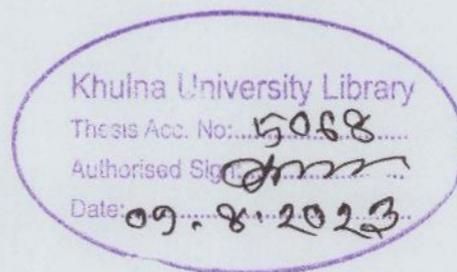


**APPRAISAL OF RESISTANT GENOTYPES AND
MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER
(BSFB) USING BOTANICALS**

A Thesis



Submitted to

Agrotechnology Discipline

Khulna University

By

Examination Roll No.: MS-120810

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Copyright by

**Hafija Sultana
Khulna, Bangladesh**

APRIL 2016

KHULNA UNIVERSITY
AGROTECHNOLOGY DISCIPLINE
FINAL ORAL EXAMINATION OF THE M. S. Hort. Thesis

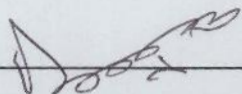
The undersigned certify that they have read and recommended to the
Agrotechnology Discipline for acceptance, an M. S. Hort. Thesis entitled

**“APPRAISAL OF RESISTANT GENOTYPES AND MANAGEMENT OF
BRINJAL SHOOT AND FRUIT BORER (BSFB) USING BOTANICALS”**

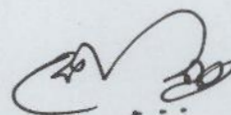
By

Examination Roll: MS-120810

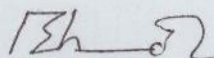
In Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN HORTICULTURE



Dr. Md. Abdul Mannan
Professor
Supervisor



Khan Golam Quddus
Professor
Co- Supervisor



Prof. Dr. Mohammad Bashir Ahmed

Chairman, Examination Committee
and

Head, Agrotechnology Discipline

(The signature of the Chairman does not necessarily signify that the Chairman
has read the thesis)

April 2016

DEDICATED

TO

MY BELOVED

PARENTS

ACKNOWLEDGEMENT

To Allah Almighty, the most gracious, the most merciful in debt and remains, who blessed the author with courage to accomplish this task. The words are inadequate to express the deepest sense of appreciation and devotion to my worthy supervisor Dr. Md. Abdul Mannan, Professor, Agrotechnology Discipline, Khulna University, Khulna. The author expresses extremely grateful for his scholastic and sympathetic attitude, generous assistance, timely advice and enlightened supervision in accomplishment of this dissertation.

The author expresses her deep sense of gratitude to Khan Golam Quddus, Professor, Agrotechnology Discipline, Khulna University, Khulna, co-supervisor for his able guidance and supervision which enabled her to complete this research work. Sincere appreciation and gratification to Discipline Head and all the respected teachers specially Mr. Shimul Kumar Das, Assistant Professor of the Agrotechnology Discipline, Khulna University, Khulna for his valuable advice, suggestions and constructive criticism about the research work and thesis preparation. Her special thanks to Syed Abdul Motin, innovator and researcher for providing botanicals and thanks also go to all the staff of the Agrotechnology Discipline, Khulna University for their direct and indirect helpful cooperation to complete the research work.

The author expresses her boundless gratitude to her parents and sisters for their sacrifices, inspiration, and continuous blessings opened the gate and paved the way for her higher study. She would like to convey her love to her friends especially Nusrat Jahan, Nasrin Sultana, Sheuli Mazumder and Tahmina Akhter for their continuous help and sacrifice throughout the research work.

April, 2016



The Author

ABSTRACT

The main purposes of the study were to determine the effect of botanical extracts on the control of brinjal shoot and fruit borer (BSFB) and to find out the best BSFB resistant variety of brinjal. Two experiments were conducted; first experiment was carried out at Prof. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University (KU) Khulna during the period from December 2013 to June 2014 and the second experiment was conducted in sack at the germplasm centre, Agrotechnology Discipline, Khulna University, Khulna during February 2014 to August 2014. In the first experiment six botanicals and control were used as seven treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD), with 3 replications. There were 7 treatments viz., T_0 = Control (only water), T_1 = Neem leaf extract, T_2 = Neem oil, T_3 = Mahogany oil, T_4 = Mahogany (oil + cake), T_5 = Garlic extract and T_6 = Tobacco leaf extract. The brinjal variety 'Makra' differed considerably for treatment variations in terms of crop growth characters as well as yield and yield contributing characters. Data were collected on total numbers of shoot, total numbers of infested shoot, percentage of shoots damage, percentage reduction of shoots infestation, numbers of larvae per infested shoot, total numbers of fruits, percentage of fruits damage, percentage reduction of fruits infestation, numbers of larvae per infested fruits, cost of production, gross return and benefit cost ratio (BCR). In all the parameters Mahogany (oil + cake) showed the best performance followed by Neem oil and the lowest performance was observed from Control (only water).

In the second experiment thirteen varieties were used as treatment. This is a one factor experiment that was laid out in CRD using thirteen varieties with five replications. The varieties were V_1 =BARI begun-1, V_2 =BARI begun-4, V_3 =BARI begun-5, V_4 =BARI begun-6, V_5 =BARI begun-7, V_6 =BARI begun-8, V_7 =BARI begun-9, V_8 =BARI begun-10, V_9 =Makra, V_{10} =Muktokashi, V_{11} =Lalita, V_{12} =Hazra, V_{13} =Chaga. Data were collected on total number of shoot, total number of infested shoot, percentage of shoot damage, percentage of shoot infestation reduction, numbers of larvae per infested shoot, total number of fruit, percentage of fruit damage, percentage of fruit infestation reduction, numbers of larvae per infested fruit. The maximum numbers of fruits was observed in V_1 and minimum in V_9 and in V_{10} . Percent of fruit infestation was maximum in V_{10} (Muktokashi) and minimum in V_4 (BARI begun-6).

From the present study it was found that Mahogany (oil + cake) showed the best result and BARI begun-6 showed the highest performance against brinjal shoot and fruit borer.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	ACKKNOWLEDGEMENT	I
	ABSTRACT	II
	LIST OF TABLE	III - IIII
	LIST OF FIGURES	IIII
	LIST OF ACRONYMS	IIIV
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-22
	2.1. Physico-morphic characters	4-7
	2.2. Infestation	7-10
	2.3. Integrated pest management	10-16
	2.4. Resistance/susceptibility	16-21
	2.5 Botanicals	21-22
III	MATERIALS AND METHODS	23-35
	3.1 Experiment 1: Effect of botanical extract on the management of brinjal shoot and fruit borer (BSFB).	23
	3.1.1 Experimental site	23

3.1.2 Climate of the experimental site	23
3.1.3 Characteristics of soil	23
3.1.4 Plant material used	24
3.1.5 Raising of seedlings	24
3.1.6 Preparation of plots	24
3.1.7 Design and layout of the experiment	24
3.1.8 Transplanting of brinjal seedlings	25
3.1.9 Treatments of the experiment	25
3.1.10 Preparation of treatments	25
3.1.10.1 Preparation of Neem leaf extracts and the stock solution	25
3.1.10.2 Preparation of Garlic extract and the stock solution	26

3.1.10.3 Preparation of Tobacco leaves extract and the stock solution	26
3.1.11 Treatment application	26
3.1.12 Untreated control	27
3.1.13 Intercultural operations	27
3.1.13.1 Gap filling	27
3.1.13.2 Weeding	27
3.1.13.3 Irrigation	27
3.1.13.4 Harvesting	27
3.1.14 Data collection	27
3.1.14.1 Total numbers of shoot	28
3.1.14.2 Total numbers of infested shoot	28
3.1.14.3 Percentage of shoots damage	28
3.1.14.4 Percentage of shoots infestation reduction	28
3.1.14.5 Numbers of larvae per infested shoot	28

3.1.14.6 Total numbers of fruits	28
3.1.14.7 Total numbers of infested fruits	29
3.1.14.8 Percentage of fruits damage	29
3.1.14.9 Percentage of fruits infestation reduction	29
3.1.14.10 Numbers of larvae per infested fruits	29
3.1.14.11 Weight of healthy and infested fruits	29
.3.1.14.12 Cost of production	29
3.1.14.13 Gross return	30
3.1.14.14 Benefit from the product	30
3.1.14.15 Benefit cost Ratio (BCR)	30
3.1.14.16 Data analysis	30

3.2 Experiment 2: Performance of brinjal varieties against brinjal shoot and fruit borer (BSFB).	30
3.2.1 Experimental site	31
3.2.2 Climate	31
3.2.3 Soil	31
3.2.4 Preparation of bags	31
3.2.5 Planting materials	31
3.2.6 Raising of seedlings	32
3.2.7 Transplanting of brinjal seedlings	32
3.2.8 Varieties of the experiment	32
3.2.9 Intercultural operations	33
3.2.10 Gap filling	33
3.2.11 Weeding	33
3.2.12 Irrigation	33
3.2.14 Data collection	33
3.2.14.1 Total numbers of shoot	33
3.2.14.2 Total numbers of infested shoot	34
3.2.14.3 Percentage of shoots damage	34
3.2.14.4 Numbers of larvae per infested shoot	34
3.2.14.5 Total numbers of fruits	34
3.2.14.6 Total numbers of infested fruits	34
3.2.14.7 Percentage of fruits damage	34
3.2.14.8 Numbers of larvae per infested fruits	34
3.2.14.9 Weight of healthy and infested fruits	35
3.2.10 Data analysis	35



IV	RESULTS AND DISCUSSION	36-66
	4.1 Experiment 1: Effect of botanicals on the management of brinjal shoot and fruit borer (BSFB)	36-51
	4.1.1 Infestation of shoot in vegetative stage (30-60 DAT)	36-37
	4.1.2 Infestation of shoot in early fruiting stage (60-90 DAT)	37-38
	4.1.3 Infestation of shoot in mid fruiting stage (90-120 DAT)	38-39
	4.1.4 Infestation of shoot in late fruiting stage (120-150 DAT)	39-40
	4.1.5 Percent shoot infestation in different stages	40-41
	4.1.6 Percent shoot infestation reduction over control in different stages	42-43
	4.1.7 Infestation of fruit in early fruiting stage (60-90 DAT)	43-44
	4.1.8 Infestation of fruit in mid fruiting stage (90-120 DAT)	44-45
	4.1.9 Infestation of fruit in late fruiting stage (120-150 DAT)	45-46
	4.1.10 Percent fruit infestation by in different stages	46-47
	4.1.11 Percent fruit infestation reduction over control in different stages	47-48
	4.1.12 Effect of botanicals on brinjal yield	49-50
	4.1.13 Cost and return analysis of brinjal production	50-51

4.2 Experiment 2: Performance of brinjal varieties against brinjal shoot and fruit borer (BSFB).	51-66
4.2.1 Performance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in vegetative stage (30-60 DAT)	51-52
4.2.2 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in early fruiting stage (60-90 DAT)	52-53
4.2.3 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in mid fruiting stage (90-120 DAT)	54-55
4.2.4 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in late fruiting stage (120-150 DAT)	55-56
4.2.5 Performance of different brinjal varieties against percent shoot infestation by brinjal shoot and fruit borer (BSFB) on different stages	56-58
4.2.6 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in early fruiting stage (60-90 DAT)	58-59
4.2.7 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in mid fruiting stage (90-120 DAT)	60-61
4.2.8 Performance of different varieties against brinjal	61-62

	shoot and fruit borer (BSFB) on fruit infestation in late fruiting stage (120-150 DAT)	
	4.2.9 Performance of different brinjal varieties against percent fruit infestation by brinjal shoot and fruit borer (BSFB) on different stages	63-64
	4.2.10 Resistance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) infestation	64-65
	4.2.11 Yield Performance of different varieties	65-66
V	SUMMARY AND CONCLUSION	67-70
VI	REFERENCES	71-84
	APPENDICES	85-101

LIST OF TABLES

Table no.	Title	Page no.
1	Effect of botanicals on brinjal shoots infestation by brinjal shoot and fruit borer (BSFB) in vegetative stage (30-60 DAT)	37
2	Effect of botanicals on brinjal shoots infestation by brinjal shoot and fruit borer (BSFB) in early fruiting stage(60-90 DAT)	38
3	Effect of botanicals on brinjal shoots infestation by brinjal shoot and fruit borer (BSFB) in mid fruiting stage(60-90 DAT)	39
4	Effect of botanicals on brinjal shoots infestation by brinjal shoot and fruit borer (BSFB) in late fruiting stage (120-150 DAT)	40
5	Effect of botanicals on brinjal fruits infestation by brinjal shoot and fruit borer (BSFB) in early fruiting stage (60-90 DAT)	44
6	Effect of botanicals on brinjal fruits infestation by brinjal shoot and fruit borer (BSFB) in mid fruiting stage (90-120 DAT)	45
7	Effect of botanicals on brinjal fruits infestation by brinjal shoot and fruit borer (BSFB) in late fruiting stage (120-150 DAT)	46
8	Cost and return analysis of brinjal production	50-51

9	Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in vegetative stage (30-60 DAT)	51-52
10	Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in early fruiting stage (60-90 DAT)	52-53
11	Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in mid fruiting stage (90-120 DAT)	53-54
12	Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in late fruiting stage (120-150 DAT)	55
13	Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in early fruiting stage (60-90 DAT)	57-58
14	Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in mid fruiting stage (90-120 DAT)	58-59
15	Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in late fruiting stage (120-150 DAT)	5-60
16	Resistance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) infestation	62
17	Yield Performance of different varieties	63

LIST OF FIGURES

Figure no.	Title	Page no.
1	Percent shoot infestation in different stages	41
2	Percent shoot infestation reduction over control in different stages	43
3	Percent fruit infestation in different stages	47
4	Percent fruit infestation reduction over control in different stages	48
5	Effect of botanicals on brinjal yield	50
6	Percent shoot infestation in different stages	58
7	Percent fruit infestation in different stages	63

LIST OF ACRONYMS

BSFB = Brinjal Shoot and Fruit Borer

CV = Co-efficient of Variation

DAT = Days After Transplanting

DMRT = Duncan's Multiple Range Test

MoP= Murate of Potash

TSP= Triple Super Phosphate

CHAPTER I

INTRODUCTION

Brinjal (*Solanum melongena*) is one of the typical vegetables in that its' cultivation helps to improve human nutrition and generate income. It is the most common, popular and principal vegetable in Bangladesh and other parts of the world (Nonnecke, 1989). This vegetable is cultivated largely on small, family-owned farms where weekly sale of its produce brings in a ready cash income (Alam *et al.*, 2003). It contains some very essential nutrients that are highly beneficial for the human body. It is rich in dietary fiber, vitamins and minerals. The statistics have been sourced from USDA that the nutrients in brinjal value/100 g (raw) are water 92.30 g, energy 25 kcal, protein 0.98 g, carbohydrate 5.88 g, dietary fiber 3.0 g and sugar 3.53g. Bajaj *et al.* (1979) reported that on an average the oblong fruited brinjal cultivars are rich in total water soluble sugars, whereas the long fruited cultivars contain large amounts of free reducing sugars, anthocyanin, phenols, glycoalkaloids (as solasodine), dry matter and amide proteins. What's more, they contain negligible calories, making them an ideal component of both low-fat and weight loss diets.

In tropical and subtropical climates, brinjal can be sown directly into the garden (Doijode, 2001). Brinjal is one of the most important vegetables in South and South-East Asia (Thapa, 2010) having hot-wet climate (Hanson *et al.*, 2006). The cultivation of brinjal is more than 1,600,000 ha producing around 50 million MT throughout the world, among which, ninety percent of production from five countries, of which china shares 58 percent of output, India, 25%, followed by Iran, Egypt and Turkey (FAO, 2012). The higher yield and longer fruiting and harvesting period lure the farmer on eggplant production (Ghimire *et al.*, 2007). Brinjal, the most popular and preferred vegetable, is widely grown in Bangladesh. It covers about

15% of the total vegetable area of the country producing 1.6 million tons annually. The production of brinjal is 60-65 t/ha (BARI, 2005) which is not satisfactory to meet up the growing demand of it. The production of brinjal is affected severely by different pest attack. Brinjal is susceptible to the attack of various insects from seedling to fruiting stage. In Bangladesh about eight insect species are considered as major pests causing damage to the crops (Biswas *et al.*, 1992). Among them brinjal shoot and fruit borer (*Leucinodes orbonalis*, Guenee) is one of the most destructive insect pests of brinjal in Bangladesh (Alam, 1969). As a result of its feeding inside fruit, the fruits become unmarketable and yield losses up to 90 percent (Baral, *et al.*, 2006). It also reduces the content of vitamin C in fruit up to 80 percent (Sharma, 2001). Brinjal shoot and fruit borer is the most destructive pest which caused 31-86% fruit damage in Bangladesh (Alam *et al.*, 2003) reaching up to 90% (Rahman, 1997), 37-63% in India (Dhankar, 1988) and 50-70% in Pakistan (Saeed and Khan, 1997). In this condition brinjal production is in threat in the recent years due to increased cost of production on management of insect pest complex. Farmers of Bangladesh as well as of other Asian countries in most cases solely depend on insecticides for the management of the pest. Such dependence on insecticides has created many problems such as very frequent application of insecticides (up to 140 times in a season), excessive residues on marketed vegetables that concerns general consumer's health and the environment, pesticide resistance, trade implications, poisoning, hazards to non-target organisms, increased production costs etc. (Alam *et al.*, 2003; Pedigo, 2002; Debach and Rosen, 1991). The cost of pesticide to total material input cost was 55% for brinjal and it ranked first when compared to tomato (31%) and cabbage (49%) in the Philippines (Orden *et al.*, 1994), whereas it was 40-50% in Bangladesh (SUSVEG Asia, 2007). In the meantime, the insect is becoming tolerant to the

chemicals, making it more difficult to control. The current pesticide use is not only non-sustainable but, if continued, it will adversely affect brinjal and other vegetable production (Anjali *et al.*, 2012). For this reason the farmers are losing their crops and income greatly.

Now-a-days, emphasis is given on the use of plant extracts as biopesticides in insect control measures (Singh, *et al* 2007; Gupta and Raghuraman, 2004; Oerke, 2006 and Gokce, 2010). This is because that the use of plant based biopesticides in insect control is non-toxic and safe biodegradable alternatives to the conventional chemical control (Prakash and Rao, 1997; Anil Kakker and Pandey, 2001; Dolui and Debnath, 2010). Much of the efforts have been expanded by several workers towards the screening of indigenous plants for their reproductive deterrent or anti fertility properties against some insect pests (Sukumar and Osmani, 1981).

In the context of damage for ensuring food safety and minimization of severity, environmental hazards, appropriate management practice for BSFB incorporating different methods as needed and ought to be devised consistent with modern pest management. The research and development activities to combat BSFB have largely been confined to select the most effective botanical extracts and determining the resistant variety of brinjal. This has led to decrease dependence on pesticides and consequent adverse effects of higher costs of production, environmental pollution and destruction of natural enemies of pests. The present study will be very helpful for the improvement of the farmer's condition. So, proper choice of brinjal variety and botanical extract for the management practices of brinjal shoot and fruit borer is essential. Therefore the present study was undertaken with the following objectives:

- To determine the effectiveness of botanicals on the control of BSFB.
- To find out the best BSFB resistant variety of brinjal

CHAPTER II

REVIEW OF LITERATURE

It is an essential requirement of a scientist or researcher that he acknowledges the contributions of the previous workers. No one can be successful without knowing what others have done before. It is an innate desire of all willing to contribute in his field, to learn from other people on this regard. For everything, there must be some previous information. A real researcher will never ignore going through those information. Literature review, therefore, constitute one of the basic requirements of any research report or dissertation. During the present work a good number of literatures were consulted. The main sources were books, journals, abstracts, popular articles etc. The seminar library of Agrotechnology Discipline in Khulna University and Central Library of Khulna University were exploited. Relevant web sites in the internet were regularly browsed.

