ECOFRIENDLY MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER BY SOME CHEMICAL AND BOTANICAL INSECTICIDES AND THEIR IMPACT ON NATURAL ENEMIES

BY

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CERTIFICATE

This is to certify that thesis entitled **"ECOFRIENDLY MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER BY SOME CHEMICAL AND BOTANICAL INSECTICIDES AND THEIR IMPACT ON 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 **RUHUL AMIN, Registration no. 06-02041** 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: June, 2013
Place: Dhaka, Bangladesh

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DEDICATED TO
MY
BELOVED PARENTS

ABBREVIATIONS AND ACRONYMS

AEZ	:	Agro-Ecological Zone
et al.	:	And others
BBS	:	Bangladesh Bureau of Statistics
cm	:	Centimeter
CV	:	Coefficient of variation
DAT	:	Days After Transplanting
°C	:	Degree Celsius
d.f	:	Degrees of freedom
etc.	:	Et cetera
EC	:	Emulsifiable Concentrate
FAO	:	Food and Agriculture Organization
Fig.	:	Figure
g	:	Gram
ha	:	Hacter
p^H	:	Hydrogen ion conc.
J.	:	Journal
Kg	:	Kilogram
LSD	:	Least Significant Difference
L	:	Liter
m	:	Meter
MS	:	Mean sum of square
mm	:	Millimeter
MP	:	Murate of Potash
no.	:	Number
%	:	Percent
RCBD	:	Randomized Complete Block Design
SAU	:	Sher-e-Bangla Agricultural University
m^2	:	Square meter
t	:	Ton
TSP	:	Triple Super Phosphate

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ECOFRIENDLY MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER BY SOME CHEMICAL AND BOTANICAL INSECTICIDES AND THEIR IMPACT ON NARATUL ENEMIES

RUHUL AMIN

ABSTRACT

A field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Dhaka during November, 2012 to May, 2013 to evaluate some botanicals and chemical insecticides and hand picking and destruction of infested shoots and fruits and their impact on natural enemies for eco-friendly management of brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee. Eight treatments were used at 7 days interval. Results presented the lowest shoot (6.80%) and fruit infestation (13.67%) and lowest plant infestation (19.71%) and maximum fruit length and girth, number of fruit per plant (16.08) and highest fruit yield (23.95 t/ha) were achieved by Ripcord 10EC @1 ml/L of water compared to all other treatments. Suntap 50 SP @ 2 ml/L of water also performed all these results significantly. Hand picking and destruction of infested shoots and fruits from the field showed the least performance as deed the botanical insecticides such neem oil, neem seed karnel extract, neem leaf extract and garlic extract. The fruit yield of brinjal was highly significant and negatively correlated with shoot and fruit infestation. Considering the impact of management practices on the population of natural enemies, Ripcord 10EC adversely affected and reduced the highest population of ladybird beetle adult (87.43%) and larvae (87.71%); and field spider (88.12%) over control as counted visually. Suntap 50SP also showed the higher adverse effects on the natural enemies, whereas hand picking and destruction of infested shoots and fruits performed the least hazardous treatment ladybird beetle adult and larvae as well as field spider and other arthropods. Though, Ripcord and Suntap reduced the highest level of BSFB infestation, but they were mostly harmful to the arthropod biodiversity in the brinjal ecosystem by reducing the maximum level of the natural enemy population than other botanicals and cultural control which were comparatively safe in eco-friendly management of brinjal shoot and fruit borer.

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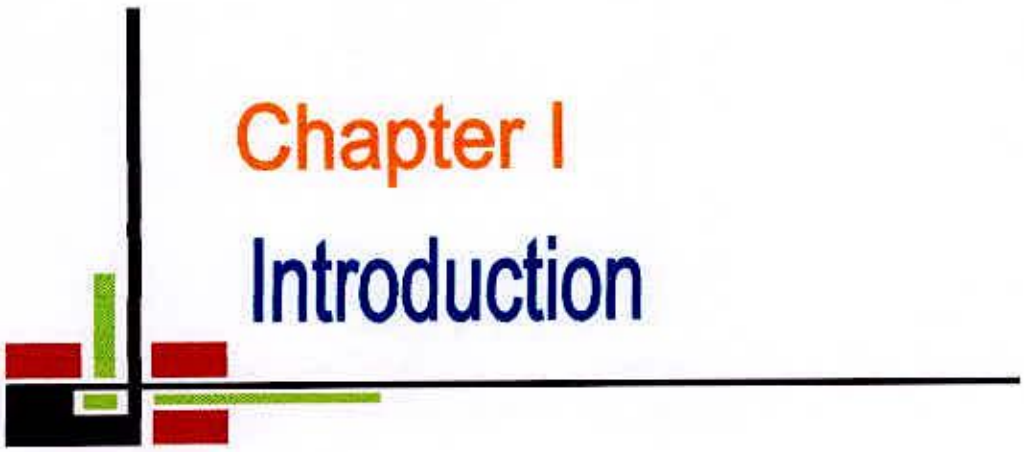


Chapter I

Introduction

CHAPTER I

INTRODUCTION

Brinjal is the most common, popular and principal vegetables in Bangladesh and other parts of the world (Nonnecke, 1989). It is locally known as '*Begoon*' and its early European name is 'Eggplant'. It is grown extensively in India, Bangladesh, Pakistan, China and the Philippines. Brinjal is the second most important vegetables crops after potato in relation to its total production (Anon., 1996). This useful crop is grown all the year round in Bangladesh and covers 46558 ha with a production of 341000 tons (Anon., 2010) with about 25.4% of the total vegetable area of the country. The main growing districts are Bogra, Chittagong, Comilla, Dhaka, Dinajpur, Faridpur, Jamalpur, Jessore, Khagrachari, Khulna, Mymensingh, Rangamati, Rangpur, Rajshahi, Sylhet, and Tangail (Anon., 2010).

Brinjal is susceptible to attack of various insects from seedling to fruiting stage. This crop is infested by 18 different insect species including brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee; epilachna beetle, *Epilachna vigintioctopunctata* Fab. and aphid, *Aphis gossypii* Glover. In Bangladesh, about eight insect species are considered as major pests causing damage to the crop (Biswas *et al*., 1992). Hill (1983) reported 50 insect pests cause damage to brinjal. The losses caused by these pests vary from season to season depending upon environmental factors as reported by Gangwar and Sachan (1986) and Patel *et al*. (1988). Various insect pests cause enormous losses to brinjal in every season and every year in Bangladesh (Alam, 1969). The yield loss caused by this pest has been estimated up to 67% in Bangladesh. Among them, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis*Gueneeis one of the most destructive insect pest of brinjal in Bangladesh (Alam, 1969). The genus *Leucinodes* includes three species namely *Leucinodesorbonalis* Guenee, *Leucinodesdiaphana* Hampson and*Leucinodes opicalis* Hampson (Alam *et al*., 1964).

The damage caused by *L. orbonalis* starts soon after transplanting of seedlings and continues till the last harvest of the fruit. In early stage of growth, the newly hatched larvae bore into petioles and midribs of large leaves and young tender shoot and close the entry holes with their excreta and feed inside (Butani and Jotwani, 1984). The damage is caused by the larvae through boring inside the shoot in the early stage of growth. As a result of the larval activities within the shoot transmission mechanism of

the plant sap is affected causing dropping and withering of shoots. With the onset of flowers the insect changes over its infestation to flowering parts and passes larval development period inside the fruits. The environmental factors such as temperature, humidity, rainfall and total sunshine greatly influence the life of insect (Kismoto and Dyck, 1976). Brinjal shoot and fruit borer is phytophagous in habit and the pest is active throughout the year at having moderate climate but its activity is adversely affected by severe cold. This pest can also infest potato and solanaceous crops and wild plant (Karim, 1994).

Currently farmers rely exclusively on the application of insecticides to control brinjal shoot and fruit borer and to produce blemish-free fruit. Insecticide use is very intensive for killing the larvae before they bore inside shoots or fruits. Since neonate larvae can enter the fruits or shoots within only a few hours of hatching from the eggs, insecticides have to be applied in order to have sufficient toxic residues on the plant surface adequate enough to kill the crawling larvae. Surveys conducted in Bangladesh indicated that farmers use insecticides up to 84 times during a 6-7 month cropping season (Anon., 1995). The research and development activities to combat BSFB have largely been confined to screening insecticides to select the effective chemical and determining the frequency of their use. At one time, research developed insecticide spray schedules that involved calendar spraying whether the pest was present or not (Atwal, 1976; Srivastava and Butani, 1998). This approach has led to increase dependence on insecticides and consequent adverse effect of higher costs of production, environmental pollution, destruction of natural enemies and development of insecticide resistance in BSFB, toxic residues in fruits and ultimately pest resurgence. The current insecticide use is not only non-sustainable but if continued, it will adversely affect eggplant and other vegetable production. Therefore, it is now an urgent need to use safe but effective, biodegradable insecticides with no or less toxic effects on non-target organisms. Botanical insecticides are broad spectrum in pest control and many are safe to apply, unique in action and can easily be processed and used.

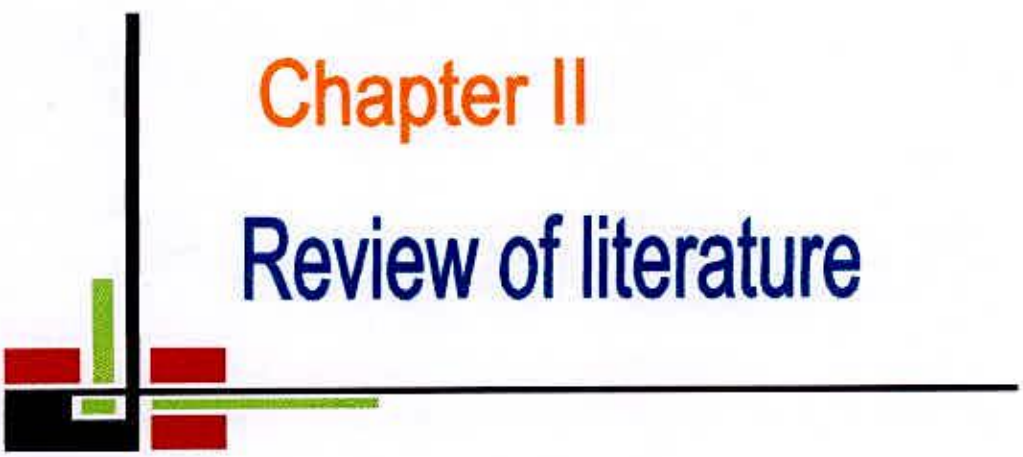
In Bangladesh, the age-old traditional botanical products for pest control are being used by the farmers for more than thousand years. The indigenous plant materials are available everywhere and can easily be produced by the farmers and small traders. The main advantages of botanicals are that they are easily produced by the farmers

and small industries and are potentially less expensive. Among them neem oil has extensively been used and has proved its pest controlling efficacy against several insect pests both in field and storage (Saxena *et al.*, 1981; Heyde *et al.*, 1983 and Mariappan and Saxena, 1984). Neem oil has no adverse effects in the agroecosystem and its costs of production are likely to be less compared to that of chemical insecticides (Saxena *et al.*, 1981). However, a very few scientific and continues research work have been done in Bangladesh to explore our locally available plant materials effective for the control of harmful pest of brinjal plant. The present research will be undertaken to investigate the incidence of brinjal shoot and fruit borer and to determine the efficacy of some botanicals and chemical insecticides and their impact on natural enemies.

OBJECTIVES

Considering the above points in view, this research work has been carried out to fulfill the following objectives:

1. To determine the level of infestation caused by brinjal shoot and fruit borer (BSFB);
2. To evaluate efficacy of some botanicals as compared with chemical insecticides applied against BSFB;
3. To evaluate the impact of botanical and chemical insecticides on the population of predatory ladybird beetle, field spider and other beneficial arthropods during the management of BSFB.



Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

Brinjal is an important vegetable crop in Bangladesh, but the crop faces various problems during its cultivation. Brinjal is infested by large number of insect pests that cause considerable yield loss. Among them, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee is the serious pest that adversely affects the quality and quantity of brinjal. The damage caused by brinjal shoot and fruit borer varies from 12-16% for shoot and 20-63% for fruit (Alam, 1969). Literature regarding the management tactics for brinjal shoot and fruit borer by using botanical and chemical insecticide is found to be sufficient. However, an attempt has been taken in this chapter to review the pertinent research work related to the present study. The information is given below under the following headings:

2.1. General review

2.1.1. Nomenclature of brinjal shoot and fruit borer

Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee is one of the most destructive insect pests of brinjal (*Solanum melongena* L.) in Bangladesh. It is phytophagous in nature and belongs to the Family Pyralidae under Lepidoptera order. The genus *Leucinodes* has three species, *Leucinodes orbonalis*Guen.,*Leucinodes diaphana* Hamps and *Leucinodes apicalis* Hamps. (Alam *et al.*, 1964).

2.1.2. Origin and distribution of brinjal shoot and fruit borer

Brinjal shoot and fruit borer was first described as *Leucinodes orbonalis* by Guenee in 1854 (Alam *et al.*, 1964). The brinjal shoot and fruit borer genus *Leucinodes* has different species (Alam *et al.*, 1964). Among them *Leucinodes orbonalis* Guenee is the most serious insect pest through the Indian sub continent (Tewari and Sandana, 1990) and also in South Africa (Alam *et al.*, 1964; Butani and Jotwani, 1984). Waterhouse (1990) reported that the origin of this pest is Africa and South East Asia and distributed in Myanmar, Thailand, Laos, Combodia, Vietnum, Malaysia, Bruneo and Philippines. Brinjal is attacked severely in the topic but not in temperate region (Yamaguchi, 1983).

2.1.3. Host range

The brinjal shoot and fruit borer is the most obnoxious pest of brinjal and also infest potato, pods of green peas and can also be reared on *Solanum torvum* Swartz (Alam and Sana, 1962; Atwal, 1986). Several wild species of *Solanum* are also attacked by this pest (Karim, 1994). The larva also feeds on pods of green peas (Alam *et al.*, 1964). Ishaque and Chaudhuri (1983) observed that besides brinjal, some other plants severed as host plant and caused varying levels of infestation during different periods of the year. These plants *Solanum nigrum, S. indicum, S. myriacanthum, S. tuberosum* have been reported as the alternative host plants of the pest.

2.1.4. Seasonal abundance

The seasonal abundance of brinjal shoot and fruit borer varies considerably due to different climatic conditions throughout the year. Hibernation does not take place and insects are found active in summer months, especially in rainy season. A study revealed that the population of *Leucinodes orbonalis* began to increase from the first week of July and peaked (50 larvae per sq m) during the third week of August. The population of this pest positively correlated with average temperature, mean relative humidity and total rainfall (Shukla, 1989). The brinjal shoot and fruit borer is less active during February-April (Alam, 1969). During winter months, different stages of this pest last for longer periods and overlapping generations were observed.

There is a considerable mortality of larvae caused by predatory black ant *Camponotus compressus* during summer (Alam, 1969). Pupal mortality has observed during rainy season due to attack of ichneumonid parasitoid and the wasp, *Trichogamma chilonis* (Hageman, 1990). The black ant, *Camponotus compressus* also attack the adult moths. Maximum populating of adult moths has been observed during the month of December and April (Alam, 1969).

Panda (1999) conducted a field experiment on 1974 brinjal cultivars for resistance to *Leucinodes orbonalis* at Bhubaneswar, India. None of brinjal entries was immune to larval attack of brinjal shoots and fruits. The mean performance of brinjal shoots infestation varied from 1.61 to 44.11% and fruit damage varied from 8.5 to 100.00%. Maximum shoot damage was recorded at 75 DAT and 99 DAT, 114 DAT in susceptible and resistant cultivars, respectively.

Pawar *et al.* (1986) reported that infestation of shoots began 30 days after transplanting, peaked in the 2nd week of September and reached zero in the 1st week of November. Fruit was infested from the 3rd week of September and the infestation peaked in the 2nd week of January. On the summer crop, shoots were infested from the 3rd week of January and the infestation peaked in the 2nd week of February. Infestation of fruit peaked in the 1st week of April. Infestation levels were lower during summer than kharif.

Patel *et al.* (1988) showed that brinjal (cv. Doll-S) transplanted in May was more damaged by *Leucinodes orbonalis* than the crops transplanted in January, July, September and November. They also observed that among environmental factors, low variation in minimum and maximum temperature, high relative humidity and suitable rainfall enhanced the population of this pest.

