



Evaluation of the Efficacy of Chemical Insecticides and Biopesticides against Flea Beetle in Cabbage (*Brassica oleracea var. Capitata*)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MAL and MA planned & designed the study along with review & editing. Author FF managed the literature searches, data collection & curation, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/APRJ/2021/v7i430159

Editor(s):

(1) Dr. Michael Ignatius Ferreira, Western Cape Department of Agriculture, South Africa.

Reviewers:

(1) Savitha M. Murthy, Mount Carmel College, India.

(2) Saurav Gupta, SKUAST-Jammu, India.

(3) Ghananand Tiwari, India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/67342>

Original Research Article

Received 10 February 2021

Accepted 20 April 2021

Published 26 April 2021

ABSTRACT

Aims: This study aimed to evaluate chemical insecticides and bio-pesticides against flea beetle in cabbage.

Study Design: The experiment was laid out at a randomized complete block design with three replications.

Place and Duration of Study: Experimental farm of Sher-e-Bangla Agricultural University, Bangladesh during the period from October 2017 to March 2018.

Methodology: The experiment consisted of nine treatments viz. T₁ (Sevin 85 WP @ 2g/L of water), T₂ (Decis 2.5 EC @ 1.0 ml/L of water), T₃ (Voliam flexi @ 0.5 ml/L of water), T₄ (Ripcord 10 EC @ 1.0 ml/L of water), T₅ (Dursban 20EC @ 1 ml L⁻¹ of water), T₆ (Tobacco leaf extract @ 3 g L⁻¹ of water), T₇ (Neem seed kernel extract @ 3 g L⁻¹ of water), T₈ (Bioneem plus 1 EC @ 1 ml L⁻¹ of water) and T₉ (Untreated Control) were used at 7 days interval.

Results: Stripped flea beetle (*Phyllotreta striolata*) and white-spotted flea beetle (*Monolepta signata*), these two species of flea beetle were found in the experimental field. Among all the treatments T₄ (Ripcord 10EC) performed the best in managing flea beetles based on the lowest

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percentage of leaf infestation (5.84%), lowest no. of holes per plant (6.13), lowest percentage of head infestation by number (18.04) and highest percentage of infestation reduction over control on all parameters at vegetative stage of plant. Again, the lowest leaf infestation intensity (5.73%), lowest number of holes per infested head (14.00), lowest percentage of infestation of head by number (6.69) were achieved at harvesting stage from the same treatment (T_4) whereas the highest values of all these parameters were achieved from untreated control treatment (T_9). T_4 treatment provided the best performance in yield where yield was increased (112.51 %) over control, giving maximum yield 75.76 tons ha^{-1} . Bioneem plus 1 EC (T_8) performed the best among the biopesticides while the neem seed kernel extract showed less effectivity against flea beetle.

Conclusion: It is concluded that in case of chemical insecticides Ripcord 10EC while in case of biopesticides Bioneem plus 1 EC would be effective for flea beetle management.

Keywords: Flea beetle; Monolepta signata; Phyllotreta striolata; voliam flexi; Bioneem plus; tobacco leaf extract.

1. INTRODUCTION

For cabbage production, there are many limiting factor i.e. unavailability of quality seeds of high yielding varieties, delayed sowing after the harvesting of transplanted aman rice, fertilizer management, improper and limited irrigation facilities and infestation of different insect pests. Insects play an important role in decreased production of cabbage in Bangladesh. Cabbage caterpillar, Flea beetle, Cabbage aphid, Semi looper, Diamond back moth, Cutworm, Whitefly, Cabbage worm etc are the most common insect infesting cabbage [1,2].

Flea beetles are included in the most important pest of cruciferous plants [3]. It is common name of an insect of Chrysomelidae family and belongs to the order Coleoptera. Pale striped Flea beetle, Elongate Flea beetle, Hop Flea beetle, Red headed Flea beetle, Three spotted Flea beetle, Western black Flea beetle, Toothed Flea beetle etc are the various genus and species of Flea beetle. Beetles can cause substantial damage on host plants by feeding on the leaves, especially in early stages of development [4]. They occasionally damage vegetables, flowers, and even trees. Adult's flea beetle, which produce most plant injuries are typically small often shiny, and have larger rear legs that allow them to jump like a flea when disturbed and also produce characteristics injury known as "shot holing". When occurring in large numbers can rapidly defoliate and kill plants. The pest if left unabated and in severe infestation can result in total crop failure while moderate infestation leads to at least 25 % foliage damage characterized by "shot holes" on the foliage. The importance of flea beetles as pests is aggravated by the fact that several species also vector plant pathogens

[5]. Some species are vectors of serious diseases such as potato blight and bacterial wilt of corn.

