rated. This was made on February 14, March 6, April 3 and April 19, 1972. The relative abundance of the different lepidopterous pests was determined by making counts of larvae and pupae from 20 randomly selected plants per treatment. A new randomization was used each time an infestation count was made. In determining the degree of aphid infestation, the number of infected leaves per plant was used as a criterion.

The effects of the treatment against the different lepidopterous pests were assessed by indexing the degree as follows: 0 — sound = no damage; 1 — slight = 1-3 leaves with holes; 2 — moderate = 4-6 leaves with holes; 3 — heavy = most leaves with holes and 4 — severe = all leaves with holes and skeletonized.

The effectiveness of the different treatments in terms of yield was determined using the total weights (in kilograms) of marketable heads of 20 plant selected randomly in each treatment.

Statistical analysis was done by the Los Baños Computing Center through the use of an IBM 1620 electronic computer. The larval and pupal counts of *P. xylostella* and *Crocidolomia binotalis* and the counts on the number of aphids infested cabbage leaves were subjected to the square root transformation of the type XII. The analysis of variance using the Duncan's Multiple Range Test (DMRT) followed this transformation.

RESULTS AND DISCUSSION

Insect Pests Observed:

The most important insect pests observed during the study were the diamond-back moth, *P. xylostella* (Linnaeus); the cabbage worm, *C. binotalis* Zeller; the cutworm, *Spodoptera litura* (Fabricius); the corn earworm, *Helicoverpa armigera* Hubner; and the cabbage aphid *Myzus persicae* Linnaeus.

The corn semi-looper *Chrysodeixes chalcites* (Esper) was also encountered but they were few to be considered important.

The diamond-back moth started infesting the plants at the seedling stage and also in the field a few days after transplanting. This species appeared persistently as the most important pest until harvest time. The adults laid singly or in groups yellowish oval eggs on the leaves. The larvae fed by chewing off small holes until the whole leaf became almost consumed except the midrib and larger veins. They fed on the undersurface of the leaves where pupation also took place with the pupae inside silken cocoons. Adults were observed to be numerous 6 weeks after planting and until harvest.

The presence of the cabbage worm, *C. binotalis* was noted on the sixth week after transplanting. The eggs were laid in groups on the leaves and the young larvae fed on the surface while the later instars bored through the newly formed head and remained inside. Pupation took place inside the tunnel made by the larvae.

Aphid infestation was considerably minor. The aphids did not affect the normal growth of the plants. Their infestation was mainly confined on the first 1 – 4 leaves from the base of the plant.

The other insects mentioned earlier were very low in number. They were observed to feed on few leaves. The common cutworm were observed to be abundant from transplanting until the sixth week. The eggs were laid in clusters on the leaves and the newly hatched larvae fed on the spot where they hatched and gradually spread to other plants but this insect was few in number in the later larval stages.

Effects of Treatments on the Number of P. xylostella Larvae:

Table 2 and 3 show the effectiveness of the treatment against the larvae and pupae of *P. xylostella*, respectively. In the first counting made 3 weeks after transplanting, there was significant difference between the treated plots and the control. There were significantly more diamond-back moth larvae in the control than all the treated plots. All treatments used were effective in reducing the number of larvae feeding on the plants. Larval counts for the sixth week showed no significant difference between the control and treatments 1, 2, 3, 4, 5, 6, 8 and 11. Treatments 7 (Bayrusil 5kg/ha.) contained significantly the least number of *P. xylostella* larvae over all treatments followed by treatments 9, (Phosdrin 5kg/ha.) and treatment 10 (Biotrol 3kg/ha.). The third counting made on the 9th

TABLE 2. **Mean number of P. xylostella larva per plant based on 20 plant samples. UPCA Experiment. Dry season, 1972.**

Treatment Number	Counting Dates and Number of Weeks After Transplanting							
	February 14, 1972		March 6, 1972		April 3, 1972		April 19, 1972	
	3 weeks		6 weeks		9 weeks		12 weeks	
	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*
1	2.18	1.74 a	4.09	2.25 c	2.80	1.94 ab	1.49	1.57 abc
2	1.30	1.50 a	6.74	2.77 c	2.28	1.75 ab	1.05	1.42 abc
3	1.23	1.48 a	6.18	2.62 c	2.71	1.89 a	1.40	1.55 abc
4	1.56	1.58 a	6.31	2.66 c	1.82	1.61 a	1.74	1.64 bc
5	1.35	1.47 a	4.26	2.29 c	1.16	1.44 a	1.40	1.55 abc
6	1.58	1.57 a	5.85	2.53 c	7.31	2,82 bc	1.21	1.49 abc
7	.25	1.10 a	.41	1.18 a	.06	1.03 a	.06	1.03 a
8	1.44	1.53 a	8.65	3.08 c	3.19	2.01 ab	2.06	1.72 bc
9	2.02	1.73 a	2.06	1.75 ab	2.41	1.83 a	2.46	1.84 c
10	.52	1.21 a	3.86	2.18 bc	.99	1.39 a	.46	1.20 ab
11	1.68	1.63 a	5.22	2.49 c	2.84	1.91 ab	1.05	1.42 abc
12	5.03	2.43 b	9.20	3.19 c	11.04	3.34 c	1.31	1.49 abc

