INCIDENCE AND ECOFRIENDLY MANAGEMENT OF CAPSICUM FRUIT BORER, *Helicoverpa armigera (Hubner)*

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DHAKA-1207

JUNE, 2022

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A Thesis

Submitted to the Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka,

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (MS)

IN

ENTOMOLOGY

SEMESTER: JANUARY- JUNE, 2022

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CERTIFICATE

*This is to certify that the thesis entitled, "**INCIDENCE AND ECOFRIENDLY MANAGEMENT OF CAPSICUM FRUIT BORER, Helicoverpa armigera (Hubner)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in ENTOMOLOGY**, embodies the result of a piece of bona-fide research work carried out by **SHAMSUN NAHAR**, Registration no. **15-06698** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENT

All praises are due to Almighty Allah, the Great, Gracious and Merciful, whose blessings enabled the author to complete this research work successfully.

The author like to express her deepest sense of gratitude sincere appreciation to her respected supervisor Professor Dr. Ayesha Akter, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for her scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing.

The author also expresses her gratefulness and best regards to respected co-Supervisor, Professor Dr. Tahmina Akter, Department of Entomology, Sher-e Bangla Agricultural University, Dhaka for her scholastic guidance, helpful comments and constant inspiration, inestimable help, valuable suggestions throughout the research work and preparation of the thesis.

The author expresses her sincere respect to the Chairman, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Entomology, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses her sincere appreciation to her brother, sisters, relatives, well-wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

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ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2020 to March 2021 to study the incidence and ecofriendly management of Capsicum fruit borer. The experiment consists of control measures and plant extract. The experiment was laid out in Randomized Complete Block Design replicated with four times. For this study having six treatment, *viz:* Treatment T_1: Field Sanitation + Netting; T_2: Field sanitation + rice straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ Black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; T_6 : control were included in this study. The results showed that the presence of capsicum fruit borers (*Helicoverpa armigera* Hubner) at various fruiting stages destroys the capsicum fruit contents and is one of the major constraints to increasing bell pepper yields. Thus, for the management of capsicum fruit borer, it was discovered that treatment T_3 (Field sanitation + Spinosad at 7-day intervals) was the most effective treatment for reducing insect pest infestation at all growing stages. While the lowest performance was observed in T_6 (Control) was followed by T_1 (Field Sanitation + Netting) treatment. The highest total yield hectare^{-1} was found from T_2 (23.43 ton), while the lowest yield hectare^{-1} was found from T_6 (19.54 ton) treatment. The yield of capsicum was highly significant (p=0.05), very strong and negatively correlated with infested fruit yield (t/ha) i.e., the total yield of capsicum increased with the infested fruit yield (t/ha) decreased. From the study, it may be concluded that treatment T_3 which comprised with the Field sanitation + Spinosad at the 7 days intervals used as a best treatment against Capsicum fruit borer which was followed by spraying of T_5 treatment.

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LIST OF SYMBOLS AND ABBREVIATION

SYMBOLS AND ABBREVIATIONS	FULL WORD
%	Percent
et all	And others
J	Journal
No.	Number
Cm	Centimeter
Agric.	Agriculture
ºC	Degree centigrade
Etc.	Etcetera
TSP	Triple Super Phosphate
MP	Murate of Potash
BARI	Bangladesh Agricultural Research Institute
LSD	Least Significant Difference
RCBD	Randomized Completely Block Design
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Viz.	Namely
@	At the rate of
BRRI	Bangladesh Rice Research Institute
i.e.	That is
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of Co-efficient of Varience
g	Gram
kg	Kilogram
mg	Miligram
t	Ton
Agril.	Agricultural
BARC	Bangladesh Agricultural Research Council
UNDP	United Nations Development Programme
AEZ	Agro-ecological Zones

CHAPTER I

INTRODUCTION

The Solanaceae family is the most important, representing a diverse group of different vegetables that are indispensable in every kitchen. The potato, tomato, and chilli are important constituents of many foods; these can be used singly or blended with different foods like eggplant and bell pepper (Gebhardt, 2016). Among the fruit vegetables, bell pepper has a specific identity. The bell pepper (*Capsicum annuum* L. var. grossum Sendt; 2n = 24) is known by various names such as *Capsicum*, sweet pepper, bell pepper, Simla Mirch, vegetable paprika, etc (Swamy, 2023). This differs from common hot peppers in size and shape of the fruits, capsaicin content and usage. Bell pepper is used for salads, stuffing, cooked as a vegetable, pickle, or processed and appreciated worldwide for their flavor, aroma, color and as an important source of pro-vitamin A (at the red stage) and vitamin C. Its consumption is increasing all over the world with the increase in the fast food industries and many hidden uses. Bell pepper is a versatile crop and its many uses make it a major commodity even though it is listed as a minor crop in many countries. In Bangladesh, bell pepper is considered a minor vegetable crop cultivated in an area of 13400 acre with production of 38890 metric tons in 2019–2020 season (BBS, 2020). Dhaka is the major capsicum cultivating district with an area of 2900 acre and production of 17400 metric tons followed by Sylhet, Rangamati and Sirajganj (BBS, 2020). Capsicum has attained the status of a high value crop in Bangladesh during recent years. The high market price it fetches is attributed to the heavy demand from the urban consumers, and even a small blemish on the fruit drastically reduces its market value. Under these circumstances, insect pests that reduce the fruit quality and production are important (Rahman *et al.*, 2022).

Insect pest problem is most important constraint for chilli production. Due to its tender and supple nature and its cultivation under high moisture and input regimes, bell pepper is more prone to pest attack. A total of 57 species of insect and mite pests were recorded damaging chilli (Reddy and Puttaswamy, 1984). Pest complex of chilli includes sucking pests like thrips, *Scirtothrips dorsalis* (Hood), yellow mite, *Polyphagotarsonemus latus*

(Banks) and lepidopteran pests like fruit borer, *Helicoverpa armigera* (Hübner) and *Spodoptera litura* (Fabricius). *H. armigera*, a polyphagous pest, reported to cause destruction of the capsicum fruit contents with infestation up to 92 percent of the plants and 77 percent fruit damage (Katagihallimath, 1963). These pests are the major constraints in getting higher bell pepper yields (Mannan *et al.*,2020).

Among these pests, fruit borer, *Helicoverpa armigera* (Hübner) is the most destructive insect pest, not only on chilli pepper but also in other vegetable crops, especially during the dry season. *H. armigera* caused yield loss of chili pepper up to 60 percent (Mariyono, 2016). The pest is difficult to be eradicated because it has many alternative host plants, such as tobacco, maize, sorghum, cotton, potato, okra, cabbage, green peas, chrysanthemum, tomato, carrot, lettuce, eggplants, and other horticultural crops (Singla and Singh, 2020). The pest problem has increased many folds on chilli as the number of sprays increased 2-3 folds compared to normal 5-6 sprays. This has enormously increased the cost of cultivation of chilli, making it non-profitable. Quicker control strategy for these pests and quests of getting higher yields, led to indiscriminate use of pesticides. In addition, sole dependence on chemical insecticides resulted in collapse of natural enemy fauna and resulted in resurgence of pests and environmental pollution besides upsetting the natural ecosystem. Study in some countries indicated that *H. armigera* is resistant to major conventional groups of pesticides, such as pyrethroids, organophosphates, organochlorines, and carbamates (Chaturvedi, 2007).

In this regard the utilization of botanical and bio-pesticides for controlling the crop pests can serve as an alternative means over the chemical pesticides. But they are not very target specific. Though bio pesticides do not harm beneficial insects, they are also not target specific. This causes problems on a broader level. Unlike their counterparts, biopesticides are generally slow in nature. They take a lot of time to act on the pests and diseases. At times, this might cause damage to the crop because of the additional life that the pest and diseases gets (Lengai and Muthomi, 2018).

In view of above problems, faced by the application of different types of insecticides for the management of insect pests, there is a need to manage these by safer and eco-friendly approaches, so that the least disturbance to the environment could happen. To maintain the intermediate and long-term sustainability of agriculture in Bangladesh, an alternative to prophylactic pest control is eco-friendly pest management (EPM), which endeavors to employ the rational use of insecticides as well as the harmonious integration of different control strategies such as cultural, physical, mechanical and biological method of pest control (Lundin *et al*., 2021). The area under bell pepper is increasing every year, and subjected to several insect pests, among which *H. armigera* acts one of the major production constraints, of which no reports are availables. Any non-chemical strategy or reduced insecticides for managing fruit borer with bio-rational approaches in mind could be a welcome approach. Therefore by considering the above facts, the present study entitled, “Incidence and eco-friendly management of capsicum fruit borer” was undertaken with the following objectives:

- To assess the infestation level and damage severity of fruit borer of capsicum, and
- To find out the effective control measures of capsicum fruit borer as means of eco-friendly management.

CHAPTER II

REVIEW OF LITERATURE

Capsicum has been found to be infested by different insect and mite species. In different growing zones, capsicum fruit borers inflict significant crop damage. Based on the information collected through the survey literatures and researches carried out on different aspects of this insect and their managements the present investigation entitled "Incidence and eco-friendly management of capsicum fruit borer" has been reviewed in this chapter under the under following sub heads:

2.1 Taxonomy of capsicum fruit borer

Paul *et al.* (2003) stated the taxonomic classification of capsicum fruit borer

Common name: Capsicum fruit borer, African cotton boll worm corn, ear worm gram, pod borer grub, tomato old world bollworm, tobacco budworm.

Domain: Eukaryota

Kingdom: Metazoa

Phylum: Arthropoda

Subphylum: Uniramia

Class: Insecta

Order: Lepidoptera

Family: Noctuidae

Genus: *Helicoverpa*

Species: *Helicoverpa armigera*

2.2 Geographical distribution of capsicum fruit borer

Capsicum fruit borer is a versatile and widely distributed polyphagous insect. Beside Bangladesh, this pest occurs in Southern Europe, probably the whole of Africa, the Middle East, India, Central and South East Asia to Japan, the Philippines, Indonesia, New Guinea, the Eastern part of Australia, New Zealand and a number of pacific islands except for desert and humid region (Mahmood *et al.*, 2021).

2.3 Life cycle of capsicum fruit borer

Helicoverpa armigera completes its life cycle (from egg to adult) in 4-5 weeks at an average temperature of 28 ^{0}C (Jai *et al*., 2020). Egg, larva, pupa and adult are four major stages of its life cycle (Plate 1).

Eggs

A female moth can lay up to 3000 eggs. Eggs are generally laid on leaves, pods and flowers. Oviposition period may last for 5-24 days and egg incubation occurs in 3-5 days depending upon temperature and host plant. Color of freshly laid eggs is yellowish-white that change into shady brown prior to hatching (Ali *et al*., 2009).

Larva

After hatching, larvae are released having six distinct instars (1-6 instars caterpillar). Initially larvae feed on leaves, younger twigs and flowers but in later stages they enter into the developing pods by making holes from the pod basis (Singh and singh, 2007).

Pupa

Pre-pupa period lasts for 1-4 days. Generally, the pupal period ranges from 10-16 days however it depends on temperature by taking 6 days at 35 ^{0}C and up to 30 days on 15 ^{0}C. Under very low temperature (in winter) and very high temperature (in summer) it exhibits a facultative diapause to stay alive under unfavorable environmental conditions. Pupae exposed to exceeding 30 ^{0}C temperatures produce pale colored adults (Patil *et al*., 2017).

