COMPARATIVE STUDY FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER AND EPILACHNA BEETLE WITH BOTANICALS AND SOME SELECTED CHEMICAL INSECTICIDES

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CERTIFICATE

This is to certify that thesis entitled "COMPARATIVE STUDY FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER AND EPILACHNA BEETLE WITH BOTANICALS AND SOME SELECTED CHEMICAL INSECTICIDES" 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 HAPPY MALLIK, Registration no. 12-05214 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, 2018
Place: Dhaka, Bangladesh

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DEDICATED
TO
MY BELOVED
PARENTS

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ABSTRACT

A field experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University to find out the effective as well as hazards free management practice(s) of brinjal, cultivated during Rabi season (November, 2017 to March, 2018). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental treatments were T_1 comprised of spraying of neem oil @ 3 ml neem oil and 10 ml trix mixed with 1 liter of water @ 7 days interval; T_2 comprised of spraying of neem seed kernel extract @ 5.0 ml/L of water at 7 days interval; T_3 comprised of spraying of bioneem plus @ 3.0 ml/L of water at 7 days interval; T_4 comprised of spraying of Marshal 25 EC@ 3.0 ml/L of water at 7 days interval; T_5 comprised of spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 comprised of spraying of Imitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 comprised of spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 comprised of untreated control. Treatment T_7 contributed to reduce the highest number of brinjal shoot and fruit borer (2.17 brinjal shoot and fruit borer/plant), number of bore (1.12 bores/five fruits), number of infested shoot (2.08 infested shoot/five plants), number of infested fruits caused by BSFB (1.39 fruit/plant), percent fruit infestation at early fruiting stage (4.93%), mid fruiting stage (10.00%) and late fruiting stage (13.84%) in number and early fruiting stage (19.52%), mid fruiting stage (16.11%) and late fruiting stage (15.31%) in weight, number of epilachna beetle (1.14 epilachna beetle/plant), percent leaf and plant infestation by epilachna beetle (9.20%) and (8.33%), percent of edible portion of infested fruit (90.49%), single fruit weight (39.00 gm) and yield (35.36 ton/ha). T_1 also contribute to reduce the incidence of infestation by considering the above mentioned parameters. The yield found in the T_1 treated plots was 28.58 ton/ha. Considering the environmental hazard and effect of incidence of beneficial arthropods T_1 was the best treatment against brinjal shoot and fruit borer and epilachna beetle of brinjal.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
BADC	Bangladesh Agricultural Development Corporation
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCPC	British Crop Production Council
BSFB	Brinjal Shoot and Fruit Borer
CV	Coefficient of variation
^{o}C	Degree Celsius
d.f.	Degrees of freedom
et al.	And others
EC	Emulsifiable Concentrate
FAO	Food and Agriculture Organization
G	Gram
Ha	Hectare
IPM	Integrated Pest Management
CRSP	Collaborative Research Support Project
J.	Journal
Kg	Kilogram
LSD	Least Significant Difference
Mg	Milligram
Ml	Milliliter
MP	Muriate of Potash
OSFB	Okra Shoot and Fruit Borer
%	Percent
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate
WP	Wettable Powder

CHAPTER I

INTRODUCTION

Brinjal or eggplant (*Solanum melongena* L.) is the most common, popular and principal vegetables in Bangladesh and other parts of the world (Nonnecke, 1989). It is a native of India and is extensively grown in all the Southeast Asian countries. Brinjal is one of the three most important vegetables in South Asia (India, Nepal and Srilanka). This region of South Asian accounts for almost 50% of the world area under brinjal cultivation (Alam *et al.,* 2003). This useful crop is grown year round in Bangladesh and covers 48679 ha with a production of 507000 tons (BBS, 2017) with about 25.4% of the total vegetable area of the country. Brinjal is grown in Bangladesh throughout the year including the summer season, when the supply of vegetables in the market is scarce. Thus, the farmers find it as a cash crop, which serves as a source of continuous flow of income (FAO, 2003). Sales of eggplant throughout the prolonged harvest season provide farmers with valuable cash income (Alam *et al.,* 2003). Brinjal is intensively grown in winter season in Jessore, Mymensingh, Narsingdi, Cumilla, Bogura, Jamalpur, Dinajpur, Rajshahi districts of Bangladesh. Brinjal is well known for its nutritive value as a source of carbohydrate, proteins, minerals and vitamin (FAO, 1995). It is also a good source of dietary fiber and folic acid, and is very low in saturated fat, cholesterol and sodium.

The crop is infested by various arthropods pest species in the field. El-Shafie (2001) recorded 28 species of insect pests under 7 different insect orders from the brinjal ecosystem in Sudan. Latif (2007) observed 20 species of pests under 6 different orders, jassid was the second most common in the field after brinjal shoot and fruit borer. Srinivasan (2009) reported that, eggplant production is severely constrained by several insect and mite pests. Some important insect pests are brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis*), epilachna beetle (*Epilachna* *vigintioctopunctata*), leafhopper (*Amrasca bigutulla bigutulla*), aphid (*Aphis gossypii*) and whitefly (*Bemisia tabaci*) (Latif *et al*., 2009). Among the various pests which hinder the realization of the yield potential, the most destructive and serious pest is brinjal shoot and fruit borer (BSFB), *L. orbonalis* Guenee (Lepidoptera: Crambidae) (Latif *et al*., 2010; Chakraborti and Sarkar, 2011). It is monophagous and remained a major pest of brinjal in all growing areas (Dutta *et al*., 2011). The pest is more prevalent in areas having hot and humid climate (Srinivasan, 2009). The yield losses may reach up to 85 to 90 per cent (Misra, 2008; Jagginavar *et al*., 2009).

The larva soon after emergence causes dead hearts by boring into the petiole and midrib of leaves, tender shoots (AVRDC, 1998; Alpureto, 1994; CABI, 2007). On appearance of the flowers and fruits in the later stages, the larvae cause severe loss to the economic parts. The larvae, after hatching, bore inside fruit and the minute entrance hole is closed by the excreta of feeding larvae (Alam *et al*., 2006). But once fruit setting is initiated, shoot infestations become negligible (Kumar and Dharmendra, 2013) or completely disappear (Naqvi *et al*., 2009). Larvae feed on the mesocarp of fruit and the feeding and excretion result in fruit rotting (Neupane, 2001), making it unfit for human consumption (Baral *et al*., 2006). On an average, a larva can infest 4-7 fruits during its life span (Jayaraj and Manisegaran, 2010). Adult and larva of epilachna beetle feed on leaves by scraping the surface cells between veins leaving marks, which are initially C-shaped that later on result in irregularly-shaped holes or strips. High level of infestation severely damages the leaves, giving them a skeletonized or lace-like coupled with slight yellowish to brownish appearance due to drying of affected tissues (Esguema and Gebriel, 1969).

Farmers spray synthetic insecticides four to six times for managing these pests, resulting in the reduction of natural enemies and beneficial organisms. Even though, neonicotinoids are widely used for managing these insect pest, very little work on their side effects on natural enemy has been carried out (Cloyd and Bethke, 2011).

The management of these pests through various non-chemical method namely, cultural, mechanical, biological and host plant resistant etc. was limited throughout the world. Management practices in Bangladesh and other countries are still limited to frequent spray of toxic chemical pesticides (Singh *et al*., l99I; Ali and Karim, l994; Yadgirwar *et al.*, 1994; Singh and Choudhary, 2001; Bhargava *et al*., 2001; Misra and senap ati, 2003; Alam, 2005; Anon., 2005). Farmers spray synthetic insecticides four to six times for managing these pests, resulting in the reduction of natural enemies and beneficial organisms. The insecticides used mostly belong to organophosphates, carbamates, and synthetic pyrithroides. But this kind of insect pest control strategy relying solely on chemical protection had got many limitations and undesirable side effects (Husain 1993, 1984) and this in the long run led to many insecticides related complications (Frisbie, 1984) such as direct toxicity to beneficial insect, fishes and other non-target organism (Munakata, 1997; Goodland *et al.*, 1985; Pimentel, 1981), human health hazards (Bhaduri *et al.*, 1989) resurgence of pests (Husain, 1993; Luckmann and Metcalt, 1975) out-break of secondary pest (Hagen and Franz, 1973) and environmental pollution (Fiswick, 1988; Kavadia *et al.*, 1984). To overcome the hazards of chemical pesticides, botanicals such as neem seed kernel extract, neem oil, soap water are now used in many developed and developing countries for combating this pest infestation with the aim of increasing crop yield (Hossain *et al.*, 2003; Mote and Bhavikatti, 2003; Singh and Kumar, 2003; Rao and Rajendran, 2002; Gahukar, 2000; Lawrence *et al*., 1996). But in Bangladesh, information on the efficacy of neem and other botanicals, soap water are scanty. Nowadays, there are many plant extracts and plant products that are eco-friendly and control pests as effectively as chemical insecticides. Shreth *et al.* (2009) suggested use of neem products and lantana products to protect plants against aphids. Neam extract, neam oil, neam seed carnel etc. are also effective to control brinjal shoot and fruit borer and epilachna beetle in brinjal field. To use these botanicals human health hazard become low and incidence of beneficiary insects remain hazard free, so that, they can control the insect pest of brinjal keeping the environment sound.

Keeping this perspective in view of the experiment was undertaken against sucking and foliage insects like leafhopper, aphid, epilachna beetle, leaf roller etc. to fulfill the following objectives:

I. To assess the level of infestation caused by brinjal shoot and fruit borer and epilachna beetle of brinjal in filed condition

II. To estimate the reduction of infestation of brinjal shoot and fruit borer and epilachna beetle of brinjal using botanicals and other insecticides in field condition and

III. To evaluate the effectiveness of selected botanicals and chemical insecticides against brinjal shoot and fruit borer and epilachna beetle

CHAPTER II

REVIEW OF LITERATURE

2.1. Brinjal shoot and fruit borer

2.1.1. Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Crambidae

Genus: *Leucinodes*

Specis: *L. orbonalis*

2.1.2. Origin and distribution

In India this pest enjoy a country wide distribution. Besides, India it is also found in Sri Lanka, Mayanmar, Malaysia, Congo and South Africa.

2.1.3. Host range

L. orbonalis Guenee is practically monophagous, feeding principally on eggplant; however, other plants belonging to family Solanaceae are reported to be hosts of this pest. In the area of global eggplant cultivation, *L. orbonalis* also occurs on different host plants. Major recorded are: *Solanum melongena* Linnaeus (eggplant), *Solanum tuberosum* Linnaeus (potato) but there are several minor host, like *Ipomoea batatas* Linnaeus (sweet potato), *Lycopersicon esculentum* Mill (tomato), *Pisum sativum var. arvense* Linnaeus (Austrian winter pea) *Solanum indicum* Linnaeus, *Solanum myriacanthum* Dunal, *Solanum torvum* Swartz (turkey berry) and wild host *Solanum gilo* Raddi (gilo), *Solanum nigrum* Linnaeus (black nightshade) (CABI, 2007). In addition, *Solanum* *anomalum* Thonn (Singh and Kalda, 1997) and *Solanum macrocarpon* Linnaeus (Kumar and Sadashiva, 1996) are wild hosts of *L. orbonalis*.

2.1.4. Natural abundance

The pest is reported from regions of eggplant cultivation in Africa, South of the Sahara and South-East Asia, including China and the Philippines (CABI, 2007). In Asia, it is the most important and the first ranked pest of India, Pakistan, Srilanka, Nepal, Bangladesh, Thailand, Philippines, Cambodia, Laos and Vietnam (AVRDC, 1994). Its distribut ion is mostly higher in those areas having hot and humid climate (Srinivasan, 2009).

2.1.5. Life cycle

The egg takes incubation period of 3-5 days in summer and 7-8 days in winter and hatch into dark white larvae (Rahman, 2006). The present findings are also in accordance with Jat *et al*. (2003), Pal *et al*. (2003), Wankhede *et al*. (2009), Kumar *et al*. (2011) and Bindu *et al*. (2013) have reported the egg period varies from 3 to 6 days at different laboratory conditions.

Newly hatched larva was glabrous, dirty white in colour, the body colour of the larva changed from whitish to dark pinkish. The larva passed through five instars to become full grown larva. In this study it was found that the larval period ranged from 9 to 12 days du ring three generations and average larval period recorded was 11.29 days. These findings are in accordance with Alam *et al*. (1982), Sandanayake and Edirisinghe (1992), Yin (1993), Pal *et al*. (2003) and Maravi *et al*. (2013) have found that larval period ranges from 9 to 18 days at different laboratory conditions.

The pupation took place on the glass jar, soil, muslin cloth, sometimes inside the fruits and on the leaves of the plants. The pupal colour was pinkish which later turned dark brown. The pupa was obtect type with blunt anterior end and conical in shape posteriorly, having distinct body divisions and a pair of spiracles on each abdom in al segment. In this study it was observed that the pupal period ranged from 7 to 8 days during three generations, with an average of 7.35 days. The pupal period lasts 6 to 17 days depending upon temperature (Alam *et al*., 2003). The present findings were also found similar with Alam *et al*. (1982), Baang and Corey (1991), Yin (1993), Suresh *et al*. (1996), Singh and Singh (2001a), Jat *et al*. (2003), Pal *et al*. (2003), Wankhede *et al*. (2009), Radhakrishore *et al.* (2010), Maravi *et al*. (2013) and Onekutu *et al.* (2013) reported that pupal period lasted for 7 to 12 days at different laboratory conditions.

The adult moths were small in size with whitish wings, blackish brown head and thorax. The whitish wings had brown and black markings which were bigger on the forewings. Hind wings were dirty white with black dots and angled margin. The abdomen of female was swollen and seemed to be ovate in structure whereas, in the males, it was thinner and cylindrical. The abdominal tip of females was tapering and pointed towards the end whereas, in males it was blunt with some white hairy structures. In this study it was recorded that adult longivity varies from 3.5 to 4.5 days during three generations, with and average of 4.03 days. Various scientists have reported fluctuating results on biology of shoot and fruit borer viz. Alam *et al*. (1982), Mehto *et al*. (1983), Baang and Corey (1991), Singh and Singh (2001a), Jat *et al*. (2003), Harit *et al*. (2005), Wankhede *et al*. (2009), Kumar *et al*. (2011), Pramanik *et al*. (2012), Maravi *et al*. (2013) and Onekutu *et al*. (2013) who found that adult longevity lasted from 2 to 7 days at different laboratory conditions. In this study during the total life cycle of shoot and fruit borer, *Leucinodes orbonalis* varied from 23.17 to 28 days during three generations, with an average of 26.40 days. These studies are in confirmity with the study of Alam *et al*. (1982), Suresh *et al*. (1996), Jat *et al*. (2003), Pal *et al*. (2003), Ghosh *et al*. (2005), Patial *et al*. (2007), Wankhede *et al*. (2009), Pramanik *et al*. (2012), Maravi *et al*. (2013) and Onekutu *et al*. (2013) reported that total life cycle period varies from 19 to 44 days at different laboratory conditions.

The moths emerged out from pupae of *L. orbonalis* were collected, reared and distinguished based on sexual diamorphism characters. Present study indiacting slight dominance of female populat ion. In this study it was recorded that male and female ratio varied from 1:1.6 to 1:2.25 during three generations, with an average ratio of 1:1.95. These studies are in confirmity with the study of Pal *et al*. (2003) Maravi *et al*. (2013) and Onekutu *et al*. (2013) who have reported that male female ratio varies from 1:1.07 to 1:2 at different laboratory conditions.