Butany and Jotwany (1984) reported that the brinjal shoot and fruit borer cause 1 to 16% damage to shoots and 16 to 64% to fruits in Bangladesh. Ali and Ali, (1980) made a brief observation on the incidence of shoot and fruit borer on 72 cultivars of brinjal. They observed that the cultivars Baromashi showed no shoot and fruit infestation. Lowest percentage of fruit infestation (25%) occurred in Singnath and highest (86%) in Jhumki.

Alam (1969) found that the brinjal shoot and fruit borer is less active during February-April. During winter months, different stages of this pest last for longer periods and overlapping generations were observed. There is a considerable mortality of larvae caused by predatory black ant *Camponotus spillir* during summer. Maximum population of adult moths has been observed during the months of December to April. Alam *et al.* (1969) observed that the damage caused by the brinjal shoot and fruit borer varies from 12-16% in shoots and 20-63% in fruits.

2.1.5. Life history of brinjal shoot and fruit borer

Egg: Adult female lay eggs on the foliage. The number of eggs laid by an average female varies from 80 to 253. Oviposition takes place at the night and eggs are laid singly on the lower surface of the young leaves, green stems, and flower buds. Egg is flattened, elliptical, and 0.5 mm in diameter. They are creamy-white soon after they are laid, but change to red before hatching. Eggs hatch in 3 to 6 days.

Larva: Larvae are commonly known as caterpillar. The newly hatched larvae are about 1.5 mm long and dull-white in colour, whereas the full grown larvae are 15 to 18 mm long, light pink in colour and have prominent tubercles with hair on each thoracic and abdominal segments. The full grown larvae showed a pre pupal period of 3-4 days before pupation.

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 or a semi dark place usually 1-3 cm below in the soil (Yein, 1993). The full grown pupa measures 6.4 mm× 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.

Adult: The adult moths are white, small and cryptic in nature (Alam, 1969) with 22 to 26 mm 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 Corry, 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 fore wings have conspicuous black and brown patches and dots. Fore pair of wing are longer and broader and the opalescent hind pair with black dots along the margins (Butani and Jatwani, 1984). They are weak 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 deposition.

2.2. Effect of insecticides on brinjal shoot and fruit borer

Singh (2003) evaluated fourteen insecticides in combination with Carbofuran, along with a control against theshoot and fruit borer. Deltamethrin was the most effective insecticide in controlling the borer in shoots followed by Fenvalerate and Cypermethrin at 25g a.i./ha, with shoot infestation ranging from 0.63-2.97, 0.98-4.26 and 1.13-4.56%, respectively. Among the conventional insecticides, endosulfan at 0.25kg a.i./ha and fentrothion at 25g a.i./ha in combination with carbofuran, were effective. Deltramethrin at 5kg a.i./ha, Fenvalerate at 25g a.i./ha and Cypermethrin at 25g a.i./ha were highly effective against the pest and resulted in higher yield of healthy fruits i.e. more than 1.75kg/m^2 compared to other treatments.

Nine insecticides were evaluated for efficacy in controlling *Leucinodes orbonalis* in cv. aubergine in Rajasthan, Idia, during the kharif season of 1999 and 2000 (Jat and Pareek, 2001). The treatment were Endosulfan 35EC at 0.07%, Malathion 57EC at 0.05%, Carbaryl 50WP at 0.2%, Neemgold at 0.15EC at 1.21 litre/ha, Nimbicidine at 0.03EC at 1.5 litre/ha, Bacillus thuringiencis (Bt) at 0.012%, Bt-endosulfan (0.012%+0.035%), Bt+carbaryl (0.012%+0.10%), cypermethrin 25EC at 0.007% and control. Nimbicidine was the least effective in controlling the pest and resulted in the lowest yield. The heist yield was obtained with cypermathrin followed by Carbaryl and Endosulfan.

Chowdhury *et al.* (1993) conducted a 3-years study in Bangladesh on the effectiveness of some insecticides against *L. orbonalis* on brinjal, Carbofuran 3G at 30 kg/ha applied every 20 days after transplanting showed the efficacy. The same compound applied at flowering also gave good control as did cypermathrin 10EC at 1ml/L of water applied at first sign of infestation followed by 3 subsequent spraying at 30 days intervals.

Field trials of Fenvalerate (0.01%), Cypermathrin (0.01%), Endosulfun (0.5%) and Carbaryl (0.2%) alone and half concentration mixed with Neemark (5%) (Extract of *Azadirachta indica*) against *L. orbonalis* on brinjal were carried out in Maharashtra, India in 1990-91 (Temurde *et al.*, 1992). They found that all the synthetic insecticides gave better control and higher yield than Neemark alone. Mixing Neemark with Cypermathrin or Fenvalerate gave better control of the pest than did Neemark itself.

Nine insecticides including Diazinon, Cypermathrin, Furadan, Profenofos and Alphamathrin were evaluated for their efficacy against *L. orbonalis* at Joydebpur, Gazipur, Bangladesh (Anonymous, 1991). None of the insecticides had exceeded 80% reduction in infestation over the untreated control.

Senapati, (2006) carried out an experiment in kakdwip, West Bengal, India, during the winter season of 1998/99 and 1999/2000 to evaluate the efficacy of few insecticidal schedules against brinjal shoot and fruit borer, *L. orbonalis*, along with their cost effectiveness. The treatments were: carbofuran (Furadan 3G) at 0.5 kg/ha, carbaryl (Sevin 50WP) at 0.1 kg/ha, clorpyrifos (Dursban 20EC) at 0.05 kg/ha, cartap hydrochloride (Padan 50SP) at 0.05 kg/ha, triazophos (Hostathion 40EC) at 0.05 kg/ha, carbofuran+carbaryl, carbofuran+clorpyrifos, carbofuran+cartap hydrochloride,

carbofuran+triazophos, and control. The application of cartap hydrochloride alone and carbofuran+cartap hydrochloride, carbofuran+triazophos at 15 days interval starting from 30 days after planting were very effective in lowering the shoot infestation compared to untreated control treatments of fruit damage. In case of total and healthy fruit yields, the application of cartap hydrochloride alone were superior to others. It recorded total and healthy fruit yields of 9.60 and 6.73 t/ha compared to 4.55 and 2.14 t/ha, in the untreated control, respectively. Cartap hydrochloride application also secured the highest monetary benefit of Rs22.74 for each rupee on insecticide application.

2.3. Effect of botanicals on brinjal shoot and fruit borer

Experiment were conducted in Tamil Nadu,India during kharif and rabi seasons of 1995 to 1997 on the management of brinjal shoot and fruit borer, *L. orbonalis* (Raja *et al.*, 1999). The pooled data analysis indicated that neem products viz., neem oil (4%), neem seed kernel extract (NSKE) at 5% and their combination with endosulfan (0.07%) were effective in fruit borer damage. Neem oil and NSKE reduced fruit borer damage by 10.13 and 11.56% respectively, against 36.9% infestation in the untreated control. Plant extracts neem cake at 20 q/ha, neem oil at 3% and karanja oil at 3% were evaluated against the brinjal shoot and fruit borer, *L. orbonalis* had significant effect of the pest population.

In a field experiment in Tamil Nadu with brinjal, neem based products were comparable or better than endosulfan in controlling shoot and fruit borer, *L. orbonalis* (Srinivasan, 1998). Fruit yield with Nimbecidine (13.02 t/ha) and Neem Azal (12.80 t/ha) were higher than with endosulfan (10.92 t/ha). Evaluation of neem oil revealed a significant effect on the pest population. The neem oil provided 49% reduction over control (Anon, 1995).

Rahman *et al.* (1999) conducted an experiment at Gazipur, Bangladesh during August 1997-April 1998 to evaluate the efficacy of cypermathrin (Cymbus 10EC) and Carbofuran (Furadan 5G) in controlling the brinjal shoot and fruit borer, *L. orbonalis*, infesting brinjal fruit. The treatment comprised of application of Furadan 5G at 1.5 kg a.i./ha at 20 days after transplanting (T_1), T_1+application at the time of fruit initiation (T_2), spray of cymbus 10EC at 1ml/L of water at 5% level of infestation and repeated at 15 days interval (T_3), T_2+T_3(T_4), and untreated control. The intensity of infestation

per fruit was grouped into 4 scales: low intensity (1-2 borers per fruit; scale 1), moderate intensity (3-4 borers per fruit; scale 2) high intensity (5-6 borers per fruit; scale 3), and very intensity (>=7 borers per fruit; scale 4). The treatments displayed a highly significant effect in number and weight, respectively, showed highly significant effect in reducing the infestation intensity as well as in protecting the edible yield. The infested fruit belonging to scale 4 were only 0.38% and 0.48% in T_4 and T_2, respectively, while those belonging to scale 1 were 72.31% and 66.16% in T_4 and T_2, respectively, compared with 4.99% for scale 4 and 42.65% for scale 1 in the control. The infestation intensity had quite a significant effect in size, extent of damage and weight of fruit. The fruit belonging to scale 4 were very small, had suffered considerably more damage and had very low edible yield compared to those belonging to scale 1, which were of much bigger size, had suffered less damage and had much more edible yield.

Sahu *et al.* (2004) conducted an experiment during rabi season of 1999-2000 at Bhubaneswar, Orissa, India to evaluate the bioefficacy of thiodicarb (0.28125,0.46875 and 0.75 kg a.i./ha) and other insecticides, i.e. cartap hydrochloride (0.5 kg a.i./ha) and diflubenzuron (0.1 kg a.i./ha), carbofuran (1kg a.i./ha), triaazophos (0.5 kg a.i./ha) and fipronil (0.5 kg a.i./ha), against the brinjal shoot and fruit borer, *L. orbonalis*. The result revealed the superiority of thiodicarb at its highest dose of 0.75 kg a.i./ha as it recorded the lowest shoot (1.41%) and fruit damage (20.86%). This compound at its highest dose also recorded the highest aubergine fruit yield of 148.45 q/ha.

2.4. Use of natural enemies in biological control of brinjal shoot and fruit borer

The effective control of the brinjal shoot and fruit borer by methods other than chemical insecticides has not yet been found. Khorsheduzzaman *et al.*(1998) observed that sixteen parasitoids, three predators and three pathogens have so far been found as natural enemies of brinjal shoot and fruit borer from all over the world. *Trathala flavo-orbitalis* Cam.parasitizes the BSFB. Parasitism increased the host pupal period to 11 to 18 days, as compared to 6 to 14 days for healthy pupae, and parasitism varied from 3.57 to 9.06%. Adult parasitoids lived for 4-7 days in the laboratory (Mallik *et al.*, 1989). Tewari and Sandana (1990) observed a larval ecto-parasitoid, *Bracon* sp. was found attached to the thorax of the host (*L. orbonalis*) larva in Karnataka, India. It pupated in a silken cocoon inside the tunnel made by its host and parasitization ranged from 9.2 to 28.1%. It was regarded as promising parasitoid.The brinjal shoot and fruit

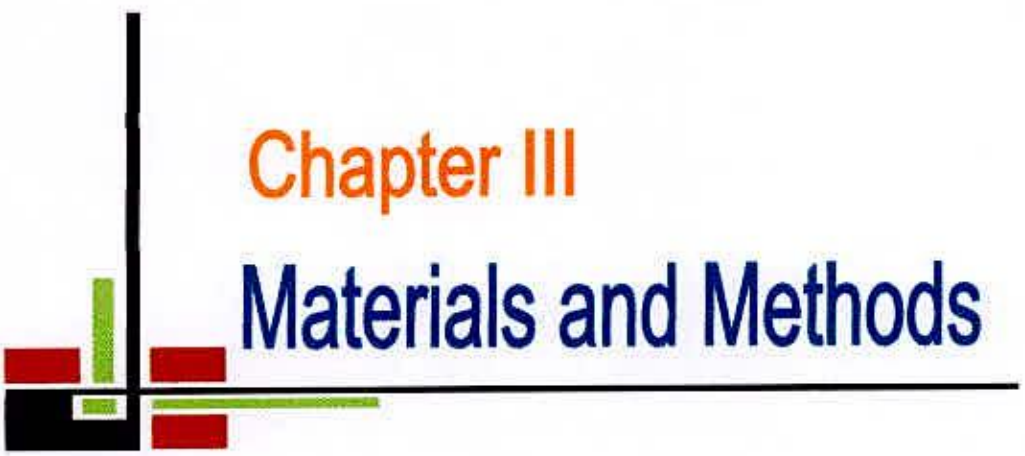
borer larval population peaked in May and the pest was active throughout the where *Trathala* sp. caused 12.90-18.18% parasitism in larvae. The parasitoid was active throughout the winter and summer seasons and preferred mature host larvae (Naresh *et al.*, 1986).

Das and Islam (1984) reported that *Cremustus, Trathala flavo-orbitalis, Epitranus areolatus, E. giganticus, E. indictus, E. melongenus, E. rossicorpus* and *Pristomerus testaceus* as the parasitoids of BSFB while black ant, *Componotus compressus* Fab. and spiders as predators. *Itamoplex* sp. was reported from Kulu Valley, Himachal Pradesh, India where the winter temperature drops as low as -8^{0}C. The parasitoids emerged from 9-15% of the larval cocoon of BSFB. *Itamoplex (Cryptus)* sp. was also recorded attacking a range of Lepidopteranian cocoon (Varma and Lal, 1985).

The efficacy of *Bacilus thuringiencis* subsp. *kurstaki* was studied with alternate applications of endosulfan/fenvalerate and methomyl under different spraying schedules in a field experiment with brinjal cv. KB 5 in Keonjar, Orissa, India during 1994. Spraying of endosulfan (0.07%) at 30 days after planting (DAP) and Fenvalerate (0.02%) at 60 DAP resulted in the lowest fruit damage (33.3%) by *Leocinodes orbonalis* as compared with 64.2-65.1% damage in the untreated control and had the highest Benefit Cost ratio (40.3:1). The microbial insecticides *B. thuringiensis* subsp. *kurstaki* at a concn.of 0.05% was not found to be cost effective against *Leocinodes orbonalis* under different spraying schedules (Patnaik and Singh, 1997).

Qureshi *et al.* (1998) was conducted a field experiment in 1995 in Rajasthan, brinjal treated with Dipel 8 (formulation of *Bacilus thuringiensis* var. *kurstaki*) with or without insecticides. Treatment with 2ml/litre of Dipel 8 significantly reduced fruit damage caused by *Leocinodes orbonalis* compared with untreated control (8.78 vs. 12.34%) and produced higher fruit yield than the control (12.07 vs 9.98 t/ha). Treatment with 1ml Dipel 8 + 0.80g Methomyl/litre of water produced the lowest percentage of fruit damage and the highest fruit yield of 16.41 t/ha.

During a survey for natural enemies of *Leocinodes orbonalis* on brinjal in India, *Diadegma apostata* was recorded from the pest for the first time (Krishnamoorthy and Mani, 1998).



Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The study was conducted in the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 during the period from November,2012 to May, 2013 to ecofriendly management of brinjal shoot and fruit borer using some botanical and chemical 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. Location of the experimental plot

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2012 to May, 2013. The site is 23^0 46' N and $90^0$24 'E Latitude and at Altitude of 9 m from the sea level, close to the University administrative building.

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. The morphological characters of soil in the experimental plots were indicated by UNDP (1998).

3.3. Climate

The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to September, 2012) and scanty in the Rabi season (October to March, 2013). There was few or no rain fall during the month of December, January and February. The average maximum temperature during the period of experiment was 35.10°C and the average minimum temperature was 30.40°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity the period of the experiment were collected from Bangladesh Meteorological Department, Agargon, Dhaka- 1207, Dhaka and have been presented in Appendix II.

3.4. Land preparation and fertilization

The plot selected for the experiment was opened in the first week ofNovember 2012with 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 tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings. During land preparation 10 t/ha decomposed cow dung were mixed with soil and following fertilizers were applied. Urea, TSP, MP as the source of Nitrogen(N),Phosphorus(P_2O_5), Potassium(K_2O) fertilizers recommended by Rashid *et al.* (2006):Urea150 kg/ha, TSP 100kg/ha, MP 125 kg/ha. Urea was applied at top dressing in three equal splits at 20, 40 and 60 DAT.

3.5. Variety used for the experiment

The variety Singnath of brinjal was selected for the experiment during rabi season 2012. It was an open pollinated high yielding variety developed by the Vegetable Division of Horticulture Research Center under Bangladesh Agricultural Research Institute (BARI). The seeds of this variety were collected from market.

