

RESEARCH ARTICLE

BIOPESTICIDES MITIGATE THE LARVAL POPULATION OF LEPIDOPTERAN INSECTS ON CABBAGE (*Brassica oleracea* var. *capitata* L.)

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ABSTRACT

The infestation of insect pests has a significant impact on cabbage yield. Lepidopteran insects are one of the most important insect pests in the reduction of cabbage output. The present study aimed to evaluate some biopesticides used against major cabbage insect pests. The experiment was set up in a Randomized Complete Block Design (RCBD) with three replications. There were seven treatments used: T₁ (Abamectin 1.2EC @ 1 ml/L of water); T₂ (Azadirachtin 1EC @ 1 ml/L of water); T₃ (Potassium salt of fatty acid @ 1 ml/L of water); T₄ (Spinosad 45SC @ 1 ml/L of water); T₅ (*Bacillus thuringiensis* @ 1 ml/L of water); T₆ (Abamectin + *Bacillus thuringiensis* @ 1 ml/L of water) and T₇ (untreated control). All of the treatments were given seven days apart. T₄ that reduced the highest incidence over control of cabbage caterpillar and diamondback moth larvae (50.33 % and 51.90 %, respectively) had the lowest mean incidence of cabbage caterpillar (6.82 larvae/5 plants) and diamondback moth larvae (4.87 larvae/5 plants), whereas the untreated control treatment (T₇) had the highest values of all these parameters. T₄ had the lowest cabbage head infestation (21.37 %) and the maximum cabbage yield (36.40 t/ha), followed by T₁ (34.07 t/ha). According to the results of the study, treatment T₄ (Spinosad 45SC @ 1 ml/L of water at 7-day intervals) had the best performance of all the treatments tested.

KEYWORDS

Biopesticides, *Bacillus thuringiensis*, Azadirachtin, Cabbage, Diamondback moth.

1. INTRODUCTION

Bangladesh's vegetable production is insignificant in comparison to the country's actual needs. Total vegetable production area (summer and winter seasons) was 434 thousand hectares in 2018-2019, with total production of 4.32 million tons (BBS, 2019). Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the five most popular Cruciferae vegetables in Bangladesh. In the 2018-2019 crop year, 2320 thousand metric tons of cabbage were produced on 19008 hectares of land, placing it sixth among the vegetables grown in the country (BBS, 2019). Vegetable intake in our country is 33 kg/head/year, although it is 7-8 times higher in wealthy countries (FAO, 2015).

There are several variables that limit cabbage output, and insect pests play a significant influence in the reduction of cabbage production. A variety of insect pests wreak havoc on the cabbage crop. Lepidopteran insects such as the cabbage semi-looper (*Trichoplusia ni* Hub.), diamondback moth (*Plutella xylostella* L.), and cabbage caterpillar/prodenia caterpillar (*Spodoptera litura* Fab) are the most damaging insect pests of cabbage (Iqbal et al., 2015). Cabbage looper (*Trichoplusia ni* Hub.) is one of the most devastating pests, with its voracious appetite for cabbage leaves. They lay their eggs on the underside of leaves, towards the leaf edge. Semi-looper caterpillars are voracious eaters who cause havoc by digging holes in cabbage tops (Natwick et al., 2017).

Spodoptera litura Fab., the cabbage caterpillar, is a polyphagous pest that wreaks havoc on plants (Srivastava et al., 2018). According to the cabbage caterpillar (*Spodoptera litura* Fab.) is one of the most serious insect pests of crops in the Asian tropics, and the pest has been discovered in cabbage-growing areas (Reddy et al., 2017). Cabbage caterpillars inflict 3.99 percent to 13.44 percent damage to leaves and 23.33 percent to 58.33

percent damage to plants in Bangladesh (Ahmed, 2008). The diamondback moth (*Plutella xylostella* L.) is a severe cabbage pest that causes large losses owing to larval feeding (Parajuli and Paudel, 2019). Infestations of the diamondback moth (*Plutella xylostella* L.) caused yield losses of up to 12.00- and 20.7-tons ha⁻¹ in the first season, and up to 27.00- and 48.7-tons ha⁻¹ in the second season (Bhatia, 1994).

