STUDY ON THE EFFECTIVENESS OF SOME PROMISING INSECTICIDES AGAINST BRINJAL SHOOT AND FRUIT BORER AND ITS NATURAL ENEMIES

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DECEMBER, 2013

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REGISTRATION NO. 12-5234

A Thesis

Submitted to the Department of Entomology, Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)
IN
ENTOMOLOGY

SEMESTER: JULY-DECEMBER, 2013

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CERTIFICATE

*This is to certify that thesis entitled "STUDY ON THE EFFECTIVENESS OF SOME PROMISING INSECTICIDES AGAINST BRINJAL SHOOT AND FRUIT BORER AND ITS NATURAL ENEMIES" submitted to the **Faculty of Agriculture,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment 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 MUHAMMED ABDUR RAHMAN, **Registration no. 12-5234** 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.

Dated: December, 2013
Place: Dhaka, Bangladesh

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ABBREVIATIONS AND ACRONYMS

AEZ	:	Agro-Ecological Zone
et al.	:	and others
BBS	:	Bangladesh Bureau of Statistics
BSFB	:	Brinjal Shoot and Fruit Borer
BSMRAU	:	Bangabandhu Sheikh Mujibur Rahman Agricultural University
cm	:	Centimeter
CV	:	Coefficient of variation
DAT	:	Days After Transplanting
^{o}C	:	Degree Celsius
d.f	:	Degrees of freedom
etc.	:	*et cetera*
EC	:	Emulsifiable Concentrate
FAO	:	Food and Agriculture Organization
Fig.	:	Figure
g	:	Gram
Ha	:	Hectare
I.U.	:	International Unit
P^{H}	:	Hydrogen ion concentration
q	:	quintal
J.	:	Journal
Kg	:	Kilogram
LSD	:	Least Significant Difference
L	:	Liter
m	:	Meter
MS	:	Mean sum of square

mm	:	Millimeter
MP	:	Muriate of Potash
MT	:	Metric ton
no.	:	Number
%	:	Percent
RARS	:	Regional Agricultural Research Station
RCBD	:	Randomized Complete Block Design
SAU	:	Sher-e-Bangla Agricultural University
SRDI	:	Soil Resource Development Institute
M^2	:	Square meter
Mcq	:	Milli equivalents
Ppm	:	Parts per million
t	:	Ton
TSP	:	Triple Super Phosphate

ACKNOWLEDGEMENT

All the praises due to the Almighty Allah, who enabled the author to pursue his education in Agriculture discipline and to complete this thesis for the degree of Master of Science (M.S.) in Entomology.

I am proud to express my deepest gratitude, deep sense of respect and immense debtedness in to my supervisor, ***Professor Dr. Md. Mizanur Rahman,*** *Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his constant supervision, invaluable suggestion, scholastic guidance, continuous inspiration, constructive comments and encouragement during my research work and guidance in preparation of this manuscript.*

I express my sincere appreciation, profound sense, respect and immense debtedness in to my respected co-supervisor, ***Dr. Tahmina Akter,*** *Associate Professor and Chairman, Department of*

Entomology, Sher-e-Bangla Agricultural University, Dhaka for providing me with all possible help during the period of research work and preparation of the thesis.

I would like to express my deepest respect and boundless gratitude to my honorable teachers, and staffs of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for their valuable teaching, sympathetic co-operation and inspirations throughout the course of this study and research work.

Cordial thanks are also due to all field workers of SAU farm for their co-operation to complete my research work in the field.

I would like to express my last but not least profound and grateful gratitude to my beloved parents, friends and all of my relatives for their inspiration, blessing and encouragement that opened the gate of my higher studies in my life.

Dated: December, 2013 *The Author*

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ABSTRACT

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 during the period from February to September, 2013 to evaluate promising insecticides in comparison with conventional insecticides for management of brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee and their impact on natural enemies. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and six treatments applied at 7 days interval. The treatments were T_1 (Acimix @ 1ml/L of water); T_2 (Calipso @ 1ml/L of water); T_3 (Neem oil @ 3mml/L of water); T_4 (Neem Seed Karnel Extract @ 100g/L of water); T_5 (Nexaid @ 1.5ml/L of water); T_6 (Untreated Control). The result reveled that amongst newer insecticides Acimix @ 1ml/L of water was most effective in reducing shoot infestation (66.72%) and Calipso @ 1ml/L of water was found most effective in reducing fruit infestation by number and weight (68.56 and 61.04%), over control followed (66.56, 53.7% respectively) by Acimix, whereas Neem Seed Kernel Extract @100gm/L of water from the field showed the least performance (19.40 and 9.17%, respectively). The best treatment, though, T_1 and T_2 reduced the highest level of shoot and fruit infestation respectively, they increased the maximum level of plant and fruit related yield attributes. T_2 increased the maximum height, number of branch per plant, fruit length and girth, number of fruit per plant, and single fruit weight (27.06, 36.50, 43.40, 55.91, 68.41 and 61.04%, respectively) of eggplant over control followed by Acimix (13.33, 33.46, 33.95, 39.00, 66.56 and 53.7%, respectively), whereas Neem Seed Kernel Extract @ 100g/L of water showed the least performance. Calipso also increased the highest fruit yield (15.360 t/ha) over control (14.860 t/ha) followed by Acimix (40.987%). Considering the impact of management practices on the population of natural enemy, Calipso had adversely affected and reduced the highest population of adult and larvae of ladybird beetle, and field ant (81.34, 72.42 and 63.18% respectively) over control followed by Acimix (67.81, 52.99, and 52.21%, respectively), whereas Neem Seed Kernel Extract performed as the least hazardous treatment. Though, Calipso reduced the highest level of BSFB infestation followed by Acimix, conversely they mostly harmful to the arthropod biodiversity in the brinjal ecosystem by reducing the maximum level of the natural enemy population than any other newer insecticides which were comparatively safe , and would be fit well into the management of brinjal shoot and fruit borer (BSFB).

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CHAPTER I

INTRODUCTION

Brinjal (*Solanum melongena* L.) occupies a distinct place in the realm of vegetable crops. It is a bushy plant, commonly known as eggplant. It belongs to the family *Solanaceae.* It is one of the most popular and important vegetable crops grown in Bangladesh and many parts of the world. It is native of Indian sub-continent, with India as the probable centre of origin. In Bangladesh, brinjal covers 115,000 acres with a production of 341000 tons (BBS, 2010). Brinjal constitutes about 25.4% of the total vegetable area of the country. Brinjal is the second most important vegetables crops after potato in relation to its total production (Anonymous, 1996). The fruit is large pendent, berry, ovoid or oblong in shape and smooth in texture. It has been cultivated in kitchen garden in Bangladesh from time immemorial. Presently it is cultivated extensively in the field as a cash crop during both summer and winter (Nonnecke, 1989).

Brinjal is well known as a source of carbohydrate, protein, minerals and vitamins. It is also a good source of dietary fiber and folic acid and is very low in saturated fat, cholesterol and sodium (FAO, 1995). Composition per 100 g of edible portion of brinjal is calories 24.0, moisture content 92.7%, carbohydrates 4.0%, protein 1.4g, fat 0.3g, fiber 1.3g, vitamin-A 124.0 I.U., oxalic acid 18.0mg, iron 0.38mg, vitamin C 12.0mg (Anonymous, 2007). It is used in Ayurvedic medicine for curing the diabetes. It is also used as a good appetizer.

Brinjal is grown round the year having two major growing seasons such as summer and winter. Although this vegetable is grown throughout the country, it is intensively and commercially grown in Jessore, Narsingdi, Gazipur, Dhaka, Comilla and Bogra districts (Rahman, 2010). Brinjal is subjected to severe damage by different insect pests leading to significant loss in yield. There are 26 insect pests species infesting brinjal. Among them brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* (Guen.); Whitefly, *Bemisia tabaci* (Genn.); Leafhopper, *Amarasca devastans* (Distant); Epilachna beetle, *Epilachna vigintioctopunctata* (Fab.); Aphid, *Aphis* *gossypii* (Glover.); Mealy bug, *Coccidohystrix insolitus* (Guen.); Wing lace bug, *Urentius hystricellus* (Richter.) and non insect pest, red spider mite, *Tetranychus macfurlanei* (Andre) cause severe damage, necessitating initiation of control measures quite frequently (Vevai, 1970). Infestation due to leafhopper, whitefly and shoot and fruit borer results in about 70-92 per cent loss in yield of brinjal (Rosaiah, 2001). As brinjal is a vegetable crop and harvesting of fruits is done at regular short intervals, safer and effective insecticides are needed for controlling the insect pest complex.

BSFB is a monophagous insect and belongs to the family pyralidae under the order Lepidoptera. The genus *Leucinodes* includes three species *L. orbonalis* Guenee, *L. diaphana* Hampson, *L. apicalis* Hampson. In Bangladesh, *L. orbonalis* Guenee is active throughout the year but its activity can be reduced by severe cold (Alam *et al*. 1964). The larvae of *L. orbonalis* can cause damage to shoot from 12.00-20.00% and fruit from 20.00-60.00% in a crop season (Maureal *et al*. 1982). It is very active during the rainy and summer seasons and the yield loss has been estimated up to 86.00 percent in Bangladesh (Ali *et al*. 1980).

At present synthetic pyrethroids are regularly used for the control of brinjal shoot and fruit borer and their indiscriminate use, leading to whitefly, aphid and mite resurgence is well documented (Reddy and Srinivasan, 2009).Farmers mostly depend on chemical insecticides to manage the pest and synthetic chemical insecticides dominate over other means for controlling of BSFB (Singh and Singh, 2003). A survey in Jessore district of Bangladesh reported that 98.00% of the farmers relied exclusively on insecticides and 60.00% farmer sprayed their crop 140 times or more in the 6-7 months of cropping season (Alam *et al.* 2003). The insecticides used by the farmers belong to the groups organophosphates, carbamates and synthetic pyrethroides.

The present day emphasizes not only the use of different groups of chemicals that are eco-friendly but also satisfactory control of insect pest population by their novel mode of action. Information on the seasonal incidence of the insect pests in brinjal ecosystem and their management, particularly in this agro-climatic situation in the recent past is meager. The abuse of pesticides, including the use of excessive rates and non-registered chemicals, as well as disregard for re-entry and harvest-delay intervals, have resulted both loss of effectiveness of pesticides and damage to the environment and human health (Rashid *et al*, 2004). The indiscriminate use of chemical insecticides also create adverse effects on natural enemies, pest resistance and secondary pest outbreak, health hazards and environmental pollution (Bhadauria *et al.* 1999). Injudicious use of insecticides frequently kills the natural enemies and affects arthropod biodiversity. Insecticides are still a single weapon now for managing BSFB by the farmer of Bangladesh. So, it is required to use insecticide in proper dose, time and method of application and they should be less hazardous and not harmful for natural enemy.

Therefore, under the above circumstances the present study was conducted with the following objectives.

Objectives:

1. To study the performance of the selected insecticides against BSFB, *Leucinodes orbonalis* (Guen.) and their natural enemies
2. To find out the most effective insecticide (s) for managing BSFB
3. To know the role of natural enemy of BSFB by exposing them to the selected insecticides
4. To identify the safer ecofriendly insecticide (s) for the natural enemy of BSFB

CHAPTR II

REVIEW OF LITERATURE

Brinjal (*Solonum melongena* Linn.) is the most common, popular and principal vegetable in Bangladesh and other parts of the world (Nonnecke, 1989). Brinjal is locally known as "Begoon" and its early European name is “Eggplant”. It is grown extensively in India, Bangladesh, Pakistan, China and the Philippines. It is also popular in other countries like Japan, Indonesia, Turkey, Italy, France, United States, Mediterranean and Balkan area (Bose and Som, 1986). Brinjal belongs to the family solanaceae and is normally a self-pollinated annual crop. It is usually grown as seasonal crop and widely cultivated both in rabi and kharif seasons. It is a principal vegetable crop of Bangladesh, occupying second highest position in terms of production and consumption following potato (Anonymous, 2008).

Brinjal requires warm climatic conditions over 6 months growing period to give a satisfactory yield of good quality fruits. The optimum average monthly temperature range is 21^0-30^0 C, with a maximum of 35^0 C and a minimum of 18^0 C and growth stops at temperature below 17^0 C. When temperature and humidity are high brinjal plants becomes more vegetative (FAO 2003). This climatic condition favors rapid buildup of arthropod community in the brinjal field. Arthropod community in the brinjal field comprises different pests and their natural enemies. Review of available literature relevant to the major insect pests of brinjal, natural enemies in the brinjal field, management practices of BSFB, efficacy of chemical insecticides against BSFB and their compatibility with arthropod biodiversity are presented below:

2.1. Insect pests of Brinjal

In Bangladesh brinjal is attacked by 18 species of insects and mites, out of which 8 species are considered to be major and 10 are minor insect pests (Alam *et al.* 1964). The major pest are Brinjal Shoot and Fruit Borer, Epilachna beetle, Mealy bug, cutworm, Brown ant, field-cricket and white fly.

Alam *et al*. (2004) conducted a surveying from intensive brinjal growing area of Jessore, Narsingdi, Comilla and Gazipur reported BSFB (*Leucinodes orbonalis*

Guenee), white fly (*Bemicia tabaci*), red mite (*Tetranychu bioculatus*), jassid (*Amrasca biguttula biguttula*), as major insect pests.

In Madhya Pradesh, India 13 species of brinjal insect pests were recorded, among which BSFB, jassid, aphid, leaf roller (*Antoolivacea*) and stem borer (*Euzopher aperticella*) were the most common (Bhadauria *et al*. 1999). Ag Anon *et al*. (1997) reported that BSFB, jassid, leafhopper and thrips (*thripstabaci*) were the most common insect pests of brinjal in the field.

According to El-shafie (2001), in Sudan 28 species of insect pests were recognized in brinjal ecosystem, out of which 7 species were associated with the damage of reproductive part (flower, bud and fruit) .

