ECO-FRIENDLY MANAGEMENT OF INSECT PEST OF Bt BRINJAL FOR ENSURING YIELD AND QUALITY SEED PRODUCTION

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Dedicated To

My BelovedParents

Department of Entomology
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CERTIFICATE

This is to certify that thesis entitled, **ECO-FRIENDLY MANAGEMENT OF INSECT PEST OF Bt BRINJAL FOR ENSURING QUALITY YIELD**submitted to the Faculty of Agriculture,Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **INSTITUTE OF SEED TECHNOLOGY,** embodies the result of a piece of bona fide researchwork carried out by Mst. Lucky Khatun, Registration No. 14-05951 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 2021
Dhaka, Bangladesh

Prof.Dr. TahminaAkter
Supervisor

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ABSTRACT

The experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to evaluate the eco-friendly management of insect pest of bt brinjal for ensuring quality yield during the period from October, 2020 to April 2021. BARI Bt Begun-1 was used as the test crop and the experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Seven treatments, viz. Treatment T_1 (Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals); T_2 (Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals); T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals)**;** T_4 (Actara 25WG @ 0.3gm/L at the 15 days intervals); T_5 (Larval parasitoid + Yellow sticky board traps); T_6 (Field sanitation + Yellow sticky board traps) and T_7 (untreated control) were included in this study. In case of different treatments performance, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL @ 0.5 ml/L at the 7 days intervals) showed the best results in terms of incidence of brinjal shoot and fruit borer, number of Jassid, Aphid, Epilachna beetle and Whitefly plant^{-1}, yield of healthy fruit and infested fruit, yield contributing characters and yield (t/ha) of bt brinjal. In term of total yield, the highest yield of brinjal (53.08 t/ha) was observed in T_3 treatment which was closely similar with others treatment except untreated control. There was negative relationship present in number of brinjal shoot and fruit borer, jassid, Aphid, Epilachna beetle, Whitefly and fruit infestation in weight basis with the yield of bt brinjal, i.e. when the number of brinjal shoot and fruit borer and percentage of fruit infestation in weight basis was increased the yield of bt brinjal was decreased. From the study, it may be concluded that treatment T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL @ 0.5 ml/L at the 7 days intervals) was more efficacy of different treatment for the eco-friendly management of insect pest of bt brinjal for ensuring quality yield which was followed by spraying of T_2 (Larval parasitoid + Bamper 20SL @ 0.5 ml/L at the 7 days intervals).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF SYMBOLS AND ABBREVIATION

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

CHAPTER I

INTRODUCTION

Brinjal or eggplant (*Solanum melongena* L.) is an important solanaceous crop grown in Bangladesh. It is one of the major vegetables and its production ranks third among all vegetables in the world (BBS 2020). Brinjal is a versatile and economically important vegetable among small-scale farmers and low-income consumers of the entire universe (FAO 2020). Nutritionally brinjal offer substantial amounts of some vitamins and minerals (Nonnecke 1989). It is a perennial but grown commercially as an annual crop. Although Bangladesh produced huge amount of brinjal it is only a fraction of the world's production. In Bangladesh, over 1,24,526 acres of total cultivable land is devoted to brinjal cultivation (BBS 2020).

Brinjal is grown across Bangladesh round the year. It is cultivated on small, family- owned farms where sale of its product serves as a ready source of cash income throughout the year. It is rich in protein, calorie, riboflavin, calcium and iron. A number of cultivars are grown throughout the country depending on yield, size and shape as well as consumer’s preference. The actual area under brinjal cultivation is not available due to its seasonal nature of cultivation. In Bangladesh total cultivated area of kharif and rabi brinjal reported to be 22,221 hectares and 42,836 hectares of land respectively and total production was 3,78,000 metric tons (BBS 2020). The wide range of variability was observed in respect of morphological traits, but till date very few systematic assessments of genetic diversity on this crop has been done. Brinjal has been a popular vegetable in our diet since ancient times. It is liked by both poor and rich. Contrary to the common belief, it is quite rich in nutritive value and can be compared with tomato (Choudhury 1976). But its productions is hampered due to the infestation of different insects like root and shoot borer. Ultimately the control approach based entirely on toxic pesticides and chemicals is not working properly in the field. On the other hand, the chemicals and pesticides led to higher costs of production, environmental pollution, destruction of natural enemies, development of pesticide resistance etc.

Only the caterpillars of BSFB cause 78.66% damage to top shoot in vegetative phase and then shifted to flowers and fruits with infestation reaching 67% in reproductive phase (Singh *et al.* 2000). Because of its devastating effect inside fruit, the fruits wind up noticeably unmarketable and yield reduction up to 90 percent (Baral *et al.* 2006). In order to control such notorious pests, farmers in Bangladesh apply insecticides unwisely. Even, to control BSFB infestation, famers apply insecticides 140- 180 times in a cropping season. Huge chemicals in environment leads to pollution that poses serious health risk among mankind. Hostplant resistance is one of the ways that can omit pesticide use; thus transgenic/genetically modified technology has emerged as an alternative to chemicals in controlling insect pests. Nevertheless, the first GM food crop viz. Bt brinjal, has been developed by India based Maharashtra Hybrid Seed Company (Mahyco) by using a Bacillus thuringiensis cry1Ac gene to transform brinjal to be resistant in BSFB (Shelton *et al.* 2017). Bangladesh approved four Bt brinjal varieties in 2013, and subsequently distributed to selected farmers in major brinjal growing regions across the country

The Bt brinjal is a suite of transgenic brinjals created by inserting a crystal protein gene (Cry1Ac) from the soil bacterium *Bacillus thuringiensis* into the genome of various brinjal cultivars. *Bacillus thuringiensis* microbial formulations have been shown to be very specific to target insect pests. Bt is a trait and not a variety of Brinjal and it is important to point this out because people tend to confuse trait and variety. This Bt trait is added to existing varieties of Brinjal by back-crossing. For example, there are hundreds of varieties of Bt-Cotton in India, just as there are many non-Bt varieties as well. Bt brinjal provides an effective environmentally friendly and economically sustainable solution to tackle crop losses resulting from fruit and shoot borer infestation. The cry1-Ac protein produced in Bt brinjal is similar in structure and activity to that found in nature and is already available and used commercially in the form of Bt-based bio-pesticides, often used by organic growers. However, pesticidal sprays are only effective during a brief window then the larvae hatches from the egg and bores into the fruit or shoot of the brinjal plant. Once the larvae take refuge within the fruit, they are safe from surface sprays however intensive they may be, and are free to destroy the crop from within. Bt brinjal, in which the cry1-Ac gene is genetically engineered into the brinjal, ensures a built-in resistance against the fruit and shoot borer larvae. From the very beginning of Bt brinjal propaganda, controversy is also going with the flow. Many argued on the so-called sustained resistance of Bt gene upon BSFB. It needs to regular observation whether Bt gene is showing its performance as described or not.

Management of insect pests of brinjal in Bangladesh is basically based on chemical insecticides. Among various insecticides available in the market, few are effective against BSFB of brinjal. As many insecticides are under investigation to check their efficacy against brinjal pests, many of them reported as resistant as well as relatively toxic to human (Teotia and Singh 1971). Bangladesh Agricultural Research Institute (BARI) is involved in research to improve the production and quality of Bt brinjal. Already they released four variety of Bt brinjal. The varieties are BARI Bt Begun-1 (Uttara), BARI Bt Begun- 2 (Kajla), BARI Bt Begun-3 (Nayantara) and BARI Bt Begun-4 (ISD006). Further researches are carried on to find out most effective in relation to conventional insecticides and which are less toxic to manage pest population.

Sequel to the above, present research has been undertaken:

* To determine the Incidence and damage severity of insect pests of Bt brinjal and their natural enemies during the study period
* To assess efficacy of management practices for controlling insect pests of Bt brinjal and
* To assess the yield of brinjal for ensuring quality seed production.

CHAPTER II

REVIEW OF LITERATURE

An attempt has been made to bring out review relating to the "Eco-friendly management of insect pest of bt brinjal for ensuring yield and quality seed production" A brief resume of the work done in the past by various workers given in this chapter.

2.1. Brinjal: Morphological characters

Brinjal or eggplant (*Solanum melongena* L.) is the admired, common and predominant non-tuberous vegetable in Bangladesh and other parts of the world. The genus *Solanum* under the family *solanaceae* is consists of diverse flowering plants among which few high-value economically important food crops exist (Annon. 2018). Brinjal is one of the prominent food crops among them. It is well known for its high-water content and low calorific value (Kandoliya *et al.* 2015). According to Wankhede (2009), brinjal fruit contains moisture 91.5 per cent, protein 1.3 per cent, minerals 6.5 per cent, carbohydrates 6.4 per cent, calcium 0.02 per cent, phosphorus 0.06 per cent and iron 1.3 per cent respectively. It also contains vitamin A 5 mg /100 g, vitamin B 45 mg / 100 g, nicotinic acid 0.08 mg / 100 g, riboflavin 90 mg / 100 g, vitamin C 23 mg / 100 g.

Chowdhury *et al.* (2007) conducted an experiment in the Olericulture Division of Horticulture Research Centre (HRC) of Bangladesh Agricultural Research Institute (BARI) during the winter season 2003-04,) to evaluate and compare aubergine genotypes Uttara, BL-081, B-009, BL-SA-02, Nayantara, BL-097, BL-102, BL-113, BL-114, ISD-006, BL072, EG-195, BL-095, BL-081, BL-099 and Kazla representing samples from the different districts of Bangladesh. Various morphological and yield contributing characters of these aubergine genotypes were observed. Significant variations for most of the morphological 6 characters were observed among the aubergine genotypes. The results revealed that the maximum number of fruits per plant was obtained from the line BL-099 (43.67). The maximum fruit weight (410.9 g), fruit weight per plant (4.79 kg) and fruit breadth (8.71 cm) were recorded from the line ISD-006. The longest fruit was recorded from the line B009 (30.22 cm).

Beside its food value, brinjal has immense importance in terms of medicinal value. Fruit phenols such as anthocyanins and strychnine from brinjal have potential to cure a variety of disease like cancer, hypertension, hepatosis (Magioli and Mansur 2005 and Silva *et al.* 1999). Mutalik *et al.* (2003) reported that brinjal has beneficial effects in the treatment of inflammatory stress, cardiac debility, neuralgias, bronchitis and asthma. A study by Igwe *et al.* (2003) suggested that brinjal can have positive consequences on visual function. A 1984 study by Vohora *et al.* revealed that brinjal contains fraction of crude alkaloid that has significant analgesic effect. Such nutritional and medicinal qualities of brinjal make it worth consuming.

Kushwah and Bandhyopadhya (2005) observed variability and correlation analyses for 13 traits (number of days to 50% flowering, number of flowers per cluster, number of fruits per cluster, number of days to first picking, number of pickings, fruit length, fruit diameter, fruit weight, number of fruits per plant, leaf area, number of leaves, plant height, and fruit yield per plant) of aubergine which were conducted in Tehri Garhwal, Uttaranchal, India during the kharif of 2000. Highly significant variation among the genotypes was recorded for all traits. High phenotypic and genetic coefficients of variation, and high genetic advance were recorded for fruit weight, number of flowers per cluster, and fruit diameter. Except for leaf area and number of leaves, high heritability estimates were recorded, suggesting that selection for the remaining characters would be effective. At the genetic level, the number of fruits per plant, fruit diameter, and number of pickings showed a 7 significant positive correlation with yield per plant. At the phenotypic level, fruit yield was positively correlated with the number of pickings, fruit diameter, and number of fruits per plant, but was negatively correlated with the number of days to first picking. Fruit weight and diameter were negatively correlated with the number of fruits per plant, fruit length, number of fruits per cluster, and number of flowers per cluster.

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2.2. Bt brinjal adoption in Bangladesh

Upon the application of BARI (Shelton *et al.* 2018) to the National Technical Committee on Crop Biotechnology (NTCCB), NTCCB core committee; with the follow-up of National Committee on Bio-safety released four varieties (BARI Bt brinjal varieties 1, 2, 3 and 4). However, government during the period granted approval for ‘limited’ cultivation. During 2014, seedlings of these varieties were distributed among some selected farmers across the country. Bt Brinjal-1 variety, popularly referred as Uttara, was distributed in Rajshahi region; Bt Brinjal-2 (former Kajla) in Barisal region; Bt Brinjal-3 (Nayantara) in Rangpur and Dhaka regions; and Bt Brinjal-4 variety, Iswardi/ISD006, was planted in Pabna and Chittagong regions of the country. However, according to Choudhury *et al.* (2014), Bt gene would be incorporated in more five promising brinjal varieties in Bangladesh namely Dohazari, Shingnath, Chaga, Islampuri and Khatkatia. Bangladesh Agricultural Development Corporation (BADC) in collaboration with Bangladesh Agricultural Research Institute (BARI) is currently responsible for multiplication and distribution of Bt brinjal varieties in Bangladesh.

