Original Research Article

Effectiveness of Some Bio-pesticides in Managing Major Lepidopteran Insect Pests of Cabbage (*Brassica oleracea var. capitata* L.)

ABSTRACT

Aims: The study aimed to evaluate the efficacy of some bio-pesticides applied against major insect pests of cabbage.
Study design: With three replications, the experiment was set up in a Randomized Complete Block Design (RCBD).
Place and Duration of Study: The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October, 2019 to January, 2020
Methodology: Seven treatments, viz. T_1 (Abamectin 1.2EC @ 1 ml/L of water); T_2 (Azadirachtin 1EC @ 1 ml/L of water); T_3 (Potassium salt of fatty acid @ 1 ml/L of water); T_4 (Spinosad 45SC @ 1 ml/L of water); T_5 (*Bacillus thuringiensis* @ 1 ml/L of water); T_6 (Abamectin + *Bacillus thuringiensis* @ 1 ml/L of water) and T_7 (untreated control) were used. All the treatments were applied at seven days interval.
Results: Among the management practices, the lowest mean infestation of cabbage leaf by cabbage caterpillar (6.00 leaves/5 plants) and diamond back moth larvae (4.48 leaves/5 plants) was found in T_4 treated plot that reduced the highest leaf infestation over control (62.02% and 49.85 % respectively); whereas the highest infestation by cabbage caterpillar (15.80 leaves/5 plants) and diamond back moth larvae (8.93 leaves/5 plants) was found in un treated plot (T_7). The lowest cabbage head infestation (21.37%) was recorded in T_4, that gave the highest yield of cabbage (36.40 t/ha) followed by T_1 (34.07 t/ha).
Conclusion: From the above study it was found that, the treatment T_4 comprised of 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.

Keywords: Biopesticides; Bacillus thuringiensis; Azadirachtin; Cabbage caterpillar; Diamondback moth.

1. INTRODUCTION

Vegetable production in Bangladesh is very low as compared to the actual requirements. In 2018-2019, total vegetable (summer and winter season) production area was 434 thousand ha with total production of 4.32 million tons [1]. Cabbage (*Brassica oleracea var. capitata* L.) is one of the five leading vegetables in the country which belong to the Cruciferae family. In 2018-2019, 2320 thousand metric tons of cabbage was produced in 19008 ha of land, which ranked fifth among the vegetables produced in the country [1]. In our country the consumption rate of vegetables is 33 kg/head/yr. but in developed countries it is 7-8 times higher [2].

There are many limiting factors of cabbage production and insect pests play a vital role to the decreased production of cabbage. The cabbage crop is harmed by a variety of insect pests. The most harmful insect pests of cabbage are Lepidopterous insects such as the cabbage semi-looper (*Trichoplusia ni* Hub.), diamondback moth (*Plutella xylostella* L.), and cabbage caterpillar/prodenia caterpillar (*Spodoptera litura* Fab). [3]. Cabbage looper (*Trichoplusia ni* Hub.) is one of the most damaging pests, devouring cabbage leaves with its ferocious appetite. They laid their eggs at the leaf edge on the underside of leaves. Semi-looper caterpillars are ravenous eaters who wreak havoc on cabbage heads by making holes in them [4].

The cabbage caterpillar (*Spodoptera litura* Fab.) is a polyphagous pest that wreaks havoc on plants [5]. It is one of the most important insect pests of crops in the Asian tropics, according to [6], and the pest has been detected in cabbage growing areas. In some cabbage genotypes, it can lower output by more than half [7]. According to [8], cabbage caterpillars in Bangladesh cause 3.99 percent to 13.44 percent damage to leaves and 23.33 percent to 58.33 percent damage to plants, depending on the types.

The diamondback moth (*Plutella xylostella* L.) is a major pest of cabbage fields, causing significant losses due to larval feeding [9]. The adult moth's egg laying site is on the underside of the lower leaves, where they lay eggs singly or in clusters. Larvae eat all sections of the plant, but they prefer to eat around the bud of little transplants. Young larvae crawl between the bottom and upper leaf sections, while older larvae build irregular short tunnels while keeping the upper surface intact [3].

Diamondback moth (*Plutella xylostella* L.) infestations resulted in yield losses of up to 12.00- and 20.7-tons ha^{-1} in the first season, and 27.00- and 48.7-tons ha^{-1} in the second season [7]. In circumstances where pest infestation levels are high, a yield loss of up to 30% was regarded bearable as an alternative to severe insect damage. During the summer, these insect pests cause more substantial harm to cabbage [10].