A survey in Kerala, India observed that BSFB, jassid, aphid (*Aphis gossypii*) and epilachna beetle (*Henosepilachna ctopunctata vigintio*) were the most abundant insect pests of brinjal (Reghunath *et al*. 1989).

Alam *et al.* (2003) conducted a survey in collaboration with Asian Vegetable Research and Development Center (AVRDC) and reported that BSFB was the most destructive pest in the most major brinjal producing countries of South Asia.

FAO (2003) reported that the BSFB was the major insect pest of brinjal in Asia. A research work was conducted during March to August 2005, in the research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University and found BSFB, jassid, white fly, epilachna beetle and aphid were the important pests of brinjal (Latif, 2007). Report on the surveys of vegetable insect pests from 2000-2003 in seven intensive rice-based vegetable growing areas of Bangladesh revealed that BSFB was the most prevalent and damaging pest of all the studied areas. Three insects, which had insignificant incidence in the recent past, are becoming alarming pests of brinjal, white fly (*Bemicia tabaci*), and red mite (*Tetranychus biculatus*) in Jessore, Narsingdi and Comilla region and jassids (*Amrasca biguttula biguttula*) in Gazipur region.

According to Alam *et al*. (2004), The jassid was highly prevalent during the dry periods, particularly from February to April.

2.2. Brinjal shoot and fruit borer (*Leucinodes orbonalis*, Pyralidae: Lepidoptera)

2.2.1. Morphological Description of BSFB

2.2.1.1. Adults

The adult moths are white, small and cryptic in nature (Alam, 1969) with 22 to 26mm long at wing expanse (Butani and Jotwani, 1984). Longevity of adult female is 2 to 7.5 days and male 1 to 4 days (Baang and Corey, 1991). Head and thorax are variegated with black and brown color. Head is small, hypognathus and globular with 2 separated compound eyes. Two pairs of well-developed white fore wings have conspicuous black and brown patches and dots. Fore pair of wings are longer and broader and the opalescent hind pair with black dots along the margins (Butani and Jotwani, 1984). They are week fliers and are unable to fly more than 2m high. Mating takes place in the later part of night after emergence. The male dies after copulation and female longevity continuous until egg disposition.

2.2.1.2. Egg

Eggs are laid during the later part of the night and continue till early hours in the morning (Alam, 1969). The female moth lays 11-68 eggs with an average of 42. Atwal (1986) found that 80-120 creamy white eggs laid singly or in batches of 2-4 on the lower surface of the leaves, shoots, green steins, and flower buds and on the petioles. Butani and Jatwani (1984) reported that a female lays an average of 250 eggs. Baang and Corey (1991) reported that the average number of eggs laid per female was 121.5 ± 0.45 and of those of 79.24% were viable

2.2.1.3. Caterpillar

The young larvae on hatching measure 1.49 mm X 0.41 mm with slender abdomen taper posteriorly. The full -fed larva measures 16.3 mm X 3.16 mm in its widest part. The body is lighting pinkish in color with creamy tinge. The thoracic and the I^{s1} three abdominal segments are more pinkish than those of the rest (Alam *et al.,* 1964). After hatching the caterpillar search for a Suitable place on the host for boring.

2.2.1.4. Pupa

The pupa is formed within a boat shaped cocoon of dirty brown colored silk which is spun by the full grown larvae before pupation in suitable dark a semi dark place usually 1-3 cm below in the soil (Yein, 1993) The full grown pupa measures 6.4 mm x 1.66 mm. The pupal period varies from 7 to 10 days during summer and 13-15 days in winter (Butani and Jatwani. 1984: Alam and

Sana, 1962). According to Alam *et al.* (1982) the total length of life cycle ranged from 19 to 28 days

2.2.2 Nature of damage

The BSFB *L. Orbonalis* (Guenee) starts to attack soon after transplanting the crop and continue till the last harvest. The eggs are laid singly and deposited on the ventral surface of the leaves, shoots, flower buds, and petiole and occasionally on the fruit. BSFB larvae are very active, within one hour after hatching, the larvae of BSFB bores into the nearest tender shoot, flower or fruit. Soon after boring into shoots or fruits, they plug the entrance hole with excreta. In young plants caterpillars are reported to bore inside petioles and midribs of large leaves. As a result affected leaves may drop off (Butani and Jotwani, 1984). Larval feeding inside shoots results in wilting of young shoot, which reduces plant growth, number of fruits and fruit size. Larval feeding in flowers, a relatively rare occurrence, results in failure to form fruit from damaged flowers. Larval feeding inside the fruit results in destruction of fruit tissue. The feeding tunnels are often clogged with frass, which makes even slightly damaged fruit unfit for marketing (Alam *et al.* 2003).

BSFB is one of the most destructive pests in South and Southeast Asia. It is also found throughout the tropics in Asia and Africa, where it can reduce yield by as much as 70.00%. Hence, the farmers in the region rely exclusively on the application of chemical insecticides to combat BFSB, which has resulted in a tremendous misuse of pesticides. Despite intensive insecticide applications, the pest can not be controlled due to its resistance to commonly used pesticides (Srinivasan, 2009).

2.2.3. Natural enemies in the brinjal field

FAO (2003) reported that, in the brinjal field ladybird beetles, carabid beetle (ground beetles), lacewings, preying mantid, spider, earwig, predatory bug, syrphid fly, *Trathala*, true bug, predatory flies and predatory mite were found as natural enemies.

2.2.3.1. Predators

The common arthropod predators in brinjal agro-ecosystem are spiders, ladybird beetles, syrphid flies, lacewings, earwigs, preying mantids etc. (FAO 2003).

FAO (2003) also reported that, eight different taxonomic groups of soil dwelling natural enemies also were recorded, among them Formicidae, Forficulidae, Araneae, Gryllidae, Carabidae and Staphylinidae were common.

El-shafie (2001) reported that, in Bangalore, India, ladybird beetle, green lacewing were found as very active natural enemies in the brinjal field. Predators of five different orders were found in brinjal ecosystem, such as Coleoptera (60.00%), Neuroptera, Diptera, Hymenoptera and Mantoidea with frequency of 10.00% each.

Latif (2007) recorded the following 10 species of plant dwelling natural enemies in a research work. They are ladybird beetle, carabid beetle, staphylinid beetle, syrphid fly or hover fly, mirid bug, pentatomid bug, preying mantid, green lacewing, black ant and lynx spider. Latif (2007) also recorded 7 surface dwelling predacious arthropods families; which are Formicidae, Lycosidae, Carabidae, Gryllidae, Forficulidae, Staphylinidae and Cicindellidae.

2.2.3.2. Parasitoids

Parasitoids of brinjal pests are commonly wasps and flies. According to FAO (2003), the major parasitoids found in brinjal field are *Trathala* sp., *Trichogramma* sp., *Bracon* sp., *Eriborus* sp, *Pediobius foveolatus* and *Ceranisus menes* etc. Major parasitoids recorded in the brinjal field were *Trathala* sp., *Trichogramma* sp., *Erioborus* sp.,*Ceranisus* sp.

2.2.4. Pest status and host range of brinjal shoot and fruit borer

The brinjal shoot and fruit borer is the most obnoxious pest of eggplant and also infest potato, pods of green peas and can also be reared on *Solarum torvum* Swartz (Alam and Sana, 1962; Awal, 1986). Hill (1983) also reported that Tomato, potato and peas are attacked by this pest. The pest also attacks other wild species of *Solatium* (Karim, 1994). According to Ishaque and Chaudhuri (1983) the alternate hosts of BSFB were *Solanum nigrum*, *S. torvum*, *S. indicum*, *S. muriacztum* and potato.

Damage by this pest starts soon after transplanting the crop and continues till the harvest of the fruits. FAO (2003) reported that brinjal shoot and fruit borer was the most serious pest of brinjal especially during the fruiting stage. The extent of fruit damage varied from 1.00 to 90.00% (Butani and Jotwani 1984) in India but Dhankar (1988) found 37.00 to 63.00% in different stages.

In Bangladesh, Rahman *et al*. (2006) reported 44.49% fruit infestation, while Islam and Karim (1991) found 67.00% fruit infestation. Alam *et al*. (2003) reported that the pest damage 31.00 and 33.00% of the brinjal crop in 1999 and 2000 croping year, respectively, while Alam (1969) reported 20.00-63.00% fruit and 12.00-16.00% shoots infestation. The percent fruit infestation was varied on different varieties of brinjal.

Kabir *et al.* (1993) found 34.97 (var. Pusa purple long) to 61.39% (var. Uttara) fruit infestation among 17 varieties. Fruit infestation was the highest (91.86%) on Islampuri and that was the lowest (32.81%) on (Rahman,1997). Alam and Mannan (1999) tested 16 different varieties of brinjal and observed the highest fruit infestation (98.06%) on Talbegun and lowest (6.48%) on year round variety.

2.2.5. Seasonal abundance

Shoot and fruit borer in brinjal is the major pest causing severe losses to marketable yield throughout the country. A moderate range of temperature coupled with high humidity was found to be favorable for the borer. Brinjal crop planted during March to September recorded a higher level of shoot (3.4 - 10.62%) and fruit damage (53.39 -61.23%) than the crops planted during remaining months (Senapathi 2006). Singh *et al.* (2009) revealed that *L. orbonalis* infested the crop shoots during the end of August (73.33%), which peaked (86.66%) in the third week of September with an intensity of 2.09 per plant. The shoot damage ranged between 30.23 and 36.23%, while fruit damage ranged 37.51 to 42.23 % from May to July.

Murthy (2001) found that the pest was relatively more during September month on potato shoot under protected condition. Infestation of *L. orbonalis* in brinjal shoots started in the first week of August and remained up to second week of October, with peak in second week of September. Infestation in shoots decreased after fruit setting and completely disappeared thereafter. The infestation in fruits was recorded in the second week of September and remained up to third week of October. The infestation increased gradually and reached maximum in the first week of October (63.09% on number basis and 51.45% on weight basis). The infestation of fruit borer started declining and persisted only up to third week of October. The effect of abiotic factors on *L. orbonalis* revealed that maximum temperature had positive significant effect on fruit infestation; whereas, negative significant correlation was computed between borer infestation and minimum temperature.

Naqvi *et al.,* (2009) reported that relative humidity had positive significant effect on shoot and fruit borer. Rainfall had no effect on shoot and fruit borer infestation.

Bharadiya and Patel (2005) reported that the activity of shoot and fruit borer, *L. orbonalis*, on shoots started in the first week of September (4.9% incidence) and reached the peak level (17.1%) before migrating to fruits by fourth week of October.

Dhamdhere *et al.* (1995) found that pest commenced from 45 and 55 days after transplanting of brinjal seedlings in summer and kharif season, respectively and continued up to harvest. The infestation in summer and kharif season ranged from 7.56 to 23.55 and 17.24 to 30.87 on shoots and 10.06 to 25.27 and 23.34 to 47.75 per cent fruit number and weight basis, respectively.

Tripathi *et al.* (1996) revealed that highest incidence of the pest on shoots was noticed in 46th standard week (8.05 %) and lowest in 31st standard week (0.98 %). The highest fruit damage occurred at low mean temperature of 19.4 °C and 61 per cent relative humidity. The extent of damage on weight basis ranged between 4.03 and 57.01 per cent and followed a similar trend as on number basis.

Anil Kumar *et al.* (1997) observed that infestation by the pest was significantly affected by temperature than other environmental factors. The peak shoot (15.71%) and fruit infestation (71.09% by weight) were recorded during the last week of June and first week of July, respectively.

Singh *et al.,* (2009) observed that shoot infestation during 4th week of August, 2008 and the incidence had non-significant relationship with temperature, relative humidity and rainfall but significant relationship with coccinellids and spiders. In another study Singh *et al.* (2011) observed that incidence of shoot and fruit borer was started in the month of April and continued till the end of the June.

The peak period of the pest on shoot was recorded in the first week of June (29.45%) and fourth week of May (25.24%) during the first and second cropping seasons respectively. However, the incidence of the pest on fruit was highest during the second week of June, 2003 (67.16%) and third week of June, 2004 (72.25%). The correlation study revealed that average temperature and relative humidity showed significant positive association while average sunshine observed significant negative association with the infestation of the pest on brinjal.

2.2.6. Management practices of BSFB

Management practices to control brinjal shoot and fruit borer in Asia are mainly limited to frequent spray of insecticides. A survey in Jessore district of Bangladesh indicated that 98% farmers relied on the use of pesticides and more than 60.00% farmers sprayed their crop 140 times or more during the 6-7 months of cropping period (Alam *et al*. 2003). In another study in India revealed that majority of the farmers (63.30%) controlled the pest by blanked spraying of one or more insecticides and 35.00% farmers practiced removal and destruction of the affected shoots (George *et al.* 2002). The widespread and increased use of pesticides for vegetable production is occurring all over Asia and such use in Bangladesh has been documented (Sabur and Mollah 2000). Researchers have developed various management practices for the control of this obnoxious pest. The practices include cultural, mechanical, biological and chemical methods. Rahman (2006) compiled the available methods of controlling BSFB in brinjal crop in Bangladesh.

2.2.6.1. Cultural control

Karim (1994) reported that the pest might be suppressed by cultural method like hand picking and pruning, clean cultivation, destroying crop residues and alternate host, use of balanced fertilizer, shifting of planting and harvesting time, crop rotation, etc.

Sanitation practices such as cleaning the soil of the field to remove BSFB pupae, normally found on dead and fallen leaves reduced populations of the pest (Sasikala *et al.* 1999). In another study Choudhury and Kashyap (1992) reported that early transplantation resulted in increased incidence and the largest infestation found at the greatest plant density.

