# INCIDENCE AND MANAGEMENT OF SOME MAJOR INSECT PESTS OF OKRA

**SHAKILA NAZNEEN**

**DEPARTMENT OF ENTOMOLOGY**
**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**
**SHER-E-BANGLA NAGAR, DHAKA-1207, BANGLADESH**

**JUNE, 2013**

# INCIDENCE AND MANAGEMENT OF SOME MAJOR INSECT PESTS OF OKRA

**BY**
**SHAKILA NAZNEEN**
**REGISTRATION NO. 06-02106**

A Thesis
Submitted to the faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

**MASTER OF SCIENCE (MS)**
**IN**
**ENTOMOLOGY**

**SEMESTER: JANUARY-JUNE, 2013**

**Approved by**

…………………………………… ....................................................
**Prof. Dr. Md. Razzab Ali** **Dr. Tahmina Akter**
**Supervisor** **Co-Supervisor**

……………………………..

**Dr. Tahmina Akter**
**Chairman**
**Examination Committee**

**DEPARTMENT OF ENTOMOLOGY**
Sher-e-Bangla Agricultural University
**Sher-e-Bangla Nagar, Dhaka-1207**

# CERTIFICATE

This is to certify that thesis entitled, **"INCIDENCE AND MANAGEMENT OF SOME MAJOR INSECT PESTS OF OKRA"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **SHAKILA NAZNEEN, Registration no. 06-02106** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

**Date: June, 2013**
**Place: Dhaka, Bangladesh**

**(Prof. Dr. Md. Razzab Ali)**
**Supervisor**
**Department of Entomology**
**Sher-e-Bangla Agricultural University**
**Dhaka-1207**

**DEDICATED TO MY BELOVED PARENTS AND FAMILY MEMBERS**

## ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, the great, the gracious, merciful and supreme ruler of the universe to complete the research work and thesis successfully for the degree of Master of Science (MS) in Entomology.

The author expresses the deepest sense of gratitude, sincere appreciation and heartfelt indebtedness to her reverend research supervisor **Professor Dr. Md. Razzab Ali,** Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, innovative suggestions, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.

The author also expresses her sincere appreciation, profound sense, respect and immense indebtedness to her respected co-supervisor **Dr. Tahmina Akter**, Associate Professor and Chairman of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207 for extending her generous help, scholastic guidance, constructive criticism, continuous inspiration and valuable suggestions during the research work and preparation of the manuscript of the thesis.

The author would like to express her deepest respect and boundless gratitude to all respected teachers of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207 for their sympathetic co-operation and inspirations throughout the course of this study and research work. Special thanks to Ruhul Amin, Lecturer, Department of Entomology, SAU for his sincere co-operation in data processing, management and analysis of this thesis.

The author extends her heartiest thanks and special gratefulness to Muhaymen Anas Khalid, Shaila Begum Shelly, Nurun Nahar Shahinur and many other well wishers for their inspiration, encouragement, help and active co-operation for carrying out the present study.

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

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

**Dated: June, 2013** **The Author**
**SAU, Dhaka**

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF PLATS

# INCIDENCE AND MANAGEMENT OF SOME MAJOR INSECT PESTS OF OKRA

**By**
**SHAKILA NAZNEEN**

## ABSTRACT

The present experiment was conducted at the laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April to August, 2012 to evaluate the efficacy of synthetic insecticides and botanical product against okra shoot and fruit borer and white fly. The treatments were comprised of seven synthetic chemical insecticides one botanical product and one untreated control and these were $T_1$ =Spraying of Actara 25WG @1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @1.5ml/L of water at 7 days interval; $T_7$ = Marshal100 EC @1.5ml/L of water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval and $T_8$ = Untreated Control. The experiment was laid out in single factor Randomized Complete Block Design (RCBD) with three replications. The data were recorded on shoot infestation; fruit infestation by number and weight at early, mid and late fruiting stages; plant and yield related attributes as well as yield of okra and also on the incidence of white fly. Among eight treatments, Ripcord 10EC reduced the highest percent of shoot infestation (59.68%) over control at fruiting stage followed by Actara 25WG (52.85%), whereas Neem oil showed the least performance (11.51%). In case of plant infestation, Ripcord 10EC reduced the highest percent of plant infestation (27.41%), whereas Neem oil showed the least performance (4.15%). In case of fruit infestation by number and fruit infestation by weight, Ripcord 10EC reduced the highest percent of fruit infestation 45.30% and 45.49% respectively over control at different stages, followed by Actara 25WG 35.34% and 31.61% respectively, whereas Neem oil showed the least performance (10.91% and 4.91% respectively). In term of incidence of whitefly and leaf infestation by Okra Yellow Vein Clearing Mosaic Virus, Ripcord 10EC reduced the highest percent (45.29% and 31.22% respectively), whereas Neem oil showed the least performance (8.50% and 3.33% respectively). Considering plant and yield related attributes, Ripcord 10EC increased the highest percent of plant height (77.33%), fruit length of healthy & infested fruits were 67.37% and 87.73%, girth of healthy & infected fruits were 35.03% and 85.20% respectively, over control followed by Actara 25 WG, Suntap 50 WP, Marshal 100 EC, Quinalphos, Decis 2.5 EC and Shorbicron 450 EC, where Neem oil showed the least performance. Similarly the highest fruit yield (13.77 ton/ha) was also achieved by Ripcord 10EC with the increase of 242.51% yield over control than Actara 25 WG and other tested insecticides, whereas Neem oil showed the least performance (6.340 ton/ha) with the lowest percent yield increase (57.76%). Okra yield was increased due to increases of fruit length, girth and plant height; on the other hand fruit yield was decreased due to increase of fruit infestation by number and weight occurs to OSFB. Thus Ripcord 10EC could be considered as an effective tool against okra shoot and fruit borer.

# CHAPTER I

# INTRODUCTION

Okra or lady's finger, *Abelmoschus esculentus* L., is a popular and most common vegetable crop in Bangladesh and in other tropical and sub-tropical parts of the world (Tindall, 1986). It is locally known as bhendi or dheros. It belongs to the family Malvaceae and originated in tropical Africa (Thomson and Kelly, 1979). Though okra is produced mainly in the kharif season but it can be grown throughout the year. Okra is an important summer vegetable in Bangladesh which plays an important role to meet the demand of vegetables of the country when vegetables are scanty in the market (Ahmed, 1995 and Rashid, 1999). About 38,508 metric tons of okra is produced from 9786 hectares of land per year in Bangladesh, and its average yield is about 3.93 ton $ha^{-1}$ (BBS, 2009). The yield is very low as compared to the yield 9.7-10 t $ha^{-1}$ of other developed countries of the world (Thomson and Kelly, 1979).

Okra is a nutritious fruit vegetable, which provides an important source of vitamins, calcium, potassium and other mineral matters which are often lacking in the diet of developing countries (IBPGR, 1990). A 100 gram edible portion of okra fruit contains moisture 89.6 g, protein 1.9 g, fat 0.2 g, fibre 1.2 g, phosphorus 56.0 mg, sodium 6.9 mg, sulphur 30 mg, riboflavin 0.1 mg, oxalic acid 8 mg, minerals 0.7 g, carbohydrates 6.4 g, calcium 66 mg, iron 0.35 mg, potassium 103 mg, thiamine 0.07 mg, nictonic acid 0.6 mg, vitamin C 13 mg, magnesium 53 mg and copper 0.19 mg (Gopalan *et al.*, 2007).

Okra is cultivated mainly for its immature fruits, which are generally cooked as vegetable. Okra soups and stews are also popular dishes. When ripe, black or brown white- eyed seeds are sometimes roasted and used as a substitute for coffee. Tender fruits have high mucilage content and are used in soups and gravies. Besides being a vegetable, it acts as clarifying agent in jiggery preparation (Chauhan, 1972). Crude fiber derived from the stem of okra plant is used for rope making. The fruits also have some medicinal value. A mucilaginous preparation from the pod can be used for plasma replacement or blood volume expansion (Savello *et al.*, 1980).

In the year 2009-2010,the total production of okra was about 42000 tons from 10121 hectors of land with an average yield of 4.15t/ha (BBS,2011).The yield is very low compared to that of other developing countries where the yield as high as 7-12 t/ha (Yamaguchi,1998).

Okra is susceptible to the attack of various insects from seedling to fruiting stage such as okra shoot and fruit borer, *Earias vittella*, okra jassid, cut worm, white fly, aphids etc. Among the insect pest of okra, whitefly, *Bemisia tabaci*, okra shoot and fruit borer (OSFB), *Earias vittella* F. are the most serious pests.

Okra shoot and fruit borer (OSFB), *Earias vittella* is the most serious pest which cause direct damage to tender shoots and fruits. It is reported that about 69% losses in marketable yield due to attack of this insect pest. The adult female of okra shoot and fruit borer, *Earias vittella* lays eggs individually on leaves, floral buds and on tender fruits. Small brown caterpillars bore into the top shoot and feeds inside the shoot before fruit formation. The shoot wilt and dry as a result the damaged plant develop branches. Later on caterpillars bore into the fruits and feed inside as a result the infested plant bears smaller and deformed pods. A larva attacks a number of stems and pods one after another. Damaged plant tissues serve as entrance for disease causing microorganisms such as fungi. Kabir *et al*. (1994) reported that some commercially available insecticides like Ripcord 10EC an Fenom 10 EC were tested over three consecutive cropping seasons at Gazipur and Jessore against shoot and fruit borer but internal borer showed resistance against those insecticides. Ngo *et al*. (1999) reported that Proclaim 05 SG showed very little resistance because emamectin benzoate (proclaim) penetrates the plant cuticle to form a reservoir of active ingredient.

The whitefly, *Bemisia tabaci* causes damage to okra by feeding cell sap from plants and plant parts of okra. The damage is caused not only by desapping the plants and exuding honeydew, but also they act as vector of virus diseases transmitting the mosaic, the leaf curl virus diseases (Butani and Jotwani, 1984). Incidence and severity of okra mosaic is directly related to availability and abundance of its insect vector, *B. tabaci* Genn. (Nath and Saika, 1993). It can be mentioned that *Okra yellow vein clearing mosaic virus* (OkYVCMV) is a member of Geminivirus group, which is semipersistently transmitted by whitefly, *B. tabaci* Genn. in the field (Kumar and

Moorthy, 2000). OkYVCMV causes drastic reduction in yield and quality of okra has been considered to be one of the most important constrain in okra cultivation in India and some other okra growing countries (Harender *et al*., 1993) including Bangladesh. OkYVCMV has been reported to be the most important yield limiting factors of okra, which may cause more than 90% yield loss (Sastry and Sing, 1974). Parvin (2004) and Begum (2002) reported that the incidence of OkYVCMV infection. Studies were conducted in West Bengal, India during 2000-2001 to determine an environmentally safe management of yellow vein mosaic disease of okra through the use of tolerant cultivars such as Parbhani Kranti, Arka abhoy, Arka Pankaj, Sevendhari Green and an F1 hybrid, cost effective scheduling of efficient insecticides such as metasystox [demeton-S-methyl], carbofuran and phorate, and plant product-based vector (whitefly, *Bemisia tabaci*) control measures (Srabani *et al.*, 2002). Atiri *et al*. (1991) reported that only treatments with the synthetic pyrethroid, lambda-cyhalothrin @ 15 g a.i. /ha and aqueous neem solution at 467 liters/ha significantly reduced incidence, severity and total damage caused by *Okra mosaic virus* (OMV).

Farmers always desire quick curative action for controlling pests. Since no other control measure against okra sucking pests is available, chemical insecticides have remained as the most powerful tools for controlling this pest. Insecticides are highly effective, rapid in curative action, adaptable to most situations and relatively economical. Insecticides are the only tool for pest management which is reliable for emergency action when insect pest population approach or exceed the economic threshold level (Parkash, 1988). Insecticides are highly effective, rapid in curative action and relatively economical. Recently, a large number of chemicals have been reported to have an effective control of insect pests in okra (Rai, 1985; Verma *et al*., 1980). The synthetic pyrethroids are powerful contact insecticides with a quick knockdown effect, a highly deserved quality to inactivate vector individuals within the period required for virus transmission (Basu, 1995).

Mixtures of various plant parts such as leaf, bark, seed and vegetable oils are traditionally being practiced in Asia and Africa for the management of this insect pest. Botanicals possess an array of properties including insecticidal activity and insect growth regulatory activity against many insect and mite pests (Prakash *et al*., 1990).

Considering the above facts the experiment has been undertaken with the following objectives:

- To know the infestation level of OSFB and white fly in okra;
- To evaluate the effectiveness of some selected synthetic insecticides and one botanical product against OSFB and whitefly ;
- To show the relationship among different infestation parameters yields attributes and yield of okra.

# CHAPTER II

# REVIEW OF LITERATURE

In Bangladesh limited work of insect pest management of okra (*Abelmoschus esculentus* Moench) in summer or winter has been done. A brief review of the literature available in Bangladesh and elsewhere related to insect pest control of okra is discussed below:

## 2.1 General review of okra shoot and fruit borer

### 2.1.1 Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Sub-phylum: Mandibulata

Class: Insecta

Order: Lepidoptera

Family: Noctuidae

Genus: *Earias*

Species: *Earias vittella*

*Earias insulana*

### 2.1.2 Distribution of okra shoot and fruit borer

Butani and Jotwani (1984) reported that okra shoot and fruit borer, *Earias vittella* (Fabricius) is widely distributed and is recorded from Pakistan, India, Sri Lanka, Bangladesh, Burma(Myanmar), Indonesia, New Guinea and Fiji. This pest is common oriental species found from India and China to North Australia (Hill, 1983). Atwal (1976) reported that *Earias vittella* is widely distributed from in North Africa, Pakistan, India, and other countries and is a serious pest of okra and cotton.

### 2.1.3 Biology of Okra shoot and fruit borer

Okra shoot and fruit borer is a holometabolous insect. So, it has four stages to complete its life cycle viz. egg, larva, pupa and adult.

**Egg**

The eggs are about 0.5 mm in diameter, spherical and bluish green in color. The egg shell (chorion) has parallel longitudinal ribs forming a crown-like structure at the top. Eggs are laid singly or in small groups on young shoots, underside of the leaves, flower buds or young pods. Depending on the species, 82-378 eggs are laid in each 4-7 days and they hatch in 3-4 days in warm weather and 8-9 days under cold weather (Rahman and Ali, 1983).

**Larva**

Newly hatched larva is 1-5 mm long; brownish-white has a dark head and prothoracic shield. The larvae undergo 4-5 molts. Larval duration varies from 9-20 days in warm weather and 50-60 days in winter (Rahman and Ali, 1983). Their main characteristics is that their body surface is irregularly spotted and spiny. Hence they are called as spiny bollworm or spotted bollworm. The fully developed (last instar) larvae are about 20 mm long, more or less spindle-shaped, greenish, dark grayish or brownish in color. The dorsal side or the back has a broad, whitish, longitudinal stripe with distinct dark spots. Two orange spots are found on the thoracic segments. Head and spiracles are black.

**Pupa**

Pupa is shiny yellowish brown, about 12-14 mm long and found in a firm, yellowish-white to light grayish cocoon, shaped like an inverted boat. The pod borer pupates on top of the soil layer or on the plant, often on dried shoots and pods. Dark brown Pupa is enclosed in a dirty white to buff color cocoon. The pupal period lasts from a few days to more than months depending upon the climate. The average pupal period being 1-3 weeks (Rahman and Ali, 1983).

**Adult**

The moth is yellowish-brown, about 12 mm long with a wingspan of about 20-25 mm. Color of fore wings is variable, depending on the season of the year (temperature), i.e. yellowish white with a pink shade or brownish-yellow and with a green (sometimes brown), more or less wedge-shaped longitudinal stripe. The dorsal side of the thorax has two green stripes. Hind wings are whitish. It has 11 generations in a year. The longest life cycle (49 days) was observed during January while the shortest life cycle (29 days) was found during July (Sharma *et al*., 1985).

### 2.1.4 Host range of okra shoot and fruit borer

Gautam and Goswami (2004) stated that okra shoot and fruit borer (*Earias vittella)* feeds on many species of malvaceous plants. Satpute *et al*. (2002) studied on different hosts of *Earias vittella* and found that okra was most preferred host for the development of the pest, followed by cotton, artificial diet and mesta (*Hibiscus sp.*) based on average minimum pupal period, highest fecundity and maximum pupal and adult weight.

Dongre and Rahaller (1992) were examined the relative food plant preference and induction of preference for feeding behavior in larvae of *Earias vittella* under dual choice conditions. Out of 5 food plants, *Abelmoschus esculentus* (okra) was the most and *Hibiscus rosa-sinensis* was the least preferred.

Butani and Jotwani (1984) found okra shoot and fruit borer as an oligophagous pest although okra and cotton are its main hosts. They also found it to feed on a large number of malvaceous plants, both wild as well as cultivated.

Khan and Verma (1946), Pearson (1958), Butani and Verma (1976), Atwal (1999), David (2001) reported that this pest has been infested to okra, cotton, hollyhock, safflower, Indian mallow, *Corchorus* sp.*, Hibiscus* sp.*, Malvas* sp.*, Malvastrum* sp.*, Sida* sp.*, Theobrome* sp. and *Urena* sp.

Atwal (1976) mentioned that okra and cotton is the most favorite host of OSFB. Plant species including sonchal (*Malva parviflora*), gulkhaira (*Althaea officinalis*), holly hock (*Althaea rosea*) and some other Malvaceous plants are appear to be its alternate hosts.

Rahman and Ali (1983) reported that when okra shoot and fruit borer were offered the choice of different parts of host plant they preferred okra fruit and shoot the best followed by cotton balls, ball. Flowers and buds of deshi cotton (*Gossypium arboretum*), buds and flower of kenaf and maize grains, flower of *Abutilon indicum,* flowers of *Hibiscus rosasinensis,* sarson (*Brassica campestris* var *sarson*), *Malvastrum tricuspidatum, Cassia fistula* and ears of pearl millet, pod of jute and soyabean.

### 2.1.5 Nature of damage

Okra shoot and fruit borer, *Earias vittella* (Fab.) is one of the key insect pest of okra. This pest causes 36-90 % loss in the fruit yield of okra (Misra *et al*., 2002).

Shah *et al.* (2001) observed that the caterpillars of *E. vittella* bore into the tender shoots and developing floral buds causing drop of fruiting bodies and developing fruits making them unfit for human consumption.

When the crop is only a few weeks old, the freshly hatched larvae bore into the tender shoots and tunnel downwards resulting withering of shoots and ultimately killing the growing points. As a result the apical dominance is lost and side shoots may arise and giving the plant a bushy appearance. With the formation of buds, flowers and fruits the caterpillars bore those and feed on the inner tissues. They move from bud to bud and fruit to fruit. The damaged buds and flowers wither and fall down without bearing any fruit. The affected fruits become deform in shape and remain stunted in growth (Butani and Jotwani, 1984; Acharya, 2010).

The larvae of okra shoot and fruit borer bore into the tender shoots, flower buds and fruits. As a result, the attacked shoot dries up while the flower buds and developing fruits dropped prematurely. Affected fruits remain on the plants become unfit for human consumption (Mohan *et al.*, 1983 and Atwal, 1976). The larvae of OSFB bore into the shoots and feed inside and also damage the seed (Karim, 1992).

The first symptom of attack by okra shoot and fruit borer was visible when the crop was three weeks old and the larvae bored into the shoots. Under severe attack, the top leaves wilted and the whole apex of the plant dropped down. In the reproductive stage of the crop, the larvae moved to the flower buds, small fruits and even mature pods and causing reduction of yield (Singh and Bichoo, 1989). Like other insects, the population of spotted bollworm is governed by their inherent capacity to increase, under the influence of various environmental factors.