Adult

Male and female adults have distinguished color pattern showing greenish grey and orange brown respectively. Pearson (1958) reported that female moths generally live longer than male. Adult insects having stout bodies with broad thorax are named as Moth.

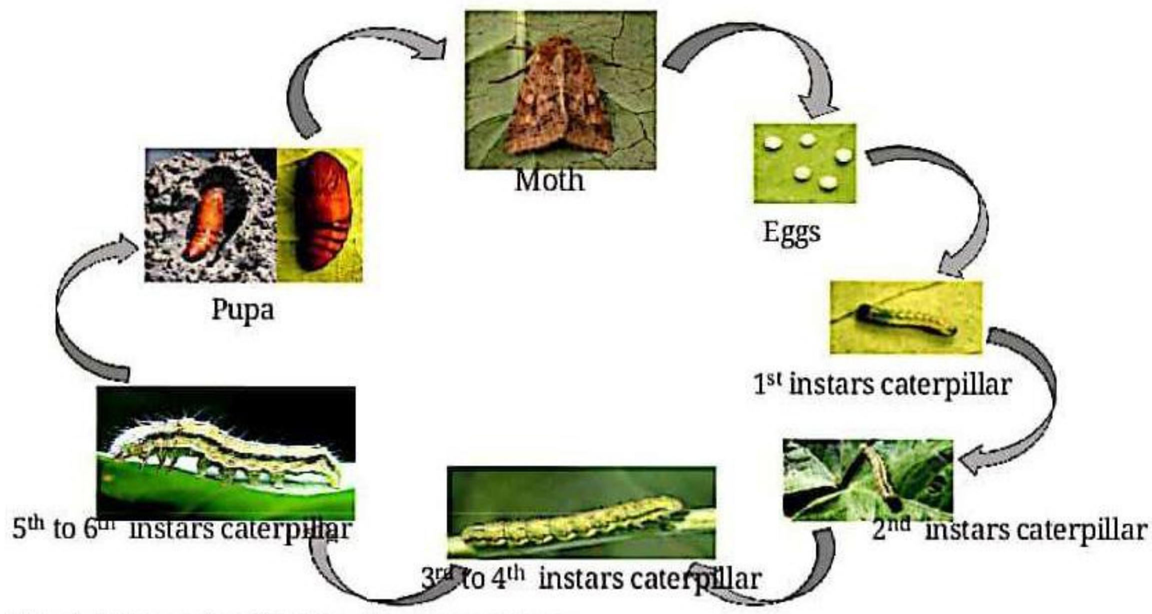

Plate 1: Life cycle of *Helicoverpa armigera* (Mahmood *et al.*, 2021).

2.4 Host plants of capsicum fruit borer

Capsicum fruit borer is a highly polyphagous species, feeding primarily on ornamental plants and flowers. Asteraceae (N= 50 genera), Fabaceae (N=42 genera), and Poaceae (N=14 genera) are ranked as the top preference (Cunningham and Zalucki, 2014). It has a preference for nitrogen-rich, harvestable fruiting parts of valuable crops. Among the numerous economically important hosts are: cotton, tobacco, tomatoes, potatoes, maize, flax, soybean, sorghum, lucerne, *Phaseolus*, chickpeas, other Leguminosae, and a number of fruits (*Prunus*, *Citrus*) and forest trees (Li *et al*., 2017).

2.5 Nature of damage of capsicum fruit borer

The capsicum fruit borer larvae cause direct damage to capsicum plants by feeding on the fruits. They create tunnels within the fruit, leading to rotting and decay. The affected fruits become unmarketable, reducing the crop's yield and quality. In addition, the entry points created by the larvae can serve as entry points for secondary infections, further compounding the damage (Rahman *et al*., 2022).

2.6 Management of capsicum fruit borer

Cultural management

A number of cultural practices such as time of sowing, spacing, fertilizer application, deep ploughing, interculture, clean cultivation, field sanitization and flooding have been reported to reduce the survival and damage by *Helicoverpa* species. Inter-cropping or strip-cropping with marigold, sunflower, linseed, mustard, or coriander can minimize the extent of damage to the main crop. Strip-cropping also increases the efficiency of chemical control. Hand-picking of large larvae can reduce *Helicoverpa* damage. However, the adoption of cultural practices depends on the crop husbandry practices in a particular agro-ecosystem. The chickpea trap crop is planted after the commercial crops to attract *H. armigera* emerging from winter diapause. The trap crops are destroyed before larvae commence pupation. As a result, the overall *H. armigera* pressure on vegetable crops is reduced, resulting in greater opportunity for adoption of soft control options, reduced insecticide use, and greater activity of the natural enemies (Patil *et al*., 2017).

Biological management

The major microorganisms causing diseases in *H. armigera* are bacteria, fungi and virus (Swodesh and Bhishma, 2019). They may cause diseases that kill insects, reduce their growth and development. Moreover different parasitoids and predators act as natural enemies of H. armigera, affecting the egg, larval, and pupal stages.. In China, *Trichogramma chilonis* has been shown to be the main egg parasitoid of *H. armigera* in cotton (Liu *et al.*, 2016). Fathipour *et al*. (2020) suggest that natural enemies provide considerable benefit in soybean, but cannot control *H. armigera* populations alone, especially in areas prone to migratory invasions. Moore *et al*. (2004) tested the potential of nuclear polyhedrosis virus (NPV) for the biocontrol of the pest in citrus tree, while Jeyarani *et al.* (2010) showed the same pattern for biocontrol in cotton and chickpeas. *B. thuringiensis* has been shown to considerably reduce European populations of *H. armigera* (Avilla *et al.*, 2005). Recently (Chen *et al*., 2020) a new virus with potential for biocontrol of *H. armigera* has been identified, *Heliothis virescens ascovirus 3i* (HAV-3i).

Mechanical management

Mechanical control, which includes the removal of infested fruits, is a safe and inexpensive control method. It was discovered that the larvae of this insect can be successfully controlled by using this method. However, a mechanical method combined with the spraying of botanical pesticides may yield better results (Nazim *et al*., 2002).

Chemical management

Insecticides such as Synthetics Pyrethroids, Fenvalerate, Deltamethrin, Cypermethrin, Endosulphan, Methyl parathion, Phosphamide etc have been used in various concentrations for management of *H. armigera* (Neupan and Sah, 1988). but endosulsulfan is most effective among them (Talekar *et al*., 2006). Application of endosulphon has increased 92% yield of tomato than non application. Flubediamide and Emamectin benzoate are novel insecticide for *Helicoverpa* management. Experiment conducted by Regmi., *et al*. in Chitwan, Nepal concluded that Flubendiamide 40SC @ 0.21ml/ltr is most effective against Helicoverpa (Regmi *et al*., 2018).

2.7 Eco-friendly pest management (EPM)

The purpose of eco-friendly pest management (EPM) can be the use of all available means to maintain pest populations below levels that would cause least economic loss while minimally impacting the environment. The tactics utilized in EPM programmers' include bio-pesticide, cultural, physical, and biological control of insect pest of capsicum (Deepika *et al*., 2016).

2.8 Eco-friendly pest management of capsicum fruit borer

Rahman *et al*. (2022) reported that application of Spinosad (Success 2.5 SC) was successful in controlling capsicum fruit borers (*Helicoverpa armigera* Hubner and *Spodoptera litura* Fab.) and reducing insect infestation while providing higher yield of capsicum fruit compared to other treatments under study. Among the different treatments as a whole, bio-pesticides were found to be effective against controlling fruit borer of Capsicum.

Singh *et al*. (2022) revealed that in tomato, application of Spinosad 45 SC formulation @ 75 g a.i./ha was found to be effective in protecting the crop and increased the yield of healthy fruits by 34.50 and 36.16% and minimized the yield loss by 35.57 and 36.26% during both the years, respectively.

Amandeep and Singh (2021) carried out an experiment to study the efficacy of chlorantraniliprole 18.5SC and spinosad 45SC was evaluated against the fruit borer *Helicoverpa armigera* (Hubner) in chilli crop during 2017 and 2018 at the Entomological Research Farm, Punjab Agricultural University, Ludhiana. Both the insecticides were found to be significantly superior, with chlorantraniliprole 18.5SC and spinosad 45SC @ 125ml/ha being the most effective, achieving less infestation as compared to their lower doses. Fruit yield was also significantly maximum with these treatments giving higher returns.

Morsy (2021) reported that in coton 11 g a.i./ha of EB (emamectin benzoate 5 SG) was the active dose for controlling the larval population of *H. armigera*. This dose caused a 64.75% reduction of boll damage over an untreated check at the end of observation in the field experiment. The yield ranged from 16.00 to 19.66 q/ha in all treatments. EB at 15 g a.i./ha was a very effective dose which was on par with the final results of 11 g a.i./ha. Entirely EB treatments augmented seed cotton yield under field conditions as compared to the control plot. The study demonstrates the potentiality of EB as an eco-friendly bioinsecticide against the American bollworm. The effective doses of EB @ 11and 15 g a.i./ha should be used in the cotton field to manage the infestation of *H. armigera.*

Islam *et al*. (2020) found that all the tested biopesticides significantly reduced the fruit infestation caused by *H. armigera* and thereafter increased the marketable yield of tomato. However, the Spinosad was found as the most effective biopesticide considering the reduction of percent fruit infestation, increasing the fruit yield and decreasing the infested fruit yield which was followed by Emamectin benzoate, Abamectin, Cartap, and L. lecanii, respectively. The highest percentage of healthy fruits (81.82%) and the lowest fruit infestation (18.18%) were recorded when the tomato plants were treated with the Spinosad.

Mannan *et al.* (2020) conducted an experiment at Regional Agricultural Research Station, Jamalpur during the period from September 2017 to March 2018 to find out the appropriate management approach for controlling major insect pests in chilli. Spraying of Spinosad (Success 2.5SC) and Abamectin (Toximite 1.8EC) along with blue & yellow sticky traps was found effective for controlling sucking insect pest in chilli. Mass trapping of *Spodoptera litura* and *Helicoverpa armigera* along with the spraying SNPV and HNPV @ 0.2g/l of water and Spinosad (Success 2.5SC) @ 1.2ml/l of water was found effective for controlling borer complex of chilli. A long-term pest population decrease is not achieved through only spraying chemical insecticides. In contrast, mass trapping with pheromone lures along with different bio-pesticides are eco-friendly, inexpensive, reliable and it facilitates the Integrated Pest Management (IPM) concept.

Biswas *et al.* (2019) conducted an experiment during the period of December 2014 to March, 2015 in the Entomology Field Laboratory, Department of Entomology, Bangladesh Agricultural University on the management of tomato fruit borer, *Helicoverpa armigera* (Hübner) using different biorational insecticides on winter tomato variety BARI-2 in Bangladesh. Experimental result revealed that application of Emamectin benzoate 5 SG provided the best result with the lowest cumulative mean percentage fruit infestation (20.95% and 17.24% based on number and weight, respectively). Percentage reduction of infested fruit was the highest (57.50 and 62.38%, by number and weight, respectively) in Emamectin treated plots. Similarly the highest percentage protection (58.99 and 63.06% by number and weight, respectively) of infested fruit was also found from the Emamectin benzoate treatment.