Kumar and Moorthy (2001) reported that shoot clipping reduced the incidence of BSFB 15-20%. Satpathy and Rai (2000) reported that about 25% reduction in infestation over control was noticed in shoot clipping. Shoot clipping treatment showed marginal reduction in infestation over Cypermethrin with 28.65% and 29.09% infestation. respectively and 38.20% in control plots. In terms of healthy yield shoot clipping treatment recorded the highest healthy yield (216.84 q/ha). The Cypermecthrin did not perform well as compared to shoot clipping (214.20 q/ha) and control (119.68q/ha).

2.2.6.2. Mechanical control

Brinjal plant can compensate a lot of injury by producing more leaves, new shoots or bigger size fruits. When plant compensate for crop injury without yield or quality loss there is no need to apply insecticides. A shoot pruning study from Bangladesh led to the conclusion that up to 50.00% loss of shoots at 75 to 100 days after transplanting could be compensated very well by the brinjal plants and was not reducing the yield as compared to unpruned control plants. Weekly removal of damaged shoots and fruits and a net barrier gave the highest number and weight of undamaged fruits; in contrast control plots had the lowest marketable yield (Arida *et al*. 2000). Removal of infested fruits also compensated the loss of yield by producing more flowers, fruits or producing larger size fruits (FAO 2003).

On the other hand, Sasikala *et al.* (1999) observed that mechanical removal and destruction of infested shoots and fruits containing larvae resulted in very good control of shoot and fruit borer damage over control in Rabi season. The percent shoot and fruit damage (on number basis) was 14.46% and 20.24% respectively in treated plot compared to 52.60% and 52.55% in control plot. Field experiment report at Regional Agricultural Research Center, during Rabi season 1993 revealed that hand picking infested shoot and fruit + spray of cymbush resulted significant yield increase over untreated control, which indicated that mechanical means might be worthy for the management of BSFB (Anon. 1994).

Moreover, many researchers reported that collection and destruction of infested shoots and fruits along with application of insecticides were effective for BSFB management (Alam *et al.* 2003, FAO, 2003 and Rahman *et al*. 2002).

2.2.6.3. Insecticides for management of major insect pests of brinjal

Brinjal growers of Bangladesh indiscriminately use different kind of pesticides to control brinjal insect pests. Farmers of Bangladesh as well as in Asia rely on pesticides to combat loss caused by insect pests of brinjal. They use variety of insecticides belonging to different chemical groups.

The evolution of synthetic organic pesticides is a significant event of the twentieth century. In fact, the discovery of the insecticidal properties of DDT in 1939 followed by a gradual but rapid introduction of other members of the organochlorine, organophosphorous, carbamate and pyrethroid groups along the compounds having herbicidal and fungicidal properties in the second generation organic pesticides was probably the most revolutionary development in the history of pest control. The synthetic organic pesticides introduced during the Second World War were soon recognized as wonderful pest control chemicals and their increasing uses in the post-war world period have significantly contributed in the well being of the mankind. Acute and chronic toxic effects of pesticides in animals are the results of interference with well established bio-chemical process (Hassall, 1990).

Chatterjee *et al.* (2009) revealed that the lowest mean shoot as well as fruit infestation (7.47 and 9.88%) was recorded in the plots treated with spinosad 2.5 SC (50g ha-1).Singh *et al.* (2009) was observed that Profenols @ 0.1% and Spinosad @0.01%

were most effective in reduction of shoot infestation of *L. orbonalis* beside recording higher brinjal fruit yield.

Removal of damaged fruits during harvesting was the best for the management of this borer. Anjali (2006) revealed that cypermethrin (0.007%) and carbaryl (0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on number and weight basis and on yield basis.

However, Deshmukh *et al.* (2006), amongst newer insecticides, cartap hydrochloride 50 SP at 0.1% was found the most effective in reducing shoot infestation (4.20%) and fruit infestation (23.72% on number basis and 25.30% on weight basis) and in increasing eggplant fruit yield (78.73 q per ha. Sharma *et al.* (2009) found that the main crop, border cropped with either baby corn or radish or guar along with two foliar sprays of spinosad @75 g per ha was very effective in minimizing the fruit borer incidence. Brinjal bordered with radish followed by foliar spray of thiamethoxam @ 20 g per ha followed by abamectin @ 15 g per ha and emamectin benzoate @ l0g per ha gave highest yield viz., 17.128 MT per ha and 26.350 MT per ha, respectively.

Studies on the ovipositional deterrent effects of two commercial Neem formulations, Neemazal TS (1.00% Azadirachtin) and Neemazal F (5.00% Azadirachtin) against *Leucinode sorbonalis* Guenee showed that Neemazal F @ 1 ml/liter was the most effective treatment. Repellency was found to be dose dependent. Investigation on their ovicidal effect against the egg of *L. orbonalis* in comparison to Endosulfan, revealed the superiority of Endosulfan in both cases (Kumar and Babu, 1998). Srinibvasan *et al*. (1998) compared the efficacy of Neem (*Azadirachtaindica*) based products and endosulfan in controlling BSFB in the field experiment in Tamil Nadu. Fruit yields were higher in Nimbicidene 0.03 EC (13.02 t/ha) and Neemazal (12.80 t/ha) than Endosulfan (10.92 t/ha). Tohnishi *et al*. (2005) studied the efficacy of Flubendiamide against 9 major Lepidopteron insect pests including resistant strains and observed that it was highly active against all of the important lepidopteron insect pests. Tohnishi (2005) reported that Flubendiamide was novel insecticide which acted through a new biochemical mode of action in lepidopteran insect pest. After foliar application, Flubendiamide had excellent fast-acting and residual activity against a broad spectrum of lepidopterous insect pests, such as *Helicoverpa* spp., *Spodoptera* spp., *Plutella* spp., and *Agrotis* spp., including resistant strains of them as well.

Latif (2007) studied the effectiveness of nine commercial chemical insecticides, such as Nimbicidene 0.03 EC, Abamectin, Chloropyriphos, Cartap, Carbosulfan, Thiodicarb, Cypermethrin, Lambda-Cyhalothrin and Flubendiamide against brinjal shoot and fruit borer (BSFB) were evaluated both in the laboratory and experimental farm. In laboratory Carbosulfan and Flubendiamide showed the best performance and provided 100.00% mortality of 4th instar BSFB larvae after 24 hours. In the field Carbosulfan and Flubendiamide showed the best performance in reducing shoot damage 87.635% and 84.46%, respectively and fruit damage 85.07% and 83.58%, respectively over control. Among the nine insecticides treated plots the percent shoot infestation was the lowest (1.18%) in the plot treated with carbosulfan followed by 1.72% in Flubendiamide treated plots before fruiting stage, as against the highest shoot infestation (7.01%) in control plots. While the Nimbicidene 0.03 EC treated plot had the highest percent of shoot infestation (4.31%) followed by Abamectin (4.17%), Thiodicarb (3.99%) Chlorpyriphos (3.68%) and Lambda-cyhalothrin (3.40%) treated plots. Cypermethrin and Curtap treated plots had 2.10% and 2.36% shoot infestation, respectively.

2.2.7. Compatibility of insecticides with biological control agents

Conventional insecticides such as chlorinated hydrocarbons, organophosphates, carbamates and pyrethroids were successful in controlling insect pests during the past five decades, minimizing thereby losses in agricultural yields. Unfortunately many of these chemicals are harmful to man and beneficial organisms and cause ecological disturbances. Today there is a great demand for safer and more selective insecticides affecting specifically harmful pests, while sparing beneficial insect species and other organisms. Some of the previous works carried out so far to determine the compatibility of insecticides with biological control agents as well as biodiversity of arthropod species are mentioned here:

Filho *et al.* (2004) reported that spraying of Chlorpyriphos decreased the activity of *Solenopsis saevissima* up to 2 weeks after spraying but recovered afterwards. It did not decrease the overall abundance of collembolan and had no effect on orbatid mites.

Frampton (1999) observed that collembolan abundance decreased after Chlorpyriphos application but increased after Cypermecthrin application. Effects of Chlorpyriphos varied spatially as a result of faunal heterogeneity among the fields. Colignon *et al*. (2001) investigated the effect of insecticide treatments (Lambda-cyhalothrin and Primicarb) on insect density and diversity in vegetable open fields and found that biodiversity in terms of family number was significantly higher in unsprayed plots. In addition, biodiversity and biomass (insect density) increased gradually during the season. Tillman and Mulroney (2001) reported that the predator *H. convergens* increased in number in lambda-cyhalothrin. Neem products are safe to spiders, numerous beneficial insect species and egg of many predators, such as coccinellids. Use of Neem based insecticides could be a substantial contribution towards preservation of biodiversity in ecosystem in spite of the fact that they are not completely safe to all stages of beneficial spider, mite and insects (Tohnishi *et al*. 2005).

Navntoft *et al.* (2006) reported that total dry mass of carabids increased by 25.00% when insecticides were reduced to one fourth of the normal application rates. At reduced dosage, the activity of the genus *Pterostichus* was increased by 62.00% and the activities of *Loricera* and *Dermetrias* were increased by 67.00% and 56.00%, respectively.

Azadirachtin has little or no negative effect on adult beneficial insects and spiders. It is reported to be relatively harmless to bees, spiders, ladybeetles, parasitoid wasps and adult butterflies. The product labels advise not to apply it when honeybees are actively foraging. In a few trials, negative effects have been noted on immature stages of beneficial species exposed to neem products. However, neem products are generally thought to be suitable for inclusion into integrated pest management programs (Banken and Stark 1997).

Spinosad is made up of complex organic compounds, spinosyn A and spinosyn D. These compounds are produced by certain microbes that were first discovered in soil found at an abandoned rum factory. Spinosad is a broad-spectrum, organic insecticide. The term broad-spectrum means that it is toxic to a wide variety of insects. It is however relatively non-toxic to mammals and beneficial insects (Anon. 2011b). Field studies have also confirmed the generally low activity of Spinosad for many beneficial insect species. Against the sensitive indicator species, *Typhlodromus pyri,* Spinosad was harmful in the laboratory but safe under field conditions at rates up to 48 g/ha approximately one week after application. Against another sensitive indicator species, *Aphidius rhopalosiphi,* Spinosad was toxic to the adult wasps, but a level of safety was confirmed to wasps developing within mummified aphids. Spinosad was harmless to *Poecilus cupreus* (ground dwelling predator) and had limited adverse effects on *Episyrphus balteatus* and *Coccinella septempunctata* (foliage dwelling predators). Against another foliage dwelling predator, *Chrysoperla carnea,* Spinosad was harmless at 36 g in an extended laboratory study involving realistic application methods (Anonymous. 2012). Another field studies with Spinosad in which bees have been introduced the day following applications to orchards have also demonstrated the lack of Spinosad impacts. Applications of Spinosad to alfalfa fields, in which honeybee hives were covered for the first 3 hours post-application, also demonstrated no adverse effects to honeybees or leafcutter bees (Saunders and Bret 2012).

Dutton *et al*. (2003) performed tritrophic experiments with *Spodoptera littoralis* and the spider mite *Tetranychusurticae* (Koch) (Acari: Tetranychidae), which is not susceptible to Bt toxins. Although adverse effects were found in lacewing larvae fed *S. littoralis*, there was no effect on larvae fed the tolerant prey, suggesting that the detrimental effects observed when lacewing larvae were fed *B. thuringiensis*-treated *S. littoralis* larvae were due to the quality of the prey and not to a direct toxic effect of the Bt toxin. The specific activity of Bt generally is considered highly beneficial. Unlike most insecticides, Bt insecticides do not have a broad spectrum of activity, so they do not kill beneficial insects. This includes the natural enemies of insects (predators and parasites), as well as beneficial pollinators, such as honeybees. Therefore, Bt integrates well with other natural controls.

Nimbicidene and flubendiamide were less harmful to arthropods species and natural enemies, while Emamectin benzoate was moderately harmful insecticide to the arthropod biodiversity in the brinjal ecosystem. Nimbicidene 0.03 EC and Flubendiamide were comparatively safe for natural enemies and would fit well to the integrated pest management (IPM) programs for brinjal (Latif, 2007).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to evaluate the eco-friendly management of brinjal shoot and fruit borer using some promising insecticides and their impact on natural enemies. The details materials and methods that were used to conduct this experiment are presented below under the following headings:

3.1. Study site

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from February to September, 2013. The site is 23^0 46' N and $90^0$24 'E Latitude and at Altitude of 9m from the sea level.

3.2. Characteristics of soil

The soil of the experimental site is a medium high land belonging to the Modhupur Tract under the Agro Ecological Zone (AEZ) 28. The soil texture was silty loam with a pH 6.7. Details of the mechanical analysis of soil sample are shown in Appendix I. The experimental site was a medium high land.

3.3. Climate

The climatic condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by the Rabi season (October to March) and heavy rainfall during kharif season (April to September). There was few or no rain fall during the month of February and March. The average maximum temperature during the period of experiment was 33.25°C and the average minimum temperature was 23.92°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the period of the experiment were collected from Bangladesh Meteorological Department, Agargon, Dhaka- 1207 and have been presented in Appendix II.

3.4. Land preparation

The plot selected for the experiment was opened in the first week of March, 2013 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilt. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.5. Manuring and fertilization

The following dose of manure and fertilizers were applied in each crop-growing season as per recommendation (Rashid 1993).

Manures/Fertilizers	Dose/hectare
Cow-dung	15 tons
Urea	250 kg
Triple Super Phosphate (TSP)	150 kg
Muriate of Potash (MP)	125 kg

The full dose of the cow-dung and TSP were applied as basal dose during land preparation. One third of MP and urea were applied in pits one week before transplanting and the rest of MP and urea were applied in three equal installments as top dressing, 20 days after transplanting, at the flower initiation followed by last top dressing at the time of fruit initiation.

3.6. Variety used for the experiment

The variety Singnath of brinjal was selected for the experiment during Rabi season 2013. It was an open pollinated high yielding variety developed by the Vegetable Division of Horticulture Research Center of Bangladesh Agricultural Research Institute (BARI). The seeds of this variety were collected from local market.