However, there are several economic and ecological hurdles in pest management, the bulk of which are caused by synthetic chemical pesticides, due to human and environmental dangers (Joshi et al., 2020). As a result, biorational techniques based on botanical preparations and natural products are gaining appeal as environmentally friendly insect pest management options (Joshi et al., 2020). Therefore, the present experiment was carried out to evaluate the effectiveness of some biopesticides in managing major lepidopteran insect pests of cabbage.

2. MATERIALS AND METHODS

2.1 Experimental Site

The soil in the experimental plot was a shallow red-brown terrace soil with a slight acidity (pH 5.8-6.5). Magic-65 was used as the planting material for summer cabbage in this experiment. Seeds were purchased from Lal Teer Seed Limited, Tejgaon, Dhaka, and sown on the seedbed on October 1, 2019. Before seed sowing, the seedbed was meticulously prepped and made optimal for seedling formation. On November 5th, 2019, healthy and uniform 35-day-old seedlings were transplanted into the experimental plots.

2.2 Treatments and Experimental Design

Seven treatments, viz. T₁ (Abamectin 1.2EC @ 1 ml/L of water); T₂

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(Azadirachtin 1EC @ 1 ml/L of water); T₃ (Potassium salt of fatty acid @ 1 ml/L of water); T₄ (Spinosad 45SC @ 1 ml/L of water); T₅ (*Bacillus thuringiensis* @ 1 ml/L of water); T₆ (Abamectin + *Bacillus thuringiensis* @ 1 ml/L of water) and T₇ (untreated control) were used. All the treatments were applied at seven days interval. We used a Randomized Complete Block Design (RCBD) with three replications to set up the experiment. A single plot of the experiment was 6 m² (3 m × 2 m) in size.

2.3 Cultural Practices

Manures and fertilizers were applied according to the fertilizer doses recommended for cabbage production per hectare (BARC, 2012). All manure fertilizers were applied at the time of final land preparation, with the exception of urea and MoP. Urea and MoP were applied in two equal installments using the ring technique at 15 and 35 days after transplanting (DAT) under moist soil conditions, and the fertilizers were fully mixed with the soil as soon as feasible for better use. Gap filling, weeding, earthing up, watering, and other intercultural operations were performed

3. RESULTS AND DISCUSSION

3.1 Incidence of Cabbage Caterpillar

Treatments	Number of cabbage caterpillar per five plants					Mean	% Reduction over control
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT		
T ₁	8.67 d	8.33 d	7.90 e	7.57 e	7.00 d	7.89 e	42.52
T ₂	9.67 c	9.17 c	8.93 c	8.53 c	8.00 c	8.86 c	35.48
T ₃	10.33 b	9.77 b	9.53 b	9.40 b	9.17 b	9.64 b	29.80
T ₄	7.83 e	7.33 e	6.83 f	6.33 f	5.77 e	6.82 f	50.33
T ₅	9.50 c	8.97 c	8.50 d	8.07 d	7.60 cd	8.53 d	37.90
T ₆	9.33 c	8.87 c	8.33 d	7.83 de	7.33 d	8.34 d	39.27
T ₇	12.67 a	13.33 a	13.66 a	14.33 a	14.67 a	13.73 a	
LSD (0.05)	0.49	0.48	0.37	0.37	0.66	0.33	
CV%	2.86	2.88	2.28	2.38	4.35	2.05	

[DAT= Days after transplanting, in a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability, T₁: Abamectin 1.2 EC; T₂: Azadirachtin 1 EC; T₃: Potassium salt of fatty acid; T₄: Spinosad 45 SC; T₅: *Bacillus thuringiensis*; T₆: Abamectin 1.2 EC + *Bacillus thuringiensis*; T₇: Untreated control]

In terms of the number of cabbage caterpillar larvae at different days after transplanting (DAT), significant differences (p>0.05) were identified across different treatments employed for management procedures. In case of mean number of cabbage caterpillar larvae, the highest number of cabbage caterpillar larvae was recorded in T₇ (13.73 larvae /5 plants) which was significantly different from all other treatments followed by T₃ (9.64 larvae /5 plants) and T₂ (8.86 larvae /5 plants), T₅ (8.53 larvae /5