2.3. Insect pests of brinjal, their host preference, nature of damage

Abrol and Singh (2003) stated that fruit and shoot borer (FSB) is a small larva that bores inside shoots and bores into petioles and midribs of large leaves and tender shoots, causing shoot tips to wilt. Later on, they also bore into flower buds and fruits. Attributable to its infestation, it affects the quality and quantity of fruits. Affected fruits are difficult to sell on the market (unless the price is discounted heavily) and contain significantly less vitamin C.

Alam *et al.* (2003) observed that the full-grown larvae come out of the infested shoots and fruits and for pupate in the dried shoots and leaves or in plant debris fallen on the ground within tough silken cocoons. There were evidences of presence of cocoons at soil depths of 1 to 3 cm. FAO (2003) made a study which stated that the full-grown larvae pupate on the surface they touch first. The pupal period lasts 6 to 17 days depending upon temperature.

Rahman (2006) stated that it is 7 - 10 days during summer, while it is 13 - 15 days during winter season. The color and texture of the cocoon matches the surroundings making it difficult to detect. Braham and Haji (2009) conducted an experiment to determine the use of insecticides based on different chemistry and found that 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. Use of pesticide was not suggested at first hand but judicious use as last option of pest management was suggested globally.

Chakraborti and Sarkar (2011) stated that eggplant fruit and shoot borer, Leucinodes orbonalis Guenee is the key pest of eggplant inflicting sizeable damage in almost all the eggplant growing areas. Dutta et al. (2011) also observed that it is most destructive, especially in south Asia. Baral *et al.* (2006) studied its feeding inside fruit; the fruits become unmarketable and yield losses up to 90 percent. Sharma (2002) stated that it also reduces the content of vitamin C in fruit up to 80 percent. Gapud and Canapi (1994) observed that many farmers leaving growing eggplant because of this pest. Therefore, pertinent literatures were gleaned and overviews prepared for the management of the *L. orbonalis* with consideration of supporting literature helpful for management.

Singh and Kumar (2005) observed breeding activities in brinjal for the development of high-yielding, early, better quality and disease resistant varieties. The color of the fruit and size and shape, the proportion of seeds to pulp, short cooking time and lower solanine levels are important traits in assessing quality. As brinjal is susceptible to several pests and diseases such as wilt, Phomopsis, little leaf and root-knot nematodes and to insects such as shoot and fruit borer, jassids, epilachna beetle, etc. the development of pest resistant varieties is a major challenge. Plants are susceptible to both low and high temperature; therefore, attempts are being made to develop chilling or frost- tolerant and heat-tolerant varieties.

Srinivasan (2008) conducted an experiment through the integrated pest management (IPM) strategy for the control of *L. orbonalis* consists of resistant cultivars, sex pheromone, cultural, mechanical and biological control methods. Successful adoption of IPM in eggplant cultivation increase profits, protect the environment and improve public health. 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.

Crawford *et al.* (2003) and Quasem (2003) conducted detailed socioeconomic studies along with large scale trials of Bt Brinjal and indicated the potential of Bt

Brinjal to increase farmers' welfare through insecticide reductions and an increase in marketable yields of brinjal fruits. Different studies were conducted separately by different universities (like the University of Hohenheim by Stuttgart, Germany and the Singapore Management University) to demonstrate the socioeconomic impact of Bt Brinjal. They found that Bt technology has a significant potential to increase farmers' welfare through insecticide reductions and sizeable increases in marketable yield. The most destructive insect pest of eggplant in the Philippines and other Asian countries is the fruit and shoot borer (FSB). Eggplant yield losses from 51 to 73% due to FSB have been reported in the country.

Neupan (2000) evaluate that the cultural practice, i.e. pruning of infested twigs and branches prevents the dissemination of *L. orbonalis*. Ghimire *et al.* (2001) observed that the periodic pinching per pruning of wilted damaged shoot, their collection and burying or burning helps to reduce pest infestation. Talekar (2002) stated that pruning will not adversely affect the plant growth as well as yield. It is especially important in early stages of the crop growth and this should be continued until the final harvest. In addition, prompt destruction of pest damaged eggplant shoots and fruits at regular intervals, reduced the pest.

Duca *et al.* (2004) reported that weekly removal of damaged fruits and shoots resulted in the highest weight of healthy fruits and lowest incidence of damaged fruits among the treatments. Rahman (2000) and Wilson (2001) stated that the brinjal fruit and shoot borer (FSB) is the most destructive insect pest in South and South East Asia. To control this insect pest, farmers all over the world use large quantities of chemical insecticides singly or in combination to get blemish free fruits. In the district of Jessore, farmers spray pesticides 140 times during a cropping season of 180-200 days. As a result, farmers suffer numerous health problems (including skin and eye irritation, nausea, and faintness), resulting from direct exposure to pesticide during handling and spraying. Alam *et al.*

(2003) reported that in Bangladesh, almost all farmers experienced sickness related to pesticide application (e.g., physical weakness or eye infection or dizziness) and 3 percent were hospitalized due to complications related to pesticide use.

Donegan *et al.* (1995) reported an important aspect of the risk assessment of transgenic plants on soil ecosystem from residual plant material following harvesting and tillage. In their experiments, they suggested that apart from Bt toxin production, genetic manipulation or tissue culturing of the plants may have produced a change in plant characteristics that can influence growth and species composition of soil micro-organisms. But they did not observe any toxic effect of Cry protein on microorganism of the soil.

Nayer *et al.* (1995) reported that brinjal is attacked by 53 species of insect pests. A pest risk analysis study was undertaken in Bangladesh in 2016 by Hossain et al. They reported 20 insect pests in brinjal among which 19 insects and 1 mite pest found. Among them brinjal shoot and fruit borer, epilachna beetle, jassid, aphid and whitefly were described as major insect pests of brinjal.

2.4. FSB of brinjal, their host preference and nature of damage

BSFB is the most notorious pest of brinjal in Bangladesh. Being phytophagous, BSFB is under the order lepidoptera and Alam and Sana (1962) reported that the genus *Leucinodes* has three main species namely *L. orbonalis* Guen., *L. diaphana* Hamps and *L. apicalis* Hamps.

Host preference

BSFB attacks not only brinjal but other solanaceous crops. Study revealed (Karim 1994) that wild relatives of genus *Solanum* can be attacked by this notorious pest. Caterpillar of this moth feed on pea pods (Alam and Sana 1962). *Solanum nigrum, Solanum myriacanthum* can potentially play significant role as alternative host of brinjal shoot and fruit borer. (CABI 2007; Ishaque and Chaudhuri 1984).

Nature of damage

The higher percent of the larvae was in fruits taken after by shoots, blossoms, bloom buds and midrib of leaves (Alpuerto 1994). Inside one hour in the wake of bring forth, *L. orbonalis* caterpillar drills into the closest delicate shoot, bloom, or fruit. Not long after in the wake of drilling into shoots or fruits, they attachment or stop up the passageway opening (nourishing passage) with excreta (Alam *et al.* 2006).

Larval nourishing in bloom was uncommon, if happen, inability to shape fruit from harmed blossoms (Alam *et al.* 2006). The caterpillars of L. orbonalis bore into the developing points of young tender shoots and a wilted drooping shoots a run of the mall manifestation, which at last shrivels away. The fruiting beads droop down while the fruits indicate round about openings, which are the leave gaps.

L. orbonalis attacks for the most part on blossoming, fruiting and vegetative developing stage on fruits/units, developing parts and inflorescence (CABI 2007). Like other members of the order lepidoptera, *L. orbonalis* goes through four growth stages: egg, larva, pupa and adult. The larval period is the longest, followed by pupal and incubation period. Oviposition takes place during the night and eggs are laid singly on the lower surface of the young leaves, green stems, flower buds, or calyces of the fruits and number of eggs laid by a female varies from 80 to 253 (Taley *et al.*1984; Alpuerto 1994). The eggs are laid in the early hours of the morning singly or in the batches on the ventral surface of the leaves (CABI 2007). Eggs are flattened, elliptical with 0.5 mm in diameter and colour is creamy-white but change to red before hatching (Alam *et al*. 2006). The egg takes incubation period of 3-5 days in summer and 7-8 days in winter and hatch into dark white larvae. The larval period lasts 12-15 days during summer and 14-22 days during winter season (Rahman 2006). Larvae pass through at least five instars (Shaukat *et al.* 2018; Atwal 1976) and there are reports of the existence of six larval instars (FAO 2003; Baang and Corey 1991).

Incidence of brinjal shoot and fruit borer

L. orbonalis is energetic amid the time at places having direct air however its development is antagonistically impacted by genuine chilling detailed by Naqvi *et al.* (2009). They found that BSFB pervasion on brinjal begun in Eminent and accomplished its peak in October and a while later started declining. Concurring to Farman *et al.* (2016), a moo pervasion (18.66%) of borer was famous within the third week of May, severe pervasion (75.50%) within the to begin with week of Eminent, and a tall pervasion (42.64%) within the final week of September at the conclusion of the crop growing season. Ghosh and Senapati (2009) found that this bug causes the foremost annihilation and is most energetic in the midst of the late spring months, i.e., from May to Admirable. It turns out to be less energetic in the midst of the winter months, particularly in December and January. Varma *et al.* (2009) considered the event and wealth of BSFB in Allahabad, India and observed the foremost raised rate on brinjal in December. Patel *et al.* (1988) found shoot and natural product harm in brinjal by BSFB was higher in May transplanted (spring) crops than that in July and September transplanted (drop) crops. The harm caused by creepy crawly alter from season to season since coordinate temperature and tall dampness bolster the people create of brinjal shoot and natural product borer (Bhushan *et al.* 2011; Shukla and Khatri 2010). Zones having a hot and sticky climate are conducive for its dissemination and rate. Patel *et al.* (1988) detailed that summer season brinjal has more defenselessness than winter season brinjal. Pawar *et al.* (1986) found most noteworthy shoot invasion amid mid-September whereas crest natural product pervasion was detailed amid mid-November.

2.5. Jassid, their host preference and nature of damage

Jassid may be a common sucking pest of brinjal and can be found throughout the world. This flexible pest may be a cause of ranchers pressure due to its wide run of have inclination and capability to cause colossal harm. (Ghauri 1963).

Host preference

Other than living on brinjal and cotton primarily, jassids moreover harbor on different herb like plants and crop as well as on numerous weeds of solanaceae, malvaceae and Cruciferae family (Prasad and Logiswaran 1997b).

Nature of damage

Das and Islam (2014) claimed jassid as the moment major pest of brinjal due to its tall populace escalated and harm seriousness. Ali *et al.* (2012) detailed that brinjal is one of the foremost top pick have plants of *A. biguttula biguttula*. Numerous researchers distinguished jassid as major key pest of Brinjal (Latif et al. 2009; Iqbal *et al.* 2008). Iqbal *et al.* (2008) expressed that oriental locales i.e. tropical and subtropical are appropriate for jassid populace due to the reality that the climate conditions winning in these districts are conducive for host-plant interaction. These authors also reported early damage in brinjal by jassid. Most importantly, they don’t reduce the plant vigor by sucking cell sap only, also they spread mosaic virus disease as a vector and thus affect the fruit yield rigorously (Samal and Patnaik 2008). Jassid is phytophagous in nature and the degree of jassid harm to number and weight of brinjal may well be as much as 54 percent (Mahmood *et al.* 2002). Jassid caused annihilating impact in solanaceous crops and hampered the transportation process through the phloem tissues of plant and conceivably presented a poison that's inhibitory to photosynthesis action (Sharma and Chandar 1998).

Incidence of jassid on brinjal

A population dynamics study by Saroj *et al.* (2017) brinjal jassid first reported during 32^{nd} SW and were found up to 41^{st} SW. Highest number of jassids (12.70 jassids/ leaf) was reported during 37^{th} SW Gangwar and Singh (2014) carried out an experiment on succession of brinjal pest complex. They found jassid population from August to December i.e. the population appeared in the first week after transplanting and its population development continued up to the maturity stage of brinjal. Dabhi and Koshiya (2014) reported peak population of jassid during 16^{th}, 18^{th}, 24^{th}, 33^{rd} SW. Kadam (2003) development of jassid population was associated with Dhamdhere *et al*. (1995) observed peak population of jassid in the third week of September however, they found activity of jassid during both rabi and kharif season. Ali and Karim (1991) carried out an experiment on cotton jassid. They reported that highest number of jassids were found during 35 to 75 days after transplanting in kharif season and 65 to 135 days in rabi season. According to Prakash (1978) peak population of jassid observed during late September to mid-November.

2.6. Aphid, their host preference and nature of damage

Aphid belongs to the Aphididae family and hemiptera order. It's a major sucking pest of some commercially important food crop and phytophagous in nature. Different species of aphid such as *Aphis craccivora, Aphis gossypii, Myzus persicae* feed on brinjal, tomato and many other vegetables as well as cereal crops (Alam 1969).