3.7. Raising of seedlings and transplanting in poly bag

Brinjal seedlings were raised at the trays of experimental farm, SAU under special care. The seeds of the variety were sown in the well prepared soil in tray. The weeds, stubbles and dead roots of the previous crops were removed carefully. The trays were dried in the sun light to prevent the damping off diseases. Twenty grams of seeds were sown in the seedbed on 14 February,2013. Before sowing seeds, the germination test was done to ensure standard viability which measuring approximately 90% germination. Second transplantation of about twenty-five days old individual healthy and uniform sized seedlings was done in the polybags. Shading was provided by polythene sheet over the seedling to protect the young seedlings from scorching sunlight and rainfall. Weeding and irrigation were done regularly to provide a favorable condition for good growth and raising quality seedling.


Plate 1. Double transplanted seedling in the polybag

Plate 2. Shade on the seedling to prevent broad day light

3.8. Transplanting of seedling in experimental plot

Healthy and uniform sized and 30 days old seedling were transplanted in the experimental plots on 02 April, 2013 considering row to row distance 1.0 m and plant to plant distance 60 cm in each plot. Double transplantion of seedling was done in the afternoon and watered immediately after transplanting. The soil around the base of each seedling was pulverized during establishment and new ones from the same stock replaced the damaged seedlings.

3.9. Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications in the central farm of SAU. The field with good tilth was divided into 3 blocks. Each block was sub-divided into 6 sub plots, each of which was of 3 m x 2 m maintaining 1.0 m border.

3.10. Treatments of the experiment

The following treatments were evaluated against BSFB in the brinjal field. Where untreated control treatment was also considered

T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval

T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval

T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval

T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval

T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval

T_6 = Untreated Control.

3.11. Preparation neem seed kernel extract:

One hundred gram fresh neem seed was blended by electric blender then it was mixed with 1 L of water. The solid materials was separated from mixture by sieve.

3.12. Intercultural operations

During the cropping season of the brinjal the necessary intercultural operations were done as described below:

3.12.1. Gap filling of seedling

At the time of transplantion few seedlings were transplanted in the border of the experimental plots for gap filling. A few number of the seedlings were damaged after transplanting and such seedlings were replaced by healthy seedlings from the same seedlings planted earlier on the border of the experimental plot.

3.12.2. Weeding

The land of the each plot was kept free from weeds. Four weedings were done manually at 20, 40, 60 and 80 days after transplantion (DAT) to keep the plots free from weeds. Weeding was done by uprooting and with mechanical weed control method.

Plate 3. Experimental field after weeding

3.12.3. Irrigation and drainage

Light overhead irrigation was provided with a watering cane to the plots once immediately after transplanting. Supplementary irrigation was applied at an interval of 3 days for proper growth and development of the seedlings**.** When the soil moisture level was very low, moreover the plants of a plot had shown the symptoms of wilting, the plots were irrigated on the someday with a hosepipe until the entire plot was properly wet. Stagnant water was effectively drained out at the time of over irrigation.

3.13. Harvesting

Brinjal were harvested at seven days interval when points attained edible stage. Harvesting was started from June 2013 and was continued up to September, 2013.

3.14. Data collection

The data were recorded just before the application of the treatments in the field for the evaluation of efficiency performance of different management practices on infestation level of brinjal shoot and fruit borer, and other plant and fruit related yield contributing characters as well as impact of these management practices on the population of predatory ladybird beetle, field spider and other arthropods through direct visual counts from the brinjal field.

3.14.1. Data collection for management efficiency of BSFB infestation

The performance of different management practices were evaluated by collecting data on different parameters such as number of total and infested shoot from five randomly selected plants for each plot; total and infested fruits by number and weight from five randomly selected plants for each plot; number of total and infested plants for each plot; number of branch and fruit for five randomly selected plants for each plot; height of five selected plants for each plot; length, girth and weight of randomly selected ten healthy and ten infested fruits for each plot.

Plate 4. Healthy fruits from Calipso treated plot

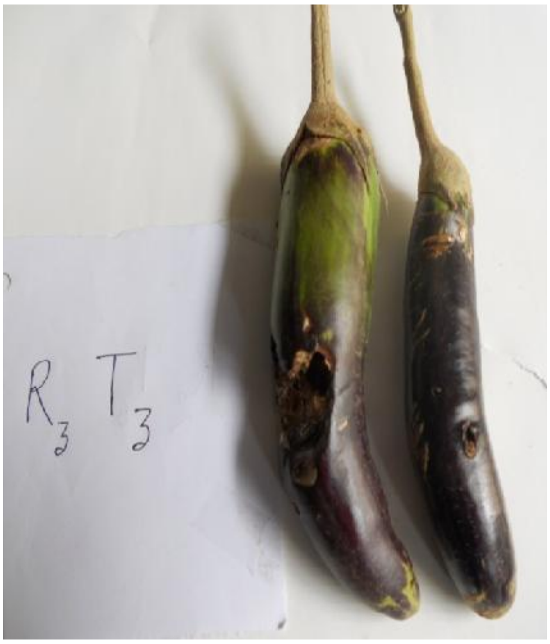


Plate 5. Infested fruits harvested from neem oil plot

Plate 6. Inside view of BSFB infested fruit

Plate 7. Larva of brinjal shoot and fruit borer

3.14.2. Data collection for impact of management practices on natural enemies

The impact of different management practices were also evaluated on the population of predatory ladybird beetle, field spider and other arthropods by collecting data on different parameters such as number of adult and larvae of ladybird beetles, and predatory field spider from five randomly selected plants for each plot by direct visual observation.

Subsequently, the tiny ladybird beetle larvae, field spider and other arthropods were identified and counted with the help of magnifying lens and simple microscope as needed.

Plate 8. Adult ladybird beetle crawling on the leaf of eggplant

3.15. Calculation of the recorded data

The data recorded on different parameters were calculated using the following formula:

$$\% \text{ plant/shoot/fruit infestation} = \frac{\text{Number of infested plant/shoot/fruit}}{\text{Total number of plant/shoot/fruit}} \times 100$$

% increase or decrease over control

$$= \frac{\text{Mean value of treated plot} - \text{Mean value of untreated plot}}{\text{Mean value of untreated plot}} \times 100$$

3.16. Data analysis

The data collected on different parameters were statistically analyzed using the MSTAT-C computer package. Mean values were ranked and compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from February to September, 2013 to evaluate the eco-friendly management of brinjal shoot and fruit borer (BSFB) by using some promising insecticides as well as their impact on the incidence of natural enemies viz. predatory ladybird beetle and field spider in the brinjal field. The results on different parameters have been interpreted, discussed and presented in following sub-headings:

4.1. Effectiveness of some promising insecticides on shoot infestation

The comparative effectiveness of various treatments on shoot infestation by the brinjal shoot and fruit borer has been evaluated in terms of percent (%) shoot infestation as well as in percent (%) reduction in infestation over control is presented in Table 2. Among the five selected insecticides treated plots the percent shoot infestation was the lowest (6.457%) in the plots treated with Acimix @ 1ml/Litre of water at 7 days interval followed by Calipso (6.94%), Neem oil (14.03%), Nexaid (14.89%) and Neem Seed Kernel Extract (15.76%) being statistically different. The highest percent shoot infestation (19.40%) was recorded in the untreated control plots than all other treatments statistically different between them.

In terms of percent shoot infestation reduction over control all insecticides reduced considerable amount of shoot damage over control as shown in the Table-1.The highest percent reduction of shoot infestation (66.72%) was recorded in Acimix treated plots followed by Calipso (64.19%), Neem oil (27.68%), Nexaid (23.25%), Neem Seed Kernel Extract (18.76%) treated plots during cropping season.

Table 1. Effectiveness of five selected promising insecticides on the infestation of brinjal shoot caused by brinjal shoot and fruit borer (BSFB)

Treatment	Healthy shoot	Infested shoot	% Infested shoot	% Reduction over control
T_1	18.71a	1.29c	6.45c	66.72
T_2	17.38ab	1.29c	6.94c	64.19
T_3	15.37bc	2.46b	14.03b	27.68
T_4	14.79c	2.75b	15.76b	18.76
T_5	14.59c	2.54b	14.89b	23.25
T_6	14.59c	3.50a	19.40a	-
$LSD_{(0.05)}$	2.06	0.430	3.09	-
CV(%)	7.14	10.22	13.19	-

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications.

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

From the above findings it was revealed that T_1 comprising spraying of Acimix @1ml/L of water at 7 days interval performed as the best treatment (66.72%) in reducing shoot infestation during the management of brinjal shoot and fruit borer followed by T_2 (64.19%) and T_3 (27.68%). As a result, the trend of results in terms of reducing the shoot infestation is $T_1>T_2>T_3>T_5>T_4>T_6$. More or less similar results were also reported by several researchers. Rahman *et al.* (2006) and Kabir *et al.* (1994) observed similar results where chemical insecticides performed the best ensuring the lowest (7.59%) shoot infestation. Duara *et al.* (2003), Singh and Singh (2003), Jat and Pareek (2001) observed the best efficacy of cypermethrin against BSFB. Moreover, the least effectiveness of nimbicidine was reported by Jat and Pareek (2001), which was similar to the result obtained in thepresent study but Srinibvasan *et al.* (1998), reported that nimbicidine provided best effectiveness compared to control.

4.2. Effectiveness of some promising insecticides on the fruit infestation by number

The comparative effectiveness of various treatments on fruit infestation by the brinjal shoot and fruit borer has been evaluated in terms of percent (%) fruit infestation by number as well as in percent (%) reduction in infestation over control is presented in Table 3. Among the five selected insecticides treated plots the percent fruit infestation was the lowest (14.77%) in the plots treated with Calipso @ 1ml/L of water at 7 days interval followed by Acimix (15.64%), Nexaid (21.94%), Neem oil (33.60%) and Neem Seed Kernel Extract (37.70%) being statistically different.

On the other hand, the highest percent fruit infestation (46.78%) was recorded in the untreated control plots followed by Neem Seed Kernel Extract (37.70%) and Neem oil (33.60%) having statistically different among them.

In terms of percent fruit infestation reduction over control all insecticides reduced considerable amount of fruit damage over control as shown in the Table-2.The highest percent reduction of fruit infestation (68.41%) was recorded in Calipso treated plots followed by Acimix (66.56%), Nexaid (53.15%), Neem oil (28.15%), Neem Seed Kernel Extract (19.40%), treated plots during cropping season.

Table 2. Effectiveness of five selected promising insecticides on the infestation of brinjal fruit by number caused by brinjal shoot and fruit borer (BSFB)

Treatment	Healthy fruit number	Infested fruit number	% Infested fruit number	% Reduction over control
T_1	18.32a	2.87c	15.64e	66.56
T_2	19.04a	2.82c	14.77e	68.41
T_3	15.05c	5.06a	33.60c	28.15
T_4	13.42d	5.09a	37.70b	19.40
T_5	17.14b	3.76b	21.91d	53.15
T_6	10.15e	4.75a	46.78a	0
$LSD_{(0.05)}$	1.11	0.75	2.95	-
CV(%)	3.94	10.21	5.71	-

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications.

[[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]]

The above results indicated that Calipso was highly effective in protecting the brinjal fruits against BSFB, while Acimix, Nexaid, Neem oil were moderately effective. From these findings it was revealed that T_2 performed as the best treatment (68.56%) in reducing fruit infestation by number during the management of brinjal shoot and fruit borer followed by T_1 (66.56%) and T_5 (53.15%). As a result, the trend of results in terms of reducing the fruit infestation is $T_2>T_1>T_5>T_3>T_4>T_6$. The above finding also indicated that BSFB preferred fruits than the shoots. Similar findings have also been reported by some researchers supporting the results of the present study need to be explained. Sparks *et al*. (1995) observed higher percent reduction of fruit damage over control in Spinosad treated plants, which were recorded 90.71 and 86.81 percent during 2005 and 2006, respectively. The results thus obtained by Rahman *et al.* (2006) reported that chemical insecticides performed the best ensuring the lowest fruit infestation (4.16%) rendering 88.06% reduction in fruit by number. Prakash (1988) also reported that insecticides also notable to suppress this borer pest below the Economic Injury Level (EIL).

4.3. Effectiveness of some promising insecticides on the fruit infestation by weight

The significant variations among different management practices were observed in respect of percent fruit infestation of brinjal by weight during the management of brinjal shoot and fruit borer throughout the cropping season. Among the five selected insecticides treated plots the percent fruit infestation by weight was the lowest (18.33%) in the plots treated with calipso @ 1ml/Litre of water at 7 days interval followed by Acimix (21.78%), Nexaid (31.81%), Neem oil (38.53%) and Neem Seed Kernel Extract (42.73%) being statistically different.

The highest percent fruit infestation by weight (47.05%) was recorded in the untreated control plots.

In terms of percent fruit infestation by weight reduction over control all insecticides reduced considerable amount of fruit damage over control as shown in the Table-3.The highest percent reduction of fruit infestation by weight (61.04%) was recorded in Calipso treated plots followed by Acimix (53.7%), Nexaid (32.38%), Neem oil (18.09%), Neem Seed Kernel Extract (9.17%) treated plots during cropping season.

Table 3. Effectiveness of five selected promising insecticides on the infestation of brinjal fruit by weight caused by brinjal shoot and fruit borer (BSFB)

Treatment	Healthy fruit Weight (g)	Infested fruit Weight (g)	% Infested fruit weight (g)	% Reduction over control
T_1	60.99ab	13.31d	21.78e	53.7
T_2	62.89a	11.53d	18.33f	61.04
T_3	55.45c	21.38b	38.53c	18.09
T_4	53.18cd	22.72ab	42.73b	9.17
T_5	59.32b	18.93c	31.81d	32.38
T_6	51.04d	24.01a	47.05a	0
$LSD_{(0.05)}$	2.55	2.31	3.37	-
CV(%)	2.45	6.84	5.57	-

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications.