2.1.6. Nature of damage

Shoot and fruit borer in brinjal is the major pest causing severe losses to marketable yield throughout the country. A moderate range of temperature coupled with high humidity was found to be favourable for the borer. Brinjal crop planted during March to September recorded a higher level of shoot (3.4 - 10.62%) and fruit damage (53.39 - 61.23%) than the crops planted during remaining months (Tripathi and Senapathi 1998). Singh *et al.* (2000) revealed that *L. orbonalis* infested the crop shoots during the end of August (73.33%), which peaked (86.66%) in the third week of September with an intensity of 2.09 per plant. The shoot damage ranged between 30.23 and 36.23%, while fruit damage ranged 37.51 to 42.23 % from May to July. Maximum and minimum temperature, evaporation and sun shine hours had positive association with shoot damage, while relative humidity had negative influence. Murthy (2001) found that the pest was relatively more during September month on potato shoot under protected condition. Infestation of *L. orbonalis* in brinjal shoots started in the first week of August and remained up to second week of October, with peak in second week of September in both the years. Infestation in shoots decreased after fruit setting and completely disappeared thereafter. The infestation in fruits was recorded in the second week of September and remained up to third week of October. The infestation increased gradually and reached maximum in the first week of October (63.09% on number basis and 51.45% on weight basis). The infestation of fruit borer started declining and persisted only up to third week of October. The effect of abiotic factors on *L. orbonalis* revealed that maximum temperature had positive significant effect on fruit infestation; whereas, negative significant correlation was computed between borer infestation and minimum temperature. Relative humidity had positive significant effect on shoot and fruit borer. Rainfall had no effect on shoot and fruit borer infestation (Naqvi *et al*., 2009). Bharadiya and Patel (2005) reported that the activity of shoot and fruit borer, *L. orbonalis*, on shoots started in the first week of September (4.9% incidence) and reached the peak level (17.1%) before migrating to fruits by fourth week of October. Dhamdhere *et al*. (1995) found that pest commenced from 45 and 55 days after transplanting of brinjal seedlings in summer and kharif season, respectively and continued up to harvest. The infestation in summer and kharif season ranged from 7.56 to 23.55 and 17.24 to 30.87 on shoots and 10.06 to 25.27 and 23.34 to 47.75 per cent fruits number and weight basis, respectively. Tripathi *et al*. (1996) revealed that highest incidence of the pest on shoots was noticed in 46th standard week (8.05 %) and lowest in 31st standard week (0.98 %). The highest fruit damage occurred at low mean temperature of 19.4 °C and 61 per cent relative humidity. The extent of damage on weight basis ranged between 4.03 and 57.01 per cent and followed a similar trend as on number basis. Anil Kumar *et al*. (1997) observed that infestation by the pest was significantly affected by temperature than other environmental factors. The peak shoot (15.71%) and fruit infestation (71.09% by weight) were recorded during the last week of June and first week of July, respectively. Singh *et al*. (2009) observed that shoot infestation during 4th week of August, 2008 and the incidence had non-significant relationship with temperature, relative humidity and rainfall but significant relationship with coccinellids and spiders. In another study Singh *et al.* (2011) observed that incidence of shoot and fruit borer was started in the month of April and continued till the end of the June. The peak period of the pest on shoot was recorded in the first week of June (29.45%) and fourth week of May (25.24%) during the first and second cropping seasons respectively. However, the incidence of the pest on fruit was highest during the second week of June, 2003 (67.16%) and third week of June, 2004 (72.25%). The correlation study revealed that average temperature and relative humidity showed significant positive association while average sunshine observed significant negative association with the infestation of the pest on brinjal. Brinjal shoot and fruit borer (*Leucinodes orbonalis* (Guenee)) is considered to be the most destructive pest of brinjal in all part of India (Mote, 1976), (Wargantiwar *et al*., 2010).

2.2. Epilachna beetle

2.2.1. Scientific classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Coccinellidae

Genus: *Epilachna*

Specis: *E. vigintioctopunctata*

2.2.2. Origin and distribution

South Canada, USA, Mexico, Guatemala, Africa and South East Asia. It occurs in Russia, China, Japan, and Korea. This species is native to southeastern Asia, primarily India, but has been accidentally introduced to other parts of the world, including Australia and New Zealand. It has also been recorded from Brazil and Argentina, beginning in 1996 (CSIRO, 2005).

2.2.3. Host range

Brinjal, potato, tomato, cucurbitaceous plants, wild solanaceous plants.

2.2.4. Natural abundance

Abiotic factors influence on the incidence of spotted leaf beetle *Henosepilachna vigintioctopunctata* in brinjal revealed that the pest population was more in the month of February (24.2) and March (27.4) in the southern part of the country. A significant positive correlation with relative humidity, maximum temperature and wind velocity and negative correlation with rainfall was observed in relation to insect population (Raghuraman and Veeravel, 1999). However, in North Indian conditions Ghosh and Senapathi (2002) reported that epilachna beetle in terai region was found active from April to middle of October on brinjal and the highest population was recorded (8.14 beetles per plant) during middle of September. Bharadiya and Patel (2005) also reported that the incidence of leaf eating beetle, *H. vigintioctopunctata* on brinjal was recorded from the fourth week of August onwards and reached the peak average count of 1.3 per plant in the 3rd week of September. Population of epilachna beetle showed significant positive correlation with average temperature, relative humidity and weekly rainfall, *H. vigintioctopunctata* damaged brinjal from first week after transplantation. Its incidence peaked from 7 to 9 weeks after transplantation, with 23.70 - 27.60 adults per three leaves. It was higher (21.80 - 27.60 beetles per three leaves) during March - April but declined thereafter. It was positively associated with maximum temperature (Muthukumar and Kalyana Sundaram, 2003b). Anandhi *et al*. (2008) revealed that incidence first noticed from the 20th week after transplanting (third week of January) with an average population of 0.27 brinjal hadda beetle per plant in 2004-05. In 2005-06, the incidence started earlier, i.e., first week of November, with an average population level of 2.85 brinjal haddabeetle per plant. The haddabeetle population reached the peaks in the third week of

February in 2004-05. It attained its peaks in the third week of November during 2005-06. The beetle incidence showed negative correlation with the maximum and minimum temperatures and positively correlated to all other abiotic factors. In the subsequent years, the pest population was positively correlated to the maximum relative humidity and wind velocity while negatively correlated to all other abiotic factors. Under severe cold conditions like in Japan the over wintered adults of *H. vigintioctopunctata* appeared in early May, adults of the first generation in late June and early July and of the second generation in August (Takeda *et al.*, 1980). Further, Hirano *et al*. (1985) reported that in Japan the over wintered adults of *H. igintioctopunctata* appeared in potato fields, and began to oviposit in May.

The first generation adults emerged late in June or early in July. The adults then moved to the fields of brinjal, tomato and other crops and oviposit mainly on brinjal. The seco nd generation adults emerged in late July or in early August. Raj and Lakshmann (1980) reported that the damage caused by this beetle to eggplant in Madurai region was greater on the crop planted in January than that planted in December. The attack by the pest could be minimized by advancing the planting date to late November or early December.

2.2.5. Life cycle

According to Butani and Jotwani (1984) the eggs are spherical in shape about half mm in diameter, light bluish green in colour and beautiful sculptured having 26 to 32 longitudinal ridges. The alternate ridges project upwards to form a crown thus the eggs look like tiny or miniature poppy fruit; full grown caterpillars are 18 to 24 mm long, stout, spindle shaped having long stiff setae. Pupae are 13 to 16 mm long and chocolate-brown in colour bluntly rounded and enclosed in inverted boat shaped cocoons. Adults are medium sized moths, 13 to 15 mm long, head and thorax ochreous white; for wings pale white with a broad wedge shaped horizontal green patch in the, middle and hind wings silvery creamy white in colour. Wing expanse is 30 to 34 mm.

Report of Butani and Jotwani (1984) also indicated that the moth emerge at dusk; mating takes place 2 to 3 days after emergence and oviposition commences after 1 to 5 days of mating. A female lays on an average 400 egg (65 to 695). They also reported that incubation, larval and papal periods were 3 to 9, 9 to 20 (50 to 60 days during winter) and 8 to 12 days respectively. A single life cycle takes 22 to 25 days extending up to 74 day during winter and there may be 8 to 12 generations in a year. There is no true hibernation but development and activity is considerably slowed down during winter.

Rehman and Ali (1983) reported that females of *E. vittella* mated for 34 to109 min for successful insemination and laid 82-378 eggs each in 4-7 days. The egg stage lasted 3-4 days, the larval stage 5-16 days, the pre-pupal stage 1 day and the papal stage 6-13 days and the adult life span 8-18 days.

The biology of OSFB was studied on okra in laboratory and field (Singl and Bichoo, 1989). They stated that the egg, larval and pupal stages lasted- 3-4. 9-17 and 6-14 days, respectively in September - October. Sardana *et al*. (1990) observed the distribution of eggs of *E. vittella* in okra field in Karnataka, India. Result indicates that this border rows tended to receive more eggs than the central rows. Ovipositing females laid most of the eggs on the top of the plants. Krishna (1987) observed higher overall mean fecundity of female OSFB when larvae reared on okra seeds compared to those reared on whole fruit.

Tripathi and Singh (1990) reported that survival of larvae was negatively correlated with larval density. The crowding also resulted in poor development and reduced weight of larvae and pupae.

Hiremath (1987) found the larval period of *E. vittella* to be 13.7 days and females laid an average of 303.2 eggs in July-August.

The biology of *E. vittella* on okra was also studied by Sharma *et al*. (1985) in the laboratory using individuals collected from the field of Bihar, India. The borer had 11 generation a year. The longest life cycle (49 days) was observed during January. While the shortest life cycle of 29 days was found during July.

2.2.6. Nature of damage

Both adult and grubs scrap the lower epidermis of leaves in characteristic manner leaving behind stripes of uneaten areas. The leaves give a stifled appearance. In severe infestation all leaves may be eaten off leaving only the veins intact (Skeletonization) and plants may wither.

2.3. Management

Seventy two genotypes of okra were screened by Kashyap and Verma (1983) in Hariana, India against *Earias* spp. under field condition. Pest infestation and fruit yield were recorded on the basis both of numbers and weights. Less than 10% (on a weight basis) infestation was obtained in Parkins long green, *Clemson spineless*, White snow and Sel round cultivars compared to more than 50% in IC 12933, wild Bhindi and RI. The rest of the genotypes were intermediate.

Madav and Dumbre (1985) studied the reaction of 14 okra varieties against OSFB grown in the hot weather season of 1981 in Maharashtra. Varieties AE 75, Pusa sawani, Long green, Indo American hybrid and White valvet showed tolerance to shoot infestation by *E. vittella*. Indo American hybrid and Koparwadi local were found resistant to fruit infestation out of 25 varieties tasted in Rabi season of 1981-82. Bhalla *et al*. (1989) screened some okra germplasm to find out the field resistant against this borer during the Karif seasons of 1986 and 1987. Some 1000 okra germplasm were evaluated for this purpose, of which only 50 were moderately resistant and none was completely resistant.

Atwal (1976) reported that OSFB can be suppressed by clean cultivation and destruction of alternate host plants. Kashyap and Verma (1987) suggested that control of OSFB may be achieved through field sanitation, early sowing and resistant varieties when cotton is not growing in a locality.

The effect of nitrogen, phosphorus and potassium fertilizers on the incidence of noct uid *E. vittella* on okra was studied by Kumar and Urs (1988) in the field in Karnataka, India. The highest infestations were recorded in the plots treated with 250 and 30 kg of nitrogen and potassium per hectare, respectively. There were positive correlatio ns between nitrogen uptake by the plant and *E. vittella* infestation. But there was negative correlation between potassium uptake by the plants and its infestation.

Mallik and Lal (1989) reported that application of neem oil cake and fertilizer (2.5 kg of each on 200 square meter plot) or of neem oil cake alone (5 kg/plot) reduced *Earias spp*. of okra infestation and increased yield.

Weekly application of neem (*Azadirachta indica*) oil at 2% was effective for controlling *E. vittella* on okra (Sardana and Kumar, 1989). They observed that the plots having lower fruit damage and increased yields in treated plots as compared those of untreated ones. Neem oil was found as effective as monocrotophos at 0.05%, and can therefore, be recommended for the use in an integrated control scheme for the pest.

Samuthiraveiu and David, (1991) reported that application of neem oil (at 0.1, 0.3 and 0.5%) and endosulfan at (0.035 and 0.07%), alone and together against the OSFB reduced damage and maximum yield was obtained with 0.07%.

Owusu *et al.* (2001) evaluated the performance of Aqueous Neem Seed Extract (ANSE) at 75 g/L of water (22.5 kg/ha) on Legon I variety of local garden egg in the field. The effect of ANSE was compared with a registered *Bacillus thuringiensis* Berl. (Biobit), a synthetic insecticide (Karate 2.5 EC) and an untreated control (water only). Karate and Biobit were applied at rate of 2.5 ml/L (800 ml/ha) and 0.8 g/L (0.24 kg/ha), respectively. The effect of each treatment on insect abundance, defoliators, shoot, bud and fruit borers were determined. Water traps were used to monitor the effect of the three products on the abundance of insect fauna associated with crop. Insects from seven major orders (Coleoptera, Lepidoptera, Odonata, Orthoptera, Diptera, Hemiptera and Hymenoptera) were found associated with the local garden egg. The major insect pests of the crop included the shoot and fruit borer, *Earias vittella*, which attacked the shoots and fruits, thebud borer (budworm) *Scrobipalpa blapsigona* (Meyrick), which oviposited into the buds and the feeding activities of the larvae, led to the abortion of buds, *Pachnoda cordata* (Drury) which scraped and chewed stem and shoot and defoliators comprising *Acraea peneleos peneleos* (Ward.), *Acraea pharsalus pharsalus* (Ward.), *Zonocerus variegatus* L., *Eulioptera* sp., *Urentius hystericellus* (Richter) and *Phaneroptera nana* (Stal.). Karate and ANSE significantly ($p<0.05$) reduced population levels of some major pests such as *P. cordata* and *Z. variegatus* than Biobit. The mean number of *E. vitella* in the shoots and buds, respectively were significantly higher ($p>0.05$) on plots treated with ANSE and Biobit than Karate. This suggests that neem seed extract and Biobit had little or no systemic action against shoot and bud borers of the crop in the field. Significantly fewer ($p<0.05$) numbers of predators mainly ants and ladybird beetles were collected from plants treated with Karate compared to either ANSE- or Biobit- treated plots. This indicates that Karate had adverse effects on beneficial insects in the garden egg ecosystem. Karate and ANSE also significantly ($p<0.05$) reduced percentage fruit damage, number of borers per fruit and the activities of leaf feeders. Although ANSE could not effectively control the shoot and bud borers as Karate, it performed better in reducing borer damage than either Biobit or control. With proper timing and innovative methods of application, aqueous neem seed extract can be used as alternative or supplement to synthetic insecticide for the management of vegetable pests of local garden eggs by resource poor farmers.

Mishra and Mishra (2002) conducted a field experiment during the wet season of 1995 and 1996 in Udayagiri, Orissa, India, to evaluate the efficacy of some biopesticides against the insect pests (*Amrasca biguttula biguttula* and *Aphis gossypii*) and defenders of okra. The botanical insecticides Neemax (neem seed kernel extract) at 1.0 kg/ha and Multineem (neem oil) at 2.5 litres/ha; and bioinsecticides Biotox (*Bacillus thuringiensis* subsp. *thuringiensis* serotype) at 1.0 kg/ha alternated with Malathion at 0.5 kg a.i./ha in different combinations were sprayed thrice over the crop at 20 days interval, starting from 20 days after germination. The results revealed lowest fruit borer incidence (8.6% fruit bored on weight basis) when Biotox was applied to the crop 2 times alternated with one Malathion application, followed by the treatment where Malathion was applied twice alternated with one Biotox application (10.6%). Multineem and Neemax combined with Malathion or sole Malathion application also lowered the fruit borer incidence (11.7-13.3%) compared to the untreated control, which had the highest incidence of 16.9%. The aphid population remained very low (50.7/top 3 leaves) in treatment where Biotox, Neemax and Multineem.

Chatterjee *et al*. (2009) revealed that the lowest mean shoot as well as fruit infestation (7.47 and 9.88%) was recorded in the plots treated with spinosad 2.5 SC (50 g a.i. ha-1). Singh *et al*. (2009) was observed that Profenofos @ 0.1% and Spinosad @0.01% were most effective in reduction of shoot infestation of *L. orbonalis* besides recording higher brinjal fruit yield. Among the nine treatments tested, Profenofos was the most effective followed by Spinosad individually and their combinations in reducing the population as well as in giving higher yield. Profenofos 50 EC @ 1000, 1500, 2000, 4000 ml per ha, Endosulfan 35 EC @ 1200 ml per ha, Chlorpyriphos 20 EC @ 1250 ml per ha and carbaryl 50 WP (4 g per litre) gave significant reduction of brinjal shoot and fruit borer as compared to control. Profenofos @ 1000 ml per ha proved effective in reducing incidence of the pest and it was almost on par with other higher dosages. The yield data also showed that profenofos recorded higher yield compared to other insecticides (Prasad kumar *et al*., 2006). Mishra *et al*. (2007), granular application of carbofuran @ 1.5 kg a.i. per ha at 10 days of planting followed by spray of triazophos @ 0.5 kg a.i. per ha, cypermethrin @ 0.150 kg a.i. per ha, azadirachtin @1500 ppm per ha and imidacloprid @ 0.025 kg a.i. per ha in sequence at 10- 15 days interval after 40 days of planting was the most effective schedule in managing brinjal shoot and fruit borer. Mandal *et al*. (2008) found that the treatment pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was best for the management of this borer. Anjali (2006) revealed that cypermethrin (0.007%) and carbaryl (0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on number and weight basis and on yield basis.