However, due to human and environmental risks, there are numerous obstacles in pest management from an economic and ecological standpoint, the majority of which are created by synthetic chemical pesticides [11]. Chemical pesticides were used indiscriminately, resulting in issues such as pesticide resistance, secondary pest outbreaks, pest resurgence, bioaccumulation of chemicals in the food chain, pollution, human health risks, and destruction of non-target creatures. Safer chemicals, such as botanicals, are gaining popularity around the world as more environmentally friendly alternatives to very persistent synthetic pesticides. As a result, biorational approaches based on botanical preparations and natural products are gaining traction as potential alternatives for environmentally acceptable insect pest management [11]. Therefore, the present experiment was carried put to evaluate the effectiveness of some biopesticides in managing major lepidopteran insect pests of cabbage.

2. MATERIALS AND METHODS

The current experimental field was located in the Sher-e-Bangla Agricultural University's central farm in Sher-e-Bangla Nagar, Dhaka, Bangladesh and the experiment was conducted during October, 2019 to January, 2020. The experimental plot's soil was a shallow red-brown terrace soil that was slightly acidic (pH 5.8-6.5). In this experiment, the planting material was Magic-65. On 1st October 2019, seeds were acquired from Lal Teer Seed Limited, Tejgaon, Dhaka and sowed on the seedbed. The seedbed was carefully prepared and made ideal for seedling formation before seed sowing. Healthy and uniform seedlings of 35 days old were transplanted in the experimental plots on 5th November, 2019. Seven treatments, viz. T_1 (Abamectin 1.2EC @ 1 ml/L of water); T_2 (Azadirachtin 1EC @ 1 ml/L of water); T_3 (Potassium salt of fatty acid @ 1 ml/L of water); T_4 (Spinosad 45SC @ 1 ml/L of water); T_5 (*Bacillus thuringiensis* @ 1 ml/L of water); T_6 (Abamectin + *Bacillus thuringiensis* @ 1 ml/L of water) and T_7 (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 m^2 (3 m × 2 m) in size. The land was thoroughly prepared before seedling transplantation, with deep plowing and laddering. On 5th November, 2019, 35 days-old seedlings were transplanted in the main field at a rate of 21 seedlings $plot^{-1}$. Manures and fertilizers were applied according to the fertilizer doses recommended for cabbage production per hectare by [12].

All manures and 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 as needed to ensure and sustain normal crop development.

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. 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.

3. RESULTS AND DISCUSSION

3.1 Leaf infestation by cabbage caterpillar

In terms of leaf infestation owing to cabbage caterpillar attack at different days after transplanting (DAT), significant differences (p>0.05) were detected across different treatments employed for management techniques (Table 2). At 15 DAT, the untreated control plot (T_7) had the highest leaf infestation (14.33 leaves/5 plants), which was different from all other treatments, followed by T_3 (11.33 leaves/5 plants) and T_5 (10.33 leaves/5 plants), but they were statistically different. T_4 (6.33 leaves/5 plants) had the lowest leaf infestation, which was significantly different from all other treatments, followed by T_1 (7.67 leaves/5 plants), T_6 (8.33 leaves/5 plants), and T_2 (9.33 leaves/5 plants), all of which were statistically distinct. More or less similar results of leaf infestation by number were also recorded at 25 DAT, 35 DAT, 45 DAT, and 55 DAT (Table 1).

In terms of mean infestation, the control plot (T_7) had the largest number of leaf infestation (15.80 leaves/5 plants), which was substantially different from all other treatments, followed by T_3 (10.33 leaves/5 plants) and T_5 (10.20 leaves/5 plants), which were statistically identical. T_4 (6.00 leaves/5 plants) had the lowest infestation, which was significantly different from all other treatments, and was followed by T_1 (7.07 leaves/5 plants), T_6 (8.07 leaves/5 plants), and T_2 (9.07 leaves/5 plants), all of which were statistically not similar (Table 1).

T_4 had the highest percent reduction of leaf infestation over control (62.02%), followed by T_1 (55.27%), T6 (48.94%), and T_2 (42.61%). T_3 (30.99%) had the smallest reduction in leaf infestation compared to control, which was quite close to T_5 (35.44%). (Table 1).