3.2 Incidence of Diamondback Moth Larvae

Treatments	Number of diamondback moth larvae per five plants					Mean	% Reduction over control
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT		
T ₁	6.33 d	6.00 cd	5.63 de	5.30 d	4.90 d	5.63 d	44.42
T ₂	7.67 b	7.23 b	6.83 c	6.50 c	6.17 c	6.88 c	32.10
T ₃	8.67 a	8.63 a	8.43 b	8.03 b	7.67 b	8.29 b	18.22
T ₄	5.43 e	5.27 d	5.0 e	4.50 e	4.13 e	4.87 e	51.92
T ₅	7.00 c	6.60 bc	6.10 cd	5.60 d	5.27 d	6.11 d	39.67
T ₆	6.77 cd	6.37 c	6.03 cd	5.53 d	5.17 d	5.97 d	41.05
T ₇	8.67 a	9.33 a	10.00 a	10.33 a	12.33 a	10.13 a	
LSD (0.05)	0.51	0.74	0.80	0.61	0.61	0.59	
CV%	4.00	5.86	6.56	5.24	5.28	4.82	

[DAT= Days after transplanting, in a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability, T₁: Abamectin 1.2 EC; T₂: Azadirachtin 1 EC; T₃: Potassium salt of fatty acid; T₄: Spinosad 45 SC; T₅: *Bacillus thuringiensis*; T₆: Abamectin 1.2 EC + *Bacillus thuringiensis*; T₇: Untreated control]

as needed to ensure and sustain normal crop development.

2.4 Data Collection

Five plants were chosen at random from each unit plot to record the necessary data on various crop attributes. Data collection began at the vegetative stage and continued until the cabbage heads were harvested. The number of infested leaves by cabbage caterpillar and diamondback moth larvae, the weight of each individual head, the height, and width of cabbage heads, and the yield (t ha⁻¹) were all recorded. At the time of harvesting, only the totally compact and marketable heads were harvested.

2.5 Statistical Analysis

Using the Statistix-10 computer package, the collected data was analyzed using ANOVA procedures. The Least Significant Difference (LSD) test was used to determine the mean separation.

plants) and T₆ (8.34 larvae /5 plants) where last two were statistically identical. On the other hand, the lowest number of cabbage caterpillar larvae was recorded in T₄ (6.82 larvae /5 plants) followed by T₁ (7.89 larvae /5 plants), (Table 1).

Considering the percent reduction of number of cabbage caterpillar larvae among different management practices over control, the highest reduction over control was achieved in T₄ (50.33%) followed by T₁ (42.52%), T₆ (39.27%) and T₅ (37.90%). On the other hand, the minimum reduction of number of cabbage caterpillar larvae over control was found in T₃ (29.80%) followed by T₂ (35.48%) (Table 1). More or less similar result was found by using Spinosad, mycojaal (*Beauveria bassiana*), malathion, lipel (*Bacillus thuringiensis* var. *kurstaki*), Azadirachtin (Debbarma et al., 2017). Spinosad was found most effective to control cabbage caterpillar registering lower extent of mean leaf damage by 24.30 percent.

In case of mean infestation, the highest number of leaf infestation was recorded in T₇ (10.13 leaves /5 plants) which was significantly different from all other treatments followed by T₃ (8.29 leaves /5 plants) and T₂ (6.88 leaves /5 plants) and they were statistically not similar. On the other hand, the lowest infestation was recorded in T₄ (4.87 leaves /5 plants) followed by T₁ (5.63 leaves /5 plants) T₆ (5.97 leaves /5 plants) and T₅ (6.11 leaves /5 plants) and they were statistically identical (Table 2).

Considering the percent reduction of leaf infestation over control, the highest 51.92% reduction over control was achieved in T₄ followed by T₁ (44.42%) and T₆ (41.05%) and T₅ (39.67%). On the other hand, the minimum reduction of leaf infestation over control was found in T₃ (18.22%) followed by T₂ (32.10%) (Table 2). This outcome was in line with the findings [Dey et al., 2017]. They found that biopesticides resulted in (70-74) percent diamondback moth larval mortality. Repellency, ant-feeding, fast knockdown, and flushing effect are all qualities of biopesticides including botanicals. The ingestion of neem extract-treated leaves did, in fact, impact the development of the diamondback moth's 4th stage larva and lowered the larval population by inducing death [Mochiah et al., 2011].