3.6. Raising of seedling

Brinjal seedlings were raised at the seedbeds of experimental farm, Sher-e-Bangla Agricultural University, Dhaka 1207 under special care. The seeds of the variety were sown in the well prepared seed bed. All weeds, stubbles and dead roots of the previous crops were removed carefully before sowing of seeds. The seed bed was dried in the sun to prevent the damping off diseases. Fifty grams of seeds were sown in the seedbed on 20 October 2012. Before sowing seeds, the germination test was done to ensure standard viability measuring approximately 90% germination. After sowing, the seedbed was covered with fine light soil. All seeds were completely germinated within 7 days after sowing. Shading was given by polythene sheet over the seed bed to protect the young seedlings from scorching sunlight and rainfall. Weeding, mulching and irrigation were done from time to time to provide a favorable condition for good growth and raising quality seedling.

3.7. Transplanting of seedling and after care

Healthy and uniform sized about one month aged seedling were transplanted in the experimental plots on 30 November, 2012 considering row to row distance 1m and

plant to plant distance 60cm in each plot. Transplanting was done in the afternoon and watered immediately after transplanting. After seedling establishment, the soil around the base of each seedling was pulverized and new ones from the same stock replaced the damaged seedlings. The young transplants were protected from scorching sunlight providing shade with pieces of banana leaf sheath during the day time. At night, they were kept open to allow receiving dew. It was continued up to 25-30 days until they were established in the soil and after that the banana leaf sheaths were removed.

3.8. Experimental design and layout

The study was laid out in RCBD in the experimental field divided into 3 blocks. Each block was sub-divided into 8 plots for eight (8) treatments, each of which was 3 m x 2 m maintaining 1.0 m border. There were three replicates for each treatment. The plant spacing was maintained considering 1m row to row distance and 60 cm plant to plant distance.

3.9. Intercultural operations

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

3.9.1. Gap filling of seedling

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

3.9.2. Weeding

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

3.9.3. Irrigation and drainage

Light overhead irrigation was provided with a watering can 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, wherever 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.

3.10. Treatments of the experiment

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

Table 1. List of treatments used in the study

Treatment	Materials used	Doses
T_1	Neem oil	3ml L^{-1} of water
T_2	Neem seed kernel extract	100g L^{-1} of water
T_3	Neem leaf extract	200g L^{-1} of water
T_4	Garlic extract	2g L^{-1} of water
T_5	Ripcord 10EC	1ml L^{-1} of water
T_6	Suntap 50SP	2 g L^{-1} of water
T_7	Hand picking and destruction of infested shoots and fruits from the plots	
T_8	Untreated control	

3.11. Preparation of plant extracts

Neem seed kernel extract: 100g fresh neem seed blended by electric blender then it mixed with 1.0 Litre of water. The solid materials separated from mixture by sieve.

Neem leaf extract: 200g fresh neem leaf blended by electric blender then it mixed with 1.0 Litre of water. The solid materials separated from mixture by sieve.

Garlic extract: 2g fresh garlic blended by electric blender then it mixed with 1.0 Litre of water. The solid materials separated from mixture by sieve.

3.12. Setting up of pitfall trap

Three pitfall traps (Plate 2) were set up in each plot, of which one in the middle and other two in two opposite corners of the plot. The traps were plastic cups with 10 cm height and an opening mouth with 5cm diameter. The traps were partially filled by

water mixed with detergent. The traps were carefully rooted in the field and the opening was leveled to the ground.

Plate 1. Experimental field of brinjal at vegetative stage

Plate 2. Pitfall trap for capturing soil inhabiting insects in the brinjal field

3.13. Harvesting

Brinjal were harvested at seven days interval when they attained edible stage. Harvesting was started from February 2013 and was continued up to May, 2013.

3.14. Data collection

The data were recorded just before the application of the treatments in the field for the 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 visually counts and pitfall trap methods 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 3. Healthy eggplants of Ripcord 10EC (T_5) treated plot

Plate 4. Shoot infested eggplant of T_7 treated plot

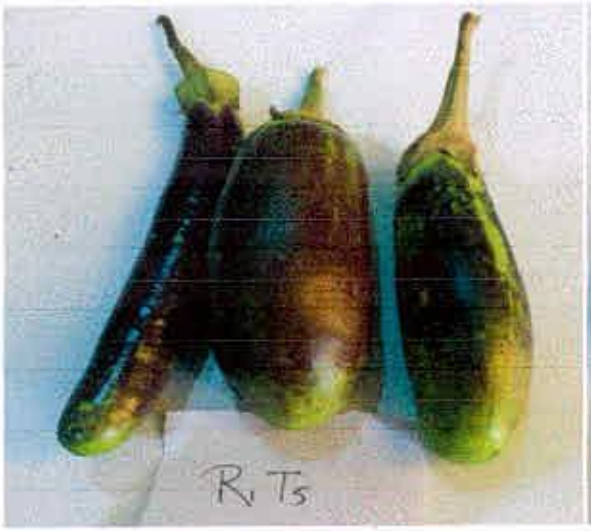


Plate 5. Healthy fruits harvested from Ripcord 10EC treated plot

Plate 6. Infested fruits harvested from Neem oil treated plot

Plate 7. Inside view of BSFB infested fruit Plate8. Larva of brinjal shoot&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. Similarly, number of adult and larvae of ladybird beetle, field spider and other arthropods were also counted by setting up three pitfall traps for each plot.

The trapped arthropods in the pitfall traps were carried in the laboratory of the Department of Entomology. 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 9. Adult ladybird beetle crawling on the leaf of eggplant

Plate 10. Adult ladybird beetle crawling over the ground of brinjal field

3.15. Calculation of the recorded data

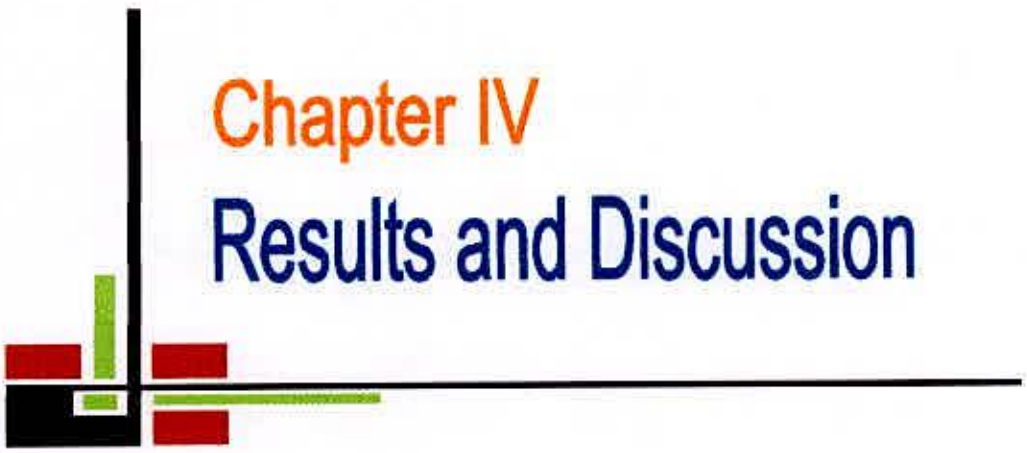
The data recorded on different parameters were calculated using the following formula:

$$\% \text{ plant/shoot/fruit infestation} = \frac{\text{No. of infested plant/shoot/fruit}}{\text{Total no. plant/shoot/fruit}} \times 100$$

$$\% \text{ increase or decrease over control} = \frac{\text{Mean value of treated plot} - \text{Mean value of untreated plot}}{\text{Mean value of untreated plot}} \times 100$$

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 1% level of significance (Gomez and Gomez, 1984).



Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2012 to May, 2013 to find out the effectiveness of some botanical and chemical insecticides as eco-friendly management of brinjal shoot and fruit borer (BSFB) 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. Effect of management practices on shoot infestation

The attack of brinjal shoot and fruit borer was found in the field when the plants showed the shoots of different treatments had significant variations among different management practices in respect of percent shoot infestation of brinjal throughout the cropping season. At this vegetative stage, the lowest shoot infestation (1.58%) was recorded in T_5 comprising spraying of Ripcord 10EC @ 1ml/L of water at 7 days interval, which was statistically different from all other treatments. T_6 comprising the spraying of Suntap 50SP @ 2 g/L of water at 7 days interval showed significantly lower infestation of 3.41% compared to T_1 – T_4 which were similar on shoot infestation (Table 2) . On the other hand, the highest shoot infestation (10.22%) was observed in T_8 (10.22%) comprising untreated control, which was statistically different from all other treatments. The infestation was similar to half of the control by hand picking and destruction of infested shoot and fruit at 7 days interval from the field. More or less similar trends of results were also observed among different management practices at early and late fruiting stages in respect of percent shoot infestation caused by brinjal shoot and fruit borer.

Considering the mean infestation, the lowest shoot infestation was observed in T_5 (6.80) which was statistically different from all other treatments followed by T_6 (7.85%), T_1 (13.03%), T_4 (14.21%), T_2 (15.42%) and T_3 (15.61%) (Table1). On the other hand, the highest shoot infestation (25.16%) was observed in T_8 (25.16%) which was statistically different from all other treatments followed by T_7 (18.11%). In case of percent reduction of shoot infestation over control, the highest reduction was found

in T_5 (72.96%) followed by T_6 (68.80%) and lowest reduction was found in T_1 (48.21%), T_4 (43.52%), T_2 (38.71%) and T_3 (37.95%)

Table 2. Percentage of shoot infestation caused by brinjal shoot and fruit borer on different treatments in the field

Treatment	Percent (%) shoot infestation				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	4.12 c	11.31 d	23.67 e	13.03 e	48.21
T_2	4.36 c	12.21 c	29.69 c	15.42 c	38.71
T_3	4.55 c	12.35 c	29.91 c	15.61 c	37.95
T_4	4.29 c	11.69 d	26.64 d	14.21 d	43.52
T_5	1.58 e	6.27 e	12.55 f	6.80 g	72.96
T_6	3.41 d	6.66 e	13.47 f	7.85 f	68.80
T_7	5.19 b	14.34 b	34.81 b	18.11 b	28.02
T_8	10.22 a	23.20 a	42.06 a	25.16 a	-
$LSD_{(0.01)}$	0.5954	0.4348	1.178	0.4547	-
CV(%)	5.20	1.47	1.82	1.29	-

In column, means containing same letter did not differ significantly under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

From the above findings it revealed that T_5 comprising spraying of Ripcord 10EC @1ml/L of water at 7 days interval performed as the best treatment in reducing 72.96% shoot infestation over control and 68.80% and 48.21% reductions in T_6 and T_1, respectively (Table 2). As a result, the trend of reducing the shoot infestation is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. Rahman *et al.* (2009) 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 the present study but Srinibvasan *et al.* (1998), reported that nimbicidine provided best effectiveness compared control.

4.2. Effect of management practices on the fruit infestation by number

BSFB started infestation when the plants were bearing fruits. 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 based on number as well as in percent (%) reduction in infestation over control as presented in Table 3. At early fruiting stage, the lowest fruit infestation (7.93%) was recorded in T_5 (7.93%) which was statistically different from all other treatments followed by T_6 (12.25%). This was also followed by T_1 (19.74%), T_4 (20.35%), T_2 (21.67%) and T_3 (23.21%). On the other hand, the highest fruit infestation (33.52%) were observed in T_8 (33.52%), which was statistically different from all other treatments followed by T_7 (25.34%). More or less similar trends of results were also observed among different practices at mid and late fruiting stage in respect of percent fruit infestation caused by brinjal shoot and fruit borer.

Considering the mean infestation, the lowest fruit infestation (13.67%) were observed in T_5 (13.67%) which was statistically different from all other treatments followed by T_6 (16.00%), T_1 (24.74%), T_4 (25.46%), T_2 (26.49%) and T_3 (27.69%). On the other hand, the highest fruit infestation (45.11%) was observed in T_8 (45.11%) which was statistically different from all other treatments followed by T_7 (33.87%). In case of percent reduction of fruit infestation over control, the highest reduction was found in T_5 (69.70%) followed by T_6 (64.53%) and lowest reduction was found in T_1 (45.16%), T_4 (43.56%), T_2 (41.28%) and T_3 (38.62%).

From these findings it was revealed that T_5 performed as the best treatment (69.70%) in reducing fruit infestation by number during the management of brinjal shoot and fruit borer followed by T_6 (64.53%) and T_1 (45.16%). As a result, the trend of results in terms of reducing the fruit infestation is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar results were also reported by several researchers. The results thus obtained by Rahman *et al.* (2009) 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).

Table 3. Percentage of fruit infestation by number caused by brinjal shoot and fruit borer on different treatments in the field

Treatment	Percent (%) fruit infestation by number				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	19.74 e	23.94 e	30.55 e	24.74 e	45.16
T_2	21.67 d	25.80 cd	32.00 cd	26.49 d	41.28
T_3	23.21 c	26.86 c	33.00 c	27.69 c	38.62
T_4	20.35 e	24.81 de	31.23 de	25.46 e	43.56
T_5	7.930 g	13.47 g	19.62 f	13.67 g	69.70
T_6	12.25 f	15.24 f	20.50 f	16.00 f	64.53
T_7	25.34 b	30.30 bf	45.98 b	33.87 b	24.92
T_8	33.52 a	40.69 a	61.11 a	45.11 a	-
$LSD_{(0.01)}$	0.6431	1.413	1.166	0.7251	-
CV(%)	1.29	2.31	1.40	1.20	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.3. Effect of management practices 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. At early fruiting stage, the lowest fruit infestation (6.83%) was recorded in T_5 (6.83%) which was statistically different from all other treatments followed by T_6 (9.99%). This was also followed by T_1 (14.29%), T_4 (16.15%), T_2 (16.65%) and T_3 (17.68%). On the other hand, the

highest fruit infestation (34.03%) were observed in T_8 (34.03%), which was statistically different from all other treatments followed by T_7 (22.26%). More or less similar trends of results were also observed among different practices at mid and late fruiting stage in respect of percent fruit infestation caused by brinjal shoot and fruit borer (Table 4).

Table 4. Percentage of fruit infestation by weight caused by brinjal shoot and fruit borer on different treatments in the field

Treatment	Percent (%) fruit infestation by weight				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	14.29 d	22.14 c	26.63 e	21.02 e	49.21
T_2	16.65 c	23.43 c	29.27 cd	23.12 d	44.14
T_3	17.68 c	23.93 c	30.93 c	24.18 c	41.58
T_4	16.15 c	22.86 c	27.93 de	22.31 d	46.10
T_5	6.83 f	12.56 d	14.67 g	11.35 g	72.58
T_6	9.99 e	14.28 d	16.97 f	13.74 f	66.80
T_7	22.26 b	28.49 b	36.62 b	29.12 b	29.64
T_8	34.03 a	36.14 a	54.01 a	41.39 a	-
$LSD_{(0.01)}$	1.786	1.957	1.798	0.8420	-
CV(%)	4.26	3.50	2.50	1.49	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the mean infestation, the lowest fruit infestation (11.35%) were observed in T_5 (11.35%) which was statistically different from all other treatments followed by T_6 (13.74%), T_1 (21.02%), T_4 (22.31%), T_2 (23.12%) and T_3 (24.18%). On the other

hand, the highest fruit infestation (41.39%) was observed in T_8 (41.39%) which was statistically different from all other treatments followed by T_7 (29.12%). In case of percent reduction of fruit infestation over control, the highest reduction was found in T_5 (72.58%) followed by T_6 (66.80%) and lowest reduction was found in T_1 (49.21%), T_4 (46.10%), T_2 (44.14%) and T_3 (41.58%).

From the above findings it was revealed that T_5 performed as the best treatment (72.58%) in reducing fruit infestation by weight during the management of brinjal shoot and fruit borer followed by T_6 (66.80%) and T_1 (49.21%). As a result, the trend of results in terms of reducing the fruit infestation is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar results were also reported by several researchers. Mahmud-Al-Parvez (2010) reported that the lowest percent (%) fruit infestation by weight was 10.57% from T_6 (Ripcord 10 EC @ 1ml/L of water at 7 days interval) where percent (%) reduction over control was 68.61% with the same treatment. Thus it is revealed from Table 2, 3 and 4 that the rate of infestation is higher in fruits than the shoots which are in consistence with the findings reported by Maleque (1998) who also observed that the caterpillars preferred the fruits to shoots during the fruiting stage.