The damage to the crop is done by two ways. First, the terminal portions of growing shoots are bored by the caterpillars, which move down by making tunnels inside. As a result, the shoots droop downward or dry up. Second, the larvae enter the fruits by making holes, rendering them unfit for human consumption (Misra *et al*., 2002).

### 2.1.6 Seasonal abundance of okra shoot and fruit borer

#### 2.1.6.1 Ecology

The insect was found to occur in high population during rainy season and its number drop in summer as the temperature increases.

The development period of different stages prolonged during winter, the longevity, fecundity and coloration of the adult also fluctuate with environmental temperature and humidity (Schmutterer, 1961).

Srinivasan and Gowder (1959) reported that 40-50% okra fruit were damaged due to attack of this pest in Madras. In another study Krisnaiah (1980) observed the attack of fruit borer to the extent of 35% in the harvestable fruit of okra.

Rana (1983) observed the pick incidence of shoot and fruit borer of okra was observed in the last week of August with a range of 34 to 45% damage to fruits. The incidence of *Earias* spp. on okra was studied by Dhanwan and Sidhu (1984). He reported that the maximum damage occurred in fruits (67.7%) and buds (52.4%) in late October. The maximum in shoots (1.7%) and flowers (1.5%) occurred in mid-August. In spring, the maximum damage to fruits was 32.04% and increased larval population 1.4/plant was observed in late July. The population of *Earias spp* increased slowly upto mid September and rapidly thereafter. Dhamdhere *et al.* (1984) reported 25.9 to 40.9% damage to fruits in October.

Butani and Jotwani (1984) reported that there is no true hibernation but development and activity is considerably slowed down during winter. Khaliq and Yousuf (1986) also reported the increased incidence of *E. vittella* with the increasing temperature and humidity.

In general, the population of OSFB fluctuates from month to month, season to season, even year to year. Dash *et al.* (1987) reported that the occurrence and seasonal abundance of noctuid *E. vittella* was maximum in shoots from July to October.

Dutt and Saha (1990) observed the lower activity of *E. vittella* during December-January and the higher activity was observed during the increasing temperature from February and a maximum peak in May-June.

Khurana and Verma (1990) observed lower incidence (12.5%) of *E. vittella* during 1983 in a condition having mean maximum and minimum temperature of $34.3^0$ C and $20.5^0$ C, respectively with a mean RH of 73%, frequent rainfall between May and September. But they found comparatively higher incidence (20.5%) of the pest during 1987, in an environment condition with mean maximum and minimum temperatures of 36.3 C and 23.2 C, respectively having a mean RH of 64.8%.

Ali (1992) reported that the peak abundance and intensity of okra shoot and fruit borer/spotted bollworm in cotton field were in October-November and were more common during early to mid season on growing shoots, buds, pin bolls and developing bolls of cotton and during late season, particularly after January they tend to disappear.

Zala *et al.* (1999) found the activity of okra shoot and fruit borer, *Earias vittella* on shoot was started from the fifth week of July on four weeks old crop and continued till fourth week of September on twelve weeks old crop during 1996. In 1997 the infestation of *Earias vittella* on shoot was started on the first week of August on five weeks old okra crop till first week of October on thirteen weeks old crop. The maximum (26%) shoot damaged plant was observed during 1996 in second week of August on six weeks old okra crop, whereas it was 22% in the third week of August on seven weeks old okra crop during 1997.

Patel *et al.* (1999) reported the infestation of *E. vittella* on okra fruits appeared from the second week of August on six weeks old okra crop and continued till last harvest of fruit during 1996-1997. The intensity of fruit damage varied from 11.11% (second week of August) to 40.43% (fourth week of September) and 10.12% (third week of August) to 47.37% (first week of October) during 1996 and 1997, respectively. The larval activity started from fifth week of August in 1996 and 1997 and continued till the last harvest of the crop. The relevant observations were also reported by Mote (1977) and Kadam and Khaire (1995).

Pareek *et al.* (2001) reported that the incidence of okra shoot and fruit borer started in first week of September and maximum fruit infestation recorded in the third week of October. Yadvendu (2001) recorded that the peak incidence of okra shoot and fruit borer and maximum fruit infestation in first and fourth week of September, respectively.

Acharya (2002) and Dangi (2004) observed that the incidence of okra shoot and fruit borer commenced from the 4th week of August (6th week after sowing).

A field experiment was conducted by Sharma *et al.* (2010) to study the fluctuation of pest population of *Earias vittella* (Fab.) and their relation with prevailing weather condition at Horticulture Farm in Udaipur, India during Kharif 2005 and 2006. The results revealed that borer incidence commenced in the 29th standard week. The peak infestation of plants (91.6 %) was observed in 45th standard week. The maximum numbers of larvae (7.5 larvae/l0 plants) were recorded in the 42nd standard week. Correlation between pest population and important weather parameters showed that *Earias* population was negatively correlated with the mean temperature and mean relative humidity but none significantly and negatively correlated with rainfall in terms of larval population and percentage of infested plants.

### 2.2. Management of okra shoot and fruit borer

Several biologically active compounds have been isolated from different parts of neem tree. Several vilasinin derivatives, salanins, salanols, salasnolactomes, vepaol, isovepaol, epoxyazadirachdone, gedunin, 7-deacetylgedunin have been isolated from neem kernels. Azadirachtin is the most potent growth regulator and antifeedant (Butterworth and Morgan, 1968; Warthen *et al.,* 1978).

The triterpenoid azadirachtin ($C_{35}H_{44}O_{16}$) was first isolated from the seeds of the tropical neem tree by Butterworth and Morgan (1968). Its definite structural formula, which resembles somewhat that of ecdysone, was finally explained in 1985 by kraus *et al*., 1985 and by Bilton *et al.*, 1985 (Figure A).

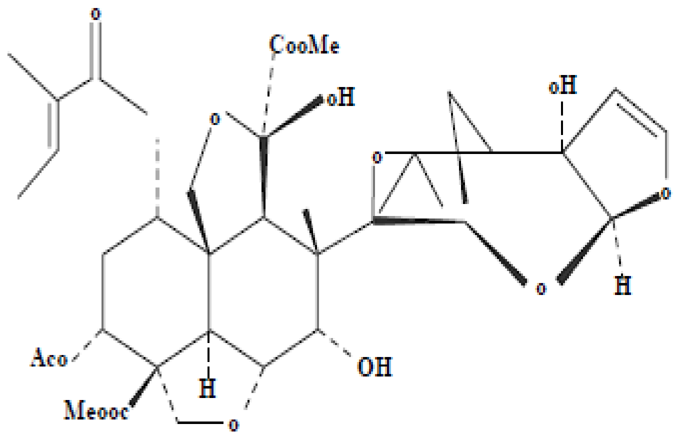


Figure A. Structural formula of azadirachtin

Azadirachtin is a limonoid alleliochemical (Butterworth and Morgan, 1968; Broughton *et al.*, 1986) present in the fruits and other tissues of the tropical neem tree (*Azadirachta indica*). The fruit is the most important aspect of neem that affects insects in various ways. The leaves, which may also be used for pest control, may reach a length of 30 cm.

A field experiment was conducted by Patil *et al.* (1991) in India for the control of okra fruit and shoot borer (*E. vittella*) with cypermethrin (15 gm/ha), fenvalerate (50gm/ha), acephat (375 gm/ha), quinaphos (250 gm/ha) and endosulfan. (250 gm/ha). All treatments reduced pod damage but cypermethrin treated plants were the least infested gave the best yield.

Nine insecticides, cypermethrin (Cyperkill 25 EC), carbaryl (Hexavin 50 WP), deltamethrin (Decis 2.8 EC), diflubenzuron (Dimilin 25 WP), endosulfan (Thiodan 35 EC), fenvalerate (Sumicidin 20 EC), fluvalinate (Mavrik 25 EC), monocrotophos (Monocil 36 SL) and quinaiphos (Ekalux 25 EC), were tested against 1 -day-old eggs of *Earias vittella*. All treatments significantly reduced egg-hatch, although diflubenzuron had occured by far the least effect (Brickle *et al.*, 2001).

Misra (1989) studied the bio-efficacy of some insecticides against the pest complex of okra. The author reported that percent shoot infestation in insecticide treated plots varied from 1.74- 10.03% compared to 15.23% in untreated control plots.

Adult pairs of males and females of *Earias vittella*, a pest of cotton and okra, were released in breeding chambers in different sets, containing the odours of the leaves of neem, *Azadirachta indica*; tulsi, *Ocimum basilicum*; eucalyptus, *Eucalyptus rosfrata*;

lantana, *Lantana camara*; bulbs of garlic, *Allium sativum* and one control set with no odour. Adult longevity did not differ significantly among the treatments. All the treatments significantly reduced the egg output as compared to the control (172 eggs). Similarly, all the odours significantfy reduced egg hatching compared to the control (90.81%). The lowest number of eggs (128) and hatching (68.15%) were recorded with *Azadirachta* leaves odour (George, 1997).

Ambekar *et al.* (2000) evaluated the efficacy of neem-based formulations and synthetic insecticides against okra shoot and fruit borer. They found that all treatments significantly reduced fruit borer infestation over the untreated control. However, cypermethrin at 0.1% was the most effective and recorded the lowest infestation of 6.57%.

Chinniah and Mohanasundaram (1999) studied the possible toxic effect or the safety of the neem derivatives to the predatory mites *Amblysieus* spp. The neem products *viz.,* neem cake extract (10%), neem seed kernel extract (5%) and neem oil (3%) proved safe by recording lower predator mortality.

### 2.2.1 Mode of action of neem

#### 2.2.1.1 Settling Behavior

Crude neem extracts deters settling and reduces feeding in *M. persicae* (Griffiths *et al*. 1978 and 1989).

#### 2.2.1.2 Oviposition Behavior

The females of some lepidopterous insects are repelled by neem products on treated plant parts or other substrates and will not lay eggs on them under laboratory conditions.

#### 2.2.1.3 Feeding Behavior

Azadirachtin is a potent insect antifeedant. Antifeedancy is the result of effects on deterrent and other chemoreceptors. The antifeedant effects of azadirachtin have been reported for many species of insects. Reduction of feeding was also observed after topical application or injection of neem derivatives, including AZA and alcoholic neem seed kernel extract.

This means that the reduction of food intake by insects is not only gustatory which means that sensory organs of the mouth parts but also non-gustatory regulate it. These two phagodeterrent/antifeedant effects were called primary and secondary (Schmutterer, 1985).

#### 2.2.1.4 Metamorphosis

Azadirachtin has different influence on the metamorphosis of the insects resulting in various morphogenetic defects as well as mortality, depending on the concentration applied.The IGR effect of neem derivatives such as methanolic neem leaf extract and azadirachtin in larvae and nymphs of insects was first observed in 1972 in Heteroptera (Leuschner, 1972) and Lepidoptera.

Molting, if it occurred, was incomplete and resulted in the death of the tested insects.Botanicals possess an array of properties including insecticidal activity and insect growth regulatory activity against many insect pests and mites (Rajasekaran and Kumaraswami, 1985; Prakash *et al*., 1987; 1989 and 1990). Low mammalian toxicity, no reported development of resistance to their production so far, less hazardous to non-target organisms, no pest resurgence problem, no adverse effect on plant growth, negligible application risks, low cost and easy availability are the advantages of plant products over synthetic chemicals.

Ahmed (1984) enlisted 2121 plant species, possessing pest control property which include neem, sweetflag, cashew, custard apple, sugar apple, derris, lantana, tayanin, indian privet, agave, crow plant etc. 1005 species of plants having biological properties against insect pests including 384 species as antifeedants, 297 as repellents, 97 as attractants and 31 as growth inhibitors.

About 413 different species/sub-species of insect pest have been listed by (Schmutterer, 1995) found to be susceptible to neem products. The listed species/sub-species belongs to different insect orders most of them were Lepidoptera (136) and Coleopteran (79).

### 2.2.2 Management by botanicals

The use of neem based insecticides as a source of biologically active substances for pest control is increasing worldwide, and have recently gained popularity as components of integrated pest management (Banken and Stark, 1997).

Maximum reduction in bollworm infestation (65.7%) was observed in garlic treated plot. Garlic extract and NSKE both at 10 per cent were found to be superior. Lowest bollworm incidence was observed with NSKE (10.3%), datura and neem oil emulsion (Anon., 1987).

Sardhana and Krishna Kumar (1989) studied the efficacy of neem oil, karanj oil (both at 0.5, 1.0 and 2.0%) and garlic oil (0.25, 0.5 and 1.0%) in comparison with monocrotophos (0.05%). Among the oils, neem oil and karanj oil offered effective control against okra fruit borers. It was concluded that weekly application of neem oil at two per cent concentration was effective in controlling fruit borer in okra and was safe to natural enemies.

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

The most probable effect of neem in Lepidopterans is the disruption of the larval-pupal molt (i.e. pupation), which has been frequently reported (Schmutterer *et al.*, 1983; Koul and Isman, 1991).

Repellent activity of neem against oviposition by Lepidopterous pests has also been reported for *Spodoptera litura* (Joshi and Sitaramaiah, 1979), *Cnaphalocrocis medinalis* (Saxena *et al*., 1981) and *E. vittella* (Sojitra and Patel, 1992). Extracts of neem and bakain caused maximum adverse effects on fecundity and hatching.

Numerous plant species have been reported to possess pest control properties but only a few seem to be ideally suited to practical utilization. Among these, neem (*Azadirachta indica* A. Juss) and bakain (*Melia azedarach* L) are the most promising plants from the entomological perspective (Schmutterer, 1990 and 1995).

Neem-based formulations have already been recommended in the management of bollworms including *E. vittella* in cotton (Gupta and Sharma, 1997 and CCSHAU, 1997).

Neem oil produced non-toxic effects after spray and acted as antifeedant, growth inhibitor and oviposition deterrent against insect's pests of okra and cotton (Ahmed *et al.*, 1995).

Patil (2000) conducted an experiment with 20 indigenous plant extracts to evaluate the antifeedant property against insect pest. *A. indica* exhibited maximum of 10-51 percent antifeedant followed by *A. calamus* (15.69%) and *A. squamosa* (17.31%) against third instar larvae of *Earias vittella.*

Morale *et al.* (2000) studied the effect of plant product against *E. vittella* of cotton under laboratory condition and revealed that neem oil 1%, karanj oil 1%, cotton seed oil 1%, neem seed extract (NSE aqueous) 5% and NSE (methanolic) 1% were significantly affected the larval period, larval mortality and fecundity of *E. vittella.*

Lakshmanan (2001) reported effectiveness of neem extract alone or in combination with other plant extracts in managing lepidopteran pest's viz., *E. vittella*, *Chilo partellus* Swinhoe, *H. armigera* and *S. litura*.

Antifeedant effect of neem in combination with sweetflag and pongam extracts on okra shoot and fruit borer was studied by the Rao *et al.* (2002) which gave 43.12 to 80.00 percent mortality protection over control.

Mudathir and Basedow (2004) found that different preparations of neem significantly reduced okra shoot and fruit borer infestation in okra.Singh *et al.* (2005) tested the efficacy of two botanicals and insecticides and reported that NSKE @ 1.5% was found superior after fenvalerate with respect to yield. NSKE (1.5%), NSKE (1%), karanj seed kernel extract (KSKE) (1.5%) and NSKE (1%) were superior by recording 58.27, 47.32, 44.25 and 41.5 q/ha yield, respectively as against 29.17 q/ha in untreated control.

### 2.2.3 Management by chemicals

Borer is the major pest of okra, committing colossal losses to okra growers. Although varies measures have been reported for controlling the pests, there is not a single such method that successfully be adopted to suppress the incidence and damage of the pests. This perhaps, is mainly due to the oligophagous nature of this pest that helps their year round population build up. However, a thorough search of review reveals that the approaches that had ever been made in controlling this pest comprise mainly the use of chemicals. Though various management approaches are practiced for this pest suggested by different workers, insecticides are found very effective which are cited below.

Brickle *et al.* (2001) tested nine insecticides, cypermethrin (Cyperkill 25 EC) carbaryl (Hexavin 50 WP), deltamethrin (decis 2.8 EC), diflubenzuron (Dimilin) 25 WP), endosulfan (Thiodan 35 EC), fenvalerate (Sumicidin 20 EC), fluvalinate (Mavrik 25 EC), monocrotophos (Monocil 36 SL) and quinaiphos (Ekalux25 EC) against 1 –day-old eggs of *Earias vittella*. All treatments significantly reduced egg-hatch, although diflubenzuron had occurred by far the least effect.

Efficacy of different pesticides and their combination against jassid and borer of okra was studied by Satpathy and Rai (1999). The result indicates that among the treatments in vegetative phase, Monocrotophps + cypermethrin combination reduced the shoot borer damage, significantly to 2.06% and 4.08% during 1996 and 1997 respectively. In the reproductive stage, protection with monocrotophos, cypermethrin, combination of these two insecticides in half doses and combination of neem (2.5 ml/litre) and endosulfan (350 g a.i./ha) were equally effective against fruit borer.

Badaya *et al*. (1999) studied the efficacy and economics of different insecticides for the control okra fruit and shoot borer, *Earias vittella* Fab. They found that among several insecticides against *Earias vittella* on okra Madhya Pradesh, India, fenvalerate at 0.02% was the most effective and profitable treatment, while dimethoate at 0.05% was relatively ineffective.

A field experiment was conducted by Patil *et al*. (1991) in India for the control of okra fruit and shoot borer (*E. vittella*) with cypermethrin (15 gm/ha), fenvalerate (50 gm/ha), acephat (375 gm/ha), quinalphos (250gm/ha) and endosulfan (250 gm/ha). All treatments reduced pod damage but cypermethrin treated plants were the least infested gave the best yield.

Chaudhury and Dadheech (1989) reported that if the insecticidal protection was not given the okra shoot and fruit borer infested fruits were as much as 57.1% with a yield of 9.83 kg/plot. But the plots protected with alternate weekly sprays of 0.03% phosphamidon and 0.05% endosulphan provided yield of 15.65 kg/plot with 10% fruit infestation.

Misra (1989) studied the bio-efficacy of some insecticides against the pest complex of okra. The athor reported that percent shoot infestation in insecticide treated plots varied from 1.74-10.03% compared to 15.23% in untreated control plots.

Sarkar and Nath (1989) conducted a field trial in Tripura, India, and indicated that decamethrin, malathion, endosulfan and carbaryl were effective to control okra shoot and fruit borer but fenvalerate (0.5 ml/L and 750 ml/ha) gave the greatest reduction in number of infected fruits.

Haque (1993) conducted an experiment on the management of oka fruit and shoot borer and found that a foliar spray of Ripcord 10 EC @ 1.5ml/l of water showed significantly the lowest level shoot and fruit infestation (7.68%, 1.13% respectively).

### 2.3 General review of whitefly

**Nomenclature**

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Sub order: Sternorrhyncha

Superfamily: Aleyrodoidea

Family: Aleyrodidae

Genus: *Bemisia*

Species: *Bemisia tabaci*

## 2.4 Origin and Distribution of whitefly

Okra whitefly *(Bemisia tabaci* Genn.) is the most important insect pest of okra in Bangladesh and acts as the vector of Okra yellow vein clearing mosaic virus (OkYVCMV) on okra. *Bemisia tabaci* was first described in 1889 as a pest of tobacco in Greece and named as *Aleyrodes tabaci*, the tobacco whitefly (Gennadius, 1889). From 1926 to 1981, *B. tabaci* was reported as sporadic pest and was the most important vector of plant viruses in subtropical, tropical and temperate zones where winters are mild enough to permit year round survival (Cock, 1986). However, whitefly related problems have historically occurred after the introduction of intensive cropping regimes that require relatively high inputs of fertilizers and pesticides (Brown *et al.*, 1995).

Worldwide distribution whitefly, *B. tabaci* was updated by CAB International Institute of Entomology, London (Showed the Below Table)

**Table. Global distribution of whitefly as updated by CAB International Institute of Entomology, London (Cock, 1986)**

| **Continent/Subcontinent** | **Countries** |
|---|---|
| Europe | Cyprus, Denmark, Finland, Greece, Switzerland, Turkey, UK etc. |
| USSR(Former) | Azerbaijan SSR, Georgian SSR |
| Africa | Angola, Cape Verde Island, Egypt, Ethiopia, Ivory coast, Sierra Leone, Somalia, South Africa etc. |
| Asia | Afghanistan, Myanmar, China, India, Indonesia etc. |
| Pacific Islands and Australia | Australia and Hawaii etc. |
| North West Atlantic | Bermuda |
| America, Northern USA | California, Florida, Texas etc. |
| Canada | British Columbia, Quebec etc. |
| Central America and Caribbean | Barbados, Costa Rica, Puerto Rico etc. |
| South America | Argentina, Brazil, Venezuela, Colombia etc. |

There are more than 1000 whitefly species in the world. Twenty species occur in Hawaii; 12 of which have been accidentally introduced in the last 20 years. The sweet potato whitefly (*Bemisia tabaci*) is one of the most pestiferous of the group. This pest was first described as *Aleyrodes tabaci* from tobacco in Greece in 1889. In Hawaii, it was first found at Pearl City, Oahu in October 1982.

When discovered it had already been in Hawaii for a considerable time. Field surveys conducted at the time turned up infestations in leeward Oahu (Pearl City), central Oahu (Kalihi), and windward Oahu (Kailua). As of October 1990, it occurs on the islands of Hawaii, Kauai, Maui, Molokai, and Oahu.

In addition to Hawaii, the sweet potato whitefly has been reported as a serious pest of cultivated crops in tropical and subtropical areas including Africa, Asia, Central America, South America, and the West Indies where it is also known as the tobacco whitefly and cotton whitefly. In North America, it has been reported from Arizona, California, District of Columbia, Florida, Georgia, Maryland, Texas and Mexico (Cock, 1986).

**2.5 Host range of whitefly**

The sweet potato whitefly has an extremely wide host range. It attacks more than 500 species of plants (Greathead, 1986) from 63 plant families (Mound and Halsey, 1978). In Hawaii, the sweet potato whitefly has been found on the following crop plants: annona (cherimoya, atemoya, sugarapple), avocado, broccoli, cauliflower, Chinese cabbage, Chinese wax gourd, cucumber, *Dendrobium* (flowers), edible gourds, eggplant, fig, green bean, guava, hibiscus, hyotan, lettuce, luffa, plumeria, poinsettia, pumpkin, rose, soy bean, squash, sweet potato, togan, tomato, ung-choi, watermelon, yard long beans and zucchini. Although not yet reported in the state, other crop hosts include cabbage, chrysanthemum, beans, bitter melon, dishrag squash, pepper, pea, and radish (Mau and Tsuda, 1991).

Weeds often serve as alternate hosts of crop pests. Some of the non-crop hosts that may serve as hosts are: *Asystasia*, *Coccinia* sp., castorbean, *Euphorbia*, ilima, *Ipomoea* spp., kikania-lai, *Malva* sp., *Momordica* sp., mountain apple, sowthistle, spurge, and *Xanthium* sp. There is no evidence to suggest that sweet potato whitefly can reproduce on these hosts' weeds.

**2.6. Biology of whitefly**

Whiteflies have six life stages - the egg, four nymphal stages, and the adult. The development time of this insect from egg to adult may range from 15-70 days dependent upon temperature and plant host. Development occurs in temperatures ranging from 50 to $89.6^0$ F (10 to $32^0$ C). $80.6^0$ F ($27^0$ C) appears to be the optimal temperature for development.

Under control conditions on cotton, the pest completes its development in 17 days at $86^0$ F ($30^0$ C).On the contentinal U.S. development from egg to adult under field conditions varies with the season; development varies from 25 to 50 days. Very little seasonal difference occurs in Hawaii. Overlapping whitefly generations occur throughout the year.

**Egg**

Female whiteflies deposit pear-shaped eggs into the mesophyll or inner tissue of the leaf from the lower surface. Eggs are attached to the leaf by a stalk-like process. Eggs are white when first laid, and become brown prior to hatching. They are generally laid on the underside surface of the younger, upper leaves of the plant. Females lay from 28-300 eggs depending on host and temperature. On cotton, a female lays 81 eggs, on average, at $80.06^0$ F ($26.7^0$ C) and 72 eggs at $89.96^0$ F ($32.2^0$ C) (Butler *et al*., 1983). Egg densities can be as high as 1,200 eggs per square inch.

Under laboratory conditions on cotton leaves, eggs hatched in 5 days at $90.5^0$ F (32.5 $^0$C) and 22.5 days at $62.1^0$ F ($16.7^0$ C) (Butler *et al*., 1983). Eggs did not hatch in temperatures above $96.8^0$ F ($36^0$ C) in the same study. Similar incubations have been reported on sweet potato and potato (El-Helay *et .al*., 1971; Azab *et. al*., 1971) and eggplant (Avidov, 1956; Butler *et. al*., 1983).

Low temperatures increase mortality. However, humidity is not a factor in egg mortality and egg incubation periods.

**Nymph**

The first nymphal stage is called crawlers and the last stage is often referred to as the pupa. After hatching the crawlers move a short distance and settle to feed. Once settled, the subsequent three nymphal stages are scale-like and sedentary. Nymphs are creamy white to light green and oval in outline. The total nymphal period lasts about 2-4 weeks.

**Adult**

Adult sweet potato whiteflies are small, approximately 1/25 inch in length, with a pale yellow body and two pairs of white wings and covered with a white waxy powder. At rest, wings are held in an inverted V position. Their compound eyes are red.

Adults usually emerge from their pupal cases in the morning hours and may copulate a few hours later. Oviposition occurs from 1 to 8 days after mating.

Adult life span ranges from 6-55 days dependent on temperature. Females live only 10-15 days under southern continental U.S. summer conditions, but can live several months during the winter.

In this species, reproduction can occur with or without copulation. Unmated females can reproduce by parthenogenesis in which the females produce only male progeny. Females lay 80 to more than 300 eggs in their lifetime. The plant host reportedly plays an important role in female fecundity. This species is similar in appearance with other whitefly species.

**2.7 Nature of damage**

*B. tabaci* continues to be an economically important pest of greenhouse and field crops throughout equatorial areas of the world (De Barro, 1995). The insect breeds throughout the year and the female lays stalked yellow spindle shaped eggs singly on the lower surface of the leaf. Nymphs and adults suck the sap usually from the under surface of the leaves and excrete honeydew. Leaves appear sickly and get coated with sooty mold. The whitefly serves as the vector for the spread of yellow vein mosaic virus (YVMV) disease causing damage to okra crop. Berlinger ( 1986) reported that whitefly, *B. tabaci* damaging the plants in three means that were discussed below :

**2.8 Direct damage**

Direct feeding damage is caused by the piercing and sucking sap from the foliage of plants. This feeding causes weakening and early wilting of the plant and reduces the plant growth rate and yield (Berlinger, 1986). It may also cause leaf chlorosis, leaf withering, premature dropping of leaves and plant death. Infestations of sweet potato whitefly nymphs are associated with the occurrence of irregular ripening of tomatoes and silver leaf of squash.

Observations of the damage caused by sweet potato whitefly in Hawaii are discussed by (Johnson *et. al.*, 1992) and reiterated here. On head lettuce, stunting, yellowing and death of plants may occur with rapid increases sweet potato whitefly populations. Surviving heads are often unmarketable and extensive damage in the field may prevent any harvest. Some oriental leafy vegetable crops experience stunting, yellowing, mottling and stem blanching during with large populations of this whitefly. Pumpkin and zucchini exhibit squash silver leaf disorder. Irregular ripening occurs on tomato.

## 2.9 Indirect damage

Indirect damage results by the accumulation of honeydew produced by the whiteflies. This honeydew serves as a substrate for the growth of black sooty mold on leaves and fruit. The mold reduces photosynthesis and lessens the market value of the plant or yields it unmarketable (Berlinger, 1986).

Mandahar and Singh (1972) studied the effect of *Okra Yellow Vein Mosaic Virus* on host. They reported that infection of *Hibiscus esculentus* induced 62-82% reduction in total chlorophyll and 56.61% reduction in total photosynthesis, while the respiration of infected tissue was increased 8.33%. It was concluded that carbohydrates were transported from healthy to diseased leaves in which they accumulate and this may account in part for infected plants not to bear any fruit.

Ramiah *et al.* (1972) observed that infection by the *Okra Yellow Vein Mosaic Virus* reduced chlorophyll a and b contents of leaves of okra and increased chlorophylls enzyme activity. Carotene and xanthophylls contents also reduced.

## 2.10 Transmission of virus

The third type of damage is caused by the vectoring of plant viruses by this insect. A small population of whiteflies is sufficient to cause considerable damage (Cohen and Berlinger, 1986). Plant viruses transmitted by whiteflies cause over 40 diseases of vegetable and fiber crops worldwide. Among the 1,100 recognized species of whiteflies in the world, only three are recognized as vectors of plant viruses. The sweet potato whitefly is considered the most common and important whitefly vector of plant viruses worldwide. It is also the only known whitefly vector of viruses categorized in the geminivirus group.

In the past decade, whitefly-transmitted plant viruses have increased in prevalence and distribution. The recent impact has been devastating with yield losses ranging from 20 to 100 percent, depending upon the crop, season, and prevalence of the whitefly. Some diseases associated with sweet potato whitefly include: Lettuce necrotic yellows, irregular ripening of tomato and silver leaf of squash, cotton leaf curl, tobacco leaf curl, and cassava mosaic. None of the whitefly vectored viruses are known to occur in Hawaii.

According to Basu (1995) batches of five or more whiteflies invariably gave significantly higher percentage of transmission than did single whiteflies. Generally the females retained infectivity for much longer periods and proved to be more efficient than the males, the exception of this generalization is also evident. However, the natural spread of a vector borne virus requires 3 basic components, namely, the virus itself, the host and the vector. Among them, the host plant is the common victim of both the vector and the virus, whereas the virus is the common beneficiary exploiting the host plant as well as the vector (Basu, 1995).

### 2.11 Management of whitefly by botanicals

High reproductive rate and multiple host sequences provide optimal conditions for whitefly population development. The varied habitats, seasonal population development and intra and inter-crop and wild host movement present an extremely complex and difficult challenge requiring new and innovative approached for formulating control and suppression methodology.

There is really no easy way of controlling the whitefly. Egg mortality is usually minimal. Weather and predation may cause high mortality rates during the crawler and first nymphal stages, but has only moderate effects on the later nymphal stages. In the past adults were easily killed with insecticides but pesticide resistance in whitefly populations is a common problem faced by many growers today .Whitefly has become resistant to chemical insecticides quite rapidly in other parts of the world, and the wisdom of relying only on chemical insecticides is questioned. Moreover, regular insecticide applications can result in resurgence of other pests.

Rosaiah (2001) reported that neem oil 0.5% was significantly superior in reducing the whitefly population and shoot and fruit borer damage on okra followed by NSKE (5%).

Jayaraj *et al.* (1986) reported that NSKE (5%) and neem oil (5%) caused 93.7 and 90.3 per cent mortality of nymphal stage of *B. tabaci* at seven days after spraying, respectively. Similarly as reported by Natarajan *et al.* (1986), *B. tabaci* population was suppressed effectively by neem oil (0.5%) when the pest population was 5 to 10 per leaf.

According to Nandihalli *et al.* (1990) two neem products, Neemax and Neem guard (3 ml/l) when combined with sub-lethal dose of monocrotophos (0.086%) gave effective control of nymphal and adult population of *B. tabaci* on cotton followed by application of NSKE (5%) and neem seed oil (5%). The efficacy was on par with insecticides like monocrotophos (0.1%) and phosphamidon (0.1%).

The effectiveness of a neem based product, Neemax as ovipositional deterrent was tested in the lab against *B. tabaci* on cotton in Gujarat. Only 30.39 eggs/plant were deposited on plants treated with (0.5%) Neemax as against 62.61 eggs/plant in case of control plants (Patel *et al.*, 1994). Similarly, in a field trial, Ahmad *et al.* (1995) observed the ovipositional deterrence of neem oil against *B. tabaci* on cotton.

Srinivasamurthy and Sharma (1997) reported some of the traditional pest management practices followed by farmers to manage whiteflies infesting cotton. Neem oil (2%), castor seed oil (5%), *Madhuca latifolia* (J. F. Gmel.) oil (0.5%), tobacco leaf extract (0.5%), fish oil rosin soap (0.2%) and nicotine sulphate (0.2%) helped to reduce the pesticide dumping in cotton ecosystem. As reported by Singh *et al.* (1999), spraying neem seed extract (5%) and neem oil (5%) resulted in considerable reduction of whitefly population on cotton.

**2.12 Management of whitefly by chemicals**

From the early period of control against Whitefly with resin soda (Thomas, 1932) and fish-oil resin soap sprays (Husain *et al*., 1939; Pruthi, 1946) the chemical control has come a long way. The advent of DDT after the Second World War ushered in a revolution in sphere of insect control.

Miah (1988) evaluated the effects of insecticides and data of planting on *Yellow Vein Mosaic Virus* of Lady's Finger. They planted okra variety pentagree (Japanese variety) in three different dates viz. 17 April, 2 May and 17 May in 1986 and applied tree insecticides namely Bidrin, Ripcord and Sumithlon in their in their experiment in Bangladesh Agricultural University Farm, Mymensingh.

Among the insecticides, Bidrin was found to be the most effective followed by ripcord in controlling the yellow vein mosaic of Lady's finger disease incidence. Sumithion used in their experiment was found ineffective. The authors recorded and pronounced effect of planting dates on the disease incidence as well as grown and yield of the crop. The lowest disease incidence was obtained in the first planting while it was the highest in the third planting.

Imidachloprid (a systemic chloronicotinyl insecticide) gained major importance for control of B. tabaci in both field and protected crops, in view of extensive resistance to Organophposphorus, Pyrethorid and Cyclodiene insecticides (Cahil *et al*. 1995).

Haider (1996) found that grafted Tomato plants sprayed with Ripcord was the very effective in managing the virus disseminating whitefly.

Azam *et al*. (1997) conducted an experiment during 1993-95 with some insecticides (Carbofuran, Endosulfan, Dimethoate, Buprofezin and Triazophos) for the control of *B. tabaci* and yellow leaf curl bigeminivirus (TYLCV) and found that Endosulfan had the most affect to control *Bemisia tabaci*.

Berlinger *et al*. (2002) found that Tomoto Yellow Leaf Curl Virus (TYLCV) is the most frequently occurring virus in the Middle East, and the most harmful. It is transmitted solely by the whitefly, *Bemisia tabaci*. Within 4-6 h of inoculative feeding. A whitefly can transmit TYCLV to a healthy plant with 80% probability. The symptoms are apparent after two or three weeks where upon fruit set is effectively terminated.

A study was conducted by Abdullah and Singh (2004) as a part of research work on insecticide hormoligosis in *B. tabaci* to investigate the changes in biological parameter of this pest in response to repeated application of insecticides. Five commonly used insecticides on cotton in Punjab (India), i.e. Quinalphos (250, 375 and 500 g), Carbaryl (625,938 and 1250 g), Acephate (750, 1125 and 1500 g), Endosulfan (438, 656 and 875 g) and Fenvalerte (25, 38 and 50 g a.i./ha), were repeatedly sprayed on potted plants of cotton. The maximum reduction was recorded in all doses of Endosulfan , followed by higher doses of other insecticides . In general, low doses of insecticides caused lower reduction in longevity compared with high doses. The results indicated that no hormoligosis was induced in longevity of the Whitefly by the tested insecticides.

The toxicity of Thiamethoxam and Imidaclorid and their efficacy against Whitefly were studied by Torres (2004). Thiamethoxam and Imidaclorid showed significant control of Whitefly in comparison with untreated plants up to 40 days after treatment in potted plants. Whitefly population had low density over time in the field with no differences between treatments and only at day 64 higher whitefly population was observed on untreated plants and plants treated with 0.5 mg (a.i.) of Thiamethoxam showed infestation of 68.7 and 31.2 %, respectively, at this time. Thiamethoxam and Imidaclorid used in cotton for whitefly control can be more successful when they are used at doses bellow 1 mg (a.i.) per plant due to shorter residual effect.

# CHAPTER III

# MATERIALS AND METHODS

## 3.1 Location of the experimental plot

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to august 2012. The site is $23^0$ $46^’$ N and $90^0$ $24^’$ E Latitude and at Altitude of 9m from the sea level.

## 3.2 Characteristics of soil

The soil of the experimental site is a medium high land belonging to the Modhupur Tract under the Agro Ecological Zone (AEZ) 28.The experimental site was a medium high land (Appendix I ).

## 3.3 Climate

The climate of the experimental site is sub-tropical characterized by heavy rainfall during April to July and sporadic during the rest of the year. The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to September, 2011) and scantly in the Rabi season (October to March, 2011). The average maximum temperature during the period of experiment was 33.8°C and the average minimum temperature was 23.1°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity the period of the experiment were collected from Bangladesh Meteorological Department, Agargaon, Dhaka- 1207, Dhaka and have been presented in (Appendix II).

## 3.4 Design and layout of the experiment

The study was conducted with nine treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD). The field will be divided into 3 equal sub-plots maintaining 3mx2m plot size, 1 meter block to block distance. 0.75 meter plot to plot distance, where each block will be used for each replication and each treatment will be randomly assigned in each plot.

Plant to plant distance was 50cm and row to row distance was 60cm. Each treatment was allocated randomly within the block and replicated three times.

**Plate 1. Growing okra plants in the experimental field**

### 3.5 Land preparation

The selected land for the experiment was first opened on 27 March 2011 by power tiller and expose to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and laddering to obtain good tilth followed each ploughing. The stubbles of the crops and uprooted weeds were removed from the field and the land was properly leveled. The field layout was done on accordance to the design, immediately after land preparation.

### 3.6 Manure and fertilizer application

Manures and fertilizers with their doses and their methods of application followed in this study were recommended by Haque (1993) and are shown in below:

**Table 1. Doses of manures and fertilizer and their methods of application used for this experiment (Haque, 1993)**

| Manure/Fertilizer | Dose per ha (kg) | Basal dose (kg/ha) | Top dressing(kg/ha) | |
|---|---|---|---|---|
| | | | First* | Second** |
| Cow dung | 5000 | Entire amount | - | - |
| Urea | 150 | - | 75 | 75 |
| TSP | 120 | Entire amount | - | - |
| MP | 110 | Entire amount | - | - |

*25 days after sowing, **45 days after sowing

Entire amount of cow dung, TSP and MP were applied during final land preparation. The entire amounts of urea were applied as top dressing in two equal splits at 25 and 45 days after seed sowing.

### 3.7 Collection and sowing of seeds

Seeds of Arka Anamika were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur, Dhaka. Seeds were sown in the experimental plots on 15 April, 2012 at the rate of 72 seeds/plot (three seeds per pit and 24 pits per plot).

The row to row and plant to plant spacing was maintained at 60 cm x 50 cm respectively.

The field was irrigated lightly immediately after sowing.

### 3.8 Intercultural operations

The seedlings were always kept under close observation. Necessary intercultural operations were done throughout the cropping season to obtain proper growth and development of the plants.

### 3.9 Cultural practices

#### 3.9.1 Gap filling

Dead, injured and weak seedlings were replaced by new vigour seedling from the stock on the border line of the experiment.

#### 3.9.2 Thinning

When the seedlings got established, one healthy seedling in each location was kept and other seedlings were removed.

### 3.9.3 Irrigation

Light overhead irrigation was provided with a watering can to the plots once immediately after sowing of seed and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings. When the soil moisture level was very low. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

### 3.9.4 Drainage

Stagnant water effectively drained out at the time of heavy rains.

### 3.10 Harvesting

As the seeds were sown in the field at times, the crops were harvested at different times. Green pods were harvested at four days interval when they attained edible stage. Green pod harvesting was started from 21 May and was continued up to 7 August, 2012.

### 3.11 Treatments

The comparative effectiveness of the following nine treatments for okra shoot & fruit borer and whitefly were evaluated on the basis of reduction of this pest.

$T_1$ = Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval.

$T_2$ = Neem oil @ 3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval.

$T_3$ = Decis 2.5EC @ 1ml/Litre of water at 7 days interval.

$T_4$ = Shobicron 425 EC @ 2ml/Litre of water at 7 days interval.

$T_5$ = Suntap 50 WP @ 1.2g/ Litre of water at 7 days interval

$T_6$ =Ripcord 10EC @ 1.5ml/ Litre of water at 7 days interval

$T_7$ =Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval

$T_8$ =Quinalphos @ 2ml/Liter of water at 7 days interval

$T_9$ = Untreated control

### 3.12 Application of the treatments

Spraying was done at 12.00 pm to avoid moisture on leaves. The selected insecticides with their assigned doses were started to apply in their respective plots after 55 days of germination. Treatments were applied at 7 days interval. Spraying was done by knapsack sprayer having a pressure of 4.5 kg/cm$^2$. To get complete coverage of plant spraying was done uniformly on the entire plant with special care. In case of untreated control, only fresh water was sprayed for respective plots.

### 3.13 Data collection

Data on infestation by okra shoot and fruit borer under different treatments were recorded during both vegetative and reproductive stages. Infested shoots from 5 randomly selected plants were counted and recorded at two days interval by the presence of bores and excreta on flower bud, shoot and fruit at stages respectively.

### 3.14 Collection of data on yield and yield contributing character

Infestation of okra by okra shoot and fruit borer was monitored during both vegetative and reproductive stages. Infested shoots and fruits were counted and recorded at 7 days intervals after observing the bores and excreta in both vegetative and reproductive stage.

**3.15 Data recorded:** The data on the following parameters were recorded at different time intervals as given below:

- Number of white fly after applying different treatments
- Incidence of Okra Yellow Vein Clearing Mosaic Virus infected plants
- Incidence of Okra Yellow Vein Clearing Mosaic Virus infected leaves
- Incidence of shoot infestation caused by OSFB
- Incidence of fruit infestation by number due to OSFB
- Fruit infestation by weight due to OSFB
- Yield of Okra

Yield contributing characters/yield attributes

- The number of fruits per plants
- Single fruit length
- Single fruit weight
- Girth of fruit
- Height of plants

### 3.16.1 Percent of OkYVCMV infected plant in number

Number of infested plant was counted from total plants per plot and percent plant infection by OkYVCMV was calculated by using the following formula:

$$\textbf{\%}\ \text{OkYVCMV infested plant} = \frac{\text{No. of OkYVCMV infested plant}}{\text{Total no. of plants per plot}} \times 100$$

### 3.16.2 Percent of OkYVCMV infected leaf in number

Number of infested leaves was counted from total leaves per five tagged plants per plot and percent leaf infestation by OkYVCMV was calculated by using the following formula:

$$\textbf{\%}\ \text{OkYVCMV infected leaf} = \frac{\text{No. of OkYVCMV infested leaf}}{\text{Total no. of leaves}} \times 100$$

### 3.16.3 Method of recording % infestation of shoots and fruits

**Shoot infestation**

Total numbers of shoots as well as the number of infested shoots were recorded at two days interval from 5 tagged plants in each treatment. The percent infestation of shoot was calculated with the following formula:

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

**Fruit infestation**

The data on the number of healthy and infested fruits were recorded from 5 tagged plants in each treatment. The percent infestation of fruit was calculated with the following formula:

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

**Plate 2. Leaves infected by Okra Vein Clearing Mosaic Virus**

**Plate 3. Healthy Okra plants, flower and fruits**

**Plate 4. Okra fruit showing infestation symptom caused with OSFB larvae**

**Plate 5. Infested Okra fruit with hole by Okra Shoot and Fruit Borer**

**Plate 6: Infested Okra fruit with insect excreta**

### 3.16.4 Fruit infestation by weight due to OSFB

The data on the weight of healthy and infested fruits were recorded from 5 tagged plants in each treatment. The percent of fruit infestation by weight was calculated with the following formula:

$$\text{\% infestation of fruit} = \frac{\text{Weight of OSFB infested fruits}}{\text{Weight of total number of fruits}} \times 100$$

### 3.16.5 Length and girth of fruit

Length and girth of fruits from randomly selected 10 healthy and 10 OSFB infected fruits was taken and then averaged for each treatment separately. The percent increase of fruit length and girth over control were calculated with the following formula:

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

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

### 3.16.6 Height of plant

Height of plant from randomly selected 5 plants were taken and then averaged for each treatment separately. The percent increase of fruit length and girth over control was calculated using the above mentioned formula.

### 3.16.7 Weight of single fruit

Mean weight of fruits from randomly selected 5 plants were measured for each plot of the experiment for each treatment separately. The percent increase of single fruit over control was calculated using the above mentioned formula.

**Plate 7: Healthy Okra fruits**

**Plate 8: Okra fruits infested with Okra Shoot and Fruit Borer**

### 3.16.8 Yield per hectare

Total yield of okra per hectare for each treatment was calculated in tons from cumulative fruit production in a plot. Effect of different treatments on the increase and decrease of okra yield over control was also calculated by the following formula:

$$\% \text{ increase of yield over control} = \frac{\text{Yield of treated plot- Yield of control plot}}{\text{Yield of control plot}} \times 100$$

## 3.17 Statistical analysis of data

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT program (Gomez and Gomez, 1976). The treatment means were separated by Duncan's Multiple Range Test (DMRT).

# CHAPTER IV

# RESULTS AND DISCUSSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during Kharif I season for 2011 find out the efficacy of some botanicals and chemical insecticides applied against okra shoot and fruit borer as well as whitefly, *Bemisia tabaci* infestation in the field of okra. The results of the present study have been interpreted and discussed under the following sub-headings:

### 4.2.1 Shoot infestation at vegetative stage

Effect of different treatments in controlling okra shoot and fruit borer in the present study showed a statistically significant difference in term of % shoot infestation at the vegetative stage. Highest % of shoot infestation (9.71%) was observed in $T_9$ (untreated control) treatment which was closely followed by $T_2$ (8.09%) and $T_4$ (7.01%) treatments respectively. On the other hand the lowest % of shoot infestation (1.88%) was observed in $T_6$ (spraying of Ripcord 10 EC @ 1.5 ml/L of water at 7 days interval) treatment which was closely followed by $T_1$ (2.81%) treatment (spraying of Actara 25WG @ 1g/ L of water at 7 days interval).

### 4.2.2 Shoot infestation at different fruiting stages

A significant difference was found in terms of shoot infestation at the early fruiting stage among different treatments for the control of okra shoot and fruit borer. The highest % of shoot infestation (33.22%) was recorded in $T_9$ (untreated control) treatment which was closely followed by $T_2$ (27.57%) and $T_4$ (24.12%) treatments respectively. On the other hand the lowest % of shoot infestation (9.717%) was recorded in $T_6$ treatment which was closely followed by $T_1$ (11.77%) treatment (Table 2). Similar trend of results were also found from mid and late fruiting stages of okra (Table 2).

**Table 2: Effect of different treatments on the shoot infestation caused by okra shoot and fruit borer at vegetative stage and different fruiting stages**

| Treatment | % Shoot infestation | | | | | |
|---|---|---|---|---|---|---|
| | Vegetative stage | Early fruiting stage | Mid fruiting stage | Late fruiting stage | Mean | % Reduction over control |
| $T_1$ | 2.81 gh | 11.77 h | 21.83 h | 33.17 h | 17.54 h | 52.85 |
| $T_2$ | 8.09 b | 27.57 b | 41.47 b | 56.31 b | 32.92 b | 11.51 |
| $T_3$ | 6.103 cd | 21.04 d | 34.66 d | 47.23 d | 26.70 d | 28.23 |
| $T_4$ | 7.01 c | 24.12 c | 38.41 c | 51.86 c | 29.91 c | 19.60 |
| $T_5$ | 3.72 fg | 13.19 g | 24.43 g | 36.76 g | 19.35 g | 47.98 |
| $T_6$ | 1.88 h | 9.717 i | 18.56 i | 28.65 i | 15.00 i | 59.68 |
| $T_7$ | 4.50 ef | 14.87 f | 27.04 f | 40.06 f | 20.90 f | 43.82 |
| $T_8$ | 5.44 de | 17.31 e | 30.21 e | 42.46 e | 23.26 e | 37.47 |
| $T_9$ | 9.71 a | 33.22 a | 49.14 a | 61.05 a | 37.20 a | - |
| $LSD_{(0.01)}$ | 1.040 | 1.357 | 1.708 | 2.279 | 1.429 | - |
| CV (%) | 7.95 | 2.96 | 2.26 | 2.16 | 2.42 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

In $T_6$ treatment shoot infestation percentage over control was estimated the highest value (59.68%) and lowest value (11.51%) from $T_2$ treatment (Table 2). From the findings it was revealed that $T_6$ performed the lowest % of shoot infestation at the vegetative stage and the different fruiting stages. Whereas in control treatment ($T_9$) the situation was reverse. Shukla *et al*. (1997) reported that before fruiting stage shoot infestation reached at a peak of 8.5%.

### 4.3 Fruit infestation by number due to okra shoot and fruit borer at different fruiting stages

A significant difference was found in case of fruit infestation at the early fruiting stage among different control methods for the management okra shoot and fruit borer. The highest % of fruit infestation (19.89%) was recorded in $T_9$ (untreated control) treatment which was closely followed by $T_2$ (17.54%) treatment. On the other hand the lowest % of fruit infestation (10.44%) was recorded in $T_6$ treatment which was closely followed by $T_1$ (11.95%) treatment (Table 3). Similar trend of results were also found from mid and late fruiting stage of okra (Table 3).

**Table 3: Effect of different treatments on the fruit infestation by number due to okra shoot and fruit borer at different fruiting stages**

| Treatments | % Fruit Infestation by Number | | | | |
|---|---|---|---|---|---|
| | Early fruiting stage | Mid fruiting stage | Late fruiting stage | Mean | % Reduction over control |
| $T_1$ | 11.95 f | 20.27 g | 26.79 g | 20.27 g | 35.34 |
| $T_2$ | 17.54 b | 27.93 b | 36.61 b | 27.93 b | 10.91 |
| $T_3$ | 15.82 c | 25.88 cd | 34.01 cd | 25.88 cd | 17.45 |
| $T_4$ | 16.64 bc | 26.79 bc | 35.34 bc | 26.79 bc | 14.55 |
| $T_5$ | 13.55 e | 21.82 fg | 30.06 f | 21.82 fg | 30.40 |
| $T_6$ | 10.44 g | 17.15 h | 23.47 h | 17.15 h | 45.30 |
| $T_7$ | 14.37 de | 23.01 ef | 31.29 ef | 23.01 ef | 26.60 |
| $T_8$ | 14.83 d | 24.65 de | 32.86 de | 24.65 de | 21.37 |
| $T_9$ | 19.89 a | 31.35 a | 41.10 a | 31.35 a | - |
| $LSD_{(0.01)}$ | 0.8955 | 1.651 | 2.343 | 1.651 | - |
| CV (%) | 2.50 | 2.85 | 3.03 | 0.36 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

In $T_6$ (Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval) treatment, fruit infestation percentage over control was estimated the highest value (45.30%) and lowest value (10.91%) from $T_2$ treatment (Table 3). From the findings it was revealed that $T_6$ performed the lowest % of fruit infestation at different fruiting stages. Whereas in control treatment ($T_9$) the situation was reverse. Shukla *et al.* (1997) observed that fruit infestation of okra started at the beginning of fruiting, increased progressively and reached a peak of 41.25% before harvesting in the first week of June which was similar to the findings of present study. The findings were supported by Maleque (1998) who observed that the caterpillars preferred fruits to shoots during the fruiting stage.

### 4.4 Effect of different treatments on the fruit infestation by weight due to okra shoot and fruit borer at different fruiting stages

A significant difference was found in terms of fruit infestation by weight at the early fruiting stage among different control methods for the management okra shoot and fruit borer. The highest % of fruit infestation by weight (50.89%) was recorded in $T_9$ (untreated control) treatment which was closely followed by $T_2$ (46.12%) treatment.

On the other hand the lowest % of fruit infestation by weight (25.53%) was recorded in $T_6$ treatment (Table 4). Similar trend of results were also found from mid and late fruiting stage (Table 4).

**Table 4: Effect of different treatments on the fruit infestation by weight due to okra shoot and fruit borer at different stages**

| Treatments | % Fruit Infestation by weight | | | | |
|---|---|---|---|---|---|
| | Early fruiting stage | Mid fruiting stage | Late fruiting stage | Mean | %Reduction over control |
| $T_1$ | 33.62 h | 40.23 h | 47.76 h | 35.51 h | 31.61 |
| $T_2$ | 46.12 b | 54.33 b | 56.44 b | 49.37 b | 4.91 |
| $T_3$ | 40.23 d | 50.13 d | 53.71 d | 44.72 d | 13.87 |
| $T_4$ | 42.64 c | 52.52 c | 54.31 c | 46.77 c | 9.92 |
| $T_5$ | 34.84 g | 45.62 g | 49.93 g | 38.78 g | 25.31 |
| $T_6$ | 25.53 i | 34.35 i | 37.74 i | 28.30 i | 45.49 |
| $T_7$ | 35.75 f | 47.72 f | 50.13 f | 40.57 f | 21.86 |
| $T_8$ | 38.12 e | 49.63 e | 52.46 e | 42.99 e | 17.20 |
| $T_9$ | 50.89 a | 55.46 a | 58.69 a | 51.92 a | - |
| $LSD_{(0.01)}$ | 0.1508 | 0.1847 | 0.1067 | 0.1306 | - |
| CV (%) | 0.16 | 0.17 | 0.09 | 0.12 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

In $T_6$ treatment fruit infestation percentage over control was estimated the highest value (45.49%) and lowest value (4.91%) from $T_2$ treatment (Table 4). From the findings it was revealed that $T_6$ performed the lowest % of fruit infestation at different fruiting stages. Whereas in control treatment ($T_9$) the situation was reverse. About similar results were also observed by different researchers. Shukla *et al.* (1997) reported that before fruiting stage shoot infestation reached a peak of 8.5%. Krishna (1987) obtained 41.23% and Chaudhury (2001) recorded 29.84% fruit infestation in untreated control plot at late fruiting stage in okra.

## 4.5 Effect of different treatments on the plant infestation by number due to okra shoot and fruit borer at different days after sowing (DAS)

From the results in table 5 showed significant variation due to the effect of different treatments on percent of reduction of okra shoot and fruit borer at different days after sowing (DAS).

Among different treatments on plant infestation by okra shoot and fruit borer, Ripcord 10 EC @ 1.5ml/L of water showed the highest control against okra shoot and fruit borer and botanical insecticide, Neem oil @ 3ml/L of water showed lower performance in reducing the okra shoot and fruit borer. Whereas, Ripcord 10 EC @ 1.5ml/L of water reduce the maximum okra shoot and fruit borer attack (7.953,28.87,56.34,70.74,81.87,93.13 and 61.63 at 7,14,21,28,35 and 42 DAS respectively) which showed more reduction (27.41% ) of okra shoot and fruit borer and supported to make sure the more yield of okra.

In the similar trend, Neem oil @ 3ml/L of water showed lower performance to control the okra shoot and fruit borer while minimum reduction (4.15%) was recorded on okra research field (Table 5). About similar results were also observed by different researchers. Shukla *et al.* (1997) reported that before fruiting stage plant infestation reached a peak of 8.5%. Choi In Hu *et al.* (2004) reported that Proclaim showed 87% plant infestation reduction. Islam *et al.* (1999) observed the minimum acceptable level of shoot infestation reduction over control was 80%.

**Table 5: Effect of different treatments on the plant infestation by number due to okra shoot and fruit borer at different days after sowing (DAS)**

| Treatments | % plant infestation by number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 DAS | 14 DAS | 21 DAS | 28 DAS | 35 DAS | 42 DAS | Mean | %Reduction over control |
| $T_1$ | 10.81 f | 36.22 f | 61.77 g | 76.80 e | 87.60 d | 96.53 d | 65.48 ef | 22.87 |
| $T_2$ | 21.59 b | 67.07 b | 91.32 ab | 96.34 a | 99.10 a | 99.62 a | 81.38 ab | 4.15 |
| $T_3$ | 17.32 cd | 56.43 c | 83.87 c | 91.80 b | 98.23 a | 99.16 ab | 77.20 bc | 9.07 |
| $T_4$ | 18.84 c | 60.65 c | 89.33 b | 94.87 a | 98.69 a | 99.38 ab | 77.49 bc | 8.73 |
| $T_5$ | 13.56 e | 43.04 e | 68.13 f | 81.18 d | 92.83 c | 97.44 cd | 69.49 de | 18.15 |
| $T_6$ | 7.953 g | 28.87 g | 56.34 h | 70.74 f | 81.87 e | 93.13 e | 61.63 f | 27.41 |
| $T_7$ | 14.77 e | 48.60 d | 74.56 e | 86.37 c | 95.16 bc | 98.23 bc | 73.55 cd | 13.37 |
| $T_8$ | 15.62 de | 50.96 d | 78.74 d | 89.10 bc | 96.85 ab | 98.89 ab | 72.82 d | 14.23 |
| $T_9$ | 24.79 a | 75.04 a | 92.99 a | 97.51 a | 99.14 a | 99.95 a | 84.90 a | - |
| $LSD_{(0.01)}$ | 2.281 | 4.948 | 3.360 | 2.791 | 2.708 | 1.085 | 4.022 | - |
| CV(%) | 5.93 | 4.00 | 1.82 | 1.34 | 1.20 | 0.46 | 2.29 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

### 4.6 Effect of different treatments on the incidence of whitefly, *Bemisia tabaci* during the management of insect pest of okra at different days after sowing (DAS)

From the results in table 6 showed significant variation due to the effect of different treatments on incidence and percent reduction of white fly, *Bemisia tabaci* on okra plant at different days after sowing (DAS). Among different management practices on management of insect pest of okra, chemical insecticide, Ripcord 10 EC @ 1.5ml/L of water showed the highest control against white fly and botanical insecticide, neem oil @ 3ml/L of water showed lower performance on reduction of white fly. Whereas, Ripcord 10 EC @ 1.5ml/L of water reduce the maximum white fly attack (1.60,4.73,8.240,10.76,13.13,14.39 and 9.010 at 7,14,21,28,35 and 42 DAS respectively) which showed more reduction (45.29% ) of white fly and supported to make sure the more yield of okra.

**Table 6: Effect of different treatments on the incidence of white fly, *Bemisia tabaci***

| Treatments | Incidence of Whitefly (no./plant) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **7 DAS** | **14 DAS** | **21 DAS** | **28 DAS** | **35 DAS** | **42 DAS** | **Mean** | **%Reduction over control** |
| $T_1$ | 2.02 g | 5.29 fg | 10.38 f | 12.58 ef | 14.38 f | 16.33 fg | 10.03 f | 39.10 |
| $T_2$ | 3.97 b | 9.54 b | 15.57 b | 18.71 b | 22.10 b | 24.84 b | 15.07 b | 8.50 |
| $T_3$ | 3.80 d | 8.57 c | 13.89 c | 16.75 bc | 19.43 c | 22.15 c | 13.73 c | 16.64 |
| $T_4$ | 3.74 b | 9.09 bc | 15.02 b | 17.80 bc | 20.27 c | 23.14 bc | 14.62 b | 11.23 |
| $T_5$ | 2.38 f | 6.023 ef | 11.25 e | 13.77 de | 15.91 e | 18.08 ef | 11.22 e | 31.88 |
| $T_6$ | 1.60 h | 4.73 g | 8.240 g | 10.76 f | 13.13 g | 14.39 g | 9.010 g | 45.29 |
| $T_7$ | 2.85 e | 6.69 de | 12.04 e | 15.25 cde | 17.04 de | 19.50 de | 11.72 e | 28.84 |
| $T_8$ | 3.15 de | 7.60 d | 12.86 d | 16.14bcd | 18.17 d | 20.97 cd | 12.66 d | 23.13 |
| $T_9$ | 4.98 a | 12.36 a | 19.26 a | 23.70 a | 29.67 a | 37.46 a | 16.47 a | - |
| $LSD_{(0.01)}$ | 0.3537 | 0.9359 | 0.7910 | 2.600 | 1.156 | 2.255 | 0.5842 | - |
| CV (%) | 4.75 | 5.06 | 2.52 | 6.75 | 2.56 | 4.32 | 1.92 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

In the similar trend, Neem oil @ 3ml/L of water showed lower performance to manage the white fly while minimum reduction (8.50%) was recorded on okra research field (Table 6). Similar works were done by Khan and Mukhopadhyay (1985) and they reported that the soil application of methyl phosphorodithioate (Furtox 10G) reduced average whitefly population to 59.66 (from 231) per plant and enhanced yield to 59.45 kg/ha (from 23.8). Marcano and Gonzalez (1993) also reported the Imidacloprid performed as the most effective insecticide in reducing the incidence of white fly, *Bemisia tabaci* on okra.

### 4.7 Effect of different treatments on the leaf infestation by Okra Yellow Vein Clearing Mosaic Virus

From the results in table 7 showed significant variation due to the effect of different treatments on incidence and percent of reduction of white fly, *Bemisia tabaci* which causes by Okra Yellow Vein Clearing Mosaic Virus on leaves at different days after sowing (DAS). Among different management practices on management of okra Vein Clearing Mosaic Virus on leaf, chemical insecticide Ripcord 10 EC @ 1.5ml/L of water showed greatest control against Okra Vein Clearing Mosaic Virus on leaf and botanical insecticide Neem oil @ 3ml/L of water showed lower performance on restricted the Okra Vein Clearing Mosaic Virus on leaf. OkYVCMV cause large amount destruction on okra production. Whereas, Ripcord 10 EC @ 1.5ml/L of water reduce the maximum OkYVCMV attack (9.210, 27.01, 48.19, 70.57, 80.91, 90.36 and 54.37 at 7, 14, 21, 28, 35 and 42 DAS respectively) which showed more reduction (31.22% ) of white fly on okra and supported to make sure the more yield of okra. Probably, control measures ensure optimum photosynthesis as well as maximum accumulation of nutrients which ultimately contributed to increase the yield fruit.

**Table 7: Effect of different treatments on the leaf infestation by Okra Yellow Vein Clearing Mosaic Virus at different days after sowing (DAS)**

| Treatments | % Leaf infestation by OkYVCMV | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 DAS | 14 DAS | 21 DAS | 28 DAS | 35 DAS | 42 DAS | Mean | %Reduction over control |
| $T_1$ | 10.41 f | 31.83 f | 53.90 f | 78.23 f | 84.31 e | 93.46 f | 58.69 h | 25.76 |
| $T_2$ | 18.67 b | 59.96 b | 85.52 a | 96.32 ab | 98.59 a | 99.48 ab | 76.42 b | 3.33 |
| $T_3$ | 16.22 bcd | 50.45 c | 79.79 b | 90.93 c | 95.49 bc | 98.58 bcd | 71.91 d | 9.03 |
| $T_4$ | 17.21 bc | 53.32 c | 83.74 a | 94.01 b | 97.49 ab | 98.99 abc | 74.13 c | 6.22 |
| $T_5$ | 11.77 ef | 38.30 e | 59.79 e | 82.84 e | 87.17 d | 95.13 e | 62.50 g | 20.94 |
| $T_6$ | 9.210 f | 27.01 g | 48.19 g | 70.57 g | 80.91 f | 90.36 g | 54.37 i | 31.22 |
| $T_7$ | 13.45 de | 43.73 d | 67.21 d | 86.00 d | 89.78 d | 97.51 d | 66.28 f | 16.15 |
| $T_8$ | 14.53 cde | 46.04 d | 74.26 c | 88.98 cd | 93.13 c | 98.14 cd | 69.18 e | 12.49 |
| $T_9$ | 23.45 a | 65.55 a | 88.15 a | 97.96 a | 99.23 a | 99.93 a | 79.05 a | - |
| $LSD_{(0.1)}$ | 2.712 | 3.659 | 4.549 | 3.018 | 2.618 | 1.040 | 1.807 | - |
| CV(%) | 7.58 | 3.32 | 2.68 | 1.45 | 1.20 | 0.45 | 1.11 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

In the similar trend, Neem oil @ 3ml/L of water showed lower performance to manage the OkYVCMV while minimum reduction (3.33%) was recorded on okra research field (Table 7). About similar works were also done by Khan and Mukhopadhyay (1985) and they reported that the soil application of methyl phosphorodithioate (Furtox 10G) reduced Okra yellow vein clearing mosaic virus disease incidence up to 23.26% (control 81.22%) and enhanced yield to 59.45kg/ha.

### 4.8 Effect of different treatments on the length of healthy fruit during the management of okra shoot and fruit borer at different fruiting stage

Length of healthy fruit in different treatments for controlling okra shoot and fruit borer showed statistically significant difference. In case of early fruiting stage it was releaved that the maximum length of healthy fruit (18.04 cm) was recorded in $T_6$ (spraying Ripcord 10 EC @ 1.5ml/L of water at 7 days interval) treatment which was statistically identical (17.55 cm) by $T_1$ (Spraying of Actara 25WG @ 1g/L of water at 7 days interval) treatment and closely followed by $T_5$ (Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval) treatment (Table 8). On the other hand the minimum length of healthy fruit (10.44 cm) was recorded in $T_9$ (untreated control) treatment which was closely followed (11.30 cm) by $T_2$ (Spraying of Neem oil @ 3ml/L of water at 7 days interval) treatment. Probably, control measures ensure optimum photosynthesis as well as maximum accumulation of nutrients which ultimately contributed to increase the length of the fruit.

**Table 8: Effect of different treatments on the length of healthy fruit during the management of okra shoot and fruit borer at different days after sowing (DAS)**

| Treatment | Length of healthy fruit(cm/fruit) | | | | |
|---|---|---|---|---|---|
| | Early fruiting stage | Mid fruiting stage | Late fruiting stage | Mean | % Increase over control |
| $T_1$ | 17.55 a | 17.16 a | 16.22 a | 16.88 b | 62.00 |
| $T_2$ | 11.30 g | 11.10 g | 10.69 fg | 11.06 h | 6.14 |
| $T_3$ | 13.57 e | 13.30 e | 12.14 e | 12.87 f | 23.51 |
| $T_4$ | 12.50 f | 12.15 f | 11.07 f | 11.77 g | 12.96 |
| $T_5$ | 16.72 b | 16.27 b | 15.13 b | 15.89 c | 52.50 |
| $T_6$ | 18.04 a | 17.27 a | 16.69 a | 17.44 a | 67.37 |
| $T_7$ | 15.77 c | 15.35 c | 14.15 c | 14.97 d | 43.67 |
| $T_8$ | 14.91 d | 14.60 d | 13.35 d | 14.16 e | 35.89 |
| $T_9$ | 10.44 h | 10.55 h | 10.08 g | 10.42 i | - |
| $LSD_{(0.01)}$ | 0.6310 | 0.3109 | 0.6310 | 0.3617 | - |
| CV(%) | 1.82 | 0.91 | 1.99 | 1.10 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC@ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

Similar trend of result in length of healthy fruit also found for mid and late fruiting stages of okra (Table 8). Butani and Jotwani (1984) and Thakur *et al.* (1986) reported that the length of the okra fruit affected by the Okra shoot and fruit borer.

### 4.9 Effect of different treatments on the length of infested fruit

Length of infested fruit in different treatments for controlling okra shoot and fruit borer showed statistically significant difference. In case of early fruiting stage it was releaved that the maximum length of infested fruit (9.83 cm) was recorded in $T_6$ (spraying Ripcord 10 EC @ 1.5ml/L of water at 7 days interval) treatment which was statistically identical (8.87 cm) by $T_1$ (Spraying of Actara 25WG @ 1g/L of water at 7 days interval) treatment and closely followed by $T_5$ (Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval) treatment (Table 9). On the other hand the minimum length of infested fruit (5.77 cm) was recorded in $T_9$ (untreated control) treatment which was closely followed (6.57cm) by $T_2$ (Spraying of Neem oil @ 3ml/L of water at 7 days interval) treatment. Probably, control measures ensure optimum photosynthesis as well as maximum accumulation of nutrients which ultimately contributed to increase the length of the fruit.

**Table 9: Effect of different treatments on the length of infested fruit at different fruiting stages**

| Treatments | Length of infested fruit (cm/fruit) | | | | |
|---|---|---|---|---|---|
| | Early fruiting stage | Mid fruiting stage | Late fruiting stage | Mean | % increase over control |
| $T_1$ | 8.87 b | 8.58 b | 7.33 b | 8.17 b | 69.85 |
| $T_2$ | 6.57 h | 5.87 f | 4.93 g | 5.50 h | 14.35 |
| $T_3$ | 7.57 f | 7.19 d | 6.17 e | 6.87 f | 42.83 |
| $T_4$ | 6.87 g | 6.67 e | 5.75 f | 6.33 g | 31.60 |
| $T_5$ | 8.58 c | 8.22 bc | 7.22 b | 7.880 c | 63.83 |
| $T_6$ | 9.83 a | 9.37 a | 8.23 a | 9.03 a | 87.73 |
| $T_7$ | 8.27 d | 8.01 c | 6.88 c | 7.58 d | 57.59 |
| $T_8$ | 7.86 e | 7.35 d | 6.44 d | 7.14 e | 48.44 |
| $T_9$ | 5.77 i | 4.62 g | 4.00 h | 4.81 i | - |
| $LSD_{(0.01)}$ | 0.1306 | 0.4332 | 0.1508 | 0.1067 | - |
| CV (%) | 0.69 | 2.49 | 0.96 | 0.62 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

Similar trend of result in length of infested fruit also found for mid and late fruiting stages of okra (Table 9). Butani and Jotwani (1984) and Thakur *et al.* (1986) reported that the length of the okra fruit affected by the Okra shoot and fruit borer.

## 4.10 Effect of different treatments on the girth of healthy fruit during the management of okra shoot and fruit borer at different fruiting stages

Girth of healthy fruit in different treatments for controlling okra shoot and fruit borer showed statistically significant difference. In case of early fruiting stage it was releaved that the maximum girth of healthy fruit (6.17 cm) was recorded in $T_6$ (spraying Ripcord 10 EC @ 1.5ml/L of water at 7 days interval) treatment which was statistically identical (5.92 cm) by $T_1$ (Spraying of Actara 25WG @ 1g/L of water at 7 days interval) treatment and closely followed by $T_5$ (Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval) treatment (Table 10). On the other hand the minimum girth of healthy fruit (4.59 cm) was recorded in $T_9$ (untreated control) treatment which was closely followed (4.74 cm) by $T_2$ (Spraying of Neem oil @ 3ml/L of water at 7 days interval) treatment. Probably, management practices ensure optimum photosynthesis as well as maximum accumulation of nutrients which ultimately contributed to increase the girth of the fruit.

Similar trend of result in girth of healthy fruit also found for mid and late fruiting stages of okra (Table 10). More or less similar works were done by some researchers, such as Butani and Jotwani (1984) and Thakur *et al.* (1986) and reported that the girth of the okra fruit affected by the Okra shoot and fruit borer.

**Table 10: Effect of different treatments on the girth of healthy fruit at different fruiting stages**

| Treatments | Girth of healthy fruit (cm/fruit) | | | | |
|---|---|---|---|---|---|
| | Early stage | Mid stage | Late stage | Mean | %Increase over control |
| $T_1$ | 5.92 b | 5.71 b | 5.06 b | 5.52 b | 28.07 |
| $T_2$ | 4.74 h | 4.62 h | 4.14 g | 4.46 h | 3.48 |
| $T_3$ | 5.18 f | 5.04 f | 4.62 e | 4.94 f | 14.62 |
| $T_4$ | 5.02 g | 4.89 g | 4.43 f | 4.78 g | 10.90 |
| $T_5$ | 5.71 c | 5.45 c | 4.99 b | 5.35 c | 24.13 |
| $T_6$ | 6.17 a | 6.05 a | 5.30 a | 5.82 a | 35.03 |
| $T_7$ | 5.54 d | 5.32 d | 4.90 c | 5.22 d | 21.11 |
| $T_8$ | 5.36 e | 5.20 e | 4.74 d | 5.09 e | 18.10 |
| $T_9$ | 4.59 i | 4.43 i | 4.05 h | 4.31 i | - |
| $LSD_{(0.01)}$ | 0.07541 | 0.1067 | 0.07541 | 0.07541 | - |
| CV (%) | 0.62 | 0.86 | 0.74 | 0.56 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

### 4.11 Effect of different treatments on the girth of infested fruit at different fruiting stages

Girth of infested fruit in different treatments for controlling okra shoot and fruit borer showed statistically significant difference. In case of early fruiting stage it was releaved that the maximum girth of infested fruit (4.98 cm) was recorded in $T_6$ (spraying Ripcord 10 EC @ 1.5ml/L of water at 7 days interval) treatment which was statistically identical (4.85 cm) by $T_1$ (Spraying of Actara 25WG @ 1g/L of water at 7 days interval) treatment and closely followed by $T_5$ (Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval) treatment (Table 11). On the other hand the minimum girth of infested fruit (2.76 cm) was recorded in $T_9$ (untreated control) treatment which was closely followed (4.11 cm) by $T_2$ (Spraying of Neem oil @ 3ml/L of water at 7 days interval) treatment.

**Table 11: Effect of different treatments on the girth of infested fruit at different fruiting stages**

| Treatments | Girth of infested fruit (cm/fruit) | | | | |
|---|---|---|---|---|---|
| | Early stage | Mid stage | Late stage | Mean | %Increase over control |
| $T_1$ | 4.85 b | 4.64 b | 4.10 b | 4.50 b | 80.00 |
| $T_2$ | 4.11 h | 3.94 h | 3.73 f | 3.79 g | 51.60 |
| $T_3$ | 4.39 f | 4.22 f | 3.83 d | 4.13 e | 65.20 |
| $T_4$ | 4.27 g | 4.13 g | 3.67 e | 4.02 f | 60.80 |
| $T_5$ | 4.75 c | 4.56 c | 4.07 bc | 4.43 b | 77.20 |
| $T_6$ | 4.98 a | 4.77 a | 4.23 a | 4.63 a | 85.20 |
| $T_7$ | 4.64 d | 4.47 d | 4.03 bc | 4.34 c | 73.60 |
| $T_8$ | 4.50 e | 4.36 e | 4.00 c | 4.24 d | 69.60 |
| $T_9$ | 2.76 i | 2.62 i | 2.12 g | 2.50 h | - |
| $LSD_{(0.01)}$ | 0.07541 | 0.07541 | 0.07541 | 0.07541 | - |
| CV (%) | 0.83 | 0.89 | 0.78 | 0.59 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

Similar trend of result in girth of infested fruit also found for mid and late fruiting stages of okra (Table 11). More or less similar works were done by Butani and Jotwani (1984) and Thakur *et al.* (1986) reported that the girth of the okra fruit affected by the Okra shoot and fruit borer.

### 4.12 Effect of different treatments on the height of okra plants at different fruiting stage

Statistically significant variation in plant height among different treatments in controlling okra shoot and fruit borer was observed under the present trail. In case of per plot it was releaved that the highest height (95.67 cm) was recorded in $T_6$ (spraying Ripcord 10 EC @ 1.5ml/L of water at 7 days interval) treatment which was closely followed by (88.03) cm was recorded in $T_1$ (Spraying of Actara 25WG @ 1g/L of water at 7 days interval) treatment on the other hand the lowest height (53.95 cm) was recorded in $T_9$ (untreated control) treatment, which was closely followed by(63.59 cm) was recorded in $T_2$ (Spraying of Neem oil @ 3ml/L of water at 7 days interval) treatment (Table 12).

**Table 12: Effect of different treatments on the height of okra plants**

| Treatments | Plant height | % Increase over control |
|---|---|---|
| $T_1$ | 88.03 b | 63.17 |
| $T_2$ | 63.59 h | 17.87 |
| $T_3$ | 70.74 f | 31.12 |
| $T_4$ | 67.69 g | 25.47 |
| $T_5$ | 82.29 c | 52.53 |
| $T_6$ | 95.67 a | 77.33 |
| $T_7$ | 77.45 d | 43.56 |
| $T_8$ | 74.14 e | 37.42 |
| $T_9$ | 53.95 i | - |
| $LSD_{(0.01)}$ | 2.301 | - |
| CV (%) | 1.29 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/L of water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

Similar trend of results also found in height (cm) from the (table 12). Different management practices ensure the optimum vegetative growth and other yield contributing characters as well as maximum height. Krishna (1987) obtained 56.78% increase over control and Chaudhury (2001) recorded 61.83% increase over control on the height of okra plants during the management of okra shoot and fruit borer.

### 4.13 Effect of different treatments on the yield of fruit at different fruiting stages

Statistically significant variation in yield per plot or hectare among different treatments in controlling okra shoot and fruit borer was observed under the present trail. In case of per plot it was releaved that the highest yield (13.77 kg) was recorded in $T_6$ (spraying Ripcord 10 EC @ 1.5ml/L of water at 7 days interval) treatment which was closely followed by (12.84) kg was recorded in $T_1$ (Spraying of Actara 25WG @ 1g/L of water at 7 days interval) treatment on the other hand the lowest yield per plot(4.023 kg) was recorded in $T_9$ (untreated control) treatment, which was closely followed by (6.340 kg) was recorded in $T_2$ (Spraying of Neem oil @ 3ml/L of water at 7 days interval) treatment (Table 13). Similar trend of results also found in yield (ton/ha) from the table 13. Different management practices ensure the optimum vegetative growth and other yield contributing characters as well as maximum yield per hectare. Choi In Hu *et al.* (2004) observed that proclaim exhibit the highest fruit yield of okra.

**Table 13: Effect of different treatments on the yield of fruit during the management of okra shoot and fruit borer**

| Treatments | Yield | | |
|---|---|---|---|
| | Kg/plot | Ton/ha | % Increase over control |
| $T_1$ | 12.84 ab | 14.26 a | 219.23 |
| $T_2$ | 6.340 g | 7.047 g | 57.76 |
| $T_3$ | 9.120 e | 10.13 e | 126.77 |
| $T_4$ | 7.597 f | 8.437 f | 88.87 |
| $T_5$ | 12.33 bc | 13.69 bc | 206.47 |
| $T_6$ | 13.77 a | 15.30 a | 242.51 |
| $T_7$ | 11.50 cd | 12.78 cd | 186.10 |
| $T_8$ | 10.81 d | 12.01 d | 168.86 |
| $T_9$ | 4.023 h | 4.467 h | - |
| $LSD_{(0.01)}$ | 1.149 | 1.275 | - |
| CV (%) | 4.90 | 4.91 | - |

In a column, means having same letter(s) are statistically similar at 1% level of significance.

[$T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC @ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval; $T_7$ = Marshal 100 EC @ 1.5ml/Lof water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval; $T_9$ = Untreated Control]

**4.14 Relationship between yield of okra and length of healthy fruit among different management practices**

Correlation study was done to establish the relationship between yield of okra fruit and length of healthy fruit among different management practices. From the Figure 1, it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = 1.391x-8.487 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.954) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the length of healthy fruit was strongly as well as positively correlated with the yield (ton/ha) of okra, i.e., fruit yield was increased due to increase of the fruit length.

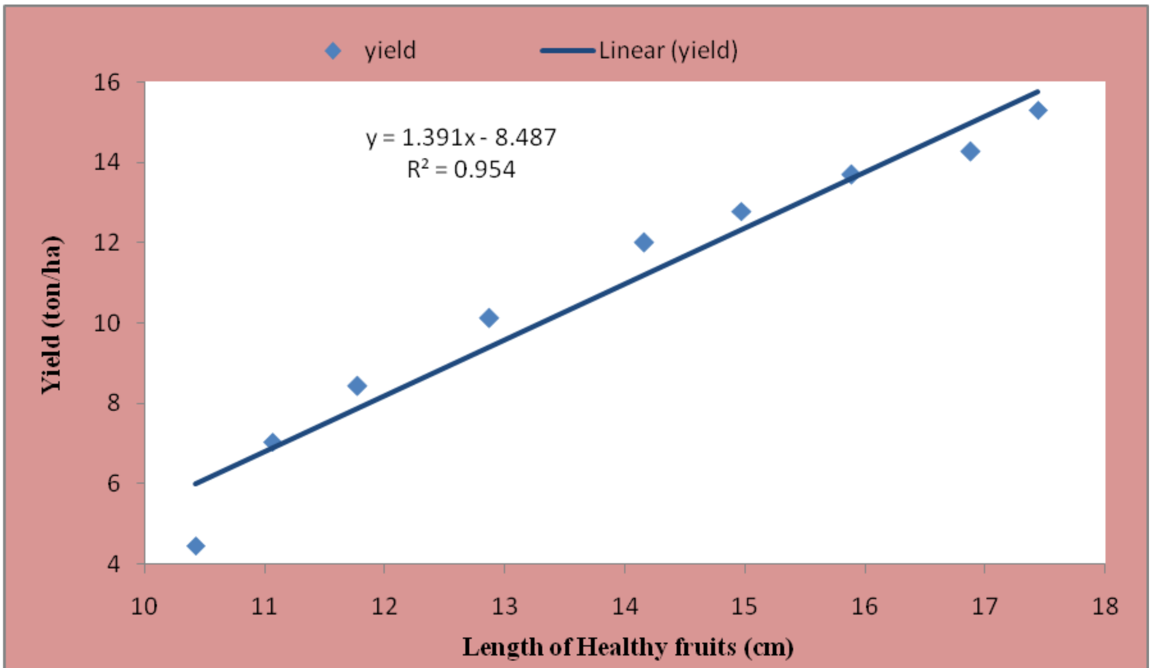


**Figure 1. Relationship between length of healthy fruits and yield of okra**

### 4.15 Relationship between yield of okra and girth of healthy fruit among different management practices

Correlation study was done to establish the relationship between yield of okra fruit and girth of healthy fruit among different management practices. From the Figure 2, it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = 7.286x - 25.92 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.958) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the girth of healthy fruit was strongly as well as positively correlated with the yield (ton/ha) of okra.

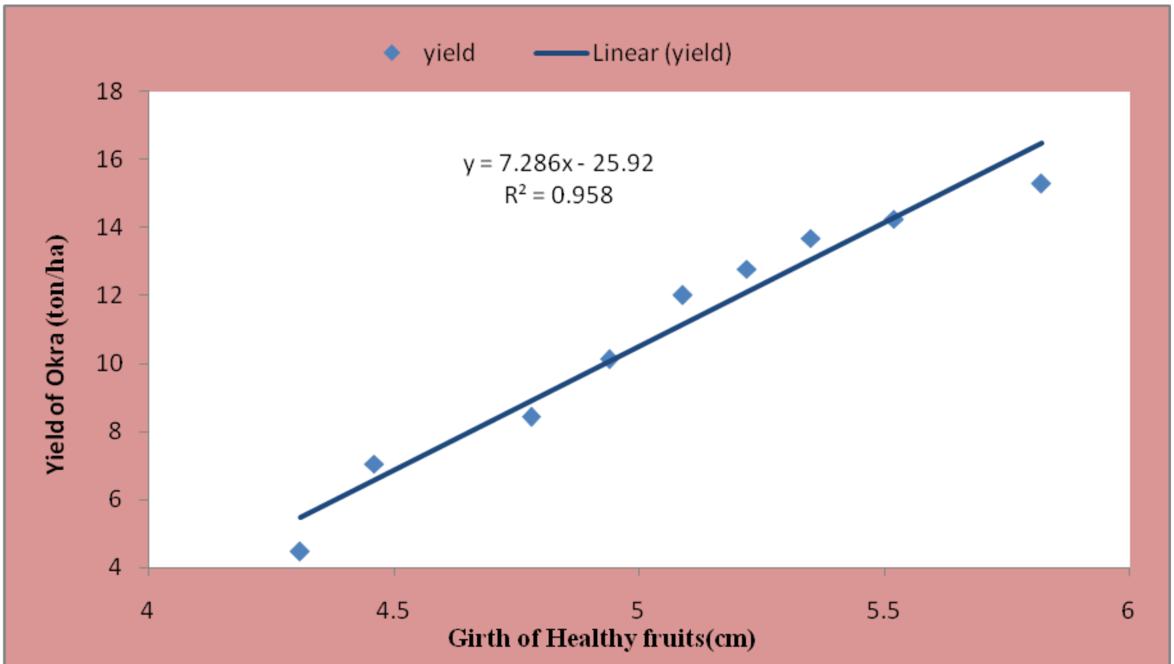


Figure 2. Relation between girth of healthy fruits and yield of okra

**4.16 Relationship between yield of okra and fruit infestation by number due to OSFB among different management practices**

Correlation study was done to establish the relationship between yield of okra fruit and fruit infestation by number due to OSFB among different management practices. From the Figure 3, it was revealed that negative correlation was observed between the parameters. It was evident that the equation y = - 0.821x + 30.87 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.934) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the fruit infestation by number due to OSFB was strongly as well as negatively correlated with the yield (ton/ha) of okra i.e., fruit yield was decreased due to increase of the fruit infestation by number of the okra.

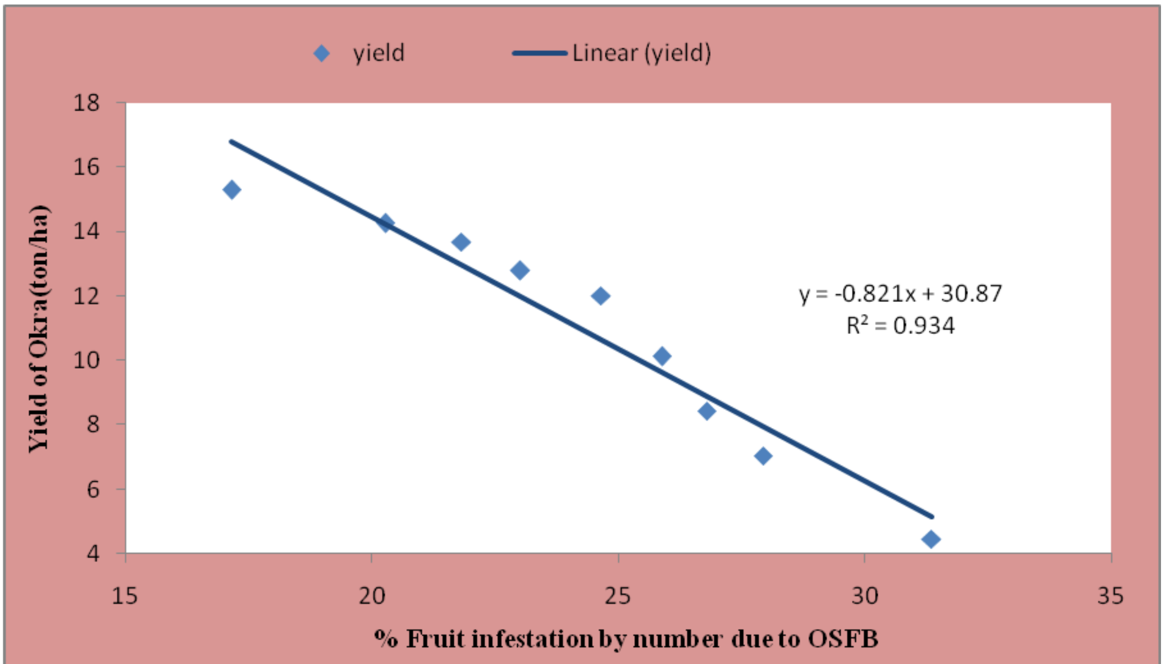


**Figure 3. Relation between fruit infestation by number due to OSFB and yield of okra**

### 4.17 Relationship between yield of okra and fruit infestation by weight due to OSFB among different management practices

Correlation study was done to establish the relationship between yield of okra fruit and fruit infestation by weight due to OSFB among different management practices. From the Figure 4 it was revealed that negative correlation was observed between the parameters. It was evident that the equation y = -0.466x + 30.54 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.873) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the fruit infestation by weight due to OSFB was strongly as well as negatively correlated with the yield (ton/ha) of okra.

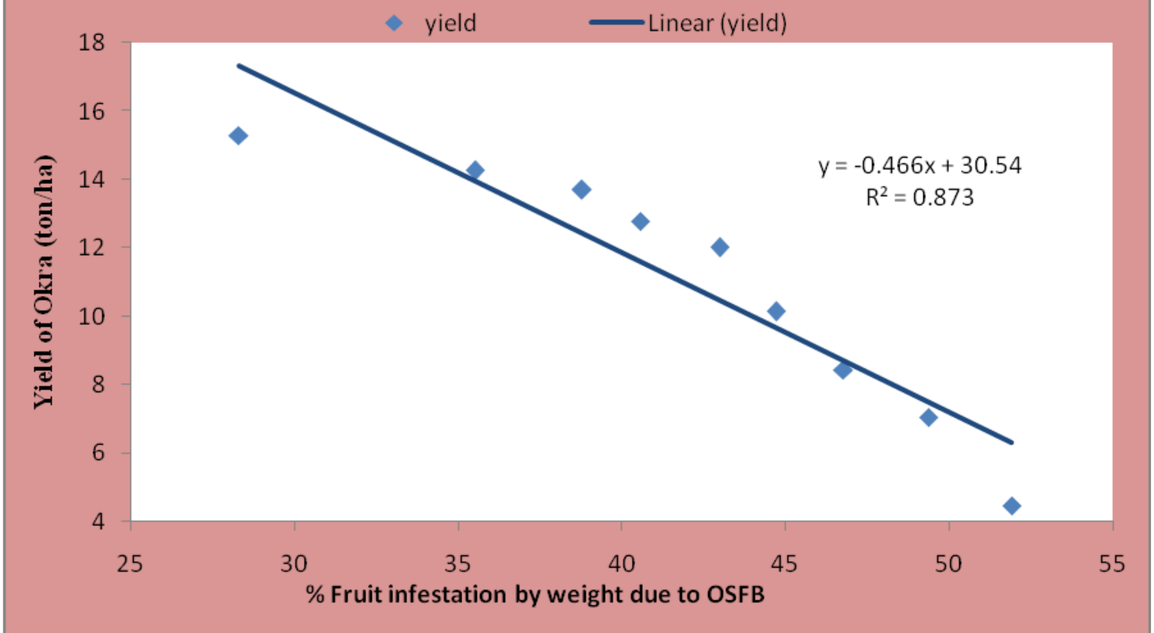


**Figure 4. Relation between Fruit infestation by weight due to OSFB and yield of okra**

**4.18 Relationship between yield of okra and height of okra plant among different management practices**

Correlation study was done to establish the relationship between yield of okra fruit and height of okra plant among different management practices. From the Figure 5 it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = 0.276x - 9.762 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.935) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the height of okra plant was strongly as well as positively correlated with the yield (ton/ha) of okra.

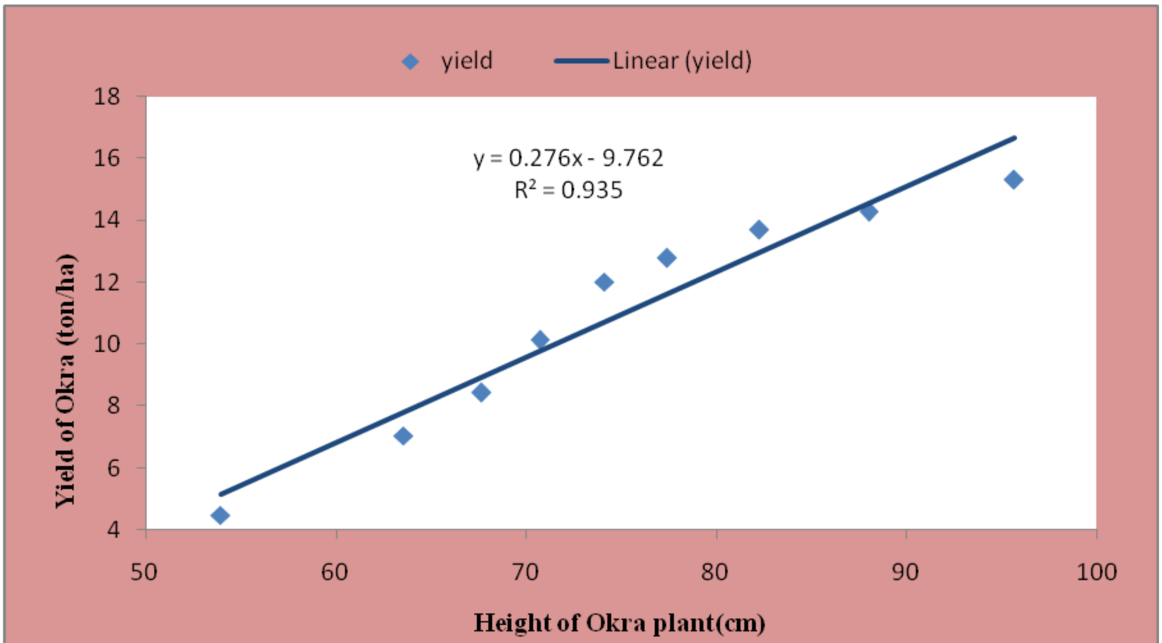


**Figure 5. Relationship between height of okra plant and yield of okra**

# CHAPTER V

# SUMMARY AND CONCLUSION

The present experiment was conducted at the field laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April to August, 2012 to evaluate the efficacy of synthetic insecticides and one botanical products against okra shoot and fruit borer (*Earias vittella* Fab.) and white fly *(Bemisia tabaci)*. The treatments are comprised with seven synthetic chemical insecticides, one botanical product and one untreated control and these are $T_1$ =Spraying of Actara 25WG @ 1g/L of water at 7 days interval; $T_2$ = Spraying of Neem oil @ 3ml/L of water at 7 days interval; $T_3$ = Spraying of Decis 2.5 EC@ 1ml/L of water at 7 days interval; $T_4$ = Spraying of Shorbicron 450 EC @ 2ml/L of water at 7 days interval; $T_5$ = Spraying of Suntap 50 WP @ 1.2g/L of water at 7 days interval; $T_6$ = Spraying of Ripcord 10 EC@1.5ml/L of water at 7 days interval; $T_7$ = Marshal100 EC@ 1.5ml/L of water at 7 days interval; $T_8$= Quinalphos @ 2ml/L of water at 7 days interval and $T_8$ = Untreated Control. The experiment was laid out in single factor Randomized Complete Block Design (RCBD) with three replications.

**SUMMARY**

Considering the efficiency of different management practices on different parameters, the findings of the results have been summarized below:

In terms of percent shoot infestation by number at the early fruiting stages, $T_6$ comprising Spraying of Ripcord 10 EC@ 1.5ml/L of water at 7 days interval performed best result in terms of percent shoot infestation reduction (59.68%) over control. Spraying of Neem oil @ 3ml/L of water at 7 days interval was showed the least performance (11.51%) in reducing percent shoot infestation by number at the early fruiting stage over control. The rank order of different management practices in terms of present shoot infestation reduction was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$(Suntap 50 WP)> $T_7$ ( Marshal 100EC ) >$T_8$ (Quinalphos ) > $T_3$ (Decis 2.5EC ) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of fruit infestation by number due to okra shoot and fruit borer at the early fruiting stages, $T_6$ comprising Spraying of Ripcord 10EC @ 1.5ml/L of water at 7 days interval performed best result in terms of percent fruit infestation by number reduction (45.30%) over control. As a result, order the trend of different management practices in terms of present fruit infestation reduction by number was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$ (Suntap 50 WP)> $T_7$ (Marshal 100 EC) >$T_8$ (Quinalphos) > $T_3$ (Decis 2.5 EC) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of fruit infestation by weight due to okra shoot and fruit borer at the early fruiting stage, $T_6$ comprising Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval performed best result in terms of percent fruit infestation by weight reduction (45.49%) over control followed by $T_1$ (31.61%) comprising Spraying of Actara 25WG @ 1g/L of water at 7 days interval. As a result, order the trend of different management practices in terms of present fruit infestation reduction by weight was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$ (Suntap 50 WP)> $T_7$ (Marshal 100EC) >$T_8$ (Quinalphos) > $T_3$ (Decis 2.5 EC) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In term of percent plant infestation by number due to okra shoot and fruit borer at the early fruiting stage, $T_6$ comprising Spraying of Ripcord 10 EC@ 1.5ml/L of water at 7 days interval performed best result in terms of percent plant infestation by number reduction (27.41%) over control followed by $T_1$ (22.87%) comprising Spraying of Actara 25WG @ 1g/L of water at 7 days interval. As a result, order the trend of different management practices in terms of present plant infestation reduction by number was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$ (Suntap 50 WP)> $T_7$ (Marshal 100EC) >$T_8$ (Quinalphos) > $T_3$ (Decis 2.5EC) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of effect of management practices of okra pests, the incidence of whitefly, *Bemisia tabaci* during the management of insect pest of okra at different days after sowing (DAS), $T_6$ comprising Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval performed best result in terms of percent incidence of whitefly reduction (45.29%) over control. As a result, order the trend of different management practices in terms of present incidence of whitefly reduction was $T_6$ (Ripcord 10EC)>

$T_1$ (Actara25 WG)> $T_5$ (Suntap 50 WP)> $T_7$ (Marshal 100EC) >$T_8$ (Quinalphos) > $T_3$ (Decis 2.5EC) > $T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of the effect of management practices on the leaf infestation by Okra Yellow Vein Clearing Mosaic Virus during the management of insect pest of okra at different days after sowing (DAS), $T_6$ comprising Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval performed best result in terms of percent leaf infestation by Okra Yellow Vein Clearing Mosaic Virus reduction (31.22%) over control. Spraying of Neem oil @ 3ml/L of water at 7 days interval was showed the least performance (3.33%) in reducing percent the leaf infestation by Okra Yellow Vein Clearing Mosaic Virus during the management of okra pests at the early fruiting stage over control. As a result, order the trend of different management practices in terms of present leaf infestation by Okra Yellow Vein Clearing Mosaic Virus reduction was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$(Suntap 50 WP)> $T_7$ ( Marshal 100EC ) >$T_8$ (Quinalphos ) > $T_3$ (Decis 2.5EC ) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of length of healthy fruit during the management of okra shoot and fruit borer at the early fruiting stage, $T_6$ comprising Spraying of Ripcord 10 EC@ 1.5ml/L of water at 7 days interval performed best result in terms of percent length of healthy fruit increase (67.37%) over control. As a result, order the trend of different management practices in terms of present length of healthy fruit incrase was $T_6$ (Ripcord 10EC) > $T_1$ (Actara25 WG) > $T_5$ (Suntap 50 WP) > $T_7$ (Marshal 100 EC) >$T_8$ (Quinalphos) > $T_3$ (Decis 2.5EC) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of length of infested fruit during the management of okra shoot and fruit borer at the early fruiting stage, $T_6$ comprising Spraying of Ripcord 10 EC@ 1.5ml/L of water at 7 days interval performed best result in terms of percent length of infested fruit increase (87.73%) over control. As a result, order the trend of different management practices in terms of present length of infested fruit increase was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$ (Suntap 50 WP)> $T_7$ (Marshal 100 EC) >$T_8$ (Quinalphos) > $T_3$ (Decis 2.5 EC) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In caes of girth of healthy fruit during the management of okra shoot and fruit borer at the early fruiting stage, $T_6$ comprising Spraying of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval performed best result in terms of percent girth of healthy fruit increase (35.03%) over control. As a result, order the trend of different management practices in terms of present girth of healthy fruit increase was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$(Suntap 50 WP)> $T_7$ ( Marshal 100EC ) >$T_8$ (Quinalphos ) > $T_3$ (Decis 2.5EC ) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of girth of infested fruit during the management of okra shoot and fruit borer at the early fruiting stage, $T_6$ comprising Spraying of Ripcord 10 EC@ 1.5ml/L of water at 7 days interval performed best result in terms of percent girth of infested fruit increase (85.20%) over control. As a result, order the trend of different management practices in terms of present girth of infested fruit increase was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$ (Suntap 50 WP)> $T_7$ (Marshal 100EC) >$T_8$ (Quinalphos ) > $T_3$ (Decis 2.5EC ) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In term of height of okra plants during the management of okra shoot and fruit borer, $T_6$ comprising Spraying of Ripcord 10 EC@ 1.5ml/L of water at 7 days interval performed best result in terms of percent height of okra plants increase (77.33%) over control. As a result, order the trend of different management practices in terms of present height of okra plants increase was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$(Suntap 50 WP)> $T_7$ ( Marshal 100EC) >$T_8$ (Quinalphos ) > $T_3$ (Decis 2.5EC ) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

In case of yield of fruit during the management of okra shoot and fruit borer,$T_6$ comprising Spraying of Ripcord 10 EC@ 1.5ml/L of water at 7 days interval performed best result in terms of percent yield of fruits increase (242.51%) over control. As a result, order the trend of different management practices in terms of present yield of fruits increase was $T_6$ (Ripcord 10EC)> $T_1$ (Actara25 WG)> $T_5$(Suntap 50 WP)> $T_7$ ( Marshal 100EC) >$T_8$ (Quinalphos) > $T_3$ (Decis 2.5EC ) >$T_4$ (Shobicron 425 EC) >$T_2$ (Neem oil) >$T_9$ (Untreated control).

Yield of okra was negative correlated with fruit infestation by number due to OSFB ($r^2$ = 0.934) and fruit infestation by weight due to OSFB ($r^2$ =0.873), but negatively correlated with fruit length ($r^2$ =0.954), girth ($r^2$ =0.958) and plant height ($r^2$ =0.935).

## CONCLUSION

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

- Ripcord 10 EC@ 1.5ml/L of water at 7 days interval reduced highest shoot infestation (59.68%), fruit infestation by number (45.30%), fruit infestation by weight (45.49%), plant infestation by number (27.41%), incidence of white fly, *Bemisia tabaci* (45.29%) and leaf infestation by Okra Yellow Vein Clearing Mosaic Virus (31.22%). On the other it increased length of healthy fruit (67.37%), length of infested fruits (87.73%), girth of healthy fruit (35.03%), girth of infested fruit (85.20%) and height of okra plants (77.33%), yield of okra (242.51%). This was closely followed by Actara 25WG and Suntap 50 WP respectively.

- Neem oil@ 3ml/L of water at 7 days interval days interval was showed the least performance compare to all of the insecticides. Neem oil reduced highest shoot infestation (11.51%), fruit infestation by number (10.91%), fruit infestation by weight (4.91%), plant infestation by number (4.15%), incidence of white fly, *Bemisia tabaci* (8.50%) and leaf infestation by Okra Yellow Vein Clearing Mosaic Virus (3.33%). On the other it increased length of healthy fruit (6.14%), length of infested fruits (14.35%), girth of healthy fruit (3.48%), girth of infested fruit (51.60%) and height of okra plants (17.87%), yield of okra (57.76%). This was closely followed by Neem oil and Shobicron 425 EC respectively.
- Okra yield was increased due to increases of fruit length, girth and plant height on the other hand fruit yield was decreased due to increase of fruit infestation by number and by weight occurs to okra shoot and fruit borer (OSFB).

**Considering the findings of the study the following recommendations can be suggested:**

- Application of Ripcord 10 EC @ 1.5ml/L of water at 7 days interval may be recommended as an effective control measure applied against OSFB and whitefly infested okra.
- Further intensive studies based on different doses of Ripcord and Actara may be conducted.
- More chemicals and botanicals with their derivatives should be included in further elaborative research for controlling OSFB and whitefly.

# CHAPTER VI

# REFERENCES


Abdullah, N.M.M. and Singh, J. (2004). Effect of insecticides on longevity of the whitefly, *Bemisia tabaci* Gennadius on cotton. *University Aden J. Natural Appl. Sci*. **8**(ii):261-268.

Acharya, M.C. (2002). Determination of economic threshold levels and integrated management of fruit borer, *Earias vittella* (Fab.) on okra, *Abelmoschus esculentus* (L.) Moench. M.Sc. Thesis, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.

Acharya, M.C. (2010). Determination of Economic Threshold level and Integrated Management of Okra Fruit Borer *Earias vittella* (Fab.). *J. Prot. Society*. **2**: 47-61.

Ahmed, S.S. (1984). Some promising plant species for use as pest control agent under traditional farming system. In: Proceedings on 2nd Neem Conference Reschhdzhouson FRG. pp. 565-580.

Ahmed, K.U. (1995). Pal-Phul O Shak-Shabji (In Bengali) 5th ed. Mirpur, Dhaka, Bangladesh. p. 400.

Ahmad, F., Khan, F.R. And Khan, M.R., (1995), Comparative efficacy of some traditional and non- traditional insecticides against sucking insect pests of cotton. *Sarhad J. Agriculture*, **11** : 733-739.

Ahmed, H., Ali, S., Khan, M.A. and Habib, A. (1995). Efficacy of neem oil and synthetic growth regulators on control of okra insect pests as compared to chemical pesticides. *J. Sustan. Agric Environ.* **5**(1-2): 232-245.

Ali, M.I. (1992). Seasonal occurrence of different cotton bollworms on cotton in Bangladesh. *Bangladesh J. Entomol*. **2**(1 & 2).

Ambekar, J.S., Pawar, A.S. and Sakhare, M.V. (2000). Bio-efficacy of certain neem products against okra fruit borer. *J. Maharashtra Agril. Uni.* **25**(1): 42-43.

Anonymous. (1987). Annual Report for (1986-87). Central Institute for Cotton Research, Nagpur. P. 27.

Anonymous. (1993). Research and development of vegetable crops. Paper presented in the workshop on importance of okra as summer vegetable on March 9-10, IPSA, Gazipur.pp.1-07.

Atiri, G.I., Ivbijaro, M.F. and Oladele, A.D. (1991). Effects of natural synthetic chemicals on the incidence severity of okra mosaic virus in okra. *Tropical Agril*. **68** (ii):178-180.

Atwal, A.S. (1976). Agricultural Pest of India and South-East Asia. Kalayani Publishers, New Delhi. pp. 283-285.

Atwal, A.S. (1999). Pests of Cotton. 4 th Edn., Kalyani Publishers, New Delhi. pp. 224-234.

Avidov, Z. (1956). Bionomics of the tobacco whitefly (*Bemisia tabaci* Gennad.) in Israel. Katvim. 7: 25-41.

Azab, A.K., M.M. Megahed and D.H. El-Mirsawi. (1971). On the Biology of *Bemisia tabaci* (Genn.). *Societe Entomol. D'Egypte Bull*. 55: 305-315.

Azam, K.M., Razvil, Z. and Al-Raeesi, A.A. (1997). Management of whitefly *Bemisia tabaci* Gennadius and tomato leaf curl virus in tomato crops. *Arab and Near East Plant Protect. Newsl.* No. 25, 27.

BBS (Bangladesh Bureau of Statistics). (2009). Ministry of Planning, Government of Peoples Republic of Bangladesh. Yearbook of Agric. Statistics of Bangladesh. Dhaka.

Badaya, A.K., Deshpande, R.R. and Ali. S.A. (1999). Efficacy and economics of different insecticides for the control of okra fruit and shoot borer, *Earias vittella* Fab. *Bhartiya Krishi Anusandhan Patrika,* **6**(3-4): 181-185.

Basu, A. N. (1995). *Bemisia tabaci* Gennadius-Crop pest and principal whitefly vector of plant viruses. Oxford &IBH Pub. Co. Pvt. Ltd. New Delhi. pp. 183.

Banken, J.A.O. and Stark, J.D. (1997). Stage and age influence on the susceptibility of *Coccinella septempunctata* after direct exposure to neemix, a neem insecticide. *J. Eco. Entomol.* **90**(5): 1102-1105.

Begum, M.A. (2002). Prevalence and spread of *Okra yellow vein clearing mosaic virus (*OkYVCMV*)* in the field and its impact on growth and yield of okra. M.S. Thesis. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. pp 135.

Berlinger, M.J. (1986). Host Plant Resistance to *Bemisia tabaci*. *Agric. Ecosystems Environ*. **17**: 69-82.

Berlinger, M.J., Taylor, R.A.J. Lebiush-Mordechi, S., Shalhevet, S. and Spharim, I. (2002). Efficacy of exclusion screens for preventing whitefly transmission of tomato yellow leaf curl virus of tomatoes in Israel. *Bull. Entomol. Res*. **92**(5):367-373.

Bilton, J.N., Broughton, H.B., Ley, S.V., Lidert, Z., Morgan, E.D., Rzepa, H.S. and Sheppard, R.N. (1985). Structural reappraisal of the limonoid insect antifeedant azadirachtin. *J. Chem. Soc., Chem. Commun*. pp. 968-971.

Borah, R.K. and Nath, P.D. (1995).Evaluation of an insecticide schedule on the incidence of whitefly, *Bemisia tabaci* Genn. and yellow vein mosaic in okra. *Indian J. Virol*. **11**(ii):65-67.

Brickle, D.S., Tumiseed, S.G. and Sullivan, M.J. (2001). Ovicidal effects of insecticides on eggs of gram podborer (*Helicoverpa armigera*) and spotted bollworm (*Earias vittella*). *Indian J. Agril. Sci*. **63**(12):853-855.

Broughton, H.B., Bilton, J.N., Ley, S.V., Lidert, Z., Morgan, E.D., Rzepa, H.S. and Sheppard, R.N. (1986). Structural reappraisal of the limonoid insect antifeedant azadirachtin. *J. Chem. Soc., Chem. Commun*. pp. 968-971.

Brown, J.K., Frohilch, D.R. and Rossel, R.C. (1995). The sweet potato or silverleaf whiteflies: Biotype of *Bemisia tabaci* or a species complex. *Ann. Rev. Entomol*. **40**:511-34.

Butani, Dhomo K. and Jotwani, M.G. (1984). Insects in vegetables. Periodical expert Book Agercy, India. p: 356.

Butani, K. and Verma, S. (1976). Insect pests of vegetables and their control. **10**: pp. 31-37.

Butler,G.D.J.,T.J. Henneberry and T.E. Clayton. (1983). *Bemisia tabaci* (Homoptera: Aleyrodidae): Development, Oviposition, and Longevity in Relation to Temperature. *Ann. Entomol. Soc. America*. **76**(2): 310-313.

Butterworth, J.H. and Morgan, E.D. (1968). Isolation of substance that suppresses feeding in locusts. *J. Chem. Commun*. pp. 23-24.

CCSHAU. (1997). The Package of Practices for Kharif Crops. Hisar: India. CCS Haryana Agricultural University.

Cahill, M., Byrne, F.J., Gorman, K., Denholm, I., and Devonshire, A.L. (1995). Pyrethroid and Organophosphate resistance in tobacco whitefly, *Bemisia tabaci* (Homoptera:Aleyrodidae). *Bull. Entomol. Res*. **85:** 181-187.

Chaudhury, H. R. and Dadheech, L.N. (1989). Incidence of insects attacking okra and the avoidable losses caused by them. *Ann. Arid Zone*. **28** (3-4):305-307.

Chaudhury, D.S. (2001). Evaluation of synthetic and bio-pesticides against OSFB. Current Research Report. Mahatama Phula Agril. Univ. **2**(1): 256-261.

Chauhan, D.V.S. (1972). Vegetable production in India. 3rd Edition. Published by Ram Prasad Sons, Agra. pp. 28-30.

Chinniah and Mohanasundaram, M., (1999). Evaluation of neem derivatives for their toxic effect on safety to predatory mites, *Amblyseius* spp. (Acarina : Phytoseidae) in cotton ecosystem. *Pestology*, 123 : 45-48. cotton aphid (*Aphis gossypii*). *Indian J. Agric. Sci.*, **63** : 134- 135.

Choi In Hu, Jang YongSeok, Kim GilHah and Kim JeongWha, (2004). Control effects of some insecticides on different stages of the stone leek leafininer , *Liriomyza chinensis* Kato (Diptera:Agromyzidae).*Korean AppI. Entomol*. **43**(2): 169-173.

Cock, M.J.W.Ed. (1986). *Bemisia tabaci*, A Literature Survey on the Cotton Whitefly with an Annotated Bibliography. Food and Agriculture Organization of the U.N., C.A.B. Int. Inst. Biol. Cont. 121 pages.

Cohen, S. and M.J. Berlinger. (1986). Transmission and Cultural Control of Whitefly-borne Viruses. *Agric. Ecosystems Environ*. **17**: 89-97.

Dangi, P.R. (2004). Incidence of *Earias vittella* (Fabricius) and its management in okra, *Abelmoschus esculentus* (L.) Moench. M.Sc. Thesis, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.

Dash, A.N., Mahapatra, H., Pradhan, A.C. and Patnaik, N.C. (1987). Effect of mixed and inter cropping on occurrence of some pest in Orissa. *Environ. Ecol.* **5**(3): 526-530.

David, B.R. (2001). Elements of Economic Entomology. Population Book Report, Chennai. pp: 198-207.

De Barro, P.J. (1995). *Bemisia tabaci* Biotype B: a review of its biology, distribution and control. Division of Entomol .Technical paper no. 33. *Common. Sci. Indus. Res. Org*., Canberra, Australia.

Dhamdhere, S.V., Bhadur, I. and Mishra, U.S. (1984). Studies on occurrence and succession of pests of okra at Gwalior. *Indian J. Plant Prot.* **12**: 9-12.

Dhawan, A.K. and Sidhu, A.S. (1984). Incidence and relative abundance of different species of spotted bollworms on okra at Ludhiana, Punjab. *J. Res. Punjab Agric.Univ.* **21**: 533-542.

Dongre, T.K. and Rahalkar, G.W. (1992). Relative host plant preference and induction of preference for feeding behavior in spotted bollworm. *Indian Ecol*. **19**(1): 61-64.

Dutt, A.K. and Saha, J.L. (1990). Insect pest management of winter planted cotton in coastal rice fallow of West Bengal. *Tropical pest manage.* **36**(2): Pp. 89-92.

El-Helaly, M.S., A.Y.El-Shazil, and F.H. El-Gayar. (1971). Biological studies on *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae) attacking cotton in the coastal plain of Israel. *Bull. Entomol. Res.* **70**: 213-219.

Gautam, R.K. and Goswami, N. (2004). Different food varies for amino acids in moth larvae. *Uttar Pradesh Zool*. **24** (2):183-186.

Gennadious, P. (1889). Disease of the tobacco plantation in the Triconia. The aleurodid of tobacco. *Ellenike Ga*. **5**:1-3.

George, P.J.E. (1997) Effect of some plant odours in the breeding environment on fecundity and hatching of okra shoot and fruit borer, *Earias vittella* Fab. Under laboratory conditions. *Crop Res. Hisar*. **13** (3):157-161.

Gomez, K.A. and Gomez, A.A. (1976). Statistical Procedure for Agricultural Research ($2^{nd}$ Ed). A Willey Inter science Publication, New York. P. 680.

Gopal an, C., Rama Sastri, B.V. and Balasubramanian, S. (2007). Nutritive Value of Indian Foods, published by National Institute of Nutrition (NIN), ICMR.

Greathead, A.H. (1986). Host Plants. Chapter 3, pp. 17-25. In: *Bemisia tabaci* - a literature survey on the cotton whitefly with an annotated bibliography (Ed. M.J.W. Cock). CAB International Institute of Biological Control, Ascot, UK. P. 121.

Griffiths, D.C., Greenway, A.R. and Lioyd, S.L. (1978). The influence of repellent materials and aphid extracts on settling behavior and larviposition of *Myzus piersicae* (Sulzer) (Hemiptera: Aphididae). *Bull. Ent. Res.* **68:** 613-619.

Griffiths, D.C., Pickett, J.A., Smart, L.E. and Woodcock C.M. (1989). Use of insect antifeedant against aphid vectors of plant virus disease. *Pestic. Sci*. **27**: 269-276.

Gupta, G.P. and Sharma, K. (1997). Neem-based pest management strategy in cotton system. *Pesticide Res. J*. **9**: 190–197.

Haider, M.Z. (1996). Effectiveness of some IPM packages for the management of virus-disseminating whitefly on tomato. M.S. thesis in Entomology, IPSA, Salna, Gazipur, Bangladesh. 1-65 pp.

Harender, R. Bhardwaj, M. L. and Sharma, N.K. (1993). Performance of commercial okra( *Hibiscus esculentus*) varieties in relation to disease and insect pests. *Indian J. Agric. Sci*. **63**(xi): 747-748.

Haque, M.M. (1993). Tomato, Brinjal and Okra. In: Ahmed and Sahajahan, M. (ed). Homestead vegetable production, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. p. 61.

Hill, D.S. (1983). Agricultural Pests of the Tropics and their control. Cambridge University press. Cambridge, New York. pp. 64-367.

Husain, M.A., Trehan K.N. and Verma, P.N. (1939). Eonomics of field scale spraying against the whitefly of cotton (*Bemisia gossypiperda*, M. and L.). *Indian J. Agric. Sci*. **9**: 109-126.

International Board for Plant Genetic Resources IBPGR. (1990). Report on International Workshop on Okra Genetic resources held at the National bureau for Plant Genetic Resources, New Delhi, India

Islam, M.N., Kumar, N.K. and Karim, M.A. (1999). Efficacy of different insecticides for the control of okra shoot and fruit borer , *Earias vittella* F. Annual Report.(1998-99). BARI, Joydevpur, Gazipur, Bangladesh: pp. 33-34.

Jayaraj, S., Rangarajan, G.A.V., Murugesan, S., Santharam, G. Vijayaraghavan, S. And Thangaraj, D., (1986), Outbreak of whitefly *Bemisia tabaci* (G.) on cotton in Tamil Nadu and its management. *All Indian Group Discussion on Whitefly in Cotton,* Guntur, April 29-30, (1986).

Johnson, M.W., D.E. Ullman, B.E. Tabashnik, H. Costa and A. Omer. (1992). Sweetpotato Whitefly Information from Hawaii. (Given to me by Amir, get reference to include the appropriate information, he did not want this paper cited).

Joshi, B.G. and Sitaramaiah, S. (1979). Seed kernel as an oviposition repellent for *Spodoptera litura* (F.) moths. **7**: 199–202.

Kabir, K.H., Rouf, F.M.A., Islam, M.N. and Malakar, P.K. (1994). Efficacy of different insecticides in controlling brinjal shoot and fruit borer, Leucinodes orbonalis Guen. Univ. 3. Zool., Rajshahi Univ. 13: 1-8.

Kadam, J.R. and Khaire, V.M. (1995). Raining and relative humidity: key factors to suppress *Earias vittella* Fab infestation on Okra crop. *J. Ento. Res.* **19**(3): 201-205.

Karim, M.A. 26-29 January (1992). Vegetable production and marketing. Proceedings of a national review of planning workshop hold at BARI, Gazipur, Bangladesh.

Khaliq, A. and Yousuf, M. (1986). Effect of weather on the light-trap captures of some insect pests of cotton. *J. Agric. Res. Lahore.* **24** (4): 313-319.

Khan, M.A. and Mukhopadhyay, S. (1985). Effect of different pesticide combinations on the incidence of yollow vein mosaic virus of okra (*Abelmoschus esculentus*) and its whitefly vector *Bemisia tabaci* Genn. *Indian J. Virol*. **1**(ii):147-151.

Khan, M.H. and Verma, P.M. (1946). Studies on *Earias spp* (the spotted bollworm of cotton) in the Punjub. The biology of the common parasites of *Earias fabia* stoll, *E. insulana* (Boisd) and *E. cupreoviridis* (WK). *Indian J. Entomol.* **7**: 41-63.

Khurana, A.D. and Verma, A.N. (1990). Comparative damage caused by bollworms and yield of seed cotton during a dry and wet year in Haryana. *J. Insect Sci.* **3**(2): 180-182.

Koul, O. and Isman, M.B. (1991). Effects of azadirachtin on the dietary utilization and the development of the variegated cutworm *Performa saucier*. *J. Insect. Physiol.* **37**: 591-598.

Kraus, W., Bokel, R., Klenk, A. and Pohnl, H. (1985). Constituents of neem and related species: A reversed structure of azadirachtin. Third Int. Conf. of Chemistry and Biotechnology of Biologically Active Natural products (Sofia, Bulgaria, 1985), Abstr. pp. 446-450.

Krishna, S.S. (1987). Nutritional modulation of reproduction in two phytophagous insect pests. *Id. Aca. Sci.* **96**(3): 153-169.

Krishnaiah, K. (1980). Methodology for assessing crop losses due to pests of vegetables "Assessment of crop losses due to pest and diseases". USA Tech. Series no. **33**: 259-267.

Kumar, N. K. K. and Moorthy, P. N. K. (2000). Transmission of Yellow vein mosaic geminivirus to imidacloprid treated okra by the white fly, *Bemisia tabaci* Gennadious. *Insect Environ*. **6** (i): 46-47.

Lakshmanan, K.K. (2001). Neem a natural pesticide. *The Hindu, March* 1. P.8.

Leuschner, K. (1972). Effects of an unknown substance on a shield bug. *Naturwissenshaften*. **59**: 217.

Maleque, M.A. (1998). Judicious application of insecticides for the management of Brinjal shoot and fruit borer. M.S. Thesis, BSMRAU, Salna, Gazipur, Bangladesh. management of fruit borer, *Earias vittella* (Fab.) on okra, *Abelmoschus esculentus* (L.) Moench. M.Sc. Thesis, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.

Mandahar, C.L. and Singh, J.S. (1972). Effect of bhendi yellow vein mosaic on its host. *Acta. Acad. Sci. Hungaricae* **7**: 187-191.

Marcano, R. and Gonzalez, E. (1993). Evaluation of insecticides for the control of the whitefly *Bemisia tabaci* (Gennadius) in tomato. *Bol.Entomol. Venezolana*. **8** (ii): 123-132.

Mau, Ronald F.L. and Dick Tsuda. (1991). Sweetpotato whitefly *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae).

Miah, M.A.S. (1988). Effect of date of planting and insecticidal spray on control of yellow vein mosaic of Lady`s finger (*Hibiscus esculenturs* L.) abstracts of Theses (1966-1990). Department of plant pathology, Bangladesh Agricultural University, Mymensingh-2202, March, (1991).79 p. *Maharashtra Agric. Univ.* **2**(2): 175.

Misra, P.N. (1989). Bio-efficacy of some newer insecticides against the pest complex of okra. *Bangladesh Hort*. **17**(1):1-4.

Misra, H.P., Dash, D.D. and Mahapatro, D. (2002). Efficacy of some insecticide against okra fruit borer and leaf roller. *Ann. Pl. Proect. Sci.* **10**: 51-54.

Mohan, J., Krishnaiah, K. and Prasead, V.G. (1983). Chemical control of insect pest of okra. *Indian J. Entomol.* **45**(2): 252-258.

Morale, R.S., Sarnaik, D.N., Satpute, U.S. and Sadawarte, A.K. (2000). Effect of plant products on growth and development of *Helicoverpa armigera* on cotton. *Pestol*. **24**(6): 50-55.

Mote, U.N. (1977). Seasonal incidence of okra shoot and fruit borer, *Earias vittella. J.*

Mound L.A. and S.H. Halsey. (1978). *Bemisia tabaci* (Gennadius). pp. 118-124. In Whitefly of the World, A Systematic Catalog of the Aleyrodidae (Homoptera) with Host Plant and Natural Enemy Data. British Museum (Natural History ) and John Wiley & Sons, Chichester, New York, Brisbane, Toronto. 340 pages.

Mudathir, M. and Basedow, T**.** (2004). Field experiments on the effects of neem products on pests and yields of okra *Abelmoschus esculentus* in the Sudan. *Mitteil. Deutsch. Gesellsch. allgem. angew. Ent*. **14**: 407-410.

Ngo, N., Moore, S., Lawson, S., Dugger, P. and Richter, D. (1999). Ovicidal research with emamectin benzoate against tobacco budworm eggs. Beitwide Cotton Conferences, Orlando, Florida, USA, 3-7 January, (1999):1090-109. (1988). Schedule of insecticidal application against insect pest complex of brinjal with special reference to brinjal shoot & fruit borer,- *Leucinodes orbonalis* Guen. *Indian J*. **50** (1): 16-19.

Nandihalli, B.S., Parameshwara Hugar And Patil, B.V. (1990). Evaluation of neem and neem products against cotton whitefly, *B. tabaci* (Genadius). *Karnataka J. Agril. Sci.*, **3** : 58-61.

Nath, P. and Saikia, A.K. (1993). Assessment of yield loss due to yellow vein mosaic of okra (Abelmoschus esculentus L. ) in *Assam J. Agric. Sci. Soc*., North East India. **6** (iv): 87-88.

Pareek, B.L., Kumawat, R.L. and Patni, S.K. (2001). Effect of abiotic factors on the incidence of okra insect pests in semi-arid conditions. Proceeding of the National Conference on plant protection- New Horizons in the Millennium, Feb. 23-25, Udaipur. pp. 1-8.

Parvin, S. (2004). Performance of four okra varieties relation to *Okra Yellow Vein Clearing Mosaic Virus* (OkYVCMV) incidence and its impact on growth and yield. M. S. Thesis. Department of plant pathology BSMRAU, Salna. Gazipur.

Patel, M.S., Yadav, D.N. And Rai, A.B., 1994, Neemark (Azadirachtin) as ovipositional deterrent against cotton pests. *Pestol.*, **18** : 17-19.

Patel, N.C., Zala, S.P. and Patel, J.R. (1999). Impact of weather on magnitude of *Earias vittella* infesting okra. *Indian J. Ento*. **61**(4): 351-355.

Patil, C.S., Pawer, S.A., Mote, U.N. and Khaire, V.M. (1991). Evaluation of cypermethrin (SIRcis and RIS-cis isomers) against okra fruit borer. *Ann. AppI. Biol*. **118** (suppl.):20-21.

Patil, R.S. (2000). Utilization of plant products in the management of okra shoot and fruit borer *Earias vittella* in okra crop. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Pearson, E.O. (1958). The insect pests of cotton in tropical Africa. *Int. J. Applied Entomol.* **12**: 71-74.

Prakash, A., Rao, J., Pasalu, I.C. and Mathur, K.C. (1987). Rice Storage and Insect Management. B.R. Publishing Corporation, New Delhi. p.337.

Parkash, O. (1988). Schedule of Insecticidal Application against insect pest complex of brinjal with special reference to brinjal shoot and fruit borer , *Leucinodes orbonalis* Guen. *Indian J. Entomol*. **50 (1)**:16-19.

Prakash, A., Rao, J., Jevari, S.N. and Gupta, S.P. (1990). Rice agro ecosystem management by pesticides and its consequences. *Nat con. Publ. in Growth Develop.Natural Res. Conservations*. pp. 131-137.

Pruthi, H.S. (1946). Report of the Imperial Entomologist. Abridged science Reports, Agricultural Research Institute, New Delhi. (1941-44). **99**: 64-71.

Rahman , M.H. and H. Ali. 1983.Biology of spotted bollworm of cotton, *Earias vittella* Fab. *Pakistan J. Biol*. **13**(1-2): 105-110.

Rai, S. (1985). Chemical control of Bhindi pests . *Indian J. Entomol.* **7** (2): 173-178.

Rajasekaran, B. and Kumarswami, Y. (1985). Antifeedent properties of certain plant products against *Spodoptera litura* (F.). In: Proceedings of National Seminar on Behavioral Physiology Appr. Mrmt. Crop pests, Tamil Nadu Agricultural University. pp. 25-28.

Ramiah, M., Vidhyasekaran, P. and Kandaswamy, T.K. (1972). Changes in photosynthetic pigments of bhendi infected by yellow vein mosaic disease. *Madras Agril. J.* **59**:402-404.

Rana, B.S. (1983). Studies in the effectiveness of some insecticides against insect pests of bhendi, *Abelmoschus esculentus* (L.) Moench. M.Sc. Thesis, Udaipur University, Rajasthan.

Rao, S.N., Rajendran, R. and Raguraman, S. (2002). Antifeedant and growth inhibitory effects of neem in combination with sweet-flag and pungam extracts on Okra shoot and fruit borer, *Earias vittella* (Fab.). *J. Entomol. Res*. **26** (3): 233-238.

Rashid, M. M. (1999). Shabjibiggayan (In Bengali). Rashid Publishing House, 94 Old DOHS, Dhaka-1206. P. 49.

Rosaiah, R., (2001), Performance of different botanicals against the pests complex in bhendi. *Pestol*, **25** : 17-19.

Sardana, H.R. and Krishnakumar, N.K. (1989). Effectiveness of plant oils against leafhopper, shoot and fruit borer in okra. *Indian J. Entomol*. **51** (2): 167- 171.

Sarkar, B.B. and Nath, B.C. (1989). Field evaluation of various insecticides against fruit borer and effect on yield of lady’s finger seed. *Pestol*. **13**(4): 19-21.

Sastry, K. S. M. and Singh, S. J. (1974).Yellow vein mosaic virus infection on growth and yield of lira crop. *Indian Phytopath*. **27**: 294-297.

Satpathy. S and Rai, S. (1999). Efficacy of different pesticides and combination against jassid borer of okra. *Vege. Sd*. **26**(1):78-81.

Satpute, N.S., Deshmukh, S.D., Mane, P.N., Rao, N.G.V. and Nimbalkar, S.A.(2002). Growth and development of spotted bollworm, *Earias vittella* (Fab.) reared on different hosts under laboratory conditions. *PKV. Res.* **26**(1/2):47-50.

Savello, P.A., Mortin, F.W. and Hill, J.M. (1980). Nutritional composition of okra seed meal. *Agril. Food Chem.* **28**: 1163-1166.

Saxena, R.C., Waldbauer, G.P., Liquido, N.J. and Puma, B.C. (1981). Effects of neem seed oil to the rice leaf folder, *Cnaphalocrocis medinalis*. In: Natural

Pesticides from the Neem Tree (*Azadirachta indica* A. Juss) and Other Tropical Plants. Ed. by Schmutterer, H.; Ascher, K. R. S. Rottach-Egern, Germany: Eschborn: GTZ, 189–204.

Schmutterer, H. (1961). The most important pests of crops in the central rainlands of the Sudan and their control. *Anz. Schadlinge.* **34**: 177-180.

Schmutterer, H., Saxena, R.C. and Heyde, V.D.J. (1983). Morphogenetic effects of some partially-purified fractions and methanolic extracts of neem seeds on *Mythimna separata* (Walker) and *Caphalocrocis medinalis* (Guyenne). *Z. Angew. Entomol*. **95**: 230-237.

Schmutterer, H. (1985). Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. *Annu. Rev. Entomol*. **35**: 271-297.

Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. *Ann. Rev. Ent*. **35**: 271–290.

Schmutterer, H. (1995). The neem tree, *Azadirachta indica* A. Juss and other eliaceous plants Sources of unique natural products for integrated pest management, medicines, industry and other purposes. VCH Publishers Inc., New York, USA. P. 253.

Shah, B.R., Vyas, H.N. and Jhala, R.C. (2001). Population dynamics of major insect pests of okra *Abelmoschus esculentus* (L.) in relation to weather parameters. *In:* Abstracts National conference: Plant Protection –New Horizons in the Millennium (NCPP). Udaipur (Raj.) p$^{4}$.

Sharma, I.N., Lall, B.S., Sinha, R.P. and Singh, B.N. (1985). Biology of spotted bollworm *Earias vittella. Bull. Entomol*. **26**(1): 38-41.

Sharma, R.P., Swaminathan, R. and Bhati, K.K. (2010). Seasonal incidence of fruit and shoot borer of Okra along with climatic factors in Udaipur region of India. *Asia J. Agril. Res.* **4** (4): 232-236.

Shukla, A., Pathak, S.C. and Agrawal, R.K. (1997). Seasonal incidence of okra shoot and fruit borer, *Earias vittella* and effect of temperature on its infestation level. *Plant Sci.* **10** (1): 169-172.

Singh, Y. and Bichoo, S.L. (1989). Some biological and bionomical observation of *Earias* spp. *Bull. Entomol. New-Delhi*. **30** (1): 84-91.

Singh, M.P., Sharma, D. P. And Mishra, H.P., (1999), Efficacy of plant extracts against cotton whitefly, *Bemisia tabaci* (genn.). *Annals of Plant Protection Sciences*, **26**: 46-48.Singh, B.K., Singh, A.K. and Singh, H.M. (2005). Efficacy of certain synthetic insecticides and two botanicals against the okra fruit and shoot borer, *Earias vittella* (Fab.). *Pest Manage. Economic Zool*. **13**(1): 99-103.

Sojitra, I.R. and Patel, J.R. (1992). Effects of plant extracts (including Azadirachta indica, Ricinus communis and Pongamia pinnata) on ovipositional behaviour of spotted bollworm (*Earias vittella*) infesting okra (*Abelmoschus esculentus*). *Indian J. Agric. Sci.* **62**: 848–849.

Srabani, Debnath, Nath, P. S. and Denath, S. (2002). Management of yellow vein mosaic disease of okra through insecticides, plant products and suitable varieties. *Ann. Plant Protect. Sci*. **10** (ii):340-342.

Srinivasan, P.M. and Gowder, R.B. (1959). A preliminary note on the control of the okra shoot and fruit borer, *Earias fabia* and *E. insulana. Indian J. Agric. Sci.* **30** (1): 55-57.

Srinivasan Murthy, K. And Sharma, D.P., (1997), Traditional pest management in cotton. *Insect Environ.,* **3** : 73-74.

Thakur, M.R., Arora, S.K., Bose, T.K. and Son, M.G. (1986). Vegetable crops in India. $6^{th}$ edition. Calcutta, India. p. 678.

Thomson, H.C. and Kelly, W.C. 1979. (3rd ed.) Vegetable crops. Mcgraw Hill Co. New York. P. 562.

Tindall, H.D. (1986). Vegetables in the Tropics. 1st edition, Macmillan Publishers, Hong kong. pp. 325-327.

Torres, J.B. Ruberson, J.R. (2004). Toxicity of thiamethoxam and imidacloprid to *Podisus nigrispinus* (Dallas) (Heteroptera:Pentatomidae) nymphs associated to aphid and whitefly control in cotton. *Neotropic. Entomol*. **33**(i):99-106.

Verma, S, Gupta, R.S., Vishwa nath, S.P., Kawal, D. and Sing, R. (1980). Control of pests of okra. *Indian J. Entomol*. **42**: 822-823.

Warthen, J.D., Uebel, J., Dutky, E.C., Luspy, S.R. and Finegold, W.R. (1978). Adult house fly feeding deterrent from neem seeds. *USDA/SEA Agric. Res. Results, Northeast.* **2**: 1-11.

Yadvendu, T.C. (2001). Evaluation of newer insecticides against insect pests of okra (*Abelmoschus esculentus*). M.Sc. Thesis, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan

Yamaguchi, M. (1998). World Vegetables Principles, Production and Nutritive Values. Van Nostrand Reiduction. New York, USA. pp. 415.

Zala, S.P., Patel, J.R. and Patel, N.C. (1999). Impact of weather on magnitude of *Earias vittella* infesting okra. *Indian J. Ent.* **61** (4): 351-355.

# APPENDICES

## Appendix I. Physiological properties of the initial soil

| Characteristics | Value | Critical value |
|---|---|---|
| Partical size analysis | | |
| % sand | 26 | - |
| % silt | 45 | - |
| % clay | 29 | - |
| Textural class | Silty clay | - |
| pH | 5.6 | Acidic |
| Organic carbon (%) | 0.45 | - |
| Organic matter (%) | 0.78 | - |
| Total N (%) | 0.03 | 0.12 |
| Available P (ppm) | 20.00 | 27.12 |
| Exchangeable K (me $100^{-1}$ g soil) | 0.10 | 0.12 |
| Available S (ppm) | 45 | - |

## Appendix II: Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from April 2012 to August, 2012

| Date/Week | Temperature | | Relative humidity (%) | Rainfall (mm) (Total) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| April | 33.8 | 23.1 | 63 | 125 |
| May | 33.1 | 24.4 | 75 | 237 |
| June | 32.3 | 26.2 | 81 | 316 |
| July | 32.0 | 26.5 | 79 | 359 |
| August | 31.4 | 26.2 | 83 | 411 |
| September | 32.2 | 26.5 | 76 | 206 |

**Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargaon, Dhaka- 1207**