Havanoor and Rafee (2018) reported that application of spinosad 45 SC @ 0.1 ml/l recorded the lowest fruit borers population (0.18/plant) in chilli plant.

Agale *et al.* (2017) conducted a laboratory experiment to evaluate the efficacy of different biopesticides against the second instar larva of *Helicoverpa armigera* at International Crops Research Institute for the Semi-Arid Tropics during 2016-2017. Varied doses of biopesticides were used during experiment against second instar larvae of *H. armigera* and recorded the per cent morality. Among the selected biopesticides neem seed powder, HaNPV and Spinosad showed superior and recorded maximum percent morality at 24 hr and 48 hr day after release. The metarhizium anisopliae, Streptomyces sp. and consortia were at par with each other.

Roy and Sarkar (2017) evaluated the new molecules against the chilli pest complex and its safety towards natural enemies and reported that, Chlorfenapyr 10 SC @ 90 g.a.i/ha and Diafenthiuron 50 WP at 400 g.a.i./ha were efficient in recording the maximum per cent reduction of thrips (84.6 and 83.2), mites (74.1 and 72.3) and fruit borer (72.3 and 75.2) and also found that, these molecules were safe to the natural enemies by recording maximum population of coccinellid, *Coccinella septumpunctata* (Linn.) (3.3 and 5.8 per plant), *Chilomenos sexmaculatus* (4.0 and 5.2 per plant).

Baikar and Naik (2016) conducted a laboratory experiment was conducted to test the efficacy of some insecticides against fruit borer, Helicoverpa armigera (Hubner) infesting chilli. The data on mean corrected mortality (%) of third instar larvae of H. armigera at 24, 48 and 72 hours after treatment (HAT) were recorded. The result at 24 HAT revealed that the treatment emamectin benzoate (0.002 %) recorded 36.67 percent corrected mortality of fruit borer, *H. armigera* and was found to be the best treatment which was at par with spinosad (0.014 %) by recording 30.00 percent corrected mortality, while zero per cent corrected mortality was recorded in azadirachtin (0.003 %), Bacillus thuringiensis (Berliner) var. kurstaki (2 g/lit.) and untreated control. The observations recorded at 48 HAT revealed that the highest corrected mortality (76.67 %) of fruit borer, *H. armigera* was recorded in the treatment of emamectin benzoate 0.002 percent. The lowest corrected mortality (0.00 %) was recorded in the treatment of azadirachtin 0.003 percent which was at par with untreated control (0.00 %). After 72 HAT, it was revealed that the highest corrected mortality (96.30 %) was recorded in the treatment of emamectin benzoate 0.002 percent which was at par with spinosad (0.014 %) by recording 92.59 per cent corrected mortality. The lowest corrected mortality (0.00 %) was recorded in azadirachtin 0.003 percent and untreated control.

Singh and Aggarwal (2016) reported that the fruit borer, *Helicoverpa armigera* (Hübner) is the most destructive insect pest that devastates the crop of bell pepper, a widely consumed vegetable in India. In an effort to control its spread, they tested a spectrum of pesticides and showed that under field conditions, and emamectin benzoate are most efficient in reducing larval population percent fruit infestation with highest number of healthy fruits in these treatments. Based on weight of fruits of bell pepper per plant, spinosad and emamectin benzoate are found to be most effective. Treatments with spinosad and emamectin benzoate provide highest marketable fruit yields with highest B: C ratio recorded in plots treated with spinosad and emamectin benzoate.

Carneiro *et al.* (2014) performed an experiment with different chemical groups including the Spinosad demonstrated that Spinosad was highly effective to produce the highest yield of tomato. Spinosad also produced the highest percentage increase of healthy fruit over control by number (80.51%) percentage increase of healthy fruits over control by weight (81.45%) and increased yield over control (80.63%).

Sarkar *et al.* (2015) caried out an experiment to evaluated different bio-pesticides against red cotton bug (*Dysdercus koenigii* F.) and fruit borer (*Helicoverpa armigera* H.) in okra at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal during pre-kharif season of 2013. Results revealed that lowest mean fruit damage (1.05%) was recorded in spinosad treated plots followed by B.t. (7.88%). Highest marketable yield of okra was also recorded in spinosad treated plots (53.67 q/ha) followed by B.t. (42.26 q/ha), *B. bassiana* (39.28 q/ha) and azadirachtin (37.92 q/ha), respectively. Whereas, the yield obtained from untreated control plots was only 24.81 q/ha.

Sreekant *et al.* (2014) experimented on the efficacy of new insecticides against H. armigera, viz, chlorantraniliprole 20SC, flubendiamide 480SC and spinosad 45SCand found that these are effective against *Helicoverpa armigera* population management.

Gandhi *et al.* (2013) in his experiment carried out comprising of sorghum hybrid CSH-16 to evaluate the bio-efficacy of spinosad 45SC (0.1ml/l), cyppermethrin 10 EC(0.5ml/l, novaluran 10EC (1ml/l), azadirachtin 5% and *Bacillus thuringiensis* (1ml/l) insecticides against earhead caterpillar *Helicoverpa armigra* in sorghum. Spinosad 45SC (0.1ml/l), novaluran 10EC (1ml/l) and azadirachtin 5% emerge as superior by recording 72.0, 66.0 and 63.0% population reduction a grain loss of 43.46, 42.23 and 41.16 q/ha, respectively.

Rahman *et al.* (2011) carried out an experiment on testing the comparative efficacy of some chemical insecticides and botanicals against chilli fruit borer, *H. armigera* in

Bangladesh and reported highest benefit cost ratio (BCR) (3.51) in the treatments of neem leaf extract @ 0.5 kg/2 litre of water at 7 days interval. On the other, hand the minimum benefit cost ratio (1.21) was recorded in treatment with application of diazinon @ 6.0 ml/2 litre of water at 7 days interval.

Roopa and Kumar (2011) revealed that the biorationalinsectides viz. spinosad and emamectin benzoate arevery effective for the management of pest of fruit borer in bell pepper.

Vojoudi *et al.* (2011) evaluated the effect of biorarionals for the control of *H. armigera* where they found that Spinosad showed good performance against this pest and in increasing of healthy fruit number.

Ghosh *et al.* (2010) studied on bio-efficacy of spinosad against tomato fruit borer. They reported that spinosad was effective against *H. armigera* on tomato at 73 to 84 gm a.i./ha than quinalphos, lambda cyhalothrin and cypermethrin.

Singh and Chander (2009) found that plots treated with spinosad 45 SC @ 75g a.i./ha had reduced bollworm damage in cotton

Kuttalam *et al*. (2008) tested the efficacy of different doses of flubendiamide 480 SC at 24, 36 and 48 g a.i./ha, indoxacarb 14.5 SC at 75 g a.i./ha and spinosad 2.5 SC at 75 g a.i./ha against fruit borer *H. armigera* in tomato. They observed that flubendiamide, indoxacarb and spinosad were significantly superior to untreated control in reducing *H. armigera*, population and mean fruit damage in tomato. While flubendiamide 480 SC at 48 g a.i./ha recorded lowest population of *H. armigera* than other remaining treatments.

Ravi *et al.* (2008) worked on the efficacy of different sequential application of microbials *viz., Ha*NPV @ 1.5x1012 POB/ha, *Bacillus thuringiensis* var. *kurstaki*, spinosad 45 SC @ 75 g a.i./ha and neem (neemazol 1.2 EC @ 1000 ml/ha) against *H. armigera* in comparison with sequential application of synthetic insecticides and untreated control on tomato. They found that different sequential application of microbials and neeml were equally effective as that of sequential application of synthetic chemical insecticides *viz.*, endosulfan 35 EC @ 350 g a.i./ha, quinalphos 25 EC @ 250 g a.i./ha and indoxacarb 14.5

SC @ 75 g a.i./ha in reducing *H. armigera* larval population and fruit damage.

Gundannavar *et al*. (2007) reported that the secondary metabolites from microbes are known to kill various insects including *H. armigera* and *S. litura*. Moreover, among the bacteria, Bacillus thuringiensis (Bt) is the most studied due to the efficacy of the toxins (cry toxins) it produces to kill the larvae of *H. armigera*.

Gupta (2007) studies the efficacy of indigenous products like neem leaf and seed kernel extract, neem oil, cow and buffalo butter milk, garlic and red pepper extract and biological pesticides *Bt.* against *H. armigera.* The result revealed the indigenous product, garlic + Red pepper. Cow butter milk, buffalo butter milk and biological insecticide *Bt.* Were highly effective and statically at per with chemical pesticides.

Patil *et al.* (2007) reported that indoxacarb @ 75 g a.i./ha and spinosad @ 50 g a.i./ha were found equally effective against bollworms by registering significantly lowest larval population of 1.55 and 1.59 larvae/plant, respectively followed by profenophos 50 EC @ 1000 g a.i./ha (1.84 larvae/plant) and quinalphos 25 EC 500 g a.i./ha (2.07 larvae/plant). The lowest damage to fruiting body was also noticed in spinosad and indoxacarb which gaves higher yield of 18.37 and 18.31 q ha^{-1}, respectively.

Siddegowda *et al.* (2006) tested the efficacy of spinosed 45 SC, indoxacarb 14.5 SC, profenofos 50 EC and chlorpyrifos 20 EC against *H. armigera.* Spinosad @ 22.5 g a.i./ha and indoxacarb @ 21.75 g a.i./ha recorded significantly lower pod damage (6.68 and 7.74%) as compared to other chemicals.

Singh and Yadav (2006) reported to keeping in view, the economic importance of the *H. armigera*, an investigation was laid out to assess the efficacy of three modern insecticides. One conventional insecticide two *Bt.* Based and three neem based formulation. Among bio-insecticides halt was found superior over biolep whereas significantly superior to neem based formulation. Among neem based formulation, nimbicidine showed best result.

Murray *et al.* (2005) reported that indoxacarb and spinosad were consistently superior to other tested insecticides against *H. armigera.*

Visalakshmi *et al*. (2005) reported that application of neem effectively reduced the oviposition by *H.armigera* throughout the cropping period. Among various IPM component, neem, HaNPV were as effective as endosulfan in reducing the larval population and pod damage.

Kumar and Prasad (2002) conducted a field trail at Research Farm of Birsa Agricultural University, Kanke, Ranchi to evaluate the efficacy of neem based insecticide and bio-pesticides against *Helicoverpa armigera* (Hub) infesting chickpea under the natural condition. Larval reduction ranging from 59.59 to 95.32 per cent, 67.17 to 94.86 percent, 67.17 to 92.49 per cent, 67.17 to 90.09 percent, 51.01 to 92.79 per cent and 51.01to 92.49 per cent were recorded with the application of flufenoxuron (Cascade 10 DC @ 200-300 ml/ha) cartap hydrochloride (Caldon 50 SP@ 1.0 kg/ha), HaNPV (Heliokill @ 500 ml/ha), Neem based Rakshak (5 L/ha), Rakshak gold (2 L/ha) and Bt. (Dipel 8L @1.0 L/ha) respectively, HaNPV was found to be the effective biopesticide recording lowest pod damage and highest grain yield of chickpea.