3.3 Effect of Biopesticides on Cabbage Head Infestation

In case of healthy cabbage heads, T₄ had the healthiest cabbage heads (11.67), which was statistically different from all other treatments, followed by T₁ (10.67) and T₆ (10.67). (10.33). T₇ (4.33), on the other hand, had the lowest number of healthy cabbage heads (statistically different from all other treatments), followed by T₃ (7.33). (Table 3). T₇ (7.42) had the highest number of cabbage head infestations, which was significantly different from the other treatments. T₄ (3.17) had the fewest cabbage head infestations, which was statistically equal to T₁ (3.33), while T₆ had the most (3.83).

In terms of percent cabbage head infestation, T₇ had the highest rate of 55.77 %, which was statistically distinct from all other treatments, and was followed by T₃ (41.35 %). T₄ (21.37 %), on the other hand, had the lowest cabbage head infestation by number, which was statistically similar to T₁ (23.80 %) and T₆, respectively (26.80 %).

Treatments	Healthy Head/Plot	Infested Head/Plot	Infestation (%)	Infestation Reduction Over Control (%)
T ₁	10.67 b	3.33 de	23.80 ef	57.32
T ₂	8.67 d	4.33 c	33.14 c	40.56
T ₃	7.33 e	5.17 b	41.35 b	25.84
T ₄	11.67 a	3.17 e	21.37 f	61.68
T ₅	9.67 c	4.17 c	30.09 cd	53.95
T ₆	10.33 bc	3.83 cd	26.80 de	51.94
T ₇	4.33 f	7.42 a	55.77 a	-
LSD (0.05)	0.95	0.61	5.18	
CV (%)	5.97	7.59	8.78	

[DAT= Days after transplanting, in a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability, T₁: Abamectin 1.2 EC; T₂: Azadirachtin 1 EC; T₃: Potassium salt of fatty acid; T₄: Spinosad 45 SC; T₅: *Bacillus thuringiensis*; T₆: Abamectin 1.2 EC + *Bacillus thuringiensis*; T₇: Untreated control]

3.4 Single Head Weight (kg) and Total Yield (t ha⁻¹) During Harvesting

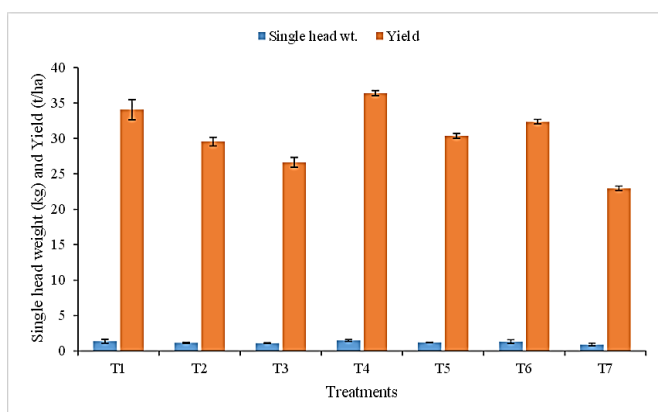


Figure 1: Individual head weight (kg) and total yield (ton/ha) of cabbage in different treatments during harvesting

[Means \pm SD are calculated from three replications where each replication is derived from 5 plants per treatment; T₁: Abamectin 1.2 EC; T₂: Azadirachtin 1 EC; T₃: Potassium salt of fatty acid; T₄: Spinosad 45 SC; T₅: *Bacillus thuringiensis*; T₆: Abamectin 1.2 EC + *Bacillus thuringiensis*; T₇: Untreated control]

In case of single head weight (kg) of cabbage, T₄ had the highest single head weight (1.50kg), which was substantially higher than all other treatments, followed by T₁ (1.39kg) and T₆ (1.34kg). T₇, on the other hand, had the smallest single head weight (0.92 kg), which was much lower than the other treatments. However, in the treated plots, T₃ had the smallest single head weight (1.12 kg), which was statistically equivalent to T₂ (1.17 kg) and T₅ (1.23 kg) (Figure 01). In terms of total yield (t/ha), T₄ produced the highest yield (36.40 t/ha), which was significantly higher than all other treatments. T₁ (34.07 t/ha) and T₆ (32.37 t/ha) followed. T₇ had the lowest yield (22.97 t/ha), which was significantly lower than the other treatments. However, in the treated plots, T₃ had the lowest yield (26.63 t/ha), followed by T₂ (29.57 t/ha), and T₅ (30.37 t/ha) (Figure 01).