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

(2007) revealed that Proclaim 5 SG (Emamectin benzoate) showed moderate level of efficacy providing 62.8% reduction of BSFB population over control it is concluded that this pest might have developed resistance against the tested insecticides. Islam *et al*. (2004) found that Fenvalerate (0.02%) was the best treatment followed by carbofuran 3 G at 0.5 kg a.i per ha, removal and destruction of infested plant parts, neem oil at 0.2% concentration, neem leaf extract at 1:1 ratio and dipel at 0.15 per cent concentration. Radhika *et al*. (1997) found that application of 0.1% triazophos on need basis (when > 20% of the fruits was infested by the pest) produced the highest fruit yield and the highest return. Jena *et al*. (2006) revealed that application of carbaryl, cartap hydrochloride [cartap], endosulfan, diflubenzuron, azadirachtin and chlorpyrifos at 1.0, 0.5, 0.7, 0.07, 0.075 and 0.4 kg a.i. per ha at 30, 45, 60, 75 and 90 days after transplanting (DAT), respectively, reduced shoot and fruit infestation, and gave the highest fruit yield (196.61 quintal per ha) and benefit cost ratio (3.76:1). However Mishra *et al*. (2004) found that triazophos gave the lowest average fruit borer incidence (14.36%) and the highest average fruit yield (20.75 q per ha).

Studied bioefficacy of some botanical and their combination with chemicals and (Yogi and Kumar 2010) evaluated some chemical insecticides against (*Leucinodes orbonalis*) from Allahabad.

The integrated pest management (IPM) strategy for the control of *L. orbonalis* consists of resistant cultivars, sex pheromone, cultural, mechanical and biological control methods (Srinivasan, 2008). Successful adoption of IPM in eggplant cultivation increase profits, protect the environment and improve public health (Alam *et al*., 2003).The profit margins and production area significantly increased, whereas pesticide use and labor requirement decreased for those farmers who adopted the IPM technology. But, the efforts to expand the *L. orbonalis.*

IPM technology to other regions of South and Southeast Asia are underway (Srinivasan, 2008). Use of crop management practice in IPM model is easy method of pest management. The interaction of intercrop and antifeedant showed that coriander-intercropped eggplant along with foliar spray of Neemarin significantly reduced fruit damage (Satpathy and Mishra, 2011). Different researcher developed the different module of pest *L. orbonalis* management. Chakraborty and Sarkar (2011) found that integration of phytosanitation, mechanical control and prophylactic application of Neem Seed Kernel Extract (NSKE) exerted a satisfactory impact on the incidence and damage of *L. orbonalis*. Sanitation and destruction of alternate host reduces the pest damage to fruit if such practice is coupled with other community wide means to reduce immigration of pest adults into the area (Alam *et al*., 2003). Use of pheromone and microbial is compatible strategy in pest management. Krishnamoorthy (2012) indicated that integration of egg parasitoid release with NPV, Neem and pheromone trap has been proved as possible in IPM modules. Out of different module tested by Dutta *et al*. (2011), the module with three different component, viz. pheromone trap, mechanical control and application of Peak Neem (neem based insecticide) was found best in reduction of shoot damage, fruit damage and yield increment followed by pheromone trap + Peak Neem in terms of shoot damage, farmers practices in terms fruit damage and pheromone trap + Peak Neem in terms of yield increment. The integration of *T. chilonis* and sanitation reduced infestation of *L. orbonalis* by 15 to 35 percent in the field and increased yields by 35-100 percent (Gonzales, 1999). Again, the use of insecticides based on different chemistry and with varying modes of action is an important component of an IPM strategy. Hence, insecticides continue to be an integral component of pest management programs due mainly to their effectiveness and simple use (Braham and Haji, 2009). Use of pesticide was not suggested at first hand but judicious use as last option of pest management was suggested globally. Chakraborty

(2012) demonstrated the efficient model of IPM based on yield. They are i) need-based application Flubendiamide together with NSKE, NLE, Deltamethrin + Trizophos; ii) application of new molecule of Rynaxypyr, NLE, NSKE, Clorpyriphos; iii) NSKE, Emamectin Benzoate, NLE , Clorpyriphos, Neem and Oil. The efficacy of first one is the highest and lowering on later. The use practice of pesticides of different group was proved efficient by Abrol and Singh (2003) that Endosulfan + Deltamethrin (0.07%, 0.0025%) and Endosulfan + Fenvalerate (0.07% + 0.005%) were highly effective against *L. orbonalis* that recorded only 13.3 percent damage as compared to 69.8 percent in control. The combination of compatible tactics was always superior. Any single option, such as sole mechanical control, schedule spray of Carbosulfan at 7 days interval or sole sex pheromone trap was inferior to any of other combined options and the combinations of options resulted lowest damage shoot/fruit compare to control. Thus, combination of three options produced with the highest yield of healthy fruits as well as maximum BCR (Rahman *et al*., 2009). The model of IPM having shoot clipping with alternate spraying of Multineem and Trizophos plus Deltamethrin was given by Bhushan *et al*. (2011) with minimum shoot and fruit damage and maximum yield. Sharma *et al*. (2012) reported that the treatment including pesticides and botanicals combined with cultural method lowered shoot/fruit damage and increased fruit yield. In addition, Latif *et al*. (2009) used the potash in IPM module suggesting that the application of flubendiamide at 5 percent level of fruit infestation in combination with mechanical control + potash @ 100 kg/ha + field sanitation for the management of *L. orbonalis*. Although various IPM strategies have been developed and promoted for vegetables, adoption remains low due to IPM's limited effectiveness in managing insect pests compared with chemical pesticides. Moreover, IPM has been promoted as a combination of techniques without giving due consideration to the compatibility of each component (Srinivasan, 2012).

CHAPTER III

MATERIALS AND METHODS

The present study was conducted for the management of brinjal shoot and fruit borer and epilachna beetle with botanicals and some selected chemical pesticides using a variety of BARI Brinjal-11 during Nov, 2017 to Mar, 2018. The materials and methods adopted in the study are discussed under the following sub-headings:

3.1 Description of the field experimental site

3.1.1 Experimental site

The research work was carried out at the experimental field of Entomology Department of SAU, Dhaka during the period from Nov, 2017 to Mar, 2018 for the eco-friendly management of brinjal shoot and fruit borer and epilachna beetle through bio-control agents. The experimental field was located at 90º23’58’’ east longitude and 23º46’37’’ north latitude at a height of 4 meter above the sea level. The land was medium high and well drained.

3.1.2 Climate

The experimental site was situated in the sub-tropical climatic zone, characterized by lower rainfall during the month of November to March. Monthly maximum and minimum temperature, relative humidity and total rainfall recorded during the period of study at the SAU experimental farm have been presented in the Appendix I. The recorded and calculated as monthly average temperature, relative humidity and rainfall for the crop growing period of experiment were noted from the Bangladesh meteorological Department (Climate Division), Agargaon, Dhaka-1207 and has been presented.

3.1.3 Soil

The soil of the experimental site was well drained and medium high. The soil of the st udy was silty clay in texture. The soil of the experimental plots belonged to the agro ecological zone Madhupur Tract (AEZ-28). Organic matter content was very low (0.82%) and soil pH varied from 5.47 to 5.63.

3.1.4 Design of the experiment and layout

The study was conducted considering eight treatments including a control for controlling brinjal shoot and fruit borer and epilachna beetle at seedling to harvesting stage. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. A good tilth area was divided into three main blocks. Each main block was sub-divided into 8 sub-plots each of which was of 3m × 2m with maintaining 0.75m borders and used experimental units where the treatments were assigned randomly. The distance between row to row was 100cm and that of the plants to plants was 70cm.

3.1.5 Land preparation

The experimental land was first opened with a tractor. Ploughed soil was then brought into desirable final tilt by four operations of ploughing followed by laddering. The stubbles of the crops and uprooted weeds were removed from the field and the land was properly leveled. The field layout was done on accordance to the design, immediately after land preparation. The plots were raised by 10 cm from the soil surface keeping the drain around the plots.

3.1.6 Manures, fertilizer and their methods of application

The following doses of manure and fertilizers were applied as per recommendation of Rashid (1999) for brinjal.

Manure/ Fertilizers	Dose per hectare
Cow-dung	10 tons
Urea	360 Kg
Triple Super Phosphate (TSP)	150 Kg
Muriate of Potash	250 Kg

The full dose cow-dung and TSP were applied as basal dose during final land preparation. One-third of the MP and urea were applied in the pits one week before transplanting and rest of the MP and urea were applied as the top dressing at 21, 35 and 50 days after transplanting.

3.1.7 Raising of seedling and transplanting

Brinjal seed (Vatiety: BARI brinjal-11) were collected from BARI, Gajipur. A small seed bed measuring 5m × 1m was prepared and seeds were sown in the nursery bed at SAU Entomology field on 17 Nov, 2017. Standard seedling raising practice was followed (Rashid, 1999). The plots were lightly irrigated regularly for ensuring seed proper development of the seedlings. The seedbed was mulched for ensuring proper seed germination, proper growth and development of the seedlings. Thirty days old healthy seedlings were transplanted in polybag for hardening. After twenty days that seedlings were transplanted on 29 December, 2017 in the experimental field.

3.8. Intercultural operations

3.8.1. Gap filling

At the time of transplanting few seedlings were transplanted in the border of the experimental plots for gap filling. Very few numbers of seedlings were damaged after transplanting and such seedling were replaced by healthy seedlings from the same planted earlier on the border of the experiment plot. The seedlings were transplanted with a mass of soil roots to minimize the transplanting shock.

3.8.2 Irrigation

After transplanting light irrigation was given to each plot. Supplementary irrigation was applied at an interval of 2-3 days. Stagnant water was effectively drained out at the time of over irrigation. The urea was top dressed in three splits as mentioned earlier.

3.8.3 Weeding

Weeding was done as and when necessary to break the soil crust and to keep the plots free from weeds. First weeding was done after 20 days of planting and the rest were carried out at an interval of 15 days to keep the plot free from weeds.

3.8.4 Earthing up

Earthing up was done in each plot to provide more soil at the base of each plant. It was done 40 and 60 days after transplanting.

3.9 Treatment for control measures

The experiment was evaluated to determine the efficacy of different botanical products and some chemical insecticides to compare with each other in considering the less hazardous but effective control measures against brinjal shoot and fruit borer and epilachna beetle. The botanical based treatments and chemical insecticides as well as their doses to be used in the study are given bellow:-

T_1= Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval

T_2= Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval

T_3= Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days interval

T_4= Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval

T_5= Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval

T_6= Spraying of Imitaf 20 SL @ 0.1 ml/L of water at 7 days interval

T_7= Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval

T_8= Untreated control.

3.10. Treatment preparation

3.10.1. Neem oil

The Neem oil was collected from Chawkbazar, Dhaka and the trix liquid detergent was collected from the local market of Agargoan bazaar, Dhaka. All sprays were made according to the methods described earlier. For each neem oil application, 15 ml neem oil (@ 3.0 ml/L of water i.e. 0.3% per 5 liter of water was used. The mixture within the spray machine was shacked well and sprayed on the upper and lower surface of the plants of the treatment until the drop run off from the plant. Three liters spray material was required to spray in three plot of each replication.

3.10.2. Neem seed kernel

The mature and dried neem seeds were collected fro m the neem tree found in the Horticulture Garden of SAU. Then seeds were roasted by electric oven. Then the seed kernel was separated and taken into the electric blender for blending. 250 gm of neem seed kernel powder was taken into a beaker and 250 ml water was added into the beaker. Then the beaker was shaken by electric stirrer for mixing up thoroughly the mixture. The aqueous mixture then filtered using Whatmen paper filter and preserved the aqueous extracts of neem seed kernel in the refrigerator at 4^0C for spraying in the field.

3.10.3. Bioneem plus

The bioneem plus was collected from Chawkbazar, Dhaka and the trix liquid detergent was collected from the local market of Agargoan bazaar, Dhaka. All sprays were made according to the methods described earlier. For each bioneem plus application, 15 ml neem oil (@ 3.0 ml/L of water i.e. 0.3% per 5 liter of water was used. The mixture within the spray machine was shacked well and sprayed on the upper and lower surface of the plants of the treatment until the drop run off from the plant. Three liters spray material was required to spray in three plot of each replication.

3.11. Treatment application

T_1: Neem oil @ 3.0 ml/L of water was sprayed at 7 days interval. Under this treatment, neem oil was applied @ 15 ml /5L of water mixed with trix liquid detergent @ 10 ml (1%) to make the oil easy soluble in water. After proper shaking, the prepared spray was applied with a high volume knap-sack sprayer at 7 days intervals commencing from 20 DAT.

T_2: Neem seed kernel extract @ 3.0 ml/L of water was sprayed at 7 days. Under this treatment, neem seed kernel extract was applied @ 15 ml /5L of water. After proper shaking, the prepared spray was applied with a high volume knap-sack sprayer at 7 days intervals commencing from 20 DAT.

T_3: Bioneem plus @ 3.0 ml/L of water was sprayed at 7 days interval. Under this treatment, bioneem plus was applied @ 15 ml /5L of water mixed with trix liquid detergent @ 10 ml (1%) to make the oil easy soluble in water. After proper shaking, the prepared spray was applied with a high volume knap-sack sprayer at 7 days intervals commencing from 20 DAT.

T_4: Marshal 25 EC @ 3.00 ml/L of water was sprayed at 7 days interval. For this treatment 15.0 ml of insecticides per 5 liter of water was mixed and sprayed at 7 days intervals commencing from 20 DAT.

T_5: Ripcord 20 EC @ 1.0 ml/L of water was sprayed at 7 days interval. For this treatment 5.0 ml of insecticides per 5 liter of water was mixed and sprayed at 7 days intervals commencing from 20 DAT.

T_6: Emitaf 20 SL @ 0.1 ml/L of water was sprayed at 7 days interval. For this treatment 1.0 gm of insecticides per 5 liter of water was mixed and sprayed at 7 days intervals commencing from 20 DAT.

T_7: Actara 25 WG @ 0.2 gm/L of water was sprayed at 7 days interval. For this treatment 1.0 gm of insecticides per 5 liter of water was mixed and sprayed at 7 days intervals commencing from 20 DAT.

T_8: Untreated control treatment. There was no any control measure was applied in brinjal field.

3.12 Data collection

Data were collected on different parameters as per requirement under the present study. Infestation of brinjal plants by brinjal shoot and fruit borer were monitored during both vegetative and reproductive stages. Number of infested shoots from 5 randomly selected plants per plot were counted and recorded at weekly interval after careful examination on the presence of borer and excreta at both vegetative and reproductive stage. Moreover, at reproductive stage, the infested fruits from 5 randomly selected plants were also checked for BSFB infestation and recorded at 7 days interval. The procedure and measurement of data collection were maintained as mentioned below:

3.12.1 Shoot infestation

The total number of shoots and the number of infested shoots were recorded from 5 plants from each plot at 7 days intervals. Shoot infestation was calculated in percent using the following formula:

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

3.12.2 Percent reduction of brinjal infestation over control

The number and weight of infested brinjal for each treated plot and untreated control plot were recorded and the percent reduction of brinjal infestation in number and weight was calculated using the following formula:

$$\% \text{ Infestation reduction over control} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, X_1 = the mean value of the treated plot

X_2 = the mean value of the untreated plot

3.12.3 Number of borer infested fruits

Mean number of borer infested fruits from randomly selected 5 plants were measured at each plot of the experiment. The percent infestation of fruit was calculated with the following procedures

$$\% \text{ Infested fruit} = \frac{\text{Number of infested fruit}}{\text{Total number of fruit}} \times 100$$

3.12.4 Weight of borer infested fruits

Mean weight of borer infested fruits from randomly selected 5 plants were measured at each plot of the experiment.