The literature relevant to the present study is reviewed in this chapter. A retrospection of literature pertaining to utilization of botanical extract and performance of different brinjal varieties to control brinjal shoot and fruit borer are presented below. The researcher attempted to study the most effective botanical extract and resistant variety to control brinjal shoot and fruit borer. However for the management of *Leucinodes orbonalis* (Guenee) in brinjal and other related crops are presented here under the following headings.

2.1. Physico-morphic characters

Study of morphological traits and the attack of *L. orbonalis* in brinjal were conducted among 150 lines tested, PBR 129.5, Punjab barsati and SM-174, were found to be highly resistant and Punjab chamkila was the most susceptible to damage by the borer (Dilbagh *et al.*, 1991).

Evaluation of twenty eight brinjal varieties was conducted on morphological cleaved of plant leaf and fruit for antixenosis against brinjal shoot and fruit borer. It was observed that varieties with characteristics like hair and prickles on stems, leaves and fruit stalks result in lowest percentage of fruit infestation as compared to those without hair and prickles (Ali *et al.*, 1994).

Study of physical and biochemical characters of plants associated with resistance of shoot and fruit borer was conducted with ten aubergine cultivars. The anatomical characters such as more lignified hypodermis, compact vascular bundles and narrow shoot pith were less susceptible cultivars. It was found that there was significant negative correlation between silica contents and the degree of shoot infestation. Borer doesn't prefer light green fruits and were less infested as they had narrow pericarp and mesocarp with compact seedlings and seeds closely arranged. Certain biochemical characters of the plants were positively correlated with fruit infestation such as total sugar contents, free amino acid and crude oil protein (Jat and Pareek, 2003).

Comparative study of the ratoon cropping of two hybrids and a local cultivar for their additive and non-additive characteristics was conducted. Although the plant height was more in MBH-10 hybrid yet its leaf surface index was less than other hybrid, Manjrigota. Contrarily, MBH-10 was high in yield compared to Manjrigota and other cultivar. However, shoot and fruit borer infestation was comparatively less in hybrids as compared to normal cultivar (Page *et al.*, 2004).

Experiment to determine the factor of resistance in aubergine against shoot and fruit borer was performed. The number of infested shoot and fruit along with morphological character,

including plant height, leaves per plant, mean leaf area, leaf area per plant, primary branches per plant, thickness of terminal shoots, terminal shoots per plant, and fruit per plant and fruit length was recorded. These morphological characters were highly correlated to the infestation of shoot and fruit borer. It was concluded that lower the moisture, sugar and protein contents in fruit make them less susceptible to *L. orbonalis* infestation (Hazaraet al., 2004).

A study was conducted with four interspecific crosses of aubergine on F < sub > 4 < sub > generation, EP 65 *Solanum viarum*, *S. viarum* MDU 1, EP 45 *solanum*, and Co 2 *S. viarum*. Data on plant height, number of branches per plant, number of fruit per plant, fruit length, fruit girth, mean fruit weight, calyx length, marketable yield per plant, and shoot and fruit borer (*L. orbonalis*) infestation was recorded. The genotype coefficient of variation was found to be high for fruit and shoot borer infestation (Prabhu et al., 2007).

The combined ability of eight lines with three starters of aubergine for additive gene flow, fruit number and their yield were studied. Non-additive ability was also focused by heterosis process. High rate of additive and non-additive characteristics were observed in hybrid lines of the parent cultivars (Kamalakkannan et al., 2007).

Studies were conducted on aubergine, white potato, sweet potato, tomato, okra, polestar and black night shade under the aspect of different host range of *L. orbonalis*. The insect's eggs were recorded three days after infestation at vegetative and fruiting stages. Aubergine was found preferred as host and eggs were seen on lower surface of top and middle leaves (Ardez et al., 2008).



Study was performed on different morphological and biochemical aspects of shoot and fruit borer in two brinjal varieties. HLB-12 a resistant genotype manifested 29% less damage against BR-112 which demonstrated 42-61.5% damage as highly susceptible variety. Resistance was positively attributed to pericarp and mesocarp thickness and compactness of seed ring. Moisture contents, crude protein and nitrogen showed positive correlation but total sugar, fiber contents tannin, potassium and manganese were negatively affected (Chandrashekhar *et al.*, 2009).

2.2. Infestation

In an experiment, 28.52%, 25.37%, 5.54%, 28.73% and 29.53% fruit borer infestation was observed on Black beauty, Muktakeshi, Pusa purple long, Bananas giant and Pusakranti cultivars of *melongena*, respectively (Mote and Shivu, 2003). It was reported that *L. orbonalis* found where ever the egg plant is grown and cause significant damage i.e. 12-16% on shoot and 20-63% on fruits (Alam, 1969).

Considerable damage was observed by *L. orbonalis* which adversely affected the quality and quantity of the brinjal crop. Damage by brinjal shoot and fruit borer started at seedling stage and continued till last harvesting of the eggplant (Islam and Karim, 1991).

In another experiment it was observed at vegetative phase that the larvae after hatching bore into the petioles, young tender shoots and large leave's midribs. It has also been observed that the larvae prefer to enter into the tender fruit through the calyx while boring flower buds. Examining the bored holes the infested fruit can easily be identified by the presence of dark colored excreta. Certain microorganisms because secondary infections resulting in further

deterioration of the fruit and ultimately made it unfit for the human consumption (Islam and Karim, 1994).

Irradiated lines of brinjal were compared for growth, yield and borer infestation. Very low infestation of fruit and shoot borer was observed in these irradiated lines as compared to the control one. It was observed that purple pigmentation, tough calyx cover and high phenolic contents in these lines, might be the reason for their resistance to borer's infestation (Babu *et al.*, 1999).

Field experiment for fruit borer infestation and yield characters of eight brinjal cultivars and four related *Solanum* species was carried out. Considerable differences both in phenotypic and genotypic characteristics were observed. Major factors like diameter and length of fruit with yield potential were highly genetic variations (Behera *et al.*, 1999).

The incidence of bacterial wilt and the attack of fruit and shoot borer on nine genotype of brinjal were studied. The fruit borer infestation in these varieties ranged from 2.88 to 5.64% (Chaudhry and Sharma, 2000). Similarly, twelve cultivars were compared for borer infestation and found 33 to 53% damage of fruit in different cultivars (Kumar and Shukla, 2002).

The infestation level of fruit and shoot borer on a local brinjal cultivar with high yield potential of 5-11 fruits per plant was observed. Along with *L. orbonalis* other sucking and chewing insect pests were also observed. The mechanical suppression of these pests was found to be successful in managing these insect pests below economic injury level (Karmakar and Bhattacharya, 2000).

Survey of sixty farmer's fields was conducted in Orissa, India regarding the severity of *L. orbonalis* infestation in aubergine and local practices used for their management. Farmers found this insect pest as the most dangerous for the brinjal crop and considered blanket spraying as the most important management tool using Carbaryl, Endosulfan, Carbofuran and Cypermethrin. The farmers growing vegetables like aubergine were having negligible knowledge of beneficial insects (Krishna *et al.*, 2001).

A field experiment was conducted to examine the inheritance of resistance in eggplant for number of infested and non-infested shoot and total number of infested fruits per plant damaged by brinjal shoot and fruit borer was also recorded (Divya *et al.*, 2007).

A field trial was conducted in India to screen twenty five brinjal cultivars against *L. orbonalis* from July to December. Infestation progress was calculated on weekly basis using a 1-10 scale for classification in various categories. Pusa purple and Black Beauty proved to be resistant (1-10%) but Aspara, Brinjal-925, Shabnam and MEBH-11 with 11-20% fruit infestation were recognized as moderately resistant cultivars (Elanchezhyan *et al.*, 2008).

In another study including twelve brinjal cultivars shoot and fruit infestation was recorded from 4.0 to 11.1% and 16.24 to 45.7%, respectively (Senapati, 2003). A field experiment was conducted, based on different levels of infestation of brinjal shoot and fruit borer, to evaluate the comparative effectiveness of three IPM packages. The first IPM package was mechanically controlled grafted aubergine, the second package included application of neem oil, kerosene and wild Ipomoea extract, while third IPM package contained application of cypermethrin verses untreated control. Cypermethrin showed lowest fruit infestation when treated on grafted plants. Grafted brinjal were used in IPM packages 1 and 3, where the

quantity of invisible portion of infested fruit was found lower. In all IPM packages; the intensity of attack was higher including the control, in all the plants at early and late stages of fruiting (Rahman and Islam, 2004).

2.3. Integrated pest management

Efficacy of different methods either singly or in combinations for control of *L. orbonalis* was observed. *Trichogramma* was found more effective than control plots for the management of shoot and fruit borer. The main results comprised on neem oil (0.2%), neem oil (0.1%) + lufenuron (0.01%), neem oil (0.1%) + B.T. (0.075%), and neem oil (0.1%) + carbaryl (0.075%) which resulted in higher fruit yield compared with control plots (Sasikala *et al.*, 1999).

Efficacy of *Bracon brevicornsis* biological control agent against *L. orbonalis* was studied. There was about 10% damage in the parasitoid release was observed. However, an increase in fruit damage was observed with increasing plant age (Mohanty *et al.*, 2000).

A comparative study for the infestation level of major insect pests of garden egg (*S. integrifolium* L.) with aqueous neem seed extracts was conducted. Karate was observed with adverse effects on beneficial insects in the garden egg's ecosystem. Whereas ANSE and Karate's application has significantly reduced; the fruit damage, activities of leaf feeders and count of borers per fruit. On the other side, ANSE could not effectively control the shoot and fruit borer as Karate; however, it managed better reduction in borer damage as compared to both Biobit and control. It was recommended that innovative methods of application, proper timing and aqueous neem seed extract can be other alternative or supplement to synthetic

insecticide for the management of vegetable pests by poor farmers (Owusu-Ansah *et al.*, 2001).

Comparative study of different formulations of *Bacillus thuringiensis* (biological agent), neem and chemical insecticides against brinjal shoot and fruit borer was carried out. Five sprays of Dipel was gave 10% reduction in fruit and shoot damage (Puranik *et al.*, 2002).

Study for evaluation of natural parasites and extent of parasitism to brinjal shoot and fruit borer was performed. They found three parasites namely *Trathalaflavo orbitalis*, an unidentified dipteran fly and an unidentified mermaid. Rate of parasitism was more in later crop stage with mild weather conditions compared to hot and dry climate (Singh and Singh, 2002).

The host spectrum of a microsporidian, *Vairimorpha* sp., isolated from *Helicoverpa armigera* was determined in a study. It was found that microsporidian were highly pathogenic and all the tested species were susceptible with marked sluggishness and less irritability. However, its infection decreased with increase in stage of the larvae of the tested insect pests including *L. orbonalis* (Narayanan and Gopalakrisnan, 2003).

Comparative study for the current status of research on the use of entomopathogenic nematodes as biological control agents including the target vegetable pests, their culturing and bioefficacy against *Eariasvittella*, *Agrotis, ipsilon*, *L. orbonalis* and *S. litura*. They also compared their compatibility with neem products, pesticides and oil cakes (Hussaini *et al.*, 2003).

Study on delta and wing traps baited with synthetic female sex pheromone of *L. orbonalis* more effective which caught and retained ten times more moths than either *Spodoptera* or uni-trap designs. However, windows cut in the side panels of delta traps significantly increased trap catch from 0.4 to 2.3 adult moths per trap per night. The efficiency of locally-produced water and funnel traps were also compared, which prove to be as effective as delta traps. The incorporation of these traps with insecticide application proved to be the most efficient way to manage this insect pest (Cork *et al.*, 2003).

A study was conducted on the development of multifaceted adaptable IPM in aubergine by using five different crop protection modules, which comprised bio-intensive (module I), mechanical plus bio-intensive (module II), bio-intensive + mechanical + culture + chemical (module III), prevalent farmers protection (module IV) and untreated control as module V. They collected data on the basis of number of adult shoot and fruit borer, and incidence of leaf hopper including other pest and pathogen attacking on plant. Module III gave the best result for the integrated management of *L. orbonalis* and other pathogens (Sardana *et al.*, 2004).

Six brinjal cultivars (BH-1, BH-2, Punjab Jamuni Gola, Punjab Naeelam, Barsati and Punjab SadaBahar) were included in an experiment conducted to reduce the insecticide usage against Brinjal shoot and fruit borer. These cultivars were transplanted under net house under field condition. Five alternate sprays of insecticide; Thiodan, 35 EC at 2 l/ha, Sevin, 50WP at 2 kg/ha, Monocil 36EC at 1375 ml/ha, Decis 2.8 EC at 400 ml/ha were recommended in open field condition i.e. they were applied on appearance of pest, in comparison to net house condition where the soil was sterilized by Formalin and no insecticide spray was applied to control pest. Thus on weekly basis, clean cultivation was performed. The removal of infested

shoots was done along with each fruits picking infested by *L. orbonalis* to destroy them mechanically. It was concluded that net house crops were better protected as lower fruit damage 2.8-2.9% was recorded when compared with field condition where even after spray; the damage was 55.08% (Sandeep *et al.*, 2004).

The host range of entomopathogenic nematodes *Heterorhabditis indica*, *Steinernema asiamkayai* and *S. glasieri*, determined when isolated and tested against larval, pupal and adult stages of different lepidopterous pests, from different areas in Tamil Nadu, India. *H. indica*, *S. glasieri* and *S. siamkayai* have demonstrated mortality of all insects including *L. orbonalis* (Umamaheswari *et al.*, 2004).

IPM has demonstrated best results as multidimensional approach of crop protection using mechanical, cultural and chemical control methods, when explored for the control of aubergine insect pests. It was recommended that the use of all the possible mechanisms of management of insect pests and pathogens in integration approach for better yield should be applied (Sardana *et al.*, 2004).

In a field experiment conducted to study four components of Integrated Pest Management, including application of Neem, Oil cake at 100 kg/acre at transplanting stage, Pheromone traps installation at 25 piece/acre at starting stage of buds and flowers in 45 days old crop on weekly basis, and Mechanically removal of infested shoots following neem oil spray at 10-12 days intervals. These IPM components significantly reduced *L. orbonalis* infestation on brinjal cultivars. This approach has demonstrated better yield of marketable fruits, with increase in cost (Rath and Maity, 2005).

Traps as a management technique when used against male moths of *L. orbonalis*, by using locally prepared and clear plastic traps (12cm length x 14 cm bass x 21 cm height) with modification in the shape and number of entry holes in the trap, more male moths of brinjal shoot and fruit borer can be trapped. They also described that significantly more male moths were caught in traps treated with water containing powdered detergent, liquid detergent, light gear oil or insecticide. All water traps when tested caught significantly higher number of moths than sticky delta traps with open sides under farmer's field conditions (Cork *et al.*, 2005).

Evaluation of an integrated pest management module for the management of brinjal shoot and fruit borer (*L. orbonalis*) was done in the fields. This IPM module includes, the application of neem cake at 100 kg/acre (50kg during land preparation and 50kg at three weeks after transplanting), installation of about 25-30 pheromones traps per acre from flower bud initiation until the final harvesting and for mass trapping changing the lures on monthly basis, mechanical clipping of infested shoot on weekly basis and spraying of neem oil every 10-12 days interval. A socio-economic survey among the user was also conducted. Comparison of IPM and Non IPM plot has demonstrated a clear difference in infested shoots which was 1.83 and 1.79% in IPM plots while 12.67 and 9.52% in Non IPM. Fruit damage in IPM plots was also lower which was 13.07 and 6.56% while in non IPM plots it was 43.34 and 27.30%. This experiment also gave higher average yields (12-20 and 13-10 t/ha.) and cost: benefit ratio (1:1.81 and 1:2.95) (Rath and Dash, 2005).

A field experiment was conducted to check the efficacy of bioagents and neem products in comparison to Malathion against *L. orbonalis*. The results showed that the bioagents and

neem products were not better to Malathion, while *B. thuringiensis* sufficiently controlled this pest (Yadav and Sharma, 2005).

For two consecutive years at farmer field scale; different integrated approaches were evaluated for better management of *L. orbonalis* in brinjal cultivars. It was suggested that the use of neem powder at transplanting with pheromone traps for moth capturing was better than other techniques included clipping of the infested shoots with neem oil spray. These practices helped to increase the fruit yield with minimum expenditure at pest control level (Rath and Maity, 2005).

An isolation of microsporidian was done from larvae of *S. litura* and found their systemic presence with mature spores being produced in nervous tissue, midgut, labial glands, muscles, gonads, tracheae, malpighian tubules, epidermis and more extensively in adipose tissues. These were found in nine important lepidopterous insect pests including *L. orbonalis* and were recommended as potential bio-control agents (Johnny and Muralirangan, 2005). Comparative data of locally produced different clear plastic water traps at large-scale were collected. Amass trapping trials for control of brinjal shoot and fruit borer was laid out. They observed non-significant effect by changing the shape (triangular or square) and number of entry holes (two or four) in the water trap on trap catch. There was increase noted in catch of male moths in traps treated with water containing powdered detergent compared to liquid detergent, gear oil or insecticide with more effective catch in water traps compared to sticky traps at farmer's field level. Increase of 46.1%, 58.6% and 69.1% healthy fruits were harvested for the farmers practice, farmer's practice plus IPM and IPM alone, respectively. They strongly suggested the incorporation of these traps in IPM practices along with other managements (Cork *et al.*, 2005).

An experiment carried out with the use of bio fertilizers in addition to farm yard manure neem cake, poultry manure and macho cake and found that the infestation of shoot and fruit borer can be reduced. It was reported that the shoot and fruit borer damage was consistently less in the plots treated with PM + Bio fertilizers + N.C. IPM +Bio fertilizers + NC, along with the field release of bio control agents and FYM + Bio fertilizers + NC+ field release of bio control agents significantly reduced the shoot and fruit borer damage throughout the duration of the experiment (Kavilharaghavan *et al.*, 2006).

2.4. Resistance/susceptibility

The study of relative susceptibility of different cultivars against *Leucinodes orbonalis* has confirmed that it depends upon two factors, softness of shoot and fruit pulp and different intrinsic characters of tolerances (Painter, 1951).

In an experiment to check the resistance of different brinjal varieties against insect pests, it was found that Choklasi, Pusa purple and Doli-5 were resistant against *L. orbonalis* and Jassid. Further it was revealed that varieties having dark colored fruit showed negative correlation ($r=80$) and were found resistant to brinjal shoot and fruit borer (Jyani *et al.*, 1995).

The research has shown that resistance does not depend on any single characteristic like spineness, size of fruit, its shape and arrangement of seeds in fruit. Almost all of the varieties were found to be attacked by brinjal shoot and fruit borer. However local cultivars were less attacked by this pest as compared to the exotic ones (Gangopadhyay *et al.*, 1996).

A study was carried out for screening of selected genotypes of eggplant under field conditions. It was that observed variability in relation to infestation by brinjal shoot and fruit

borer was present. This research work has confirmed that cultivars *S. indicum*, *S. gilo* and *S. incanum* were resistant against *L. orbonalis* (Behera *et al.*, 1999). In same pattern in another study of 19 brinjal cultivars two other cultivars horn penny and black penny 11-407 were confirmed as highly resistant cultivars to borer attack (Panda *et al.*, 1971).

Pusa purple long and Pundibari were under focus in a two year study to check their susceptibility against brinjal shoot and fruit borer, degree of damage and crop yield. It was found that both of them were highly susceptible to this pest. *Thripstabaci* and *Bemisiatabaci* were the key sucking insect pests of most of the brinjal cultivars used for this study (Ghosh and Senapati, 2001).

In the field trails to evaluate thirteen *Solanum* spp. and 30 F₁ crosses of *S. melongena* for resistance to *L. orbonalis*, Arkakeshra was found to be resistant to this pest. Four from genotypes and eleven from F₁ crosses were recorded as resistant species with their fruit damage ranging from 2.75 - 10.00% (Sharma *et al.*, 2001).