Among the various control practices in cabbage to suppress the prevalence of flea beetle insecticides are the mostly used. Foliar applied insecticides are effective when beetle populations have reached an economic threshold level and treatments are timed properly. There are many insecticides labeled for treating flea beetles. For conventional growers, pesticides containing pyrethroids or carbamates (Sevin) are generally effective [6]. Organophosphate insecticides are widely used as it is comparatively safer than other insecticides. Farmers are eagerly using insecticides as it shows instant result in controlling pest populations. However, there are many challenges in case of pest management from economic and ecological point of view due to human and environmental hazards and most of them are caused by synthetic chemical pesticides [7]. Now a day, biopesticides is being used an alternative of chemical insecticides. Rotenone was often used in the past, but it is not ideal because it has a relatively high mammalian toxicity and its availability has become limited. Neem-based insecticides are known for their pesticidal activity against more than 400 species of insects [8]. However, they are not toxic to humans and many beneficial arthropods, and targeted pests are unlikely to develop resistance; therefore, these insecticides have been advocated to replace synthetic insecticides as they are more sensible to be used in most pest management programs [9]. Therefore, an attempt was taken to evaluate the efficacy of some commonly used chemical insecticides and biopesticides against flea beetle in cabbage.

2. MATERIALS AND METHODS

2.1 Experimental Site

The location of the present experimental field was at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experiment was laid during the period of October 2017 to March 2018. The soil of the experimental plot was shallow red-brown terrace soil and little less than neutral (pH 5.8-6.5) in nature.

2.2 Experimental Treatment and Design

The test crop used in the experiment was cabbage variety Atlas-70. It is an imported high yielding variety with average yield 55-60 t/ha¹. Nine treatment were used in this experiment and all the treatments were applied at seven days interval from 10 days after harvesting. We laid out the experiment in a Randomized Complete Block Design (RCBD) with three replications. The area of a single plot of the experiment was 4 m² (2.5 m x 1.6 m).

2.3 Crop Husbandry

The seeds were collected from the local market and were sown on the seedbed on October 15, 2017. Before seed sowing, the seedbed was prepared well and made suitable for seedling production. Before seedling transplantation, the land was prepared well by deep ploughing followed by laddering. 28 days old seedlings were transplanted in the main field on 15 November, 2017 at the rate of 16 seedlings plot⁻¹. Application of manures and fertilizers was done according to the recommended fertilizer doses for cabbage production per hectare by [10]. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. The total amount of cowdung, TSP and MoP was applied as basal dose at the time of land preparation. The total amount of Urea was applied in three installments at 10, 30 and 50 days after transplanting (DAT). Intercultural operations such as gap filling, weeding, earthing up, irrigation, etc. were done as and when required for ensuring and maintaining the normal growth of crops.

2.4 Data Collection

Five plants were randomly selected from each unit plot for the recording of necessary data on

different crop attributes. Data collection was started at the vegetative stage at 15 DAT to cabbage head harvest. The data on crop characters like the number of infested leaves, no. of holes, no. of healthy and infested head, the weight of individual head; length and girth of cabbage heads; yield (t ha⁻¹) were recorded. Only the fully compact and marketable heads were harvested at the time of harvesting.

2.5 Statistical Package

Collected data were analyzed following ANOVA techniques by using MSTAT computer package program. Mean values were ranked and compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance [11].