Host preference

Aphid is a versatile crop pest and can be found all over the world. Singh *et al.* (2014) carried out an experiment for host plants of *A. gossypii* in India and recognized 29 plant species of the family Solanaceae to be host for the *A.*

gossypii and recognized *C. annuum* as the most important host. Shakeel *et al.* (2014) reported aphid as a serious threat to agricultural crops. Evans and Halbert (2007) prepared a checklist of aphids of Honduras on different host plants and reported *A. gossypii* and *M. persicae* on *Solanum melongena*. Nayer *et al.* (1976) said that *Aphis craccivora* is the most common aphid species and found to infest a wide range of vegetables and pulse crops.

Nature of damage

Miller *et al.* (2009) stated that the direct consequences of aphid infestation causes yield losses, decline in quality and increased agricultural potential risks. Aphids can accumulate in high densities on young tender parts of the plants because they have high colonising capacity; eventually they suck the sap especially from the lower side of the young leaves. Infested plants turn pale, leaves become distorted, curled and crinkled leading to stunted growth of the plants. Aphids secrete honey dew, which attracts ants and which can further deter natural enemies of aphids and may turn out to be pests on brinjal plants, especially damaging the flowers. Excessive honey dew secretion can lead to the development of sooty mould which affects the photosynthesis and if present on the fruits reduce the size as well as the market value of the brinjal (Ghosh *et al.* 2004).

Incidence of aphid in brinjal

Shakeel *et al*. (2014) reported that the aphid population development in brinjal had a significant negative correlation with the maximum temperature, minimum temperature and rainfall, whereas relative humidity was positively correlated with the population size. They found peak aphid population in February which decreased with increasing temperature. Rajabpour and Yarahamadi (2012) studied succession of *A. gossypii* on *Hibiscus rosa-chinensis*, and found that the aphids started infesting the crop in November and attained a peak density during January-February with aggregated population in the field. Shah *et al*. (2009) reported *A. gossypii* populations on brinjal crop to be prevalent from first week of May to first week of September with highest infestation during last week of July. A research by Touhidur *et al*. (2006) revealed that population abundance and spatial distribution of *A. gossypii* varied with weather parameters. And peak aphid populations were found on 56 DAT. According to Rondon *et al.* (2005) peak aphid nymphal density was in March whereas peak adult aphid population abundance recorded in February and March. Musa *et al.* (2004) did a monitoring work in potato fields for *M. persicae* in Kosovo and compared three locations and two varieties. Results revealed that aphids occurred in May-June and then were present throughout the season with peak activity during July-August. Aphid population decreases to negligible from last week of November to first week of December.

2.7. Epilachna beetle, their host preference and nature of damage

Among the coccinellids, the beetles belonging to the subfamily Epilachninae constitute one-sixth species. Around 500 species have been found under the genus *Epilachna* (Jamwal *et al.* 2013). This pest is widely distributed in South East Asia, Australia, China, India and many other countries.

Host preference

Epilachna beetles are phytophagous in nature and attack a wide range of plants belonging to solanaceae, cucurbitaceae, fabaceae, convolvulaceae as well as malvaceae family. Brinjal, tomato, potato, tobacco, melon, cucumber, gourds, pumpkin and many other important food crops are frequently being under attack of epilachna beetle (Rath 2005; Ahmad *et al*. 2001).

Nature of damage

Infestation of epilachna beetle can significantly reduce yield by hampering crop growth and yield. (Maurice *et al*. 2013). Both adult and grub feed on brinjal leaves; especially epidermal tissue of leaves, flowers and fruits, scrap the tissue and thus inflict serious damage of brinjal plant during the whole season i.e. seedling stage to maturity (Varma and Anandhi 2008; Ghosh and Senapati 2001; Reddy 1997; Imura and Ninomiya 1978). Srivastava and Katiyar (1972) stated 35-75 percent leaf injury caused by epilachna population. On the other hand, Rajagopal and Trivedi (1989) reported 80 percent damage by feeding of eilachna beetle.

Incidence of epilachna beetle

Varma and Anandhi (2008) reported that epilachna started infestation by the first week of November with an average population of 2.85 beetles per plant and maximum infestation occurred in the third week of February with the first peak at third week of November. According to Omprakash and Raju (2014b), maximum temperature and minimum temperature has positive significant correlation with population dynamics which is negatively correlated with rainfall and humidity. But their results didn't show conformity with the study of Haseeb *et al.* (2009). He reported that highest number of epilachna found during third week of February and reaching to the least during April. However, it started infestation from the initial crop growth period. And he found positive correlation of relative humidity and rainfall with the succession and population dynamics of epilachna beetle.

2.8. Whitefly, their host preference and nature of damage

Whitefly is phytophagous in nature and a serious pest of crops. It belongs to Aleyrodidae family and Homoptera order. There are 12,000 different species found worldwide (Bartlett and Gawel 1993). Importantly, whitefly includes 41 distinctly isolated species population with 24 populations of a specific biotypes. (Perring 2001). Whitefly can cause considerable yield loss and damage to brinjal plants (Mandal *et al.* 2010).

Host preference

Whitefly is the most abundant and versatile crop pests which infest around 600 different crop plants and wild plants (Cueller and Morales 2006). Arnal *et al.* (1993) in his research, reported that whitefly can attack 500 species of plants belong to 74 taxonomic families. Among the plants squash, tomato, brinjal, potato, pumpkin, cucurbits, brinjal, beans are noteworthy. Parthenium is one of the most favourite host of whitefly. It also feeds on some weed like *Itsit*, datura, milkweed, *Chenopodium* sp.

Nature of damage

A most important fact is whitefly plays as a vector of virus disease and surprisingly, it transmits nearly 114 virus species and some can bring havoc to crops. Whitefly causes crop damage by causing chlorosis, leaf withering, premature leaf drops and wilting. As a sap sucking insect, it feed the phloem sap of plant tissue (Brown *et al.* 1995). Followed by feeding, plant physiological disorder happens, because of contamination of the crops with excreted honeydew by whitefly which leads to development of sooty mould thus reducing the effective leaf area for photosynthesis (Henneberry *et al*. 2001).

Incidence of Whitefly

According to the experiment of Ramrao (2012), whitefly was first recorded in the third week of December (50^{th} SW) and the activity of the pest continued from second week of December to first week of May. Though, he stated that weather factors have no significant effect on population dynamics, on the contrary Prasad and Logiswaran (1997b) reported that relative humidity showed positive impact on pest population. Sharma (2012) reported that the activity of white fly was started from second week of August (33^{th} SW) and continued up to the crop period i.e. first week of February. The maximum white fly population (19/ plant) was recorded in last week of September (39^{th} SW), when maximum and minimum temperature and humidity were 34.3˚C, 26.2˚C and 71.7 per cent respectively.

2.9. Management of insect pest complex of brinjal

Due to the huge production loss and crop damage inflicted by insect pest complex of brinjal, it is important to summarize the management practices and technology suggested by other scholars. Therefore, pertinent literatures were gleaned and overviews prepared for the management of the major insect pests of brinjal with consideration of supporting literature helpful for management.

Cultural control

The cultural practice can help in controlling pest population. Pruning is one of the best ways to control pest abundance especially BSFB. Neupane (2000) reported that pruning of infested twigs and branches prevents the further spreading of *L. orbonalis* in the field. As a part of crop sanitation procedure, the intermittent pinching/pruning of damaged shoot, their collection and further burrying or burning helps to decline pest infestation (Ghimire *et al.* 2007; Som and Maity 1986; Rao and Rao 1955). According to Paul *et al.* (2015), intercropping of brinjal with coriander helped in reducing BSFB infestation. Salunke and Shyam (2015) reported that color of brinjal especially blue or pink attracts BSFB moth to lay eggs. All crop stubbles should be removed soon after harvesting. There should be some distinct isolation distance to grow seedling from the stubble heaps (Rahman *et al.* 2009; Satpathy 2005; Arida *et al.* 2003; Talekar 2002). Refuges crop can help in managing sucking pests of brinjal. Landis *et al.* (2000) reported that a pest-suppressive agroecosystem which will be designed to facilitate a suitable intercrop as refuge crop will help in controlling sucking pests of brinjal. *B. thuringiensis*-transgenic brinjal plants are highly resistant to damage by lepidopteran pests, and consequently, the application of chemical insecticides can be greatly reduced. This makes Bt brinal a valuable component of integrated pest management programs, with many environmental, economic, and health benefits.

Mechanical control

An experiment to this effect was conducted in which a combination of barrier and sanitation was utilized to minimize BSFB damage to brinjal plants. The highest marketable fruit yield and as well as lowest fruit infestation in terms of number and weight was obtained from use of barrier with clipping practices rather than by the use of barrier alone, though later one is the best for farmers practice in small scale production (Ghimire 2001). Apart from the fact that mechanical control is more labour intensive and needs much time, it gives quick results. Some of the common mechanical crop protection measures include: handpicking of large larvae or adults; imposing of mechanical barriers; removal of crop stubbles and other unwanted plants prior to, during or after the cropping season (also termed sanitation); and denying pests alternative hosts. Due to the small size of sucking pests and their position in lower side of leaves, its very difficult to control them by mechanical means.

Sex pheromone traps

In case of non-Bt brinjal, pheromone is the another best one to practice managing the BSFB. The sex pheromone works by confusing the male adult for mating and thus prevents fertilized egg production by trapping large number of male moths, which results in reduction of larval and adult population development (Rahman 2006). Among different types of pheromone traps, water trap is the most preferred one, placed at crop canopy level which caught significantly more male moths than placed 0.5 m above the canopy (Cork *et al.* 2003). He concluded that the sex pheromone was potential component in the IPM program. Delta traps and funnel traps are useful for the adult luring by the sex pheromone in the field conditions.

Biological control

Among different biological control measures against pest complex of brinjal *Passilomyces fumosoresus* @ 1l/ha was recorded lowest population of all the pests recorded with highest yield (85.06 q / ha) (Satyendra 2013). The best-known virus of insect is the *Nuclear Polyhedrosis Viruses* (NPV). This parasitoid has been reported to be present in and Bangladesh (Alam and Sana 1964); however, its contribution to pest control was rarely documented and does not appear to be significant. Since, biological control is an important component in IPM and very little information is available on the role of biological control agents in combating BSFB in the region. There is also significant relationship between incidence of *L. orbonalis* in terms of shoot infestation and with coccinellids and spiders (Singh *et al.* 2009). Sucking pests of brinjal and other vegetables have showed susceptibility to any biocontrol agents. Microbial pathogens especially fungal pathogens such as *Beauveria bassiana*, *Metarhizium anisopliae* and *Verticillium lecanii* have been experimented for a wide range of sucking pests. . The larvae of *Chrysoperla carnia* are predacious, feeding on the eggs and neonates of lepidopterous larvae, nymphs and adults of whitefly, aphids thrips, scale insect, mealy bugs and mites. It has great potential as bioagent against citrus aphids, whiteflies, citrus psylids and citrus mealy bugs (Balasubramani and Swamiappan 1994).

Chemical control

Management of insect pests in Bangladesh is mainly chemical dependant; in many cases, farmers rely solely on insecticides to get rid of pest problems. A wide range of pesticides from diverse genre are available in commercial forms. Many pesticidal trials have been done previously by researchers to check the efficacy of those chemicals and susceptibility of various insect pests to them. Many promising insecticides have been invented recently.

Spinosad is one of such new chemicals which is derived from fermentation broth of soil actinomycetes, *Saccharopolyspora spinosa*, containing a naturally occurring mixture of spinosyn A and spinosyn D. It is not hazardous to the nymphs and adults of the natural enemies. Spinosad has been registered in over 30 countries for the control of lepidoptera, coleoptera, diptera and thysonaptera (Williams *et al.* 2004). Yousafi *et al*. (2015) reported that Spinosad (Tracer 240SC) proved to be the most effective insecticide to control fruit infestation. A trial experiment was carried out by Patra *et al.* (2009) on the efficacy of Spinosad on BSFB. Results revealed that spinosad was the most effective against BSFB. Rani *et al.* (2005) reported that spinosad effectively protected the cotton crop with minimum incidence of spotted boll worm. Chowdhury *et al.* (1993) in their experiment stated that Spinosad was more effective in controlling BSFB and less effective in controlling sucking pests of brinjal. Due to its high nutritional value and increasing demand, brinjal cultivation in Bangladesh needs special attention. Many minor pests have emerged as major pests and even gained the key pest status recently. Unwise and indiscriminate application of pesticides not only degrading the ecological balance but also disrupting the pest behavior. To get acquainted with new challenges of global climate change, sound knowledge of nature of damage, seasonal abundance as well as succession of insect pest complex and mode of action of insecticides are necessary.

Malathion is a synthetic chemical insecticide that has been manufactured in the U.S. and is being used since 1950. It is a colourless to amber liquid with a garlic or skunk like odour that is used to control a wide range of insects that infest vegetable plants. Malathion is the most overused insecticide and his insecticide has been used so indiscriminately that many major pests have been developed resistance against it. A research was carried out by Singh *et al.* (2008) to check the efficacy of malathion and some other insecticides. Three insecticides i.e. Endosulfan (0.05%), Cypermethrin (0.05%) and Malathion (0.05%) were sprayed against the infestation of shoot and fruit borer to evaluate suitable control measure against the pest to get the higher yield. The minimum (21.5%) infestation was observed with Endosulfan followed by Cypermethrin (24.13%) and Malathion (25.17%). That implies the lowest efficacy of malathion against BSFB. An experiment was done by Mhaske and Mote (2005) for controlling insect pest complex of brinjal. They found imidacloprid to be the most effective in controlling sap sucking pests of brinjal.