4.4. Effect of management practices on the plant infestation

The significant variations among different management practices were observed in respect of percent plant infestation by number during the management of brinjal shoot and fruit borer throughout the cropping season. At vegetative stage, the lowest plant infestation was recorded in T_5 (4.22%) which was statistically different from all other treatments followed by T_6 (5.08%). This was also followed by T_1 (9.15%), T_4 (10.09%), T_2 (10.71%) and T_3 (11.03%). On the other hand, the highest plant infestation (23.53%) were observed in T_8 (23.53%), which was statistically different from all other treatments followed by T_7 (15.20%). More or less similar trends of results were also observed among different practices at early and late fruiting stage in respect of percent plant infestation by number caused by brinjal shoot and fruit borer (Table 5).

Considering the mean infestation, the lowest plant infestation (19.71%) were observed in T_5 (19.71%) which was statistically different from all other treatments followed by T_6 (20.88%), T_1 (33.28%), T_4 (34.52%), T_2 (36.24%) and T_3 (37.74%). On the other hand, the highest plant infestation (44.72%) was observed in T_8 (44.72%) which was

statistically different from all other treatments followed by T_7 (40.31%). In case of percent reduction of plant infestation over control the highest reduction was found in T_5 (55.93%) followed by T_6 (53.31%) and lowest reduction was found in T_1 (25.58%), T_4 (22.81%), T_2 (18.96%) and T_3 (15.61%).

Table 5. Percentage of plant infestation caused by brinjal shoot and fruit borer on different treatments in the field

Treatment	Percent (%) plant infestation by number				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	9.15 c	30.65 f	60.03 d	33.28 f	25.58
T_2	10.71 c	35.26 d	62.74 c	36.24 d	18.96
T_3	11.03 c	38.31 c	63.89 c	37.74 c	15.61
T_4	10.09 c	32.36 e	61.11 d	34.52 e	22.81
T_5	4.22 d	22.10 g	32.82 f	19.71 h	55.93
T_6	5.08 d	22.61 g	34.96 e	20.88 g	53.31
T_7	15.20 b	40.28 b	65.44 b	40.31 b	9.86
T_8	23.53 a	42.02 a	68.60 a	44.72 a	-
$LSD_{(0.01)}$	2.483	1.230	1.468	0.9813	-
CV(%)	9.18	1.54	1.07	1.21	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2ml/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

From the above findings it was revealed that T_5 performed as the best treatment (55.93%) in reducing plant infestation by number during the management of brinjal

shoot and fruit borer followed by T_6 (53.31%) and T_1 (25.58%). As a result, the trend of results in terms of reducing the fruit infestation is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar results were also reported by several researchers. Mahmud-al-Parvez (2010) and Rashedul Islam (2006) also reported that the plant of brinjal seriously affected by brinjal shoot and fruit borer and application of cypermethrin is the best management practices than nimbicidine.

4.5. Effect of management practices on the plant height

Height of plant was significantly influenced by different management practices (Table 6). At vegetative stage, the highest plant height (63.04cm) was recorded in T_5 (63.04cm) which was statistically different from all other treatments followed by T_6 (62.06cm). This was also followed by T_1 (57.15cm), T_4 (55.10cm), and T_2 (53.16cm). On the other hand, the lowest plant height (50.74cm) were observed in T_8 (50.74cm), which was statistically different from all other treatments followed by T_7 (51.37cm) and T_3 (52.30cm). More or less similar trends of results were also observed among different practices at early and late fruiting stage.

Considering the mean infestation, the highest plant height (67.48cm) were observed in T_5 (67.48cm) which was statistically different from all other treatments followed by T_6 (66.08cm), T_1 (59.46cm), T_4 (57.47cm), T_2 (55.24cm) and T_3 (53.97cm). On the other hand, the lowest plant height (51.43cm) was observed in T_8 (51.43cm) which was statistically different from all other treatments followed by T_7 (52.73). In case of percent increase of plant height over control the highest increase was found in T_5 (31.20%) followed by T_6 (28.48%) and lowest increase was found in T_1 (15.61%), T_4 (11.74%), T_2 (7.41%) and T_3 (4.94%).

From these findings it was revealed that T_5 performed as the best treatment (31.20%) in increasing plant height during the management of brinjal shoot and fruit borer followed by T_6 (28.48%) and T_1 (15.61%). As a result, the trend of results in terms of increasing the plant height is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar works was done by Parvez (2010) and reported that plant hight affected by brinjal shoot and fruit borer.

Table 6. Effect of management practices on the height of brinjal plants

Treatment	Height of plant (cm/plant)				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	57.15 b	59.01 b	62.22 c	59.46 c	15.61
T_2	53.16 d	55.51 d	57.05 e	55.24 e	7.41
T_3	52.30 dc	53.99 e	55.62 f	53.97 f	4.94
T_4	55.10 c	57.26 c	60.05 d	57.47 d	11.74
T_5	63.04 a	66.75 a	72.66 a	67.48 a	31.20
T_6	62.06 a	65.70 a	70.50 b	66.08 b	28.48
T_7	51.37 ef	52.41 f	54.43 g	52.73 g	2.52
T_8	50.74 f	51.17 f	52.38 h	51.43 h	-
$LSD_{(0.01)}$	1.057	1.375	1.124	0.6960	-
CV(%)	0.78	0.98	0.76	0.49	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.6. Effect of management practices on the number of branches of brinjal plant

The number of branches of brinjal plant was significantly influenced by different management practices (Table 7). At vegetative stage, the highest number of branches per plant (9.51) was recorded in T_5 (9.51) which was statistically different from all other treatments followed by T_6 (9.13). This was also followed by T_1 (8.18), T_4 (7.54), and T_2 (7.27). On the other hand, the lowest number of branches per plant (6.22) were observed in T_8 (6.22), which was statistically different from all other treatments followed by T_7 (6.44) and T_3 (6.67). More or less similar trends of results were also observed among different practices at early fruiting stage and late fruiting stage.

Table 7. Effect of management practices on the number of branches per plant during the management of brinjal shoot and fruit borer

Treatment	Number of branches /plant				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	8.18 b	8.89 c	9.91 b	8.99 c	24.85
T_2	7.27 c	8.59 cd	9.29 cd	8.38 d	16.38
T_3	6.67 d	8.33 d	8.89 d	7.96 e	10.51
T_4	7.54 c	8.76 cd	9.62 bc	8.64 cd	19.95
T_5	9.51 a	10.83 a	12.19 a	10.85 a	50.63
T_6	9.13 a	10.24 b	11.67 a	10.35 b	43.69
T_7	6.44 d	7.43 e	8.24 e	7.37 f	2.36
T_8	6.22 d	7.29 e	8.11 e	7.20 f	-
$LSD_{(0.01)}$	0.5325	0.4612	0.5380	0.3686	-
CV(%)	2.88	2.17	2.28	1.74	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the mean infestation, the highest number of branches per plant (10.85) were observed in T_5 (10.85) which was statistically different from all other treatments followed by T_6 (10.35), T_1 (8.99), T_4 (8.64), T_2 (8.38) and T_3 (7.93). On the other hand, the lowest number of branches per plant (7.20) was observed in T_8 (7.20) which was statistically different from all other treatments followed by T_7 (7.37). In case of percent increase of number of branches per plant over control the highest increase was found in T_5 (50.63%) followed by T_6 (43.69%) and lowest increase was found in T_1 (24.85%), T_4 (19.95%), T_2 (16.38%) and T_3 (10.51%).

From the above findings it was revealed that T_5 performed as the best treatment (50.63%) in increasing branch number per plant during the management of brinjal shoot and fruit borer followed by T_6 (43.69%) and T_1 (24.85%). As a result, the trend of results in terms of increasing the number of branches per plant is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

4.7. Effect of management practices on the length of healthy fruit

The significant variations among different management practices were observed in fruit length during the management of brinjal shoot and fruit borer throughout the cropping season (Table 8). At early fruiting stage, the highest length of healthy fruit (19.99cm) was recorded in T_5 (19.99cm) which was statistically different from all other treatments followed by T_6 (18.70cm). This was also followed by T_1 (16.52cm), T_4 (15.19cm), T_2 (15.01cm) and T_3 (14.57cm). On the other hand, the lowest length of healthy fruit (13.20cm) were observed in T_8 (13.20), which was statistically different from all other treatments followed by T_7 (14.03cm). More or less similar trends of results were also observed among different practices at mid fruiting stage and late fruiting stage.

Considering the mean infestation, the highest length of healthy fruit (17.51cm) were observed in T_5 (17.51cm) which was statistically different from all other treatments followed by T_6 (16.33cm), T_1 (13.95cm), T_4 (13.08cm), T_2 (12.76cm) and T_3 (12.32cm). On the other hand, the lowest length of healthy fruit (11.20cm) was observed in T_8 (11.20cm) which was statistically different from all other treatments followed by T_7 (11.76cm). In case of percent increase of length of healthy fruit over control the highest increase was found in T_5 (56.34%) followed by T_6 (45.80%) and lowest increase was found in T_1 (24.55%), T_4 (16.79%), T_2 (13.93%) and T_3 (10.00%) over control.

From these findings it was revealed that T_5 performed as the best treatment (56.34%) in increasing the length of healthy fruit during the management of brinjal shoot and fruit borer followed by T_6 (45.80%) and T_1 (24.55%). As a result, the trend of results in terms of increasing the length of healthy fruit is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar results were also reported by several researchers. Butani and Jotwani (1984) reported that the length of the brinjal fruit affected by the brinjal shoot and fruit borer.

Table 8. Effect of management practices on the length of healthy fruit during the management of brinjal shoot and fruit borer

Treatment	Length of healthy fruit (cm/fruit)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	16.52 c	13.24 c	12.08 c	13.95 c	24.55
T_2	15.01 d	11.82 de	11.44 de	12.76 d	13.93
T_3	14.57 de	11.27 ef	11.13 e	12.32 e	10.00
T_4	15.19 d	12.32 d	11.73 d	13.08 d	16.79
T_5	19.99 a	16.87 a	15.68 a	17.51 a	56.34
T_6	18.70 b	15.53 b	14.75 b	16.33 b	45.80
T_7	14.04 e	10.89 f	10.37 f	11.76 f	5.00
T_8	13.20 f	10.58 f	9.817 g	11.20 g	-
$LSD_{(0.01)}$	0.7648	0.8455	0.3261	0.3686	-
CV(%)	1.97	2.72	1.10	1.10	

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.8. Effect of management practices on the length of infested fruit

The significant variations among different management practices were observed in fruit length during the management of brinjal shoot and fruit borer throughout the cropping season. At early fruiting stage, the highest length of infested fruit (16.69cm) was recorded in T_5 (16.69cm) which was statistically similar to T_6 (15.98cm) and different from all other treatments followed by T_1 (14.75cm), T_4 (14.22cm), T_2 (13.76cm) and T_3 (13.58cm). On the other hand, the lowest length of infested fruit (12.96cm) were observed in T_8 (12.96cm), which was statistically similar to T_7 (13.22cm), T_3 (13.58cm), T_2 (13.76cm) and T_4 (14.22cm). More or less similar trends

of results were also observed among different practices at mid fruiting stage and late fruiting stage (Table 9).

Table 9. Effect of management practices on the length of infested fruit during the management of brinjal shoot and fruit borer

Treatment	Length of infested fruit (cm/fruit)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	14.75 bc	11.54 c	9.76 c	12.02 c	16.02
T_2	13.76 cd	11.08 cd	9.37 cd	11.40 de	10.03
T_3	13.58 cd	11.01 cd	9.20 d	11.26 e	8.68
T_4	14.22 cd	11.04 cd	9.68 c	11.65 d	12.45
T_5	16.69 a	15.13 a	11.90 a	14.57 a	40.64
T_6	15.98 ab	13.42 b	10.48 b	13.29 b	28.28
T_7	13.22 d	10.40 de	8.42 e	10.68 f	3.09
T_8	12.96 d	10.07 e	8.05 e	10.36 f	-
$LSD_{(0.01)}$	1.256	0.8171	0.4415	0.3522	-
CV(%)	3.59	2.86	1.89	1.22	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the mean infestation, the highest length of infested fruit (14.57cm) were observed in T_5 (14.57cm) which was statistically different from all other treatments followed by T_6 (13.29cm), T_1(12.02cm), T_4 (11.65cm), T_2 (11.40cm) and T_3 (11.26cm). On the other hand, the lowest length of infested fruit (10.36cm) was observed in T_8 (10.36cm) which was statistically similar to T_7 (10.36cm) and different from all other treatments followed by T_1 (12.02cm). In case of percent increase of length of infested fruit over control the highest increase was found in T_5(40.64%)

followed by T_6 (28.28%) and lowest increase was found in T_1 (16.02%), T_4 (12.45%), T_2 (10.03%) and T_3 (8.68%).

From the above findings it was revealed that T_5 performed as the best treatment (40.64%) in increasing the length of infested fruit during the management of brinjal shoot and fruit borer followed by T_6 (28.28%) and T_1 (16.02%). As a result, the trend of results in terms of increasing the length of infested fruit is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

4.9. Effect of management practices on the girth of healthy fruit

The significant variations among different management practices were observed on the girth of healthy fruit during the management of brinjal shoot and fruit borer throughout the cropping season. At early fruiting stage, the highest girth of healthy fruit (11.88cm) was recorded in T_5 (11.88cm) which was statistically different from all other treatments followed by T_6 (10.69cm). This was also followed by T_1 (9.05cm), T_4 (8.83cm), T_2 (8.46cm) and T_3 (8.33cm). On the other hand, the lowest girth of healthy fruit (8.03cm) were observed in T_8 (8.03), which was statistically similar to T_7 (8.15cm), T_3 (8.33cm) and different from all other treatments followed by T_1 (9.05cm). More or less similar trends of results were also observed among different practices at mid fruiting stage and late fruiting stage (Table 10).

Considering the mean infestation, the highest girth of healthy fruit (10.98cm) were observed in T_5 (10.98cm) which was statistically different from all other treatments followed by T_6 (10.05cm), T_1 (9.04cm), T_4 (8.24cm), T_2 (7.51cm) and T_3 (7.10cm). On the other hand, the lowest girth of healthy fruit (6.79cm) was observed in T_8 (6.79cm) which was statistically different from all other treatments followed by T_7 (7.01cm). In case of percent increase of girth of healthy fruit over control the highest increase was found in T_5 (61.54%) followed by T_6 (47.86%) and lowest increase was found in T_1 (33.04%), T_4 (21.27%), T_2 (10.59%) and T_3 (4.46%).

From these findings it was revealed that T_5 performed as the best treatment (61.54%) in increasing the girth of healthy fruit during the management of brinjal shoot and fruit borer followed by T_6 (47.86%) and T_1 (33.04%). As a result, the trend of results in terms of increasing the girth of healthy fruit is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar works were done by Butani and Jatwani (1984) and Thakur *et al.*(1986)

and reported that the girth of the brinjal fruit affected by the brinjal shoot and fruit borer.

Table 10. Effect of management practices on the girth of healthy fruit during the management of brinjal shoot and fruit borer

Treatment	Girth of healthy fruit (cm/fruit)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	9.05 c	9.60 b	8.46 b	9.04 c	33.04
T_2	8.46 d	7.60 d	6.47 cd	7.51 e	10.59
T_3	8.33 de	6.93 de	6.02 d	7.10 f	4.46
T_4	8.83 c	8.77 c	7.13 c	8.24 d	21.27
T_5	11.88 a	10.65 a	10.40 a	10.98 a	61.54
T_6	10.69 b	9.94 ab	9.52 a	10.05 b	47.86
T_7	8.15 de	6.98 de	5.88 d	7.01 f	3.13
T_8	8.03 e	6.75 e	5.61 d	6.79 f	-
$LSD_{(0.01)}$	0.3261	0.7332	0.9783	0.3605	-
CV(%)	1.45	3.60	5.41	1.77	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.10. Effect of management practices on the girth of infested fruit

The significant variations among different management practices were observed on the girth of infested fruit during the management of brinjal shoot and fruit borer throughout the cropping season. At early fruiting stage, the highest girth of infested fruit (10.35cm) was recorded in T_5 (10.35cm) which was statistically different from all other treatments followed by T_6 (9.78cm). This was also followed by T_1 (8.74cm), T_4 (8.53cm), T_2 (8.21cm) and T_3 (8.10cm). On the other hand, the lowest girth of

infested fruit (7.78cm) were observed in T_8 (7.78cm), which was statistically similar to T_7 (8.04cm), T_3 (8.10cm), T_2 (8.21cm) and different from other treatments followed by T_1 (8.74cm). More or less similar trends of results were also observed among different practices at mid fruiting stage and late fruiting stage.

Table 11. Effect of management practices on the girth of infested fruit during the management of brinjal shoot and fruit borer

Treatment	Girth of infested fruit (cm/fruit)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	8.73 c	6.96 bc	6.40 c	7.36 c	14.57
T_2	8.21 cde	6.60 bc	5.72 de	6.84 e	6.42
T_3	8.10 de	6.41 c	5.60 de	6.70 ef	4.25
T_4	8.53 cd	6.81 bc	5.91 cd	7.08 d	10.22
T_5	10.35 a	8.12 a	8.34 a	8.94 a	39.04
T_6	9.78 b	7.54 ab	7.62 b	8.32 b	29.39
T_7	8.04 de	6.34 c	5.47 de	6.62 f	3.00
T_8	7.78 e	6.19 c	5.30 e	6.43 g	-
$LSD_{(0.01)}$	0.5213	0.9351	0.5040	0.1883	-
CV(%)	2.46	5.59	3.29	1.09	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the mean infestation, the highest girth of infested fruit (8.94cm) were observed in T_5 (8.94cm) which was statistically different from all other treatments followed by T_6 (8.32cm), T_1 (7.36cm), T_4 (7.08cm), T_2 (6.84cm) and T_3 (6.70cm). On the other hand, the lowest girth of infested fruit (6.43cm) was observed in T_8 (6.43cm) which was statistically different from all other treatments followed by T_7 (6.62cm). In

case of percent increase of girth of infested fruit over control the highest increase was found in T_5 (39.04%) followed by T_6 (29.39%) and lowest increase was found in T_1 (14.57%), T_4 (10.22%), T_2 (6.42%) and T_3 (4.25%).

From the above findings it was revealed that T_5 performed as the best treatment (39.04%) in increasing the girth of infested fruit during the management of brinjal shoot and fruit borer followed by T_6 (29.39%) and T_1 (14.57%). As a result, the trend of results in terms of increasing the girth of infested fruit is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

4.11. Effect of management practices on the number of fruit per plant

The significant variations among different management practices were observed on the number of fruit per plant during the management of brinjal shoot and fruit borer throughout the cropping season (Table 12). At early fruiting stage, the highest number of fruit per plant (14.38) was recorded in T_5 (14.38) which was statistically different from all other treatments followed by T_6 (13.14). This was also followed by T_1 (12.71), T_4 (11.47), and T_2 (10.77). On the other hand, the lowest number of fruit per plant (9.46) were observed in T_8 (9.46), which was statistically similar to T_7 (10.44), and different from all other treatments followed by T_1 (12.71). More or less similar trends of results were also observed among different practices at mid fruiting stage and late fruiting stage.

Considering the mean infestation, the highest number of fruit per plant (16.08) were observed in T_5 (16.08) which was statistically different from all other treatments followed by T_6 (13.72), T_1 (12.27), T_4 (12.09), and T_2 (11.32). On the other hand, the lowest number of fruit per plant (9.33) was observed in T_8 (9.33) which was statistically different from all other treatments followed by T_7 (11.08). In case of percent increase of number of fruit per plant over control the highest increase was found in T_5 (72.22%) followed by T_6 (46.94%) and lowest increase was found in T_1 (31.41%), T_4 (29.48%), and T_2 (21.24%).

From these findings it was revealed that T_5 performed as the best treatment (72.22%) in increasing number of fruit per plant during the management of brinjal shoot and fruit borer followed by T_6 (46.94%) and T_1 (31.41%). As a result, the trend of results in terms of increasing the number of fruit per plant is $T_5> T_6> T_1> T_4> T_2> T_3> T_7> T_8$. More or less similar results were also reported by several researchers. Biradar *et*

al.(2001) observed the highest number of fruit was obtained with Cypermethrin followed by Carbaryl and Endosulfan.

Table 12. Effect of management practices on the number of fruit per plant during the management of brinjal shoot and fruit borer

Treatment	Number of fruit /plant				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	12.71 b	12.99 c	11.09 bc	12.27 c	31.41
T_2	10.77 cd	12.36 c	10.82 bc	11.32 c	21.24
T_3	11.13 cd	12.02 c	10.67 bc	11.27 c	20.70
T_4	11.47 c	13.11 c	11.71 b	12.09 c	29.48
T_5	14.38 a	17.61 a	16.25 a	16.08 a	72.22
T_6	13.14 b	15.69 b	12.32 b	13.72 b	46.94
T_7	10.44 d	12.05 c	10.75 bc	11.08 c	18.67
T_8	9.46 e	9.25 d	9.29 c	9.33 d	-
$LSD_{(0.01)}$	0.8243	1.814	2.170	1.386	-
CV(%)	2.90	5.68	7.69	4.69	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.12. Relationship between shoot infestation and yield attributes of eggplant

As depicted in the Figure 1, it was revealed that both number of branch and fruit 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. That is the best treatment (T_5) reduced the highest percent of shoot infestation, but increased the maximum number of branch per plant as well as maximum number of fruit per plant.

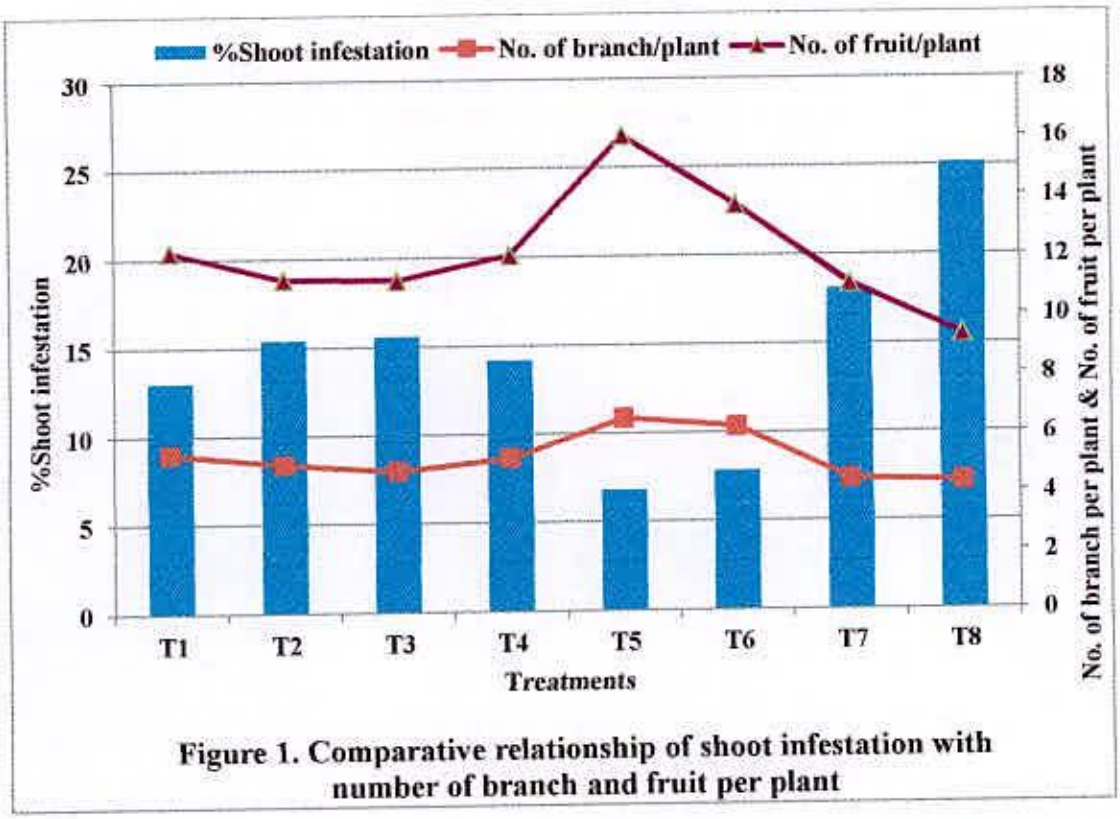


Figure 1. Comparative relationship of shoot infestation with number of branch and fruit per plant

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.13. Effect of management practices on the weight of healthy fruit (g/fruit)

The significant variations among different management practices were observed on the weight of healthy fruit during the management of brinjal shoot and fruit borer throughout the cropping season (Table 13). At early fruiting stage, the highest weight per healthy fruit (73.40g) was recorded in T_5 (73.40g) which was statistically different from all other treatments followed by T_6 (64.04g). This was also followed by T_1 (57.16g), T_4 (49.71g), T_2 (48.08g) and T_3 (46.64g). On the other hand, the lowest weight per healthy fruit (39.70g) were observed in T_8 (39.70g), which was statistically different from all other treatments followed by T_7 (45.01g). More or less similar trends of results were also observed among different practices at mid fruiting stage and late fruiting stage.

Considering the mean infestation, the highest weight per healthy fruit (71.53g) were observed in T_5 (71.53g) which was statistically different from all other treatments followed by T_6 (63.65g), T_1 (54.19g), T_4 (49.65g), T_2 (48.11g) and T_3 (46.44g). On the

other hand, the lowest weight per healthy fruit (37.48g) was observed in T_8 (37.48g) which was statistically different from all other treatments followed by T_7 (43.61g). In case of percent increase of weight per healthy fruit over control the highest increase was found in T_5 (90.85%) followed by T_6 (69.82%) and lowest increase was found in T_1 (44.58%), T_4 (32.47%), T_2 (28.36%) and T_3 (23.91%).

Table 13. Effect of management practices on the weight of healthy fruit during the management of brinjal shoot and fruit borer

Treatment	Weight of healthy fruit (g/fruit)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	57.16 c	60.02 c	45.39 c	54.19 c	44.58
T_2	48.08 d	56.67 de	39.58 cd	48.11 d	28.36
T_3	46.64 d	55.67 e	37.00 cde	46.44 de	23.91
T_4	49.71 d	58.34 d	40.89 cd	49.65 d	32.47
T_5	73.40 a	73.63 a	67.57 a	71.53 a	90.85
T_6	64.04 b	71.33 b	55.58 b	63.65 b	69.82
T_7	45.01 d	51.80 f	34.00 de	43.61 e	16.36
T_8	39.70 e	43.33 g	29.40 e	37.48 f	-
$LSD_{(0.01)}$	5.169	1.665	8.673	4.044	-
CV(%)	4.01	1.16	8.17	3.21	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2ml/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

From the above findings it was revealed that T_5 performed as the best treatment (90.85%) in increasing the weight per healthy fruit during the management of brinjal shoot and fruit borer followed by T_6 (69.82%) and T_1 (44.58%). As a result, the trend of results in terms of increasing the weight per healthy fruit is

$T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar results were also reported by several researchers. Duara *et al.* (2003) carried out a field experiment and observed the highest weight of a healthy fruit with cypermathrin.

4.14. Effect of management practices on the weight of infested fruit

The significant variations among different management practices were observed on the weight of infested fruit during the management of brinjal shoot and fruit borer throughout the cropping season. At early fruiting stage, the highest weight per infested fruit (49.79g) was recorded in T_5 (49.79g) which was statistically similar to T_6 (46.64g) and different from all other treatments followed by T_1 (40.89g), T_4 (35.35g), T_2 (32.59g) and T_3 (31.16g). On the other hand, the lowest weight per infested fruit (30.09g) were observed in T_8 (30.09g), which was statistically similar to T_7 (31.22g), T_3 (31.16g) and T_2 (32.59g) and different from all other treatments followed by T_4 (35.35g). More or less similar trends of results were also observed among different practices at mid fruiting stage and late fruiting stage (Table 14).

Considering the mean infestation, the highest weight per infested fruit (50.35g) were observed in T_5 (50.35g) which was statistically different from all other treatments followed by T_6 (46.86g), T_1 (42.10g), T_4 (39.90g), T_2 (38.67g) and T_3 (37.65g). On the other hand, the lowest weight per infested fruit (32.34g) was observed in T_8 (32.34g) which was statistically different from all other treatments followed by T_7 (36.04g). In case of percent increase of weight per infested fruit over control the highest increase was found in T_5 (55.69%) followed by T_6 (44.90%) and lowest increase was found in T_1 (30.18%), T_4 (23.38%), T_2 (19.57%) and T_3 (16.22).

From these findings it was revealed that T_5 performed as the best treatment (55.69%) in increasing the weight per infested fruit during the management of brinjal shoot and fruit borer followed by T_6 (44.90%) and T_1 (30.18%). As a result, the trend of results in terms of increasing the weight per infested fruit is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

Table 14. Effect of management practices on the weight of infested fruit during the management of brinjal shoot and fruit borer

Treatment	Weight of infested fruit (g/fruit)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	40.89 b	48.21 bc	37.20 c	42.10 c	30.18
T_2	32.59 cd	47.83 bc	35.60 cd	38.67 de	19.57
T_3	31.16 cd	47.02 c	34.78 cd	37.65 de	16.42
T_4	35.35 c	47.98 bc	36.38 cd	39.90 cd	23.38
T_5	49.79 a	52.63 a	48.63 a	50.35 a	55.69
T_6	46.64 a	51.25 ab	42.68 b	46.86 b	44.90
T_7	31.22 cd	45.42 c	31.49 de	36.04 e	11.44
T_8	30.09 d	39.21 d	27.73 e	32.34 f	-
$LSD_{(0.01)}$	4.056	3.310	5.194	2.580	-
CV(%)	4.48	2.87	5.81	2.62	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.15. Relationship between fruit infestation and fruit related yield attributes

As depicted in the Figure 2, it was revealed that maximum length, girth and weight of single fruit were found in the treatments where the fruit infestations 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_5)increased the maximum length, girth and weight of single fruit by reducing the fruit infestation at minimum level.

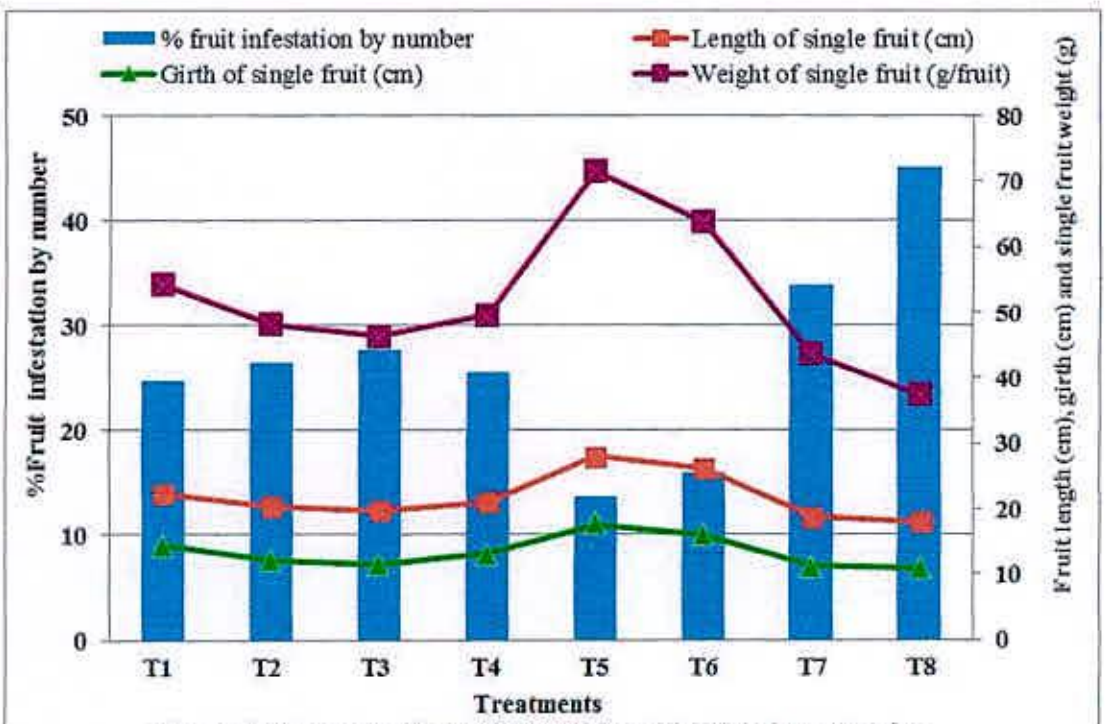


Figure 2. Comparative relationship of fruit infestation by number with length, girth & weight of single fruit

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.16. Effect of management practices 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 brinjal shoot and fruit borer (Table 15). In case of yield of brinjal fruit per plot the highest yield (21.55kg/plot) was observed in T_5 (21.55kg/plot) which was statistically different from all other treatments followed by T_6 (19.80kg/plot), T_1 (14.36kg/plot), T_4 (13.83kg/plot) and T_2 (13.23kg/plot). On the other hand, the lowest (8.70kg/plot) yield of brinjal fruit was observed in T_8 (8.70kg/plot), which was statistically different from all other treatments followed by T_7 (11.38kg/plot) and T_3 (12.83kg/plot). 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 T_5 (23.95t/ha) which was statistically different from all other treatments followed by T_6 (21.99t/ha), T_1 (15.95t/ha) and, T_4 (15.37t/ha). On the other hand, the lowest (9.66t/ha) yield of brinjal fruit was observed in T_8 (9.66t/ha), which was statistically

different from all other treatments followed by T_7 (12.65t/ha), T_3 (14.26t/ha) and T_2 (14.70t/ha).

Table 15. Effect of management practices on the yield of fruit during the management of brinjal shoot and fruit borer

Treatment	Yield of fruits		
	(kg/plot)	(ton/ha)	% Increase over control
T_1	14.36 c	15.95 c	65.06
T_2	13.23 d	14.70 d	52.13
T_3	12.83 d	14.26 d	47.57
T_4	13.83 cd	15.37 cd	59.06
T_5	21.55 a	23.95 a	147.85
T_6	19.80 b	21.99 b	127.57
T_7	11.38 e	12.65 e	30.91
T_8	8.70 f	9.66 f	-
$LSD_{(0.01)}$	1.011	1.122	-
CV(%)	2.88	2.87	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the percent yield increase over control the highest (147.85%) increase was recorded in T_5 (147.85%) followed by T_6 (127.57%), T_1 (65.06%), T_4 (59.06%), and T_2 (52.13%). On the other hand, the lowest yield increase over control was recorded in T_7 (30.91%) followed by T_3 (47.57%).

From the above findings it was revealed that T_5 performed as the best (147.85%) management practices in increasing the fruit yield over control and lowest (30.91%) increase recorded in T_7. As a result, the trends of different management practices in terms of percent yield increase is $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$. More or less similar

results were also reported by several researchers. Jat and Pareek (2001) and Misra (1993) reported that nimbicidine was the least effective in controlling the BSFB and resulted lowest yield but Srinibvasan *et al.* (1998) reported that nimbicidine provided higher yield (13.02 t/ha) than endosulfan. The less effectiveness of cypermethrin and other insecticides was also reported by some researchers (Kabir *et al.*, 1993; Anonymous, 1991) but several researchers reported the best performance of cypermethrin in producing highest (22-25 t/ha) yield of brinjal (Duara *et al.*, 2003, Singh and Singh 2003; Biradar *et al.*, 2001).

4.17. Relationship between shoot infestation and yield of brinjal

Correlation study was done to establish the relationship between the percent shoot infestation caused by brinjal shoot and fruit borer and yield of brinjal. From the study it revealed that highly significant correlation ($R^2 = 0.923$) was observed between the parameters (Figure 3). It was evident from the Figure 3 that the equation $y = -0.704x + 24.69$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.923$) showed that, fitted regression line had a significant regression co-efficient. From these relations it can be concluded that yield of brinjal was strongly ($R^2 = 0.923$) as well as negatively correlated with the shoot infestation, i.e., the yield of brinjal decreased with the increase of shoot infestation.

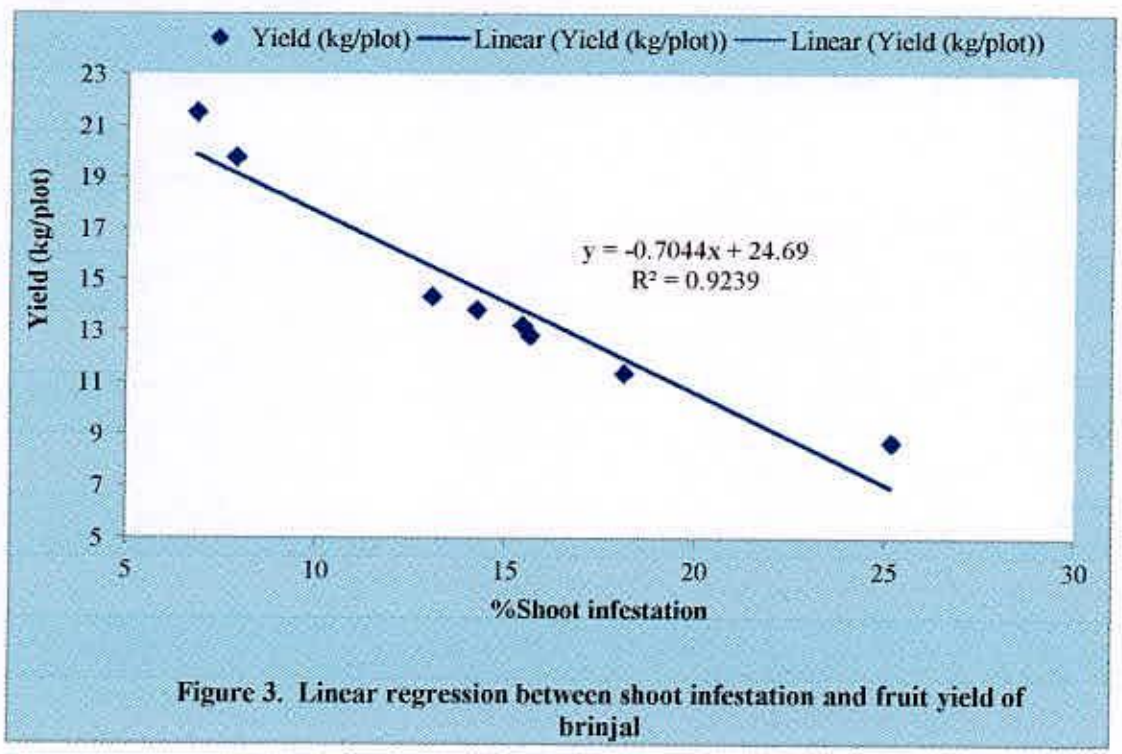


Figure 3. Linear regression between shoot infestation and fruit yield of brinjal

4.18. Relationship between fruit infestation and yield of brinjal

Correlation study was done to establish the relationship between the percent fruit infestation caused by brinjal shoot and fruit borer and yield of brinjal. From the study it was revealed that highly significant (p=0.01) correlation was observed between the parameters (Figure 4). It was evident from the Figure 4 that the equation y = -0.408x + 25.33 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.90) showed that, fitted regression line had a significant regression co-efficient. From these relations it can be concluded that yield of brinjal was strongly (R^2 = 0.90) as well as negatively correlated with the fruit infestation, i.e., the yield of brinjal decreased with the increase of fruit infestation.

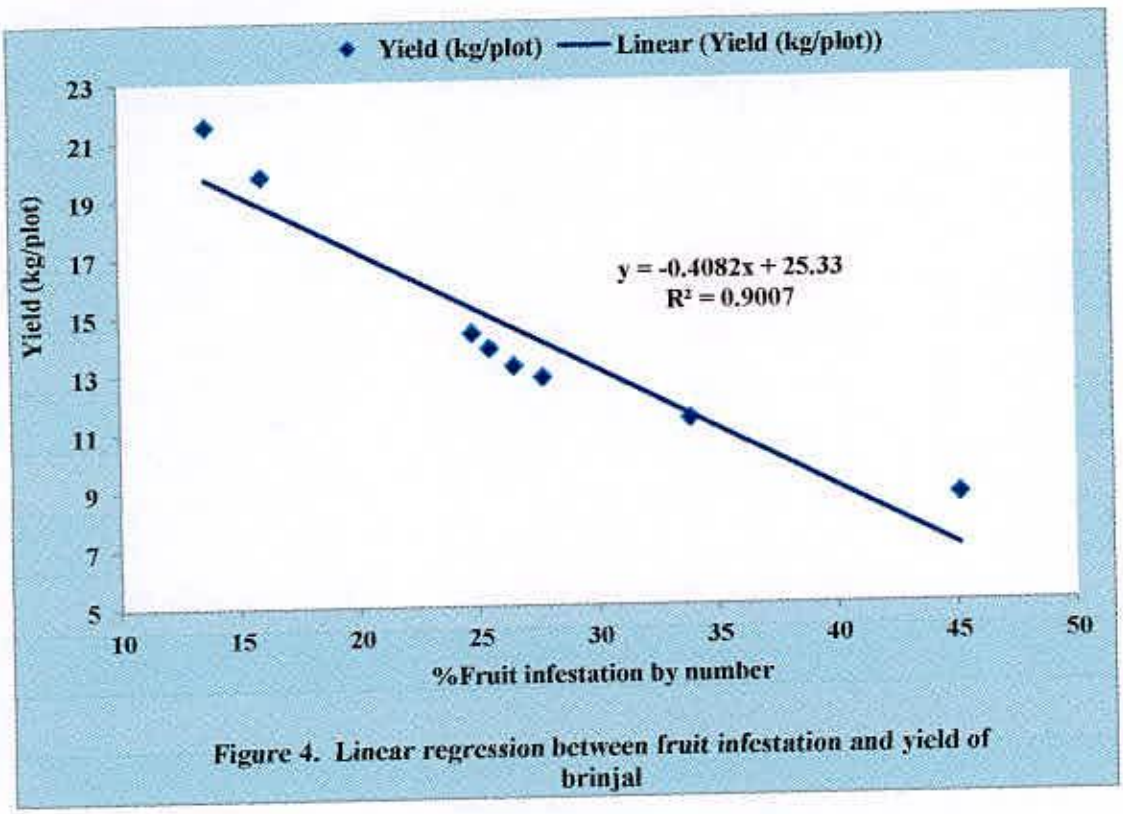


Figure 4. Linear regression between fruit infestation and yield of brinjal

4.19. Effect on the incidence of adult lady bird beetle counted visually

Significant variations were observed among different management practices in terms of lady bird beetle population through visual count during the management of brinjal shoot and fruit borer in the field (Table 16). In case of vegetative stage, the highest number of adult lady bird beetle per plant was recorded in T_8 (0.83 adult per plant) comprising untreated control which was statistically different from all other treatments and then the number decreased in T_7 (0.71 adult per plant), T_3 (0.60 adult per plant) and T_2 (0.55 adult per plant). On the other hand, the lowest number of adult

lady bird beetle through visual count was recorded in T_5 (0.076 adult per plant) which was statistically similar with T_6 (0.12 adult per plant) and then decreased in T_1 (0.36 adult per plant) and T_4 (0.46 adult per plant). More or less similar trends of adult lady bird beetle insect population among different treatments were also observed in case of early fruiting stage and late fruiting stage.

Table 16. Number of adult lady bird beetle counted through visual observation in the brinjal field

Treatment	Incidence of adult lady bird beetle (No./plant)				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	0.36 e	0.35 e	0.53 d	0.46 f	60.58
T_2	0.55 c	0.55 c	0.64 cd	0.68 d	42.01
T_3	0.60 c	0.60 c	0.76 bc	0.78 c	33.16
T_4	0.46 d	0.45 d	0.58 cd	0.54 e	53.73
T_5	0.076 f	0.07 f	0.24 e	0.15 h	87.43
T_6	0.12 f	0.12 f	0.32 e	0.26 g	77.72
T_7	0.71 b	0.71 b	0.84 ab	0.98 b	16.31
T_8	0.83 a	0.84 a	0.98 a	1.17 a	-
$LSD_{(0.01)}$	0.07686	0.1883	0.1719	0.07686	-
CV(%)	8.06	10.03	11.89	4.15	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

The population of adult ladybird beetle was the same at the vegetative stage and early fruiting stage and it increased at the late fruiting stage (Table 16) at vegetative, early fruiting stage and late fruiting stage. Considering the mean population of adult lady bird beetle counted visually, the highest number of adult lady bird beetle per plant

was also observed in T_8 (1.17) comprising untreated control which was statistically different from all other treatments followed by T_7 (0.98), T_3 (0.78) and T_2 (0.68). On the other hand, the lowest number of adult lady bird beetle through visual count was observed in T_5 (0.15) which was statistically similar with T_6 (0.26) followed by T_1 (0.46). 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 T_5 (87.43%) followed by T_6 (77.72%) and T_1 (60.58%). On the other hand, the lowest reduction was observed in T_7 (16.31%) followed by T_3 (33.16%). As a result, the trend of reduction of adult lady bird beetle population among different management practices was $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

From the above findings it revealed that T_5 reduced the highest population comprising Ripcord 10EC @ 1ml/L of water at 7 days interval and showed the most adverse effect in reducing (87.43%) the adult lady bird beetle population during the management of brinjal shoot and fruit borer that closely flowed by T_6 (77.72%) comprising spraying of Suntap 20EC @ 2g/L of water at 7 days interval. On the other hand, T_7 (16.31%) showed the least adverse effect in reducing (16.31%) the adult lady bird beetle population during the management of brinjal shoot and fruit borer followed by T_3 (33.16%) comprising spraying of Neem Leaf extract @ 200g/L of water at 7 days interval and T_2 (42.01%) comprising spraying of Neem Seed Kernel extract @ 100g/L of water at 7 days interval.

In comparison with synthetic chemical and botanical based management practices, synthetic chemical insecticide Ripcord 10EC and Suntap 50SP (Cartap) reduced the highest number of adult lady bird beetle population than botanical based management practices such as Neem Leaf extract (33.16%), Neem Seed Kernel extract (42.01%) etc. More or less similar findings were also reported by several researchers. Anon. (2003) reported that application of insecticides reduced the population of beneficial insects especially lady bird beetle from the brinjal agroecosystem.

4.20. Effect on the incidence of lady bird beetle larvae counted visually

Significant variations were observed among different management practices in terms of larvae of lady bird beetle population through visual count during the management of brinjal shoot and fruit borer in the field. In case of vegetative stage, the highest number of larval lady bird beetle per plant was recorded in T_8 (0.39) comprising

untreated control which was statistically different from all other treatments followed by T_7 (0.29), T_3 (0.16) and T_2 (0.13). On the other hand, the lowest number of larvae of lady bird beetle through visual count was recorded in T_5 (0.02) which was statistically similar with T_6 (0.04) followed by T_1 (0.06) and T_4 (0.09). More or less similar trends of larvae of lady bird beetle insect population among different treatments were also observed in case of early fruiting stage and late fruiting stage (Table 17).

Considering the mean population of larvae of lady bird beetle counted visually the highest number of lady bird beetle larvae per plant was also observed in T_8 (0.60) comprising untreated control which was statistically different from all other treatments followed by T_7 (0.48), T_3 (0.36) and T_2 (0.29). On the other hand, the lowest number of lady bird beetle larvae through visual count was observed in T_5 (0.07) which was statistically similar with T_6 (0.16) followed by T_1 (0.20). In case of percent reduction of lady bird beetle larvae over control due to application of different management practices against brinjal shoot and fruit borer, the highest reduction was observed in T_5 (87.71%) followed by T_6 (73.73%) and T_1 (65.93%). On the other hand, the lowest reduction was observed in T_7 (19%) followed by T_3 (40.22%). As a result, the trend of reduction of lady bird beetle larval population among different management practices was $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

From these findings it revealed that T_5 reduced the highest population comprising Ripcord 10EC @ 1ml/L of water at 7 days interval and showed the most adverse effect in reducing (87.71%) the larvae of lady bird beetle population during the management of brinjal shoot and fruit borer that closely flowed by T_6 (73.73%) comprising spraying of Suntap 50SP @ 2g/L of water at 7 days interval. On the other hand, T_7 (19%) showed the least adverse effect in reducing (19%) the larvae of lady bird beetle population during the management of brinjal shoot and fruit borer flowed by T_3 (40.22%) comprising spraying of Neem Leaf extract @ 200g/L of water at 7 days interval and T_2 (50.85%) comprising spraying of Neem Seed Kernel extract @ 100g/L of water at 7 days interval.