3. RESULTS AND DISCUSSION

3.1 Available Flea Beetle Species

Two species of flea beetle were found in the experimental field i.e; Stripped flea beetle (*Phyllotreta striolata*) and white-spotted flea beetle (*Monolepta signata*). Species were identified according to mainly external marks such as colours and patterns of the elytrae, the shape of the yellow patterns, punctuation of the head and the forehead, presence or absence of metallic shade on the back of the prothorax and the elytrae, the specific colour of the elytrae, the shape of the prothorax, the punctuation of the elytrae, the colour of the segments of the antenna, the tibia and the tarsus [12,13].

3.2 Percent leaf Infestation by Number at Different Days after Transplanting

The significant variations were observed among the different treatments used for the management in terms of percent leaf infestation by number due to attack of flea beetle at different days after transplanting (DAT). In terms of mean infestation of leaf by number, the highest was found in T₉ (37.41%) comprised of untreated control which was significantly different from all other treatments. On the other hands the lowest mean leaf infestation by number was found in T₄ (5.837%) which was followed by T₃ (11.78%) and significantly different from all other treatments (Table 2).

In case of percent reduction over control, the highest reduction over control was achieved by T₄ (84.42%) where the lowest was found in T₇ (54.56%). In Bangladesh, during the end of

Table 1. Treatments used in the experiment

| Treatments | Group name | Trade name | Doses |
|----------------|------------------------------------|--------------------------|---------------------------------|
| T ₁ | N-methyl carbamate | Sevin 85WP | 2 g L ⁻¹ of water |
| T ₂ | Deltamethrin | Decis 2.5 EC | 1 ml L ⁻¹ of water |
| T ₃ | Chlorantraniliprole + Thiamethoxam | Voliam flexi | 0.5 ml L ⁻¹ of water |
| T ₄ | Cypermethrin | Ripcord 10EC | 1 ml L ⁻¹ of water |
| T ₅ | Chloropyrifos | Dursban 20EC | 1 ml L ⁻¹ of water |
| T ₆ | Nicotine extract | Tobacco leaf extract | 3 g L ⁻¹ of water |
| T ₇ | Azadirachtin | Neem seed kernel extract | 3 g L ⁻¹ of water |
| T ₈ | Azadirachtin | Bioneem plus 1 EC | 1 ml L ⁻¹ of water |
| T ₉ | | Untreated control | |

Table 2. Leaf infestation of cabbage by number due to attack of flea beetle at different days after transplanting (DAT) in different treatments

| Treatments | % Leaf infestation | | | | | Mean | % Reduction over control |
|-----------------------|--------------------|---------|---------|---------|----------|---------|--------------------------|
| | 15 DAT | 25 DAT | 35 DAT | 45 DAT | 55 DAT | | |
| T ₁ | 10.54b | 12.87 d | 19.63 c | 20.76 b | 13.55 de | 15.47 c | 58.70 |
| T ₂ | 11.67 b | 15.88 c | 17.75 d | 14.79 f | 14.31 c | 14.88 d | 60.27 |
| T ₃ | 8.88 c | 10.51 e | 9.72 e | 15.81 e | 13.98 cd | 11.78 f | 68.55 |
| T ₄ | 2.62 e | 4.22 f | 8.47 f | 7.01 g | 6.87 g | 5.84 g | 84.42 |
| T ₅ | 10.88 b | 19.66 b | 18.01 d | 17.67 c | 12.53 e | 15.75 c | 57.95 |
| T ₆ | 5.17 d | 16.83 c | 19.82 c | 16.33 d | 15.68 b | 14.76 d | 60.58 |
| T ₇ | 11.18 b | 20.69 b | 21.19 b | 18.90 b | 16.13 b | 17.02 b | 54.56 |
| T ₈ | 6.10 d | 9.59 e | 19.15 c | 16.68 d | 10.78 f | 12.46 e | 66.73 |
| T ₉ | 18.63 a | 32.38 a | 44.74 a | 47.65 a | 43.88 a | 37.41 a | -- |
| LSD _(0.05) | 1.07 | 1.04 | 1.01 | 0.48 | 0.94 | 0.46 | -- |
| CV% | 6.48 | 3.81 | 2.93 | 1.46 | 3.29 | 1.64 | -- |

In column, means containing same letter(s) indicate significantly similar under DMRT at 5% level of significance, T₁ = Sevin 85WP @ 2.0 g/L of water, T₂ = Decis 2.5 EC @ 1.0 ml/L of water, T₃ = Voliam flexi @ 0.5 ml/L of water, T₄ = Ripcord 10EC @ 1.0 ml/L of water, T₅ = Dursban 20EC @ 1.0 ml/L of water, T₆ = Tobacco leaf extract @ 3.0 g/L of water, T₇ = Neem seed kernel extract @ 3.0 g/L of water, T₈ = Bioneem plus 1 EC @ 1.0 ml/L of water, T₉ = Untreated control].