The disease transferring and pest resistance characteristic were studied on *S. indicum*, *S. melongena*, *Doli-5* and *Morbi 4-2*, through interspecific hybridization. Physico-morphic characters like fruit colour, fruit shape and prickles were under consideration in this trail. Hybrids; *S. indicum**Doli-5* produces medium oblong fruit, while *S. indicum**Morbi4-2* showed complete dominance and produced round solitary fruits. It was also observed that the hybrid had high resistance against *L. orbonalis* infestation but is susceptible to leaf diseases (Patel *et al.*, 2001).

An experiment was conducted on fifty four wild and native brinjal cultivars for resistance to *L. orbonalis*. It was observed that cultivars with oblong fruit and tightly arranged seeds were

found more resistant to *L. orbonalis*. Only three out of twenty nine cultivars of aubergine were found resistant to *L. orbonalis* and rest of twenty six were susceptible to this key pest (Singh and Singh, 2001).

A comparison was carried out in a study of different interspecific crosses for resistance to *L. orbonalis*. In this trial *S. indicum* was found to be resistant to *L. orbonalis* infestation as compared to others (Behera and Singh, 2002).

Relationship of phenol and chlorophyll contents for resistance to *L. orbonalis* was established on twelve brinjal cultivars in a field experiment. It was found that the increased phenol and chlorophyll content influence the infestation of fruit borers in brinjal (Asati *et al.*, 2002).

Screening of native isolate of *Heterorhabditis indica* was carried out. Sixteen species of four orders were recorded as hosts of *Heterorhabditis indica*. *Ergolismerione*, *Syleptaderogata*, *Leucinodes orbonalis* and *A. sty* were recorded as new hosts of *H. indica* (Banu and Rajendran, 2002).

Evaluation of ten aubergine cultivars for resistance to *L. orbonalis* was performed. The variation in shoot infestation was observed ranging from 3.28% to 12.71%. The lowest shoot damage was recorded in Arka Kusumakara (3.28%) while fruit infestation was lowest in SM-10 which was 20.23%. The fruit infestation was highest in Pusa Purple Round (46.51%). Further it was found that Arka Kusumakar and SM-10 were resistant to shoot and fruit borer (Jat *et al.*, 2003).

Field experiment conducted on ten aubergine cultivars in search of resistance varieties against brinjal shoot and fruit borer. They examined that all the screened cultivars were

susceptible to pest under study. Out of these ten four i.e. Pusa Purple Long, Naeelam Long, Black Beauty and BR-112 were recorded least susceptible, whereas Pusa Purple Round was susceptible, while Krishma and Kanahya (the local variety) were highly susceptible to borer attack (Yadav *et al.*, 2003).

To assess resistance to *L. orbonalis* a comparative study of three local and nine improved brinjal cultivars was conducted. The positive correlation was observed between number of larvae; per fruit with calyx diameter, number of holes per plant and chlorophyll content. However, number of larvae was negatively correlated with phenol contents and plant height (Asati *et al.*, 2004). Similarly, a field experiment was conducted for the screening of eighteen aubergine cultivars against shoot and fruit borer, in which lowest occurrence of *L. orbonalis* (on shoot and fruit of eggplant) was recorded in SKN BSR- 14 (Bharadiya and Patel, 2004).

The population dynamics of shoot and fruit borer have shown great variation ranging from 0.03-0.99 and 0.01 to 0.60 in a field experiment. The seasonal variation was recorded as; third week of September and November supported highest population of eggs and larvae as compared to third week of December and second week of September. A positive correlation was found between minimum temperature vs. egg and larval population (Bodkhe *et al.*, 2007).

A study was designed to analyze qualitative amino acids of highly susceptible and resistant aubergine cultivars infested with *L. orbonalis*. Overall, identification or presence of lysine with increased number of spots was also considered to be responsible for resistance (Anand, 2004).

A field experiment conducted to evaluate eleven aubergine cultivars for their resistance to *L. orbonalis*. They categorized these cultivars into three classes; Pusa Purple Long, Brinjal green Long, and Selection Puja was less susceptible with (<25% infestation), Pusa Hybrid-5, Pusakranti, Kokila, PusaUpkar and Aarti moderately susceptible (25-35% infestation) and Narkiran, PusaUttam and Pusa Hybrid-6 were highly susceptible (more than 35% infestation) (Yadav and Sharma, 2005).

In another screening experiment under field conditions, eighteen aubergine cultivars against the shoot and fruit borer infestation were included. They found that SKN and BSR-14 have given the lowest chance of infestation of *L. orbonalis* to shoots and fruits (Bharadiya and Patel 2004).

To observe the infestation of shoot and fruit borer on aubergine cultivars a field experiment was conducted. Three out of twelve cultivars of aubergine were found to be less susceptible to *L. orbonalis* with infestation less than 25% (Yadav and Sharma, 2005).

Comparative data collected on twenty five genotypes for their tolerance level. Out of these genotypes, two were highly susceptible to *L. orbonalis* with more than 41% fruit damage. Only two were highly tolerant (1-10% fruit damage) while five with moderate level (11-20% fruit damage). The possibility of tolerant species to *L. orbonalis* favors the incorporation of host plant resistance in pest management tactics (Elanchezhyan *et al.*, 2008).

In another comparative study, highly susceptible to resistant brinjal cultivars against shoot and fruit borer on predator *Chrysoperla carnea* and the egg parasitoid, *Trichogramma chilonis* were observed. Flower extract of highly susceptible cultivar when examined has shown about 70% egg parasitism as compared to 47% in control. Similar trend of attraction



and improving the efficacy of *C. carnea* was observed in the flower extracts with 85% predation (Elanchezhyan *et al.*, 2008).

2.5 Botanicals

It has been found that there are many plant species available throughout the tropics so far having some kind of pesticidal properties. According to Kiritani (1979), eco-friendly, less costly measures, such as, cropping system approach, botanicals (Prakash *et al.*, 2008) are more advantageous over insecticides, as they fit well in IPM. The safer plant products are useful in developing sound pest management strategies (Gupta and Singh, 2002).

Azadirachtin containing extracts from neem seeds have antifeedant and sterilent properties. It was found that azadirachtin also act as a chitin synthesis inhibitor which control over the neuroendocrine system, ecdysone and juvenile hormone synthesis. However, the result regarding use of azadirachtin based pesticides on management of *L. orbonalis* vary greatly. In the same experiment Saimandir and Gopal (2012) reported that NSKE was effective, however Nimbo Bas non-effective. Udaiyan and Ramarathinam (1994) and Muregesam and Muruges, (2009) proved the effectiveness of Nimbecidine. The product Neem cake extract @ 5 percent and *Calotropis gigantean* (Linnaeus) @ 5 percent were also quite effective in *Kharif* crop reducing fruit damage by more than 50 percent. The oil product of botanicals was found to be efficient for *L. orbonalis* management. Neem oil @ 2 percent was the best treatment both in *Kharif*(60.20%) and *Rabi* (59.91%) followed by Nimbecidine @ 2 ml/litre (57.42%) (Murugesam and Muruges, 2009). Several earlier workers have also demonstrated the effectiveness of Neem oil against *L. orbonalis* (Udaiyan and Ramarathinam, 1994). Similarly, Mathure *et al.* (2012) showed that 2 percent of newer botanical oils of Pungam (*Pongamiapinnata*) and Iluppai (*Madhucaindica*) in IPM modules proved to be quite

effective in lowering both shoot and fruit infestation and can thus be utilized in resistance management strategy.

All the botanicals, such as Ecogold @ 10 ml/litre of water; Alata soap @ 5 g/litre of water; Garlic @ 30 g/litre of water; Neem oil @ 3 ml/l of water; Papaya leaves @ 92 g/litre of water and Wood ash @ 10 g/plant significantly reduced the different pest of brinjal including *L. orbonalis*. Therefore, it is considered as pest management options to reduce insect pest populations and increase brinjal productivity (Mochiah *et al.*, 2011).

Among many other plant products, Chitra *et al.* (1993) reported the ether extracts of *Aregemon maxicana* Linnaeus 0.1 percent was comparable to Monocrotophos 0.04 percent and Endosulfan 0.07 percent. Equally effective were *A. indica* A. Juss. and *Annonas quamosa* Linnaeus against brinjal pest complex including *L. orbonalis* with first spray 3 days after transplanting and later 3 at fortnightly intervals.

From the above description, it was revealed that no work has so far been done in Bangladesh to compare the resistance of local and BARI varieties of brinjal against brinjal shoot and fruit borer. Although many researches were done on botanicals especially neem based biopesticide but few researches were done on mahogany and tobacco but their performance better. So, further study is required to find out their performance.

CHAPTER III

MATERIALS AND METHODS

The study was undertaken during November 2013 to August 2014 to evaluate the most effective biopesticides among seven botanicals and to identify most resistant variety against brinjal shoot and fruit borer. The materials used and the methodology adopted for conducting the experiments to fulfill the objectives set forth in the present study is presented here under.

3.1 Experiment 1: Effect of botanicals on the management of brinjal shoot and fruit borer (BSFB).

3.1.1 Experimental site

The experiment was conducted at Prof. Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna during the period from December 2013 to June 2014.

3.1.2 Climate of the experimental site

The climate of the experimental area was subtropical in nature, which was characterized by high temperature, heavy rainfall, high humidity and relatively long day during the months of April to September and low rainfall associated with moderately low temperature, low humidity and short day during the rest of the year.

3.1.3 Characteristics of soil

The experiment was carried out on a medium high land belonging to Agro-ecological zone - 13, (AEZ-13). The texture of the soil was clay-loam with a pH 7.5.

3.1.4 Plant material used

The local seed of brinjal variety named Makra was collected from local market Gollamari and raised as seedling in germplasm centre in Khulna University, used in the experiment.

3.1.5 Raising of seedlings

Brinjal seedling was raised in seedbed of 3m × 1m size. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed. Weeding, mulching and irrigation were done when required. Seedling was raised at germplasm centre in Khulna University.

3.1.6 Preparation of plots

At the beginning of the land preparation half dose of cowdung was mixed with the soil. The rest half dose of cowdung, full TSP, one-third Urea and one-third MoP were mixed during pit preparation. Rest of the Urea and MoP were applied 21 DAT, 35 DAT and 50 DAT. The plots were pre-labeled for each variety and treatment after randomization.

3.1.7 Design and layout of the experiment

The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The entire experimental plot was divided into 3 blocks each containing 7 units plots. Totally there were 21 unit plots. The treatments were randomly assigned to each unit plot so as to allot one treatment combination once in each block. The unit plots were 3m×2m in size with 75 cm distance between the blocks and 50 cm between the unit plots. Each plot was contained 16 plants.

3.1.8 Transplanting of brinjal seedlings

Healthy seedlings were uprooted from the seedbed and were transplanted in the experimental plots during late afternoon on December, 2013 maintaining a spacing of 75 cm between the rows and 50 cm between the plants. This allowed an accommodation of 16 plants per plot. Immediately after planting, the seedlings were watered. Seedlings were also planted around the experimental area for gap filling and to check the border effect.

3.1.9 Treatments of the experiment

The following treatments were applied with three replications:

T_0 = Control

T_1 = Neem leaf extract

T_2 = Neem oil

T_3 = Mahogany oil

T_4 = Mahogany (oil + cake)

T_5 = Garlic extract

T_6 = Tobacco leaf extract

3.1.10 Preparation of treatments

3.1.10.1 Preparation of Neem leaf extracts and the stock solution

Fresh leaves of *Azadirachata indica* (Neem) were collected from the plants at the Khulna University campus. Then the collected leaves were dried in shade and were ground with a domestic grinder. Fifty grams (50g) of the ground leaves were added with water and left

overnight to make 1000 ml solution. The mixture was then filtered and the filtrate poured into a flat bottom flask as stock for the field spraying five gram of wheel powder was added to increase its adhesiveness (Murugesam and Muruges, 2009).

3.1.10.2 Preparation of Garlic extract and the stock solution

Bulbs of garlic were brought from the market, 30 g of garlic bulbs were chopped into pieces using knife and such material was ground thoroughly, mixed with 50 ml of water and the ground mixture was soaked in little quantity of water over night and squeezed through muslin cloth and the volume was made up to 1 liter to get 3 per cent extract five gram of wheel powder was added to increase its adhesiveness (Murugesam and Muruges, 2009).

3.1.10.3 Preparation of Tobacco leaves extract and the stock solution

Tobacco leaves were brought from the market, 30 g of tobacco leaves were chopped into pieces and such material was ground thoroughly in mixed with 50 ml of water and the ground mixture was soaked in little quantity of water over night and squeezed through muslin cloth and the volume was made up to 1 liter to get 3 per cent extract five gram of wheel powder was added to increase its adhesiveness (Murugesam and Muruges, 2009).

The rest of the treatments were collected from the local market and from Syed Abdul Motin, innovator and researcher. Those were neem oil, mahogany oil, mahogany cake.

3.1.11 Treatment application

The treatments were applied as foliar sprays starting after 20 days of transplanting and repeated subsequently at 7 days interval and mahogany cake was applied in the plot and incorporated with soil. Care was taken to avoid drifting of treatment to neighboring plots.

3.1.12 Untreated control

No pest control technique was applied in control plots. However, an equal volume of water, which was used for other plots, was sprayed at 7 days intervals.

3.1.13 Intercultural operations

After transplanting of seedlings, various intercultural operations were accomplished for better growth and development of the plants, which were as follows:

3.1.13.1 Gap filling

When the brinjal seedlings were well established, the soil around the base of each seedling was pulverized. A few gaps filling was done by healthy seedlings of the same stock where initially planted seedlings failed to survive.

3.1.13.2 Weeding

Weeding and mulching were accomplished as and whenever necessary to keep the crop free from weeds, for better soil aeration and to break the crust. It also helped in soil moisture conservation.

3.1.13.3 Irrigation

Irrigations were given throughout the growing period at 10-15 days interval. The irrigations were given to increase the yield.

3.1.13.4 Harvesting

Harvesting of fruits was started at 60 days after transplanting and continued up to 150 days after transplanting with an interval of 7 days. Harvesting was usually done manually.

3.1.14 Data collection

In order to know the effects of the treatments on controlling BSFB, data in respect of the following parameters were collected from vegetative to late fruiting stage. Data were

collected from randomly selected five plants from each treatment per plot excluding the border plants.

3.1.14.1 Total numbers of shoot

The total number of shoots was recorded from 5 tagged plants of each plot at weekly intervals.

3.1.14.2 Total numbers of infested shoot

The total number of infested shoots was recorded from 5 tagged plants of each plot at weekly intervals.

3.1.14.3 Percentage of shoots damage

The data on infested shoot was recorded by direct count but percentage of infested shoots was calculated by using the following formula.

$$PSD = IS/TS * 100$$

Where, PSD= Percentage of shoots damage, IS = Numbers of infested shoot/plant, TS = Total numbers of shoot/plant

3.1.14.4 Percentage reduction of infestation in shoot

Percentage reduction of infestation in shoot was calculated by using the following formula.

$$P = (P_0 - Pr / P_0) * 100$$

Where, P_0 = Total no. of infested shoot/plant in control, Pr = Total no. of infested shoot/plant in treatment

3.1.14.5 Number of larvae per infested shoot

The total number of larvae was counted from infested shoots.

3.1.14.6 Total numbers of fruits

The total number of fruits was recorded from 5 tagged plants of each plot at weekly intervals.

3.1.14.7 Total numbers of infested fruits

The total number of infested fruits was recorded from 5 tagged plants of each plot at weekly intervals.

3.1.14.8 Percentage of fruits damage

The data on infested fruits was recorded by direct count but percentage of infested shoots was calculated by using the following formula.

$$PFD = IF/TF*100$$

Where, PFD= Percentage of fruits damage, IF = Numbers of infested fruits/plant, TF = Total numbers of fruits /plant

3.1.14.9 Percentage of infestation reduction in fruit

Percentage of infestation reduction in fruit was calculated by using the following formula.

$$P = (P_0 - P_r / P_0) * 100$$

Where, P_0 = Total no. of infested fruits /plant in control, P_r = Total no. of infested fruits /plant in treatment

3.1.14.10 Number of larvae per infested fruits

The total number of larvae was counted from infested fruits.

3.1.14.11 Weight of healthy and infested fruits

Fruits were harvested at 7 days interval and the number of healthy and infested fruits was recorded for calculating the percent fruit infestation. The weight of healthy and infested fruits was noted separately per plot per treatment. The cumulative yield of healthy and infested fruits per plot was transformed into healthy, infested and total yield per hectare in tons, respectively.

3.1.14.12 Cost of production

For benefit cost analysis, records of the costs incurred for labor, fertilizer, treatment application in each time were maintained. It is to be noted here that expenses incurred referred to those only on pest control. The price of the harvested marketable healthy fruits of each treatment and that of control were calculated at market rate. The Benefit-Cost Ratio (BCR) was analyzed. The production cost was recorded and all accumulates in case of individual treatment that was spent during production time.

3.1.14.13 Gross return

The total sell price was counted which was termed as gross return.

3.1.14.14 Benefit from the product

It was counted by the following formula: The price of the total yield- cost of production. It may be termed as net return.

3.1.14.15 Benefit cost Ratio (BCR)

It was calculated by the following formula:

$$\text{B: C ratio} = \frac{\text{Gross return (Tk. ha}^{-1}\text{)}}{\text{Cost of cultivation (Tk. ha}^{-1}\text{)}}$$

3.1.14.16 Data analysis

Data were analyzed by using MSTAT-C software for analysis of variance after square root transformation for per stage data. ANOVA was made by F variance test and the pair comparisons were performed by Duncan's Multiple Range Test (DMRT) (Gomez & Gomez, 1984).

3.2 Experiment 2: Performance of brinjal varieties against brinjal shoot and fruit borer.

3.2.1 Experimental site

The experiment was conducted at the Germplasm Centre of Agrotechnology Discipline, Khulna University, Khulna during February 2014 to August 2014.

3.2.2 Soil

The soil used in bags was collected from the garden of Germplasm Centre of Agrotechnology Discipline, Khulna University, Khulna. The average character of the soil was clay loam to clay. After collecting the soil it was sun dried and ground well. Then the soil debris was removed by sieving and the soil was put into bags after mixing with manure and fertilizer.

3.2.4 Preparation of bags

In this experiment medium size bazaar bags were selected as growing container. Each bag was filled-up with sun dried soil and kept under natural light. Cowdung was uniformly incorporated to the soil before filling bags. The rest half dose of cowdung, full TSP, one-third Urea and one-third MoP were mixed during pit preparation in the bag. Rest of the Urea and MoP were applied 21 DAT, 35 DAT and 50 DAT. The bags were pre-labeled for each variety.

3.2.5 Planting materials

Seeds were collected from local market Gollamari and Bangladesh Agricultural Research Institute (BARI).

3.2.6 Raising of seedlings

Brinjal seedlings were raised in seedbed of 3m × 1m size. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed. Weeding, mulching and irrigation were done when required. Seedling was raised at Germplasm centre, Khulna University.

3.2.7 Transplanting of brinjal seedlings

Healthy seedlings were uprooted from the seedbed and were transplanted in the experimental bags during late afternoon on February, 2014.

3.2.8 Treatments of the experiment

Eight improved varieties released by BARI and 5 local cultivar were used as treatment. The brinjal varieties were

V₁=BARI begun-1

V₂=BARI begun-4

V₃=BARI begun-5

V₄=BARI begun-6

V₅=BARI begun-7

V₆=BARI begun-8

V₇=BARI begun-9

V₈=BARI begun-10

V₉=Makra

V₁₀=Muktokashi

V_{11} =Lalita

V_{12} =Hazra

V_{13} =Chaga.

3.2.9 Intercultural operations

After transplanting of seedlings, various intercultural operations were accomplished for better growth and development of the plants, which were as follows:

3.2.10 Gap filling

When the seedlings were weak it was required to fill the gaps. Gap filling was done by healthy seedlings of the same stock where initial planted seedlings failed to survive.

3.2.11 Weeding

Weeding and mulching were accomplished as and whenever necessary to keep the crop free from weeds, for better soil aeration and to break the crust. It also helped in soil moisture conservation.

3.2.12 Irrigation

Irrigations were given throughout the growing period at 7days interval during dry season. The irrigations were given to increase the yield.

3.2.14 Data collection

In order to know the performance of different brinjal varieties against brinjal fruit and shoot borer (BSFB) data in respect of the following parameters were collected from vegetative to late fruiting stage. Data were collected from every plant.

Pest Control: No pest control measures were used in the experiment.

3.2.14.1 Total numbers of shoot

The total number of shoots was recorded from plant of each bag at weekly intervals.

3.2.14.2 Total numbers of infested shoot

The total number of infested shoots was recorded from every bag at weekly intervals.

3.2.14.3 Percentage of shoots damage

The data on infested shoot was recorded by direct count but percentage of infested shoots was calculated by using the following formula.

$$PSD = IS/TS \times 100$$

Where, PSD= Percentage of shoots damage, IS = Numbers of infested shoot/plant, TS = Total numbers of shoot/plant

3.2.14.4 Numbers of larvae per infested shoot

The total number of larvae was counted from infested shoots.

3.2.14.5 Total numbers of fruits

The total number of fruits was recorded from plants of each bag at weekly intervals.

3.2.14.6 Total numbers of infested fruits

The total number of infested fruits was recorded from plants of every bag at weekly intervals.

3.2.14.7 Percentage of fruits damage

The data on infested fruits was recorded by direct count but percentage of infested shoots was calculated by using the following formula.

$$PSD = IS/TS \times 100$$

Where, PSD= Percentage of fruits damage, IS = Numbers of infested fruits plant, TS = Total numbers of fruits /plant

3.2.14.8 Numbers of larvae per infested fruits

The total number of larvae was counted from infested fruits.

3.2.14.9 Weight of healthy and infested fruits

Fruits were harvested at 7 days interval and the number of healthy and infested fruits was recorded for calculating the percent fruit infestation. The weight of healthy and infested fruits was noted separately per plot per treatment. The cumulative plot yield of healthy and infested fruits were transformed into healthy, infested and total yield per hectare in tons, respectively

3.2.10 Data analysis

Data were analyzed by using MSTAT-C software for analysis of variance after square root transformation. ANOVA was made by F variance test and the pair comparisons were performed by Duncan's Multiple Range Test (DMRT) (Gomez & Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The efficacy of some botanicals and performance of some brinjal varieties were evaluated against the brinjal shoot and fruit borer (*Leucinodes orbonalis*, Guenee) major damaging insect of brinjal. The results obtained from the experiment are discussed under the following heads:

4.1 Experiment 1: Effect of botanicals on the management of brinjal shoot and fruit borer (BSFB)

4.1.1 Infestation of shoot in vegetative stage (30-60 DAT)

Various plant extract were significantly affected on the infestation by BSFB (Appendix 8). The data on producing shoot/plant as influenced by the application of different plant extract are shown in Table 1. A significant variation was observed in terms of total shoot number per plant, infested shoot number per plant, mean number of larvae per infested shoot in vegetative stage. The total number of shoots was found the maximum (6.50) in Mahogany oil + Mahogany cake followed by neem oil (6.00) and tobacco leaf extract (6.00) and the minimum was obtained from the control (3.00). The lowest number of infested shoots (1.10) was found in Mahogany oil + Mahogany cake and the highest number of infested shoots (1.60) was observed in tobacco leaf extract. Mean number of larvae per infested shoot was recorded the maximum (3.10) in the control and the minimum (1.00) in neem oil which was statistically similar to Mahogany oil + Mahogany cake (1.09).

Ashadul *et al.* (2014) also reported that protection of shoot and fruit borer had higher over control (92.50 and 91.30%, respectively) and fruit yield increment over control had higher (61.70%) in neem leaf extract. Among all the characters control treatment produced lower results in the study. Use of neem leaf extract was highly effective to reduce the shoot and fruit infestation as well as to get higher yield.

Table 1. Infestation of shoot in vegetative stage (30-60 DAT)

Treatments	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
Control	3.00d	1.35c	3.10a
Neem leaf extract	5.00bc	1.35c	1.70bc
Neem oil	6.00ab	1.10e	1.00c
Mahogany oil	4.500c	1.50b	2.30b
Mahogany oil + Mahogany cake	6.500a	1.10e	1.09c
Garlic extract	4.00cd	1.30d	2.20b
Tobacco leaf extract.	6.00ab	1.0a	1.30c
Level of significance	**	**	**
CV (%)	10.90	14.31	14.46

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.2 Infestation of shoot in early fruiting stage (60-90 DAT)

All the shoot characteristics like total number of shoot, number of infested shoot, mean number of larvae per infested shoot were statistically significant (Appendix 9). From the Table 2 it can be observed that the maximum number of shoot was produced in tobacco leaf extract (11.00) followed by Mahogany oil + Mahogany cake (10.50) and neem oil (10.00) and the minimum was recorded from the control (7.00). The number of infested shoot was found the lowest in Mahogany oil + Mahogany cake (1.60) and neem oil (1.60) and the highest was recorded from the control (3.00). Mean number of larvae per infested shoot was

recorded the lowest in Mahogany oil + Mahogany cake (1.10) preceded by neem oil (1.40) and the highest was recorded from the control (2.50).

All the botanicals, such as Ecogold @ 10 ml/litre of water; Alata soap @ 5 g/litre of water; Garlic @ 30 g/litre of water; Neem oil @ 3 ml/l of water); Papaya leaves @ 92 g/litre of water and Wood ash @ 10 g/plant significantly reduced the different pest of brinjal including *L. orbonalis*. Therefore, it was considered as pest management options to reduce insect pest populations and increase brinjal productivity (Mochiah et al., 2011).

Table 2. Infestation of shoot in early fruiting stage (60-90 DAT)

Treatments	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
Control	7.00c	3.00a	2.50a
Neem leaf extract	9.00abc	2.20bc	2.10ab
Neem oil	10.00ab	1.60c	1.40c
Mahogany oil	9.00abc	2.30b	2.40a
Mahogany oil + Mahogany cake	10.50ab	1.60c	1.10c
Garlic extract	8.50bc	2.60ab	2.30a
Tobacco leaf extract.	11.00a	2.50ab	1.50bc
Level of significance	**	**	**
CV (%)	8.92	11.12	12.04

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.3 Infestation of shoot in mid fruiting stage (90-120 DAT)

A significant variation ($p \leq 0.01$) was observed (Appendix 10) due to the effect of botanicals on brinjal shoots infestation by brinjal shoot and fruit borer (BSFB) in mid fruiting stage (90-120 DAT) due to the application of different treatments (Table 3). In mid fruiting stage the result revealed that, the highest number (15.00) of total shoots per plant was found in tobacco leaf extract and the lowest from the control (10.00). The highest number of total infested

shoots per plant was recorded from the control (4.00) and the lowest was found in Mahogany oil + Mahogany cake (1.80) and neem oil (1.80). The Mean number of larvae per infested shoot was the highest in control (2.50) and the lowest in Mahogany oil + Mahogany cake (1.08).

Among many other plant products, Chitraet *al.* (1993) reported the ether extracts of *Aregemon maxicana* L. 0.10 percent was comparable to Monocrotophos 0.04 percent and Endosulfan 0.07 percent. Equally effective were *A. indica* A. Juss. and *Annonas quamosa* L. against brinjal pest complex including *L. orbonalis* with first spray 3 days after transplanting and later 3 at fortnightly intervals.

Table 3. Infestation of shoot in mid fruiting stage (60-90 DAT)

Treatments	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
Control	10.00d	4.00a	2.50a
Neem leaf extract	12.50bc	2.90b	2.00a
Neem oil	13.00abc	1.80c	1.30b
Mahogany oil	12.00bcd	2.90b	2.20a
Mahogany oil +Mahogany cake	14.00ab	1.80c	1.08b
Garlic extract	11.00cd	3.00b	2.10a
Tobacco leaf extract.	15.00a	3.30ab	1.30b
Level of significance	**	**	**
CV (%)	7.38	13.68	10.51

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.4 Infestation of shoot in late fruiting stage (120-150 DAT)

In the late fruiting stage effect of botanicals were significantly varied at 1% level (Appendix 11) due to the application of different treatments (Table 4). In this stage the total number of shoots per plant was found the highest in tobacco leaf extract (16.00) and the lowest in control (11.00). The number of infested shoots per plant was recorded the maximum from the

control (3.80) followed by Garlic extract (3.00) and the minimum (1.50) in Mahogany oil + Mahogany cake. Mean number of larvae per infested shoot was found the highest (2.30) in control and the lowest (1.07) in Mahogany oil + Mahogany cake.

According to Kiritani (1979), eco-friendly, less costly measures, such as, cropping system was approached.

Table 4. Infestation of shoot in late fruiting stage (120-150 DAT)

Treatments	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
Control	11.00d	3.80a	2.30a
Neem leaf extract	13.00bcd	2.60bc	1.90a
Neem oil	14.00abc	1.70cd	1.20b
Mahogany oil	12.00cd	2.60bc	2.10a
Mahogany oil + Mahogany cake	15.00ab	1.50d	1.07b
Garlic extract	12.00cd	3.00ab	2.00a
Tobacco leaf extract.	16.00a	2.40bc	1.00b
Level of significance	**	**	**
CV (%)	8.69	14.30	10.59

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.5 Percent shoot infestation in different stages

Different botanicals were used in this experiment and they showed statistically significant results that were presented in the Appendix 12. From the experiment, it was found that in vegetative stage percent shoot infestation was the lowest in Mahogany oil + Mahogany cake (16.92%), preceded by neem oil (18.33%) and the highest (45.00%) was recorded from the control (Fig.1).

Whereas, in early flowering stage, the percent shoot infestation was the highest in control (42.86%) followed by Garlic extract (30.59%) and the lowest in Mahogany oil + Mahogany



(15.24%). In the mid flowering stage, the percent shoot infestation was the highest in control (40.00%) and the lowest in Mahogany oil + Mahogany cake (12.86%) and finally in reproductive stage, the highest percent shoot infestation was observed also estimated from the control (34.50%) and the lowest was in Mahogany oil + Mahogany cake(10.00%).

Ashadul *et al.* (2014) also reported that protection of shoot and fruit borer had higher over control (92.50 and 91.30%, respectively) and fruit yield increment over control had higher (61.70%) in neem leaf extract. Among all the characters, control treatment produced lower results in this study. Use of neem leaf extract was highly effective to reduce the shoot and fruit infestation as well as to get higher yield.

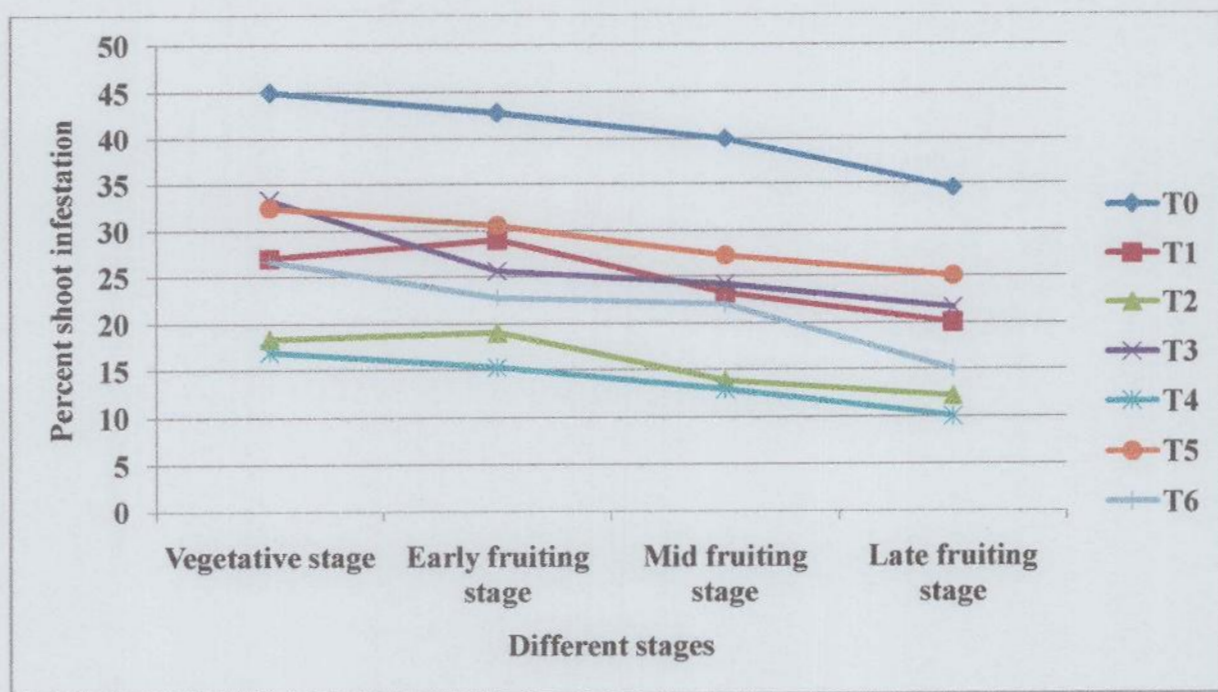


Fig 1. Percent shoot infestation in different stages

T₀ = Control, T₁ = Neem leaf extract, T₂ = Neem oil, T₃ = Mahogany oil, T₄ = Mahogany (oil + cake), T₅ = Garlic extract and T₆ = Tobacco leaf extract

4.1.6 Percent shoot infestation reduction over control in different stages

The percent shoot infestation reduction over control by brinjal shoot and fruit borer (BSFB) in different stages was statistically significant (Appendix 13). The results indicated that among the seven treatments percent shoot infestation reduction over control was found the highest in Mahogany oil + Mahogany cake (62.39%) the lowest in the Mahogany oil (25.93%) in the vegetative stage. At the early stage of fruiting the highest (64.44%) was found in Mahogany oil + Mahogany cake and the lowest in the Garlic extract (28.60%). Whereas, in the mid fruiting stage, the percent shoot infestation reduction over control was the highest Mahogany oil + Mahogany cake (67.86%) the lowest Garlic extract (31.82%). Finally in late fruiting stage, the percent shoot infestation reduction over control was recorded the highest from Mahogany oil + Mahogany cake (71.05%) and the lowest in the Garlic extract (27.63%).

From the result, it was recorded that in all the growth stages of brinjal namely early fruiting stage, mid fruiting stage and late fruiting stage, percent shoot infestation reduction over control was found the highest in Mahogany oil + Mahogany cake and the lowest in the Garlic extract.

Botanicals (Prakash *et al.*, 2008) are more advantageous over insecticides, as they fit well in IPM. The safer plant products are useful in developing sound pest management strategies (Gupta and Singh, 2002).

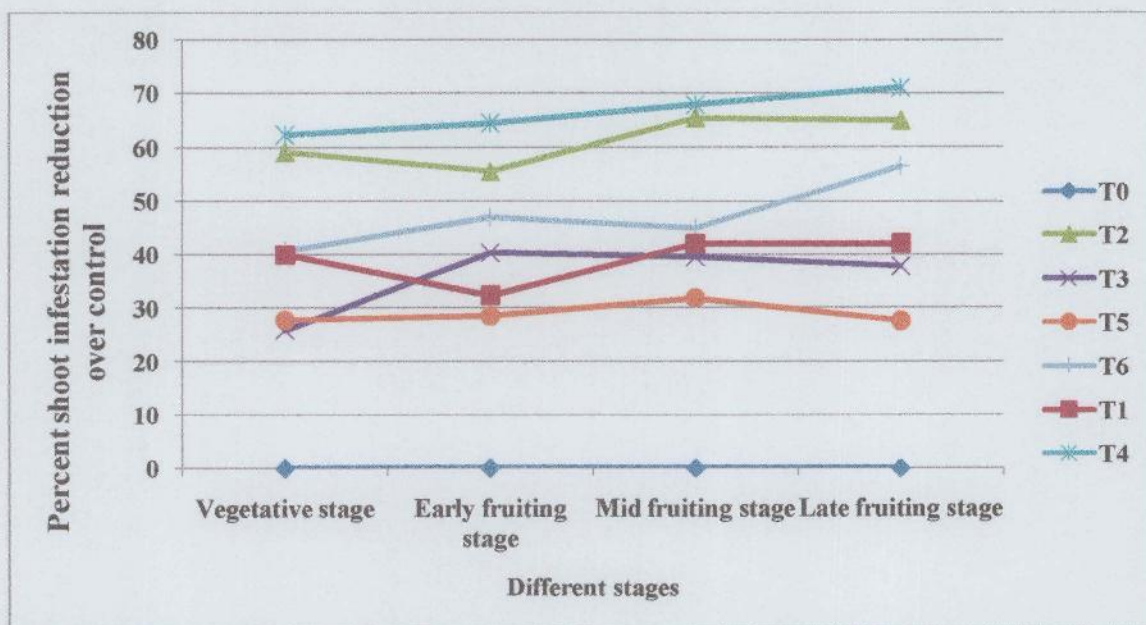


Fig 2. Percent shoot infestation reduction over control in different stages

T₀ = Control, T₁ = Neem leaf extract, T₂ = Neem oil, T₃ = Mahogany oil, T₄ = Mahogany (oil + cake), T₅ = Garlic extract and T₆ = Tobacco leaf extract

4.1.7 Infestation of fruit in early fruiting stage (60-90 DAT)

Effect of botanicals on brinjal fruits infestation by brinjal shoot and fruit borer (BSFB) in early fruiting stage (60-90 DAT) differed significantly due to application of different treatments (Appendix 14). In early fruiting stage, mean number of fruits per plant was found the highest in tobacco leaf extract (6.90) and the lowest in the control (3.50). Infested fruit per plant was the maximum in the control (2.60) followed by garlic extract (2.50) and the minimum in Mahogany oil + Mahogany cake (0.60). Mean number of larvae per infested fruit plant was found the highest in control (3.80) and the lowest in Mahogany oil + Mahogany cake (1.500) followed by neem oil (1.70) (Table 5).

Udaiyan and Ramarathinam (1994) and Muregesam and Murugesu, (2009) proved the effectiveness of Nimbecidine. The product Neem cake extract @ 5 percent and *Calotropis gigantea* (Linnaeus) @ 5 percent were also quite effective in *Kharif* crop in reducing fruit damage by more than 50 percent.

Table 5. Infestation of fruit in early fruiting stage (60-90 DAT)

Treatments	Mean number of fruits per plant		Mean number of larvae per infested fruit
	Total	Infested	
Control	3.50d	2.60a	3.80a
Neem leaf extract	4.50cd	1.80b	1.90c
Neem oil	5.50bc	1.10c	1.70c
Mahogany oil	4.90c	2.40a	1.80c
Mahogany oil + Mahogany cake	6.30ab	0.60c	1.50c
Garlic extract	4.40cd	2.50a	2.40b
Tobacco leaf extract.	6.90a	2.10ab	1.50c
Level of significance	**	**	**
CV (%)	9.66	13.18	10.28

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.8 Infestation of fruit in mid fruiting stage (90-120 DAT)

Different botanicals were used in this experiment and they showed statistically significant results that were presented in the (Appendix 15). In mid fruiting stage mean number of fruits per plant was found the highest in tobacco leaf extract (5.25) followed by neem oil (5.00) and Mahogany oil + Mahogany cake (5.00) and the lowest in neem leaf extract (4.10). Infested fruits per plant were the maximum in control (2.80) and garlic extract (2.80) followed by Mahogany oil (2.60) and the minimum in Mahogany oil + Mahogany cake (0.60). Mean number of larvae per infested fruit plant was observed the highest in the control (3.20) and the lowest in Mahogany oil + Mahogany cake (1.06) (Table 6).

The oil product of botanicals was found to be efficient for *L. orbonalis* management. Neem oil @ 2 percent was the best treatment both in *Kharif* (60.20%) and *Rabi* (59.91%) followed by Nimbecidine @ 2 ml/litre (57.42%) (Murugesam and Muruges, 2009).

Table 6. Infestation of fruit in mid fruiting stage (90-120 DAT)

Treatments	Mean number of fruits per plant		Mean number of larvae per infested fruit
	Total	Infested	
Control	4.75ab	2.80a	3.20a
Neem leaf extract	4.10b	2.10abc	1.50bc
Neem oil	5.00a	1.50c	1.30bc
Mahogany oil	4.50ab	2.60ab	1.90b
Mahogany oil+ Mahogany cake	5.00a	0.60d	1.06c
Garlic extract	4.50ab	2.80a	1.90b
Tobacco leaf extract.	5.25a	2.00bc	1.30bc
Level of significance	**	**	**
CV (%)	6.40	14.53	15.010

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.9 Infestation of fruit in late fruiting stage (120-150 DAT)

The mean number of fruits per plant and infested; mean number of larvae per infested fruit plant was statistically significant, shown in the Appendix 16. In late fruiting stage mean number of fruits per plant was found the highest in tobacco leaf extract (7.10) followed by Mahogany oil + Mahogany cake (6.50) and the lowest in the control (4.00). Infested fruits per plant were found the maximum in the control (2.80) and garlic extract (2.80) and the minimum in Mahogany oil + Mahogany cake (0.60). Mean number of larvae per infested fruit plant was the highest in the control (3.20) and the lowest in Mahogany oil + Mahogany cake (1.07) followed by neem oil (1.10) (Table 7).

Several workers have also demonstrated the effectiveness of Neem oil against *L. orbonalis* (Udaiyan and Ramarathinam, 1994). Similarly, Mathur *et al.* (2012) showed that 2 percent of newer botanical oils of Pungam (*Pongamia pinnata*) and Iluppai (*Madhuca indica*) in IPM modules proved to be quite effective in lowering both shoot and fruit infestation and can thus be utilized in resistance management strategy.

Table 7. Infestation of fruit in late fruiting stage (120-150 DAT)

Treatments	Mean number of fruits per plant		Mean number of larvae per infested fruit
	Total	Infested	
Control	4.00d	2.80a	3.20a
Neem leaf extract	5.00bcd	2.10ab	1.40bc
Neem oil	6.00abc	1.30c	1.10c
Mahogany oil	5.40abcd	2.50ab	1.80b
Mahogany oil + Mahogany cake	6.50ab	0.60d	1.07c
Garlic extract	4.30cd	2.80a	1.60bc
Tobacco leaf extract.	7.10a	1.90bc	1.20bc
Level of significance	**	**	**
CV (%)	14.51	14.36	13.52

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.10 Percent fruit infestation in different stages

Effect of botanicals on brinjal percent fruit infestation by brinjal shoot and fruit borer (BSFB) in different stages differed significantly in different treatments at $p \leq 0.01$ level (Appendix 17).

The maximum percent of fruit infestation by brinjal shoot and fruit borer (BSFB) was observed in the control (74.29%, 58.95% and 70.00% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage respectively. And the minimum percent of fruit

infestation was found in Mahogany oil + Mahogany cake (9.520, 12.00 and 9.23 respectively) in early fruiting stage, mid fruiting stage and late fruiting stage, respectively.

Efficacy of different methods either singly or in combinations for control of *L. orbonalis* was observed. *Trichogramma* was found more effective than control plots for the management of shoot and fruit borer. The main results comprised on neem oil (0.20%), neem oil (0.10%) + lufenuron (0.01%), neem oil (0.10%) + B.T. (0.07%), and neem oil (0.10%) + carbaryl (0.07%) which resulted in higher fruit yield compared with control plots (Sasikalaet al., 1999).

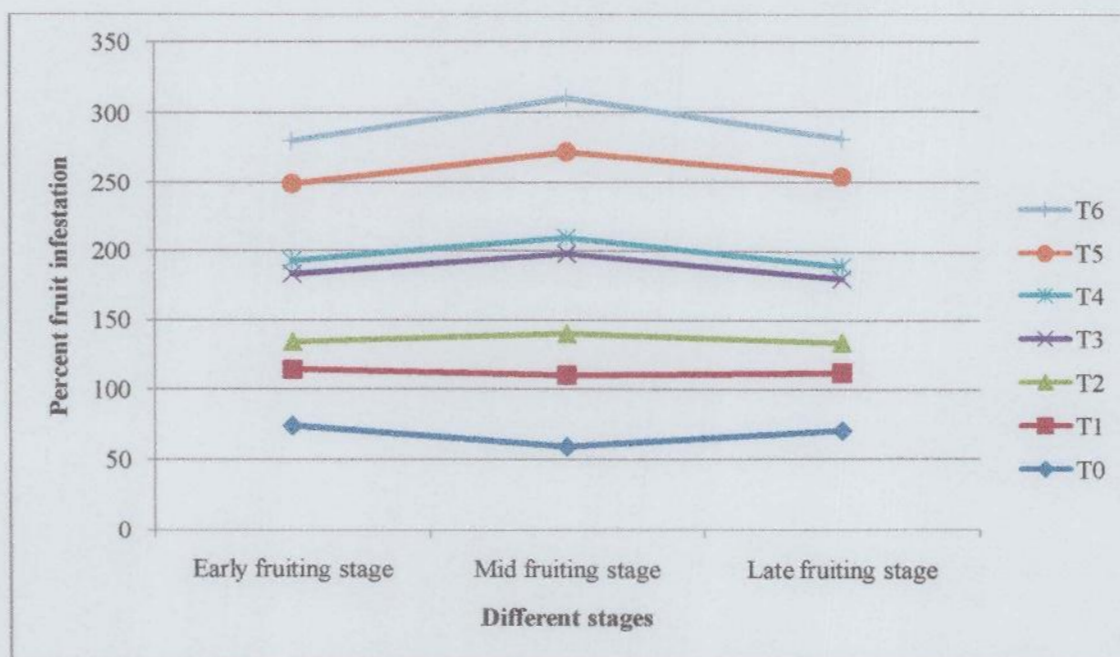


Fig 3. Percent fruit infestation in different stages

T₀ = Control, T₁ = Neem leaf extract, T₂ = Neem oil, T₃ = Mahogany oil, T₄ = Mahogany (oil + cake), T₅ = Garlic extract and T₆ = Tobacco leaf extract

4.1.11 Percent fruit infestation reduction over control in different stages

Different botanicals were used in this experiment and they showed statistically significant results that were presented in the Appendix 18. Percent of fruit infestation reduction over control by brinjal shoot and fruit borer (BSFB) was observed the maximum Mahogany oil + Mahogany cake (86.70%, 85.08% and 85.50% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage respectively. And the minimum percent of fruit infestation reduction over control was found in garlic extract (17.40%, 9.06% and 9.80% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage, respectively.

It was recommended that innovative methods of application, proper timing and aqueous neem seed extract can be other alternative or supplement to synthetic insecticide for the management of vegetable pests by poor farmers (Owusu-Ansah *et al.*, 2001).

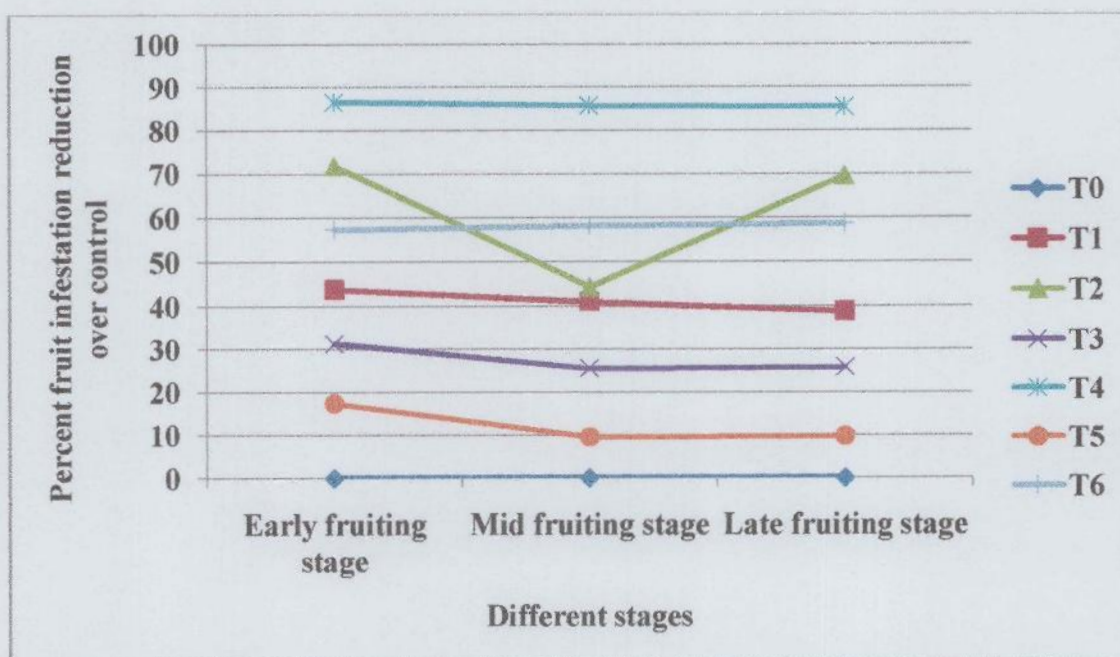


Fig 4. Percent fruit infestation reduction over control in different stages

T₀ = Control, T₁ = Neem leaf extract, T₂ = Neem oil, T₃ = Mahogany oil, T₄ = Mahogany (oil + cake), T₅ = Garlic extract and T₆ = Tobacco leaf extract

4.1.12 Effect of botanicals on brinjal yield

In case of fruit yield per plot significant variation also found among all the treatments (Appendix 19). The yield was found the maximum (35.82t/ha) when in the field Mahogany oil + Mahogany cake was applied and the minimum in control (16.48t/ha). Increased yield over control was recorded the maximum in Mahogany oil + Mahogany cake (17.49t/ha) and the minimum in garlic extract (5.34t/ha).

In a field experiment conducted to study four components of Integrated Pest Management, including application of Neem, Oil cake at 100 kg/acre at transplanting stage, Pheromone traps installation at 25 piece/acre at starting stage of buds and flowers in 45 days old crop on weekly basis, and Mechanically removal of infested shoots following neem oil spray at 10-12 days intervals. These IPM components significantly reduced *L. orbonalis* infestation on brinjal cultivars. This approach has demonstrated better yield of marked fruits, with increase in cost (Rath and Maity, 2005)

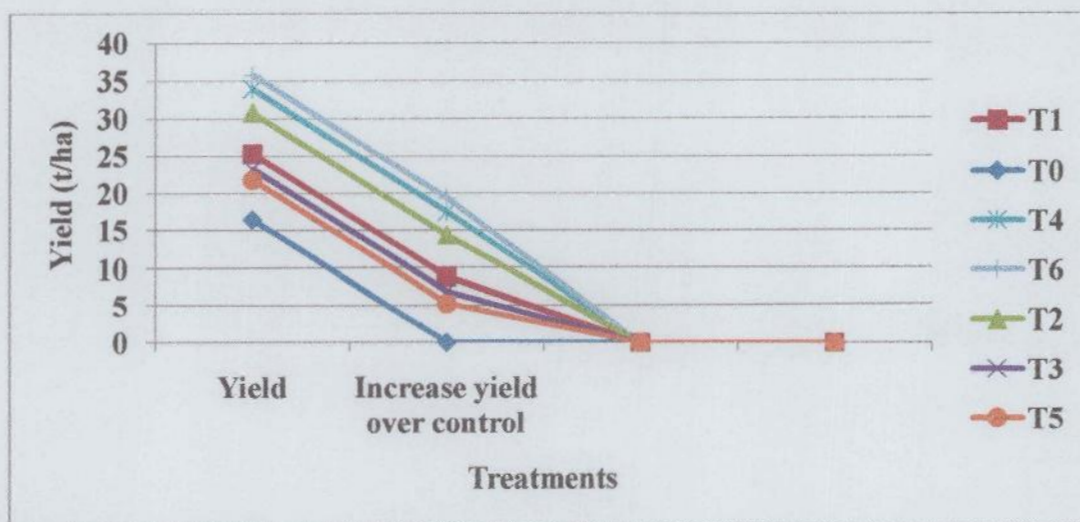


Fig 5. Effect of botanicals on brinjal yield

T₀ = Control, T₁ = Neem leaf extract, T₂ = Neem oil, T₃ = Mahogany oil, T₄ = Mahogany (oil + cake), T₅ = Garlic extract and T₆ = Tobacco leaf extract

4.1.13 Cost and return analysis of brinjal production

According to the procedure of Ramakrishna and Palled (2005), cost and return analysis in details was done and has been shown in Table 8. Material, Non-material and overhead cost were recorded for all treatments on unit plot basis and calculated per hectare. The total cost of production range between 291666 Tk. and 491666 Tk/ha. The highest cost of production was found in neem oil (491666 Tk/ha) followed by tobacco leaf extract (411666) and the lowest was found in the control (291666 Tk/ha). The range between the gross return was 264000 Tk to 949700 Tk/ha. The treatment Mahogany oil + Mahogany cake gave the highest net return of Tk. 949700 followed by tobacco leaf extract of Tk. 888200 and the lowest was found in control (264000 Tk/ha). The maximum benefit cost ratio was found 2.35 in the

Mahogany oil + Mahogany cake which was statistically similar with tobacco leaf extract (2.16) and the minimum in control (0.91).

Considering the economic return per hectare, this experiment demonstrated that application of Mahogany oil+ Mahogany cake was found more appropriate for brinjal production for controlling brinjal shoot and fruit borer.

Latif *et al.* (2009) showed the better performance by reducing 80.63% fruit infestation over control and produced the highest number of healthy and total fruits/plant (25.00 and 27.20, respectively). The same package also increased 108.83% healthy fruit yield and decreased 74.13% infested fruit yield over control. The highest benefit cost ratio (5.53) was recorded in IPM package 2 (Potash @100 kg/ha + flubendiamide24WG applied at 5% level of fruit infestation), where 9 sprays were required. The BCR of 4.12 and 4.00 was obtained in IPM package 6 and package 5 with 8 and 5 sprays, respectively.

Table 8. Cost and return analysis of brinjal production

Treatments	Yield (t/ha)	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio(BCR)
Control	16.48d	264000g	291666	-27670g.	0.910c
Neem leaf extract	25.32bc	573200d	341666	231500d	1.68b
Neem oil	30.85ab	808500c	491666	276800c	1.64b
Mahogany oil	23.32cd	448200e	391666	56500e	1.14c
Mahogany oil + Mahogany cake	33.97a	949700a	403333	506300a	2.35a
Garlic extract	21.82cd	403200f	361666	41500f	1.11c
Tobacco leaf extract.	35.82a	888200b	411666	476500b	2.16a
Level of significance	**	**		**	**
CV (%)	11.17	11.47		28.16	12.19

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2 Experiment 2: Performance of brinjal varieties against brinjal shoot and fruit borer (BSFB).

4.2.1 Performance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in vegetative stage (30-60 DAT)

Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in vegetative stage was varied statistically ($p \leq 0.01$) (Appendix 21). The total number of shoots per plant was found the highest in BARI begun-1 (8.40) and the lowest in makra (3.40). The maximum number of infested shoot was present in BARI begun-1 (3.650) and the minimum in makra (1.35). It was observed that mean number of larvae per infested shoot was the highest in chaga (4.53) and the lowest in makra (1.16).

Study of morphological traits and the attack of *L. orbonalis* in brinjal were conducted among 150 lines tested, PBR 129.50, Punjab barsati and SM-174, were found to be highly resistant and Punjab chamkila was the most susceptible to damage by the borer (Dilbagh *et al.*, 1991).

Table 9. Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in vegetative stage (30-60 DAT)

Varieties	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
BARI begun-1	8.40a	3.65a	2.00e
BARI begun-4	7.20b	3.00abc	2.15de
BARI begun-5	8.80a	3.00abc	2.40d
BARI begun-6	8.20a	2.40cd	1.70f
BARI begun-7	6.20c	2.60bcd	2.75c
BARI begun-8	6.60bc	2.20d	1.16g
BARI begun-9	6.80bc	3.55a	2.89c
BARI begun-10	6.00c	2.60bcd	3.20b
Makra	3.40e	1.35e	4.47a
Muktokashi	4.40d	2.00de	4.39a
Lalita	6.40bc	3.30ab	3.26b
Hazra	6.60bc	3.30ab	3.24b
Chaga.	4.40d	2.40cd	4.53a
Level of significance	**	**	**
CV (%)	8.20	14.49	5.04

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.2 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in early fruiting stage (60-90 DAT)

Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in early fruiting stage was varied statistically ($p \leq 0.01$) (Appendix 22). The total number of shoots per plant was found the highest in BARI begun-5 (16.40) and the lowest in makra (7.60). The maximum number of infested shoot was observed in BARI begun-1 (7.40) and the minimum in BARI begun-8(4.00). It was observed that mean number of larvae per infested shoot was the highest in chaga (4.48) and the lowest in makra(4.12).

It was observed that varieties with characteristics like hair and prickles on stems, leaves and fruit stalks result in the lowest percentage of fruit infestation as compared to those without hair and prickles (Ali *et al.*, 1994).

Table 10. Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in early fruiting stage (60-90 DAT)

Varieties	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
BARI begun-1	14.80ab	7.40a	2.15f
BARI begun-4	13.20bc	5.80bcd	2.22f
BARI begun-5	16.40a	5.80bcd	2.38f
BARI begun-6	16.00a	5.20bcde	1.40g
BARI begun-7	11.004c	5.00cde	2.74ef
BARI begun-8	12.20c	4.00e	1.25g
BARI begun-9	11.80c	6.20abc	2.74ef
BARI begun-10	12.60c	5.40bcd	3.40cd
Makra	7.60d	4.60de	4.12 ab
Muktokashi	8.40d	4.00e	4.22ab
Lalita	11.80c	6.40ab	3.02de
Hazra	11.00bc	7.20a	3.72bc
Chaga.	8.80d	5.20bcde	4.48a
Level of significance	**	**	**
CV (%)	9.46	12.13	11.580

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.3 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in mid fruiting stage (90-120 DAT)

Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in mid fruiting stage was evaluated which varied statistically ($p \leq 0.01$) (Appendix 23). The total number of shoots per plant was found the highest in BARI begun-5 (21.40) and the lowest in makra(11.60). The maximum number of infested shoot was observed in hazra (10.00) and the minimum in BARI begun-8(5.60). It was observed that mean number of

larvae per infested shoot was the highest in makra (4.34) and that was the lowest in BARI begun-8 (1.19).

Jat and Pareek (2003) reported that there was significant negative correlation between silica contents and the degree of shoot infestation. Borer doesn't prefer light green fruits and were less infested as they had narrow pericarp and mesocarp with compact seedlings and seeds closely arranged. Certain biochemical characters of the plants were positively correlated with fruit infestation such as total sugar contents, free amino acid and crude oil protein.

Table 11. Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in mid fruiting stage (90-120 DAT)

Varieties	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
BARI begun-1	18.80bc	9.60a	1.73e
BARI begun-4	18.60bc	6.60bcd	1.96de
BARI begun-5	21.40a	7.40bc	2.04de
BARI begun-6	20.00ab	6.00cd	1.71e
BARI begun-7	15.40de	6.80bcd	2.23d
BARI begun-8	17.00cd	5.60d	1.19f
BARI begun-9	17.60bcd	9.60a	2.68c
BARI begun-10	17.80bcd	8.00b	2.92bc
Makra	11.60f	7.20bcd	4.34a
Muktokashi	13.20ef	6.80bcd	4.26a
Lalita	17.40cd	9.80a	3.26b
Hazra	17.60bcd	10.00a	3.30b
Chaga.	12.80f	7.60bc	4.30a
Level of significance	**	**	**
CV (%)	7.96	11.62	9.04

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.4 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in late fruiting stage (120-150 DAT)

Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in late fruiting stage was evaluated which varied statistically ($p \leq 0.01$) (Appendix 24). The total number of shoots per plant was found the highest in BARI begun-5 (26.40) and the lowest in makra (15.00). The maximum number of infested shoot was observed in hazra (13.00) and the minimum in BARI begun-8 (6.80). It was observed that mean number of larvae per infested shoot was the highest in makra (4.11) and the lowest in BARI begun-8 (1.07).

Comparative study of the ratoon cropping of two hybrids and a local cultivar for their additive and non-additive characteristics was conducted. Although the plant height was more in MBH-10 hybrid yet its leaf surface index was less than other hybrid, Manjrigota. Contrarily, MBH-10 was high in yield compared to Manjrigota and other cultivar. However, shoot and fruit borer infestation was comparatively less in hybrids as compared to normal cultivar (Page *et al.*, 2004).

Table 12. Performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in late fruiting stage (120-150 DAT)

Varieties	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
BARI begun-1	23.80bc	11.60b	1.64fg
BARI begun-4	23.40bc	9.80cd	1.86ef
BARI begun-5	26.40a	9.00de	1.91ef
BARI begun-6	25.20ab	7.40f	1.34gh
BARI begun-7	18.60d	8.00ef	2.15de
BARI begun-8	21.60c	6.80f	1.07h
BARI begun-9	21.80c	11.00bc	2.50cd
BARI begun-10	23.20bc	10.20cd	2.79bc
Makra	15.00e	9.00de	4.11a
Muktokashi	16.60e	8.00ef	4.06a
Lalita	21.80c	12.00ab	2.88bc
Hazra	23.20bc	13.00a	3.06b
Chaga.	15.80e	9.60d	4.08a
Level of significance	**	**	**
CV (%)	5.600	7.330	9.600

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.5 Performance of different brinjal varieties against percent shoots infestation by brinjal shoot and fruit borer (BSFB) on different stages

The variation of different brinjal varieties against percent shoot infestation by brinjal shoot and fruit borer (BSFB) on different stages was statistically significant at 1% level (Appendix 25). In vegetative stage the maximum shoot infestation was found in chaga (54.00%) and the minimum in BARI begun-6 (29.60%). The infestation was observed the highest in makra (60.36%, 62.03% and 60.02% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage respectively. And infestation was the lowest in BARI begun-6 (32.40%, 29.86% and 29.38% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage, respectively (Table. 18).



29.86% and 29.38% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage, respectively (Table. 18).

Experiment to determine the factor of resistance in aubergine against shoot and fruit borer was performed. The number of infested shoot and fruit along with morphological character, including plant height, leaves per plant, mean leave area, leaf area per plant, primary branches per plant, thickness of terminal shoots, terminal shoots per plant, and fruit per plant and fruit length was recorded.. These morphological characters were highly correlated to the infestation of shoot and fruit borer. It was concluded that lower the moisture, sugar and protein contents in fruit make them less susceptible to *L. orbonalis* infestation (Hazaraet al., 2004).



Fig 6. Percent shoot infestation in different stages

V₁=BARI begun-1, V₂=BARI begun-4, V₃=BARI begun-5, V₄=BARI begun-6, V₅=BARI begun-7, V₆=BARI begun-8, V₇=BARI begun-9, V₈=BARI begun-10, V₉=Makra, V₁₀=Muktokashi, V₁₁=Lalita, V₁₂=Hazra and V₁₃=Chaga.

4.2.6 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in early fruiting stage (60-90 DAT)

Production of number of fruits is a genetically matters and different varieties produce different number of fruits and showed statistically significant at 1% level (Appendix 26). The maximum number of fruits was observed in BARI begun-1 (5.00) and the minimum in makra (0.90) and in muktokashi (0.90). The highest number of infested fruits was found in chaga (2.10) and the lowest in lalita (0.60). Mean number of larvae per infested shoot was the maximum in chaga (4.96) and the lowest in BARI begun-8 (1.52) (Table 13). Resistance was positively attributed to pericarp and mesocarp thickness and compactness of seed ring. Moisture contents, crude protein and nitrogen showed positive correlation but total sugar, fiber contents tannin, potassium and manganese were negatively affected (Chandrashekhar *et al.*, 2009).

Table 13. Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in early fruiting stage (60-90 DAT)

Varieties	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
BARI begun-1	5.00a	1.90ab	2.03gh
BARI begun-4	4.00b	1.60c	2.47fg
BARI begun-5	2.75c	1.20de	2.56f
BARI begun-6	2.80c	0.70gh	1.89hi
BARI begun-7	2.75c	0.80fgh	2.70ef
BARI begun-8	1.90d	1.00ef	1.52i
BARI begun-9	2.90c	0.90fg	3.10e
BARI begun-10	3.00c	1.60bc	4.25bc
Makra	0.90e	0.60gh	4.37b
Muktokashi	0.90e	0.70fgh	3.70d
Lalita	0.90e	0.60h	3.87cd
Hazra	1.90d	1.30d	3.88cd
Chaga.	2.80c	2.10a	4.96a
Level of significance	**	**	**
CV (%)	13.50	13.51	8.49

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.7 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in mid fruiting stage (90-120 DAT)

A significant response was obtained at 1% level in respect of performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation at the mid fruiting stage (Appendix 27). In mid fruiting stage the maximum number of fruits was observed in BARI begun-1 (10.00) and the minimum in chaga (0.90). The highest number of infested fruits BARI begun-1 (3.70) and the lowest in chaga (0.80). Mean number of larvae per infested shoot was found the maximum chaga (4.76) and the lowest in BARI begun-8 (1.44) (Table 14).

Irradiated lines of brinjal were compared for growth, yield and borer's infestation. Very low infestation of fruit and shoot borer was observed in these irradiated lines as compared to the control one. It was observed that purple pigmentation, tough calyx cover and high phenolic contents in these lines, might be the reason for their resistance to borer's infestation (Babu *et al.*, 1999).

Table 14. Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in mid fruiting stage (90-120 DAT)

Varieties	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
BARI begun-1	10.00a	3.70a	1.93fg
BARI begun-4	9.20b	3.60b	2.36ef
BARI begun-5	6.80c	3.00b	2.42e
BARI begun-6	3.80ef	1.00fg	1.76gh
BARI begun-7	3.50fg	1.00fg	2.58de
BARI begun-8	4.50e	2.30c	1.44h
BARI begun-9	5.30d	1.70de	2.96d
BARI begun-10	5.70d	3.20b	4.06b
Makra	2.90g	2.00cd	4.17b
Muktokashi	1.95h	1.40ef	3.54c
Lalita	2.80g	1.70de	3.72bc
Hazra	2.75g	1.80de	3.74bc
Chaga.	0.90i	0.80g	4.76a
Level of significance	**	**	**
CV (%)	9.87	10.70	8.53

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.8 Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in late fruiting stage (120-150 DAT)

Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in late fruiting stage was varied significantly at 1% level among different treatments (Appendix 28). In late fruiting stage the maximum number of fruits was observed

in BARI begun-4 (10.00) and the minimum in makra (2.00). The highest number of infested fruits was recorded from BARI begun-4 (4.00) and the lowest from BARI begun-9 (0.80). Mean number of larvae per infested shoot was the maximum chaga (4.56) and the lowest in BARI begun-8 (1.32) (Table 15).

The incidence of bacterial wilt and the attack of fruit and shoot borer on nine genotype of brinjal were studied. The fruit borer infestation in those varieties ranged from 2.88 to 5.64% (Chaudhry and Sharma, 2000). Similarly, twelve cultivars were compared for borer infestation and found 33 to 53% damage of fruit in different cultivars (Kumar and Shukla, 2002).

Table 15. Performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in late fruiting stage (120-150 DAT)

Varieties	Mean number of shoots per plant		Mean number of larvae per infested shoot
	Total	Infested	
BARI begun-1	9.20b	3.50b	1.84fg
BARI begun-4	10.00a	4.00a	2.25ef
BARI begun-5	6.80c	3.00c	2.32e
BARI begun-6	4.50e	1.10fg	1.66gh
BARI begun-7	3.50fg	1.00fg	2.44de
BARI begun-8	3.55fg	1.80de	1.32h
BARI begun-9	2.75ghi	0.80g	2.84d
BARI begun-10	5.75d	3.15bc	3.94b
Makra	2.00i	1.30ef	4.04b
Muktokashi	3.00fgh	2.10d	3.36c
Lalita	3.75ef	2.20d	3.60bc
Hazra	2.75ghi	1.80de	3.62bc
Chaga.	2.40hi	1.80de	4.56a
Level of significance	**	**	**
CV (%)	9.98	11.88	9.16

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.9 Performance of different brinjal varieties against percent fruit infestation by brinjal shoot and fruit borer (BSFB) on different stages

A significant ($p \leq 0.01$) response was found among different brinjal varieties against percent fruit infestation by brinjal shoot and fruit borer (BSFB) on different stages (Appendix 29). The fruit infestation was found the highest in chaga (75.28%, 74.40% and 73.90% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage respectively. And the infestation was recorded the lowest in BARI begun-6 (25.16%, 27.42% and 25.40% respectively) in early fruiting stage, mid fruiting stage and late fruiting stage respectively.

In an experiment to check the resistance of different brinjal varieties against insect pests, it was found that Choklasi, Pusa purple and Doli-5 were resistant against *L. orbonalis* and Jassid. Further it was revealed that varieties having dark colored fruit showed negative correlation ($r=80$) and were found resistant to brinjal shoot and fruit borer (Jyani *et al.*, 1995).

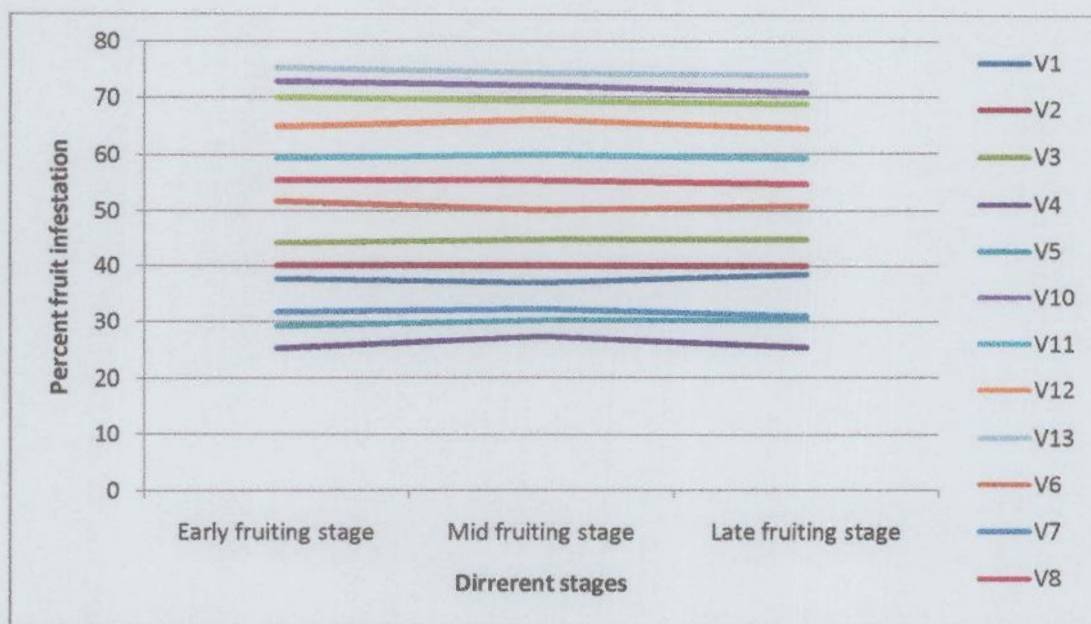


Fig 7. Percent fruit infestation in different stages

V₁=BARI begun-1, V₂=BARI begun-4, V₃=BARI begun-5, V₄=BARI begun-6, V₅=BARI begun-7, V₆=BARI begun-8, V₇=BARI begun-9, V₈=BARI begun-10, V₉=Makra, V₁₀=Muktokashi, V₁₁=Lalita, V₁₂=Hazra and V₁₃=Chaga.

4.2.10 Resistance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) infestation

Resistance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) infestation was varied significantly at 1% level (Appendix 30). Number of fruits per plant was found the maximum in BARI begun-1 (60.00) and in BARI begun-4 (60.00) and the minimum was recorded in muktokashi (14.40). Number of infested fruits per plant was found the highest in BARI begun-1 (17.40) and the lowest in BARI begun-6 (5.80). Percent of fruit infestation was observed the maximum in muktokashi (59.05) and the minimum in BARI begun-6 (19.28) (Table 16).

To observe the infestation of shoot and fruit borer in aubergine cultivars a field experiment was conducted. Three out of twelve cultivars of aubergine were found to be less susceptible to *L. orbonalis* with infestation less than 25% (Yadav and Sharma, 2005).

Table 16. Resistance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) infestation

Varieties	Number of fruits per plant	Number of infested fruits per plant	Percent of fruit infestation
BARI begun-1	60.00a	17.40a	29.09cdef
BARI begun-4	60.00a	16.60ab	27.52def
BARI begun-5	42.00b	14.40b	34.30cd
BARI begun-6	30.00cd	5.80e	19.28g
BARI begun-7	26.00de	6.00e	23.09fg
BARI begun-8	33.60c	10.00c	30.00cde
BARI begun-9	27.20de	7.20de	26.60ef
BARI begun-10	44.80b	15.60ab	34.86c
Makra	15.60gh	8.40cde	53.93a
Muktokashi	14.40h	8.40cde	59.05a
Lalita	16.40fgh	8.80cd	57.33a
Hazra	22.40ef	9.80cd	43.67b
Chaga.	21.60efg	9.40cd	43.42b
Level of significance	**	**	**
CV (%)	11.26	13.70	10.16

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.11 Yield Performance of different varieties

Significant difference ($p \leq 0.01$) was found in different varieties in term of yield performance (Appendix 31). Number of fruits per plant was found the highest in BARI begun-1 (60.00) and in BARI begun-4 (60.00) and the lowest in muktokashi (14.04). Weight of fruits per plant was recorded the maximum in BARI begun-10 (4.70) and the minimum in lalita (2.13) (Table 17).

Field experiment conducted on ten aubergine cultivars in search of resistance varieties against brinjal shoot and fruit borer. They examined that all the screened cultivars were susceptible to pest under study. Out of these ten four i.e. Pusa Purple Long, Naeelam Long, Black Beauty and BR-112 were recorded least susceptible, whereas Pusa Purple Round was

susceptible, while Krishma and Kanahya (the local variety) were highly susceptible to borer attack (Yadav *et al.*, 2003).

Table 17. Yield Performance of different varieties

Varieties	Number of fruits per plant	Weight of fruits per plant (Kg)
BARI begun-1	60.00a	3.77bc
BARI begun-4	60.00a	3.35cd
BARI begun-5	42.00b	4.20ab
BARI begun-6	30.00cd	3.15cde
BARI begun-7	26.00de	2.85def
BARI begun-8	33.60c	3.23bcd
BARI begun-9	27.20de	2.99cde
BARI begun-10	44.80b	4.704a
Makra	15.60gh	3.12cde
Muktokashi	14.40h	2.45ef
Lalita	16.40fgh	2.13f
Hazra	22.40ef	3.14cde
Chaga.	21.60efg	3.20cde
Level of significance	**	**
CV (%)	11.26	13.23

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

CHAPTER V

SUMMARY AND CONCLUSION

Summary

Judicious use of chemical insecticides to control the brinjal shoot and fruit borer (BSFB) in field condition may cause numerous problems such as severe health hazards to consumers and environmental pollution. So it is very essential to find out an eco-friendly and safe alternative to chemical insecticides. For this reasons, in first experiment six botanical extracts and control were used as seven treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. There were 7 treatments viz., Control (only water), Neem leaf extract, Neem oil, Mahogany oil, Mahogany (oil + cake), Garlic extract and Tobacco leaf extract. In the second experiment thirteen varieties were used as treatment. This was a one factor experiment that was laid out in CRD using thirteen varieties with five replications. The varieties were BARI begun-1, BARI begun-4, BARI begun-5, BARI begun-6, BARI begun-7, BARI begun-8, BARI begun-9, BARI begun-10, Makra, Muktokashi, Lalita, Hazra and Chaga. The data obtained from different growth and yield components were analyzed statistically by analysis of variance (ANOVA-1) technique and the means of the parameters were compared by Duncan's New Multiple Range Test (DMRT) using MSTAT-C computer program.

Several parameters such as total numbers of shoot, total numbers of infested shoot, percentage of shoots damage, percentage of shoots infestation reduction over control, numbers of larvae per infested shoot, total numbers of fruits, percentage of fruits damage, percentage of fruits infestation reduction over control, numbers of larvae per infested fruits, cost of production, gross return, benefit cost ratio (BCR) were taken into consideration for

data collection to justify the performance of brinjal in different treatments and comparison of different brinjal varieties. Data were collected weekly intervals.

Total numbers of shoot was significantly differed among different treatments. The numbers of shoot was the highest in Mahogany oil + Mahogany cake followed by neem oil and tobacco extract throughout the all observations and control maintained the lowest.

The total number of infested shoot statistically differed at 1% level and the lowest was found in Mahogany oil + Mahogany cake and the highest recorded from the control.

Percentage of shoots damage and percentage of shoot infestation reduction over control showed statistically significant results. In all stages percent shoot infestation was the lowest in Mahogany oil + Mahogany cake followed by neem oil and the highest was recorded in control and percentage of shoots infestation reduction over control was the highest was recorded in Mahogany oil + Mahogany cake the lowest in control.

Total numbers of fruit was significantly differed among different treatments. The highest numbers of fruit was observed in tobacco extract followed by Mahogany oil + Mahogany cake and the lowest was found in control. Number of healthy fruit was the highest in Mahogany oil + Mahogany cake and the lowest in control. In all stages percent fruit infestation was the lowest in Mahogany oil + Mahogany cake followed by neem oil and the highest was recorded in control and percentage of fruit infestation reduction over control was the highest in Mahogany oil + Mahogany cake and the lowest in control.

Mean number of larvae per infested shoot and fruit were the lowest in Mahogany oil + Mahogany cake followed by neem oil and the highest was recorded in control.

In case of economic analysis, the effect of different botanicals was also significant. The maximum gross return was found in Mahogany oil + Mahogany cake because of its high yield, the lowest infestation and the highest percentage of fruit infestation reduction over control. The second highest gross return was found in tobacco extract which was statistically different from the high value. The cost of production was high in neem oil due to its high cost.

In second experiment total numbers of shoot, total number of infested shoot, mean number of larvae per infested shoot was significantly differed among different varieties due to their genetic characteristics. In most of the cases, the total number of shoots per plant was the highest in BARI begun-1 and the lowest in makra the maximum number of infested shoot was found in BARI begun-1 and minimum was observed in makra, mean number and the larvae per infested shoot was the highest in chaga and the lowest in makra.

The variation of different brinjal varieties against percent shoot infestation by brinjal shoot and fruit borer (BSFB) on different stages was statistically significant at 1% level. In most of the cases the maximum shoot infestation was found in chaga and minimum in BARI begun-6.

Production of number of fruits is a genetically matters and different varieties produce different numbers of fruits and showed statistically significant at 1% level. The maximum numbers of fruits was observed in BARI begun-1 and minimum in makra and in muktokashi. Percent of fruit infestation was found maximum in muktokashi and minimum in BARI begun-6.

Conclusion

From the study it is found that percentage of shoot damage and percentage of fruit damage were the lowest in Mahogany oil + Mahogany cake followed by neem oil and the highest was recorded in control. The percentage of shoot and fruit infestation reduction over control was recorded the highest from Mahogany oil + Mahogany cake and the lowest from the control. Mean numbers of larvae per infested shoot and fruit were the lowest in Mahogany oil + Mahogany cake followed by neem oil and the highest was recorded in control. The highest BCR was found in Mahogany oil + Mahogany cake. In case of varietal experiment BARI begun-6 provide better performance than others it can for best benefit.

Brinjal is one of the three most popular and economically important vegetables among small-scale farmers and low income consumers. During the past two decades this crop has been increasingly ravaged by brinjal shoot and fruit borer (BSFB). Farmers have resorted to frequent sprays of pesticides to kill the larva that increases the cost of production. For controlling BSFB botanical extracts will be applied.

Therefore, it can be concluded that this study established the fact that eco-friendly management measures namely natural products like mahogany (oil + cake), neem oil and tobacco leaf extract played tremendous role to prevent the severe damage of brinjal caused by brinjal shoot and fruit borer (BSFB), in the field, resulting in its' higher production in cost effective way, of which mahogany (oil + cake), was proved to be highly effective against brinjal shoot and fruit borer (BSFB). Thus, the study to improve the eco-friendly management practices will benefit our agriculture sectors in such a manner that these eco-friendly management practices have less environmental impact on its associated biota in comparison to enormous insecticidal hazards.

CHAPTER VI

REFERENCES

- Alam, M. Z. 1969. Insect pest of vegetables and their control in East Pakistan. The Agriculture Information service, Deptt. Agric.; East Pakistan, pp. 146.
- Alam, S. N., Rashid, M. A., Rouf, F. M. A., Jhala, R. C., Patel, J. R., Satpathy, S., Shivalingaswamy, T.M., Wahundeniya, S.Rai, I., Ammaranan, A., Cork, C. and Talekar, N. S. 2003. Development of an integrated pest management strategy for eggplant fruit and shoot borer in South Asia. Shanhua, Taiwan: AVRDC—the World Vegetable Center. Technical Bulletin No. 28. AVRDC Publication No. 03-548. pp. 56
- Ali, M. I. 1994. Host plant resistance in brinjal against the brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. In: Annual Research Report 1993-94. Entomology Division, BARI, Joydebpur, Gazipur, pp: 52-55.
- Anand, M. 2004. Qualitative analysis of amino acids of highly and less susceptible varieties of brinjal to *Leucinodes orbonalis* Guenee. *Indian Journal of Entomology*, 66(1): 71-73.
- Anil, K. and Pandey, M. C. 2001. Role of Biopesticides in plant protection system. BiopestConf. BET., Chandigarh, India. p.113.
- Anjali, M., Singh, N. P. and Singh, S. 2012. Management of Brinjal Shoot and Fruit Borer: Dilemma of Adopting Bt Brinjal over Integrated Pest Management Technology. International Conference on Clean and Green Energy IPCBEE, IACSIT Press, Singapore. pp: 93.

- Ardez, K. P., Sumalde, A. C. and Taylo, L. D. 2008. Ovipositional preference, host range and life history of eggplant fruit and shoot borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). *Philippine Entomologist*, 22(2): 173-183.
- Asati, B. S., Sarnaik, D. A., Thakur, B. S. and Guhey, A. 2002. Shoot and fruit borer incidence as influenced by total phenol and total chlorophyll content in round fruited brinjal varieties. *Orissa Journal of Horticulture*, 30(2): 100-104.
- Ashadul, M. I., M. A. Hussain, S. A. Shapla, H. Mehraj and A. F. M. Jamal Uddin 2014. Plant Extract for the Management of Brinjal Shoot and Fruit Borer (*Leucinodes orbonalis* Guenee). *American-Eurasian J. Agric. & Environ. Sci.*, 14 (12): 1409-1414.
- Babu, S. G. R., Gowda, P. H. R., Shivashankar, K. T. and Krishnappa, K. S. 1999. Evaluation of M4 single plant progenies of *Solanum macrocarpon* for growth, yield and shoot and fruit borer resistance. *South Indian Horticulture*, 47(1): 182-184.
- Bajaj, K. L., Kaur, G. and Chadha, M. L. 1979. Combining ability over environments for shoot and fruit borer resistance and other quantitative traits in *Solanum melongena* L. *Plant Foods*, 3. pp: 163-168.
- Bangladesh Agricultural Research Institute (BARI) 2005. Annual Research Report 1993-94. Joydebpur, Gazipur, Bangladesh: BARI. pp: 319.
- Banu, J. G. and Rajendran, G. 2002. Host records of an entomopathogenic nematode, *Heterorhabditis indica*. *Insect Environment*, 8(2): 61-63.
- Baral, K., Roy, B. C., Rahim, K. M. B., Chatterjee, H., Mondal, P., Mondal, D., Ghosh, D. and Talekar, N. S. 2006. Socio-economic parameters of pesticide use and assessment

- of impact of an IPM strategy for the control of eggplant fruit and shoot borer in West Bengal, India. Technical Bulletin No. 37. AVRDC publication number 06-673. AVRDC – The World Vegetable Center, Shanhua, Taiwan. pp: 36.
- Behera, T. K. and Gyanendra, S. 2002. Studies on resistance to shoot and fruit borer(*Leucinodes orbonalis*) and interspecific hybridization in eggplant. *Indian Journal of Horticulture*, 59(1): 62-66.
- Behera, T. K., Singh, N. and Kalda, T. S. 1999. Genetic diversity in eggplant for resistance to shoot and fruit borer. *Indian Journal of Horticulture*, 56(3): 259-261.
- Bharadiya, A. M. and Patel, B. R. 2004. Screening of brinjal varieties/genotypes for resistance to the shoot and fruit borer, *Leucinodes orbonalis* Guenee under north Gujarat conditions. *Pest Management and Economic Zoology*, 12(2): 223-225.
- Biswas, G. C., Sattar, M. A. and Saba, M. C. 1992. Survey and monitoring of insect pests of brinjal at Khagrachari Hilly Region. Annual Report, 1991-92, Ent. Div., BARI, Joydebpur, Gazipur. pp. 44-42.
- Bodkhe, G. R., Shetgar, S. S. and Nalwandikar, P. K. 2007. Population dynamics of brinjal shoot and fruit borer. *Journal of Maharashtra Agricultural Universities*, 32(1): 111-113
- Chandrashekhar, C. H., Malik, V. S. and Singh, R. 2009. Morphological and Biochemical Factors of Resistance in Eggplant against *Leucinodes orbonalis* (Lepidoptera: Pyralidae). *Entomologia Generalis*, 31(4): 337-345.

- Chaudhary, D. R. and Sharma, S. D. 2000. Screening of some brinjal cultivars against bacterial wilt and fruit borer. *Agricultural Science Digest*. 20(2): 129-130.
- Chitra, K. C., Pao, S. J., Pao, P. K and Nagalah, K. 1993. Field evaluation of certain plant products in the control of brinjal pest complex. *Indian Journal of Entomology* 55(3): 237-240.
- Cork, A., Alam, S. N., Rouf, F. M. A. and Talekar, N. S. 2003. Female sex pheromone of brinjal fruit and shoot borer, *Leucinodes orbonalis* (Lepidoptera: Pyralidae): trap optimization and application in IPM trials. *Bulletin of Entomological Research*, 93(2): 107-113.
- Cork, A., Alam, S. N., Rouf, F. M. A. and Talekar, N. S. 2005. Development of mass trapping technique for control of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera: Pyralidae). *Bulletin of Entomological Research*, 95(6): 589-596.
- Debach, P. and Rosen, D. 1991. Biological control by natural enemies. Cambridge University Press, Cambridge, United Kingdom. pp.: 537.
- Dhankar, D. S. 1988. Progress in resistance studies in eggplant (*Solanum melongena* L.) against shoot and fruit borer of brinjal (*Leucinodes orbonalis* Guenee) infestation. *Tropical Pest Management*. 34: 343-345.
- Dilbagh, S., Chandha, M. L. and Singh, D. 1991. Effect of morphological characters of brinjal on incidence of *Leucinodes orbonalis*. *Journal of Research, Punjab Agriculture University*, 28:345-353.

- Divya, A. and More, T. A. 2007. Inheritance of resistance to shoot and fruit borer (*Leucinodes orbonalis* Guen.) in brinjal (*Solanum melongena* L.). *Journal of Soils and Crops*, 17(1): 93-100.
- Doijode, S. D. 2001. Seed storage of horticultural crops (pp 157). Haworth Press: ISBN 1-56022-901-2 Expert Book Agency. pp:356.
- Dolui, A. K. and Debnath, M. 2010. Antifeedant activity of plant extracts to an insect *Helopeltis theivora*. *Journa of l Environment Biology*, 31(5): 557-559.
- Elanchezhyan, K., Baskaran, R. K. M. and Rajavel, D. S. 2008. Reaction of brinjal genotypes to *Leucinodes orbonalis*. *Annals of Plant Protection Sciences*, 16(1): 231-232.
- Food and Agricultural Organization (FAO) 2012. FAOSTAT data 2012 (Avalilable at: <http://www.fao.org> Retrived on 25 February, 2014).
- Gangopadhyay, C., Maity, T. K. and Mandal, S. K. 1996. Screening of brinjal germplasms against fruit and shoot borer, *Leucinodes orbonalis* Guen. *Environment and Ecology*, 14(4): 834-836.
- Ghimire, S. N., Upreti, G., Thapa, R. B. and Manandhar, D. N. 2007. Ecofriendly management of brinjal fruit and shoot borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). *IAAS Research Advances*, 2: 127-131.
- Ghosh, S. K. and Senapati, S. K. 2001. Evaluation of brinjal varieties commonly grown interai region of West Bengal against pest complex. *Crop Research Hisar*, 21(2): 157-163.

- Gokce, A. 2010. Toxicity and Antifeedant activity of selected plant extract against larval obliquebanded leaf roller *Choristoneura rosateana* (Harris). *The open Entomol. Journal*. 4: 18 - 24.
- Gomez, K. A. and Gomez, A. A. 1984. Statistical procedures for agricultural research. 2nd edition. International Rice Research Institute, John Willey and Sons, Singapore. pp: 490
- Gupta, G. P. and Raghuraman, M. 2004. Utilization of biopesticides in cotton pest management In: Biopesticides for sustainable agriculture: prospects and constraints. (Kaushik, N., Ed.) CAB abstracts Teri Press, The Energy and Resource Institute. pp: 43.
- Gupta, R. C. and Singh, N. P, 2002. Neem: A natural pesticide for sustainable agriculture. *Pestology* 26(8): 50-57.
- Hanson, P. M., Yang, R, Y., Tsou, S. C. S., Ledesma, D., Engle, L. and Lee, T. C. 2006. Diversity of eggplant (*Solanum melongena*) for superoxide scavenging activity, total phenolics and ascorbic acid. *Journal of Food composition and Analysis* 19(6-7): 594-600.
- Hazra, P., Dutta, R. and Maity, T. K. 2004. Morphological and biochemical characters associated with field tolerance of brinjal (*Solanum melongena* L.) to shoot and fruit borer (*Leucinodes orbonalis*) and their implication in breeding for tolerance. *Indian Journal of Genetics and Plant Breeding*, 64(3): 255-256.
- Hussaini, S. S., Rabindra, R. J. and Nagesh, M. 2003. Progress of research work on Entomopathogenic nematodes in India. Current status of research on

- entomopathogenic nematodes in India Workshop on the Entomopathogenic Nematodes in India, pp. 27-68.
- Islam, M. M. and Karim, M. A. 1991. Management of Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) in field. In: Ann. Res. Report 1990-91 Entomol. Div., Gazipur, Bangladesh, pp 44-46.
- Islam, M. N. and Karim, M. A. 1994. Integrated management of the brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee at Joydebpur. In: Ann. Res. Rep., 1993-94. Entomol. Div., BARI, Joydebpur, Gazipur, pp. 41-42.
- Jat, K. L. and Pareek, B. L. 2003. Biophysical and bio-chemical factors of resistance in brinjal against *Leucinodes orbonalis*. *Indian Journal of Entomology*, 65(2): 252-258.
- Johny, S. and Muralirangan, M. C. 2005. A microsporidian parasite (Protozoa: Microspora) infecting *Spodopteralitura* (Fabricius) (Lepidoptera: Noctuidae) in India: its morphology, host range and efficacy. *Entomology*, 30(2): 147-155.
- Jyani, D. B., Patel, N. C., Ratanpara, H. C., Patel, J. R. and Board, P. K. 1995. Varietal resistance in brinjal to insect-pest and disease. Dept. of Entomol., B. A. College Agric. Univ. Res. J., 21: 59-63.
- Kamalakkannan, T., Karuppaiah, P., Sekar, K. and Senthilkumar, P. 2007. Line tester analysis in brinjal for yield and shoot and fruit borer tolerance. *Indian Journal of Horticulture*, 64(4): 420-424.

- Karmakar, K. and Bhattacharya, B. 2000. Performance of a local brinjal variety (*Solanum melongena* L.) and its pest management under terai agro-ecological conditions. *Environment and Ecology*, 18(2): 344-346.
- Karvilharaghavan, Z., Ragendran, R. and Vigayaraghavan, C. 2006. Influence of organic amendments against brinjal shoot and fruit borer *Leucinodes orbonalis* (Guenee). *International Journal of Agriculture Science*, 2(2): 344-348
- Kiritani, K. 1979. Pest management in rice. *Annual Review of Entomology* 24: 279-312.
- Krishna, T. M., Lal, O. P. and Srivastava, Y. N. 2001. Extent of losses caused by shoot and fruit borer, *Leucinodes orbonalis* Guen., to promising varieties of brinjal, *Solanum melongena* L. *Journal of Entomological Research (New Delhi)*, 25(3): 205-212.
- Kumar, A. and Shukla, A. 2002. Varietal preference of fruit and shoot borer, *Leucinodes orbonalis* Guen. on brinjal. *Insect Environment*, 8(1): 44.
- Latif M. A., Rahman M. M., Alam M. Z. and Hossain M. M. 2009. Evaluation of Flubendiamide as an IPM Component for the Management of Brinjal Shoot and Fruit Borer, *Leucinodes Orbonalis* Guenee. *Mun. Ent. Zool.* Vol. 4, No. 1, 257-267.
- Mathur, A., Singh, S., Singh, N. P. and Meena, M. 2012. Field evaluation of plant products and microbial formulations against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee under semi-arid conditions of Rajasthan. *Journal of Biopesticides* 5(1): 71-74.
- Mochiah, M. B., Banful, B., Fening, K. N., Amoabeng, B. W., Offei-Bonsu, K., Ekyem, S., Braimah, H. and Owusu-Akyaw, M. 2011. Botanicals for the management of insect

- pests in organic vegetable production. *Journal of Entomology and Nematology* 3(6): 85-97.
- Mohanty, J. N., Anand, P. and Jagadiswari, R. 2000. Management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. by release of *Bracon brevicornis* Wesm. in the field. *Journal of Applied Zoological Researches*, 11(2/3): 96-97.
- Murugesam, N. and Muruges, T. 2009. Bioefficacy of some plant products against brinjal fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). *Journal of Biopesticides* 2(1): 60-63.
- Narayanan, K. and Gopalakrisnan, C. 2003. Cross infectivity of microsporidian, *Vairimorphasp.* against certain lepidopterous insect pests. *Insect Environment*, 9(2): 65-66.
- Nonnecke, J. L. 1989. Vegetable Production. Van Nostrand Reinhold, New York, pp: 247.
- Oerke, E. C. 2006. Crop losses to pests. *Journal of Agriculture Science*, 144: 31 - 43.
- Orden, M. E. M., Patricio, M. G. and Canoy, V. V. 1994. Extent of pesticide use in vegetable production in Nueva Ecija: Empirical evidence and policy implications. *Research and Development Highlights 1994*, Central Luzon State University, Republic of the Philippines. pp: 196-213
- Owusu-Ansah, F., Afreh-Nuamah, K., Obeng-Ofori, D. and Ofosu-Budu, K. G. 2001. Managing infestation levels of major insect pests of garden eggs (*Solanum integrifolium* L.) with aqueous neem seed extracts. *Journal of the Ghana Science Association*, 3(3): 70-84.

- Page, G. V., Jagtap, K. B. and Patil, S. D. 2004. Studies on ratoon crop of brinjal. *Journal of Maharashtra Agricultural University*, 29(2): 219-220.
- Painter, R. H. 1951. Insect Resistant to Crop Plants McGraw Hill Book Co. Inc. NewYork, pp: 679.
- Panda, N., Mahapatr, A. and Sahoo, M. 1971. Field evaluation of some brinjal varieties for resistance to shoot and fruit borer, *Leucinodes orbonalis* (Guen.). *Indian Journal of Agricultural Sciences*, 41(7): 597-601.
- Patel, D. A., Shukla, P. T. and Jadeja, G. C. 2001. Morphological studies on interspecific hybrids between *Solanum indicum* L. and *Solanum melongena* L. *Indian Journal of Genetics and Plant Breeding*, 61(2): 180-182.
- Pedigo, L. P. 2002. Entomology and Pest Management. 4th Edition. Prentice Hall, Upper Saddle River, New Jersey, USA. pp: 633.
- Prabhu, M., Natarajan, S. and Pugalendhi, L. 2007. Variability and heritability in segregating generation of eggplant (*Solanum melongena* L.). *Advances in Plant Sciences*, 20(2): 435-437.
- Prakash, A. and Rao, J. 1997. Botanical pesticides in agriculture Lewis Publishers First Edn. India.p. 480.
- Prakash, A., Rao, J. and Nandagopal, V. 2008. Future of botanical pesticides in rice, wheat, pulses and vegetables pest management. *Journal of Biopesticides* 1(2): 154-169.
- Puranik, T. R., Hadapad, A. B., Salunkhe, G. N. and Pokharakar, D. S. 2002. Management of shoot and fruit borer, *Leucinodes orbonalis* (Guenee.) through *Bacillus thuringiensis*

- formulations on brinjal. *Journal of Entomological Research* (New Delhi), 26(3): 229-232.
- Rahman, A. K. M. Z. 1997. Screening of 28 brinjal line for resistance/tolerance against the brinjal shoot and fruit borer. Annual Report. Entomology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh. pp. 32-35.
- Rahman, M. S. and Islam, K. S. 2004. Effect of some integrated pest management (IPM) package against brinjal shoot and fruit borer *Lucinodes orbonalis* Guen. *Indian journal of entomology*, 66(1):48-52.
- Ramakrishna, T. and Palled, Y. B. 2005. Effect of Plant Geometry and Fertilizer Levels Growth and Yield of Chilli. *Karnataka Journal of Agricultural Sciences*. 18: 892-895
- Rath, L. K. and Maity, B. K. 2005. Evaluation of a non-chemical IPM module for management of brinjal shoot and fruit borer. *Journal of Applied Zoological Researches*, 16(1): 3-4.
- Rath, L. K. and Dash, B. 2005. Evaluation of a non-chemical IPM module for the management of brinjal shoot and fruit borer. *Vegetable Science*, 32(2) 207-209.
- Saeed, M. Q. and Khan, I. A. 1997. Population abundance and chemical control of brinjal fruit borer *Leucinodes orbonalis* Guen. (Lepidoptera: Pyralidae). *Sarhad Journal of Agriculture*. 13: 399-402.
- Saimandir, J. and Gopal, M. 2012. Evaluation of synthetic and natural insecticides for the management of insect pest control of eggplant (*Solanum melongena* L.) and Pesticide Residue Dissipation Pattern. *American Journal of Plant Sciences* 3(2): 214-227.

- Sandeep, K., Bal, S. S., Gulshanjit, S., Sidhu, S. A. and Dhillon, S. T. 2004. Management of brinjal shoot and fruit borer, *L. orbonalis* Guenee through net house cultivation. *Acta Horticulture*, 659(1): 345-350.
- Sardana, H. R., Arora, S., Singh, K. D. and Kadu, N. L. 2004. Development and validation of adaptable IPM in eggplant, *Solanum Melongena* L. in a farmer's participatory approach. *Indian journal of plant protection*, 32(1):123-128.
- Sasikala, K., Rao, P. A. and Krishnayya, P. V. 1999. Comparative efficacy of eco-friendly methods involving egg parasitoid, *Trichogramma japonicum*, mechanical control and safe chemicals against *Leucinodes orbonalis* Guenee infesting brinjal. *Journal of Entomological Research*, 23(4): 369-372.
- Senapati, A. K. 2003. Comparative susceptibility of different brinjal cultivars against brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen. *Journal of Interacademia*, 7(1): 127-129.
- Sharma, V., Lal, R. and Choudhary, A. 2001. Screening of brinjal (*Solanum* spp.) germplasm against shoot and fruit borer, *Leucinodes orbonalis* Guen. *Insect Environment*, 7(3): 126-127.
- Singh, K. I., Athokpam, S., Singh, M. P., Singh, T. R. and Singh, N. G. 2007. Effect of planting dates on incidence of the shoot and fruit borer, *Leucinodes orbonalis*(Guenee.) and its seasonal abundance in brinjal crop at Manipur climate. *Journal of Applied Zoological Researches*, 18(1): 15-20.

- Singh, Y. P. and Singh, P. P. 2001. Screening of brinjal (*Solanum melongena* L.) cultivars against shoot and fruit borer (*Leucinodes orbonalis* Guen.) at medium high altitude hills of Meghalaya. *Indian Journal of Plant Protection*, 29(1-2): 34-38.
- Singh, Y. P. and Singh, P. P. 2002. Natural parasites and extent of parasitism to shoot and fruit borer (*Leucinodes orbonalis*) of brinjal (*Solanum melongena*) at medium high altitude hills of Meghalaya. *Indian Journal of Entomology*, 64(2): 222-226.
- Sukumar, K. and Osmani, Z. 1981. Insect sterilants from *Catharanthus roseus*. *Curr. Sci.* 50 : 552 – 553
- SUSVEG-Asia. 2007. SUSVEG-Asia Brinjal integrated pest management (IPM). <http://susveg-asia.nri.org/susvegasiabrinjalipm4.html> (Accessed on 19 September 2007)
- Thapa, R. B. 2010. Integrated management of brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen: An overview. *Journal of Institute of Agriculture and Animal Science* 30 & 32: 1-16
- Udaiyan, K. and Ramarathinam, S. 1994. Bioefficacy of neem derivatives on the incidence of some major insect pests of rice, jowar, cotton, groundnut, vegetables and tea. *Pestology* 18(1): 40-42.
- Umamaheswari, R., Sivakumar, M. and Subramanian, S. 2004. Host range of native entomopathogenic nematodes from Tamil Nadu. *Insect-Environment*, 10(4): 151-152.
- Yadav, D. S. and Sharma, M. M. 2005. Comparative efficacy of bioagents, neemproducts and malathion against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Pesticide Research Journal*, 17(2): 46-48



- Yadav, D. S. and Sharma, M. M. 2005. Evaluation of brinjal varieties for their resistance against fruit and shoot borer, *Leucinodes orbonalis* Guenee. *Indian Journal of Entomology*, 67(2): 129 - 132.
- Yadav, L. N., Sharma, J. K. and Yadav, S. K. 2003. Varietal screening of brinjal against shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Annals of Agri Bio Research*, 8(1): 77-80.

APPENDICES

Appendix 1. Percent shoot infestation in different stages

Treatments	Vegetative stage (30-60DAT) (%)	Early fruiting stage (60-90 DAT) (%)	Mid fruiting stage (90-120 DAT) (%)	Late fruiting stage (120-150 DAT) (%)
Control	45.00a	42.86a	40.00a	34.50a
Neem leaf extract	27.00bc	29.00bc	23.20bc	20.00bc
Neem oil	18.33cd	19.00ef	13.85d	12.14d
Mahagoni oil	33.33b	25.56cd	24.17bc	21.60b
Mahogany oil + Mahogany cake	16.92d	15.24f	12.86d	10.00d
Garlic extract	32.50b	30.59b	27.27b	25.00b
Tobacco leaf extract.	26.67bc	22.73de	22.00c	15.00cd
Level of significance	**	**	**	**
CV (%)	12.91	7.43	8.08	13.72

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 2 Percent shoot infestation reduction over control in different stages

Treatments	Vegetative stage (30-60 DAT) (%)	Early fruiting stage (60-90 DAT) (%)	Mid fruiting stage (90-120 DAT) (%)	Late fruiting stage (120-150 DAT) (%)
Control	0.00c	0.00f	0.00d	0.00e
Neem leaf extract	40.00ab	32.33de	42.00bc	42.11c
Neem oil	59.26a	55.67ab	65.38a	64.85ab
Mahagoni oil	25.93b	40.37cd	39.58bc	37.28cd
Mahogany oil + Mahogany cake	62.39a	64.44a	67.86a	71.05a
Garlic extract	27.78b	28.60e	31.82c	27.63d
Tobacco leaf extract.	40.74ab	46.97bc	45.00b	56.58b
Level of significance	**	**	**	**
CV (%)	26.74	10.05	9.97	13.33

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 3. Percent fruit infestation in different stages

Treatments	Early fruiting stage (60-90 DAT) (%)	Mid fruiting stage (90-120 DAT) (%)	Late fruiting stage (120-150 DAT) (%)
Control	74.29a	58.95a	70.00a
Neem leaf extract	40.00bc	51.22ab	42.00cd
Neem oil	20.00cd	30.00c	21.67de
Mahagoni oil	48.98ab	57.78a	46.30bc
Mahogany oil + Mahogany cake	9.52d	12.00d	9.23e
Garlic extract	56.82ab	62.22a	65.12ab
Tobacco leaf extract.	30.43bcd	38.10bc	26.76cde
Level of significance	**	**	**
CV (%)	25.97	13.87	22.57

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 4. Percent fruit infestation reduction over control in different stages

Treatments	Early fruiting stage (60-90 DAT) (%)	Mid fruiting stage (90-120 DAT) (%)	Late fruiting stage (120-150 DAT) (%)
Control	0.00g	0.00e	0.00g
Neem leaf extract	43.90d	41.10bc	38.90d
Neem oil	71.90b	44.30b	69.50b
Mahagoni oil	31.50e	25.60cd	25.90e
Mahogany oil + Mahogany cake	86.70a	85.80a	85.50a
Garlic extract	17.40f	9.06de	9.80f
Tobacco leaf extract.	57.40c	58.20b	58.70c
Level of significance	**	**	**
CV (%)	5.45	16.29	7.73

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 5. Effect of botanicals on brinjal yield

Treatments	Yield (t/ha)	Increased yield over control (t/ha)
Control	16.48d	0.00d
Neem leaf extract	25.32bc	8.84bc
Neem oil	30.85ab	14.37ab
Mahagoni oil	23.32cd	6.84cd
Mahogany oil + Mahogany cake	33.97a	17.49a
Garlic extract	21.82cd	5.340cd
Tobacco leaf extract.	35.82a	19.34a
Level of significance	**	**
CV (%)	11.17	22.18

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 6. Performance of different brinjal varieties against percent shoot infestation by brinjal shoot and fruit borer (BSFB) on different stages

Varieties	Vegetative stage (30-60DAT) (%)	Early fruiting stage (60-90) (%)	Mid fruiting stage (90-120) (%)	Late fruiting stage (120-150) (%)
BARI begun-1	43.47abcde	50.19bc	51.06cd	48.70de
BARI begun-4	41.79bcde	43.83d	35.87f	41.99f
BARI begun-5	34.17def	35.54e	34.56f	34.06g
BARI begun-6	29.60f	32.40e	29.86f	29.38g
BARI begun-7	41.90bcde	43.75d	44.20e	43.07f
BARI begun-8	33.33ef	32.82e	32.92f	31.47g
BARI begun-9	52.14ab	52.58bc	54.44bc	50.56cd
BARI begun-10	43.33abcde	42.82d	44.90de	44.05ef
Makra	40.00cdef	60.36a	62.03a	60.02a
Muktokashi	46.00abcd	47.46cd	51.43cd	48.16de
Lalita	51.43abc	54.25ab	56.36abc	55.07bc
Hazra	50.00abc	55.40ab	56.75abc	56.07ab
Chaga.	54.00a	59.210a	59.62ab	60.94a
Level of significance	**	**	**	**
CV (%)	14.60	7.42	7.95	6.00

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 7. Performance of different brinjal varieties against percent fruit infestation by brinjal shoot and fruit borer (BSFB) on different stages

Varieties	Early fruiting stage (60-90) (%)	Mid fruiting stage (90-120) (%)	Late fruiting stage (120-150) (%)
BARI begun-1	37.68fg	37.04hi	38.60g
BARI begun-4	40.18f	40.24gh	40.14fg
BARI begun-5	44.24f	44.88fg	44.88f
BARI begun-6	25.16h	27.42j	25.40h
BARI begun-7	29.22h	30.38j	30.38h
BARI begun-8	51.86e	50.14ef	50.88e
BARI begun-9	31.82gh	32.40ij	31.06h
BARI begun-10	55.44de	55.48de	54.82de
Makra	69.98ab	69.28ab	68.76ab
Muktokashi	72.82a	72.08ab	70.76a
Lalita	59.52cd	60.06cd	59.30cd
Hazra	64.90bc	65.96bc	64.30bc
Chaga.	75.28a	74.40a	73.90a
Level of significance	**	**	**
CV (%)	8.55	7.05	7.01

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 8. Analysis of variance of infestation of shoot in vegetative stage (30-60 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	6	4.70**	0.27**	1.65**
Error	12	0.36	0.05	0.08

**= Significant at 1% level

Appendix 9. Analysis of variance of infestation of shoot in early fruiting stage (60-90 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	6	4.16**	1.16**	1.23**
Error	12	0.75	0.07	0.07

**= Significant at 1% level

Appendix 10. Analysis of variance of infestation of shoot in mid fruiting stage (90-120 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	6	9.25**	2.27**	1.05**
Error	12	0.88	0.16	0.05

**= Significant at 1% level

Appendix 11. Analysis of variance of infestation of shoot in late fruiting stage (120-150 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	6	7.87**	2.13**	0.92**
Error	12	1.31	0.13	0.04

**= Significant at 1% level

Appendix 12. Analysis of variance of percent shoots infestation in different stages

Source of variation	Degrees of Freedom	Mean square			
		Vegetative stage (30-60 DAT)	Early fruiting stage (60-90 DAT)	Mid fruiting stage (90-120 DAT)	Late fruiting stage (120-150 DAT)
Treatment	6	301.31**	288.57**	277.00**	229.19**
Error	12	13.82	3.50	3.65	7.49

**= Significant at 1% level

Appendix 13. Analysis of variance of percent shoots infestation reduction over control in different stages

Source of variation	Degrees of Freedom	Mean square			
		Vegetative stage (30-60 DAT)	Early fruiting stage (60-90 DAT)	Mid fruiting stage (90-120 DAT)	Late fruiting stage (120-150 DAT)
Treatment	6	1531.77**	1562.37**	1576.61**	1711.14**
Error	12	92.17	17.67	18.86	35.09

**= Significant at 1% level

Appendix 14. Analysis of variance of infestation of fruit in early fruiting stage (60-90 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of fruits per plant		Mean numbers of larvae per infested fruits
		Total	Infested	
Treatment	6	6.04**	1.44**	2.44**
Error	12	0.23	0.06	0.05

**= Significant at 1% level

Appendix 15. Analysis of variance of infestation of fruit in mid fruiting stage (90-120 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of fruits per plant		Mean numbers of larvae per infested fruits
		Total	Infested	
Treatment	6	0.78**	1.52**	1.53**
Error	12	0.10	0.08	0.08

**= Significant at 1% level

Appendix 16. Analysis of variance of infestation of fruit in late fruiting stage (120-150 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of fruits per plant		Mean numbers of larvae per infested fruits
		Total	Infested	
Treatment	6	4.81**	1.69**	1.78**
Error	12	0.62	0.08	0.06

**= Significant at 1% level

Appendix 17. Analysis of variance of percent fruit infestation in different stages

Source of variation	Degrees of Freedom	Mean square		
		Early fruiting stage (60-90 DAT)	Mid fruiting stage (90-120 DAT)	Late fruiting stage (120-150 DAT)
Treatment	6	2682.08**	946.17**	1789.95**
Error	12	127.95	33.42	89.93

**= Significant at 1% level

Appendix 18. Analysis of variance of percent fruit infestation reduction over control in different stages

Source of variation	Degrees of Freedom	Mean square		
		Early fruiting stage (60-90 DAT)	Mid fruiting stage (90-120 DAT)	Late fruiting stage (120-150 DAT)
Treatment	6	2716.89**	2498.18**	2715.86**
Error	12	6.35	50.87	11.72

**= Significant at 1% level

Appendix 19. Analysis of variance of effect of botanicals on brinjal yield

Source of variation	Mean square		
	Degrees of Freedom	Yield (t/ha)	Increased yield over control (t/ha)
Treatment	6	168.51**	168.51**
Error	12	8.46	8.46

**= Significant at 1% level

Appendix 20. Analysis of variance of cost and return analysis of brinjal production

Source of variation	Degrees of Freedom	Mean square					
		Yield (t/ha)	Increased yield over control (t/ha)	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (B/CR)
Treatment	6	168.505**	168.505**	205680477194.96**	11801196666.71	142753085255.87**	0.92**
Error	12	8.46	8.46	4795561616.92	0.00	3798297093.11	0.04

**= Significant at 1% level

Appendix 21. Analysis of variance of performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in vegetative stage (30-60 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	12	12.95**	2.20**	5.74**
Error	52	0.28	0.16	0.02

**= Significant at 1% level

Appendix 22. Analysis of variance of performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in early fruiting stage (60-90 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	12	36.97**	5.70**	5.40**
Error	52	1.32	0.454	0.11

**= Significant at 1% level

Appendix 23. Analysis of variance of performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in mid fruiting stage (90-120 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	12	41.34**	11.42**	5.73**
Error	52	1.80	0.81	0.06

**= Significant at 1% level

Appendix 24. Analysis of variance of performance of different varieties against brinjal shoot and fruit borer (BSFB) on shoot infestation in late fruiting stage (120-150 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of shoots per plant		Mean numbers of larvae per infested shoot
		Total	Infested	
Treatment	12	66.24**	17.57**	5.41**
Error	52	1.41	0.50	0.06

**= Significant at 1% level

Appendix 25. Analysis of variance of performance of different brinjal varieties against percent shoot infestation by brinjal shoot and fruit borer (BSFB) on different stages

Source of variation	Degrees of Freedom	Mean square			
		Vegetative stage (30-60 DAT)	Early fruiting stage (60-90 DAT)	Mid fruiting stage (90-120 DAT)	Late fruiting stage (120-150 DAT)
Treatment	12	290.09**	448.22**	600.78**	538.59**
Error	52	39.72	12.13	14.08	7.74

**= Significant at 1% level

Appendix 26. Analysis of variance of performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in early fruiting stage (60-90 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of fruits per plant		Mean numbers of larvae per infested fruits
		Total	Infested	
Treatment	12	7.06**	1.29**	5.76**
Error	52	0.11	0.02	0.07

**= Significant at 1% level

Appendix 27. Analysis of variance of performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in mid fruiting stage (90-120 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of fruits per plant		Mean numbers of larvae per infested fruits
		Total	Infested	
Treatment	12	36.83**	4.95**	5.40**
Error	52	0.20	0.05	0.06

**= Significant at 1% level

Appendix 28. Analysis of variance of performance of different varieties against brinjal shoot and fruit borer (BSFB) on fruit infestation in late fruiting stage (120-150 DAT)

Source of variation	Degrees of Freedom	Mean square		
		Mean numbers of fruits per plant		Mean numbers of larvae per infested fruits
		Total	Infested	
Treatment	12	33.44**	5.01**	5.20**
Error	52	0.21	0.06	0.07

**= Significant at 1% level

Appendix 29. Analysis of variance of performance of different brinjal varieties against percent fruit infestation by brinjal shoot and fruit borer (BSFB) on different stages

Source of variation	Degrees of Freedom	Mean square		
		Early fruiting stage (60-90 DAT)	Mid fruiting stage (90-120 DAT)	Late fruiting stage (120-150 DAT)
Treatment	12	1483.50**	1379.30**	1363.83**
Error	52	18.75	12.79	12.41

**= Significant at 1% level

Appendix 30. Analysis of variance of resistance of different brinjal varieties against brinjal shoot and fruit borer (BSFB) infestation

Source of variation	Degrees of Freedom	Mean square		
		Numbers of fruits per plant	Numbers of infested fruits per plant	Percent of fruit infestation
Treatment	12	1216.47**	80.33**	875.11**
Error	52	12.86	2.10	14.20

**= Significant at 1% level

Appendix 31. Analysis of variance of yield performance of different varieties

Source of variation	Mean square		
	Degrees of Freedom	Number of fruits per plant	Weight of fruits per plant (kg)
Treatment	12	1216.47 **	80.333 **
Error	52	12.86	2.108

**= Significant at 1% level

Appendix 32. Some pictorial presentation of brinjal variety 'Makra' as influenced by different botanicals



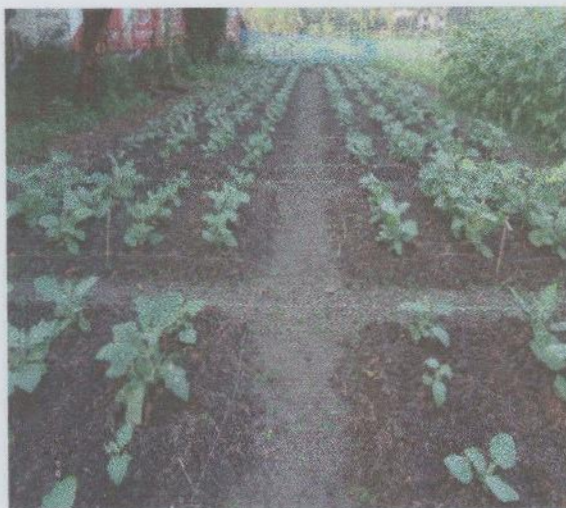
Pic 1. Preparation of land



Pic 2. Transplanting seedlings



Pic 3. Different treatment materials



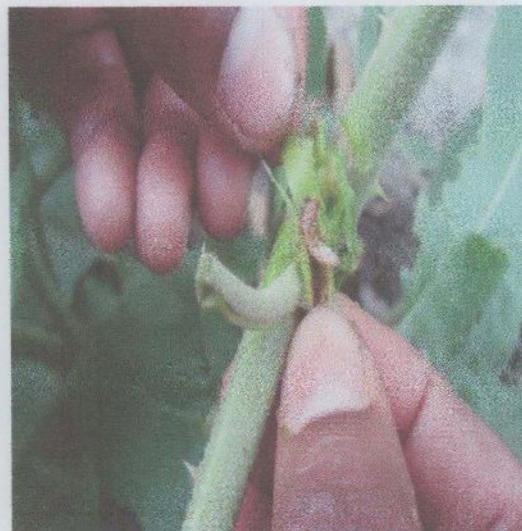
Pic 4. Vegetative stage of plant



Pic 5. Infestation by BSFB



Pic 10. Infested shoot



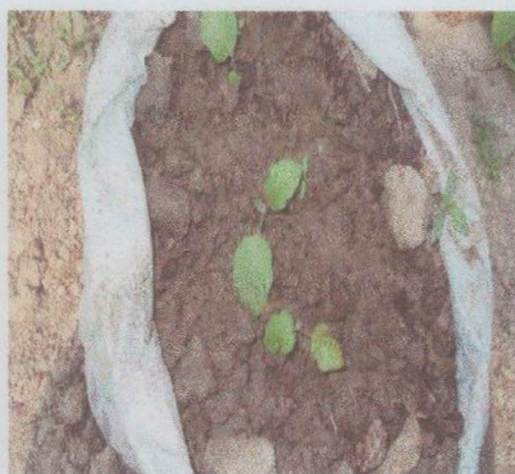
Pic 11. Removal of insect from infested
Shoot



Appendix 33. Some pictorial presentation of different brinjal varieties



Pic 12. Transplanting of different varieties



Pic 13. Individual sac



Pic 14. Vegetative stage of plant



Pic15. Flowering stage of plant