Satyavir and Yadav (2002) reported that in *H. armigera* neem oil inhibited the egg hatching by 88.3% when treated with 2.5% concentration and was only 13.3% when treated with 0.5% Neem oil was found effective against larvae of pod borer showing larval mortality 83.3% when fed with diet containing 5% neem oil LC50 for different instar of *S.litura* and *H. armigera* ranged from 1.97 to 1.38% Thus the quality neem oil holds high promise for the field control of *S. litura* and *H. armigera* on different crops under integrated pest management schedule.

Dandule *et al.* (2000) from their study proved that Spinosad was more effective in controlling the *H. armigera* than synthetic pyrethroids and increasing of fruit yield.

CHAPTER III

MATERIALS AND METHODS

A field experiment entitled "Incidence and Ecofriendly Management of Capsicum fruit borer" was conducted in the *Rabi* season. The predominant edaphic and climatic conditions during the crop period, selection of site, cropping history along with the criteria used for treatment evaluation and methods adopted during experimentation are presented in this chapter.

3.1 Experimental period

The experiment was conducted during the period from November, 2020 to April, 2021 in Rabi season.

3.2 Description of the experimental site

3.2.1 Geographical location

The experiment was conducted in the Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.2.2 Agro-Ecological Zone

The experimental site belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2.3 Soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.6 (Anon., 1989). The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0–15 cm depths were collected from the Sher-e-Bangla Agricultural University (SAU) Farm, field. The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The morphological and physicochemical properties of the soil are presented in Appendix-II.

3.2.4 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-III.

3.3 Planting material

BARI Misti Morich 2 was used as planting material for this experiment. The important characteristics of these are mentioned below:

Variety Releasing Institute : Bangladesh Agricultural Research Institute.

Characteristics of the species

- ❖ It weighs 80-90 grams.
- ❖ Attractive Bell shaped fruit.
- ❖ Glossy green fruit, yellow when ripe.
- ❖ There are 12-13 fruits per tree.
- ❖ Yield 15-20 tons per hectare.
- ❖ Life span: 125-135 days.

Plate 2. BARI Misti Morich 2

3.4 Collection of seed and raising seedling

The seeds of selected capsicum variety i.e. Yellow capsicum (bell pepper) seeds were collected from Siddik Bazar, Gulistan, Dhaka. Before sowing, the germination test of seeds was done and, on an average, 92% germination was found for this variety. Seeds were then sown in seedbed containing a mixture of equal proportion well decomposed cow-dung and loam soil. After sowing seeds, the seedbeds were irrigated regularly. After germination, the seedlings were sprayed with water by a hand sprayer. Soil was spaded 3 or 4 days a week.

3.5 Land preparation

Initially the field was prepared with the help of tractor drawn implement. After giving one deep ploughing the experimental field was cross harrowed and levelled properly to break the clods and bring the soil to the desired tilth. The plots were prepared manually for the transplanting of the subsequent crops for the experimental study. The land preparation was done at 9 November, 2020.

3.6 Fertilizer management

The following doses of fertilizer were applied for cultivation of sweet pepper (Saha, 2001).

Fertilizers	**Quantity (kg/ha)**
Cowdung	10000
Urea	250
TSP	350
MoP	250
Gypsum	110
Zinc oxide	5

The fertilizers N, P, K, S, and Zn were applied in the form of urea, TSP, MoP, gypsum, and zinc oxide, respectively. Initially, filed soil was mixed with half the amount of cowdung. During the final stage of land preparation, the remaining half of cowdung, the entire amount of TSP, ZnO, Gypsum, and one-third each of urea and MoP were applied. The remaining Urea and MoP were applied in two equal parts, *viz*, 25 and 50 days after field transplanting.

3.7 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 18 (6 × 3) unit plots altogether in the experiment. The size of each unit plot was 1.5 m × 1.5 m. Block to Block and plot to plot distances were 1 m and 0.5 m, respectively. The treatments of the experiment was distributed randomly among the experimental plots.

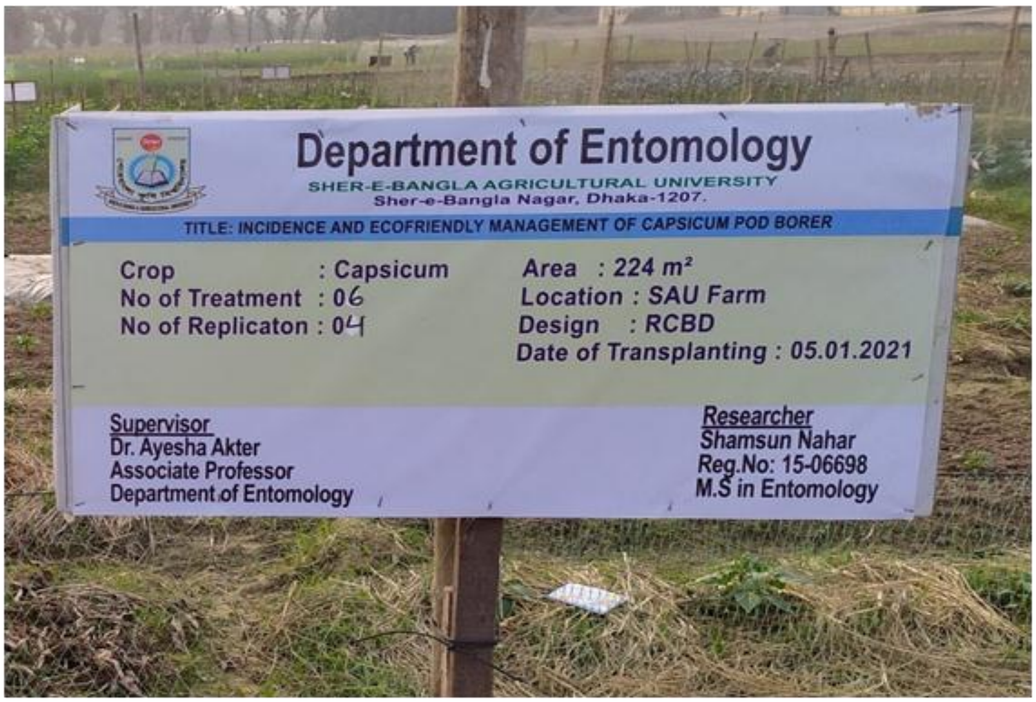

Plate 3: Experimental field during the study period

3.8 Seedling transplanting

Capsicum seedlings were transferred in polybags when they were 20 days old and healthy. The healthy transferred seedlings were then transplanted into the main field when they were 25 days old. Each plot contains 12 capsicum seedlings in two rows separated by 50 cm × 50 cm (row to row and plant to plant distances, respectively).

3.9 Experimental treatments

The experiment comprised six treatments including an untreated control. The details of the treatments are given below:

- ❖ T_1: Field sanitation + Netting
- ❖ T_2: Field sanitation + Rice straw mulch
- ❖ T_3: Field sanitation + Spinosad (Taccer)@ 0.5ml/L of water at the 7 days intervals
- ❖ T_4: Black polythene mulch + leaf extract of neem at the 7 days intervals
- ❖ T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals
- ❖ T_6: Control

3.10 Collection of straw mulch, white net, botanicals and bio-pesticides

White net and rice straw mulch were collected from the farm of Sher-e-Bangla Agricultural University, Dhaka, 1207. The fresh neem oil was collected from Chawkbazar, Dhaka and the trix liquid detergent was collected from the local market of Agargoan bazaar, Dhaka. Bio-pesticide Spinosad was collected from Bangladesh Jute Research Institute, Sher-e-Bangla Nagar, Dhaka.

Plate 4. Some insecticides which used as a treatment of research work

3.11 Intercultural operations

i. Application of irrigation water

Irrigation water was added to each pot according to the critical stage. It was given by using water pipe.

ii. Weeding

The crop was infested with some common weeds, which were controlled by uprooting and removed them three times from the pot during the period of experiment. Weeding was done after 20, 35 and 50 days after transplanting.

iii. Top dressing

The remaining two-third of urea and MoP were applied as top dressing in each plot by 2 installments.

iv. Earthing up

Earthing up process was done at two times, during crop growing period. First was done at 35 DAT and second was at 50 DAT.

3.12 Control of pest

For controlling the different insect-pest in the experimental field of capsicum different treatments of this experiment were followed.

3.13 Procedure of botanicals and bio-pesticides application

In a knapsack sprayer with a pressure of 4-5 kg cm^{-2}, the precise amount of each botanicals and bio-pesticides was added, thoroughly mixed with water, and sprayed on the appropriate plot as per treatment requirement. By using a measuring cylinder in the sprayer, the necessary dosage of botanicals and biological pesticides was taken.

3.14 Harvesting of Capsicum fruit

Harvesting of capsicum fruit was done on February to April, 2021. The capsicum of each plot was separately harvested, bagged and tagged and brought to the laboratory. Harvesting was done manually by hand.

3.15 Data collection

i. Incidence of fruit borer

Data on the number of insect pests on randomly selected six tagged plants per plot were collected and counted separately for each treatment.

ii. Total number of fruits

At each plot of the experiment, the mean weight of healthy fruits from six randomly chosen plants were measured.

iii. Number of borer infested fruits

At each plot of the experiment, the average number of fruits infested with borer from six randomly chosen plants was counted.

iv. Weight of healthy fruits

The average number of healthy fruits from six randomly selected plants from each plot were counted and weighed using an electric precision balance, and the mean value was calculated as the method for measuring the weight of capsicum healthy fruits.

v. Weight of borer infested fruits

The average number of infested fruits from six randomly selected plants from each plot were counted and weighed using an electric precision balance, and the mean value was calculated as the method for measuring the weight of capsicum healthy fruits.

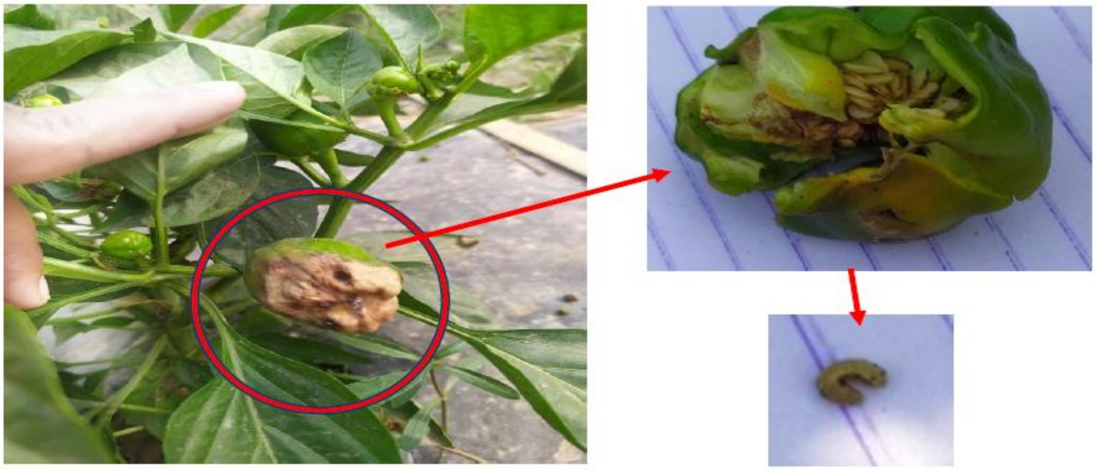

Plate 05: Fruit borer infested rotted capsicum fruit

vi. Infestation percentage

At various growth stages, the total number of healthy and infested fruits from six selected plants from each plot were counted. Infestation was recorded at each observation, then pooled and expressed as a percentage.