3.12.5 Weight of healthy fruits

Mean number of healthy fruits from randomly selected 5 plants were measured at each plot of the experiment.

3.12.6 Total number of fruits/plot

Mean weight of healthy fruits from randomly selected 5 plants were measured at each plot of the experiment.

3.12.7 Total fruit weight/plot

Total fruit weight/plot was taken from randomly selected 5 plants and converted to per plot measurement of total population of 6 m^2 plot.

3.12.8 Length of healthy fruit/plant

Length of healthy fruit from randomly selected 5 plants was taken and then averaged.

3.12.9 Girth of healthy fruit/plant

Girth of healthy fruit from randomly selected 5 plants was taken and then averaged.

3.12.10 Length of infested fruit/plant

Length of infested fruit from randomly selected 5 plants was taken and then averaged.

3.12.11 Girth of infested fruit/plant

Girth of infested fruit from randomly selected 5 plants was taken and then averaged.

3.12.12 Total fruit yield/ha

Total fruit yield/ha was measured from total yield of 6 m^2 plot.

3.12.13 Total healthy fruit yield/ha

Total weight of healthy fruit kg/ha was calculated from total healthy fruit recorded per plot.

3.13 Statistical analysis of data

Data were analyzed by using MSTAT-C software for analysis of variance after square root transformation. ANOVA was made by F variance test and the pair comparisons were performed by Duncan Multiple Range Test (DMRT).

Plate 1: Seed bed of brinjal

Plate 2: Seedlings in poly bag

Plate 3: Main field of brinjal

Plate 4: Bored brinjal by BSFB

Plate 5: Larva of BSFB into the infested brinjal

Plate 6: Epilachna beetle on infested brinjal leaf

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to evaluate the effectiveness of botanicals and some chemical insecticides for management of brinjal shoot and fruit borer and epilachna beetle of brinjal in the field under the Department of Entomology of Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2017 to March, 2018. The results have been presented and discussed, and possible interpretations have been given under the following sub-headings:

4.1. Number of brinjal shoot and fruit borer

The significant variations were observed among different treatments used for the management practices in terms of number of brinjal shoot and fruit borer at different growing stage. At vegetative stage, the lowest number of brinjal shoot and fruit borer was recorded in T_7 (1.33 brinjal shoot and fruit borer/plant), which was followed by T_5 (1.63 brinjal shoot and fruit borer/plant), T_4 (2.20 brinjal shoot and fruit borer/plant) and T_1 (2.20 brinjal shoot and fruit borer/plant). On the other hand, the highest number of brinjal shoot and fruit borer was recorded in T_8 (4.20 brinjal shoot and fruit borer/plant), which was followed by T_3 (3.83 brinjal shoot and fruit borer/plant), T_6 (3.50 brinjal shoot and fruit borer/plant) and T_2 (2.83 brinjal shoot and fruit borer/plant). More or less similar trends of number of brinjal shoot and fruit borer were also recorded at early fruiting stage, mid fruiting stage and late fruiting stage (Table 1).

In case of mean number of brinjal shoot and fruit borer per plant, the highest number of brinjal shoot and fruit borer was recorded in T_8 (5.81 brinjal shoot and fruit borer/plant) comprised of untreated control, which was significantly different from all other treatments. On the other hand, the lowest number of brinjal shoot and fruit borer was recorded in T_7 (2.17 brinjal shoot and fruit borer/plant), which was significantly different from all other treatments and followed by T_5 (2.91

brinjal shoot and fruit borer/plant), T_4 (3.51 brinjal shoot and fruit borer/plant) (Table 1). Considering the percent reduction of number of brinjal shoot and fruit borer per plant, the highest 62.65% reduction over control was achieved in T_7 followed by T_5 (49.91%) and T_4 (39.59%). On the other hand, the minimum reduction of number of brinjal shoot and fruit borer over control was found in T_3 (7.75%) followed by T_6 (16.35%).

Table 1: Effect of management practices on number of brinjal shoot and fruit borer per plant at different growing stage

Treatments	No. of brinjal shoot and fruit borer per plant					
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	Number increased over control (%)
T_1	2.20 e	4.33 e	5.37 e	3.63 e	3.88 e	33.22
T_2	2.83 d	4.77 d	5.73 d	4.13 d	4.37 d	24.78
T_3	3.83 b	5.73 b	6.70 b	5.17 b	5.36 b	7.75
T_4	2.20 e	3.77 f	4.87 f	3.20 f	3.51 f	39.59
T_5	1.63 f	3.23 g	4.23 g	2.53 g	2.91 g	49.91
T_6	3.50 c	5.23 c	6.13 c	4.57 c	4.86 c	16.35
T_7	1.33 g	2.87 h	3.23 h	1.23 h	2.17 h	62.65
T_8	4.20 a	6.17 a	7.23 a	5.63 a	5.81 a	0.00
CV (%)	2.88	1.37	1.09	1.73	0.87	
LSD (0.05)	0.13	0.11	0.11	0.11	0.05	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing number of brinjal shoot and fruit borer per plant over control (62.65%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of brinjal shoot and fruit borer over control (33.22%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of brinjal shoot and fruit borer per plant was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8. More or less similar research was also conducted by several researchers. Owusu *et al.* (2001) evaluated the performance of Aqueous Neem Seed Extract Karate and Biobit were reduced population levels of birijal shoot and fruit borer.

4.2. Number of bore caused by brinjal shoot and fruit borer

The significant variations were observed among different treatments used for the management practices in terms of number of bore caused by brinjal shoot and fruit borer at different growing stage. At early fruiting stage, the lowest number of bore caused by brinjal shoot and fruit borer was recorded in T_7 (0.23 bore/ five fruits), which was followed by T_5 (0.57 bore/five fruits), T_4 (0.73 bore/five fruits) and T_1 (1.13 bore/five fruits). On the other hand, the highest number of bore caused by brinjal shoot and fruit borer was recorded in T_8 (2.13 bore/five fruits), which was followed by T_3 (1.73 bore/five fruits), T_6 (1.57 bore/five fruits) and T_2 (1.13 borer/five fruits). More or less similar trends of number of bore caused by brinjal shoot and fruit borer were also recorded at mid fruiting stage and late fruiting stage (Table 2).

In case of mean number of bore caused by brinjal shoot and fruit borer per plant, the highest number of bore caused by brinjal shoot and fruit borer was recorded in T_8 (3.41 bore/five fruits) comprised of untreated control, which was significantly different from all other treatments. On the other hand, the lowest number of bore caused by brinjal shoot and fruit borer was recorded in T_7 (1.12 bore/five fruits), which was significantly different from all other treatments and followed by T_5 (1.62 bore/five fruits), T_4 (1.87 bore/five fruits) (Table 2). Considering the percent reduction of number of bore caused by brinjal shoot and fruit borer per five fruits, the highest 68.63% reduction over control was achieved in T_7 followed by T_5 (54.62%) and T_4 (47.62%). On the other hand, the minimum reduction of number of borer caused by brinjal shoot and fruit borer over control was found in T_3 (14.85%) followed by T_6 (24.37%).

Table 2: Effect of management practices on number of bore caused by brinjal shoot and fruit borer per five fruits at different growing stage

Treatments	No. of bore caused by brinjal shoot and fruit borer per five fruits				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	Number increased over control (%)
T_1	1.13 e	2.57 d	3.17 c	2.29 e	35.85
T_2	1.23 d	2.63 d	3.57 b	2.48 d	30.53
T_3	1.73 b	3.07 b	4.33 a	3.04 b	14.85
T_4	0.73 f	2.17 e	2.70 d	1.87 f	47.62
T_5	0.57 g	1.53 f	2.77 d	1.62 g	54.62
T_6	1.57 c	2.80 c	3.73 b	2.70 c	24.37
T_7	0.23 h	1.40 f	1.73 e	1.12 h	68.63
T_8	2.13 a	4.07 a	4.50 a	3.57 a	0.00
CV (%)	4.58	3.41	7.14	3.41	
LSD (0.05)	0.09	0.14	0.40	0.14	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing number of bore cause by brinjal shoot and fruit borer per five fruits over control (68.63%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of bore caused by brinjal shoot and fruit borer over control (35.85%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of bore caused by brinjal shoot and fruit borer per five fruits was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Owusu *et al.*

(2001) evaluated the performance of Aqueous Neem Seed Extract Karate and Biobit were reduced the number of bore by brinjal shoot and fruit borer.

4.3. Number of infested shoot caused by brinjal shoot and fruit borer

The significant variations were observed among different treatments used for the management practices in terms of number of infested shoot caused by brinjal shoot and fruit borer at different growing stage. At vegetative stage, the lowest number of infested shoot caused by brinjal shoot and fruit borer was recorded in T_7 (3.23 shoot/ five plants), which was followed by T_5 (3.63 shoot/ five plants), T_4 (4.17 shoot/ five plants) and T_1 (4.53 shoot/ five plants). On the other hand, the highest number of infested shoot caused by brinjal shoot and fruit borer was recorded in T_8 (6.23 shoot/ five plants), which was followed by T_3 (5.63 shoot/ five plants), T_6 (5.27 shoot/ five plants) and T_2 (4.80 shoot/ five plants). More or less similar trends of number of infested shoot caused by brinjal shoot and fruit borer were also recorded at early fruiting stage, mid fruiting stage and late fruiting stage (Table 3).

In case of mean number of infested shoot caused by brinjal shoot and fruit borer per five plants, the highest number of infested shoot caused by brinjal shoot and fruit borer was recorded in T_8 (4.86 shoot/ five plants) comprised of untreated control, which was significantly different from all other treatments. On the other hand, the lowest number of infested shoot caused by brinjal shoot and fruit borer was recorded in T_7 (2.08 shoot/ five plants), which was significantly different from all other treatments and followed by T_5 (2.56 shoot/ five plants), T_4 (2.95 shoot/ five plants) (Table 3). Considering the percent reduction of number of infested shoot caused by brinjal shoot and fruit borer per five plants, the highest 57.20% reduction over control was achieved in T_7 followed by T_5 (47.33%) and T_4 (39.30%). On the other hand, the minimum reduction of number of infested shoot caused by brinjal shoot and fruit borer over control was found in T_3 (8.44%) followed by T_6 (13.99%).

Table 3: Effect of management practices on number of infested shoot by BSFB per five plants at different growing stage

Treatments	Number of infested shoot by brinjal shoot and fruit borer per five plants					
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	Number increased over control (%)
T_1	4.53 e	4.33 d	3.12 e	1.63 e	3.41 e	29.84
T_2	4.80 d	4.70 c	3.33 d	2.30 d	3.78 d	22.22
T_3	5.63 b	5.27 b	4.13 b	2.77 b	4.45 b	8.44
T_4	4.17 f	3.63 e	2.67 f	1.33 f	2.95 f	39.30
T_5	3.63 g	3.23 f	2.20 g	1.17 g	2.56 g	47.33
T_6	5.27 c	5.17 b	3.63 c	2.63 c	4.18 c	13.99
T_7	3.23 h	2.63 g	1.60 h	0.83 h	2.08 h	57.20
T_8	6.23 a	5.73 a	4.30 a	3.17 a	4.86 a	0.00
CV (%)	1.39	1.37	2.36	3.40	1.05	
LSD (0.05)	0.11	0.11	0.12	0.12	0.05	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing number of infested shoot cause by brinjal shoot and fruit borer per five plants over control (57.20%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of infested shoot caused by brinjal shoot and fruit borer over control (29.84%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of infested shoot caused by brinjal shoot and fruit borer per five plants was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

4.4. Number of infested fruit caused by brinjal shoot and fruit borer

The significant variations were observed among different treatments used for the management practices in terms of number of infested fruit caused by brinjal shoot and fruit borer at different growing stage. At early fruiting stage, the lowest number of infested fruit caused by brinjal shoot and fruit borer was recorded in T_7 (0.83 fruit/plant), which was followed by T_5 (1.13 fruit/plant), T_4 (1.33 fruit/plant) and T_1 (1.70 fruit/plant). On the other hand, the highest number of infested fruit caused by brinjal shoot and fruit borer was recorded in T_8 (3.13 fruit/plant), which was followed by T_3 (2.70 fruit/plant), T_6 (2.33 fruit/plant) and T_2 (2.13 fruit/plant). More or less similar trends of number of infested fruit caused by brinjal shoot and fruit borer per plant were also recorded at mid fruiting stage and late fruiting stage (Table 4).

In case of mean number of infested fruit caused by brinjal shoot and fruit borer per plant, the highest number of infested fruit caused by brinjal shoot and fruit borer per plant was recorded in T_8 (4.37 fruit/plant) comprised of untreated control, which was significantly different from all other treatments. On the other hand, the lowest number of infested fruit caused by brinjal shoot and fruit borer per plant was recorded in T_7 (1.39 fruit/plant), which was significantly different from all other treatments and followed by T_5 (2.21 fruit/plant), T_4 (2.71 fruit/plant) (Table 4). Considering the percent reduction of number of infested fruit caused by brinjal shoot and fruit borer per plant, the highest 68.19% reduction over control was achieved in T_7 followed by T_5 (49.43%) and T_4 (37.99%). On the other hand, the minimum reduction of number of infested fruit caused by brinjal shoot and fruit borer per plant over control was found in T_3 (5.72%) followed by T_6 (14.42%).

Table 4: Effects of management practices on number of infested fruit caused by brinjal shoot and fruit borer per plant at different growing stage

Treatments	Number of infested fruit by brinjal shoot and fruit borer per plant				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	Number increased over control (%)
T_1	1.70 e	4.83 d	2.23 e	2.92 e	33.18
T_2	2.13 d	5.23 c	2.70 d	3.36 d	23.11
T_3	2.70 b	6.17 a	3.50 b	4.12 b	5.72
T_4	1.33 f	4.63 e	2.17 e	2.71 f	37.99
T_5	1.13 g	4.17 f	1.33 f	2.21 g	49.43
T_6	2.33 c	5.73 b	3.17 c	3.74 c	14.42
T_7	0.83 h	2.17 g	1.17 g	1.39 h	68.19
T_8	3.13 a	6.23 a	3.73 a	4.37 a	0.00
CV (%)	3.05	1.22	2.56	1.01	
LSD (0.05)	0.09	0.11	0.11	0.05	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing number of infested fruit caused by brinjal shoot and fruit borer per plant over control (68.19%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of infested fruit caused by brinjal shoot and fruit borer per plant over control (33.18%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of infested shoot caused by brinjal shoot and fruit borer per five plants was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Chatterjee *et al*. (2009) revealed that the lowest mean shoot as well as fruit infestation (7.47 and 9.88%) was recorded in the plots treated with spinosad 2.5 SC (50 g a.i. ha-1).

4.5. Percent fruit infestation in number caused by brinjal shoot and fruit borer

4.5.1. Early fruiting stage

The significant variations were observed among different treatments used for the management practices in terms of percent fruit infestation in number caused by brinjal shoot and fruit borer at different growing stage. The highest number of healthy fruit at early fruiting stage was recorded in T_7 (14.67 fruit/plant), which was followed by T_5 (11.00 fruit/plant), T_4 (7.67 fruit/plant) and T_1 (5.67 fruit/plant). On the other hand, the lowest number of healthy fruit at early fruiting stage was recorded in T_8 (0.33 fruit/plant), which was followed by T_3 (1.67 fruit/plant), T_6 (2.67 fruit/plant) and T_2 (4.00 fruit/plant) (Table 5).

In case of number of infested fruit caused by brinjal shoot and fruit borer per plant, the highest number of infested fruit was recorded in T_8 (3.13 fruit/plant), which was significantly different from all other treatments and followed by T_3 (2.70 fruit/plant) and T_6 (2.33 fruit/plant). On the other hand, the lowest number of infested fruit was recorded in T_7 (0.83 fruit/plant), which was significantly different from all other treatments and followed by T_5 (1.33 fruit/plant), T_4 (1.33 fruit/plant) and T_1 (1.70 fruit/plant) (Table 5).

The highest percent of infestation of brinjal fruit was observed in T_8 (64.28%), which was followed by T_3 (40.71%), T_6 (29.53%) and T_2 (22.11%). On the other hand, the lowest percent of infestation of brinjal fruit was observed in T_7 (4.93%), which was statistically similar with T_5 (7.56%) and T_4 (11.10%) and followed by T_1 (16.60%).