TABLE 3. **Mean number of** P. xylostella **pupa per plant based on 20 plant samples. UPCA Experiment. Dry season, 1972.**

Treatment Number	Counting Dates and Number of Weeks After Transplanting							
	February 14, 1972		March 6, 1972		April 3, 1972		April 19, 1972	
	3 weeks		6 weeks		9 weeks		12 weeks	
	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*
1	.17	1.08 a	1.09	1.38 a	.44	1.19 ab	.26	1.12 a
2	.32	1.13 a	.65	1.28 a	.31	1.14 ab	.32	1.06 a
3	.05	1.02 a	.48	1.21 a	.68	1.29 ab	.22	1.11 a
4	.02	1.01 a	.39	1.17 a	.11	1.14 ab	.52	1.22 a
5	.04	1.02 a	.20	1.09 a	.19	1.08 ab	.21	1.10 a
6	.12	1.05 a	.54	1.22 a	.70	1.28 ab	.25	1.11 a
7	.02	1.01 a	.11	1.05 a	.06	1.03 a	0	1.00 a
8	.14	1.06 a	1.51	1.55 a	1.54	1.56	.40	1.18 a
9	.18	1.09 a	.19	1.09 a	1.14	1.45 ab	.72	1.30 a
10	0	1.00 a	.82	1.33 a	.76	1.29 ab	.15	1.07 a
11	.10	1.05 a	.52	1.22 a	.65	1.27 ab	.22	1.11 a
12	.28	1.12 a	.85	1.34 a	1.42	1.53 ab	.18	1.08 a

TABLE 4. **Mean number of** C. binotalis **larva per plant based on 20 plant samples. UPCA Experiment. Dry season, 1972.**

Treatment Number	Counting Dates and Number of Weeks After Transplanting							
	February 14, 1972		March 6, 1972		April 3, 1972		April 19, 1972	
	3 weeks		6 weeks		9 weeks		12 weeks	
	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*
1			.0	1.00 a	.01	1.01 a	.02	1.01 a
2			.10	1.05 a	.02	1.01 a	.14	1.06 a
3			.04	1.02 a	0	1.00 a	.08	1.04 a
4			0	1.00 a	0	1.00 a	.05	1.02 a
5			.04	1.02 a	.04	1.02 a	.06	1.03 a
6			.02	1.01 a	.05	1.02 a	.12	1.03 a
7			0	1.00 a	0	1.00 a	0	1.00 a
8			0	1.00 a	0	1.00 a	.02	1.01 a
9			0	1.00 a	.02	1.01 a	.04	1.02 a
10			0	1.00 a	0	1.00 a	.04	1.02 a
11			.12	1.06 a	0	1.00 a	.06	1.03 a
12			.01	.01	0	1.00 a	.05	1.02 a

week showed that all treatments were significantly better than the control although treatment 6 (Dipel 2kg/ha.) applied every other week showed the highest number of larvae among the treated. This may indicate that Dipel although applied in high concentration could lose its effectiveness against the *P. xylostella* larvae two weeks after it is applied in the field either because of the build-up of the pest during this time or the effect of other physical factors acting directly on Dipel. The last counting made 12 weeks after transplanting showed no significant difference between the control and treatments 1, 2, 3, 5, 6, 11 and 12. Treatments 7 and 10 showed the least number of larvae while treatments 9, 8 and 4 has the most number of larvae. Spraying was done only until the 10th week to have at least 14 days allowance before harvest. This two-week allowance is a requirement for Bayrusil to be safe from some toxic residue. *B. thuringiensis* preparations are safe to apply even up to harvest time. The pupal counts as shown in Table 4 do not show a clear picture as in the case of the larval counts. Only the third counting made after 9 weeks showed consistently that treatment 7 was effective in reducing the number of pupae per plant in all instances. All other treatments and the control in the three other countings showed no significant difference in the number of pupae.

There was no significant difference between the effects of all treatments on the larvae of *C. binotalis* and the control (see Table 4). This may be due to a very low number of larval count. But the effect of this pest was quite alarming since the damaged heads were not marketable.