The percentage of damages was calculated using the following formula:

$$\% \text{ fruit infestation (by number)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

$$\% \text{ fruit infestation (by weight)} = \frac{\text{Weight of infested fruits}}{\text{Total weight of fruits}} \times 100$$

Increase or reduction over control was calculated using the following formula:

$$\% \text{ increase over control} = \frac{\text{Value in treated plot - Value in control plot}}{\text{Value in control plot}} \times 100$$

$$\% \text{ reduction over control} = \frac{\text{Value in control plot - Value in treated plot}}{\text{Value in control plot}} \times 100$$

vii. Yield plot^{-1}

The data on the weight of healthy and infested fruits for each treatment from whole plot along with their number and weight were recorded.

viii. Yield hectare^{-1}

On the basis of healthy and infested fruits the plot yield was transformed into fruit yields in ton per hectare.

3.16 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program name Statistix 10 Data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present study was carried out on Incidence and Ecofriendly Management of Capsicum fruit borer. Performance of six treatments was investigated and the findings of the present study have been discussed under different characters on infestation by insect pest. The result of the study showed marked variation in different characters and the variation of different characters are presented in the following Tables, Figures and Plates.

4.1 Incidence of Capsicum fruit borer

4.1.1Number of fruit borer

At the early Fruiting stage of Capsicum, the consequence of different treatments on the number of fruit borer/6 plant has been shown in **Table 1**. From this table it was revealed that, the lowest number of fruit borer/6 plant (2.67) was recorded from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which statistically different from all others treatment and closely followed by (3.33) in T_5 (Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (Mulching + leaf extract of neem at the 7 days intervals treatment, whereas the highest number of fruit borer/6 plant (12.67) was recorded from T_6 (Untreated control) treatment.

In case of number of fruit borer/6 plant at the mid fruiting stage of Capsicum, the highest number of fruit borer/6 plant were collected from (30.96) T_6 (Untreated control) which was statistically different from all others treatment. On the other hand, the lowest number of number of fruit borer/6 plant were collected from (4.75) T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (5.67) in T_5 (Ield sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (Mulching + leaf extract of neem at the 7 days intervals) treatment (**Table 1**). Similar trends of result found from late fruiting stage of Capsicum.

In the same way, the lowest average number of number of fruit borer/6 plant (4.36) were observed from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (5.08) and (5.89) in T_5(field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (Black polythene + leaf extract of neem at the 7 days intervals) treatment respectively. On the other hand, the highest average number of number of fruit borer/6 plant (21.43) were observed from T_6 (Untreated control) which was closely followed by (7.30) in T_1treatment.

The results in **table 1** showed significant variations due to the Incidence and Ecofriendly Management of Capsicum fruit borerat the total Fruiting stage of Capsicum. Among different treatment, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (79.65%) due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1(Field Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (65.94%) was recorded on capsicum (**Table 1)**.

As a result, the order of incidence and ecofriendly management of Capsicum fruit borerterms of fruit infestation reduction at Fruiting stage of Capsicum is T_3>T_5> T_4> T_2> T_1>$T_{6.}$

Table 1: Incidence and Ecofriendly Management of Capsicum fruit borer on the basis of number of fruit borer at total Fruiting stage of Capsicum

Treatments	Number of fruit borer per 6 plants			Average	Reduction over control (%)
	Early fruiting stage	Mid fruiting stage	Late fruiting stage		
T_1	5.23 b	8.17 bc	8.50 b	7.30 bc	65.94
T_2	4.95 b	7.67 c	8.25 b	6.96 bc	67.52
T_3	2.67 e	4.75 e	5.67 d	4.36 e	79.65
T_4	3.75 c	6.25 c	7.67 bc	5.89 c	72.52
T_5	3.33 de	5.67 de	6.25 c	5.08 de	76.29
T_6	12.67 a	30.96 a	20.67 a	21.43 a	---
$LSD_{(0.05)}$	1.08	2.56	1.34	1.79	--
CV(%)	10.76	11.45	9.71	9.22	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications.

[Treatment T_1:field Sanitation + Netting; T_2: Field sanitation + straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.1.2 At the early fruiting stage of Capsicum

At the early fruiting stage of Capsicum, the consequence of different treatments on the number of healthy fruits/6 plant has been shown in **Table 2**. From this table it was revealed that, the highest number of healthy fruits/6 plant (27.25) was recorded from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which statistically different from all others treatment and closely followed by (26.25) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment, whereas the lowest number of healthy fruits/6 plant (17.33) was recorded from T_6 (Untreated control) treatment.

In case of number of infested fruits/6 plant at the early fruiting stage of Capsicum, the highest number of infested fruits/6 plant were collected from (10.75) T_6 (Untreated control) which was statistically different from all others treatment. On the other hand, the lowest number of infested fruits/6 plant were collected from (1.50) T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (2.33) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene+ leaf extract of neem at the 7 days intervals treatment (**Table 2**).

In the same way, the lowest percent of infestation (5.22) were observed from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (8.15) and (9.79) in T_5(field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment respectively. On the other hand, the highest percent of infestation (38.28) were observed from T_6 (Untreated control) which was closely followed by (12.77) in T_1treatment.

From the results in **table 2** showed significant variations due to the Incidence and Ecofriendly Management of Capsicum fruit borer at the early fruiting stage of Capsicum. Among different traps, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (86.37%) of infestation due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1(field Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (66.65%) was recorded on capsicum (T_1)

As a result, the order of incidence and ecofriendly management of Capsicum fruit borer terms of fruit infestation reduction at early fruiting stage of Capsicum is $T_3 > T_5 > T_4 > T_2 > T_1 > T_{6.}$

Table 2: Effect of different treatments on the basis of infested fruits and fruit infestation by number at early fruiting stage of Capsicum

Treatments	Number of fruits/6 plant		% infestation	Infestation reduction over control (%)
	Healthy fruits (No.)	Infested fruits (No.)		
T_1	22.75 cd	3.33 bc	12.77 b	66.65
T_2	24.25 bc	3.25 bc	11.82 b	69.13
T_3	27.25 a	1.50 e	5.22 e	86.37
T_4	25.33 ab	2.75 cd	9.79 c	74.42
T_5	26.25 ab	2.33 de	8.15 d	78.70
T_6	17.33 e	10.75 a	38.28 a	--
$LSD_{(0.05)}$	2.31	0.90	0.98	--
CV(%)	5.52	9.82	3.83	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications.
[Treatment T_1: field Sanitation + Netting; T_2: Field sanitation + straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.1.3 At the mid fruiting Stage of Capsicum

At the mid fruiting stage of Capsicum, the consequence of different treatments on the number of healthy fruits/6 plant has been shown in **Table 3**. From this table it was revealed that, the highest number of healthy fruits/6 plant (58.67) was recorded from T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) which statistically different from all others treatment and closely followed by (56.75) in T_5 (Ield sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (Mulching + leaf extract of neem at the 7 days intervals treatment, whereas the lowest number of healthy fruits/6 plant (42.25) was recorded from T_6 (Untreated control) treatment.

In case of number of infested fruits/6 plant at the mid fruiting stage of Capsicum, the highest number of infested fruits/6 plant were collected from (25.67) T_6 (Untreated control) which was statistically different from all others treatment. On the other hand, the lowest number of infested fruits/6 plant were collected from (3.33) T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (3.75) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment (**Table 3)**.

In the same way, the lowest percent of infestation (5.37) were observed from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (6.20) and (8.44) in T_5(field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment respectively. On the other hand, the highest percent of infestation (37.79) were observed from T_6 (Untreated control) which was closely followed by (10.91) in T_1treatment.

From the results in **table 3** showed significant variations due to the incidence and ecofriendly management of Capsicum fruit borer at the mid fruiting stage of Capsicum. Among different traps, T_3 (Field sanitation + Spinosad (Traccer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (85.79%) of infestation due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1 (field Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (71.12%) was recorded on capsicum (**Table 3**).

As a result, the order of Incidence and Ecofriendly Management of Capsicum fruit borer in terms of fruit infestation reduction at mid fruiting stage of Capsicum is T_3>T_5> T_4> T_2> T_1> $T_{6.}$

Table 3:Effect of different treatments on Capsicum fruit borer at mid fruiting stage of Capsicum

Treatments	Number of fruits/6 plant		% infestation	Infestation reduction over control (%)
	Healthy fruits (No.)	Infested fruits (No.)		
T_1	51.67 c	6.33 bc	10.91 bc	71.12
T_2	52.33 bc	5.33 cd	9.24 cd	75.54
T_3	58.67 a	3.33 f	5.37 e	85.79
T_4	54.25 b	5.00 de	8.44 d	77.67
T_5	56.75 a	3.75 ef	6.20 e	83.60
T_6	42.25 d	25.67 a	37.79 a	--
$LSD_{(0.05)}$	2.12	1.29	1.79	--
CV(%)	2.28	9.05	7.86	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications.
[Treatment T_1:Field Sanitation + Netting; T_2: Field sanitation +straw mulchl; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.1.4 At the late fruiting stage of Capsicum

At the late fruiting stage of Capsicum, the consequence of different treatments on the number of healthy fruits/6 plant has been shown in **Table 4**. From this table it was revealed that, the highest number of healthy fruits/6 plant (42.25) was recorded from T_3(Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which statistically different from all other treatments and closely followed by (39.33) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment, whereas the lowest number of healthy fruits/6 plant (31.67) was recorded from T_6 (Untreated control) treatment.

In case of number of infested fruits/6 plant at the late fruiting stage of Capsicum, the highest number of infested fruits/6 plant were collected from (17.75) T_6 (Untreated control) which was statistically different from all others treatments. On the other hand, the lowest number of infested fruits/6 plant were collected from (3.33) T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (3.67) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment (**Table 4**).

In the same way, the lowest percentage of infestation (7.31) were observed from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (8.53) and (11.05) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (Mulching + leaf extract of neem at the 7 days intervals treatment respectively. On the other hand, the highest percent of infestation (35.92) were observed from T_6 (Untreated control) which was closely followed by (13.19) in T_1treatment.

From the results in **table 4** showed significant variations due to the Incidence and ecofriendly management of Capsicum fruit borer at the late fruiting stage of Capsicum. Among different traps, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (79.66%) of infestation due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1 (Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (63.29%) was recorded on capsicum (**Table 4**).