More or less similar result was found by [13] by using Spinosad, mycojaal (*Beauveria bassiana*), malathion, lipel (*Bacillus thuringiensis var. kurstaki*), Azadirachtin. Spinosad was found most effective to control tobacco caterpillar registering lower extent of mean leaf damage by 24.30 percent.

Table 1. Effect of biopesticides on leaf Infestation of cabbage caused by cabbage caterpillar at different days after transplanting (DAT).

Treatments	Number of infested leaves per five plants					Mean	% reduction over control
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT		
T_1	7.67 f	7.67 e	7.33 de	6.67 ef	6.33 ef	7.07 e	55.27
T_2	9.33 d	9.67 c	9.33 bc	8.67 cd	8.33 cd	9.07 c	42.61
T_3	11.33 b	11.00 b	10.33 b	9.67 bc	9.33 bc	10.33 b	34.60
T_4	6.33 g	6.33 f	6.33 e	5.67 f	5.33 f	6.00 f	62.02
T_5	10.33 c	10.67 b	10.33 b	10.00 b	9.67 b	10.20 b	35.44
T_6	8.33 e	8.67 d	8.33 cd	7.67 de	7.33 de	8.07 d	48.94
T_7	14.33 a	15.67 a	16.00 a	16.33 a	16.67 a	15.80 a	
LSD (0.05)	0.67	0.90	1.16	1.25	1.00	0.62	
CV%	3.93	5.06	6.74	7.59	6.26	3.64	

[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, T_1: Abamectin 1.2 EC; T_2: Azadirachtin 1 EC; T_3: Potassium salt of fatty acid; T_4: Spinosad 45 SC; T_5: Bacillus thuringiensis; T_6: Abamectin 1.2 EC + Bacillus thuringiensis; T_7: Untreated control]

3.2 Leaf infestation by diamondback moth larvae

In terms of leaf infestation by Diamondback moth larvae at different days after transplanting, significant differences ($p>0.05$) were identified among different treatments (Table 2) for different management approaches (DAT). At 15 days after transplantation, the control plot (T_7) had the highest leaf infestation (8.33 leaves/5 plants), which was substantially different from all other treatments, followed by T_3 (6.33 leaves/5 plants) and T_6 (5.90 leaves/5 plants). T_4 (4.60 leaves/5 plants) had the lowest leaf infestation, which was significantly different from all other treatments, followed by T_1 (5.00 leaves/5 plants) and T_2 (5.60 leaves/5 plants), all of which were statistically distinct (Table 2).

In terms of mean infestation, T_7 (8.93 leaves/5 plants) had the highest number of leaves, which was statistically substantially different from all other treatments, followed by T_3 (6.52 leaves/5 plants), T_2 (5.59 leaves/5 plants), and T_5 (5.8 leaves/plants). T_2 and T_5 are statistically similar in this case. T_4 (4.48 leaves/5 plants) had the lowest infestation, followed by T_1 (4.89 leaves/5 plants) and T_6 (5.31 leaves/5 plants), which were statistically unrelated.

Considering the percent decrease of leaf invasion over control, the most noteworthy decrease over control was accomplished in T_4 (49.85%) trailed by T_1 (45.23%) and T6 (40.52%). Then again, the base decrease of leaf pervasion over control was found in T_3 (27.01%) trailed by T_2 (37.46%) and T_5 (35.01%) (Table 2). [13] discovered a similar outcome using Spinosad, mycojaal (*Beauveria bassiana*), malathion, lipel (*Bacillus thuringiensis* var. *kurstaki*), and Azadirachtin. Spinosad was shown to be the most effective at controlling diamondback moth larvae, with a 14.22 percent reduction in mean leaf damage. [14] discovered similar results in his study. Spinosad was found to be the most effective at reducing diamondback moth population by up to 94.33 percent, followed by indoxacarb (91.00 %) and Flubendiamide (78.66 %).

Table 2. Effect of biopesticides on leaf Infestation caused by diamondback moth larvae at different days after transplanting (DAT) of cabbage.