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled “Eco-friendly management of insect pest of bt brinjal for ensuring quality yield” was carried out in the experimental field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during rabi season 2020-2021. The present chapter deals with the material used and methods required. The materials and methods adopted in the study are discussed under the following sub-headings:

3.1. Description of the experimental site

The experiment was conducted during the period from October 2020 to April 2021.The present piece of research work was conducted in the experimental area of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The location of the site is 23˚74/N latitude and 90˚35/E longitude with an elevation of 8.2 meter from sea level. The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by heavy scanty rainfall during the rabi season. The soil belonged to “The Modhupur Tract”, AEZ-28 (FAO, 1988). The experimental area was flat having available irrigation and drainage system and above flood level.

3.2. Weather condition during the crop season

The average highest and the lowest temperatures in the 6 months were 31.6°C and 18.17°C respectively. During November to February, the temperature was less than the other months of the year and starts increasing after mid- march. The monthly total rainfall, average sunshine hour, temperature during the study period was shown in Appendix I.

3.3. Planting materials

BARI Bt Begun-1 (Bt uttara) was used as the test crop in this experiment. Seeds were collected from Genetic Resources Centre of BARI (Bangladesh Agricultural Research Institute), Gazipur, Bangladesh.

3.4. Experimental design and layout

The design was followed in the experiment was the randomized complete block design (RCBD) with three replications. The treatments were seven (7). The plant-to-plant distance was 25 cm and line distance was 30 cm. The total size of plot 126.7 m^2.

3.5. Land preparation and intercultural operation

Seeds were sown on September 30, 2020. The land selected for conducting the experiment was opened in the 3^{rd} week of October 2020 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth condition. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot. Seedlings were transplanted on October 25, 2020. Irrigation (9 times) and drainage were provided when required. Weeding (5 times) was done to keep the plots free from weeds, which ultimately ensured better growth and development.

3.6. Fertilizers and manure application

The fertilizers N, P, K in the form of Urea, TSP, MoP respectively and S, Zn and B in the form of Gypsum, Zinc sulphate and Borax were applied as per recommendation of Bangladesh Agricultural Research Institute (Mondal *et al.,* 2011). Urea was applied as granule. The entire amount of TSP, MP, gypsum, zinc sulphate and borax were applied during the final preparation of land. The

Urea was applied in four equal installments at Basal, 30 DAT, flowering and fruit setting.

Table 1. The amount of manure and fertilizers applied in the experimental plot (300 m^2) as per recommendation of BARI

Manures and fertilizers	Total amount applied for 300m^2	Dose (kg/300 m^2)			
		Final land preparation	1^{st} installment	2^{nd} installment	3^{rd} installment
Cowdung	300 kg	300 kg	--	--	--
Urea	13 kg	10 kg	1 kg	1 kg	1 kg
TSP	4.5 kg	4.5 kg	--	--	--
MP	8 kg	4 kg	2 kg	2 kg	
Gypsum	3 kg	3 kg	--	--	--

3.7. Sowing of brinjal seeds

Before sowing, seeds were pre-soaked, for 24 hrs to ensure germination. The seed of brinjal variety was sown separately in the seed bed on September, 2020. The intensive care and all necessary intercultural operations including irrigation, weeding, thinning etc. was done in proper time to obtain healthy seedlings.

3.8. Treatments of the experiment

Being a single-factor experiment, present study consist single factors such as variety and insecticide doses. Details of treatments are given below:

The treatments of the present study were assigned as follows:

T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.

T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals

T_3=Field sanitation + Sex pheromone traps + Bamper 20SL

T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals

T_5= Larval parasitoid + Yellow sticky board traps

T_6=Field sanitation + Yellow sticky board traps

T_7 = Control

3.9. Data recording

Data were collected on the following parameters

1. Incidence of brinjal shoot and fruit borer
2. Incidence of Jassid
3. Incidence of Aphid
4. Incidence of Epilachna beetle
5. Incidence of Whitefly
6. Number of branch per 5 selected plant
7. Number of leaves per 5 selected plants
8. Single fruit weight
9. Length of fruit
10. Girth of fruit per plant
11. Healthy fruit yield (kg)
12. Infested fruit yield (kg)
13. Total fruit yield (t/ha)

3.10. Method of treatment application

Treatments were sprayed several times on insecticide @ 0.5 ml/L at the 7 days intervals with the help of knapsack sprayer. Bamper 20SL (Imidacloprid) was sprayed seedling to before flowering stage and larval parasitoid was released at reproductive stage of brinjal plant in treatment T_2.

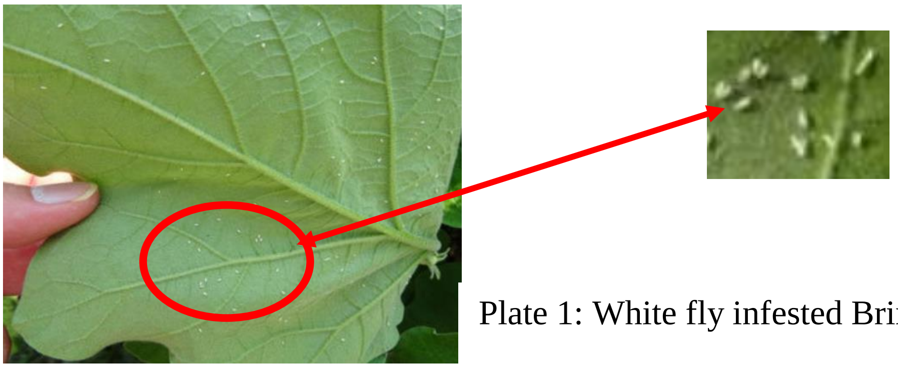

Plate 1: White fly infested Brinjal leaf with whitefly.

Plate 2: Aphid infested Brinjal leaf with aphid.

Plate 3: Jassid infested Brinjal Plant during the study period in experimental field.

3.11. Method of observation for bt-brinjal shoot and fruit borer (BSFB)

Observations on shoot and fruit borer, *L. orbonalis* infestation were recorded on 5 randomly selected tagged plants/plot. Before fruiting stage, pre-treatment observations on shoot infestation were recorded 24 hours before spraying, while post-treatment observations were taken 7 and 14 days (Sharma, 2012) after application of the treatments.

3.12. Collection of Data

3.12.1. Shoot and fruit borer

The shoot and fruit infestation was judged by counting healthy plants and plants having shoots and fruit infested by shoot and fruit borer of 5 randomly selected plants per plot from four replications. After each observation, damage shoots and fruits were removed.

$$\%\ \text{infestation of shoot} = \frac{\text{Number of infestated shoots/5 plants}}{\text{Total number of shoots/5 plants}} \times 100$$

$$\%\ \text{infestation of fruits} = \frac{\text{Number of infestated fruits/5 plants}}{\text{Total number of fruits/5 plants}} \times 100$$

3.12.2. Epilachna beetle

Number of damaged leaves/ five plants was observed to record data for epilachna beetle.

3.12.3. Jassid

All the leaves were counted from 5 randomly selected plants from middle rows of each plot and examined. The collected data were divided into early, mid and late fruiting stage. The healthy and infested fruits were counted and the percent leaves infested was calculated.

Plate 4: Brinjal shoot and fruit infested shoot of Brinjal Plant during the study period in experimental field.

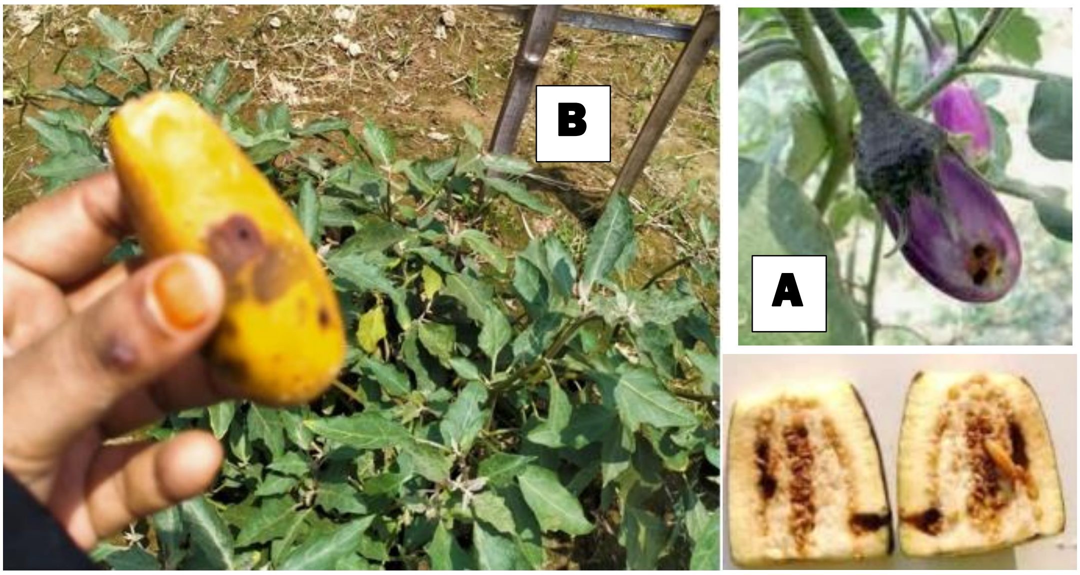

Plate 5: Brinjal shoot and fruit infested Brinjal fruit at the different stages green immature fruit (A) and ripe fruit (B) of brinjal during the study period.

3.12.4. Aphid and Whitefly

Six leaves (each from 2 upper, middle and lower per plant) were carefully examined for the presence of nymph and adults of aphids and whitefly.

3.13 Yield contributing characters of brinjal

Data were recorded on yield contributing characters and yield of brinjal on the following parameters:

3.13.1. Number of branch

During the total growing stage of the plant total numbers of branch from 5 tagged plants were recorded in each treatment.

3.13.2. Number of leaves

During the total growing stage of the plant total numbers of leaves from 5 tagged plants were recorded in each treatment.

3.13.3. Number of fruits

During the total growing stage of the plant total numbers of fruits from selected plants were recorded in each treatment.

3.13.4. Single fruit weight

The weight of single fruit was measured by a weighing scale and mean values were recorded.

3.13.5. Length of fruit

The length of fruit was recorded in centimeter (cm) during harvest time from each experimental plot. The height of every fruit was measured by a meter scale and mean values were recorded.

3.13.6. Girth of fruit

The girth of fruit was recorded in centimeter (cm) during harvest time from each experimental plot. The girth of every fruit was measured by a slide caliperse and mean values were recorded.

Plate 6: Healthy brinjal plant during the study period.

Plate 7: Healthy brinjal plant with fruit during the study period in experimental plot.

Plate 8: Healthy ripe brinjal fruits during the study period in experimental plot.

3.13.7. Weight healthy and infested of fruit

The weight of healthy and infested fruit was measured by a weighing scale and mean values were recorded.

3.13.8. Yield per hectare

Total yield of brinjal per hectare for each treatment was calculated in tons from cumulative fruit production in a plot.

3.14. Data analysis

Recorded data were put and compiled on MS excel spreadsheet. Later on, data were analyzed by using STATISTICS 10 software for analysis of variance. ANOVA was made by F variance test and the mean value comparisons were performed by LSD's test.

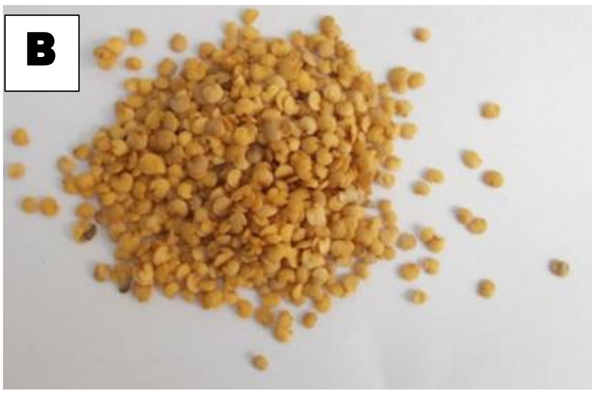

Plate 8: Healthy brinjal fruits **(A)** and seeds **(B)** during the study period after harvesting.

CHAPTER IV

RESULTS AND DISCUSSION

The present study was carried out on Eco-friendly management of insect pest of bt brinjal for ensuring quality yield. Performance of 7 treatments was investigated and the findings of the present study have been discussed under different characters on infestation by insect pest. The result of the study showed marked variation in different characters and the variation of different characters are presented in the following Tables, Figures and Plates.