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

From the above findings it was revealed that T_2 comprising spraying of Calipso @1ml/L of water at 7 days interval performed as the best treatment (61.04476%) in reducing fruit infestation by weight during the management of brinjal shoot and fruit borer followed by T_1 (53.7%) and T_5 (32.38%).

As a result, the trend of results in terms of reducing the fruit infestation is $T_2>T_1>T_5>T_3>T_4>T_6$. More or less similar results were also reported by several researchers. Sparks *et al*. (1995) observed higher percent reduction of fruit damage over control in Spinosad treated plants, which were recorded 90.71 and 86.81 percent during 2005 and 2006, respectively. The results on effectiveness of Spinosad in the present findings were in accordance with the reports of Dandale *et al*. (2001). He reported that Spinosad was found to be effective in suppressing the bollworm complex damage in green fruiting bodies in cotton up to 14 DAT. Puranik *et al.* (2002) reported that five sprays of Dipel 8L (Bt) @ 0.2% at 10 days interval resulted in minimum fruit (11.78%) infestation and proved to be the most effective treatment.

4.4. Effectiveness of some promising insecticides on the plant growth

The comparative effectiveness of various treatments on the plant growth by the brinjal shoot and fruit borer has been evaluated in terms of height of plant and number of branches per plant was significantly influenced by different management practices as well as in percent (%) increase over control is presented in Table-4. Among the five selected insecticides the highest number of branches per plant (9.41%) in the plots treated with Calipso @ 1ml/Litre of water at 7 days interval followed by Acimix (9.20%), Nexaid (8.61%), Neem oil (7.88%) and Neem Seed Kernel Extract (7.38%) being statistically different. On the other hand, the lowest number of branches per plant (6.89) recorded in the untreated control plots followed by Neem Seed Kernel Extract (7.38) and Neem oil (7.88) having statistically different between them.

In case of percent increase of number of branches per plant over control the highest increase was found in (36.50%) was recorded in Calipso treated plots followed by Acimix (33.46%), Nexaid (25.00%), Neem oil (14.31%), Neem Seed Kernel Extract (7.10%) treated plots during cropping season.

From the above findings it was revealed that Calipso performed as the best treatment (36.50%) in increasing branch number per plant during the management of brinjal shoot and fruit borer followed by Acimix (33.46%), Nexaid (25.00%), Neem oil(14.3%), Neem Seed Kernel Extract (7.10%). As a result, the trend of results in terms of increasing the number of branches per plant is $T_2>T_1>T_5>T_3>T_4>T_6$.

Table 4. Effectiveness of five selected promising insecticides on the plant growth during the management of brinjal shoot and fruit borer (BSFB)

Treatment	Number of branches/plant	% Increase over control	Height of plant (cm)	% Increase over control

T_1	9.2a	33.462	58ab	13.33
T_2	9.41a	36.50	65.03a	27.06
T_3	7.88c	14.31	52.93b	3.42
T_4	7.38d	7.1	55.38b	8.21
T_5	8.61b	25	56.21b	9.83
T_6	6.89e	0	51.18b	0.00
$LSD_{(0.05)}$	0.43	-	8.162	-
CV(%)	2.88	-	7.95	-

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications.

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

Among the five selected insecticides the highest plant height (65.03cm) in the plots treated with Calipso @ 1ml/L of water at 7 days interval followed by Acimix (58.00cm), Nexaid (56.21cm), Neem Seed Kernel Extract (55.38cm) and Neem oil(52.93cm) being statistically different.

In case of percent increase of plant height over control the highest increase was found in (27.06%) was recorded in Calipso treated plots followed by Acimix (13.33%), Nexaid (9.83%), Neem Seed Kernel Extract (8.21%) and Neem oil (3.42%), treated plots during cropping season.

From the above findings it was revealed that Calipso performed as the best treatment (27.06%) in increasing of plant height during the management of brinjal shoot and fruit borer followed by Acimix (13.33%), Nexaid (9.83%), Neem Seed Kernel Extract (8.21%) Neem oil (3.42%). As a result, the trend of results in terms of increasing the number of branches per plant is $T_2>T_1>T_5>T_4>T_3>T_6$.

4.5. Relationship between shoot infestation and yield attributes of eggplant

Relationship between shoot infestation and yield attributes of eggplant is presented in the Figure 1. It was found that both number of branch and height per plant were found higher in the treatments where the shoot infestation of eggplant were found lower and vice-versa due to application of different management practices against brinjal shoot and fruit borer the best treatment (T_1 & T_2) reduced the highest percent of shoot infestation, but increased the maximum number of branch per plant as well as maximum number of height per plant.

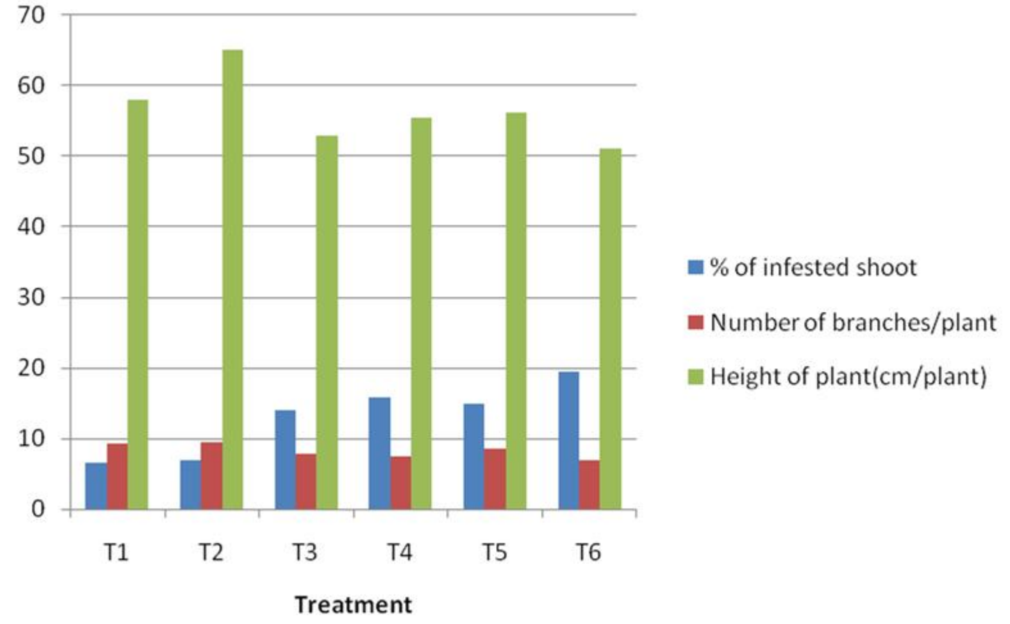


Figure 1. Relationship between shoot infestation and yield attributes of eggplant

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

4.6. Effectiveness of some promising insecticides on the fruit behavior

The significant variations among different management practices were observed in respect of fruit infestation of brinjal by length and girth during the management of brinjal shoot and fruit borer throughout the cropping season. Among the five selected insecticides treated plots the fruit infestation by length was the highest (14.10cm) in the plots treated with Calipso @ 1ml/L of water at 7 days interval followed by Acimix (13.17cm), Nexaid (12.807cm), Neem oil (11.87cm) and Neem Seed Kernel Extract (11.14cm) being statistically different. And the fruit infestation by girth was the highest (8.08cm) in the plots treated with calipso @ 1ml/Litre of water at 7 days interval followed by Acimix (7.21cm), Nexaid (6.38cm), Neem oil (6.04cm) and Neem Seed Karnel Extract (5.56cm) being also statistically different.

In terms of percent fruit infestation by length and girth increase over control all insecticides reduced considerable amount of fruit damage over control as shown in the Table-5. The highest percent increase of fruit infestation by length (43.40%) was recorded in Calipso treated plots followed by Acimix (33.95%), Nexaid (30.19%), Neem oil(20.69%), Neem Seed Kernel Extract (13.27%) treated plots during cropping season and the highest percent increase of fruit infestation by length (55.91%) was recorded in Calipso treated plots followed by Acimix (39%), Nexaid (13.13%), Neem oil (16.51%), Neem Seed Kernel Extract (7.19%) treated plots during cropping season.

Table 5. Effectiveness of five selected promising insecticides on the Fruit behavior by length, girth, caused by brinjal shoot and fruit borer (BSFB)

Treatment	infested fruit length (cm)	% Increase over control	infested fruit girth (cm)	% Increase over control
T_1	13.17b	33.95	7.21b	39
T_2	14.10a	43.40	8.08a	55.91
T_3	11.87d	20.69	6.04d	16.51
T_4	11.14d	13.27	5.56e	7.19
T_5	12.80c	30.19	6.38c	13.13
T_6	9.83f	0.00	5.18f	0.00
$LSD_{(0.05)}$	0.13	-	0.09	-
CV(%)	1.66	-	4.35	-

In column, means containing same letters indicate significantly similar results under DMRT at 5% level of significance. Values are the means of three replications.

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

From the above findings it was revealed that T_2 comprising spraying of Calipso @1ml/L of water at 7 days interval performed as the best treatment (43.40%) and (55.91%) in reducing fruit infestation by length and girth during the management of brinjal shoot and fruit borer followed by T_1 (33.95%) and T_5(30.19%) for length and T_1 (39%) and T_5(13.136%) for girth. As a result, the trend of results in terms of increasing the length and girth of infested fruit is $T_2>T_1>T_5>T_3>T_4>T_6$.

4.7 Relationship between infested fruit weight and fruit related yield attributes.

Relationship between shoot infestation and yield attributes of eggplant is presented in the Figure 2. It was revealed that maximum infested length and girth of single fruit were found in the treatments where the fruit infestations by weight were found lower and vice-versa. These variations were found due to efficiency variations of different management practices applied against brinjal shoot and fruit borer. That is the best treatment (T_2) increased the maximum length and girth of single fruit by reducing the fruit infestation at minimum level.

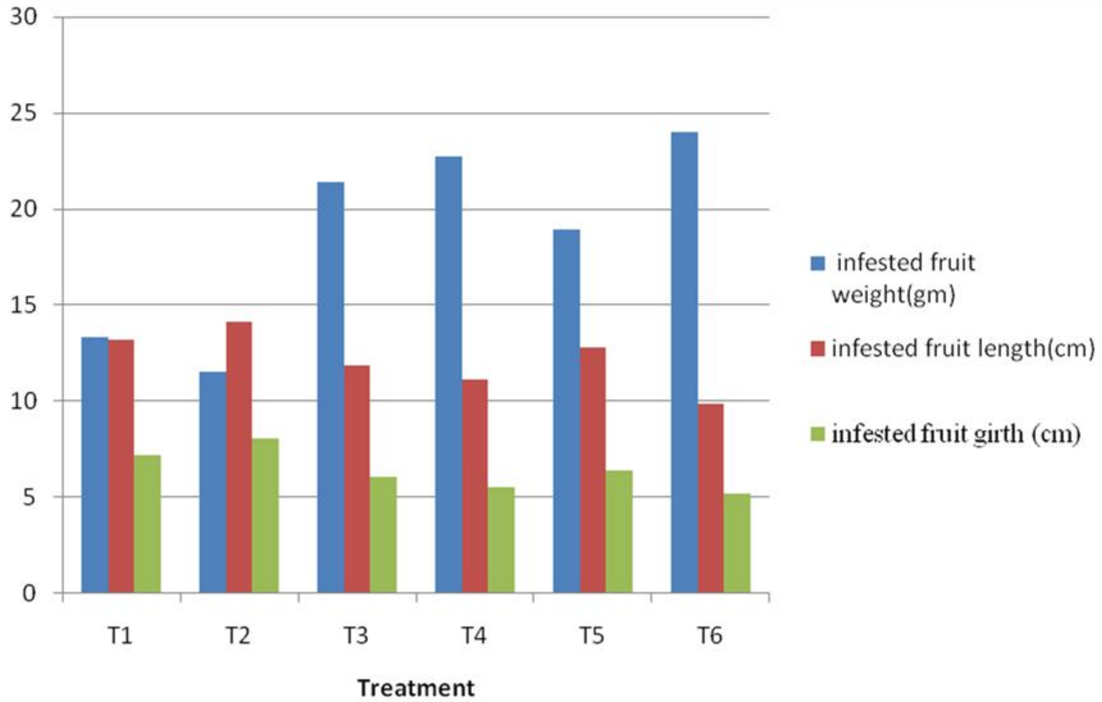


Figure 2. Relationship between infested fruit weight and fruit related yield attributes

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

4.8. Effectiveness of some promising insecticides on the incidence of ladybird beetle

Significant variation were observed among different management practices in terms of larvae and adult lady bird beetle population during the management of brinjal shoot and fruit borer in the field (Table-6).The highest number of adult lady bird beetle per plant was observed (3.37) in the untreated plots followed by Neem Seed Kernel Extract (2.75), Neem oil (2.41), Nexaid (2.38), Acimix (1.08) and Calipso (0.63) being statistically different. On the other hand, the lowest number of adult lady bird beetle was observed in (0.6300) was recorded in Calipso @ 1ml/L of water at 7 days interval treated plots followed by Acimix (1.08), Nexaid (2.38), Neem oil (2.41), Neem Seed Kernel Extract (2.75) treated plots during cropping season. In case of percent reduction of adult lady bird beetle over control due to application of different management practices against brinjal shoot and fruit borer, the highest reduction was recorded in Calipso treated plots (81.34%) followed by Acimix (67.81%), Nexaid (29.52%), Neem oil (28.43%), Neem Seed Kernel Extract (18.48%) treated plots. As a result, the trend of reduction of adult lady bird beetle population among different management practices was $T_2 > T_1 > T_5 > T_3 > T_4 > T_6$.