Considering the percent reduction of infested fruit caused by brinjal shoot and fruit borer per plant in number, the maximum 92.33% reduction over control was achieved in T_7 followed by T_5 (88.24%), T_4 (82.73%) and T_1 (74.18%). On the other hand, the minimum reduction of infested fruit caused by brinjal shoot and fruit borer per plant in number over control was found in T_3 (36.67%) followed by T_6 (54.06%).

Table 5: Effect of management practices on percent fruit infestation in number by brinjal shoot and fruit borer per plant at early fruiting stage

Treatments	Infestation of brinjal fruit by BSFB per plant			
	Healthy fruit	Infested fruit	% Infestation	Infestation decrease over control (%)
T_1	5.67 d	1.70 e	16.60 de	74.18
T_2	4.00 e	2.13 d	22.11 cd	65.60
T_3	1.67 g	2.70 b	40.71 b	36.67
T_4	7.67 c	1.33 f	11.10 ef	82.73
T_5	11.00 b	1.13 g	7.56 f	88.24
T_6	2.67 f	2.33 c	29. 53 c	54.06
T_7	14.67 a	0.83 h	4.93 f	92.33
T_8	0.33 h	3.13 a	64.28 a	0.00
CV (%)	18.72	3.05	19.70	
LSD (0.05)	0.83	0.09	8.19	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in number per plant over control (92.33%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in number per plant over control (74.18%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in number per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Mandal *et al.* (2008) found that the treatment pheromone trap +

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

4.5.2. Mid fruiting stage

The significant variations were observed among different treatments used for the management practices in terms of percent fruit infestation in number caused by brinjal shoot and fru it borer at different growing stage. The highest number of healthy fruit at mid fruiting stage was recorded in T_7 (17.00 fruit/plant), which was followed by T_5 (14.33 fruit/plant), T_4 (12.33 fruit/plant) and T_1 (10.33 fruit/plant). On the other hand, the lowest number of healthy fruit at mid fruiting stage was recorded in T_8 (3.67 fruit/plant), which was followed by T_3 (6.00 fruit/plant), T_6 (7.67 fruit/plant) and T_2 (9.33 fruit/plant) (Table 6).

In case of number of infested fruit caused by brinjal shoot and fruit borer per plant, the highest number of infested fruit was recorded in T_8 (6.23 fruit/plant), which was significantly similar with T_3 (6.17 fruit/plant) and followed by T_6 (5.73 fruit/plant). On the other hand, the lowest number of infested fruit was recorded in T_7 (2.17 fruit/plant), which was significantly different from all other treatments and followed by T_5 (4.17 fruit/plant), T_4 (4.63 fruit/plant) and T_1 (4.83 fruit/plant) (Table 6).

The highest percent of infestation of brinjal fruit was observed in T_8 (46.81%), which was followed by T_3 (40.25%), T_6 (35.14%) and T_2 (30.22%). On the other hand, the lowest percent of infestation of brinjal fruit was observed in T_7 (10.00%), which was statistically different from other treatments and followed by T_5 (21.59%), T_4 (25.29%) and T_1 (27.39%).

Considering the percent reduction of infested fruit caused by brinjal shoot and fruit borer per plant in number, the maximum 57.27% reduction over control was achieved in T_7 followed by T_5 (53.88%), T_4 (45.97%) and T_1 (41.49%). On the other hand, the minimum reduction of infested fruit caused by brinjal shoot and fruit borer per plant in number over control was found in T_3 (14.01%) followed by T_6 (18.15%).

Table 6: Effect of management practices on percent fruit infestation in number by brinjal shoot and fruit borer per plant at mid fruiting stage

Treatments	Infestation of brinjal fruit by BSFB per plant			
	Healthy fruit	Infested fruit	% Infestation	Number increased over control (%)
T_1	10.33 cd	4.83 d	27.39 e	41.49
T_2	9.33 de	5.23 c	30.22 d	35.44
T_3	6.00 fg	6.17 a	40.25 b	14.01
T_4	12.33 bc	4.63 e	25.29 f	45.97
T_5	14.33 b	4.17 f	21.59 g	53.88
T_6	7.67 ef	5.73 b	35.14 c	18.15
T_7	17.00 a	2.17 g	10.00 h	57.27
T_8	3.67 g	6.23 a	46.81 a	0.00
CV (%)	14.38	1.22	3.51	
LSD (0.05)	2.5	0.11	1.75	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in number per plant over control (57.27%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in number per plant over cont rol (41.49%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in number per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Mandal *et al*. (2008) found that the treatment pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was best for the management of this borer. Anjali (2006) revealed that cypermethrin (0.007%) and carbaryl (0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on number.

4.5.3. Late fruiting stage

The significant variations were observed among different treatments used for the management practices in terms of percent fruit infestation in number caused by brinjal shoot and fruit borer at different growing stage. The highest number of healthy fruit at late fruiting stage was recorded in T_7 (20.67 fruit/plant), which was followed by T_5 (16.00 fruit/plant), T_4 (13.33 fruit/plant) and T_1 (11.00 fruit/plant). On the other hand, the lowest number of healthy fruit at late fruiting stage was recorded in T_8 (1.33 fruit/plant), which was followed by T_3 (3.67 fruit/plant), T_6 (6.00 fruit/plant) and T_2 (8.67 fruit/plant) (Table 7).

In case of number of infested fruit caused by brinjal shoot and fruit borer per plant, the highest number of infested fruit was recorded in T_8 (3.73 fruit/plant), which was significantly similar with T_3 (3.50 fruit/plant) and followed by T_6 (3.17 fruit/plant). On the other hand, the lowest number of infested fruit was recorded in T_7 (1.17 fruit/plant), which was significantly different from all other treatments and followed by T_5 (1.33 fruit/plant), T_4 (2.17 fruit/plant) and T_1 (2.23 fruit/plant) (Table 7).

The highest percent of infestation of brinjal fruit was observed in T_8 (53.63%), which was followed by T_3 (37.89%), T_6 (33.43%) and T_2 (28.72%). On the other hand, the lowest percent of infestation of brinjal fruit was observed in T_7 (13.84%), which was statistically different from other treatments and followed by T_5 (15.09%), T_1 (16.77%) and T_4 (23.64%).

Considering the percent reduction of infested fruit caused by brinjal shoot and fruit borer per plant in number, the maximum 74.19% reduction over control was achieved in T_7 followed by T_5 (71.86%), T_1 (68.73%) and T_4 (55.92%). On the other hand, the minimum reduction of infested fruit caused by brinjal shoot and fruit borer per plant in number over control was found in T_3 (29.35%) followed by T_6 (37.67%).

Table 7: Effect of management practices on percent fruit infestation in number by brinjal shoot and fruit borer per plant at late fruiting stage

Treatments	Infestation of brinjal fruit by BSFB per plant			
	Healthy fruit	Infested fruit	% Infestation	Number increased over control (%)
T_1	11.00 cd	2.23 e	16.77 f	68.73
T_2	8.67 de	2.70 d	28.72 d	46.45
T_3	3.67 fg	3.50 b	37.89 b	29.35
T_4	13.33 bc	2.17 e	23.64 e	55.92
T_5	16.00 b	1.33 f	15.09 g	71.86
T_6	6.00 ef	3.17 c	33.43 c	37.67
T_7	20.67 a	1.17 g	13.84 h	74.19
T_8	1.33 g	3.73 a	53.63 a	0.00
CV (%)	19.07	2.56	5.75	
LSD (0.05)	3.247	0.11	1.88	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in number per plant over control (74.19%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in number per plant over control (68.73%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in number per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Mandal *et al*. (2008) found that the treatment pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was best for the management of this borer. Anjali (2006) revealed that cypermethrin (0.007%) and carbaryl (0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on number.

4.6. Percent fruit infestation in weight caused by brinjal shoot and fruit borer

4.6.1. Early fruiting stage

The significant variations were observed among different treatments used for the management practices in terms of percent fruit infestation in weight caused by brinjal shoot and fruit borer at different growing stage. The highest weight of healthy fruit at early fruiting stage was recorded in T_7 (753.00 gm/plant), which was followed by T_5 (666.30 gm/plant), T_4 (373.00 gm/plant) and T_1 (297.00 gm/plant). On the other hand, the lowest weight of healthy fruit at early fruiting stage was recorded in T_8 (104.70 gm/plant), which was followed by T_3 (157.70 gm/plant), T_6 (175.30 gm/plant) and T_2 (243.70 gm/plant) (Table 8).

In case of weight of infested fruit caused by brinjal shoot and fruit borer per plant, the highest weight of infested fruit was recorded in T_4 (206.70 gm/plant), which was significantly similar with T_5 (204.30 gm/plant) and T_7 (182.70 gm/plant). On the other hand, the lowest weight of infested fruit was recorded in T_8 (114.70 gm/plant), which was significantly different from all other treatments and followed by T_6 (142.30 gm/plant), T_1 (142.30 gm/plant) and T_3 (143.30 gm/plant) (Table 8).

The highest percent of infestation of brinjal fruit in weight was observed in T_8 (52.28%), which was followed by T_3 (47.62%), T_6 (44.81%) and T_2 (40.71%). On the other hand, the lowest percent of infestation of brinjal fruit in weight was observed in T_7 (19.52%), which was statistically different from other treatments and followed by T_5 (23.47%), T_1 (32.40%) and T_4 (35.65%).

Considering the percent reduction of infested fruit caused by brinjal shoot and fruit borer per plant in weight, the maximum 62.66% reduction over control was achieved in T_7 followed by T_5 (55.11%), T_1 (38.03%) and T_4 (31.81%). On the other hand, the minimum reduction of infested fruit caused by brinjal shoot and fruit borer per plant in weight over control was found in T_3 (8.91%) followed by T_6 (14.29%).

Table 8: Effect of management practices on percent fruit infestation in weight by brinjal shoot and fruit borer per plant at early fruiting stage

Treatments	Infestation of brinjal fruit in weight by BSFB per plant			
	Healthy fruit wt.	Infested fruit wt.	% Infestation	Number increased over control (%)
T_1	297.00 d	142.30 d	32.40 f	38.03
T_2	243.70 e	167.30 c	40.71 d	22.13
T_3	157.70 g	143.30 d	47.62 b	8.91
T_4	373.00 c	206.70 a	35.65 e	31.81
T_5	666.30 b	204.30 a	23.47 g	55.11
T_6	175.30 f	142.30 d	44.81 c	14.29
T_7	753.00 a	182.70 b	19.52 h	62.66
T_8	104.70 h	114.70 e	52.28 a	0.00
CV (%)	0.86	1.09	1.11	
LSD (0.05)	5.01	3.00	0.70	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in weight per plant over control (62.66%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in weight per plant over control (38.03%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in weight per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Mandal *et al*. (2008) found that the treatment pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was best for the management of this borer. Anjali (2006) revealed that cypermethrin (0.007%) and carbaryl (0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on weight basis.

4.6.2. Mid fruiting stage

The significant variations were observed among different treatments used for the management practices in terms of percent fruit infestation in weight caused by brinjal shoot and fruit borer at different growing stage. The highest weight of healthy fruit at mid fruiting stage was recorded in T_7 (1217.00 gm/plant), which was followed by T_5 (810.30 gm/plant), T_1 (770.70 gm/plant) and T_4 (768.00 gm/plant). On the other hand, the lowest weight of healthy fruit at mid fruiting stage was recorded in T_8 (292.70 gm/plant), which was followed by T_3 (476.70 gm/plant), T_6 (543.70 gm/plant) and T_2 (695.00 gm/plant) (Table 9).

In case of weight of infested fruit caused by brinjal shoot and fruit borer per plant, the highest weight of infested fruit was recorded in T_6 (341.70 gm/plant), which was significantly similar with

T_8 (341.00 gm/plant) and T_3 (339.70 gm/plant) and followed by T_2 (295.70 gm/plant). On the other hand, the lowest weight of infested fruit was recorded in T_1 (223.00 gm/plant), which was significantly different from all other treatments and followed by T_5 (231.30 gm/plant), T_7 (233.70 gm/plant) and T_4 (248.30 gm/plant) (Table 9).

The highest percent of infestation of brinjal fruit in weight was observed in T_8 (53.81%), which was followed by T_3 (41.61%), T_6 (38.59%) and T_2 (29.85%). On the other hand, the lowest percent of infestation of brinjal fruit in weight was observed in T_7 (16.11%), which was statistically different from other treatments and followed by T_5 (22.21%), T_1 (22.44%) and T_4 (24.43%).

Considering the percent reduction of infested fruit caused by brinjal shoot and fruit borer per plant in weight, the maximum 70.06% reduction over control was achieved in T_7 followed by T_5 (58.73%), T_1 (58.30%) and T_4 (54.60%). On the other hand, the minimum reduction of infested fruit caused by brinjal shoot and fruit borer per plant in weight over control was found in T_3 (22.67%) followed by T_6 (28.28%).

Table 9: Effect of management practices on percent fruit infestation in weight by brinjal shoot and fruit borer per plant at mid fruiting stage

Treatments	Infestation of brinjal fruit by BSFB per plant			
	Healthy fruit wt.	Infested fruit wt.	% Infestation	Number increased over control (%)
T_1	770.70 c	223.00 e	22.44 f	58.30
T_2	695.00 d	295.70 b	29.85 d	44.53
T_3	476.70 f	339.70 a	41.61 b	22.67
T_4	768.00 c	248.30 c	24.43 e	54.60
T_5	810.30 b	231.30 d	22.21 f	58.73
T_6	543.70 e	341.70 a	38.59 c	28.28
T_7	1217.00 a	233.70 d	16.11 g	70.06
T_8	292.70 g	341.00 a	53.81 a	0.00
CV (%)	0.28	0.57	0.54	
LSD (0.05)	3.26	2.72	0.28	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval;

T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in weight per plant over control (70.06%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in weight per plant over control (58.30%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in weight per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Mandal *et al*. (2008) found that the treatment pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was best for the management of this borer. Anjali (2006) revealed that cypermethrin (0.007%) and carbaryl (0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on weight basis.

4.5.3. Late fruiting stage

The significant variations were observed among different treatments used for the management practices in terms of percent fruit infestation in weight caused by brinjal shoot and fruit borer at different growing stage. The highest weight of healthy fruit at late fruiting stage was recorded in T_7 (1020.00 gm/plant), which was followed by T_5 (918.30 gm/plant), T_1 (824.30 gm/plant) and T_4 (755.70 gm/plant). On the other hand, the lowest weight of healthy fruit at late fruiting stage was recorded in T_8 (273.00 gm/plant), which was followed by T_3 (467.30 gm/plant), T_6 (558.00 gm/plant) and T_2 (671.70 gm/plant) (Table 10).

In case of weight of infested fruit caused by brinjal shoot and fruit borer per plant, the highest weight of infested fruit was recorded in T_8 (340.70 gm/plant), which was significantly different from other treatments and followed by T (268.30 gm/plant), T_3 (266.00 gm/plant)and T_2 (265.00 gm/plant). On the other hand, the lowest weight of infested fruit was recorded in T_1 (183.30 gm/plant), which was statistically similar with T_7 (184.30 gm/plant) and followed by T_5 (197.30 gm/plant) and T_4 (232.70 gm/plant) (Table 10).

The highest percent of infestation of brinjal fruit in weight was observed in T_8 (55.51%), which was followed by T_3 (36.25%), T_6 (32.47%) and T_2 (28.29%). On the other hand, the lowest percent of infestation of brinjal fruit in weight was observed in T_7 (15.31%) and followed by T_5 (17.69%), T_1 (18.22%) and T_4 (23.54%).

Considering the percent reduction of infested fruit caused by brinjal shoot and fruit borer per plant in weight, the maximum 72.42% reduction over control was achieved in T_7 and followed by T_5 (68.13%), T_1 (67.18%) and T_4 (57.59%). On the other hand, the minimum reduction of infested fruit caused by brinjal shoot and fruit borer per plant in weight over control was found in T_3 (34.70%) followed by T_6 (41.51%) and T_2 (49.04%).