4.1. Incidence of Insect pests of brinjal

Various insect pest incidences were found in the crop grown under the present study (Table 3). Brinjal shoot and fruit borer (*Leucinodes orbonalis*), epilachna beetle (*Epilachna dodecastigma*), jassid (*Amrasca biguttula biguttula*), aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci*), eggplant mealy bug (*Centrococcus insolious*), mite (*Tetranychus sp*.), green leafhopper (*Nephotettix virescens*) and two natural enemies *viz*. lady bird beetle (*Menochilus sexmaculatus*) and spider (*Argiope luzona*) were recorded in the experimental field. Among the pests, brinjal shoot and fruit borer as well as epilachna beetle were chewing pests and rest all sucking pests of brinjal. However, all insects except BSFB were leaf dwelling insects but BSFB bore into the shoot and fruit at vegetative and fruiting stage, respectively. All the natural enemies were predacious in nature. Lower number of insect pests in rabi season may be attributed to the lower temperature and relative humidity uncomfortable for maximum pests.

Table 2. Incidence of insect pest and their natural enemies during the study period in the experimental field.

Name of the insect	Scientific name	Family	Order	Habitat	Status
Brinjal shoot and fruit borer	*Leucinodes orbonalis* (Guen.)	Pyralidae	Lepidoptera	Shoot and fruit	Pest
Whitefly	*Bemisia tabaci* (Genn.)	Aleyrodidae	Hemiptera	Leaf	Pest
Epilachna beetle	*Epilachna dodecastigma* (Wied.)	Coccinellidae	Coleoptera	Leaf	Pest
Aphid	*Aphis gossypii* (Glover)	Aphidae	Hemiptera	Leaf	Pest
Jassid	*Amrasca biguttula biguttula* (Ishida)	Cicadellidae	Hemiptera	Leaf	Pest
Eggplant mealy bug	*Centrococcus insolious* (Green)	Pseudococcidae	Hemiptera	Leaf	Pest
Green leaf hopper	*Nephotettix virescens*	Cicadellidae	Hemiptera	Leaf	Pest
Mite	*Tetranychus* sp.	Tetranychidae	Acarina	Leaf	Pest
Spider	*Argiope luzona*	Argiopidae	Acarina	Leaf	Predator
Ladybird beetle	*Menochilus sexmaculatus*	Coccinellidae	Coleoptera	Leaf	Predator

4.2. Incidence of brinjal shoot and fruit borer of bt brinjal

At vegetative and fruiting stage statistically significant variation ($p>0.05$) was recorded for brinjal shoot and fruit borer due to different management practices (Table 3) at days after transplanting (DAT). In case of brinjal shoot and fruit borer, the lowest number per plant (0.00 and 0.56) was found from T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL @ 0.5 ml/L at the 7 days intervals) which was statistically different (0.23 and 0.92) with T_2 (Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml L at the 7 days intervals) followed by (0.87 and 1.33) with T_1 (Spraying Bio-neem plus botanical insecticide @ 0.5 ml L at the 7 days intervals) and (1.33 and 2.75) with T_4 treatments respectively.

On the other hand, the highest number of brinjal shoot and fruit borer was recorded in (3.75 and 7.25**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (1.73 and 3.92) by T_6 (Field sanitation + Yellow sticky board traps) and (1.57 and 3.27) T_5 (Larval parasitoid + Yellow sticky board traps) treatment.

At mean of overall growing stage, in case of brinjal shoot and fruit borer, the lowest number per plant (0.28) was found from T_3 which was statistically different (0.58) with T_2 followed by (1.10) with T_1 and (2.04) with T_4 treatments respectively.

On the other hand, the highest number of brinjal shoot and fruit borer was recorded in (5.50**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (2.83 and 2.42) by T_6 and T_5 treatment.

Incidence of brinjal shoot and fruit borer reduction over control was estimated and the highest value was found from the treatment T_3 (94.91%) which was followed by T_2 (89.45%), T_1 (80.00%) and T_4 (62.91%) treatments and the minimum reduction over control from T_6 (48.55%) followed by (56.00%) T_5 treatment.

Table 3: Comprehensive study of incidence of brinjal shoot and fruit borer on eco-friendly management of insect pest of bt brinjal for ensuring quality yield at total growing stage

Treatments	Incidence of brinjal shoot and fruit borer/plant			
	Vegetative stage	Fruiting stage	Mean	% Reduction over control
T_1	0.87 e	1.33 e	1.10 e	80.00
T_2	0.23 f	0.92 f	0.58 f	89.45
T_3	0.00 g	0.56 g	0.28 f	94.91
T_4	1.33 d	2.75 d	2.04 d	62.91
T_5	1.57 c	3.27 c	2.42 c	56.00
T_6	1.73 b	3.92 b	2.83 b	48.55
T_7	3.75 a	7.25 a	5.50 a	--
LSD $_{(0.05)}$	0.15	0.13	0.30	--
CV(%)	6.18	2.59	8.02	--

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

From the (Table 3) it was observed that among the different treatments, T_3 (T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) performed best on incidence of brinjal shoot and fruit borer and was more effective among the potential management against incidence and damage severity by major insect pests of brinjal. Whereas, T_7 (Untreated Control) showed the highest performance results on incidence of brinjal shoot and fruit borer of brinjal. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was $T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7$.

4.2.1. Infestation intensity

The effects of different treatments on the infestation intensity expressed in terms of fruits having infestation intensity corresponding to any of 3 scales such as scale 1 (low infestation intensity; 1-2 bores/fruit), scale 2 (moderate infestation intensity; 3-4 bores/fruit), Scale 3 (high infestation intensity; 5-6 bores/fruit) are presented in Table 4.

It was revealed from the Table 4 that among the infested fruits those belonging to scale 1 showed maximum (4.56) from T_7 and minimum found (3.25) from T_3 which identically similar with other treatments. Same result found from scale 3.

Among the infested fruits those belonging to scale 2 revealed that maximum found (4.03) from T_7 which followed by (3.19) T_6 and minimum found (2.85) from T_3 which closely similar with other treatments.

The most significant finding is that considerably a very high proportion of infested fruits (3.61) belonged to scale 3 in T_7 which is highly significant.

Thus it may be inferred from the above analysis that the proportion of infested fruits in the infested category under different treatment would vary greatly in terms of infestation intensity.

Table 4: Effect of brinjal treatments on infestation intensity (no. of bore/fruit) caused by brinjal shoot and fruit borer.

Treatments	Infestation intensity (no./10 fruits)		
	Scale 1 (1-2 bores/fruit)	Scale 2 (3-4 bores/fruit)	Scale 1 (>5 bores/fruit)
T_1	3.31 b	2.98 cd	2.87 b
T_2	3.29 b	2.95 cd	2.79 b
T_3	3.25 b	2.85 d	2.75 b
T_4	3.39 b	3.02 b-d	2.91 b
T_5	3.42 b	3.12 bc	2.97 b
T_6	3.52 b	3.19 b	3.09 b
T_7	4.56 a	4.03 a	3.61 a
LSD $_{(0.05)}$	**0.51**	**0.19**	**0.39**
CV(%)	**8.07**	**3.36**	**7.29**

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

4.3. Incidence of number of Jassid plant^{-1} of bt brinjal

At vegetative and fruiting stage statistically significant variation (p>0.05) was recorded for number of Jassid plant^{-1} due to different management practices (Table 5) at days after transplanting (DAT). In case of number of Jassid plant^{-1}, the lowest number per plant (5.68 and 8.25) was found from T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL @ 0.5 ml/L at the 7 days intervals) which was statistically different (6.28 and 8.75) with T_2 (Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml L at the 7 days intervals) followed by (6.78 and 9.33) with T_1 (Spraying Bio-neem plus botanical insecticide @ 0.5 ml L at the 7 days intervals) and (7.25 and 9.88) with T_4 treatments respectively.

On the other hand, the highest number of Jassid plant^{-1} was recorded in (9.65 and 14.69**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (7.95 and 10.22) by T_6 (Field sanitation + Yellow sticky board traps) and (7.49 and 9.92) T_5 (Larval parasitoid + Yellow sticky board traps) treatment.

At mean of overall growing stage, in case of number of Jassid plant^{-1}, the lowest number per plant (6.97) was found from T_3 which was closely similar (7.52) with T_2 followed by (8.06) with T_1 and (8.57) with T_4 treatments respectively.

Table 5: Comprehensive study of incidence of number of Jassid plant^{-1} on eco-friendly management of insect pest of bt brinjal for ensuring yield and quality seed production at total growing stage

Treatments	Incidence of number of Jassid/plant			
	Vegetative stage	Fruiting stage	Mean	% Reduction over control
T_1	6.78 de	9.33 cd	8.06 cd	33.77
T_2	6.28 e	8.75 de	7.52 de	38.21
T_3	5.68 f	8.25 e	6.97 e	42.73
T_4	7.25 cd	9.88 bc	8.57 bc	29.58
T_5	7.49 bc	9.92 bc	8.71 b	28.43
T_6	7.95 b	10.22 b	9.09 b	25.31
T_7	9.65 a	14.69 a	12.17 a	--
LSD $_{(0.05)}$	**0.58**	**0.69**	**0.63**	--
CV(%)	**4.48**	**3.81**	**4.07**	--

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

On the other hand, the highest number of Jassid plant^{-1} was recorded in (12.17**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (9.09 and 8.71) by T_6 and T_5 treatment.

Incidence of number of Jassid plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (42.73%) which was followed by T_2 (38.21%), T_1 (33.77%) and T_4 (29.58%) treatments and the minimum reduction over control from T_6 (25.31%) followed by (28.43%) T_5 treatment.

From the (Table 5) it was observed that among the different treatments, T_3 (T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) performed best on incidence of number of Jassid plant^{-1} and was more effective among the potential management against incidence and damage severity by major insect pests of brinjal. Whereas, T_7 (Untreated Control) showed the highest performance results on incidence of number of Jassid plant^{-1} of brinjal. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7.

4.4. Incidence of number of Aphid plant^{-1} of bt brinjal

At vegetative and fruiting stage statistically significant variation ($p>0.05$) was recorded for number of Aphid plant^{-1} due to different management practices (Table 6) at days after transplanting (DAT). In case of number of Aphid plant^{-1}, the lowest number per plant (8.25 and 9.12) was found from T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL @ 0.5 ml/L at the 7 days intervals) which was closely similarat vegetative stage and identically similar at fruiting stage from all others treatments and followed by (6.28 and 8.75) with T_2 (Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml L at the 7 days intervals) closely related (6.78 and 9.33) with T_1 (Spraying Bio-neem plus botanical insecticide @ 0.5 ml L at the 7 days intervals) and (7.25 and 9.88) with T_4 treatments respectively.

On the other hand, the highest number of Aphid plant^{-1} was recorded in (11.25 and 15.33**)** T_7 (Untreated Control) which was statistically different from all other treatments.

At mean of overall growing stage, in case of number of Aphid plant^{-1}, the lowest number per plant (8.69) was found from T_3 which was closely similar (8.99) with T_2 followed by (9.20) with T_1 and (9.59) with T_4 treatments respectively.

On the other hand, the highest number of Aphid plant^{-1} was recorded in (13.29**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (10.02 and 9.70) by T_6 and T_5 treatment.

Incidence of number of Aphid plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (34.61%) which was followed by T_2 (32.36%), T_1 (30.78%) and T_4 (27.84%) treatments and the minimum reduction over control from T_6 (24.60%) followed by (27.01%) T_5 treatment.

From the (Table 6) it was observed that among the different treatments, T_3 (T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) performed best on incidence of number of Aphid plant^{-1} and was more effective among the potential management against incidence and damage severity by major insect pests of brinjal. Whereas, T_7 (Untreated Control) showed the highest performance results on incidence of number of Aphid plant^{-1} of brinjal. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was $T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7$.

Table 6: Comprehensive study of incidence of number of Aphid plant^{-1} on eco-friendly management of insect pest of bt brinjal for ensuring yield and quality seed production at total growing stage

Treatments	Incidence of number of Aphid /plant			
	Vegetative stage	Fruiting stage	Mean	% Reduction over control
T_1	8.95 cd	9.45 b	9.20 bc	30.78
T_2	8.75 cd	9.22 b	8.99 c	32.36
T_3	8.25 d	9.12 b	8.69 c	34.61
T_4	9.32 bc	9.85 b	9.59 bc	27.84
T_5	9.45 bc	9.95 b	9.70 bc	27.01
T_6	9.83 b	10.20 b	10.02 b	24.60
T_7	11.25 a	15.33 a	13.29 a	--
LSD $_{(0.05)}$	**0.72**	**1.08**	**1.02**	--
CV(%)	**4.33**	**5.82**	**5.75**	--

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

4.5. Incidence of number of Epilachna beetle plant^{-1} brinjal

At vegetative and fruiting stage statistically significant variation (p>0.05) was recorded for number of Epilachna beetle plant^{-1} due to different management practices (Table 7) at days after transplanting (DAT). In case of number of Epilachna beetle plant^{-1}, the lowest number per plant (322 and 3.55) was found from T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL @ 0.5 ml/L at the 7 days intervals) which was identically similar at vegetative stage and closely similar at fruiting stage and followed by (3.28 and 3.55) with T_2 (Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml L at the 7 days intervals) followed by (3.35 and 3.86) with T_1 (Spraying Bio-neem plus botanical insecticide @ 0.5 ml L at the 7 days intervals) and (3.58 and 3.96) with T_4 treatments respectively.