February the temperatures increases gradually, it was around 55⁰ F to 93⁰ F. However, the rate of incidence of flea beetles infested leaves was decreased with the age of the cabbage plants and no flea beetles infested leaves was observed at 45 DAT, because the leaves that were infested at early stage of the plant growth, these were dropped off at the later stage. The same trend was found by Islam [14]. As the temperature increased after 45 DAT, the number of flea beetle decreased hence the infestation reduced at 45 DAT and during this time the temperature was around 55⁰ F to 93⁰ F.

3.3 Number of Holes/Head of a Plant at Different Days after Transplanting (DAT)

The significant variations were observed among different treatments used for the management practices in terms of number of holes/infested head of a plant due to attack of flea beetle at different days after transplanting (DAT). In terms of mean infestation/head of cabbage, the highest infestation was found in T₉ (14.87) which was significantly different from all other treatments. Among the management practices, the highest infestation was found in T₇ (9.33) which is statistically similar with T₅ (8.93), T₁ (8.40) and T₂ (8.40) followed by T₆ (7.87) and T₈ (7.60). On the other hand, the lowest mean infestation was observed in T₄ (6.13) which was followed by T₃ (6.87). In case of percent reduction over control, the highest reduction over control was achieved by T₄ (58.74%) where the lowest was found in T₇ (37.22%) which was very close to T₅ (39.99%). From the above mentioned finding it was revealed that among the different treatments, T₄ performed best in reducing the infestation intensity of leaf of cabbage by number of holes (58.74 %) due to attack of flea beetle than the other treatments; whereas, T₇ showed the least performance in reducing the infestation intensity of leaf of cabbage by number of holes (37.22%) over control.

3.4 Percent (%) Head Infestation by Number at Vegetative Stage

Significant variations were observed among the different treatments used for the management practices in terms of % head infestation by number due to attack of flea beetle at different days after transplanting (DAT) (Table 3). In case of mean infestation, the highest % head infestation (43.93%) was recorded in T₉ which was significantly different from all other

treatments. But in case of treated plots, T₇ (26.83%) showed the highest % head infestation by number which was statistically similar with T₅ (26.39%) followed by T₁ (23.70%). On the other hand, the lowest % head infestation by number (18.04%) was held in T₄ which was statistically similar with T₃ (18.31%) and closely followed by T₈ (19.21%). But the rate of % head infestation by number incidence was decreasing with the increase of the age of the cabbage plants within the treated plots. opposite feature was found in T₉ i.e. gradually increased % head infestation by number was found with the increase of the age of the cabbage.

In case of % reduction over control, the highest reduction over control was achieved by T₄ (58.93%) which was closely followed by T₃ (58.32%). Whereas the lowest reduction over control was found in T₇ (38.93%) which was very close to T₅ (39.94%) (Table 3). Stanislav in 2005 also found similar results in the infestation by using some botanical and cultural practices [15].

3.5 Leaf infestation Intensity at Harvesting

Significant variations were observed among the different treatments used for the management practices in terms of leaf infestation intensity due to attack of flea beetle during harvesting period (Table 4). The highest leaf infestation intensity (22.66%) was recorded in T₉ which was significantly different from all other treatments. But in the treated plots, the highest leaf infestation intensity was found in T₇ (14.61%) which was statistically similar with T₅ (13.96%) and T₁ (13.46%) followed by T₂ (10.96%). On the other hand, the lowest leaf infestation intensity was observed in T₄ (5.73%) which was significantly different from all other treatments followed by T₃ (8.98%) and T₈ (10.77%). The results obtained from other treatments showed intermediate level of leaf infestation intensity. In case of % reduction over control, the highest reduction over control on leaf infestation intensity was achieved by T₄ (74.69%) where the lowest was found in T₇ (35.53%) which was very close to T₅ (38.39%). During the harvesting time the infestation rate is lower than the vegetative stages as the temperature increases. Because in perspective of Bangladesh in the month of November to January, the temperature remains very low which gradually tends to increase from the end of February. At harvesting the cabbage leaf grows older it may be a reason of low infestation.