The mean number of leaves per plant infested with the aphid, *Myzus persicae* is shown in Table 5. Aphids were only observed 2 weeks after

TABLE 5. **Mean number of leaf infested by aphid** (Myzus persicae **Sulzer) based on 20 plant samples, UPCA Experiment. Dry season, 1972.**

Treatment Number	Counting Dates and Number of Weeks After Transplanting					
	February 14, 1972		March 5, 1972		April 3, 1972	
	3 Weeks		6 Weeks		9 Weeks	
	First Counting		Second Counting		Third Counting	
	Actual	Trans-formed	Actual	Trans-formed	Actual	Trans-formed
1	.46	1.19 a	.36	1.15 a	0	1.00 a
2	.28	1.12 a	.25	1.11 a	0	1.00 a
3	.15	1.07 a	.44	1.18 a	.01	1.01 a
4	.38	1.17 a	.11	1.05 a	0	1.00 a
5	.23	1.11 a	.05	1.02 a	0	1.00 a
6	.32	1.14 a	.22	1.10 a	0	1.00 a
7	0	1.00 a	0	1.00 a	0	1.00 a
8	.08	1.04 a	0	1.00 a	.19	1.09 a
9	.03	1.02 a	.02	1.01 a	0	1.00 a
10	.10	1.05 a	.30	1.14 a	0	1.00 a
11	0.32	1.14 a	.06	1.03 a	.01	1.01 a
12	0.02	1.01 a	.56	1.24 a	.44	1.18 a

TABLE 6. **Mean indices of damage by lepidopterous pests on cabbage plant based on 20 plant samples. UPCA Experiment. Dry season, 1972.**

Treatment Number	Counting Dates and Number of Weeks After Transplanting							
	February 14, 1972		March 6, 1972		April 3, 1972		April 19, 1972	
	3 weeks		6 weeks		9 weeks		12 weeks	
	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*	Actual	Transformed*
1	1.95	1.72 c	2.02	1.74 b	2.00	1.73 b	2.00	1.76 b
2	1.32	1.52 bc	2.04	1.74 b	2.02	1.74 b	2.10	1.75 b
3	2.00	1.73 c	1.99	1.73 b	2.09	1.76 b	2.00	1.73 b
4	1.35	1.52 bc	1.75	1.65 b	1.91	1.71 b	2.25	1.79 b
5	1.23	1.49 bc	1.72	1.65 b	1.92	1.71 b	2.00	1.73 b
6	2.17	1.75 c	2.62	1.90 bc	2.18	1.78 b	2.70	1.91 b
7	.45	1.20 a	.60	1.25 a	.71	1.30 a	.40	1.17 a
8	1.93	1.73 c	1.75	1.65 b	2.01	1.74 b	2.14	1.78 b
9	2.25	1.79 c	1.64	1.62 b	2.00	1.73 b	2.35	1.83 b
10	.90	1.37 ab	1.64	1.62 b	1.72	1.65 b	1.92	1.71 b
11	1.80	1.67 c	1.98	1.72 b	2.01	1.74 b	2.39	1.84 b
12	3.18	2.04 d	3.39	2.09 c	3.66	2.16 c	3.59	2.14 c

transplanting until the 9th week. There was no significant difference between all treated plots and the control.

Effects of Treatments on the Degrees of Damage by All Lepidopterous Pests:

The damage to the leaves caused by lepidopterous pests is shown in Table 6. In the first counting made 3 weeks after transplanting there was a significant difference between the treated plots and the control. The indices of damage were significantly less in treatment 7 and 10 followed by treatments 5, 2 and 4. Treatment 7 showed consistently the least damage over all treatments in all countings. All treated plots showed significantly lower indices of damage than the control in all countings.

Effects of Treatments on Yield:

The yield data in kilograms of marketable heads is shown in Table 7, All treatments have significantly increased yield than the untreated. However, there was no significant difference between the treatments.

TABLE 7. **Weight in kilograms of marketable cabbage heads (KK-hybrid) based on 20 plant samples. UPCA Experiment. Dry season, 1972.**

Treatment Number	Weight in kilograms of diff. replicates				Total	Mean*
	I	II	III	IV		
1	25.65	24.02	17.02	20.04	86.73	21.68 a
2	27.88	17.34	19.83	20.04	85.09	21.27 a
3	24.96	33.41	22.50	23.04	103.91	25.98 a
4	27.49	20.19	19.84	18.68	86.20	21.55 a
5	27.00	26.39	25.40	23.52	102.31	25.58 a
6	22.27	19.88	12.22	18.24	72.61	18.15 a
7	33.85	23.98	22.14	16.61	96.58	24.14 a
8	24.20	23.06	25.89	19.04	92.19	23.05 a
9	27.38	20.82	20.00	20.52	88.72	22.18 a
10	28.61	22.02	22.55	19.92	93.10	23.28 a
11	29.18	15.98	19.29	21.85	85.30	21.58 a
12	18.00	4.98	5.29	10.92	39.19	9.80 b

* Means not followed by the same letter differ significantly at the 5% level (Duncan's Multiple Range Test). This is also true to Tables 2 to 6.

The three best treatments in terms of controlling the diamond-back moth and giving the highest yields of marketable heads of cabbage were treatments 3 (Dipel at 0.5kg/ha., applied weekly at transplanting until harvest), 5 (Dipel at 1.0kg/ha., applied weekly at transplanting until harvest), and 7 (Bayrusil 5kg/ha., applied weekly for transplanting until 2 weeks before harvest).

Dipel in all dosages used was non-phytotoxic to cabbage, safe from toxic residues to farmers and consumers and did not affect beneficial organisms such as parasites and predators of cabbage pests.