As a result, the order of incidence and ecofriendly management of Capsicum fruit borer terms of fruit infestation reduction at latefruiting stage of Capsicum is T_3> T_5> T_4> T_2> T_1> $T_{6.}$

Table 4:Effect of different treatments on Capsicum fruit borer at the late fruiting stage of Capsicum

Treatments	Number of fruits/6 plant		% infestation	Infestation reduction over control (%)
	Healthy fruits (No.)	Infested fruits (No.)		
T_1	37.33 b	5.67 bc	13.19 b	63.29
T_2	37.75 b	5.25 c	12.21 bc	66.01
T_3	42.25 a	3.33 d	7.31 d	79.66
T_4	38.25 b	4.75 c	11.05 c	69.24
T_5	39.33 b	3.67 d	8.53 d	76.24
T_6	31.67 c	17.75 a	35.92 a	--
$LSD_{(0.05)}$	2.76	0.93	1.47	--
CV(%)	4.13	7.82	5.61	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications
[Treatment T_1:field Sanitation + Netting; T_2: Field sanitation + straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.2 Incidence of Capsicum fruit borer at weight basis

4.2.1 At the early fruiting stage of Capsicum

At the early fruiting stage of Capsicum, the consequence of different treatments on the weight of healthy fruits/6 plant has been shown in **Table 5**. From this table it was revealed that, the highest weight of healthy fruits/6 plant (2.32 kg) was recorded from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (2.11 kg) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and (2.02 kg) T_4 black polythene + leaf extract of neem at the 7 days intervals treatment, whereas the lowest weight of healthy fruits/6 plant (1.24 kg) were recorded from T_6 (Untreated control) treatment.

In case of weight of infested fruits/6 plant at the early fruiting stage of Capsicum, the highest weight of infested fruits/6 plant were collected from (712 g) T_6 (Untreated control) which was statistically different from all other treatments. On the other hand, the lowest weight of infested fruits/6 plant were collected from (128 g) T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (209 g) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment (**Table 5**).

In the same way, the lowest percentage of infestation on weight basis (5.23) were observed from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (9.01) and (11.29) in T_5(field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals) treatment respectively. On the other hand, the highest percentage of infestation on weight basis (36.48) were observed from T_6 (Untreated control) which was closely followed by (14.85) in T_1treatment.

From the results in **Table 5** showed significant variations due to the incidence and ecofriendly Management of Capsicum fruit borer at the early fruiting stage of Capsicum. Among different traps, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (85.66%) of infestation on weight basis due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1(field Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (59.30%) was recorded on capsicum (**Table 5)**.

As a result, the order of Incidence and Ecofriendly Management of Capsicum fruit borer terms of fruit infestation reduction at early fruiting stage of Capsicum is T_3>T5> T_4> T_2> T_1> $T_{6.}$

Table 5: Incidence and Ecofriendly Management of Capsicum fruit boreron the basis of infested fruits and fruit infestation by weight at early fruiting stage of Capsicum

Treatments	Weight of fruits/6 plant		% infestation	Infestation reduction over control (%)
	Healthy fruit (kg)	Infested fruit (g)		
T_1	1.87 cd	326 b	14.85 b	59.30
T_2	1.95 b-d	302 c	13.41 b	63.23
T_3	2.32 a	128 f	5.23 e	85.66
T_4	2.02 bc	257 d	11.29 c	69.06
T_5	2.11 b	209 e	9.01 d	75.29
T_6	1.24 e	712 a	36.48 a	--
$LSD_{(0.05)}$	0.19	13.03	1.62	--
CV(%)	5.74	2.21	5.93	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications

[Treatment T_1: Sanitation + Netting; T_2: Field sanitation + Mulching of soil; $T_{3:}$ Field sanitation + Spinosad (Taccer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ Mulching + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.2.2 At the mid fruiting stage of Capsicum

At the mid fruiting stage of Capsicum, the consequence of different treatments on the weight of healthy fruits/6 plant has been shown in **Table 6**. From this table it was revealed that, the highest weight of healthy fruits/6 plant (5.25 kg) was recorded from T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (4.93 kg) in T_5 (Ield sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and (4.72 kg) T_4 (Mulching + leaf extract of neem at the 7 days intervals treatment, whereas the lowest weight of healthy fruits/6 plant (3.14 kg) was recorded from T_6 (Untreated control) treatment.

In case of weight of infested fruits/6 plant at the mid fruiting stage of Capsicum, the highest weight of infested fruits/6 plant were collected from (1832 g) T_6 (Untreated control) which was statistically different from all others treatment. On the other hand, the lowest weight of infested fruits/6 plant were collected from (329 g) T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (422 g) in T_5 (Ield sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (Mulching + leaf extract of neem at the 7 days intervals treatment (**Table 6**).

In the same way, the lowest percent of infestation on weight basis (5.90) were observed from T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (7.44) and (8.21) in T_5 (Ield sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (Mulching + leaf extract of neem at the 7 days intervals treatment respectively. On the other hand, the highest percent of infestation on weight basis (36.85) were observed from T_6 (Untreated control) which was closely followed by (10.71) in T_1treatment.

From the results in **Table 6** showed significant variations due to the Incidence and Ecofriendly Management of Capsicum fruit borer at the mid fruiting stage of Capsicum. Among different traps, T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (84.00%) of infestation on weight basis due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1 (Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (73.14%) was recorded on capsicum (**Table 6)**.

As a result, the order of incidence and ecofriendly management of Capsicum fruit borer in terms of fruit infestation reduction at mid fruiting stage of Capsicum is T_3> T_5> T_4> T_2> T_1> $T_{6.}$

Table 6: Incidence and Ecofriendly Management of Capsicum fruit borer on the basis of infested fruits and fruit infestation by weight at mid fruiting stage of Capsicum

Treatments	Weight of fruits/6 plant		% infestation	Infestation reduction over control (%)
	Healthy fruit (kg)	Infested fruit (g)		
T_1	4.11 bc	493 bc	10.71 b	70.93
T_2	4.27 bc	469 c	9.90 b	73.14
T_3	5.25 a	329 d	5.90 d	84.00
T_4	4.72 a-c	422 cd	8.21 c	77.73
T_5	4.93 ab	396 cd	7.44 c	79.82
T_6	3.14 d	1832 a	36.85 a	--
$LSD_{(0.05)}$	0.86	105.05	1.36	--
CV(%)	7.11	9.15	5.84	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications
[Treatment T_1: field Sanitation + Netting; T_2: Field sanitation + straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.2.3 At the late fruiting stage of Capsicum

At the late fruiting stage of Capsicum, the consequence of different treatments on the weight of healthy fruits/6 plant has been shown in **Table 7**. From this table it was revealed that, the highest weight of healthy fruits/6 plant (3.58 kg) was recorded from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (3.42 kg) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and (3.19 kg) T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment, whereas the lowest weight of healthy fruits/6 plant (2.06 kg) were recorded from T_6 (Untreated control) treatment.

In case of weight of infested fruits/6 plant at the late fruiting stage of Capsicum, the highest weight of infested fruits/6 plant were collected from (1036 g) T_6 (Untreated control) which was statistically different from all others treatment. On the other hand, the lowest weight of infested fruits/6 plant were collected from (212 g) T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) which was closely followed by (275 g) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment (**Table 7**).

In the same way, the lowest percent of infestation on weight basis (5.59) were observed from T_3 (Field sanitation + Spinosad (Traccer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (7.44) and (9.14) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene + leaf extract of neem at the 7 days intervals treatment respectively. On the other hand, the highest percent of infestation on weight basis (33.46) were observed from T_6 (Untreated control) which was closely followed by (12.05) in T_1treatment.

From the results in **table 7** showed significant variations due to the incidence and ecofriendly management of Capsicum fruit borer at the late fruiting stage of Capsicum. Among different treatments, T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (83.29%) of infestation on weight basis due to capsicum fruit borer and supported to make sure the more yield of capsicum. In the similar trend, T_1 (field sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (64.00%) were recorded on capsicum (**Table 7)**.

As a result, the order of Incidence and Ecofriendly Management of Capsicum fruit borer in terms of fruit infestation reduction at latefruiting stage of Capsicum is T_3> T_5> T_4> T_2> T_1> $T_{6.}$

Table 7: Effect of different treatments on management of Capsicum fruit borer on the basis of infested fruits and fruit infestation by weight at the late fruiting stage of Capsicum

Treatments	Weight of fruits/6 plant		% infestation	Infestation reduction over control (%)
	Healthy fruit (kg)	Infested fruit (g)		
T_1	3.03 de	415 bc	12.05 b	64.00
T_2	3.11 cd	350 cd	10.12 c	69.77
T_3	3.58 a	212 e	5.59 e	83.29
T_4	3.19 c	321 d	9.14 c	72.68
T_5	3.42 b	275 de	7.44 d	77.76
T_6	2.06 f	1036 a	33.46 a	--
$LSD_{(0.05)}$	0.13	80.60	1.56	--
CV(%)	2.36	10.32	6.71	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications
[Treatment T_1: field sanitation + Netting; T_2: Field sanitation + straw mulch ; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.3. Effect of different treatments against Capsicum fruit borer and its impact on yield contributing characters of Capsicum

Number of leaves: The impact of different treatments on number of leaf plant^{-1} of Capsicum has been shown in **Table 8**. Significant variations were observed among the treatments in terms of number of leaf plant^{-1} of Capsicum. The highest number of leaf plant^{-1} (50.22) were recorded in T_3 which was statistically similar with 48.32 in T_5, 47.75 in T_4 and followed by 45.33 in T_2 treatment.

On the other hand the lowest number of leaf plant^{-1} of Capsicum was 40.02 in T_6(Untreated control), which was statistically different from44.82 in T_1treatment.

From the above finding it was observed that, T_3(Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment was showed the best performance for the number of leaves plant^{-1} of Capsicum.

Total number of fruit plant^{-1}: The impact of different treatments on total number of fruit plant^{-1} of Capsicum has been shown in **Table 8**. Significant variations were observed among the treatments in terms of total number of fruit plant^{-1} of Capsicum. The highest total number of fruit plant^{-1} (14.82) were recorded in T_3 which was statistically similar with 14.02 in T_5, 13.58 in T_4 and followed by 13.33 in T_2 treatment.

On the other hand the lowest total number of fruit plant^{-1} of Capsicum was 11.16 in T_6(Untreated control), which was statistically different from 13.17 in T_1 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment was showed the best performance for the total number of fruit plant^{-1} of Capsicum.

Fruit length (cm): The impact of different treatments on length of healthy fruits of Capsicum has been shown in **Table 8**. Significant variations were observed among the treatments in terms of length of healthy fruits of Capsicum. The highest length of single healthy fruits (13.58 cm) were recorded in T_3 which was statistically similar with 13.35 cm in T_5, 13.29cm in T_4 and followed by 13.13 cm in T_2 treatment.

On the other hand the lowest length of single fruit of Capsicum was 11.48 cm in T_6(Untreated control), which was statistically different from 12.98 cm in T_1 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment was showed the best performance for the length of healthy fruits of Capsicum.

Fruit diameter (cm): The impact of different treatments on diameter of healthy fruits of Capsicum has been shown in **Table 8**. Significant variations were observed among the treatments in terms of diameter of healthy fruits of Capsicum. The highest diameter of single healthy fruits (4.82 cm) was recorded in T_3 which was statistically similar with 4.72 cm in T_5, 4.70 cm in T_4 and followed by 4.66 cm in T_2 treatment.