Table 3. Infestation intensity of leaf of cabbage by number of holes due to attack of Flea beetle at different days after transplanting (DAT) in different treatments

| Treatments | No. of holes / plant | | | | | Mean | % reduction over control |
|-----------------------|----------------------|---------|---------|----------|----------|---------|--------------------------|
| | 15 DAT | 25 DAT | 35 DAT | 45 DAT | 55 DAT | | |
| T ₁ | 6.67 b | 7.67 bc | 9.67 bc | 10.00 cd | 8.00 bcd | 8.40 bc | 43.49 |
| T ₂ | 5.67 bc | 7.67 bc | 9.67 bc | 11.00 bc | 8.00 bcd | 8.40 bc | 43.49 |
| T ₃ | 5.67 bc | 6.00 cd | 7.67 d | 9.33 cde | 6.67 b | 6.87 de | 52.46 |
| T ₄ | 4.67 c | 5.00 d | 6.33 e | 7.67 e | 7.00 cd | 6.13 e | 58.74 |
| T ₅ | 6.67 b | 8.00 b | 9.67 b | 12.00 b | 8.33 bc | 8.93 b | 39.91 |
| T ₆ | 6.00 bc | 6.67 bc | 8.33 cd | 11.00 bc | 7.33 bcd | 7.87 c | 47.08 |
| T ₇ | 7.33 b | 8.33 b | 10.33 b | 12.00 b | 8.67 b | 9.33 b | 37.22 |
| T ₈ | 6.00 bc | 7.00 bc | 8.67 cd | 8.67 de | 7.67 bcd | 7.60 cd | 48.87 |
| T ₉ | 11.00 a | 14.00 a | 16.67 a | 18.33 a | 14.33 a | 14.87 a | -- |
| LSD _(0.05) | 1.59 | 1.57 | 1.32 | 1.79 | 1.37 | 0.92 | -- |
| CV% | 13.85 | 11.65 | 7.90 | 9.31 | 9.36 | 6.05 | -- |

[In column, means containing same letter(s) indicate significantly similar under DMRT at 5% level of significance, T₁ = Sevin 85WP @ 2.0 g/L of water, T₂ = Decis 2.5 EC @ 1.0 ml/L of water, T₃ = Voliam flexi @ 0.5 ml/L of water, T₄ = Ripcord 10EC @ 1.0 ml/L of water, T₅ = Dursban 20EC @ 1.0 ml/L of water, T₆ = Tobacco leaf extract @ 3.0 g/L of water, T₇ = Neem seed kernel extract @ 3.0 g/L of water, T₈ = Bioneem plus 1 EC @ 1.0 ml/L of water, T₉ = Untreated control]

Table 4. Infestation of cabbage plant by number due to attack of flea beetle at different days after transplanting (DAT) in different treatments

| Treatments | % infestation of head | | | | | Mean | % reduction over control |
|-----------------------|-----------------------|----------|---------|---------|----------|----------|--------------------------|
| | 25 DAT | 35 DAT | 45 DAT | 55 DAT | 65 DAT | | |
| T ₁ | 21.67 d | 26.46 d | 39.32 b | 16.57 d | 14.48 b | 23.70 c | 46.06 |
| T ₂ | 20.36 d | 28.39 d | 32.34 e | 12.92 e | 10.64 d | 20.93 d | 52.36 |
| T ₃ | 15.92 f | 18.47 f | 34.86 d | 10.64 f | 11.67 cd | 18.31 fg | 58.32 |
| T ₄ | 16.57 f | 20.36 ef | 32.34 e | 12.49 e | 8.46 e | 18.04 g | 58.93 |
| T ₅ | 27.35 c | 31.50 c | 39.32 b | 21.28 b | 12.49 c | 26.39 b | 39.94 |
| T ₆ | 18.78 e | 22.00 e | 31.50 e | 18.78 c | 8.26 e | 19.86 e | 54.79 |
| T ₇ | 29.05 b | 34.86 b | 36.80 c | 20.36 b | 13.08 bc | 26.83 b | 38.93 |
| T ₈ | 18.47 e | 22.00 e | 28.39 f | 16.57 d | 10.64 d | 19.21 ef | 56.27 |
| T ₉ | 36.80 a | 55.13 a | 56.39 a | 31.50 a | 39.85 a | 43.93 a | -- |
| LSD _(0.05) | 1.52 | 3.06 | 1.71 | 1.34 | 1.54 | 0.96 | -- |
| CV% | 3.83 | 6.14 | 2.69 | 4.31 | 6.16 | 2.29 | -- |