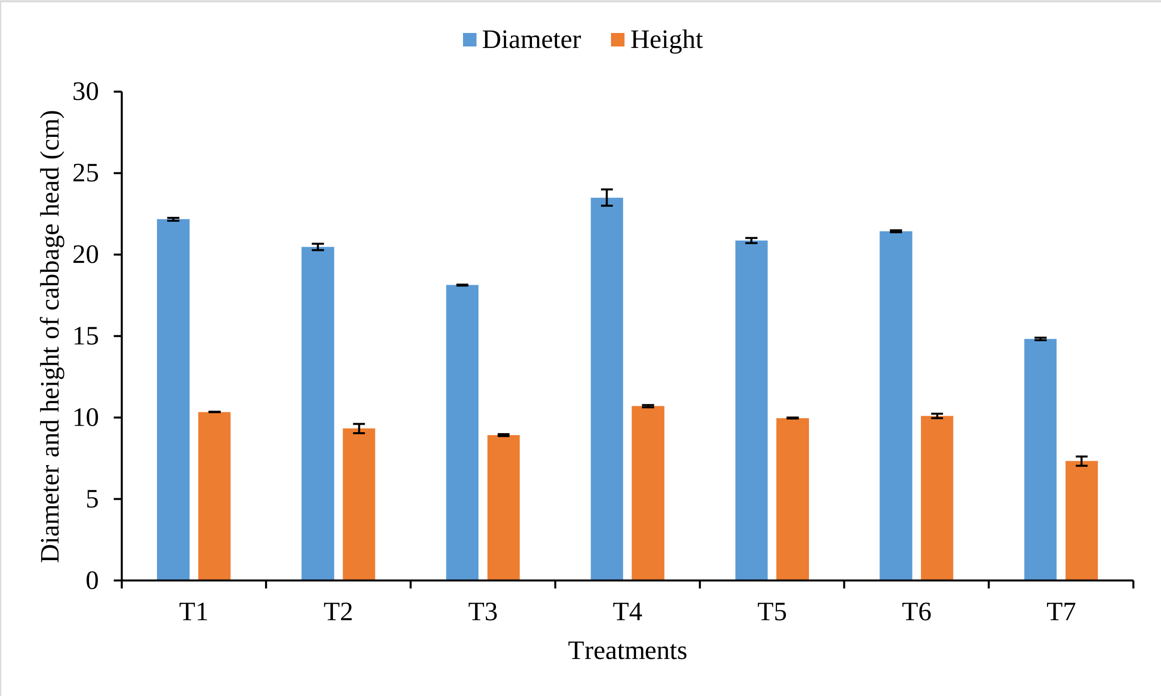
Treatments	Number of infested leaves per five plants					Mean	% reduction over control
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT		
T_1	5.00 de	5.00 f	4.90 f	4.83 d	4.73 de	4.89 e	45.23
T_2	5.60 cd	5.73 d	5.63 d	5.53 c	5.43 c	5.59 c	37.46
T_3	6.33 b	6.63 b	6.53 b	6.43 b	6.67 b	6.52 b	27.01
T_4	4.60 e	4.70 g	4.60 g	4.37 e	4.13 e	4.48 f	49.85
T_5	5.90 bc	6.03 c	5.93 c	5.63 c	4.13 e	5.81 c	35.01
T_6	5.90 bc	5.43 e	5.33 e	5.30 c	5.13 cd	5.31 d	40.52
T_7	8.33 a	8.67 a	8.67 a	9.33 a	9.67 a	8.93 a	
LSD (0.05)	0.67	0.23	0.23	0.38	0.66	0.23	
CV%	6.41	2.14	2.17	3.64	6.34	2.19	

[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, T_1: Abamectin 1.2 EC; T_2: Azadirachtin 1 EC; T_3: Potassium salt of fatty acid; T_4: Spinosad 45 SC; T_5: Bacillus thuringiensis; T_6: Abamectin 1.2 EC + Bacillus thuringiensis; T_7: Untreated control].

3.3 Effect of biopesticides on yield and yield contributing characteristics of cabbage

In case of diameter of cabbage head, T_4 had the largest head diameter (23.50 cm), which was statistically different from all other treatments, followed by T_1 (22.17 cm) and T6 (22.17 cm) (21.43cm). T_7, on the other hand, had the smallest head diameter (14.83), which was substantially different from all other treatments. T_2 (20.47 cm) and T_5 (20.87 cm) were statistically identical. In terms of percent increase in diameter above control, T_4 treatment resulted in the largest increase (58.43%), while T_3 treatment resulted in the smallest increase (22.24%) (Fig. 1).