Table 10: Effect of management practices on percent fruit infestation in weight by brinjal shoot and fruit borer per plant at late fruiting stage

Treatments	Infestation of brinjal fruit in weight by BSFB per plant			
	Healthy fruit wt.	Infested fruit wt.	% Infestation	Number increased over control (%)
T_1	824.30 c	183.30 e	18.22 f	67.18
T_2	671.70 e	265.00 b	28.29 d	49.04
T_3	467.30 g	266.00 b	36.25 b	34.70
T_4	755.70 d	132.70 c	23.54 e	57.59
T_5	918.30 b	197.30 d	17.69 g	68.13
T_6	558.00 f	268.30 b	32.47 c	41.51
T_7	1020.00 a	184.30 e	15.31 h	72.42
T_8	273.00 h	340.70 a	55.51 a	0.00
CV (%)	0.42	0.85	0.81	
LSD (0.05)	4.83	3.48	0.39	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in weight per plant over control (72.42%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in weight per plant over control (67.18%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in weight per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Mandal *et al*. (2008) found that the treatment pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was best for the management of this borer. Anjali (2006) revealed that cypermethrin (0.007%) and carbaryl

(0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on weight basis.

4.6. Infestation of epilachna beetle of brinjal

4.6.1 Number of epilachna beetle per plant

The significant variations were observed among different treatments used for the management practices in terms of number of epilachna beetle at different growing stage. At vegetative stage, the lowest number of epilachna beetle was recorded in T_7 (1.53 epilachna beetle/plant), which was followed by T_5 (2.17 epilachna beetle/plant), T_4 (2.27 epilachna beetle/plant) and T_1 (2.47 epilachna beetle/plant). On the other hand, the highest number of epilachna beetle was recorded in T_8 (4.10 epilachna beetle/plant), which was followed by T_3 (3.23 epilachna beetle/plant), T_6 (3.17 epilachna beetle/plant) and T_2 (2.63 epilachna beetle/plant). More or less similar trends of number of epilachna beetle were also recorded at early fruiting, mid fruiting stage and late fruiting stage (Table 11).

In case of mean number of epilachna beetle per plant, the highest number of epilachna beetle was recorded in T_8 (4.53 epilachna beetle/plant) comprised of untreated control, which was significantly different from all other treatments and followed by T_3 (2.94 epilachna beetle/plant), T_6 (2.68 epilachna beetle/plant) and T_2 (2.30 epilachna beetle/plant). On the other hand, the lowest mean leaf infestation by number was recorded in T_7 (1.14 epilachna beetle/plant), which was significantly different from all other treatments and followed by T_5 (1.55 epilachna beetle/plant), T_4 (1.77 epilachna beetle/plant) and T_1 (2.03 epilachna beetle/plant) (Table 11). Considering the percent reduction of number of epilachna beetle per plant, the highest 74.83% reduction over control was achieved in T_7 followed by T_5 (65.78%) and T_4 (60.93%). On the other hand, the minimum reduction of leaf infestation over control was found in T_3 (35.10%) followed by T_6 (40.84%).

Table 11: Effect of management practices of number of epilachna beetle on fully opened leaves per plant

Treatments	No. of epilachna beetle per plant					
	Vegetative stage	Early fruiting stage	Mid fruiting Stage	Late fruiting stage	Mean	Incidence reduction over control (%)
T_1	2.47 d	2.13 e	1.83 e	1.67 e	2.03 e	55.19
T_2	2.63 c	2.33 d	2.17 d	2.03 d	2.30 d	49.23
T_3	3.23 b	3.13 b	2.73 b	2.63 b	2.94 b	35.10
T_4	2.27 e	1.83 f	1.63 f	1.33 f	1.77 f	60.93
T_5	2.17 f	1.73 f	1.23 g	1.07 g	1.55 g	65.78
T_6	3.17 b	2.70 c	2.53 c	2.33 c	2.68 c	40.84
T_7	1.53 g	1.30 g	1.07 h	0.67 h	1.14 h	74.83
T_8	4.10 a	4.57 a	4.80 a	4.63 a	4.53 a	0.00
CV (%)	2.06	2.80	2.20	2.26	1.14	
LSD (0.05)	0.09	0.12	0.08	0.08	0.05	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing number of epilachna beetle per plant over control (74.83%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of epilachna beetle over control (55.19%). As a result, the order of rank of efficacy of the treatments applied against aphid including untreated control in terms of reducing number of aphid per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Sharma *et al*. (2012) reported that the treatment including pesticides and botanicals combined with cultural method reduced the number of epilachna beetle (1.72 beetle/plant).

4.6.2 Infestation of leaves by epilachna beetle per plant

The significant variations were observed among different treatments used for the management practices in terms of number of leaves by epilachna beetle at different growing stage. The highest number of leaves per five plants was recorded in T_1 (59.30 leaves/five plants), which was statistically different from other treatments and followed by T_5 (55.20 leaves/five plants), T_8 (51.70 leaves/five plants) and T_4 (50.30 leaves /five plants). On the other hand, the lowest number of leaves per five plants was recorded in T_3 (40.60 leaves /five plants), which was statistically different from other treatments and followed by T_6 (41.40 leaves /five plants), T_2 (42.47 leaves /five plants) and T_7 (47.10 leaves/five plants) (Table 12).

In case of number of infested leaves, the highest number of infested leaves per five plants was recorded in T_8 (12.33 leaves/five plants), which was statistically different from other treatments and followed by T_1 (9.00 leaves/five plants), T_3 (9.00 leaves/five plants) and T_6 (8.33 leaves /five plants). On the other hand, the lowest number of infested leaves per five plants was recorded in T_7 (4.33 leaves /five plants), which was statistically different from other treatments and followed by T_5 (5.67 leaves /five plants), T_4 (7.00 leaves /five plants) and T_2 (7.00 leaves/five plants) (Table 12).

In case of percent infestation of leaves per five plants, the highest percentage was recorded in T_8 (23.86%) comprised of untreated control, which was statistically similar with T_3 (22.16%) and followed by T_6 (20.13%). On the other hand, the lowest percentage was recorded in T_7 (9.20%), which was statistically similar with T_5 (10.27%) and followed by T_4 (13.91%), T_1 (15.18%) and

T_2 (16.48%) (Table 12). Considering the percent reduction of number of epilachna beetle per plant, the highest 61.44% reduction over control was achieved in T_7 followed by T_5 (56.96%) and T_4 (41.70%). On the other hand, the minimum reduction of leaf infestation over control was found in T_3 (7.12%) followed by T_6 (15.63%).

Table 12: Effect of management practices on infestation of fully opened leaves by epilachna beetle per five plants

Treatments	Infestation of leaves by epilachna beetle per five plants			
	No. of total leaves	No. of infested leaves	% infestation	Infestation reduction over control (%)
T_1	59.30 a	9.00 b	15.18 c	36.38
T_2	42.47 f	7.00 c	16.48 c	30.93
T_3	40.60 h	9.00 b	22.16 ab	7.12
T_4	50.30 d	7.00 c	13.91 c	41.70
T_5	55.20 b	5.67 d	10.27 d	56.96
T_6	41.40 g	8.33 b	20.13 b	15.63
T_7	47.10 e	4.33 e	9.20 d	61.44
T_8	51.70 c	12.33 a	23.86 a	0.00
CV (%)	0.22	8.75	9.25	
LSD (0.05)	0.19	1.16	2.56	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing the number of infested leaves by epilachna beetle per five plants over control (61.44%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of infested leaves by epilachna beetle per five plants over control (36.38%). As a result, the order of rank of efficacy of the treatments applied against epilachna beetle including untreated control in terms of reducing number of infested leaves by epilachna beetle per five plants was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8. More or less similar research was also conducted by several researchers. Sharma *et al*. (2012) reported that the treatment including pesticides and botanicals combined with cultural method reduced the leaf infestation percent (8.07%) caused by epilachna beetle (1.72 beetle/plant).

4.6.3 Infestation plants by epilachna beetle

The significant variations were not observed among different treatments used for the management practices in terms of number of total plants at different growing stage. In case of number of infested plants, the highest number of plants per plot was recorded in T_8 (4.33 plants/plot), which was statistically different from other treatments and followed by T_3 (3.67 plants/plot), T_6 (2.67 plants/plot), T_4 (2.33 plants/plot), T_6 (2.67 plants/plot) and T_2 (4.33 plants/plot). On the other hand, the lowest number of infested plants per plot was recorded in T_7 (1.00 plants /plot), which was statistically similar with T_1 (1.33 plants/plot) and T_5 (1.00 plants/plot) (Table 13).

In case of percent infestation of plants per plot, the highest percentage was recorded in T_8 (36.11%) comprised of untreated control, which was significantly similar with T_3 (30.55%), T_6 (22.22%), T_2 (22.22%) and T_4 (19.45%). On the other hand, the lowest percentage was recorded in T_7 (8.33%), which was statistically different from other treatments and followed by T_5 (8.33%) and T_1 (11.11%) (Table 13).Considering the percent reduction of number of epilachna beetle per plant, the highest 76.93% reduction over control was achieved in T_7 followed by T_5 (76.93%) and T_5 (69.23%). On the other hand, the minimum reduction of plant infestation over control was found in T_3 (15.40%) followed by T_6 (38.47%) and T_2 (38.47%).

Table 13: Effect of management practices on infestation of plants by epilachne beetle per plot

Treatments	Infestation of plants by epilachne beetle per plot			
	No. of total plants	No. of infested plants	% infestation	Infestation reduction over control (%)
T_1	12.00 a	1.33 d	11.11 d	69.23
T_2	12.00 a	2.67 c	22.22 c	38.47
T_3	12.00 a	3.67 b	30.55 b	15.40
T_4	12.00 a	2.33 c	19.45 c	46.14
T_5	12.00 a	1.00 d	8.33 d	76.93
T_6	12.00 a	2.67 c	22.22 c	38.47
T_7	12.00 a	1.00 d	8.33 d	76.93
T_8	12.00 a	4.33 a	36.11 a	0.00
CV (%)	00	14.89	14.89	
LSD (0.05)	0.05	0.60	4.98	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

From these above findings it was revealed that among the different treatments, T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing the number of infested plants by epilachna beetle per five plants over control (76.93%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of infested plants by epilachna beetle per five plants over control (69.23%). As a result, the order of rank of efficacy of the treatments applied against epilachna beetle including untreated control in terms of reducing number of infested plants by epilachna beetle per five plants was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Sharma *et al*. (2012) reported that the treatment including pesticides and botanicals combined with cultural method reduced the plant infestation percentage (8.13%) caused by epilachna beetle (1.72 beetle/plant).

4.7. Yield contributing characters

4.7.1. Effects of management practices on plant height

There was no significant variation among the treatments in case of plant height per plot of brinjal field. Plant height of brinjal plant shows more or less similar throughout the growing season of brinjal cultivation (Table 14).

4.7.2. Effects of management practices on number of branch

There was no significant variation among the treatments in case of number of branch per plant of brinjal field. Number of branch of brinjal plant shows more or less similar throughout the growing season of brinjal cultivation (Table 14).

4.7.3. Effects of management practices on percent edible portion

There was significant variation among the treatments on percent edible portion of infested fruit per plant. The highest percent of edible portion of infested brinjal fruit per plant was found in T_7 (90.49%), which was significantly different from all other treatments and followed by T_1 (88.53%), T_5 (87.50%) and T_4 (63.73%). On the other hand, the lowest percent of edible portion of brinjal fruit per plant was found in T_8 (22.38%), which was significantly different from all other treatments and followed by T_3 (29.37%), T_6 (35.29%) and T_2 (47.67%) (Table 14). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of increasing percent of edible portion of infested brinjal fruit per plant was $T_7 > T_1 > T_5 > T_4 > T_2 > T_6 > T_3 > T_8$.

4.7.4. Effects of management practices on percent non-edible portion

There was significant variation among the treatments on percent non-edible portion of infested fruit per plant. The lowest percent of non-edible portion of infested brinjal fruit per plant was found in T_7 (9.51%), which was significantly different from all other treatments and followed by T_1

(11.47%), T_5 (12.50%) and T_4 (36.27%). On the other hand, the highest percent of non-edible portion of brinjal fruit per plant was found in T_8 (77.62%), which was significantly different from all other treatments and followed by T_3 (70.63%), T_6 (64.71%) and T_2 (52.33%) (Table 14). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of decreasing percent of non-edible portion of infested brinjal fruit per plant was $T_7 > T_1 > T_5 > T_4 > T_2 > T_6 > T_3 > T_8$.

Table 14: Effects of management practices on plant height, number of branch, percent of edible fruit weight and percent of non-edible fruit weight throughout the growing season of brinjal

Treatments	Plant height (cm)	No. of branch	Edible portion (%)	Non edible portion (%)
T_1	45.44 a	8.67 a	88.53 b	11.47 g
T_2	41.22 a	7.78 a	47.67 e	52.33 d
T_3	46.22 a	8.33 a	29.37 g	70.63 b
T_4	46.44 a	9.33 a	63.73 d	36.27 e
T_5	48.44 a	8.44 a	87.50 c	12.50 f
T_6	47.55 a	8.44 a	35.29 f	64.71 c
T_7	44.00 a	7.56 a	90.49 a	9.51 h
T_8	45.33 a	8.33 a	22.38 h	77.62 a
CV (%)	10.04	14.76	0.49	0.68
LSD (0.05)	7.73	2.08	0.48	0.48

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

4.7.5. Fruit length of brinjal

The highest fruit length of brinjal per plant was recorded in T_7 (12.02 cm), which was significantly different from all other treatments and followed by T_5 (10.52 cm), T_4 (10.17 cm) and T_1 (9.83 cm). On the other hand, the lowest fruit length of brinjal per plant was recorded in T_8 (6.13 cm), which was significantly different from all other treatments and followed by T_3 (8.01 cm), T_6 (9.17 cm) and T_2 (9.33 cm) (Table 15).

Considering the percent increasing of fruit length of brinjal per plant, the highest 96.08% over control was achieved in T_7 followed by T_5 (71.62%), T_4 (65.91%) and T_1 (60.36%). On the other hand, the minimum increasing of fruit length of brinjal per plant over control was achieved in T_3 (30.67%) followed by T_6 (49.59%) and T_2 (52.20%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of increasing fruit length per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

4.7.6. Girth of fruit of brinjal

The highest girth of fruit of brinjal per plant was recorded in T_7 (12.67 cm), which was significantly different from all other treatments and followed by T_5 (12.51 cm), T_4 (12.33 cm) and T_1 (12.07 cm). On the other hand, the lowest girth of fruit of brinjal per plant was recorded in T_8 (9.67 cm), which was significantly different from all other treatments and followed by T_3 (10.67 cm), T_6 (11.13 cm) and T_2 (11.50 cm) (Table 15).

Considering the percent increasing of girth of fruit of brinjal per plant, the highest 31.02% over control was achieved in T_7 followed by T_5 (29.37%), T_4 (27.51%) and T_1 (24.82%). On the other hand, the minimum percent increasing of girth of fruit of brinjal per plant over control was achieved in T_3 (10.34%) followed by T_6 (15.10%) and T_2 (18.92%) (Table 15). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of percent increasing of girth of fruit per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

Table 15. Effect of management practices on fruit length and girth of fruit of brinjal during growing season

Treatments	Fruit length (cm)	Increase over control (%)	Girth of fruit (cm)	Increase over control (%)
T_1	9.83 d	60.36	12.07 d	24.82
T_2	9.33 e	52.20	11.50 e	18.92
T_3	8.01 g	30.67	10.67 g	10.34
T_4	10.17 c	65.91	12.33 c	27.51
T_5	10.52 b	71.62	12.51 b	29.37
T_6	9.17 f	49.59	11.13 f	15.10
T_7	12.02 a	96.08	12.67 a	31.02
T_8	6.13 h	0.00	9.67 h	0.00
CV (%)	0.15		0.36	
LSD (0.05)	0.05		0.08	

[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

4.7.7. Single fruit weight

The significant variations were observed among different treatments used for the management practices in terms of single fruit weight of brinjal at different growing stage. At early fruiting stage, the lowest single fruit weight of brinjal was recorded in T_8 (17.33 gm), which was followed by T_3 (22.33 gm), T_6 (23.33 gm) and T_2 (26.33 gm). On the other hand, the highest single fruit weight of brinjal was recorded in T_7 (37.53 gm), which was followed by T_1 (33.33 gm), T_5 (32.33 gm) and T_4 (27.33 gm). More or less similar trends of single fruit weight of brinjal were also recorded at mid fruiting stage and late fruiting stage (Table 16).