On the other hand, the highest number of Epilachna beetle plant^{-1} was recorded in (5.30 and 6.28**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (3.75 and 4.36) by T_6 (Field sanitation + Yellow sticky board traps) and (3.62 and 4.12) T_5 (Larval parasitoid + Yellow sticky board traps) treatment.

At mean of overall growing stage, in case of number of Epilachna beetle plant^{-1}, the lowest number per plant (3.39) was found from T_3 which was closely similar (3.48) with T_2 followed by (3.61) with T_1 and (3.77) with T_4 treatments respectively.

On the other hand, the highest number of Epilachna beetle plant^{-1} was recorded in (5.79**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (4.06 and 3.87) by T_6 and T_5 treatment.

Incidence of number of Epilachna beetle plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (41.45%) which was followed by T_2 (39.90%), T_1 (37.65%) and T_4 (34.89%) treatments and the minimum reduction over control from T_6 (29.88%) followed by (33.16%) T_5 treatment.

From the (Table 7) it was observed that among the different treatments, T_3 (T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) performed best on incidence of number of Epilachna beetle plant^{-1} and was more effective among the potential management against incidence and damage severity by major insect pests of brinjal. Whereas, T_7 (Untreated Control) showed the highest performance results on incidence of number of Epilachna beetle plant^{-1} of brinjal. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was $T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7$.

Table 7: Comprehensive study of incidence of number of Epilachna beetle plant^{-1} on eco-friendly management of insect pest of bt brinjal for ensuring yield and quality seed production at total growing stage

Treatments	Incidence of number of Epilachna beetle/plant			
	Vegetative stage	Fruiting stage	Mean	% Reduction over control
T_1	3.35 b	3.86 b-d	3.61 bc	37.65
T_2	3.28 b	3.68 cd	3.48 c	39.90
T_3	3.22 b	3.55 d	3.39 c	41.45
T_4	3.58 b	3.96 b-d	3.77 bc	34.89
T_5	3.62 b	4.12 bc	3.87 bc	33.16
T_6	3.75 b	4.36 b	4.06 b	29.88
T_7	5.30 a	6.28 a	5.79 a	--
LSD $_{(0.05)}$	**0.74**	**0.51**	**0.58**	--
CV(%)	**11.11**	**6.73**	**8.14**	--

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

4.6. Incidence of number of Whitefly plant^{-1} brinjal

At vegetative and fruiting stage statistically significant variation ($p>0.05$) was recorded for number of Whitefly plant^{-1} due to different management practices (**Table 8**) at days after transplanting (DAT). In case of number of Whitefly plant^{-1}, the lowest number per plant (6.20 and 7.11) was found from T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL @ 0.5 ml/L at the 7 days intervals) which was closely similar (6.58 and 7.35) with T_2 (Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml L at the 7 days intervals) followed by

(6.97 and 7.56) with T_1 (Spraying Bio-neem plus botanical insecticide @ 0.5 ml L at the 7 days intervals) and (7.21 and 7.69) with T_4 treatments respectively.

On the other hand, the highest number of Whitefly plant^{-1} was recorded in (8.36 and 11.42**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (7.82 and 8.21) by T_6 (Field sanitation + Yellow sticky board traps) and (7.36 and 7.93) T_5 (Larval parasitoid + Yellow sticky board traps) treatment.

At mean of overall growing stage, in case of number of Whitefly plant^{-1}, the lowest number per plant (6.66) was found from T_3 which was closely different (6.97) with T_2 followed by (7.27) with T_1 and (7.45) with T_4 treatments respectively.

On the other hand, the highest number of Whitefly plant^{-1} was recorded in (9.89**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (8.02 and 7.65) by T_6 and T_5 treatment.

Incidence of number of Whitefly plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (32.66%) which was followed by T_2 (29.52%), T_1 (26.49%) and T_4 (24.67%) treatments and the minimum reduction over control from T_6 (18.91%) followed by (22.65%) T_5 treatment.

From the (**Table 8**) it was observed that among the different treatments, T_3 (T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) performed best on incidence of number of Whitefly plant^{-1} and was more effective among the potential management against incidence and damage severity by major insect pests of brinjal. Whereas, T_7 (Untreated Control) showed the highest performance results on incidence of number of Whitefly plant^{-1} of brinjal. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was $T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7$.

Table 8: Comprehensive study of incidence of number of Whitefly plant^{-1} on eco-friendly management of insect pest of bt brinjal for ensuring quality yield at total growing stage

Treatments	Incidence of number of Whitefly/plant			
	Vegetative stage	Fruiting stage	Mean	% Reduction over control
T_1	6.97 cd	7.56 c-f	7.27 cd	26.49
T_2	6.58 de	7.35 de	6.97 d	29.52
T_3	6.20 e	7.11 e	6.66 e	32.66
T_4	7.21 c	7.69 b-d	7.45 b-d	24.67
T_5	7.36 bc	7.93 bc	7.65 bc	22.65
T_6	7.82 ab	8.21 b	8.02 b	18.91
T_7	8.36 a	11.42 a	9.89 a	--
LSD $_{(0.05)}$	**0.55**	**0.52**	**0.62**	**--**
CV(%)	**4.30**	**3.59**	**4.59**	**--**

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

4.7. Effect of different treatments against bt brinjal insect pest and its impact on yield contributing characters for ensuring yield and quality seed production of brinjal

Number of branch: The impact of different treatments on number of branch plant^{-1} of bt brinjal has been shown in Table 9. Significant variations were observed among the treatments in terms of number of branch of 5 tagged plant of bt brinjal. The highest number of branch 5 tagged plant (56.22) was recorded in T_3 which was statistically different from (53.26) in T_2, (51.33) in T_1 and followed by (50.14) in T_4 treatment.

On the other hand the lowest number of branch 5 tagged plant of bt brinjal was (42.11) in T_7 (Untreated control), which was statistically different from (48.03) in T_6 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment was showed the best performance for the number of branch 5 tagged plant of bt brinjal.

Number of leaves: The impact of different treatments on number of leaves 5 tagged plant of bt brinjal has been shown in Table 9. Significant variations were observed among the treatments in terms of number of leaves 5 tagged plant of bt brinjal. The highest number of leaves 5 tagged plant (345.22) was recorded in T_3 which was statistically similar with (335.85) in T_2, (330.60) in T_1 and followed by (328.78) in T_4 treatment.

On the other hand the lowest number of leaves 5 tagged plant of bt brinjal was (302.92) in T_7 (Untreated control), which was statistically different from (320.75) in T_6 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment was showed the best performance for the number of leaves 5 tagged plant of bt brinjal.

Single fruit weight: The impact of different treatments on number of leaves of bt brinjal has been shown in Table 9. Significant variations were observed among the treatments in terms of single fruit weight of bt brinjal. The highest single fruit weight (69.53 g) was recorded in T_3 which was statistically different from (65.12 g) in T_2, (63.50 g) in T_1 and followed by (61.28 g) in T_4 treatment.

On the other hand the lowest single fruit weight of bt brinjal was (50.79 g) in T_7 (Untreated control), which was statistically different from (59.03 g) in T_6 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment was showed the best performance for the single fruit weight of bt brinjal.

Length of fruit (cm): The impact of different treatments on number of leaves of bt brinjal has been shown in Table 9. Significant variations were found among the treatments in terms of length of fruit of bt brinjal. The maximum length of fruit (80.36 cm) was recorded in T_3 which was closely similar with (78.12 cm) in T_2, (77.36 cm) in T_1 and followed by (77.03 cm) in T_4 treatment.

On the other hand the minimum length of fruit of bt brinjal was (70.12 cm) in T_7 (Untreated control), which was statistically different from (74.95 cm) in T_6 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment was showed the best performance for the length of fruit of bt brinjal.

Girth of fruit (cm): The impact of different treatments on number of leaves of bt brinjal has been shown in Table 9. Significant variations were found among the treatments in terms of grith of fruit of bt brinjal. The maximum grith of fruit (30.25 cm) was recorded in T_3 which was identically similar with (29.33 cm) in T_2, (29.12 cm) in T_1 and followed by (28.95 cm) in T_4 treatment.

On the other hand the minimum grith of fruit of bt brinjal was (27.12 cm) in T_7 (Untreated control), which was statistically different from (28.85 cm) in T_6 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment was showed the best performance for the grith of fruit of bt brinjal.

Table 9. Effect of different treatments against bt brinjal insect pest and its impact on yield contributing characters for ensuring yield and quality seed production of brinjal

Treatments	Number of branch (No./5 tagged plant)	Number of leaves (No./5 tagged plant)	Single fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)
T_1	51.33 c	330.60 bc	63.50 bc	77.36 ab	29.12 a
T_2	53.26 b	335.85 ab	65.12 b	78.12 ab	29.33 a
T_3	56.22 a	345.22 a	69.53 a	80.36 a	30.25 a
T_4	50.14 cd	328.78 bc	61.28 cd	77.03 ab	28.95 a
T_5	49.02 de	325.62 bc	60.11 d	75.98 b	28.90 a
T_6	48.03 e	320.75 c	59.03 d	74.95 b	28.85 a
T_7	42.11 f	302.92 d	50.79 e	70.12 c	27.12 b
LSD $_{(0.05)}$	**1.35**	**14.58**	**2.89**	**3.60**	**1.63**
CV(%)	**1.52**	**2.51**	**2.65**	**2.66**	**3.17**

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

4.8. Effect of different treatments against bt brinjal insect pest for ensuring yield and quality seed production of brinjal on the basis of yield ha^{-1} during total cropping season

Number of fruit: The impact of different treatments on number of fruit plant^{-1} of bt brinjal has been shown in Table 10. Significant variations were observed among the treatments in terms of number of fruit plant^{-1} of bt brinjal. The highest number of fruit plant^{-1} (17.52) was recorded in T_3 which was statistically different from (16.12) in T_2, (15.72) in T_1 and followed by (14.35) in T_4 treatment.

On the other hand the lowest number of fruit $plant^{-1}$ of bt brinjal was (10.22) in T_7 (Untreated control), which was statistically different from (13.25) in T_6 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment was showed the best performance for the number of fruit $plant^{-1}$ of bt brinjal.

Healthy fruit yield: From table 10, significant variation was observed in terms of healthy fruit yield at the total cropping season of bt brinjal. Result showed that the highest yield of healthy fruits (51.22 t/ha) was observed in T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment which was closely followed by (47.92 t/ha) in T_2 and (46.62 t/ha) in T_1 treatment.

Whereas the lowest yield of healthy fruits (30.08 t/ha) was observed in untreated control (T_7) treatment which was followed by (42.06 t/ha) and (42.06 t/ha) in T_6 and in T_5 treatments respectively.

Infested fruit yield: From table 10, significant variation was observed in terms of infested fruit yield at the total cropping season of bt brinjal. Result showed that the lowest yield of infested fruits (1.86 t/ha) was observed in T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment which was closely followed by (2.39 t/ha) in T_2 and (3.42 t/ha) in T_1 treatment.

Whereas the highest yield of infested fruits (14.49 t/ha) was observed in untreated control (T_7) treatment which was followed by (5.21 t/ha) and (4.58 t/ha) in T_6 and in T_5 treatments respectively.

Total fruit yield: From table 10, significant variation was observed in terms of total fruit yield at the total cropping season of bt brinjal. Result showed that the highest yield of total fruits (53.08 t/ha) was observed in T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment which was closely similar with (50.31 t/ha) in T_2 and (50.04 t/ha) in T_1 treatment.

Whereas the least yield of total fruits (44.57 t/ha) was observed in untreated control (T_7) treatment which was followed by (47.27 t/ha) and (48.54 t/ha) in T_6 and in T_5 treatments respectively.

Similarly, the percentage increase of total fruit yield over control during the cropping season of bt brinjal was 19.09% in treatment T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) followed by 12.88% in T_2 and 12.27% in T_1. The minimum increase over control from T_6 (6.06%) followed by (8.91%) T_5 treatment.

Table 10. Effect of different treatments against bt brinjal insect pest for ensuring yield and quality seed production of brinjal on the basis of yield ha^{-1} during total cropping season

Treatments	Number of fruits/plant	Healthy fruit yield (t/ha)	Infested fruit yield (t/ha)	Total fruit yield (t/ha)	Percentage increase over control
T_1	15.72 b	46.62 c	3.42 c	50.04 ab	12.27
T_2	16.12 b	47.92 b	2.39 d	50.31 ab	12.88
T_3	17.52 a	51.22 a	1.86 d	53.08 a	19.09
T_4	14.35 c	45.21 cd	4.38 b	49.59 ab	11.26
T_5	14.01 cd	43.96 d	4.58 b	48.54 b	8.91
T_6	13.25 d	42.06 e	5.21 b	47.27 bc	6.06
T_7	10.22 e	30.08 f	14.49 a	44.57 c	--
LSD $_{(0.05)}$	**0.95**	**1.58**	**0.94**	**3.70**	**--**
CV(%)	**3.69**	**2.02**	**10.21**	**4.24**	**--**

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

4.8. Effect of different treatments against bt brinjal insect pest for ensuring yield and quality seed production of brinjal on the basis of seed yield during total cropping season

Seed weight fruit^{-1}: The impact of different treatments on number of fruit plant^{-1} of bt brinjal has been shown in Table 11. Significant variations were observed among the treatments in terms of seed weight fruit^{-1} of bt brinjal. The highest seed weight fruit^{-1} (3.05 g) was recorded in T_3 which was statistically similar with (3.02 g) in T_2, (2.99 g) in T_1 and followed by (2.98 g) in T_4 treatment.