In terms of cabbage height, T_4 had the highest head height (10.70 cm), which was statistically equivalent to T_1 (10.34 cm). T_7, on the other hand, had the shortest head height (7.33 cm), which was significantly lower than all other treatments (Fig. 1). However, among the treated plots, T_3 had the lowest head height (8.93cm), which was statistically equivalent to T_2 (9.33), followed by T_5 (9.97cm), and T_6 (9.97cm) (10.10 cm). T_4 (45.91%) had the highest percent increase over control on head height, followed by T_1 (40.91%), and T_3 (21.8%) had the lowest percent increase over control on head



height, which was close to T_2 (27.27%).

Fig. 1. Effect of different treatments on diameter and height of cabbage head

[Means ±SD are calculated from three replications where each replication is derived from 5 plants per treatment; T_1: Abamectin 1.2 EC; T_2: Azadirachtin 1 EC; T_3: Potassium salt of fatty acid; T_4: Spinosad 45 SC; T_5: Bacillus thuringiensis; T_6: Abamectin 1.2 EC + Bacillus thuringiensis; T_7: Untreated control].

3.4 Single head weight (kg) and total yield (t ha^{-1}) during harvesting

In case of single head weight (kg) of cabbage, T_4 had the highest single head weight (1.50kg), which was substantially higher than all other treatments, followed by T_1 (1.39kg) and T_6 (1.34kg). T_7, 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, T_3 had the smallest single head weight (1.12 kg), which was statistically equivalent to T_2 (1.17 kg) and T_5 (1.23 kg) (Fig. 2).

In terms of total yield (t ha^{-1}), T_4 produced the highest yield (36.40 t ha^{-1}), which was significantly higher than all other treatments. T_1 (34.07 t ha^{-1}) and T_6 (32.37 t ha^{-1}) followed. T_7 had the lowest yield (22.97 t ha^{-1}), which was significantly lower than the other treatments. However, in the treated plots, T_3 had the lowest yield (26.63 t ha^{-1}), followed by T_2 (29.57 t ha^{-1}), and T_5 (30.37 t ha^{-1}) (Fig. 2).

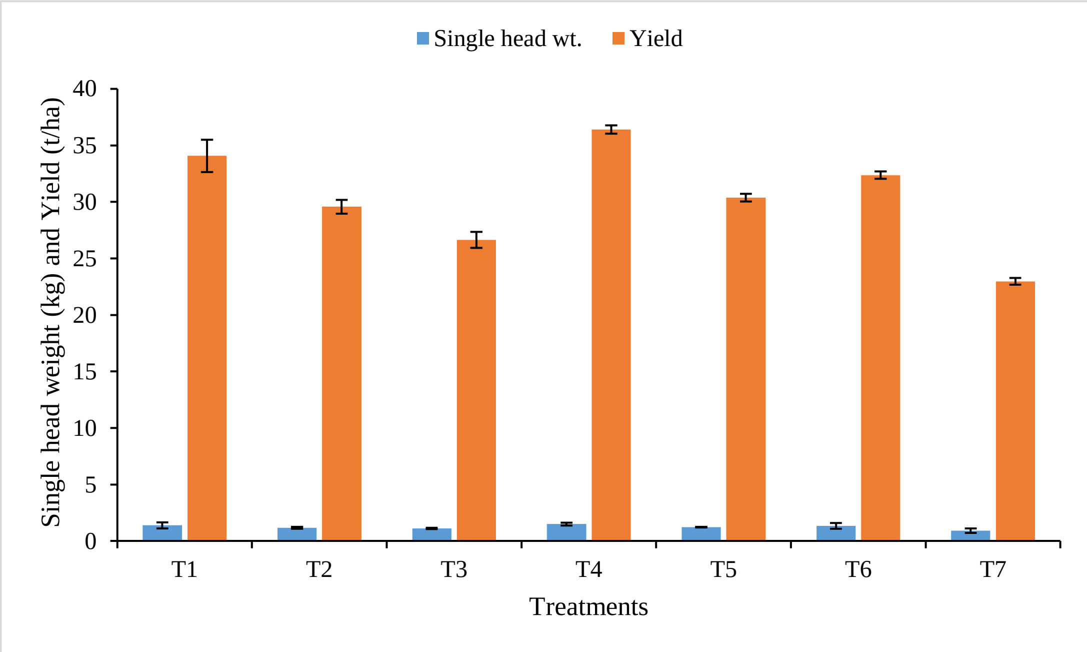


Fig. 2. Individual head weight (kg) and total yield (t ha^{-1}) of cabbage in different treatments during harvesting