[In column, means containing same letter(s) indicate significantly similar under DMRT at 5% level of significance, T₁ = Sevin 85WP @ 2.0 g/L of water, T₂ = Decis 2.5 EC @ 1.0 ml/L of water, T₃ = Voliam flexi @ 0.5 ml/L of water, T₄ = Ripcord 10EC @ 1.0 ml/L of water, T₅ = Dursban 20EC @ 1.0 ml/L of water, T₆ = Tobacco leaf extract @ 3.0 g/L of water, T₇ = Neem seed kernel extract @ 3.0 g/L of water, T₈ = Bioneem plus 1 EC @ 1.0 ml/L of water, T₉ = Untreated control]

3.6 Percent (%) Infestation of Head by Number during Harvesting

Significant variations were observed among the different treatments used for the management practices in terms of number of % infestation of head by number due to attack of flea beetle during harvesting period (Table 5). The highest % infestation of head by number (37.60) was recorded in T₉ which was significantly different from all other treatments. But in the treated plots, the highest % infestation of head by number was found in T₇ (12.92) and the lowest % infestation of head by number was observed in T₄ (6.69). The results obtained from other treatments gave intermediate level of % infestation of head by number. In case of percent reduction over

control, the highest reduction over control on percent infestation of head by number was achieved by T₄ (82.18%) where the lowest was found in T₇ (65.64%).

3.7 Girth and Length of Cabbage Head

Significant variations were observed among the different treatments used for the management practices in terms of length and girth of head due to attack of flea beetle during harvesting period. The highest length of head (13.77 cm) was recorded in T₄ and the lowest head length (9.90 cm) was found in T₉ which was significantly different from all other treatments. But in the treated plots, the lowest head length (12.26 cm) was found in T₇. The highest girth of head (20.62

Table 5. Infestation intensity of leaf of cabbage by flea beetle in different treatments during harvesting

| Treatments | % leaf infestation at harvest | % reduction over control |
|-----------------------|-------------------------------|--------------------------|
| T ₁ | 13.46 b | 40.60 |
| T ₂ | 10.96 c | 51.53 |
| T ₃ | 8.98 d | 60.35 |
| T ₄ | 5.73 e | 74.69 |
| T ₅ | 13.96 b | 38.39 |
| T ₆ | 10.92 c | 51.80 |
| T ₇ | 14.61 b | 35.53 |
| T ₈ | 10.77 c | 52.47 |
| T ₉ | 22.66 a | -- |
| LSD _(0.05) | 1.26 | -- |
| CV% | 5.87 | -- |

[In column, means containing same letter(s) indicate significantly similar under DMRT at 5% level of significance, T₁ = Sevin 85WP @ 2.0 g/L of water, T₂ = Decis 2.5 EC @ 1.0 ml/L of water, T₃ = Voliam flexi @ 0.5 ml/L of water, T₄ = Ripcord 10EC @ 1.0 ml/L of water, T₅ = Dursban 20EC @ 1.0 ml/L of water, T₆ = Tobacco leaf extract @ 3.0 g/L of water, T₇ = Neem seed kernel extract @ 3.0 g/L of water, T₈ = Bioneem plus 1 EC @ 1.0 ml/L of water, T₉ = Untreated control]