On the other hand the lowest seed weight fruit^{-1} of bt brinjal was (2.85 g) in T_7 (Untreated control), which was statistically different from (2.94 g) in T_6 treatment.

From the above finding it was observed that, T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment was showed the best performance for the seed weight fruit^{-1} of bt brinjal.

Seed weight plant^{-1}: From table 11, significant variation was observed in terms of seed weight plant^{-1} at the total cropping season of bt brinjal. Result showed that the highest seed weight plant^{-1} (54.23 g) was observed in T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment which was closely followed by (51.85 g) in T_2 and (51.11 g) in T_1 treatment.

Whereas the lowest seed weight plant^{-1} (40.14 g) was observed in untreated control (T_7) treatment which was followed by (44.98 g) and (46.72 g) in T_6 and in T_5 treatments respectively.

1000 seed weight (g): From table 11, significant variation was observed in terms of 1000 seed weight at the total cropping season of bt brinjal. Result showed that the highest 1000 seed weight (4.40 g) was observed in T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment which was closely followed by (4.35 g) in T_2 and (4.30 g) in T_1 treatment.

Whereas the lowest 1000 seed weight (4.01 g) was observed in untreated control (T_7) treatment which was followed by (4.12 g) and (4.15 g) in T_6 and in T_5 treatments respectively.

Seed weight ha^{-1}: From table 11, significant variation was observed in terms of seed weight ha^{-1} at the total cropping season of bt brinjal. Result showed that the lowest seed weight ha^{-1} (2135.6 kg) was observed in T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment which was closely similar with (2014.1 kg) in T_2 and (1985.7 kg) in T_1 treatment.

Whereas the lowest seed weight ha^{-1} (1502.5 kg) was observed in untreated control (T_7) treatment which was followed by (1685.4 kg) and (1712.5 kg) in T_6 and in T_5 treatments respectively.

Table 11. Effect of different treatments against bt brinjal insect pest for ensuring yield and quality seed production of brinjal on the basis of seed yield during total cropping season

Treatments	Seed weight fruit^{-1} (g)	Seed weight plant^{-1} (g)	1000 seed weight (g)	Seed weight ha^{-1} (kg)
T_1	2.99 ab	51.11 b	4.30 a	1985.7 ab
T_2	3.02 ab	51.85 b	4.35 a	2014.1 ab
T_3	3.05 a	54.23 a	4.40 a	2135.6 a
T_4	2.98 ab	48.02 c	4.20 a	1798.9 bc
T_5	2.95 abc	46.72 cd	4.15 a	1712.5 cd
T_6	2.94 bc	44.98 d	4.12 a	1685.4 cd
T_7	2.85 c	40.14 e	4.01 a	1502.5 d
LSD $_{(0.05)}$	**0.10**	**2.21**	**0.48**	**243.71**
CV(%)	**1.91**	**2.58**	**6.45**	**7.47**

[T_1 = Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals.; T_2 = Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals; T_3=Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals; T_4=Actara 25WG@ 0.3gm/L at the 15 days intervals; T_5= Larval parasitoid + Yellow sticky board traps; T_6=Field sanitation + Yellow sticky board traps; T_7 = Control]

4.9. Interaction with Brinjal shoot and fruit borer infestation and yield of bt brinjal

Correlation study was done to establish the relationship between percentage of brinjal shoot and fruit borer infestation and yield (t/ha) of bt brinjal in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the percentage of brinjal shoot and fruit borer and yield of bt brinjal (Figure 1). It was evident from the Figure 1 that the regression equation y = -1.4328x + 52.076 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.907) 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 percentage of brinjal shoot and fruit borer and yield of bt brinjal, i.e., the yield decreased with the increase of the percentage of brinjal shoot and fruit borer of bt brinjal in case of the performance of different treatments.

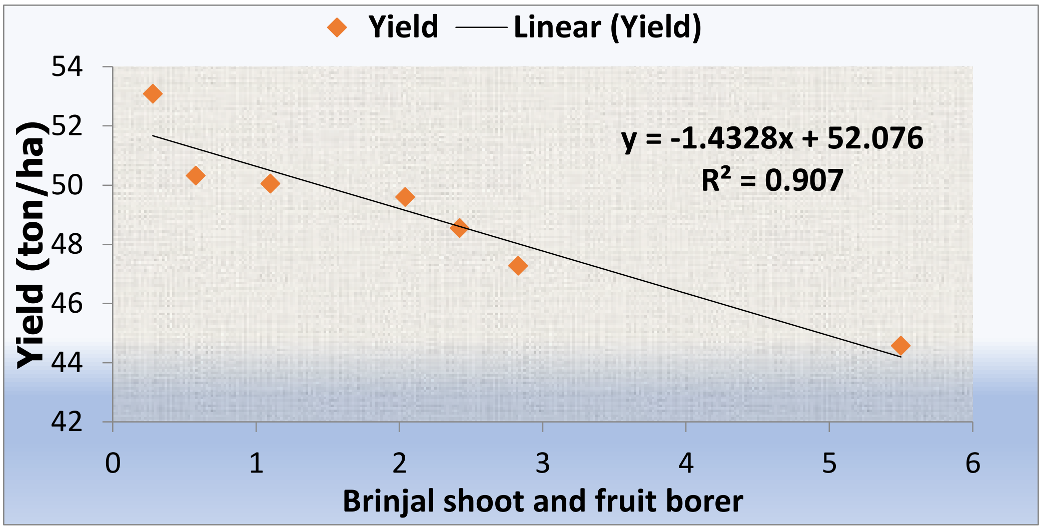

Figure 1: Relationship between percentage of brinjal shoot and fruit borer infestation and yield (t/ha) of bt brinjal during the study period.

4.10. Interaction with number of Jassid plant^{-1}and yield of bt brinjal

Correlation study was done to establish the relationship between percentage of number of Jassid plant^{-1}and yield (t/ha) of bt brinjal in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the percentage of number of Jassid plant^{-1} and yield of bt brinjal (Figure 2). It was evident from the Figure 2 that the regression equation y = -1.4947x + 62.101 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.8915) 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 percentage of number of Jassid plant^{-1} and yield of bt brinjal, i.e., the yield decreased with the increase of the percentage of number of Jassid plant^{-1} of bt brinjal in case of the performance of different treatments.

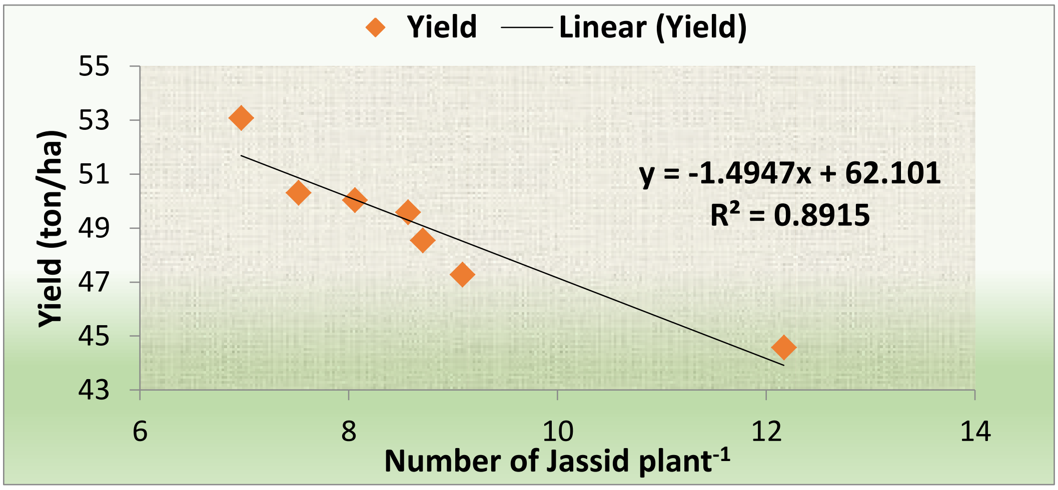

Figure 2: Relationship between percentage of number of Jassid plant^{-1}and yield (t/ha) of bt brinjal during the study period.

4.11. Interaction with number of Aphid plant^{-1}and yield of bt brinjal

Correlation study was done to establish the relationship between percentage of number of Aphid plant^{-1}and yield (t/ha) of bt brinjal in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the percentage of number of Aphid plant^{-1} and yield of bt brinjal (Figure 3). It was evident from the Figure 3 that the regression equation y = -1.5384x + 64.326 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.8011) 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 percentage of number of Aphid plant^{-1} and yield of bt brinjal, i.e., the yield decreased with the increase of the percentage of number of Aphid plant^{-1} of bt brinjal in case of the performance of different treatments.

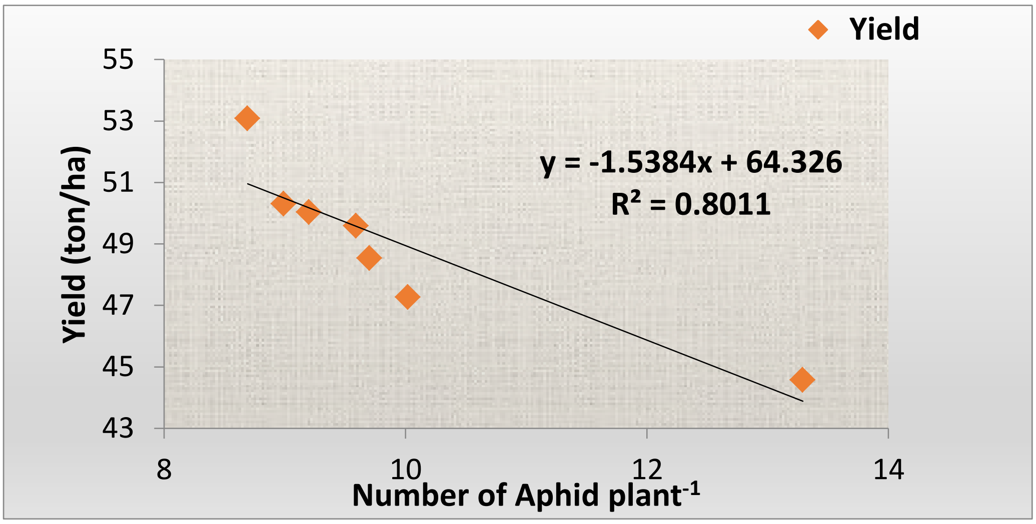

Figure 3: Relationship between percentage of number of Aphid plant^{-1} and yield (t/ha) of bt brinjal during the study period.

4.12. Interaction with number of Epilachna beetle plant^{-1}and yield of bt brinjal

Correlation study was done to establish the relationship between percentage of number of Epilachna beetle plant^{-1}and yield (t/ha) of bt brinjal in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the percentage of number of Epilachna beetle plant^{-1} and yield of bt brinjal (Figure 4). It was evident from the Figure 4 that the regression equation y = -2.8692x + 60.522 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.7869) 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 percentage of number of Epilachna beetle plant^{-1} and yield of bt brinjal, i.e., the yield decreased with the increase of the percentage of number of Epilachna beetle plant^{-1} of bt brinjal in case of the performance of different treatments.

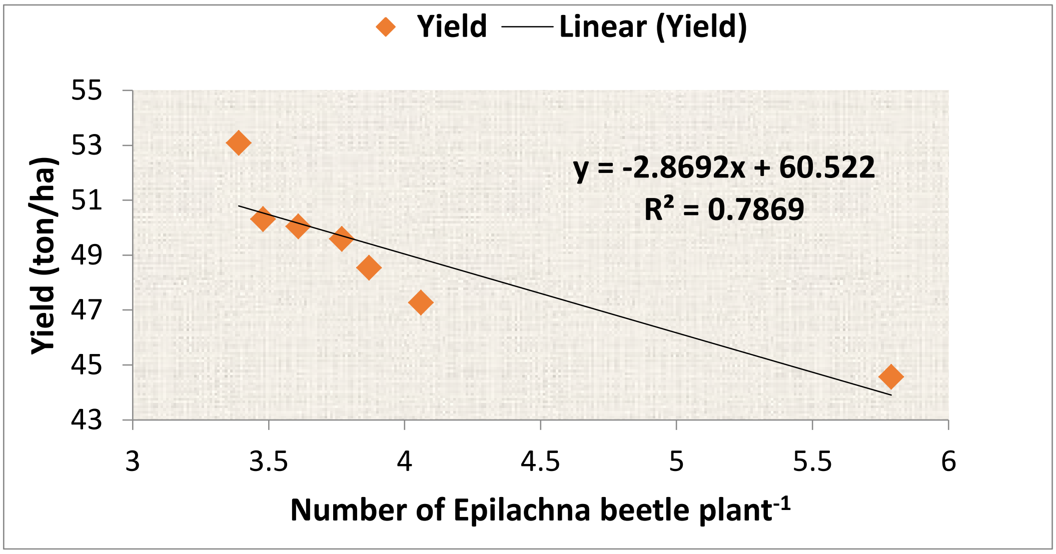

Figure 4: Relationship between percentage of number of Epilachna beetle plant^{-1} and yield (t/ha) of bt brinjal during the study period.

4.13. Interaction with number of Whitefly plant^{-1} and yield of bt brinjal

Correlation study was done to establish the relationship between percentage of number of Whitefly plant^{-1} and yield (t/ha) of bt brinjal in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the percentage of number of Whitefly plant^{-1} and yield of bt brinjal (Figure 5). It was evident from the Figure 5 that the regression equation y = -2.2997x + 66.658 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9376) 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 percentage of number of Whitefly plant^{-1} and yield of bt brinjal, i.e., the yield decreased with the increase of the percentage of number of Whitefly plant^{-1} of bt brinjal in case of the performance of different treatments.

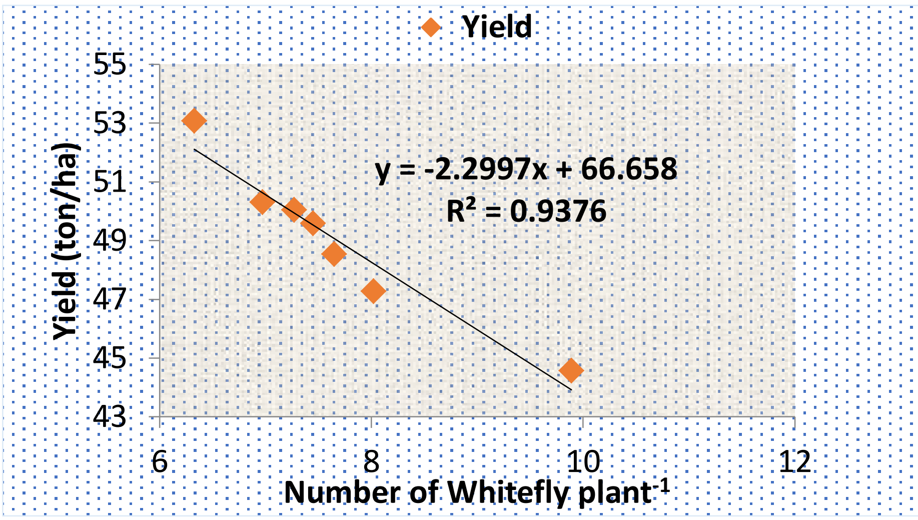

Figure 5: Relationship between percentage of number of White fly plant^{-1} and yield (t/ha) of bt brinjal during the study

4.14. Interaction with Seed weight ha^{-1} (kg) and yield of bt brinjal

Correlation study was done to establish the relationship between Seed weight ha^{-1} (kg) and yield (t/ha) of bt brinjal in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the Seed weight ha^{-1} (kg) and yield of bt brinjal (Figure 6). It was evident from the Figure 6, that the regression equation y = 0.0115x + 27.972 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9138) 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 the Seed weight ha^{-1} (kg) and yield of bt brinjal, i.e., the yield increase with the increase of the Seed weight ha^{-1} (kg) of bt brinjal in case of the performance of different treatments.

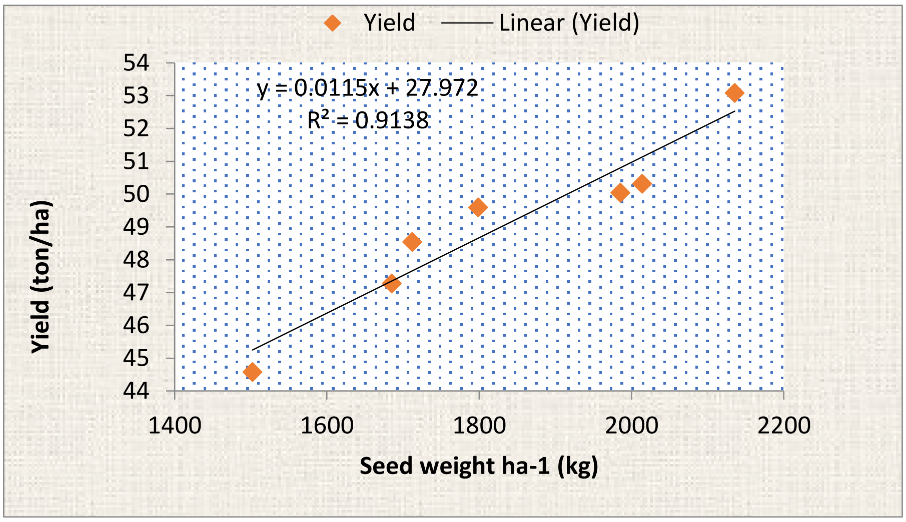

Figure 6: Relationship between percentage of Seed weight ha^{-1} (kg) and yield (t/ha) of bt brinjal during the study period.

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 October, 2020 to April, 2021 to study the eco-friendly management of insect pest of bt brinjal for ensuring yield and quality seed production (BARI Bt Begun-1). The experiment consists of control measures and plant extract.

Seven treatments, viz. Treatment T_1 (Spraying Bio-neem plus botanical insecticide @ 0.5 ml/L at the 7 days intervals); T_2 (Larval parasitoid + Bamper 20SL (Imidacloprid) @ 0.5 ml/L at the 7 days intervals); T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals)**;** T_4 (Actara 25WG@ 0.3gm/L at the 15 days intervals); T_5 (Larval parasitoid + Yellow sticky board traps); T_6 (Field sanitation + Yellow sticky board traps) and T_7 (untreated control) were included in this study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Results showed that the significant variations were observed among different stage bt brinjal in term of incidence of brinjal shoot and fruit borer, number of Jassid plant^{-1}, number of Aphid plant^{-1}, number of Epilachna beetle plant^{-1}, number of Whitefly plant^{-1}, yield of healthy fruit, infest yield of infested fruit, yield contributing characters and yield (t/ha) of bt brinjal.

Among seven treatments, it was observed that treatment T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) was the most effective treatment for reducing insect pests infestation at total growing stages.

In term of incidence of brinjal shoot and fruit borer of bt brinjal, at mean of overall growing stage, the lowest number per plant (0.28) was found from T_3 which was statistically different (0.58) with other treatments respectively.

On the other hand, the highest number of brinjal shoot and fruit borer was recorded in (5.50**)** T_7 (Untreated Control) which was statistically different from all other treatments.

In case of incidence of brinjal shoot and fruit borer reduction over control was estimated and the highest value was found from the treatment T_3 (94.91%) which was followed by T_2 (89.45%), T_1 (80.00%) and T_4 (62.91%) treatments and the minimum reduction over control from T_6 (48.55%) followed by (56.00%) T_5 treatment. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was $T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7$.

In term of incidence of number of Jassid plant^{-1} of bt brinjal**,** at mean of overall growing stage number of Jassid plant^{-1}, the lowest number per plant (6.97) was found from T_3 which was closely similar (7.52) with T_2 followed by (8.06) with T_1 and (8.57) with T_4 treatments respectively.

On the other hand, the highest number of Jassid plant^{-1} was recorded in (12.17**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (9.09 and 8.71) by T_6 and T_5 treatment.

Incidence of number of Jassid plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (42.73%) which was followed by T_2 (38.21%), T_1 (33.77%) and T_4 (29.58%) treatments and the minimum reduction over control from T_6 (25.31%) followed by (28.43%) T_5 treatment. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was $T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7$.

In term of incidence of number of Aphid plant^{-1} of bt brinjal**,** at mean of overall growing stage, in case of number of Aphid plant^{-1}, the lowest number per plant (8.69) was found from T_3 which was closely similar (8.99) with T_2 followed by (9.20) with T_1 and (9.59) with T_4 treatments respectively.

On the other hand, the highest number of Aphid plant^{-1} was recorded in (13.29**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (10.02 and 9.70) by T_6 and T_5 treatment.

Incidence of number of Aphid plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (34.61%) which was followed by T_2 (32.36%), T_1 (30.78%) and T_4 (27.84%) treatments and the minimum reduction over control from T_6 (24.60%) followed by (27.01%) T_5 treatment.

In term of incidence of number of Epilachna beetle plant^{-1} of bt brinjal**,** at mean of overall growing stage, in case of number of Epilachna beetle plant^{-1}, the lowest number per plant (3.39) was found from T_3 which was closely similar (3.48) with T_2 followed by (3.61) with T_1 and (3.77) with T_4 treatments respectively.

On the other hand, the highest number of Epilachna beetle plant^{-1} was recorded in (5.79**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (4.06 and 3.87) by T_6 and T_5 treatment.

Incidence of number of Epilachna beetle plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (41.45%) which was followed by T_2 (39.90%), T_1 (37.65%) and T_4 (34.89%) treatments and the minimum reduction over control from T_6 (29.88%) followed by (33.16%) T_5 treatment.

In term of incidence of number of Whitefly plant^{-1} of bt brinjal**,** at mean of overall growing stage, in case of number of Whitefly plant^{-1}, the lowest number per plant (6.66) was found from T_3 which was closely different (6.97) with T_2 followed by (7.27) with T_1 and (7.45) with T_4 treatments respectively.

On the other hand, the highest number of Whitefly plant^{-1} was recorded in (9.89**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (8.02 and 7.65) by T_6 and T_5 treatment.

Incidence of number of Whitefly plant^{-1} reduction over control was estimated and the highest value was found from the treatment T_3 (32.66%) which was followed by T_2 (29.52%), T_1 (26.49%) and T_4 (24.67%) treatments and the minimum reduction over control from T_6 (18.91%) followed by (22.65%) T_5 treatment. As a result the order of rank of study on the eco-friendly management of insect pest of bt brinjal for ensuring quality yield of brinjal by number was $T_3 > T_2 > T_1 > T_4 > T_5 > T_6 > T_7$.

In term of number of leaves 5 tagged plant of bt brinjal, The highest number of leaves 5 tagged plant was recorded in T_3 which was statistically similar with others treatment.

On the other hand the lowest number of leaves 5 tagged plant of bt brinjal was in T_7 (Untreated control), which was statistically different others treatment.

In term of number of branch of 5 tagged plant of bt brinjal. The highest number of branch 5 tagged plant (56.22) was recorded in T_3 which was statistically different from others treatment.

On the other hand the lowest number of branch 5 tagged plant of bt brinjal was (42.11) in T_7 (Untreated control), which was statistically different others treatment.

In term of single fruit weight of bt brinjal. The highest single fruit weight (69.53 g) was recorded in T_3 which was statistically different from others treatment.

On the other hand the lowest single fruit weight of bt brinjal was (50.79 g) in T_7 (Untreated control), which was statistically different others treatment.

In term of length and girth of fruit of bt brinjal. The maximum length and girth of fruit was recorded in T_3 which was closely similar with others treatment except control.

On the other hand the minimum length and girth of fruit of bt brinjal was in T_7 (Untreated control), which was statistically different from others treatment.

In terms of number of fruit plant^{-1} of bt brinjal. The highest number of fruit plant^{-1} (17.52) was recorded in T_3 which was statistically different from others treatment.

On the other hand the lowest number of fruit plant^{-1} of bt brinjal was (10.22) in T_7 (Untreated control), which was statistically different from others treatment.

In term of healthy fruit yield, the highest yield of healthy fruits (51.22 t/ha) was observed in T_3 treatment which was closely different from others treatment.

Whereas the lowest yield of healthy fruits (30.08 t/ha) was observed in untreated control (T_7) treatment which was statistically different from other treatments.

In term of infested fruit yield, the lowest yield of infested fruits was observed in T_3 treatment which was closely different from others treatment.

Whereas the highest yield of infested fruits was observed in untreated control T_7 treatment which was statistically different from other treatments.

In term of yield of total fruits, the highest yield of total fruits (53.08 t/ha) was observed in T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) treatment which was closely similar with (50.31 t/ha) in T_2 and (50.04 t/ha) in T_1 treatment.

Whereas the lowest yield of total fruits (44.57 t/ha) was observed in untreated control (T_7) treatment which was followed by (47.27 t/ha) and (48.54 t/ha) in T_6 and in T_5 treatments respectively.

CONCLUSION

From the above description, it can be concluded that, spraying T_3 (Field sanitation + Sex pheromone traps + Bamper 20SL@ 0.5 ml/L at the 7 days intervals) reduced the infestation of insect pest of bt brinjal of variety BARI Bt Begun-1 (Bt uttara).

RECOMMENDATIONS

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

- Diversity of insect pests may be studied in several years all over Bangladesh to identify the major insect pests of bt brinjal.
- Further trials with effective different eco-friendly management may be done at different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI

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