[Means ±SD are calculated from three replications where each replication is derived from 5 plants per treatment; T_1: Abamectin 1.2 EC; T_2: Azadirachtin 1 EC; T_3: Potassium salt of fatty acid; T_4: Spinosad 45 SC; T_5: Bacillus thuringiensis; T_6: Abamectin 1.2 EC + Bacillus thuringiensis; T_7: Untreated control]

3.5 Relationship between leaf infestation by cabbage caterpillar and yield of cabbage

When a connection was fitted between these two parameters, a significant link between caterpillar leaf infestation and cabbage yield was discovered (Fig. 3). There was a substantial (R^2=0.896) and negative (slope =-1.344) association between caterpillar leaf infestation and cabbage production, indicating that cabbage yield declined as caterpillar leaf infestation increased. Infestation of cabbage caterpillars on leaves hampered plants' ability to produce and supply nutrients and water. With a lower output, the plant's growth and development were inhibited.

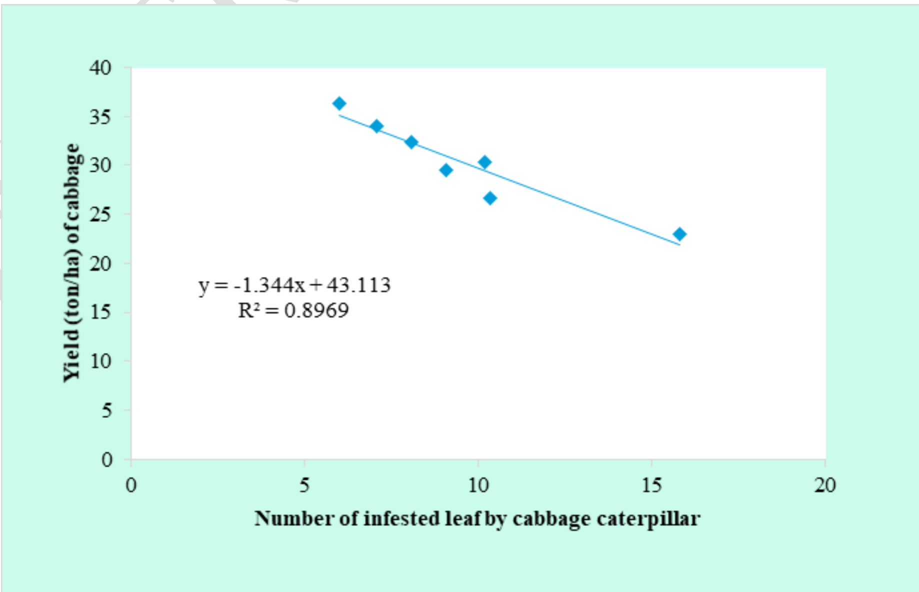


Fig. 3. Relationship between leaf infestation by cabbage caterpillar and yield of cabbage.

3.6 Relationship between leaf infestation by diamondback moth larvae and yield of cabbage

When the production of cabbage was compared to the leaf infestation by diamondback moth larvae, a significant association was discovered. These two factors had a highly significant (p0.05), very strong (R^2=0.8945), and negative (slope =-2.907) association (Fig. 4), indicating that cabbage output declined as leaf infestation by diamondback moth larvae increased. According to the findings of this study, diamond back moth larvae infested leaves hindered plants from producing and supplying nutrients and water. With a lower output, the plant's growth and development were inhibited.

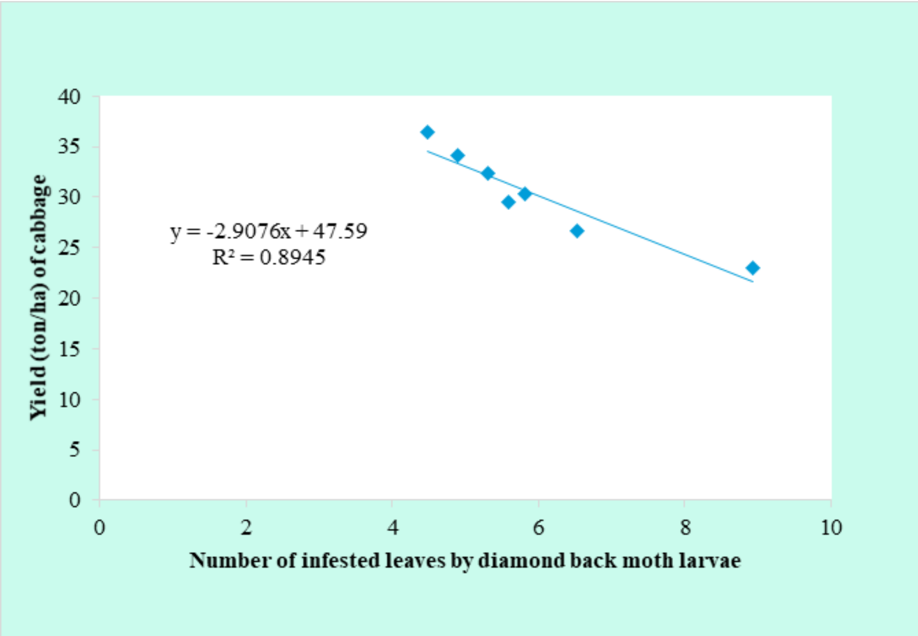


Fig. 4. Relationship between leaf infestation by diamondback moth larvae and yield of cabbage.

4. CONCLUSION

From the above discussion on summary, it may be concluded that, the treatment T_4 comprised of 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 T_3 (Potassium salt of fatty acid @ 1 ml/L of water at 7 days interval).

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCES

1. BBS. Year book of Agricultural Statistics of Bangladesh. Statistics Division, Bangladesh Bureau of Statistics (Monthly Statistical Bulletin, Bangladesh, May, 2020). Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka. 2019;295.

2. FAO. Report of a joint FAO/WHO workshop on fruit and vegetables for health. Food and Agricultural Organization. 2015;25.

3. Iqbal M, Khan AR, Rafique M, Suthar V, Solangi BK. Comparative Efficacy of Botanical and Synthetic Pesticides against Major Insect Pests of Cabbage. Eur Acad Res. 2015;3(9):10038-10057.

4. Natwick ET, Lopez MI. Insecticide Efficacy against Worm Pests in Cabbage. Arthropod Manag Tests. 2017;42(1):1-4.

5. Srivastava K, Sharma D, Anal AKD, Sharma S. Integrated Management of *Spodoptera litura*. A Review. Int J Life Sci Res. 2018;4(1):1536-1538.

6. Reddy MS, Singh NN, Mishra VK. Efficacy of insecticides against *Spodoptera litura* infesting Cabbage. Ann Plant Prot Sci. 2017;25(1):215-230.

7. Bhat MG, Joshi AB, Singh M. Relative losses of cotton yield by insects in some cotton genotypes (*Gossypium hirsutum* L.). Indian J Entomol. 1994;46:169-172.

8. Ahmed T. Study on the biology and management of cabbage caterpillar, *Spodoptera litura*. M. S. thesis, Dept. of Entomology, Bangladesh Agricultural University, Mymensingh. 2008;42-43.

9. Parajuli S, Paudel S. Eco-Friendly Management of Diamondback Moth (*Plutella xylostella* L.) of Cabbage (*Brassica oleracea* var. *capitata*) in Nepal. Int J Appl Sci Biotechnol. 2019;7(3):304-308.

10. Andrea D. Using weeds to reduce pest insect numbers in organic vegetable crops. Department for Environment, Food and Rural Affairs (DEFRA). UK, Univ. Warwick, HRI (OF0329). 2006.

11. Joshi MJ, Solanki CB, Inamdar AG, Birari VV, Varadharasu PR. Latest trends in zoology and entomology sciences. In: D.S. Ganguly (ed.), Botanical Insecticides: A Venture toward Organic Farming, Delhi, India: AkiNik Publications. 2020;53-75.

12. BARC. Fertilizer Recommendation Guide-2012. Bangladesh Agricultural Research Council, Farmgate, New Airport Road, Dhaka-1215. 2012;113.

13. Debbarma A, Singh KI, Gupta MK, Sobitadevi P. Bio-rational management of major lepidopterous pests and their influence on yield of cabbage crop under Manipur valley. J Entomol Zool Stud. 2017;5(5):1546-1551.

14. Sharma P, Kumawat KC, Khinchi SK, Kumar V, Prasad B. Bioefficacy of different insecticides against diamondback moth. Int J Che Stud. 2017;5(3):891-893.