In comparison with synthetic chemical and botanical based management practices, synthetic chemical insecticide Ripcord 10EC and Suntap 50SP (Cartap) reduced the highest number of lady bird beetle larval population than botanical based management

practices such as Neem Leaf extract (40.22%), Neem Seed Kernel extract (50.85%) etc.

Table 17. Number of ladybird beetle larvae counted through visual observation in the brinjal field

Treatment	Incidence of lady bird beetle larvae (no./plant)				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	0.06 bc	0.09 cde	0.45 cd	0.20 ef	65.93
T_2	0.13 bc	0.20 bc	0.56 bcd	0.29 cd	50.85
T_3	0.16 b	0.28 b	0.64 bc	0.36 c	40.22
T_4	0.09 bc	0.15 cd	0.49 cd	0.24 de	59.23
T_5	0.02 c	0.03 e	0.18 e	0.07 g	87.71
T_6	0.04 bc	0.07 de	0.35 de	0.16 f	73.73
T_7	0.29 a	0.41 a	0.76 ab	0.48 b	19.00
T_8	0.39 a	0.51 a	0.88 a	0.60 a	-
$LSD_{(0.01)}$	0.1087	0.1087	0.2034	0.07686	-
CV(%)	26.86	19.36	15.21	10.96	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.21. Effect on the incidence of field spider through visual count

Significant variations were observed among different management practices in terms of field spider population through visual count during the management of brinjal shoot and fruit borer in the field. In case of vegetative stage, the highest number of field spider per plant was recorded in T_8 (0.30) comprising untreated control which was statistically different from all other treatments followed by T_7 (0.23), T_3 (0.16) and T_2 (0.13). On the other hand, the lowest number of field spider through visual

count was recorded in T_5 (0.02) which was statistically similar with T_6 (0.05) followed by T_1 (0.08) and T_4 (0.10). More or less similar trends of field spider population among different treatments were also observed in case of early fruiting stage and late fruiting stage.

Considering the mean population of field spider counted visually the highest number of field spider per plant was also observed in T_8 (0.62) comprising untreated control which was statistically different from all other treatments followed by T_7 (0.50), T_3 (0.38) and T_2 (0.32). On the other hand, the lowest number of field spider through visual count was observed in T_5 (0.07) which was statistically similar with T_6 (0.15) followed by T_1 (0.22). In case of percent reduction of field spider over control due to application of different management practices against brinjal shoot and fruit borer, the highest reduction was observed in T_5 (88.12%) followed by T_6 (75.68%) and T_1 (64.33%). On the other hand, the lowest reduction was observed in T_7 (19.46%) followed by T_3 (38.38%). As a result, the trend of reduction of field spider population among different management practices was $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

From the above findings it was revealed that T_5 reduced the highest population comprising Ripcord 10EC @ 1ml/L of water at 7 days interval showed the most adverse effect in reducing (88.12%) the field spider population during the management of brinjal shoot and fruit borer flowed by T_6 (75.68%) comprising spraying of Suntap 50SP @ 2g/L of water at 7 days interval. On the other hand, T_7 (19.46%) showed the least adverse effect in reducing (19.46%) the field spider population during the management of brinjal shoot and fruit borer flowed by T_3 (38.38%) comprising spraying of Neem Leaf extract @ 20g/L of water at 7 days interval and T_2 (48.65%) comprising spraying of Neem Seed Kernel extract @ 100g/L of water at 7 days interval.

In comparison between synthetic chemical and botanical based management practices, synthetic chemical insecticides Ripcord 10EC and Suntap 50SP (Cartap) reduced the highest number of field spider population than botanical based management practices such as Neem Leaf extract (38.38%), Neem Seed Kernel extract (48.65%). 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.

Table 18. Number of field spider populatio counted through visual observation in the brinjal field

Treatment	Incidence of field spider (no./plant)				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	0.08 cde	0.27 ef	0.31 cd	0.22 ef	64.33
T_2	0.13 c	0.38 cd	0.43 bc	0.32 cd	48.65
T_3	0.16 bc	0.47 bc	0.51 b	0.38 c	38.38
T_4	0.10 cd	0.32 de	0.44 bc	0.29 de	53.51
T_5	0.02 e	0.08 g	0.11 e	0.07 g	88.12
T_6	0.05 de	0.18 fg	0.22 de	0.15 fg	75.68
T_7	0.23 ab	0.57 b	0.70 a	0.50 b	19.46
T_8	0.30 a	0.75 a	0.80 a	0.62 a	-
$LSD_{(0.01)}$	0.07686	0.1087	0.1331	0.07686	-
CV(%)	11.64	11.36	11.40	7.07	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

4.22. Relationship between shoot infestation and population of ladybird beetle and field spider

As depicted in the Figure 5, it revealed that higher population of predatory ladybird beetle adult and larvae as well as predatory field spider were found in the treatments where the shoot infestation of eggplant were found also higher. Conversely, the higher level of shoot 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 of predatory ladybird beetle adults and larvae as well as predatory field spiders in the brinjal field. That is the best

treatment (T_5) reduced the ladybird beetle adult and larvae as well as field spider at maximum level by maintaining the shoot infestation at minimum level.

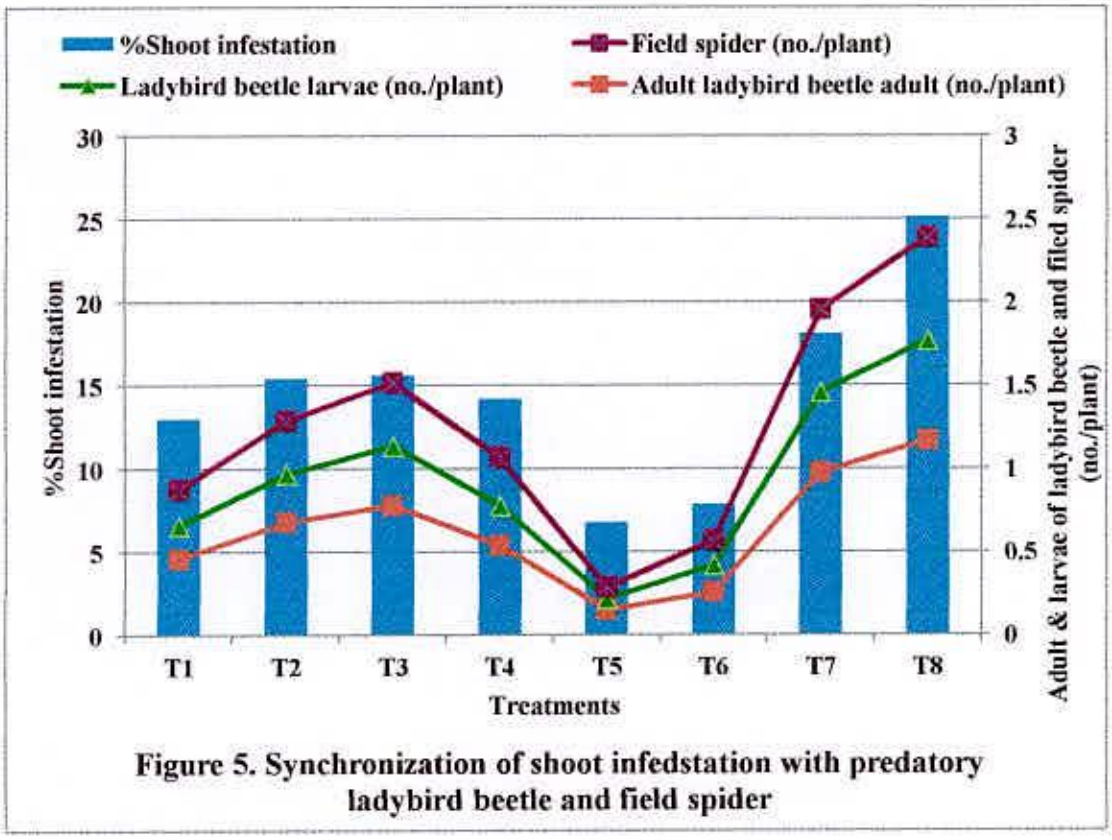


Figure 5. Synchronization of shoot infedstation with predatory ladybird beetle and field spider

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Thus, it is revealed that the chemical treatments T_5 comprising Ripcord 10EC @ $1mlL^{-1}$ of water and T_6 comprising Suntap 50SP @ $2g\ L^{-1}$ of water both sprayed at 7 days interval reduced the maximum level of shoot infestation as well as reduced the maximum population of natural enemies than any botanicals viz. neem oil, neem seed kernel extract, neem leaf extract and garlic extract.

4.23. Effect on the incidence of adult lady bird beetle through pitfall trap count

Significant variations were observed among different management practices in terms of lady bird beetle population through pitfall trap count during the management of brinjal shoot and fruit borer in the field. In case of vegetative stage, the highest number of adult lady bird beetle per plot was recorded in T_8 (1.83) comprising untreated control which was statistically different from all other treatments followed

by T_7 (1.59), T_3 (1.30) and T_2 (1.10). On the other hand, the lowest number of adult lady bird beetle through pitfall trap count was recorded in T_5 (0.13) which was statistically similar with T_6 (0.23) followed by T_1 (0.74) and T_4 (0.94). More or less similar trends of adult lady bird beetle insect population among different treatments were also observed in case of early and late fruiting stage.

Table 19. Number of adult lady bird beetle counted through pitfall trap in the brinjal field

Treatment	Incidence of adult lady bird beetle (No./pitfall trap)				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	0.74 e	0.45 ef	0.74 de	0.64 f	67.95
T_2	1.10 cd	0.84 cd	1.19 c	1.05 d	47.57
T_3	1.30 c	0.96 bc	1.57 b	1.28 c	36.05
T_4	0.94 de	0.67 de	0.92 cd	0.85 e	57.60
T_5	0.13 f	0.19 f	0.44 e	0.25 g	87.32
T_6	0.23 f	0.30 f	0.55 e	0.36 g	81.97
T_7	1.59 b	1.14 b	1.83 b	1.52 b	23.74
T_8	1.83 a	1.60 a	2.56 a	1.20 a	-
$LSD_{(0.01)}$	0.2174	0.2431	0.3074	0.1537	-
CV(%)	8.96	13.13	10.37	6.46	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the mean population of adult lady bird beetle counted by pitfall trap, the highest number of adult lady bird beetle per plot was also observed in T_7 (1.52) comprising hand picking which was statistically different from all other treatments followed by T_8 (1.20), T_3 (1.28) and T_2 (1.05). On the other hand, the lowest number

of adult lady bird beetle through pitfall trap count was observed in T_5 (0.25) which was statistically similar with T_6 (0.36) followed by T_1 (0.64). 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 T_5 (87.32%) followed by T_6 (81.97%) and T_1 (67.95%). On the other hand, the lowest reduction was observed in T_7 (23.74%) followed by T_3 (36.05%). As a result the trend of reduction of adult lady bird beetle population pitfall trap count among different management practices was $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

From the above findings it revealed that T_5 reduced the highest population comprising Ripcord 10 EC @ 1ml/L of water at 7 days interval showed the most adverse effect in reducing (87.32%) the adult lady bird beetle population during the management of brinjal shoot and fruit borer that closely flowed by T_6 (81.97%) comprising spraying of Suntap 50 SP @ 2g/L of water at 7 days interval. On the other hand, T_7 (23.74%) showed the least adverse effect in reducing (23.74%) the adult lady bird beetle population during the management of brinjal shoot and fruit borer flowed by T_3 (36.05%) comprising spraying of Neem Leaf extract @ 200g/L of water at 7 days interval and T_2 (47.57%) comprising spraying of Neem Seed Kernel extract @ 100g/L of water at 7 days interval.

In comparison with synthetic chemical and botanical based management practices, synthetic chemical insecticide Ripcord 10 EC and Suntap 50 SP (Cartap) reduced the highest number of adult lady bird beetle population than botanical based management practices such as Neem Leaf extract (36.05%), Neem Seed Kernel extract (72.57%) etc. More or less similar findings were also reported by several researchers. Tohnishi *et al.* (2005) stated that neem products were less toxic to lady bird beetle, spiders and other predators than chemical insecticides.

4.24. Effect on the incidence of larvae of lady bird beetle through pitfall trap count

Significant variations were observed among different management practices in terms of lady bird beetle larval population through pitfall trap count during the management of brinjal shoot and fruit borer in the field. In case of vegetative stage, the highest number of larvae of lady bird beetle per plot was recorded in T_8 (0.89) comprising untreated control which was statistically different from all other treatments followed

by T_7 (0.66), T_3 (0.40) and T_2 (0.27). On the other hand, the lowest number of adult lady bird beetle through pitfall trap count was recorded in T_5 (0.01) which was statistically similar with T_6 (0.03) followed by T_1 (0.17) and T_4 (0.15). More or less similar trends of larvae of lady bird beetle insect population among different treatments were also observed in case of early fruiting stage and late fruiting stage.

Table 20. Number of adult ladybird beetle larvae counted through pitfall trap in the brinjal field

Treatment	Incidence of lady bird beetle larvae (no./pitfall trap)				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	0.17 c	0.44 e	0.73 e	0.43 e	75.00
T_2	0.27 bc	0.717 cd	1.11 cd	0.70 cd	58.99
T_3	0.40 b	0.86 c	1.23 c	0.82 c	51.77
T_4	0.15 bc	0.60 de	0.87 de	0.54 de	68.37
T_5	0.017 c	0.11 f	0.23 f	0.12 f	93.16
T_6	0.03 c	0.20 f	0.37 f	0.20 f	88.09
T_7	0.66 a	1.50 b	1.72 b	1.30 b	24.02
T_8	0.89 a	1.71 a	2.51 a	1.71 a	-
$LSD_{(0.01)}$	0.2431	0.1883	0.3350	0.1883	-
CV(%)	31.09	10.00	12.68	10.22	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2g/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the mean population larvae of lady bird beetle counted by pitfall trap, the highest number of lady bird beetle larvae was also observed in T_8 (1.71) comprising untreated control which was statistically different from all other treatments followed by T_7 (1.30), T_3 (0.82) and T_2 (0.70). On the other hand, the lowest number of lady

bird beetle larvae through pitfall trap count was observed in T_5 (0.12) which was statistically similar with T_6 (0.20) followed by T_1 (0.43). In case of percent reduction of lady bird beetle larvae over control due to application of different management practices against brinjal shoot and fruit borer, the highest reduction was observed in T_5 (93.16%) followed by T_6 (88.09%) and T_1 (75.00%). On the other hand, the lowest reduction was observed in T_7 (24.02%) followed by T_3 (51.77%). As a result the trend of reduction of lady bird beetle larval population through pitfall trap count among different management practices was $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

From the above findings it revealed that T_5 reduced the highest population comprising Ripcord 10EC @ 1ml/L of water at 7 days interval showed the most adverse effect in reducing (93.16%) the larvae of lady bird beetle population during the management of brinjal shoot and fruit borer that closely flowed by T_6 (88.09%) comprising spraying of Suntap 50SP @ 2g/L of water at 7 days interval. On the other hand, T_7 (24.02%) showed the least adverse effect in reducing (24.02%) the larvae of lady bird beetle population during the management of brinjal shoot and fruit borer flowed by T_3 (51.77%) comprising Neem Leaf extract @ 200g/L of water at 7 days interval and T_2 (58.99%) comprising Neem Seed Kernel extract @ 100g/L of water at 7 days interval.

In comparison with synthetic chemical and botanical based management practices, synthetic chemical insecticide Ripcord 10EC and Suntap 50SPreduced the highest number of lady bird beetle larval population than botanical based management practices such as Neem Leaf extract (51.77%), Neem Seed Kernel extract (58.99%) etc.

4.25. Effect on the incidence of field spider & other arthropods through pitfall trap count

Significant variations were observed among different management practices in terms of field spider & other arthropods population through pitfall trap count during the management of brinjal shoot and fruit borer in the field. In case of vegetative stage, the highest number of spider & other arthropods per plot was recorded in T_8 (1.57) comprising untreated control which was statistically different from all other treatments followed by T_7 (1.12), T_3 (0.73) and T_2 (0.51). On the other hand, the lowest number of spider & other arthropods through pitfall trap count was recorded in T_5 (0.05) which was statistically similar with T_6 (0.12) followed by T_1 (0.18) and T_4

(0.23). More or less similar trends of spider & other arthropods population among different treatments were also observed in case of early fruiting stage and late fruiting stage.

Table 21. Number of field spider and other arthropods counted through pitfall trap in the brinjal field

Treatment	Incidence of field spider & other arthropods (no./pitfall trap)				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1	0.18 d	0.69 e	1.54 e	0.80 f	70.97
T_2	0.51 c	1.51 c	2.22 c	1.42 d	48.79
T_3	0.73 c	1.77 c	2.37 c	1.62 c	41.34
T_4	0.23 d	1.07 d	1.88 d	1.06 e	61.69
T_5	0.05 d	0.18 f	0.55 g	0.26 h	90.72
T_6	0.12 d	0.35 ef	1.08 f	0.51 g	81.45
T_7	1.12 b	2.51 b	2.88 b	2.17 b	21.68
T_8	1.57 a	3.51 a	3.22 a	2.77 a	-
$LSD_{(0.01)}$	0.2549	0.3437	0.3169	0.1719	-
CV(%)	18.38	9.80	6.61	5.12	-

In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications.

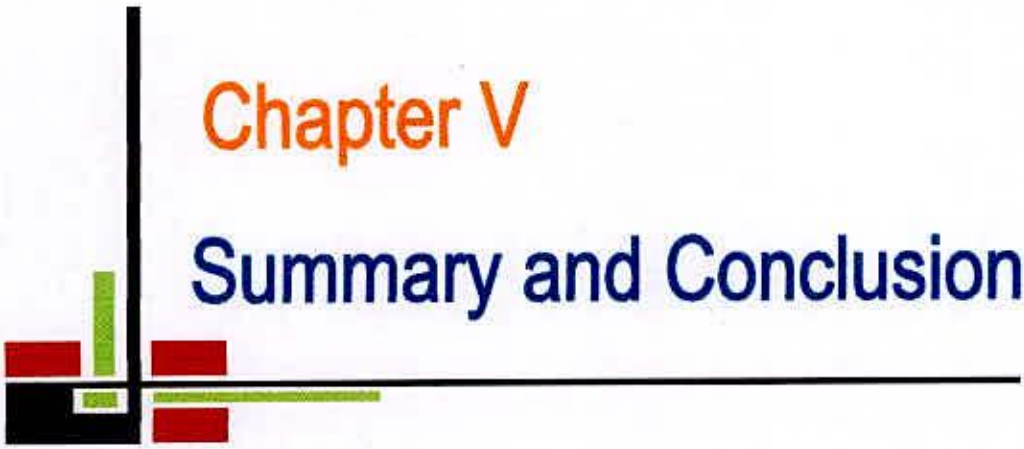
[T_1 = Spraying of Neem oil @ 3ml/Litre of water at 7 days interval; T_2 = Spraying of Neem Seed Kernel extract @ 100g/Litre of water at 7 days interval; T_3 = Spraying of Neem Leaf extract @ 200g/Litre of water at 7 days interval; T_4 = Spraying of Garlic extract @ 2g/Litre of water at 7 days interval; T_5 = Spraying of Ripcord 10 EC @ 1ml/Litre of water at 7 days interval; T_6 = Spraying of Suntap 50 SP @ 2ml/Litre of water at 7 days interval; T_7 = Hand picking and destruction of infested shoot & fruit at 7 days interval; T_8 = Untreated Control]

Considering the mean population the spider & other arthropods counted by pitfall trap, the highest number of spider & other arthropods per plot were also observed in T_8 (2.77) comprising untreated control which was statistically different from all other treatments followed by T_7 (2.17), T_3 (1.62) and T_2 (1.42). On the other hand, the lowest number of spider & other arthropods through pitfall trap count was observed in

T_5 (0.26) which was statistically similar with T_6 (0.51) followed by T_1 (0.80). In case of percent reduction of spider & other arthropods over control due to application of different management practices against brinjal shoot and fruit borer, the highest reduction was observed in T_5 (90.72%) followed by T_6 (81.45%) and T_1 (70.97%). On the other hand, the lowest reduction was observed in T_7 (21.68%) followed by T_3 (41.34%). As a result the trend of reduction of spider & other arthropods population through pitfall trap count among different management practices was $T_5>T_6>T_1>T_4>T_2>T_3>T_7>T_8$.

From the above findings it revealed that T_5 reduced the highest population comprising Ripcord 10EC @ 1ml/L of water at 7 days interval showed the most adverse effect in reducing (90.72%) spider & other arthropods population during the management of brinjal shoot and fruit borer that was close to T_6 (81.45%) comprising spraying of Suntap 50SP @ 2g/L of water at 7 days interval. On the other hand, T_7 (21.68%) showed the least adverse effect in reducing (21.68%) the spider & other arthropods population during the management of brinjal shoot and fruit borer flowed by T_3 (41.34%) comprising Neem Leaf extract @ 200g/L of water at 7 days interval and T_2 (48.79%) comprising Neem Seed Kernel extract @ 100g/L of water at 7 days interval.

In comparison with synthetic chemical and botanical based management practices, synthetic chemical insecticide Ripcord 10EC and Suntap 50SP (Cartap) reduced the highest number of spider & other arthropods population than botanical based management practices such as Neem Leaf extract (41.34%), Neem Seed Kernel extract (48.79%) etc. More or less similar findings were also reported by several researchers. Maleque *et al.* (1999) and Rahman (2006) reported that the lady bird beetles and spiders were seriously affected in the field where Cypermethrin was applied at weekly intervals.



Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2012 to May, 2013 to find out the effectiveness of botanical and chemical insecticides as ecofriendly management practices in reducing the infestation of Brinjal Shoot and Fruit Borer (BSFB) as well as the impact on the incidence of natural enemy in brinjal field. The treatments were comprised four botanical products viz. T_1 = Spraying of neem oil @ 3ml/L of water; T_2 = Spraying of neem seed kernel extract @ 100gm/L of water; T_3 = Spraying of neem leaf extract @ 200gm/L of water; T_4 = Spraying of garlic extract @ 2g /L of water; two synthetic chemical insecticides viz. T_5 = Spraying of Ripcord 10 EC @ 1ml/L of water; T_6 = Spraying of Suntap 50 SP @ 2 g/L of water; hand picking and destruction of infested shoots and fruits at seven days interval and untreated control.

In terms of percent shoot infestation during the management of brinjal shoot and fruit borer, spraying of Ripcord 10EC performed best result in reducing highest shoot infestation (72.96%) over control and the next treatments with spraying of Suntap 50SP showed the significantly higher reduction of infestation. Hand picking and destruction of infested shoot and fruit showed the least performance (28.02%) in reducing shoot infestation. As a result, the trend of different management practices in terms of percent shoot infestation reduction was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking.

In case of fruit infestation by number, T_5 performed best result in reducing highest fruit infestation by number (69.70%) over control followed by T_6 (64.53%) and T_1 (45.16%), whereas T_7 showed the least performance (24.92%) 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 Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking. Similarly, in terms of fruit infestation by weight, T_5 also performed best result in terms of percent fruit infestation by weight reduction (72.58%) over control followed by T_6 (66.80%) and T_1 (49.21%), whereas T_7 showed the least performance (29.64%). As a result, the

order of performance of different management practices in terms of percent fruit infestation reduction by weight was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking.

In terms of plant infestation by number, T_5 performed best result in terms of percent plant infestation by number reduction (55.93%) over control followed by T_6 (53.31%) and T_1 (25.58%), whereas T_7 (9.86%) showed the least performance. As a result, the trend of different management practices in terms of percent plant infestation reduction was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking. Considering the effect of management practices on the height of eggplants, T_5performed best result in increasing the maximum plant height (31.20%) over control followed by T_6 (28.48%) whereas T_7 showed the least performance (2.52%) over control. As a result, the trend of different management practices in terms of percent plant height increase was $T_5 > T_6 > T_1 > T_4 > T_2 > T_3 > T_7 > T_8$. Similarly, T_5 performed best result in increasing maximum number of branch per plant (50.63%) over control followed by T_6 (43.69%) whereas T_7 (2.36%) showed the least performance (2.36%) in increasing percent the number of branch per plant over control. As a result, the trend of different management practices was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking.

In case of fruit related yield attributes, the length of healthy fruit during the management of brinjal shoot and fruit borer, T_5 performed best result in terms of percent fruit length increase (56.34%) over control followed by T_6 (45.80%) whereas T_7 (5.00%) showed the least performance (2.52%) in increasing fruit length over control. As a result, order of the performance of different management practices in increasing fruit length was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking. Similarly, T5performed best result in increasing (61.54%) girth of healthy fruit over control followed by T_6 (47.86%) and T_1 (33.04%) whereas T7showed the least performance (3.13%) in increasing percent girth of healthy fruit due to brinjal shoot and fruit borer over control. As a result, order the trend of different management practices in terms of percent girth of healthy fruit increase was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking. Likewise of length and girth of fruits, T5also performed best result in increasing

(72.22%) number of fruit per plant over control followed by T_6 (46.94%) and T_1 (31.41%), whereas T_7 showed the least performance (18.67%) over control. As a result, order the trend of different management practices in terms of percent number of fruit per plant increase was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking. In terms of single fruit weight, T_5 performed best result in increasing maximum fruit weight (90.85%) over control followed by T_6 (69.82%) and T_1 (44.58%) whereas T_7 showed the least performance (16.36%) over control. As a result, order the trend of different management practices in terms of percent weight per healthy fruit increase was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking.

Considering the relationship of shoot and fruit infestation as compared with the plant and fruit related yield attributes, it was revealed that number of branch and fruit per plant; length, girth and single 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_5 reduced the highest percent of shoot and fruit infestation, conversely it increased the maximum number of branch and fruit per plant; length, girth and single fruit weight. These variations were found due to efficiency variations of different management practices applied against brinjal shoot and fruit borer.

In case of fruit yield, T_5 performed best result in increasing highest percent yield (147.85%) over control followed by T_6 (127.57%) and T_1 (65.06%), whereas T_7 (30.91%) showed the least performance (30.91%) over control. As a result, the order of the performance of different management practices in terms of percent yield of brinjal fruit increase was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking. From the correlation study it was revealed that there were highly significant ($p=0.01$) and strong ($r = 0.923$) correlations found between yield of brinjal and shoot infestation, where yield was negatively correlated with the shoot infestation, i.e., the yield of brinjal decreased with the increase of shoot infestation. Similarly, the highly significant ($p=0.01$), strong ($r=0.90$) and negative correlation was also observed between fruit infestation and yield of brinjal, i.e., the yield of brinjal decreased with the increase of fruit infestation.

Impact of management practices on predatory ladybird beetle and other arthropods

Considering the impact of the management practices on the population of ladybird beetle counted visually, T_5 comprising spraying of Ripcord 10EC @ 1ml/L of water at 7 days interval adversely affected and reduced the highest population (87.43%) of adult lady bird beetle over control followed by T_6 (77.72%) comprising spraying of Suntap 50SP @ 2g/L of water at 7 days interval, T_1 (60.58%), whereas T_7 (16.31%) comprising hand picking and destruction of infested shoot and fruit at 7 days interval showed the least level of adverse effect in reducing (16.31%) 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 Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking.

Similarly, T_5 also adversely affected the population of ladybird beetle larvae during the management of BSFB and reduced the highest population (87.71%) over control followed by T_6 (73.73%) and T_1 (65.93%), whereas T_7 (19.00%) showed the least level (19.00%) of adverse effect in reducing ladybird beetle larvae through visual count. As a result, order of the level of adverse impact among different management practices in reducing the population of ladybird beetle larvae was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking.

Likewise of ladybird beetle adults and larvae, T_5 also adversely affected population of predatory field spider in the brinjal field and reduced the highest population (88.12%) over control as compared with other management practices applied against brinjal shoot and fruit borer flowed by T_6 (75.68%), whereas T_7 (19.46%) showed the least adverse effect in reducing (19.46%) the field spider population.

When the population of ladybird beetle were counted through pitfall trap, it was revealed that the T_5 also adversely affected the population and reduced the highest population of ladybird beetle adult (87.32%) and larvae (93.16%) over control followed by T_6 (81.97% & 88.09%, respectively) and T_1 (67.95% & 75.00%,

respectively), whereas the reductions were lowest in T_7 (23.74% & 24.02%, respectively) over control during the management of brinjal shoot and fruit borer.

Likewise of ladybird beetle adults and larvae, when counted through pitfall trap, it was monitored that T_5 reduced the highest population (90.72%) of predatory field spider and other arthropods in the brinjal field over control followed by T_6 (81.45%) and T_1 (70.97%), whereas T_7 showed the least hazardous effect and reduced the lowest population (21.68%) over control during the management of brinjal shoot and fruit borer. As a result, order of the level of hazardous impact on the population of field spider and other arthropods was Ripcord 10EC > Suntap 50SP > Neem oil > Garlic extract > Neem seed kernel extract > Neem leaf extract > Hand picking.

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 were found in the treatments where the shoot and 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 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_5) reduced the maximum population of ladybird beetle adults and larvae as well as field spider by maintaining the shoot infestation at minimum level. Hence, it is revealed that the chemical treatments T_5 comprising Ripcord 10EC @ $1mlL^{-1}$ of water and T_6 comprising Suntap 50SP @ $2g\ L^{-1}$ of water both sprayed 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, neem leaf extract and garlic extract.

CONCLUSION

Based on the above findings of the study, the following conclusions have been drawn:

- Ripcord 10EC and Suntap 50 SP sprayed at seven days interval reduced maximum plant and shoot infestation as compared to botanical and hand picking and destruction of shoot and fruit over control.
- The chemical insecticides were more toxic to BSFB than plant products and exerted best effect on the decrease of insect damage. Such mechanical control as applied was assumed to perform results almost close to that of insecticides but could not do so.
- The significant reduction of BSFB infestation in the insecticides treated plots showed highly correlated with the increase of the yield.
- This management practice was more effective on the yield contributing characters of brinjal plants than other management practices used in this study.
- The study showed that the considerable number of ladybird beetle adult and larvae were adversely affected by Ripcord and Suntap application. These two insecticides were toxic to the natural enemy along with others. On the other hand, the botanicals and mechanical control did not show any adverse effect on the natural enemies of BSFB. These management practices encouraged the natural enemies but they could not control the BSFB infestation to the extent of spraying of insecticides.

Chapter VI
References

CHAPTER VI

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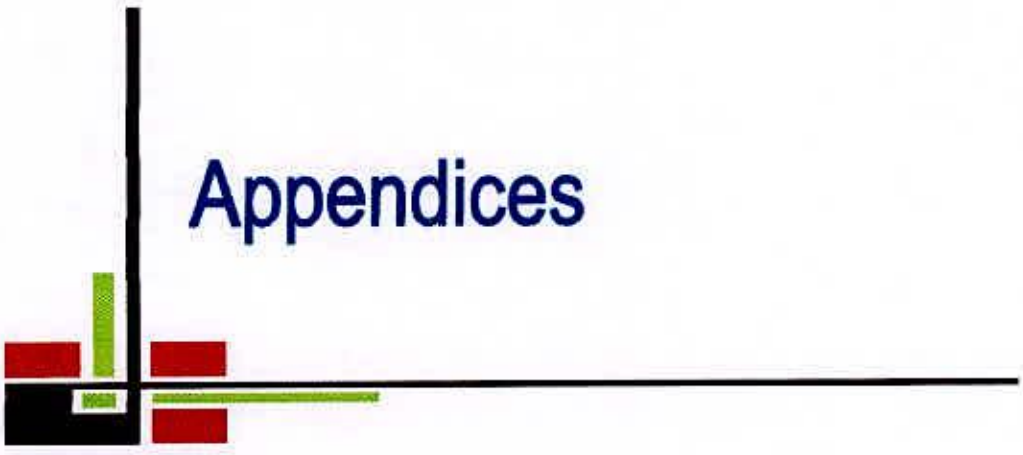

Appendices

APPENDICES

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

Soil Characteristics	Analytical results
Agrological 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 Research Development Institute (SRDI), Dhaka.

Appendix II:Monthly average air temperature, relative humidity, rainfall and sunshine hours during the experimental period (November, 2012 to May, 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			
Nov.	2012	25.23	18.20	21.80	74.90	4.0	195.00
Dec.	2012	31.35	19.40	25.33	68.78	3.0	225.50
Jan.	2013	33.20	22.00	27.60	64.13	Trace	220.30
Feb.	2013	35.00	23.81	29.41	61.4	185	232
Mar.	2013	35.00	24.95	29.98	64.27	180	240
Apr.	2013	32.50	23.00	27.75	66.00	181	238
May	2013	33.30	22.50	27.50	65.70	180	236

Source:Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka – 1207.