On the other hand the lowest diameter of single fruit of Capsicum was 4.36 cm in T_6(Untreated control), which was statistically similar4.63 cm in T_1 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment was showed the best performance for the diameter of healthy fruits of Capsicum.

Table 8. Effect of different treatments against Capsicum fruit borer and its impact on yield contributing characters of Capsicum

Treatments	Number of leaf	Total number of fruit/ plants	Fruit length (cm)	Fruit diameter (cm)
T_1	44.82 cd	13.17 b	12.98 ab	4.63 a
T_2	45.33 b-d	13.33 b	13.13 ab	4.66 a
T_3	50.22 a	14.82 a	13.58 a	4.82 a
T_4	47.75 a-c	13.58 b	13.29 a	4.70 a
T_5	48.32 ab	14.02 ab	13.35 a	4.72 a
T_6	40.02 e	11.16 c	11.48 b	4.36 a
$LSD_{(0.05)}$	3.04	1.23	1.79	0.74
CV(%)	3.74	5.21	7.76	8.92

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications

[Treatment T_1:field Sanitation + Netting; T_2: Field sanitation + straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.3.1. Effect of different treatments against Capsicum fruit borer of Capsicum on the basis of yield/ha during total cropping season

4.3.1.1 On the basis healthy fruits yield by weight during total cropping season

Significant variation was observed in terms of healthy fruit yield and increase of healthy fruit yield over control at the total cropping season of Capsicum. Result showned that the highest yield of healthy fruits (22.68 t/ha) was observed in T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (21.87 t/ha) in T_5 and (26.33 t/ha) in T_4treatment, whereas the lowest yield of healthy fruits (13.92 t/ha) was observed in untreated control (T_6) treatment which was followed by (25.12t/ha) in T_5 and in T_1treatments respectively.

In the same way, the per cent increase of healthy fruit yield over control during the cropping season of Capsicum were 46.30% in treatment T_3 followed by 30.18% in T_5treatment. The transitional per cent increase of yield over control was recorded in T_1(32.77%) treatment (**Table 9**).

4.3.1.2 On the basis infested fruits yield by weight during total cropping season

From **Table 9**, significant variation was observed in terms of infested fruit yield and decrease of infested fruit yield over control at the total cropping season of Capsicum.

Result showed that the lowest yield of infested fruits (0.75 t/ha) was observed in T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (0.93 t/ha) in T_5 and (1.06 t/ha) in T_4 treatment, whereas the highest yield of infested fruits (5.62 t/ha) were observed in untreated control (T_6) treatment which was followed by (1.52t/ha) in T_1 treatments respectively.

Similarly, the per cent decrease of infested fruit yield over control during the cropping season of Capsicum were 86.65% in treatment T_3(Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals)which was followed by 83.45% in T_5. The transitional per cent decrease of yield over control were recorded in T_1(72.95%) treatment.

Table 9. Effect of different treatments against Capsicum fruit borer of Capsicum on the basis of yield/ha during total cropping season

Treatments	Healthy fruit yield (t/ha)	Percent increase over control	Infested fruit yield (t/ha)	Percent decrease over control
T_1	20.12 bc	44.54	1.52 b	72.95
T_2	20.71 a-c	48.78	1.36 bc	75.80
T_3	22.68 a	62.93	0.75 d	86.65
T_4	21.33 a-c	53.23	1.06 cd	81.14
T_5	21.87 ab	57.11	0.93 cd	83.45
T_6	13.92c	--	5.62 a	--
$LSD_{(0.05)}$	2.14	--	0.43	--
CV(%)	6.74	--	10.03	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Values are the means of three replications
[Treatment T_1:field Sanitation + Netting; T_2: Field sanitation + straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; $T_{6:}$ Control]

4.4. Relationship between yield contributing character and total yield of capsicum at farmer field.

Relationship between total number of fruit/ plants and total yield of capsicum

The data on total number of fruit/ plants were regressed against total yield hectare^{-1} of capsicum and a positive linear relationship was obtained between them (**Figure 1**). A significant relationship was found between the total number of fruit/ plants and total yield of capsicum when correlation was made between these two parameters. The highly significant ($p<0.05$),very strong ($R^2=0.9897$) and negative ($y = 0.9066x - 6.5798$) correlation was found between total number of fruit/ plants and total yield of capsicum, i.e. total yield of capsicum increased with the total number of fruit/ plants increased.

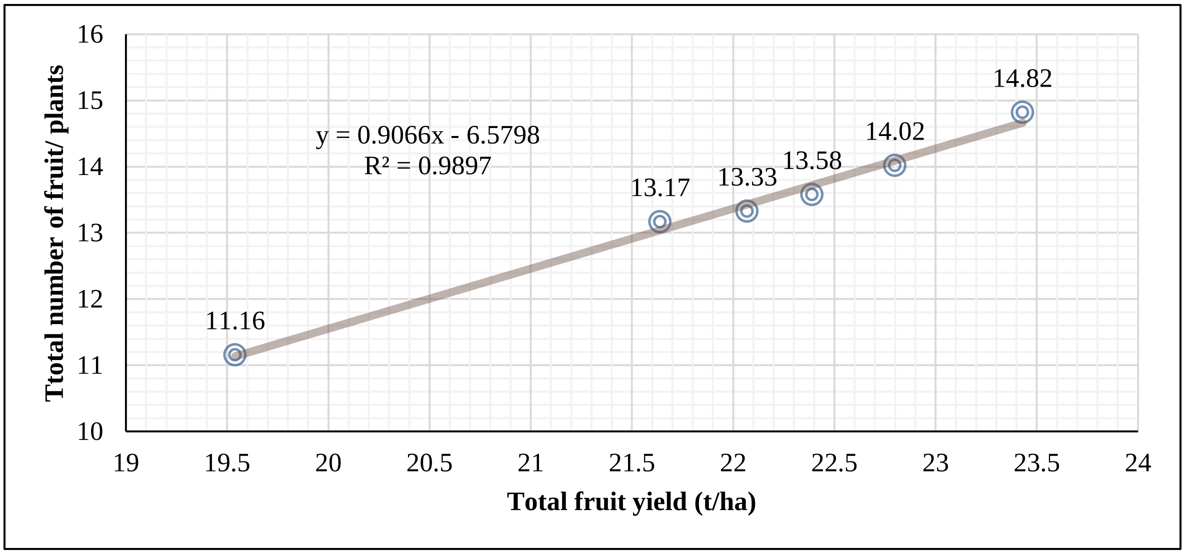

Figure 1. Relationship between total number of fruit/ plants and total yield of capsicum

Relationship between infested fruit yield (t/ha)and total yield of capsicum

The data on infested fruit yield (t/ha) were regressed against total yield hectare^{-1} of capsicum and a negative linear relationship was obtained between them (Figure 2). A significant relationship was found between infested fruit yield (t/ha) and total yield of capsicum when correlation was made between these two parameters. The highly significant ($p<0.05$),very strong ($R^2=0.896$) and negative ($y = -1.3086x + 30.634$) correlation was found between infested fruit yield (t/ha) and total yield of capsicum, i.e. total yield of capsicum increased with the infested fruit yield (t/ha) decreased.

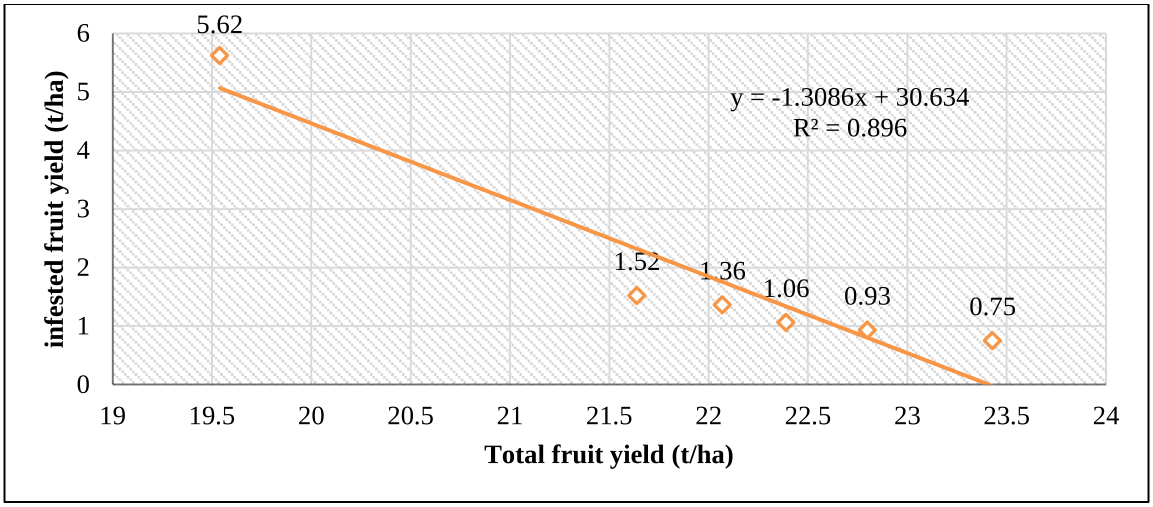

Figure 2. Relationship between infested fruit yield (t/ha)and total yield of capsicum

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2020 to March 2021 to study the incidence and ecofriendly Management of Capsicum fruit borer. The experiment consists of control measures and plant extract.

Six treatments, viz. Treatment T_1: Field Sanitation + Netting; T_2: Field sanitation + straw mulch; $T_{3:}$ Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals; $T_{4:}$ black polythene + leaf extract of neem at the 7 days intervals; T_5: Field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals; T_6 : Control were included in this study. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications.

Results showed that the significant variations were observed among different stage capsicum in term of incidence of fruit borer, number of healthy fruits, number of infested fruit and infestation percentage, healthy fruit in weight basis, infested fruit in weight basis and infestation percentage in weight basis, plant height,yield per plot (kg) and yield (t/ha) of capsicum.

Among six treatments, it was observed that treatment T_3(Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals) was the most effective treatment for reducing insect pests infestation at total growing stages.

At the total fruiting stage of Capsicum, the lowest average number of number of fruit borer/6 plant (4.36) were observed from T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) treatment which was closely followed by (5.08) and (5.89) in T_5 (field sanitation + Neem oil @ 2.0 ml/L of water with detergent at the 7 days intervals) and T_4 (black polythene+ leaf extract of neem at the 7 days intervals) treatment respectively. On the other hand, the highest average number of number of fruit borer/6 plant (21.43) were observed from T_6 (Untreated control) which was closely followed by (7.30) in T_1 treatment.

At the early fruiting stage of Capsicum,the highest number of healthy fruits/6 plant (27.25) was recorded from T_3 which statistically different from all others treatment and closely followed by (26.25) in T_5 and T_4 treatment, whereas the lowest number of healthy fruits/6 plant (17.33) was recorded from T_6 (Untreated control) treatment.

In significant variations due to the incidence and ecofriendly management of Capsicum fruit borer at the early fruiting stage of Capsicum. Among different traps, T_3 (Field sanitation + Spinosad (Tracer)@ 0.5ml/L of water at the 7 days intervals) showed more reduction (86.37%) of infestation due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In a similar trend, T_1 (field Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (66.65%) was recorded on capsicum.