Table 6. Incidence of cabbage flea beetle in the infested head on different treatments at harvesting

| Treatments | % head infestation at harvest | % reduction over control |
|-----------------------|-------------------------------|--------------------------|
| T ₁ | 11.44 bc | 69.57 |
| T ₂ | 10.64 c | 71.70 |
| T ₃ | 7.50 d | 80.05 |
| T ₄ | 6.69 d | 82.18 |
| T ₅ | 11.92 bc | 68.30 |
| T ₆ | 8.04 d | 78.62 |
| T ₇ | 12.92 b | 65.64 |
| T ₈ | 7.67 d | 79.60 |
| T ₉ | 37.60 a | -- |
| LSD _(0.05) | 1.53 | -- |
| CV% | 6.95 | -- |

[In column, means containing same letter(s) indicate significantly similar under DMRT at 5% level of significance, T₁ = Sevin 85WP @ 2.0 g/L of water, T₂ = Decis 2.5 EC @ 1.0 ml/L of water, T₃ = Voliam flexi @ 0.5 ml/L of water, T₄ = Ripcord 10EC @ 1.0 ml/L of water, T₅ = Dursban 20EC @ 1.0 ml/L of water, T₆ = Tobacco leaf extract @ 3.0 g/L of water, T₇ = Neem seed kernel extract @ 3.0 g/L of water, T₈ = Bioneem plus 1 EC @ 1.0 ml/L of water, T₉ = Untreated control]

Table 7. Effect of different treatments on yield and yield contributing characters of Cabbage

| Treatments | Length | Girth | Single head wt. (kg) | Total yield(ton/ha) |
|-----------------------|----------|---------|----------------------|---------------------|
| T ₁ | 12.52 bc | 16.96 e | 1.67 c | 58.40 d |
| T ₂ | 12.69 bc | 17.10 e | 1.70 c | 58.74 d |
| T ₃ | 13.12 ab | 20.05 b | 1.95 b | 66.95 b |
| T ₄ | 13.77 a | 20.62 a | 2.19 a | 75.76 a |
| T ₅ | 12.39 bc | 16.21 f | 1.46 d | 50.52 e |
| T ₆ | 12.72 bc | 18.07 d | 1.83 bc | 62.69 c |
| T ₇ | 12.26 c | 16.19 f | 1.44 d | 49.67 f |
| T ₈ | 12.87 bc | 18.65 c | 1.94 b | 66.76 b |
| T ₉ | 9.90 d | 13.78 g | 1.04 e | 35.65 g |
| LSD _(0.05) | 0.66 | 0.47 | 0.16 | 0.52 |
| CV% | 3.06 | 1.55 | 5.70 | 5.51 |

[In column, means containing same letter(s) indicate significantly similar under DMRT at 5% level of significance, T₁ = Sevin 85WP @ 2.0 g/L of water, T₂ = Decis 2.5 EC @ 1.0 ml/L of water, T₃ = Voliam flexi @ 0.5 ml/L of water, T₄ = Ripcord 10EC @ 1.0 ml/L of water, T₅ = Dursban 20EC @ 1.0 ml/L of water, T₆ = Tobacco leaf extract @ 3.0 g/L of water, T₇ = Neem seed kernel extract @ 3.0 g/L of water, T₈ = Bioneem plus 1 EC @ 1.0 ml/L of water, T₉ = Untreated control].

cm) was recorded in T₄ and the lowest head girth (13.78 cm) was found in T₉ which was significantly different from all other treatments. But in the treated plots, the lowest head girth (16.19 cm) was found in T₇. Ester also found more or less similar result in an experiment in 2003 [16].

3.8 Single Head Weight (kg) and Yield (t ha⁻¹) of Cabbage

Significant variations were observed among the different treatments used for the management practices in terms of single head weight (kg) and yield (t/ha) due to attack of flea beetle. The highest single head weight (2.19 kg) was recorded in T₄ and the lowest single head weight (1.04 kg) was found in T₉. But in the treated plots, the lowest single head weight (1.44 kg) was found in T₇.