The highest number of larvae of lady bird beetle per plant was observed (2.12) in the untreated plots followed by Neem Seed Kernel Extract (1.58), Neem oil (1.50), Nexaid (1.37), Acimix (1.00) and Calipso (0.58) being statistically different. On the other hand, the lowest number of adult lady bird beetle was recorded in Calipso (0.58) @ 1ml/L of water at 7 days interval treated plots followed by Acimix (1.00), Nexaid (1.37), Neem oil (1.503), Neem Seed Kernel Extract (1.58) treated plots during cropping season. In case of percent reduction of adult lady bird beetle over control due to application of different management practices against brinjal shoot and fruit borer, the highest reduction was observed in Calipso (72.42%) treated plots followed by Acimix (52.99%), Nexaid (35.26%), Neem oil(29.34%), Neem Seed Kernel Extract (25.39%) treated plots. As a result, the trend of reduction of adult lady bird beetle population among different management practices was $T_2 > T_1 > T_5 > T_3 > T_4 > T_6$.

Table 6. Effectiveness of five selected promising insecticides on ladybird beetle population counted during the management practices of brinjal shoot and fruit borer (BSFB)

Treatment	Incidence of adult lady bird beetle (No./plant)	% Reduction over control	Incidence of larvae lady bird beetle (No./plant)	% Reduction over control
T_1	1.08c	67.81	1.00cd	52.99
T_2	0.63d	81.34	0.58d	72.42
T_3	2.41b	28.43	1.50b	29.34
T_4	2.75b	18.48	1.58b	25.39
T_5	2.38b	29.52	1.377c	35.26
T_6	3.37a	-	2.12a	-

LSD$_{(0.05)}$	0.44	-	0.43	-
CV(%)	11.57	-	17.47	-

In column, means containing same letters indicate significantly similar results under DMRT at 5% level of significance. Values are the means of three replications.

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

From these findings it was revealed that T_2 reduced the highest population comprising Calipso @ 1ml/L of water at 7 days interval and showed the most adverse effect in reducing the adult and larvae of lady bird beetle population (81.34% & 72.42%), respectively during the management of brinjal shoot and fruit borer that closely followed by T_1 (67.81 & 52.99%) reduction of lady bird beetle adult and larval population, respectively comprising spraying of Acimix @ 1ml/L of water at 7 days interval. On the other hand, T_4 showed the least adverse effect in reducing (18.48% & 25.39%) spraying of Neem Seed Kernel extract @ 100g/L of water at 7 days interval the adult and larvae of lady bird beetle population during the management of brinjal shoot and fruit borer flowed by T_3 (28.43% & 29.34%) comprising spraying of Neem oil @ 3ml/L of water at 7 days interval. More or less similar findings were also reported by several researchers. FAO (2003) reported that application of insecticides reduced the population of beneficial insects especially spiders and lady bird beetle from the brinjal agro-ecosystem.

In comparison between synthetic chemical and botanical based management practices, synthetic chemical insecticide Acimix and Calipso reduced the highest number of lady bird beetle larval population than botanical based management practices such as Neem oil and Neem Seed Kernel extract. Nimbicidene and flubendiamide were less harmful to arthropods species and natural enemies, while Abamectin was moderately harmful insecticide to the arthropods biodiversity in the brinjal ecosystem (Latif, 2007). Boyd and Boethel (1998) found greater toxicity of Cypermecthrin and Methyl parathion against those predators and demonstrated that most of the newer insecticides were more selective than the older insecticides. Tohnishi *et al.* (2005) stated that neem products were less toxic to lady bird beetle, spiders and other predators than chemical insecticides.

4.9. Effectiveness of some promising insecticides on the field spider and ant.

Significant variation were observed among different management practices in terms of field spider and ant population during the management of brinjal shoot and fruit borer in the field (Table-7).The highest number of field spider per plant was observed in the untreated plots (2.04) followed by Neem Seed Kernel Extract (1.54), Neem oil (1.29), Nexaid (1.29),Calipso (0.58) and Acimix (0.50). On the other hand, the lowest number of field spider was observed in (0.50) was recorded in Acimix@ 1ml/Litre of water at 7 days interval treated plots followed by Calipso (0.58), Nexaid (1.29), Neem oil(1.29), Neem Seed Kernel Extract (1.54) treated plots during cropping season. In case of percent reduction of field spider over control due to application of different management practices against BSFB, the highest reduction was observed in (75.53%) was recorded in Acimix treated plots followed by Calipso (71.28%), Nexaid (36.71%), Neem oil (36.51%), Neem Seed Kernel Extract (24.47%) treated plots. As a result, the trend of reduction of field spider population among different management practices was

$T_1 > T_2 > T_5 > T_3 > T_4 > T_6$.

Table 7. Effectiveness of five selected promising insecticides on field spider and ant population counted during the management of brinjal shoot and fruit borer (BSFB)

Treatment	Incidence of field spider (no./plant)	% Reduction over control	Incidence of field ant (no./plant)	% Reduction over control
T_1	0.50c	75.53	1.22cd	52.21
T_2	0.58c	71.28	0.94d	63.18
T_3	1.29b	36.51	1.99ab	21.78
T_4	1.54b	24.47	1.83b	28.32
T_5	1.29b	36.71	1.75bc	31.45

T_6	2.04a	0.00	2.55a	0.00
$LSD_{(0.05)}$	0.38	-	0.56	-
CV(%)	17.54	-	18.21	-

In column, means containing same letters indicate significantly similar results under DMRT at 5% level of significance. Values are the means of three replications.

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

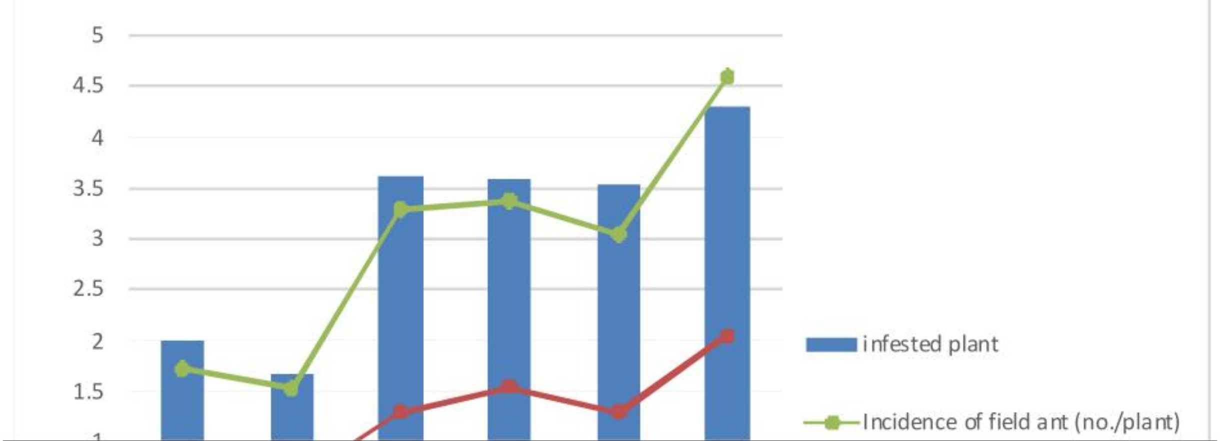
Again the highest number of ant per plant was observed in the untreated plots (2.553) followed by Neem oil (1.99), Neem Seed Kernel Extract (1.83), Nexaid (1.75), Acimix (1.22) and Calipso (0.94) being statistically different. On the other hand, the lowest number of adult lady bird beetle was observed in was recorded in Calipso (0.94) @ 1ml/L of water at 7 days interval treated plots followed by Acimix (1.22), Nexaid (1.75), Neem Seed Kernel Extract (1.83), Neem oil (1.99) treated plots during cropping season. In case of percent reduction of ant over control due to application of different management practices against BSFB, the highest reduction was observed in was recorded in Calipso treated (63.18%) plots followed by Acimix (52.21%), Nexaid (31.45%), Neem Seed Kernel Extract (28.32%), Neem oil (21.78%) treated plots. As a result, the trend of reduction of adult lady bird beetle population among different management practices was $T_2 > T_1 > T_5 > T_4 > T_3 > T_6$.

From these findings it was revealed that T_1 and T_2 reduced the highest population of spider and ant comprising Acimix @ 1ml/L of water at 7 days interval and Calipso @ 1ml/L of water at 7 days interval showed the most adverse effect in reducing the field spider and ant population (75.53 & 63.18%), respectively during the management of BSFB that closely followed by T_2 in terms of field spider (71.28%) and ant (52.21%) population reduction respectively. On the other hand, T_4 and T_3 showed the least adverse effect in reducing spraying of Neem Seed Kernel extract (24.47%) and Neem oil (21.78%), respectively the field spider and ant population during the management of BSFB .

In comparison between synthetic chemical and botanical based management practices, synthetic chemical insecticide Acimix and Calipso reduced the highest number of field spider and ant population than botanical based management practices such as Neem oil and Neem Seed Kernel extract. More or less similar findings were also reported by several researchers. Maleque *et al.* (1998) and Rahman (2006) reported that the lady bird beetles and spiders were seriously affected in the field where Cypermecthrin was applied at weekly intervals.Sauphanor *et al.*1995, reported that Azadirachtin is relatively harmless to spiders, butterflies and insects such as bees that pollinate crops and trees, lady bird beettles that consume aphids and wasps that act as parasites on various crop pests. This is because neem products must be ingested to be effective. Thus, insects that feed on plant tissue succumb, while those that feed on nectar or other insects rarely contact significant concentrations of neem products. In a few trials, negative effects have been noted on immature stages of beneficial species exposed to neem products. However, neem products are generally thought to be suitable for inclusion into integrated pest management programs (Banken and Stark, 1997).

4.10 Relationship between plant infestation and population of field spider and ant

Relationship between plant infestation and population of field spider and ant are presented in the Figure 3. It was found that higher population of field spider and ant were found in the treatments where the plant infestation of eggplant were found also higher. Conversely, the higher level of plant infestation was reduced by the treatments which had higher adverse effect on the incidence of brinjal shoot and fruit borer. Simultaneously, these highly toxic treatments also adversely affected the population field spider and ant in the brinjal field. That is the best treatment (T_1 & T_2) reduced the field spider and ant at maximum level by maintaining the plant infestation at minimum level.



[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

4.11. Effectiveness of some promising insecticides on the yield of brinjal fruit

The significant variations were observed among different treatments in terms of fruit yield of brinjal due to application of different management practices against BSFB (Table-8). In case of yield of plot the highest yield (9.2167kg/plot) was observed in in the plots treated with calipso @ 1ml/Litre of water at 7 days interval followed by Acimix (8.91kg/plot), Nexaid (8.61kg/plot), Neem oil (8.41kg/plot) and Neem Seed Kernel Extract (7.58kg/plot) being statistically different. More or less similar trends of results were also observed among different treatments. In terms of yield of brinjal fruit calculating in ton/ha were the highest yield was recorded in (15.36 MT/ha) in the plots treated with calipso @ 1ml/L of water at 7 days interval followed by Acimix (14.86 MT/ha), Nexaid (14.35 MT/ha), Neem oil (14.02 MT/ha) and Neem Seed KErnel Extract (12.63 MT/ha)

Considering the percent yield increase over control the highest (45.73%) increase was recorded in Calipso @ 1ml/Litre of water at 7 days interval followed by Acimix

(40.98%), Nexaid (36.17%), Neem oil (33.01%) and Neem Seed Kernel Extract (19.89%).

From the above findings it was revealed that T_2 performed as the best management practices in increasing the fruit yield over control (45.73%) and lowest (19.81%) increase recorded in T_4. As a result, the trends of different management practices in terms of percent yield increase is $T_2 > T_1 > T_5 > T_3 > T_4 > T_6$. Similar findings were reported by some researchers supporting the results of the present study. Jat and Preek (2001) and Misra (1993) reported that Nimbicidene was the least effective in controlling the BSFB and resulted lowest yield but Srinibvasan *et al.* (1998) reported that Nimbicidene provided higher yield (13.02 t/ha) than Endosulfan. The less effectiveness of Cypermethrin and other insecticides were also reported by some researchers (Kabir *et al*. 1993, Anonynous. 1991) but some other several researchers reported the best performance of Cypermethrin in producing highest yield of brinjal (Daura *et al*. 2003, Singh and Singh 2003).

Table 8. Effectiveness of five selected promising insecticides on the yield of fruit during the total cropping season

Treatment	Yield of fruits		
	(kg/plot)	(MT/ha)	% Increase over control
T_1	8.91ab	14.86ab	40.98
T_2	9.21a	15.36a	45.73
T_3	8.41c	14.02c	33.01
T_4	7.58d	12.63d	19.89
T_5	8.61bc	14.35bc	36.17
T_6	6.32e	10.54e	-

$LSD_{(0.05)}$	0.45	0.76	-
CV(%)	3.08	3.08	-

In column, means containing same letters indicate significantly similar results under DMRT at 5% level of significance. Values are the means of three replications.

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

4.12 Relationship between fruit infestation and yield of brinjal.

Relationship between fruit infestation and yield of brinjal is presented in figure 4, it was found that higher fruit infestation plots were given the lower yield of eggplant. Simultaneously lower fruit infestation plots were given the higher yield of eggplant. That is the best treatment (T_2) reduced the fruit infestation and given the maximum yield of eggplant.

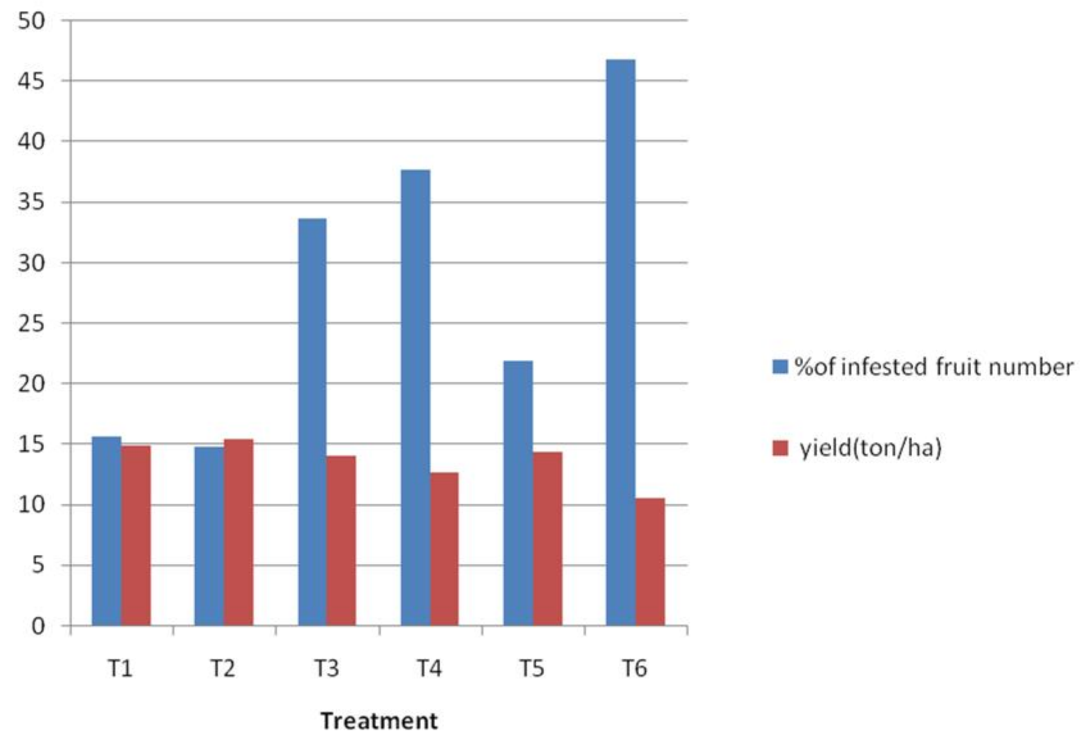


Figure 4. Relation between fruit infestation and yield of brinjal

[T_1 = Spraying of Acimix @ 1ml/L of water at 7 days interval; T_2 = Spraying of Calipso @ 1ml/L of water at 7 days interval; T_3 = Spraying of Neem oil @ 3ml/L of water at 7 days interval; T_4 = Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval; T_5 = Spraying of Nexaid @ 1.5ml/L of water at 7 days interval; T_6 = Untreated Control]

CHAPTER V

SUMMARY

Brinjal (*Solanum melongena* L.) is one of the important readily cash flow vegetable crops in Bangladesh and also in many other countries. Brinjal shoot and fruit borer (BSFB) *Leucinodes orbonalis* Guenee is a common pest of this important crop in Bangladesh as well as in Asia. Considering the efficiency of different management practices on different parameters, the findings of the results have been summarized below:

Efficacy of management practices on the level of infestation caused by BSFB

In terms of percent shoot infestation by number during the management of brinjal shoot and fruit borer, T_1 comprising spraying of Acimix @1ml/L of water at 7 days interval performed as the best treatment (66.72%) in reducing shoot infestation during the management of brinjal shoot and fruit borer followed by T_2 (64.19%) Spraying of Calipso @ 1ml/L of water at 7 days interval, whereas T_3 showed least performance (27.68%) Spraying of Neem oil @ 3mml/L of water at 7 days interval in reducing shoot infestation by number over control. As a result, the trend of different management practices in terms of percent shoot infestation reduction was As a result, the trend of results in terms of reducing the shoot infestation is T_1 (Acimix)>T_2 (Calipso)>T_3 (Neem oil)>T_5(Nexaid)>T_4 (Neem Seed Karnel Extract)>T_6(Untreated control).

In case of fruit infestation by number, T_2 performed best result in reducing highest fruit infestation by number (68.56%) over control followed by T_1 (66.56%) and T_5 (53.15%), whereas T_4 showed the least performance (19.40%) in reducing percent the fruit infestation by number over control. As a result, the order of performance of different management practices in terms of percent fruit infestation reduction by number was $T_2>T_1>T_5>T_3>T_4>T_6$. Similarly, in terms of fruit infestation by weight, T_2 also performed best result in terms of percent fruit infestation by weight reduction (61.04%) over control followed by T_1 (53.7%) and T_5 (32.38%). As a result, the order of performance of different management practices in terms of percent fruit infestation reduction by weight was $T_2>T_1>T_5>T_3>T_4>T_6$.

Considering the effect of management practices on the height of eggplants, T_2 performed best result in increasing the maximum plant height (27.06%) over control followed by Acimix (13.33%), Nexaid (9.83%), whereas the least performance showed by Neem oil (3.42%), over control. As a result, the trend of different management practices in terms of percent plant height increase was $T_2>T_1>T_5>T_4>T_3>T_6$. Similarly, T_2 performed best result in increasing maximum number of branch per plant (36.50%) over control followed by T_1 Acimix (33.46%), Nexaid(25.00%), whereas showed the least performance showed Neem Seed Karnel

Extract (7.10%) in increasing the percent of the number of branch per plant over control. As a result, the trend of different management practices was $T_2>T_1>T_5>T_3>T_4>T_6$.

In case of fruit related yield attributes, the length and girth of infested fruit during the management of brinjal shoot and fruit borer, T_2 performed the best result in terms of percent fruit length and girth increase (43.40%) and (55.91%)over control followed by T_1 (33.95%) and T_5(30.192%) for length and T_1 (39.00%) and T_5 (13.13%) for girth. As a result, order of the performance of different management practices in increasing fruit length and girth was $T_2>T_1>T_5>T_3>T_4>T_6$.

Considering the relationship of shoot and yield attributes of eggplants compared with the infested fruit weight and fruit related yield attributes, it was revealed that number of branch and fruit per plant; length, girth and fruit weight were found maximum in those treatments where the shoot and fruit infestation caused by BSFB were found minimum and vice-versa. As the best treatment T_2reduced the highest percent of fruit infestation, conversely it increased the maximum number of branch and fruit per plant; length, girth and fruit weight. These variations were found due to efficiency variations of different management practices applied against BSFB.

In case of fruit yield, T_2 performed best result in increasing highest percent yield (45.73%) over control followed by T_1 (40.98%) and T_5 (36.17%), whereas T_4(19.81%) showed the least performance over control. As a result, the order of the performance of different management practices in terms of percent increase yield of brinjal fruit was $T_2>T_1>T_5>T_3>T_4>T_6$.

Impact of management practices on predatory ladybird beetle and other arthropods

Considering the impact of the management practices on the population of ladybird beetle, T_2 comprising spraying of Calipso @ 1ml/L of water at 7 days interval adversely affected and reduced the highest population (81.34%) of adult lady bird beetle over control followed by T_1(67.81%), comprising spraying of Acimix @1ml/L of water at 7 days interval, whereas T_4 (18.48%) comprising Spraying of Neem Seed Kernel Extract @ 100g/L of water at 7 days interval showed the least level of adverse effect in reducing (18.48%) the adult ladybird beetle population over control during the management of brinjal shoot and fruit borer. As a result, order of the level of adverse impact among different management practices in reducing the population of adult ladybird beetle in the brinjal field was $T_2>T_1>T_5>T_3>T_4>T_6$.

Similarly, T_2 also adversely affected the population of ladybird beetle larvae during the management of BSFB and reduced the highest population (72.42%) over control followed by Acimix (52.99%), Nexaid (35.26%), whereas Neem Seed Kernel Extract (25.39%) showed the least level of adverse effect in reducing ladybird beetle larvae. As a result, order of the level of adverse impact among different management practices in reducing the population of ladybird beetle larvae was $T_2>T_1>T_5>T_3>T_4>T_6$.

Likewise of ladybird beetle adults and larvae, T_1 adversely affected population of predatory field spider in the brinjal field and reduced the highest population (75.53%) over control as compared with other management practices applied against brinjal shoot and fruit borer followed by Calipso (71.28%), Nexaid (36.71%), whereas T_4 (24.47%) showed the least adverse effect in reducing the field spider population. As a result, order of the level of adverse impact among different management practices in reducing the population of ladybird beetle larvae was$T_1>T_2>T_5>T_3>T_4>T_6$.

Similarly, T_2 also adversely affected the population of field ant during the management of BSFB and reduced the highest population (63.18%) over control followed by Acimix (52.99%), Nexaid (35.26%), whereas Neem Seed Kernel Extract (25.39%) showed the least level of adverse effect in reducing field ant. As a result, order of the level of adverse impact among different management practices in reducing the population of field ant was $T_2>T_1>T_5>T_3>T_4>T_6$

Considering the effectiveness of different management practices in terms of reducing the level of infestation caused by BSFB as well as their impacts on the predatory ladybird beetle and other beneficial arthropods, it was revealed that higher population of predatory ladybird beetle adult and larvae as well as predatory field spider and ant were found in the treatments where the fruit infestation of eggplant were found also higher. Conversely, the higher levels of shoot and fruit infestation were reduced by those treatments which had higher adverse effect on the incidence of brinjal shoot and fruit borer. Simultaneously, these highly effective and toxic treatments for brinjal shoot and fruit borer (BSFB) also adversely affected the population of predatory ladybird beetle adults and larvae as well as predatory field spiders in the brinjal field. Thus, the best treatment (T_2) reduced the maximum population of ladybird beetle adults and larvae as well as field ant by maintaining the fruit infestation at minimum level. Hence, it is revealed that both the chemical treatments T_2 comprising Calipso @ 1ml/L of water at 7 days interval and T_1 comprising spraying of Acimix @1ml/L of water at 7 days interval reduced the maximum level of shoot and fruit infestation caused by BSFB, consequently they reduced the maximum population of natural enemies than any other botanicals based treatments viz. neem oil, neem seed kernel extract. The experimental results broadly suggest that Introduction of the new prospective insecticides offer environmentally friendly management practices of BSFB. They are also more healthy options in the time of pesticide hazards leading to serious health problems to human and domestic animal.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

Conclusion:

Result of the present study revealed that T_2 treatment (Calipso @ 1ml/L of water) caused significant reduction over control in fruit infestation, increased plant growth (height, number of branch per plant), fruit properties (highest length, girth, number and weight of fruit per plant) and increasing the maximum fruit yield followed by Acimix, whereas Neem Seed Kernel Extract showed the least performance. Acimix reduced highest shoot infestation over control followed by Calipso and neem oil whereas Neem Seed Kernel Extract showed the least performance. Considering the management practices on the population of adult and larvae of ladybird beetle, predatory field spider and ant T_2 treatment (Calipso @ 1ml/L of water) had adversely affected and reduced the highest population of those natural enemies over control followed by T_1 treatment (Acimix @ 1ml/L of water), whereas Neem Seed Karnel Extract performed as the least hazardous treatment and reduced the lowest level of predatory adult ladybird beetle, larvae and predatory ant population over control. Though, Nexaid was safer ecofriendly insecticide for the nataural enemy and less harmful chemical insecticide to arthropod biodiversity, Calipso was the most effective insecticide for managing Brinjal Shoot and Fruit Borer (BSFB) followed by Acimix.

Recommendations:

Based on above conclusions and limitations of the study, the following recommendations are suggested for ensuring an environmentally friendly BSFB management:

- Similar study should be conducted in other location of the country.
- Further study can be conducted with different doses of other promising insecticides.

- Calipso may be suggested as chemical method against BSFB as because it was the most effective and compatible insecticide against BSFB ensuring the highest mortality of BSFB larvae and the highest healthy fruit yield per unit area and it can be recommended as effective control measure of BSFB in eggplant
- Considering the conservation of natural enemies, Neem oil and Neem Seed Kernel Extract should be used in controlling BSFB instead of synthetic chemical insecticides.

CHAPTER VII

LITERATURE CITED

Alam, M.Z. and Sana, D.L. (1962). Biology ofthe brinjal shoot and fruit borer, *L. orbonalis* G. (Pyralidae: Lepidoptera) in East Pakisthan. *The Scientist.***5** (1-4): 13-24.

Alam, M. Z. 1969. Insect pest of vegetable and their control in East Pakistan published by the Agriculture Information Services, Department of Agriculture, 3, R. K. Mission Road, Dhaka-3, East Pakistan.

Alam, Ahmed M. Z., Alam A. S. and Islam M. A. (1964). A Reviev of Research Division of Entomology (1947-1964). Agricultural Information Service. 3, R. K. Mision Road, Dhaka-3. East Pakistan Agricultural Research Institute, Department of Agriculture, Dhaka, East Pakistan. 272p.

Alam, M.A., Rao P.K. and Rao B.H.K. (1982). Biology of brinjal shoot and fruit borer,*Leucinodes orbonalis* Guenee. *Indian J. Agril. Sci*. **52** (6): 391-395.

Alam, S. N., Rashid M. A., Rouf F. M. A., Jhala R. C., Patel J. R., S., Satpathy T. M., Shivalingaswamy S. Rai, Wahundeniya I., Cork A., Ammaranan C. and N. Talekar S., (2003). Development of an integrated pest management strategy for eggplant fruit and shoot boreer in South Asia. Technical Bulletin 28. AVRDC-The World Vegetable Center, Shanhua, Taiwan. 66p.

Alam, S. N., Ahmed G. J. U., Khorseduzzamn A. K. M., Karim A. N. M. R. and Raiotte E. G.. (2004). Survey of vegetable insect pests in rice-vegetable cropping systems in Bangladesh. Annual Research Report. (2003-2004). Ent. Div. Bangladesh Agricultural Research Institute, Joydebpur, Bangladesh. pp. 44-46.

Ali, M. I., Ali M. S. and Rahman M. S. (1980). Field observation of wilt disease and shoot and fruit borer attack on different cultifffvars of brinjal. Bangladesh *J. Agil. Sci.* **7**(2): 193-197.

Anjali N. J. (2006). Control of shoot and fruit borer of brinjal, *Leucinodes orbonalis* (Lepidoptera: Pyralidae) in the field. Entomon, 31(2): 141-144.

Anonymous. (1991). Management of the brinjal shoot and fruit borer. Annual Report, 1990-1991. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh. pp. 276-279.

Anonymous, (1996). Integrated control of the brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee at Jessore. ***ln:*** Annual Research Report of (1993-94). BARI, Joydebpur, Gazipur, Bangladesh. pp 44-46.

Anonymous. (2007). Statistical pocket book of Bangladesh. Bangladesh Bureau of Statistics. Government of the Peoples Republic of Bangladesh, Dhaka, Bangladesh. 155p.

Anonymous. (2008). Year book of agricultural statistics of Bangladesh. Bangladesh Bureau of Statistics. Government of the Peoples Republic of Bangladesh, Dhaka, Bangladesh.

Arida, G. S., Punzal B. S., Ravina C. C.. Balagot G. E. and Talekar N. S. (2000). Management of egg plant shoot and fruit borer *Leucinodes orbonalis* net barrier. IPM CRSP, Annual Report. **7**: 320-322.

Atwal, A.S. (1986). Agricultural pests of India and Southeast Asia. Kalyani Publish Ludhiana 502. pp.

Banken, J. O. and Stark J. D. (1997). Stage and age influence on Susceptibility of *Coccinellaseptempunctata* after direct exposure to Neemix, a neem insecticide. J. Econ. Entomol. **90**(5): 1102-1105.

Bose, T.K. and Som M.G., (1986). Vegetables crops in India. B. Mitra, Nava Prokash, 206, BidhanSarani, Calcutta 700006, India. pp. 4-293.

Butani, D.K. and Jotwani M.G., (1984). Insect pest of vegetables. Periodical Experiment Agency. D-42, Vivek Vihar, Delhi-110032, India, 356p.

BBS, (2010). The year book of agricultural statistics of Bangladesh. Statistics Division, Ministry of Planning, Dhaka, Bangladesh.

Bhadauria, N. K. S., Bhadauria N. S. and Jakmola S. S. (1999). Insect pest complex of brinjal, Solanum melongena Linn. in North-West Madhya Pradesh. *Advances in Plant Sci.* **12**(2): 607-608.

Bose, T.K. and Som, M.G. (1986). Vegetables crops in India. B. Mitra, Nava Prokash, 206, Bidhan Sarani, Calcutta 700006, India. pp.4-293

Chatterjee, S. M. L., Mondal S. and SamantaA. (2009). Field evaluation of some new insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guen.). Pesticide Research Journal, New Delhi, India. **21**(1**)**: pp. 58-60

Choudhury, O. P. and Kashyap R. K. (1992). Effect of some management practices on the incidence of insect pest and yield of eggplant. *Tropical pest Management.* **38**(4): 416-419.

Colignon, P., P. Hastir, C. Gasper and F. Francis. (2001). Effects of insecticide treatments on insect density and diversity in vegetable open fields. *Meded Rajksuniv Gent Fak Landbouwkd Toegep Biol wet*. **66**(2a): 403-411.

Dhankar, D. S. (1988). Progress in résistance studies in eggplant (*Solanum melongena* L.) against shoot and fruit borer of brinjal (*Leucinodes orbonalis* Guenee) infestation. *Tropical pest management*. **34**: 343-345.

Dutton, A., H. Klein, J. Romeis, and F. Bigler. 2003. Prey-mediated effects of *Bacillus thuringiensis* spray on the predator *Chrysoperla carnea* in maize. Biol. Control **26**:209-215.

El-Shafie, H. A. F. (2001). The use of neem products for sustainable management of Homopterous key pests on potato and eggplant in Sudan. Ph. D. Thesis, Institute of Phytopathology and Applied Zoology Experimental station Justus Liebig University of Giessen, Germany. 165p.

FAO (Food and Agricultural Organization). (1995). Celebrates its 50th Anniversary Agricultural magagine for the Middle East and Arab world Sept-Oc. 1995. Issue No. 7.

FAO (Food and Agricultural Organization). (2003). Inter country programme for integrated pest management in vegetables in south and South-East Asia. Eggplant integrated pest management: An ecological guide. 177p.

Farmpton, G. K. (1999). Spatial variation in non-target effects of the insecticides chloropyriphos, cypermethrin and primicarb on Collembola in winter wheat. *Pesti. Sci.***55**(9): 875-886.

Filho, M. M., Guedes R. N. C., Della-Lucia T. M. C., Michereff M. F. F. and Cruz I.(2004). Non-target impact of chlorpyriphos on soil arthropods associated with no-tillage cornfields in Brazil. *International J. of Pest Management.* **50**(2): 91-99.

George, S. H., Singh S., Naik G., Babu B. S. and Chandurkar P. S. (2002). Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) status in coastal districts of Orissa. pp. 121-123.

Hassall, K. A. (1990). In: 'The Biochemistry and uses of Pesticides,' Second Edition, ELBS/Macmillan. pp. 125-128.

Hill, D. S. (1983). Agricultural insect pests of the tropics and their control 2^{nd} edn. Cambridge University Press. pp. 619-634.

Ishaque, N. M. M. and Chaudhuri R. P. (1983). Larval developmental behavior of *Leucinodes orbonalis* Guenee reared on some brinjal varieties. *J. Res. Asam. Agril. Univ*. **5**: 93-97.

Jat, K. L. and Preek B. L. (2001). Field evaluation of ecofriendly insecticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee), *Indian J. Plant Protection*. **29**(1-2): 75-85.

Kabir, K. H., Rouf F. M. A., Islam M. N. and Malaker P. K.. (1993). Efficacy of different insecticides in controlling brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. *Univ. J. Zool.* Rajshahi Univ. **13**: 1-8.

Kabir, K. H., Baksh M. E., Rouf F. M. A., Karim M. A. and Ahmed A. (1994). Insecticide usage pattern on vegetables at farmers' level of Jessore region in Bangladesh: A survey finding. *Bangladesh Journal of Agricultural Research*. **21:** pp. 241-254

Karim, M. A. (1994). Vegetable and spice insect pests and their control. A lecture in training course on winter vegetable and spices production. Horticulture Research and development project, Joydebpur, Bangladesh.

Kumar, S. P. and Babu P. C. S. (1997). Ovipositional deterrent and ovicidal effects of Neem Azal against brinjal shoot and fruit borer and leaf beetle. *Shashpa*. **5**(2): 193-196.

Kumar, S. P. and Babu P. C. S. (1998). Ovipositional deterrent and ovicidal effects of NeemAzal against brinjal shoot and fruit borer and leaf beetle. *Shashpa*. **5**(2): 193-196.

Latif, M. A. (2007). Ph. D. Dissertation on, "Effectiveness of some insecticides in managing brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee and their impact on arthropod biodiversity and soil microbial respiration", Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh.

Misra, H. P. (1993). Chemical control of brinjal shoot and fruit borer *Leucinodesorbonalis*Guen. *Indian J. Entomol*. **55**(1): 89-91.

Navntoft, S., Esbjerg P. and Riedel W. (2006). Effects of reduced pesticide dosages on carabids (Coleoptera: Carabidae) in winter wheat. *Agril. and Forest Entomol*. **8**(1): 57-62.

Puranik, T. R., Hadapad A. R., Salunke G. N. and Pokharka D. S. r. (2002). Management of shoot and fruit borer *Leucinode sorbonalis* through Bacillus thuiringiensis formulations on brinjal. Journal of Entomological Research, **16**: 229-232.

Rahman, M. S., Alam M. Z., Huq M., Sultana N. and Islam K. S. (2002). Effect of some integrated pest management (IPM) packages against brinjal shoot and fruit borer and its consequence on yield. *Online J. Biol. Sci.* **2**(7): 489-491.

Rahman, M. M. (2006). Vegetable IPM in Bangladesh, In: B. Radcliffe and W. D. Hutchinson [eds.] Radcliffe's IPM World Textbook. URL; http:/www.ipmworld.umn. edu/chapters/Rahman.htm., University of Minnesota, St. Paul, MN.

Rahman, M. M., Latif M. A., Yousuf M. and Ali M. (2006). Judicious use of cypermethrin for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Bangladesh J. Entomol*. **16**(1): 45-56.

Rahman, M. M (2010). Crop and Commodity Pest Management. In: E.B. Radcliffe, W.D. hutchison and R.E. Cancelado [eds], Radcliffe's IPM World Textbook, URL:http//ipmworld.umn.edu,University of Minnesota, St Paul, MN.

Rashid, M. A., Alam S. N., Rouf F. M. A. and Talekar N. S. (2004). Socio-economic parameters of eggplant pest control in Jessore District of Bangladesh. Shanhua, Taiwan: AVRDC-the world vegetable centre. AVRDC Publication No. **03**-556. P. 29.

Rosaiah, B. (2001). Evaluation of different botanicals against the pest complex of brinjal. *Pestology*, **25**: 14-16.

Reghunath, P., Nandakumar C. and Mohandas N. (1989). Insecticidal control of the insect pest complex of brjnjal *Solanum melongena* L. *Indian J. Entomol.* **51**(3): 242-245.

Sabur, S. A. and Mollah A. R. (2000). Marketing and economic use of pesticides: impact on crop production. ARMP contact research report. Dhaka., Bangladesh Agricultural Research Council. 114p.

Sasikala, K., Rao P. A. and Krishnaya P. V. (1999). Comparative efficiency of eco-friendly methods involving egg parasitoid, *Trichogramma japonicum*, mechanical control and safe chemicals against *Leucinodes orbonalis* Guen. Infesting brinjal. *J. Entomol. Res.***23**(4): 369-372.

Saunders, D. G. and Bret B. L. (2012). "Fate of Spinosad in the Environment." *Down to Earth,* Spinosad Technical Bulletin, **52**:14-20 (1997).

Sauphanor, B., Lenfant C. and Sureau F. (1995). Effects d'un extrait de neem (Azadirachtaindica A. Juss) sur le development de *Forficulaauricularia* L. (Dermaptera). *J. Appl. Ent.***119**: 215-219.

Senapati, A.K. (2006). Efficacy of few insecticidal schedules against shoot and fruit borer of brinjal.*Indian J. Agril. Res*. **40**(1):52-55.

Singh, Y. P. and Singh P. P.. (2003). Biology of shoot and fruit borer (*L. orbonalis* Guenee) of eggplant (*Solanum melongena* L.) at medium high altitude hills of Mehgalaya: (c) weather parameters with the development of shoot and fruit borer. *Indian J. Entomol*. **65**(2): 147-154.

Singh, S. S. (2009). Comparative efficacy of certain bio-rational insecticides and *Bacillus thuringi(nsis* based bio-insecticides against *Leucinodes orbonalis* Guen. In brinjal. Indian Journal of Horticulture. 2010-**67**(3): 353-356

Sparks, T. C., Thompson G. D., Larson L. L., Kirst H. A., Jantz, Worden O. K. T. V., Hertlein M. B. and Busacca J. D. (1995). Biological characteristics of the spinosyns: a new naturally derived insect control agent. *Proceeding of Beltwide Cotton Conference*, **2**: 903-907.

Srinivasan, R. (2009). Insect and mite pests on eggplant: a field guide for indentification and arrangement. AVRDC–The World Vegetable Center, Shanhua, Taiwan. AVRDC publication No. 09-729. 64 p.

Srinivasan, G., Babu P. C. S., Reddy P. P., Kumar N. K. K. and Verghese A.(1998). Advances in IPM for Horticultural crops. Proceedings of the First National Symposium on Pest Management in Horticultural Crops: Environmental implications and thrust, Bangalore, India, 15-17 October, 1997. pp. 87-93.

Sauphanor, B., Lenfant C. and Sureau F. (1995). Effects d'un extrait de neem (Azadirachta indica A. Juss) sur le development de *Forficula auricularia* L. (Dermaptera). *J. Appl. Ent.* **119**: 215-219.

Tripathi, S.R. and Singh A.K. (1996). Some observation on population dynamics brinjal, *Leucinodes orbonalis* Guenee (Lepidoptera:Pyralidae). *Annals.Ent*. **9**(1): 15-24.

Tillman, P. G, and Mulrooney J. E. (2001). Effect of selected insecticides on the natural enemies *Coleomegilla maculata* and *Hippodamia convergens* (Coleoptera: Coccinellidae), *Geocoris punctipes* (Hemiptera: Lygaeidae) and *Bracon mellitor, Cardiochiles nigriceps* and *Cotesia marginiventris* (Hymenoptera: Braconidae) in cotton. *J. Econ. Entomol.* **93**(6): 1638-1643.

APPENDICES

Appendix I: Physical characteristics and chemical composition of soil of the experimental plot

Soil Characteristics	**Analytical results**
Agroecological Zone	Madhupur Tract
P^H	5.47 – 5.63
Organic matter (%)	0.82
Total N (%)	0.43
Available phosphorous	22 ppm
Exchangeable K	0.42 meq / 100 g soil

Source: Soil Resource Development Institute (SRDI), Dhaka.

Appendix II: Monthly average air temperature, relative humidity, rainfall and sunshine hours during the experimental period (February to September, 2013) at Sher - e - Bangla Agricultural University campus.

Month	Year	Monthly average air temperature (^{0}C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
February	2013	35.00	23.81	29.41	61.4	185	232
March	2013	35.00	24.95	29.98	64.27	180	240
April	2013	32.50	23.00	27.75	66.00	181	238
May	2013	33.30	22.50	27.50	65.70	180	236
June	2013	31.00	24.95	27.98	82.27	310	80
July	2013	31.50	24.00	27.75	82.00	320	71
August	2013	32.00	24.50	28.25	81.00	325	70
September	2013	31.50	23.00	27.25	79.50	240	110

Source: Bangladesh Meteorological Department (Climate Division),

Agargaon, Dhaka – 1207.