At the mid fruiting stage of Capsicum, the highest number of healthy fruits/6 plant (58.67) was recorded from T_3 which statistically different from all others treatment and closely followed by (56.75) in T_5 and T_4 treatment, whereas the lowest number of healthy fruits/6 plant (42.25) was recorded from T_6 (Untreated control) treatment.

In significant variations due to the incidence and ecofriendly management of Capsicum fruit borer at the late fruiting stage of Capsicum. Among different treatments, T_3 (Field sanitation + Spinosad (Tracer) @ 0.5ml/L of water at the 7 days intervals) showed more reduction (85.79%) of infestation due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1 (field Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (71.12%) was recorded on capsicum.

At the late fruiting stage of Capsicum, the highest number of healthy fruits/6 plant (42.25) were recorded from T_3 which statistically different from all others treatment and closely followed by (39.33) in treatment, whereas the lowest number of healthy fruits/6 plant (31.67) was recorded from T_6 (Untreated control) treatment.

In significant variations due to the Incidence and Ecofriendly Management of Capsicum fruit borer at the mid fruiting stage of Capsicum. Among different traps, T_3 (Field sanitation + Spinosad (Taccer)@ 0.5ml/L of water at the 7 days intervals) showed more reduction (79.66%) of infestation due to capsicum fruit borer and supported to make sure the more yield of capsicum.

In the similar trend, T_1 (Sanitation + Netting) showed lower performance to control capsicum fruit borer while minimum reduction (63.29%) was recorded on capsicum.

More or less similar trends of Incidence of Capsicum fruit borer at weight basis per six tagged plants were also recorded at early fruiting stage, mid fruiting stage and late fruiting stage.

As a result, the order of Incidence and Ecofriendly Management of Capsicum fruit borer terms of fruit infestation reduction at total growing stage of Capsicum is T_3> T5 > T_4> T_2> T_1> $T_{6.}$

From the above finding it was observed that, T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) treatment was showed the best performance for the number of leaves,total number of fruit plant^{-1} , fruit length, diameter of healthy fruits of Capsicum.

In the same way, the per cent increase of healthy fruit yield over control during the cropping season of Capsicum was 46.30% in treatment T_3 followed by 30.18% in T_5 treatment. The transitional per cent increase of yield over control was recorded in T_1 (32.77%) treatment.Similarly, the percentage decrease of infested fruit yield over control during the cropping season of Capsicum was 62.93% in treatment T_3 (Field sanitation + Spinosad (Taccer) @ 0.5ml/L of water at the 7 days intervals) followed by 57.11% in T_5. The transitional percentage decrease of yield over control was recorded in T_1 (44.54%) treatment.

Conclusion

From the above description, it can be concluded that, spraying T_3(Field sanitation + Spinosad (Taccer)@ 0.5ml/L of water at the 7 days intervals) reduced the infestation of insect pest of capsicum.

Recommendations

Considering the findings of the present experiment, further studies in the following areas may be suggested:

- Diversity of insect pests may be studied in several years all over Bangladesh to identify the major insect pests of capsicum.

- Further trials with effective different eco-friendly management may be done at different locations of Bangladesh for accuracy of the results obtained from the present experiment.

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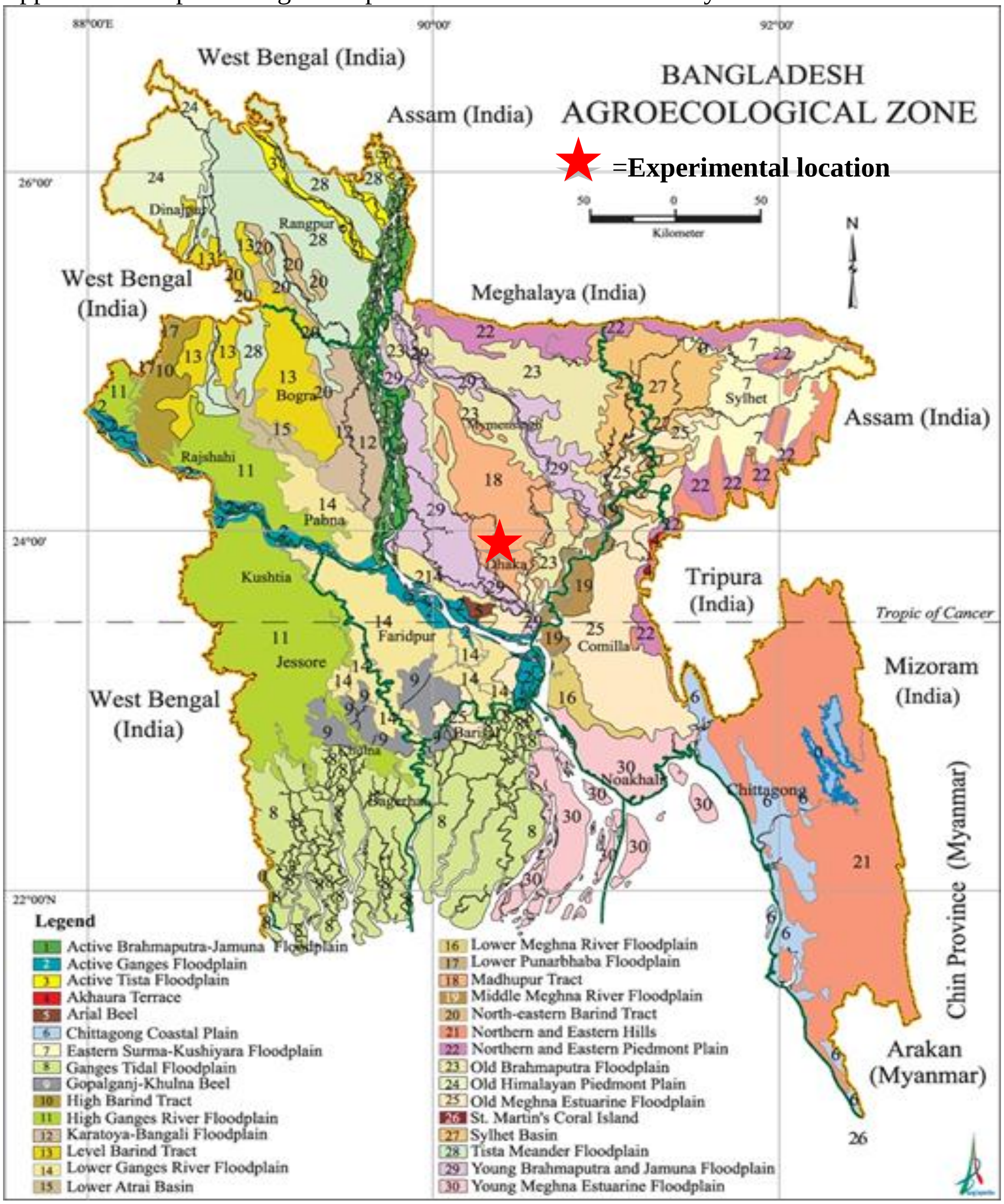
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0- 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

Sourse: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix III. Monthly meteorological information during the period from October 2020 to April, 2021.

Year	**Month**	**Air temperature (^{0}C)**		**Relative humidity (%)**	**Average rainfall (mm)**
		Maximum	**Minimum**		
2020	November	29.6	19.8	53	00 mm
	December	28.8	19.1	47	00 mm
2021	January	25.5	13.1	41	00 mm
	February	25.9	14	34	7.7 m
	March	31.9	20.1	38	71 mm
	April	34.10	23.60	67	138 mm

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV: Mean sum- square values on the basis on number of fruit borer and infested fruits and fruit infestation by number at early fruiting of capsicum from Analysis of Variance (ANOVA)

Source of variation	df	Number of fruits/6 plant at vegetative stage			Number of fruits/6 plant at early fruiting stage		
		Healthy fruits(No.)	Infested fruits (No.)	% infestation	Healthy fruits (No.)	Infested fruits (No.)	% infestation
Replication	3	0.052	0.56	6.78	4.96	0.124	18.15
Different Treatment	5	130.84**	117.271**	1735.65**	206.63**	171.78**	2172.70**
Error	15	14.30	0.640	6.81	20.185	3.061	3.65

NS=non-Significant
* *Significant at 0.05 level of probability

Appendix V: Mean sum- square values on the basis of infested fruits and fruit infestation by number at mid fruiting stageand late fruiting stage of capsicum from Analysis of Variance (ANOVA)

Source of variation	Df	Number of fruits/6 plant at mid fruiting stage			Number of fruits/6 plant at late fruiting stage		
		Healthy fruits (No.)	Infested fruits (No.)	% infestation	Healthy fruits (No.)	Infested fruits (No.)	% infestation
Replication	3	0.875	3.893	14.89	2.161	0.33	3.45
Different Treatment	5	183.49**	455.97**	1694.65**	508.38**	1118.36**	2279.19**
Error	15	28.976	3.246	8.21	17.01	6.31	12.17

NS=non-Significant
* *Significant at 0.05 level of probability

Appendix VI: Mean sum- square values on the basis of infested fruits and fruit infestation by weight at early fruiting of capsicum from Analysis of Variance (ANOVA)

Source of variation	df	Number of fruits/6 plant at early fruitingstage		
		Healthy fruits (No.)	Infested fruits (No.)	% infestation
Replication	3	0.237	1694	14.94
Different Treatment	5	2.045**	631859**	18.43**
Error	15	0.143	644	10.00

NS=non-Significant
* *Significant at 0.05 level of probability

Appendix VII: Mean sum- square values on the basis of infested fruits and fruit infestation by weight at mid fruiting stagefruiting and late fruiting stage of capsicum from Analysis of Variance (ANOVA)

Source of variation	Df	Number of fruits/6 plant at mid fruiting stage			Number of fruits/6 plant at late fruiting stage		
		Healthy fruits (No.)	Infested fruits (No.)	% infestation	Healthy fruits (No.)	Infested fruits (No.)	% infestation
Replication	3	0.043	3031	8.93	1.26	17431	8.21
Different Treatment	5	4.289**	1373793**	1586.54**	8.983**	5037773**	2063.62**
Error	15	0.061	24631	9.21	2.784	41847	7.04

NS=non-Significant
* *Significant at 0.05 level of probability

Appendix VIII: Mean sum- square values for number of leaves, total number of fruits per plant, fruit length (cm),fruit diameter (cm), healthy fruit yield (t/ha)and infested fruit yield (t/ha)of capsicum from Analysis of Variance (ANOVA)

Source of variation	Df	Number of leaves	Total number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Healthy fruit yield (t/ha)	Infested fruit yield (t/ha)
Replication	3	4.061	5.6579	0.089	1.068	2.240	0.704
Different Treatment	5	214.09**	22.73**	8.594^{NS}	0.496^{NS}	87.061**	183.242**
Error	15	35.049	5.77	12.136	2.077	17.31	0.711

NS=non-Significant
* *Significant at 0.05 level of probability
*Significant at 0.01 level of probability

PLATES

Plate 6. Black polythene mulch

Plate 7. Rice straw mulch

Plate 8. Plastic net was given around the experimental plot

Flower initiation

Early fruiting stage

Mid fruiting stage

Late fruiting stage

Plate 9. Different growth stage of capsicum

Plate 10. Harvesting of capsicum fruits