3.5 Relationship Between Incidence of Cabbage Caterpillar and Yield of Cabbage

When a linear regression was run between these two parameters, it revealed a highly significant ($P \leq 0.05$), extremely strong ($R^2 = 0.8603$), and negative (slope = -1.9013) association between caterpillar incidence and cabbage yield, i.e. cabbage yield fell as the incidence of cabbage caterpillar increased. According to the findings of this study, a higher number of cabbage caterpillar larvae enhanced cabbage leaf infestation, preventing plants from producing and supplying nutrients and water. With a lower output, the plant's growth and development were inhibited.

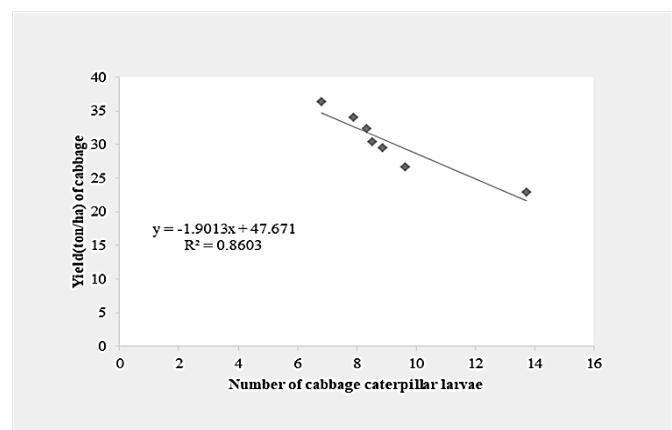


Figure 2: Relationship between incidence of cabbage caterpillar and yield of cabbage.

3.6 Relationship Between Incidence of Diamondback Moth Larvae and Yield of Cabbage

A linear regression was fitted between the incidence of diamondback moth larvae and yield of cabbage (t/ha). A highly significant ($p < 0.05$), very strong ($R^2 = 0.9499$) and negative (slope = -2.4492) correlation was found between these two parameters, i.e. yield of cabbage decreased with the increasing number diamondback moth larvae. In this study, it was revealed that the higher number of diamondback moth larvae led to the higher leaf infestation of cabbage.

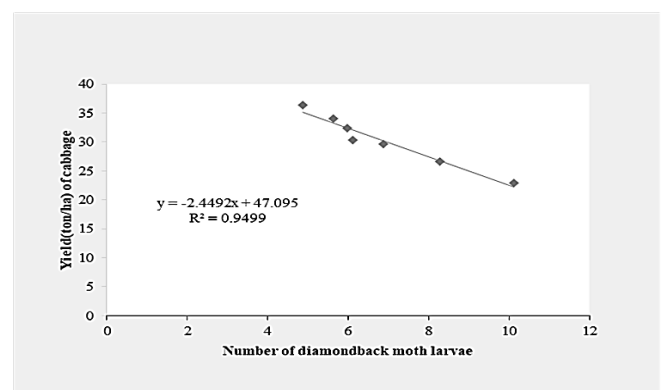


Figure 3: Relationship between incidence of diamondback moth larvae and yield of cabbage.

4. CONCLUSION

In this experiment, some bio pesticides were used against major insect pests of cabbage and it may be concluded that, Spinosad 45SC @ 1 ml/L of water at 7 days interval gave the highest performance compared to all other treatments used under the present study where the lowest performance was achieved by untreated control. On the other hand, the lowest performance among the treated plots was obtained by Potassium salt of fatty acid @ 1 ml/L of water at 7 days interval. d

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COMPETING INTERESTS

There are no competing interests stated by the authors.

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