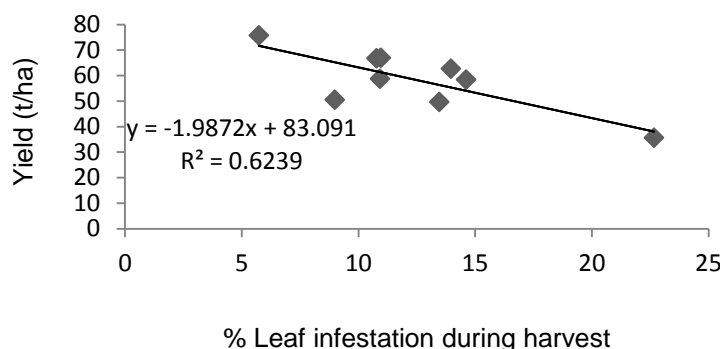
The highest total yield (75.76 t/ha) was recorded in T₄ and the lowest total yield (35.65 t/ha) was found in T₉ which was significantly different from all other treatments. But in the treated plots, the lowest total yield (49.67 t/ha) was found in T₇.

3.9 Relationship between Leaf Infestation Intensity and Yield (t/ha)

The results revealed that there was strong negative correlation between leaf infestation intensity and total yield/ha, which suggested that with the increase of leaf infestation intensity there was a significant influence on total yield/ha. A linear regression was fitted between total yield/ha weight and leaf infestation intensity (Fig.1). The correlation coefficient (r) was - 0.789 and the contribution of the regression (R²) were 0.623. In the present study, it was observed that flea beetle infestation on leaf passively prevented plants to produce and supply nutrient and water. The plants became stunted with a reduced yield.

3.10 Relationship between Percent Head Infestation during Harvest and WT. of Individual Head

The results revealed that there was strong negative correlation between leaf infestation intensity and total yield/ha, which suggested that with the increase of head infestation intensity there was a significant influence on total yield/ha.

**Fig.1. Relationship between leaf infestation intensity and yield (t/ha) of cabbage**

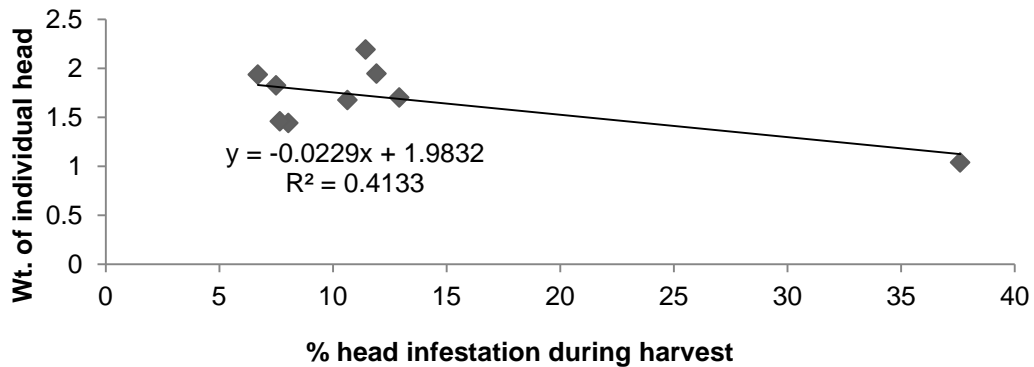


Fig.2. Relationship between percent head infestation during harvest and wt. of individual head among different treatments

A linear regression was fitted between total yield/ha weight and head infestation intensity (Fig.2). The correlation coefficient (r) was -0.642 and the contribution of the regression (R^2) were 0.413 . In the present study, it was observed that flea beetle infestation on head passively prevented plants to produce and supply nutrient and water. The plants became stunted with a reduced yield.

4. CONCLUSION

The result of the current analysis suggests that among the different treatments T_4 comprised of Ripcord 10EC @ 1.0 ml/L of water at 7 days interval gave the highest performance where the lowest performance was obtained by control treatment. On the other hand, the lowest performance among the treated plots was achieved by T_7 (Neem seed kernel extract @ 3.0 g/L of water at 7 days interval). While among the biopesticides, Bioneem plus 1 EC performed the best.

ACKNOWLEDGEMENTS

This work was supported by the National Science and Technology (NST) Fellowship, Ministry of Science and Technology, Government of the People's Republic of Bangladesh. The authors are grateful for financial support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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