In case of mean single fruit weight, the highest single fruit weight of brinjal was recorded in T_7 (39.00 gm) comprised of untreated control, which was significantly different from all other treatments and followed by T_5 (36.78 gm), T_1 (34.66 gm) and T_4 (31.78 gm). On the other hand, the lowest mean single fruit weight of brinjal was recorded in T_8 (19.11 gm), which was significantly different from all other treatments and followed by T_3 (23.22 gm), T_6 (24.66 gm) and T_2 (29.22 gm) (Table 16). Considering the percent increase of single fruit weight of brinjal, the maximum 104.08% over control was achieved in T_7 followed by T_5 (92.46%) and T_1 (81.37%). On the other hand, the minimum percent increase of single fruit weight of brinjal over control was found in T_3 (21.51%) followed by T_6 (29.04%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of single fruit weight of brinjal per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$.

4.7.8. Yield of brinjal

Significant difference was observed in brinjal fruit production under different treatments throughout the growing season. The highest yield of brinjal was observed in T_7 (35.36 ton/ha), which was statistically different from other treatments and followed by T_5 (31.80 ton/ha), T_4 (28.60 ton/ha) and T_1 (28.58 ton/ha). On the other hand, the lowest yield was observed in T_8 (15.25 ton/ha), which was statistically different from other treatments and followed by T_3 (19.28 ton/ha), T_6 (22.02 ton/ha) and T_2 (26.05 ton/ha) (Table 16). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of yield of brinjal (ton/ha) was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$. More or less similar research was also conducted by several researchers. Jena *et al*. (2006) revealed that application of carbaryl, cartap hydrochloride [cartap], endosulfan, diflubenzuron, azadirachtin and chlorpyrifos gave the highest fruit yield (196.61 quintal per ha).

Table 16: Effects of management practices on single fruit weight throughout the growing season and yield of brinjal

Treatments	Single fruit weight (gm) per plant and yield					Yield (ton/ha)
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	Infestation reduction over control (%)	
T_1	33.33 b	38.33 b	32.33 b	34.66 c	81.37	28.58 c
T_2	26.33 e	33.33 d	28.00 c	29.22 e	52.90	26.05 d
T_3	22.33 g	25.67 f	21.67 e	23.22 g	21.51	19.28 f
T_4	27.33 d	36.33 c	31.67 b	31.78 d	66.30	28.60 c
T_5	32.33 c	41.67 a	36.33 a	36.78 b	92.46	31.80 b
T_6	23.33 f	27.33 e	23.33 d	24.66 f	29.04	22.02 e
T_7	37.33 a	42.33 a	37.33 a	39.00 a	104.08	35.36 a
T_8	17.33 h	21.67 g	18.33 f	19.11 h	0.00	15.25 g
CV (%)	1.88	1.84	2.27	1.46		0.10
LSD (0.05)	0.87	1.034	1.10	0.73		0.05

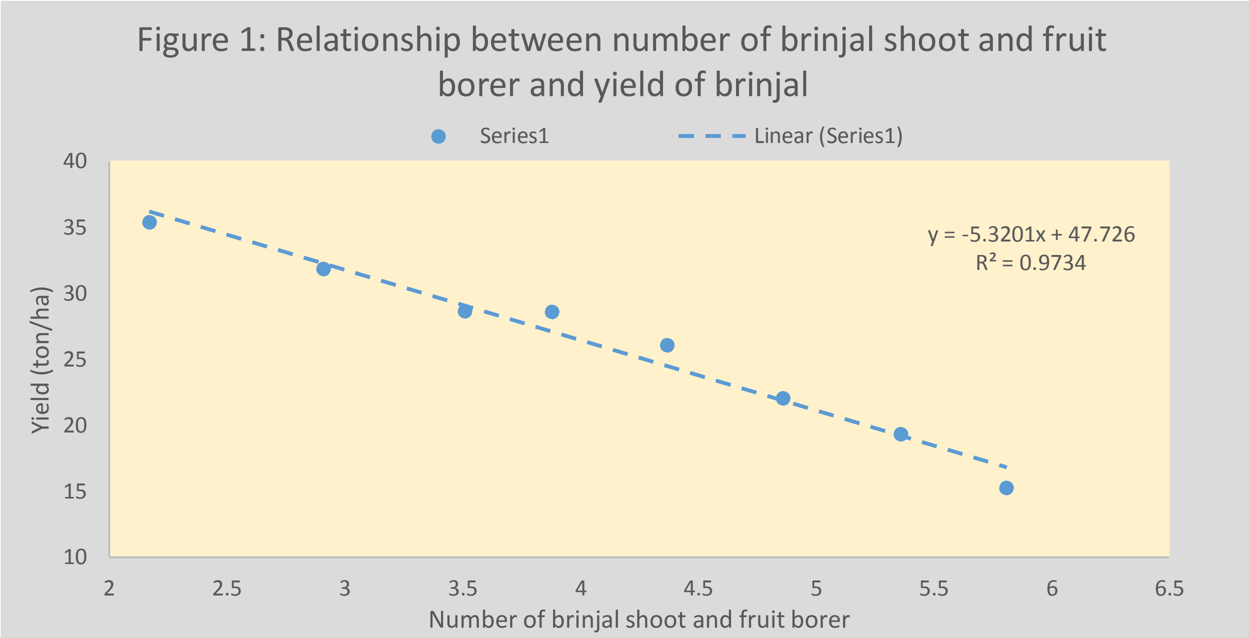
[DAT = Day After Transplanting, In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability]

[T_1 : Spraying of Neem oil @ 3.0 ml/L of water at 7 days interval; T_2 : Spraying of Neem seed kernel extract @ 3.0 ml/L of water at 7 days interval; T_3: Spraying of Bioneem plus @ 3.0 ml/L of water at 7 days; T_4 : Spraying of Marshal 25 EC @ 3.0 ml/L of water at 7 days interval; T_5 : Spraying of Ripcord 20 EC @ 1.0 ml/L of water at 7 days interval; T_6 : Spraying of Emitaf 20 SL @ 0.1 ml/L of water at 7 days interval; T_7 : Spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval; T_8 Untreated control.]

4.8. Relationship between different variables with yield of brinjal

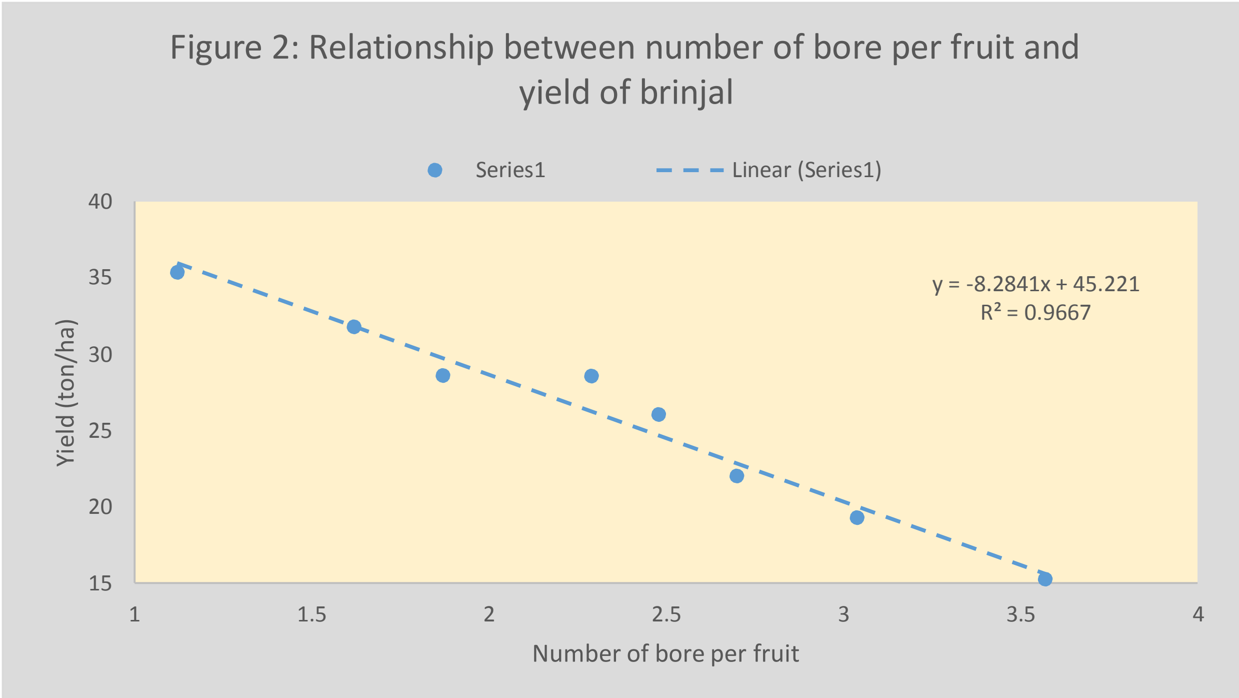
4.8.1. Relationship between number of brinjal shoot and fruit borer and yield

Correlation study was done to establish the relationship between number of brinjal shoot and fruit borer per plant and yield (t/ha) of brinjal. From the study it was revealed that significant correlation was observed between the number of brinjal shoot and fruit borer per plant and yield of brinjal (Figure 1). It was evident from the Figure 1 that the regression equation y = -5.3201x + 47.726 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9734) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the number of brinjal shoot and fruit borer per plant and yield of brinjal, i.e., the yield decreased with the increase of the number of brinjal shoot and fruit borer per plant during the growing season of brinjal.



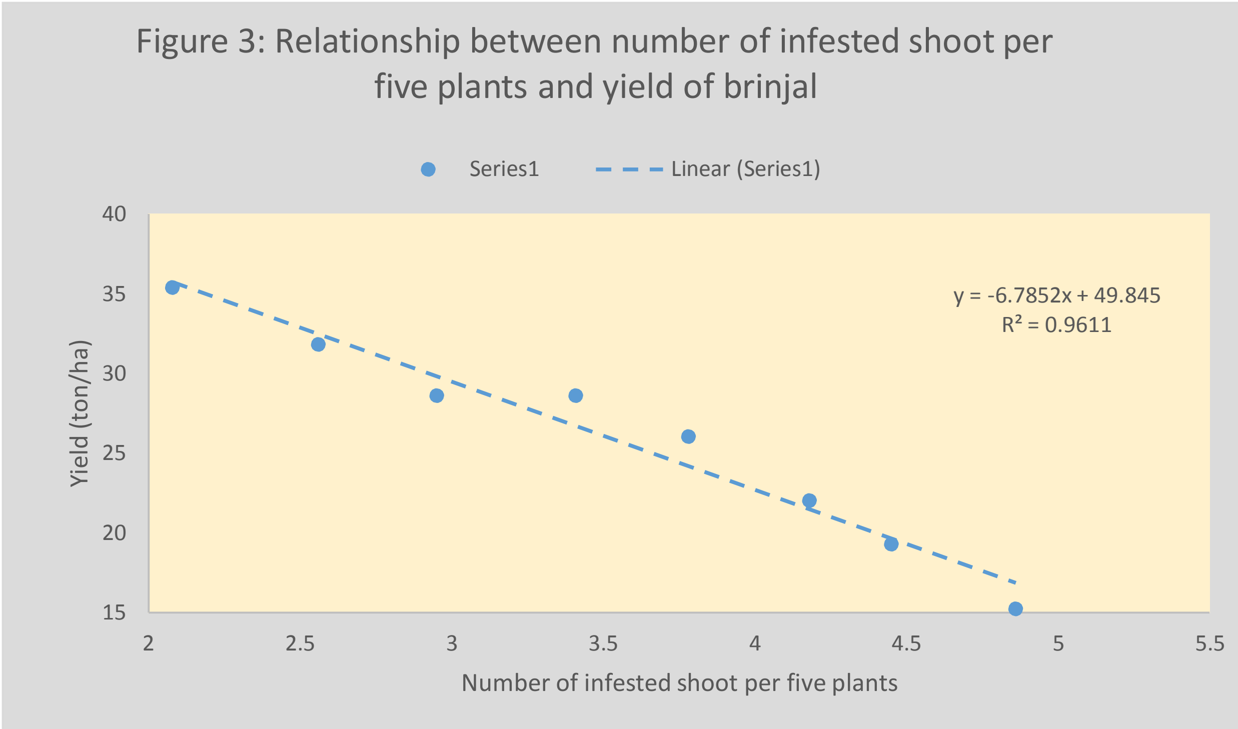
4.8.2. Relationship between number of bore per fruit and yield

Correlation study was done to establish the relationship between number of bore per fruit and yield (t/ha) of brinjal. From the study it was revealed that significant correlation was observed between the number of bore per fruit and yield of brinjal (Figure 2). It was evident from the Figure 2 that the regression equation y = -8.2841x + 45.221 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9667) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the number of bore per fruit and yield of brinjal, i.e., the yield decreased with the increase of the number of bore per fruit during the growing season of brinjal.



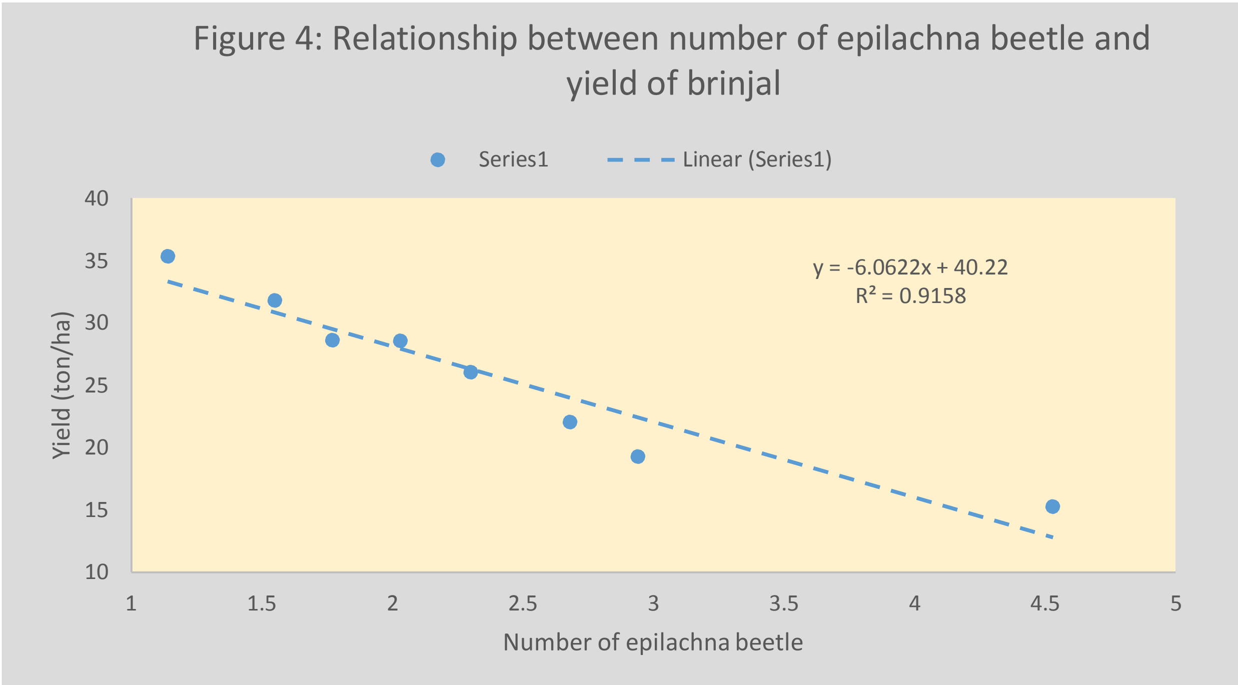
4.8.3. Relationship between number of infested shoot per five plants and yield

Correlation study was done to establish the relationship between number of infested shoot per five plants and yield (t/ha) of brinjal. From the study it was revealed that significant correlation was observed between the number of infested shoot per five plants and yield of brinjal (Figure 3). It was evident from the Figure 3 that the regression equation $y = -6.7852x + 49.845$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.9611$) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the number of infested shoot per five plants and yield of brinjal, i.e., the yield decreased with the increase of the number of infested shoot per five plants during the growing season of brinjal.



4.8.4. Relationship between number of epilachna beetle per plant and yield

Correlation study was done to establish the relationship between number of epilachna beetle per plant and yield (t/ha) of brinjal. From the study it was revealed that significant correlation was observed between the number of epilachna beetle per plant and yield of brinjal (Figure 4). It was evident from the Figure 4 that the regression equation y = -6.0622x + 40.22 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9158) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that t here was a negative relationship between the number of epilachna beetle per plant and yield of brinjal, i.e., the yield decreased with the increase of the number of epilachna beetle per plant during the growing season of brinjal.



4.8.5. Relationship between single fruit weight and yield

Correlation study was done to establish the relationship between single fruit weight per plant and yield (t/ha) of brinjal. From the study it was revealed that significant correlation was observed between the single fruit weight and yield of brinjal (Figure 5). It was evident from the Figure 5 that the regression equation y = 0.9381x - 2.0906 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9766) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a positive relationship between single fruit weight and yield of brinjal, i.e., the yield increase with the increase of the single fruit weight during the growing season of brinjal.

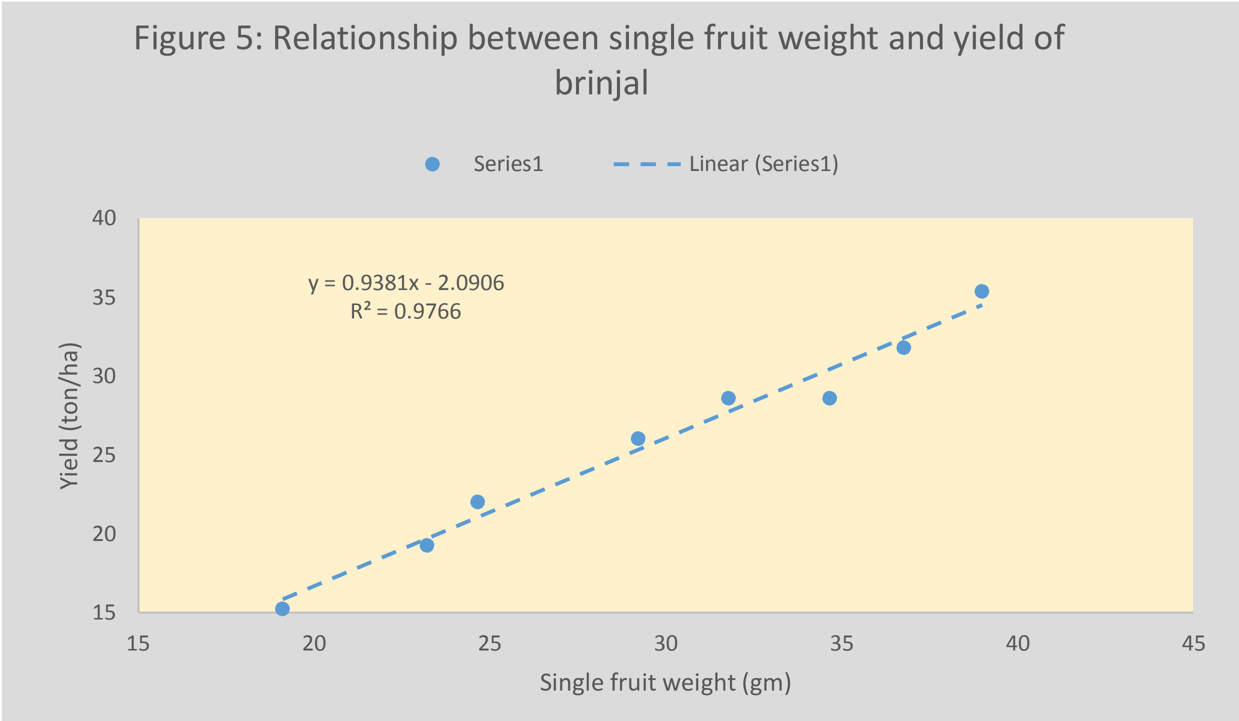


Figure 5: Relationship between single fruit weight and yield of brinjal
Series1
Linear (Series1)
y = 0.9381x - 2.0906
R² = 0.9766
Yield (ton/ha)
40
35
30
25
20
15
15
20
25
30
35
40
45
Single fruit weight (gm)

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November, 2017 to March, 2018 to evaluate some management practices applied against brinjal shoot and fruit borer and epilachna beetle of brinjal. The experiment consisted of control measures with chemical and botanical.

SUMMARY

In case of number of brinjal shoot and fruit borer per plant T_7 showed the highest decreasing over control (62.65%). Considering the botanical treatments, T_1 performed as the best treatment in terms of reducing the number of brinjal shoot and fruit borer over control (33.22%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of brinjal shoot and fruit borer per plant was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8.

In case of number of bore caused by brinjal shoot and fruit borer per five fruits T_7 showed the highest decreasing over control (68.63%). Considering the botanical treatments, T_1 performed as the best treatment in terms of reducing the number of bore caused by brinjal shoot and fruit borer over control (35.85%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of bore caused by brinjal shoot and fruit borer per five fruits was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8.

In case of number of infested shoot vaused by brinjal shoot and fruit borer per five plants T_7 showed the highest decreasing over control (57.20%). Considering the botanical treatments, T_1 performed as the best treatment in terms of reducing the number of infested shoot caused by brinjal shoot and fruit borer over control (29.84%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of infested shoot caused by brinjal shoot and fruit borer per five plants was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8.

In case of number of infested fruit by brinjal shoot and fruit borer per plant T_7 showed thwe highest decreasing over control (68.19%). Considering the botanical treatments, T_1 performed as the best treatment in terms of reducing the number of infested fruit caused by brinjal shoot and fruit borer per plant over control (33.18%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing number of infested shoot caused by brinjal shoot and fruit borer per five plants was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8.

The treatment T_7 showed the best result in reducing percent infestation of brinjal fruit in number per plant over control (92.33%). Considering the botanical treatments, T_1 performed as the best treatment in terms of reducing percent infestation of brinjal fruit in number per plant over control (74.18%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in number per plant was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8.

The treatment T_7 showed the best result in reducing percent infestation of brinjal fruit in number per plant over control (57.27%). Considering the botanical treatments, T_1 performed as the best treatment in terms of reducing percent infestation of brinjal fruit in number per plant over control (41.49%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in number per plant was T_7> T_5> T_4> T_1> T_2> T_6> T_3> T_8.

The treatment T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in number per plant over control (74.19%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in number per plant over control (68.73%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in number per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$.

The treatment T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in weight per plant over control (62.66%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in weight per plant over control (38.03%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in weight per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$.

The treatment T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in weight per plant over control (70.06%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in weight per plant over control (58.30%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in weight per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$.

The treatment T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing percent infestation of brinjal fruit in weight per plant over control (72.42%).

Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing percent infestation of brinjal fruit in weight per plant over control (67.18%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer including untreated control in terms of reducing percent infestation of brinjal fruit in weight per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$.

The treatment T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing number of epilachna beetle per plant over control (74.83%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of epilachna beetle over control (55.19%). As a result, the order of rank of efficacy of the treatments applied against aphid including untreated control in terms of reducing number of aphid per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

The treatment T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing the number of infested leaves by epilachna beetle per five plants over control (61.44%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of infested leaves by epilachna beetle per five plants over control (36.38%). As a result, the order of rank of efficacy of the treatments applied against epilachna beetle including untreated control in terms of reducing number of infested leaves by epilachna beetle per five plants was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

The treatment T_7 comprised with spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval in reducing the number of infested plants by epilachna beetle per five plants over control (76.93%). Considering the botanical treatments, T_1 comprised with spraying of Neem oil @ 3.0 ml/L of water at 7 days performed as the best treatment in terms of reducing the number of infested plants by epilachna beetle per five plants over control (69.23%). As a result, the order of rank of efficacy of the treatments applied against epilachna beetle including untreated control in terms of reducing number of infested plants by epilachna beetle per five plants was T_7> T_5> T_1> T_4> T_2> T_6> T_3> T_8.

There was no significant variation among the treatments in case of plant height per plot and number of branch per plant of brinjal field.

The highest percent of edible portion of infested brinjal fruit per plant was found in T_7 (90.49%), which wasfollowed by T_1 (88.53%) and T_5 (87.50%). On the other hand, the lowest percent of edible portion of brinjal fruit per plant was found in T_8 (22.38%), which was and followed by T_3 (29.37%) and T_6 (35.29%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of increasing percent of edible portion of infested brinjal fruit per plant was T_7> T_1> T_5> T_4> T_2> T_6> T_3> T_8.

The lowest percent of non-edible portion of infested brinjal fruit per plant was found in T_7 (9.51%), which was followed by T_1 (11.47%) and T_5 (12.50%). On the other hand, the highest percent of non-edible portion of brinjal fruit per plant was found in T_8 (77.62%), which was followed by T_3 (70.63%) and T_6 (64.71%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of decreasing percent of non-edible portion of infested brinjal fruit per plant was T_7> T_1> T_5> T_4> T_2> T_6> T_3> T_8.

The percent increasing of fruit length of brinjal per plant, the highest 96.08% over control was achieved in T_7 followed by T_5 (71.62%), T_4 (65.91%) and T_1 (60.36%). On the other hand, the minimum increasing of fruit length of brinjal per plant over control was achieved in T_3 (30.67%)

followed by T_6 (49.59%) and T_2 (52.20%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of increasing fruit length per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

The percent increasing of girth of fruit of brinjal per plant, the highest 31.02% over control was achieved in T_7 followed by T_5 (29.37%), T_4 (27.51%) and T_1 (24.82%). On the other hand, the minimum percent increasing of girth of fruit of brinjal per plant over control was achieved in T_3 (10.34%) followed by T_6 (15.10%) and T_2 (18.92%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of percent increasing of girth of fruit per plant was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

The percent increase of single fruit weight of brinjal, the maximum 104.08% over control was achieved in T_7 followed by T_5 (92.46%) and T_1 (81.37%). On the other hand, the minimum percent increase of single fruit weight of brinjal over control was found in T_3 (21.51%) followed by T_6 (29.04%). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of single fruit weight of brinjal per plant was $T_7 > T_5 > T_1 > T_4 > T_2 > T_6 > T_3 > T_8$.

The highest yield of brinjal was observed in T_7 (35.36 ton/ha), which was statistically different from other treatments and followed by T_5 (31.80 ton/ha), T_4 (28.60 ton/ha) and T_1 (28.58 ton/ha). On the other hand, the lowest yield was observed in T_8 (15.25 ton/ha), which was statistically different from other treatments and followed by T_3 (19.28 ton/ha), T_6 (22.02 ton/ha) and T_2 (26.05 ton/ha). As a result, the order of rank of efficacy of the treatments applied against brinjal shoot and fruit borer and epilachna beetle including untreated control in terms of yield of brinjal was $T_7 > T_5 > T_4 > T_1 > T_2 > T_6 > T_3 > T_8$.

CONCLUSION

From the present study, it may be concluded that incidence of brinjal shoot and fruit borer and epilachna beetle of brinjal was significantly varied among the treatments. The overall study revealed that the highest performance was achieved from T_7 comprised of spraying of Actara 25 WG @ 0.2 gm/L of water at 7 days interval. It might increase the number of beneficial arthropods, weight of single fruit, length of fruit, girth of fruit and yield. T_1 comprised of spraying of Neem oil @ 3.0 ml/L of water at 7 days interval also showed better performance against brinjal shoot and fruit borer and epilachna beetle of brinjal. Considering the results of the present study and environmental issues it can be concluded that T_1 comprised of spraying of Neem oil @ 3.0 ml/L of water at 7 days interval may be used for the management of brinjal shoot and fruit borer of brinjal.

Considering the findings of the study the following recommendations might be drawn:

1. Judicious use of chemical insecticides in management practices against brinjal shoot and fruit borer and epilachna beetle of brinjal.
2. To increase the number of beneficial arthropods in the brinjal field.
3. Further study of this experiment is needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI

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CHAPTER VII

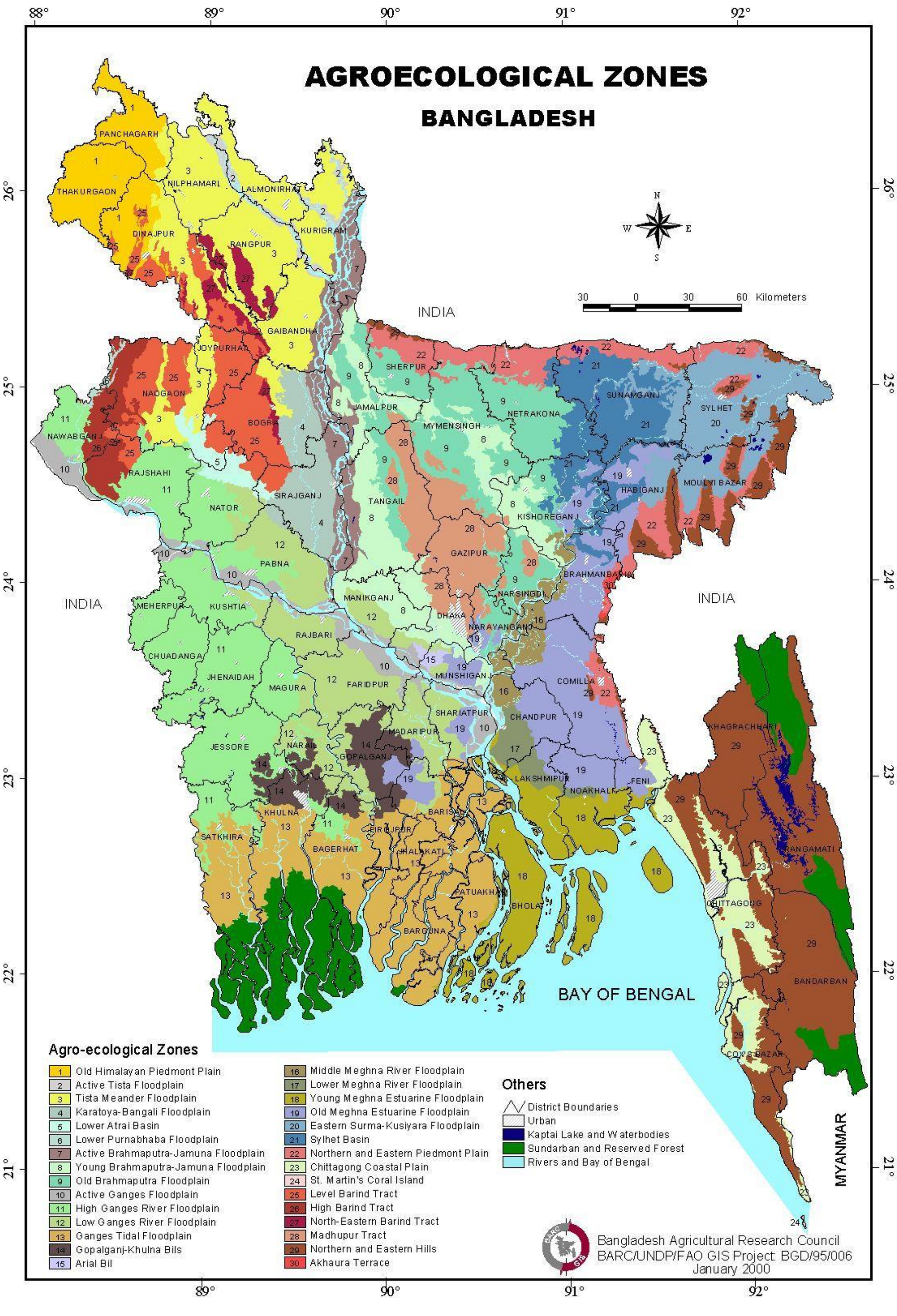
APPENDICES

Appendix 1: Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from November 2017 to March 2018

Date/Week	Temperature		Relative humidity (%)	Rainfall (mm) (Total)
	Maximum	Minimum		
November	30.2	20.6	67	6.0
December	26.8	17.1	76	33.0
January	23.6	12.6	68	0.0
February	29.2	18.1	61	20.0
March	33.3	22.3	59	3.0

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207.

Appendix II. Experimental location on the map of Agro-ecological Zones of Bangladesh.



Source: Bangladesh Agricultural Research Council, Khamarbari, Dhaka.

Appendix III. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0-15 cm depth)

Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	**Value**
Organic carbon (%)	0.45
Organic matter (%)	0.54
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17 meq/100 g soil
Boron	0.88 µg/g soil
Copper	1.64 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 meg/100g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka