DEVELOPMENT OF AN IPM PACKAGE FOR COMBATING THE OKRA SHOOT AND FRUIT BORER (*EARIAS VITTELLA* FAB.) IN OKRA

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CERTIFICATE

*This is to certify that thesis entitled, "**DEVELOPMENT OF AN IPM PACKAGE FOR COMBATING THE OKRA SHOOT AND FRUIT BORER (EARIAS VITTELLA FAB.) IN 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 field research work carried out by* ***ROSNA AFROZ,* Registration no. 05-01818** *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: December, 2010
Place: Dhaka, Bangladesh

(Prof. Dr. Md. Mizanur Rahman)
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ABSTRACT

A field experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Bangladesh during May 2011 to August 2011 to develop an IPM package for controlling Okra shoot and fruit borer in okra. The experiment was comprised with eight treatments including an untreated control and laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were as follows T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval; T_2 = Spraying of water based neem seed kernel extract @ 50g/L of water at 7 days interval; T_3 = Spraying of water based neem leaf extract @ 200g/L of water at 7 days interval; T_4 = *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval; T_5 = Spraying of neem oil @ 4ml/L of water + *T. evanescens* egg parasitoid @ 0.25g/plot at 7 days interval; T_6 = Spraying of water based neem seed kernel extract @ 50g/L of water + *T. evanescens* egg parasitoid @ 0.25g/plot at 7 days interval; T_7 = Spraying of water based neem leaf extract @ 200g/L of water + *T. evanescens* egg parasitoid @ 0.25g/plot at 7 days interval; T_8 = Untreated control. It was observed that T_5 treatment performed best results in reduction of shoot infestation (96.50 %), flower bud infestation (83.33 %), fruit infestation by number and weight (93.80 % and 86.90 % respectively) and infestation intensity (77.47 %) over control. The lowest number of larva per fruit (0.32) was recorded in T_5 whereas, the highest number of larva per fruit (1.60) was recorded from untreated control. The yield contributing characters provided best performance in yield which found in T_5 where yield was increased (99.37 %) over control and also gave maximum (6.46) Benefit Cost Ratio (BCR) in the same treatment.

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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; Rashid 1999). About 38,508 metric tons of okra is produced from 9786 hectares of land per year in Bangladesh, (BBS, 2009).

Okra is a popular nutritious fruit vegetable. Okra provides an important source of vitamins, calcium, potassium and other mineral matters which are often lacking in the diet of developing countries (Anon., 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 jaggery 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).

Okra production in Bangladesh is affected by many factors, among them insect pest attack is the major one. Since okra belongs to the family Malvaceae, nineteen insect pests and four mites have been reported on okra (Anon., 2000). The fruit borer complexes create havoc by causing both quantitative and qualitative loss to the crop. The fruit borers include shoot and fruit borers *Earias vittella* and *Earias insulana* and American bollworm, *Helicoverpa armigera*. However, *Earias* spp. alone causes damage ranging from 52.33 to 70.75 percent (Pareek and Bhargava, 2003). In general the overall damage due to insect pest mounts to 48.97 percent loss in pod yield (Kanwar and Ameta, 2007). Okra shoot and fruit borer larvae cause damage both in vegetative and reproductive phase of the crop. When the crop is young, larvae bore into the tender shoots and feed on the internal tissue and tunnel downwards which wither, drop down and killed the growing points. In reproductive stage, larvae bore into the flower buds and fruits, and feed on inner tissues. As a result, the infested flower buds droop off and infested fruits become deformed in shape with low market value (Dahiya *et al*., 2008).

Farmers always desire quick curative action for controlling this notorious insect pest of okra. So, the farmer of Bangladesh solely depends on chemical insecticide to control the pest. Due to mitigate the losses by the pest, a huge quantity of pesticides is used in okra. It is usually found that the vegetable growers apply 10-12 sprays in a season and thus the fruits, which are harvested at the short intervals, are likely to retain unavoidably high level of pesticide residues which may be highly hazardous to consumers. Due to indiscriminate use of pesticides, the pest has developed resistance besides, that pesticides are hazardous to human health, reduce the density of beneficial insect and soil micro-organisms. High levels of pesticide residues have been detected in cabbage, cauliflower, tomato, capsicum, leafy greens, okra and brinjal (Awasthi, 1998). Therefore, it is need to develop alternate methods of pest management other than the use of insecticides (Greathead, 1986).

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). The advantages of plant products over synthetic chemicals are low mammalian toxicity, no reported development of resistance, less hazardous to non-target organisms, no pest resurgence problem, no adverse effect on plant growth, negligible application risks, low cost and easy availability.

Biological control is a component of an integrated pest management strategy. Biological control aims at suppressing the pest species by using natural enemies of the pests with least or no emphasis on the use of insecticides. The advantage of biological control is environmentally safe, no evidence of arising pesticide resistance and resurgence etc. It is reported that the natural incidence of *Bracon hebetor*, *B. greeni* and *Trichogramma* spp. on *Earias* spp. in okra fields (Mani *et al.*, 2005). *Trichogramma* is one such tool that is extensively exploited for successful management of Lepidopteran pests in many crop ecosystems. To harness them in most effective manner and successful implementation in bio-control program, one has to understand their interrelations with host plant and insect pest. To mitigate the adverse effects of synthetic pesticides, plant based substances along with indigenous practices offer safe and alternative methods of pest management (Narayanasamy, 1999).

The concept of Integrated Pest Management is becoming a practicable and acceptable approach over the world. The idea is to maintain the pest below economic threshold rather than eradicate it. This approach advocates an integration of all possible or at least some of the known natural means of control (cultural control, physical control, biological control, mechanical control etc.) with or without insecticides. So that, the best insect management in terms of economics and maintenance of pest population below the economic injury level is achieved (Govindachari, 1992).

Considering the above facts view in mind, the experiment has been undertaken with the following objectives:

- To know the infestation status of okra shoot and fruit borer.
- To identify the most suitable control tactics for combating okra shoot and fruit borer.
- To know the relationship between the infestation of shoot, flower bud and fruit with the yield of okra.
- To determine the benefit cost ratio (BCR) in okra cultivation.

CHAPTER II

REVIEW OF LITERATURE

Okra (*Abelmoschus esculentus* L.) is an important vegetable crop in Bangladesh is infested by a large number of insect pests that cause considerable yield loss. Among them okra shoot and fruit borer, *Earias vittella* F. is a notorious pest, occurring sporadically or in epidemic form every year throughout Bangladesh. But published literature on this pest especially on it's infestation status and management are scanty in Bangladesh. Literatures cited below under the following headings and sub-headings reveal some information about the present study.

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* (Fab.)

Earias insulana

2.1.2. Origin and distribution

Okra shoot and fruit borer is a versatile and widely distributed insect pest of okra. *Earias vittella* is common oriented species found from India, China to North Australia (Hill, 1983).

It has been recorded in India, Pakistan, Srilanka, Bangladesh, Burma, Indonesia, New Guinea, and Fiji (Butani and Jotwani, 1984). It is distributed widely throughout North Africa, India, Pakistan and other countries (Atwal, 1976).

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 (Rehman 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 (Rehman 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

Okra shoot and fruit borer is an oligophagous insect pest though okra and cotton are its main hosts (Butani and Jotwani, 1984). This pest has been reported to infest okra, cotton, hollyhock, safflower, indian mallow, *Corchorus sp, Hibiscus sp, Malvas sp, Malvastrum sp, Sida sp, Theobrome sp* and *Urena sp* (Khan and Verma, 1946; Pearson, 1958; Butani and Verma, 1976; Atwal, 1999; David, 2001).

Atwal (1976) mentioned that okra and cotton are 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.

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 dry 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; 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 (Singh and Bichoo, 1989). 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 hot and humid climate and its number drop in heavy rainfall.

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).

2.1.6.2. Seasonal abundance

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 were 32.04% and increased larval population 1.4/plant were observed in late July. The population of *Earias* spp increased slowly upto mid September and rapidly there after. 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 fluctuate 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^{0} C and 23.2^{0} 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, *E. vittella* on shoot was started from the fifth week of July and continued till fourth week of September on twelve weeks old crop during 1996. In 1997 the infestation of *E. vittella* on shoot 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 (Mote, 1977; 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 *E. 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 non 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

2.2.1. Botanicals

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*. and by Bilton *et al.* (Figure A).

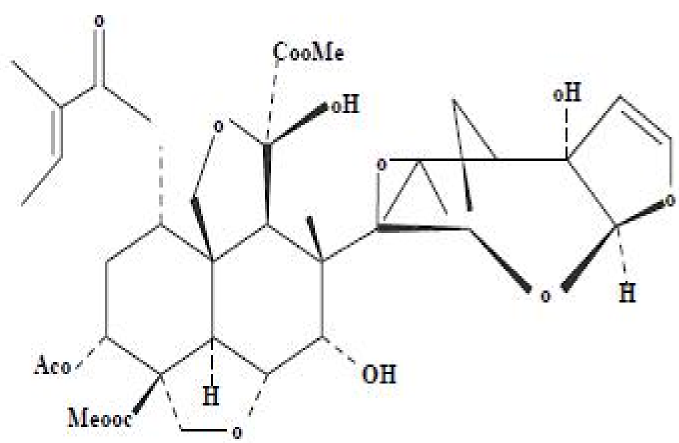

Figure A. Structural formula of azadirachtin

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.

2.2.1.1. Mode of action of neem

1. Settling Behavior

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

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.

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).

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 nymphs and larvae 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 and Rao, 1986 and 1987; 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 (Bhaskaran and Narayansamy, 1995).

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 belong to different insect orders most of them were Lepidoptera (136) and Coleopteran (79).

2.2.1.2. 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 Neen Seed Kernel Extract 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 Krishnakumar (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 Krishnakumar, 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.) 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; Anon., 1997).

Neem oil produced non-toxic effects after spray and acted as antifeedant, growth inhibitor and oviposition deterrent against insects 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. *Apis 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 pests viz., *E. vittella*, *Chilo partellus* Swinhoe, *Helicoverpa armigera* and *Spodoptera 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.

2.2.2. Biological control

Biological control is a component of an integrated pest management strategy. It is defined as the reduction of pest populations by natural enemies and typically involves an active human role. Natural enemies of insect pests, also known as biological control agents include predators, parasitoids, and pathogens. Biological control aims at suppressing the pest species by using natural enemies of the pests with least or no emphasis on the use of insecticides. The success of biological control largely depends upon conservation of naturally occurring bio-control agents like predator, parasite, parasitoid, pathogens etc.

2.2.2.1. Egg parasitoid

Parasitoids are one of the most important bio-control agent. They are the organisms that, during its development, lives in or on the body of a host individual, eventually killing that individual and develop as a free living adult. Among the parasitoids *Trichogramma* is a potential biological control agent against Lepidopteran insect pest. *Trichogramma* spp. are extremely tiny wasps in the family Trichogrammatidae under the order Hymenoptera. *Trichogramma* belongs to the category of egg parasitoid of biological agents. Trichogramma wasps seek out eggs, but do not feed on or harm vegetation. It is a particularly effective control agent because it kills its host before a plant can be damaged. It attacks the pest at the egg stage itself and hence damage done by larvae is avoided. The *Trichogramma* eggs on hatching, feed the embryonic contents of host's egg, completes its development and adult comes out of the host egg by chewing a circular hole. *Trichogramma* spp., the most widely used bio-control agent in the world and is effective against bollworms of cotton, stem borers of sugarcane, fruit borers of fruits and vegetables. It offers a lower cost but more effective plant protection option in comparison to insecticides. A single *Trichogramma*, while multiplying itself, can thus destroy over 100 eggs of the pest.

2.2.2.2. Management of okra shoot and fruit borer by egg parasitoid

Natural enemies, parasitoids and predators are the main sources of reduction in the populations of noxious insect pests (Pfadt, 1980). Biological control agents (spider, ant, lady bird beetle, *Orius*, myrid bug, *Laius, Chrysoperla, Trichogramma* etc.), botanicals (neem oil or biosal and tobacco extracts) and microbial control (*Bacillus thuringiensis*) should be integrated for economic management of insect pests (Arora *et al*., 1996; Abro *et al.*, 2004 and Memon *et al.*, 2004).

Panchabhai *et al.* (2005) obtained significantly minimum infestation of 10.26 and 6.31 percent damage due to *E. vittella* in squares, flowers and green bolls with treatment of *T. chilonis* @ 1.5 lakh + *Chrysoperla carnea* 4 eggs/plant and was comparable with endosulfan 0.07% (9.95 and 5.99, respectively).

Among the various groups of biocontrol agents, *Trichogramma* are well known parasitoids for the management of different Lepidopteran pests, including okra fruit borer complex. Mani *et al.* (2005) reported the natural incidence of *Bracon hebetor, B. greeni* and *Trichogramma* spp., on *Earias* spp. in okra fields.

Sheeba and Narendran (2007) reported that preferences of the parasitoid vary with host insects. Agarwal and Gupta (1986) and Forehand *et al.* (2006) reported that mass releases of egg parasitoid *T. chilonis* and *T. acheae,* egg larval parasitoid, *C. blackburni* and larval parasitoid *B. kirkpatriki* during square formation stage reduced the incidence of all three species of bollworms in cotton.

2.2.3. IPM package for combating okra shoot and fruit borer

IPM is an integration of all possible natural means of control measures (cultural control, physical control, biological control, pheromone trap, botanicals etc.) with or without chemical insecticides. If a insect is not controlled by a single tactic in that time if IPM should be adopted to control this pest. IPM is the use of all possible means of control which do not cause any ecological imbalance.

Mathur *et al.* (1998) evaluated different modules against fruit borer in okra. Of all the modules, lowest fruit damage (4.21%) and highest fruit yield (40.67 q/ha) were recorded in the module consisting of first spray of monocrotophos 36 SL (1 l/ha), followed two sprays of combination of *Bacillus thuringiensis Krustaki* (Btk) (Dipel 8L, 1.0 l/ha) and methomyl 40 SP (0.625 kg/ha).

Application of NSKE 5% + ¾ dose of endosulfan (0.045%), monocrotophos 0.05% and NSKE 5% + ½ dose of endosulfan (0.03%) were found to be promising by registering lowest fruit damage of 13.05, 14.50 and 15.28 percent, respectively (Sarode and Gabhane, 1998). Tomar (1998) reported that Dipel + endosulfan and Dipel + fenvalerate were found to be effective in reducing the per cent shoot and fruit borer infestation.

Praveen and Dhandapani (2001) reported that application of biocontrol agents *viz., T. chilonis*, *Chrysoperla carnea* and *Bacillus thuringiensis* was superior in reducing larval population and okra fruit damage (8.37%) by *Helicoverpa armigera* compared to farmers plot (8.56%) and also recorded 30 per cent parasitization of *E. vittella* eggs by *T. chilonis*.

Brar *et al*. (2002) reported that 3 sprays for cotton bollworm + 8 release of *T. chilonis* at 1,50,000/ha weekly + one release of *Chrysoperla carnea* at 10,000/ha performed excellent in yield by 44.5 percent and reduced the damage due to bollworm with 70.3 percent over insecticides alone.

Panickar *et al.* (2003) revealed that among 4 modules tested application of two rounds of synthetic insecticide, endosulfan (0.035%) followed by two rounds of neem based products *viz.,* Achook (0.15% EC) (M-III) proved to be superior against sucking pest and *E. vittella* infesting okra.

Biocontrol agents and neem extracts have been reported eco-friendly options for management of insect pests of okra (Al-Eryan *et al.*, 2001; Bindu *et al.*, 2003; Singh and Brar, 2004; Paulraj and Ignacimuthu, 2005).

Installation of 10 pheromone traps per acre, release of *T. chilonis* from 25 day after sowing and release of *C. carnea* were effective in managing okra pest (Paulraj and Ignacimuthu, 2005).

Sardana *et al.* (2005) evaluated five crop protection modules *viz.*, bio-intensive (module-I), cultural + mechanical biointensive (module-II), cultural + mechanical + bio-intensive + chemical (module-III) farmers practices (module-IV) and untreated control (module-V). Module III comprising of releases of egg parasitoid *T. chilonis* @ 1 lakh/ha based on monitoring of pest population using pheromone trap, three spray of NSKE @ 5% intermittently with need based application of chemical pesticides and periodic removal of borer and disease affected plants was superior over all other modules in managing the pest complex of okra crop.

CHAPTER III

MATERIALS AND METHODS

The present study was conducted to develop an IPM package for combating Okra shoot and fruit borer in the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, during May 2011 to August 2011. The materials and methods adopted in the study are discussed under the following heading and sub-headings:

3.1. Experimental Site

The experimental field was located at 90º 33.5´ E longitude and 23º 77.4´ N latitude at an altitude of 9 meter above the sea level. The field experiment was set up on the medium high land of the experimental farm.

3.2. Soil

The soil of the experiment site was a medium high land, clay loam in texture and having P^H 5.47-5.63. The land was located in Agro-ecological Zone of 'Madhupur Tract' (AEZ No. 28).

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.

3.4. Design of the experiment and layout

The study was conducted with eight treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD). The entire experimental field was divided into three blocks. Each block was divided into eight plots. Two adjacent unit plots and blocks were separated by 1m apart. Each experimental plot comprised of 3m x 2m area and the total area covered 12m x 20.5m. Each treatment was allocated randomly within the block and replicated three times (Plate 1).

Plate 1. The experimental plot at SAU, Dhaka

3.5. Land Preparation

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

3.6. Manures, Fertilizer and their Methods of 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 Table 1:

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, 45 days after seed sowing.

3.7. Collection and Sowing of Seeds

Seeds of BARI dheros-1 were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur, Dhaka. Seeds were sown in the experimental plots at the rate of 60 seeds/plot (three seeds per pit and 20 pits per plot). Seeds were sown on 1st May, 2011. The row to row and plant to plant spacing was maintained at 60 cm x 50 cm respectively.

3.8. Cultural practices

After sowing seeds light irrigation was given to each plot. Supplementary irrigation was applied when needed. Single healthy seedling with luxuriant growth per pit was allowed discarding others. Propping of each plant by bamboo sticks was provided to avoid their lodging. Weeding was done five times to break the soil crust and to keep the plot free from weeds. Stagnant water was drained out at the time of heavy rain. Necessary intercultural operations were done through out the cropping season for proper growth and development of the plants.

3.9. Treatments

The comparative effectiveness of the following eight treatments for okra shoot and fruit borer was evaluated on the basis of reduction of this pest.

T_1 = Neem oil @ 4ml/Litre of water sprayed at 7 days interval.

T_2 = Neem seed kernel extract @ 50 g/Litre of water sprayed at 7 days interval.

T_3 = Neem leaf extract @ 200g/Litre of water at 7 days interval.

T_4 = *Trichogramma evanescens* @ 0.5g/plot at 7 days interval.

T_5 = *Trichogramma evanescens* @ 0.25g/plot at + neem oil @ 4ml/Litre of water sprayed at 7 days interval.

T_6 = *Trichogramma evanescens* @ 0.25g/plot + neem seed kernel extract @ 50g/Litre sprayed at 7 days interval.

T_7 = *Trichogramma evanescens* @ 0.25g/plot + neem leaf extract @ 200g/Litre of water at 7 days interval.

T_8 = Untreated control.

3.10. Preparation of the treatments

3.10.1. Neem oil

For proper management of okra shoot and fruit borer 4 ml neem oil was poured in 1Litre of water and then 1ml trix was mixed to obtain fine droplet to spray 3m x 2m area.

3.10.2. Neem seed kernel extract

50 gm of neem seed kernel crushed and dissolved in 1Litre of water for 24 hours. The solution had to be filtered through fine gauze (cloth) to remove the bigger particles. The filtered water was sprayed in 3m x 2m area for proper management of the target pest.

3.10.3. Neem leaf extract

200 gm fresh leaves of neem were mixed with 1Litre of water and grind with a blender to obtain neem leaf extract. The mixture was then sieved to obtain a uniform extract and sprayed in okra field, covering 3m x 2m area.

3.10.4. *Trichogramma evanescens*

The freshly laid and cleaned *Sitotroga cerealella* eggs were taken and glued on a strip of card sheet (12 inch x 8 inch) in single layer using ten percent gum arabica and these cards were exposed to *Trichogramma evanescens* for 8 to 10 hours to maintain the culture (Plate 2). After 24 hours, the parasitized cards were withdrawn and placed in convenient glass containers. The open end of the container was closed using muslin cloth fastened by rubber band. The parasitoids that emerged from the cards were released in the selected experiment plots.

Plate 2. Trichocard tagged on okra leaf

3.11. Application of the Treatments

Spraying was done at 12.00 pm to avoid moisture on leaves. First application was done 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.

3.12. Data collection

Data on infestation by okra shoot and fruit borer under different management 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.

3.13. Method of recording % infestation of shoots, buds and fruits

3.13.1. 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 (Plate 3). The percent infestation of shoot was calculated with the following formula:

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

Plate 3. Shoot infested by okra shoot and fruit borer

3.13.2. Bud infestation

The data on the number of healthy and infested buds were recorded from 5 tagged plants in each treatment (Plate 4 and 5). The percent infestation of bud was calculated with the following formula:

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

Plate 4. Healthy flower bud and flower

Plate 5. Flower bud infested by okra shoot and fruit borer

3.13.3. Fruit infestation

The data on the number of healthy and infested fruits were recorded from 5 tagged plants in each treatment (Plate 6 and 7). The percent infestation of fruit was calculated with the following formula:

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

Plate 6. Healthy fruits

Plate 7. Fruits infested by okra shoot and fruit borer

3.14. 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. 15. Benefit cost ratio analysis

For benefit cost analysis, records of the costs incurred for labour, inputs, application of inputs in each treatment and that of control without insecticide were maintained. The untreated control (T_8) did not require any pest management cost. The price of the marketable healthy fruit of each treatment and that of control was calculated at market rate. The result of Benefit-Cost analysis was expressed in terms of Benefit-Cost Ratio (BCR).

Net return was calculated by subtracting treatment wise management cost from gross return. The adjusted net return was determined by subtracting the management cost involved in untreated control plot from the net return obtained from each treatment which as follows:

Adjusted net return = Net return in treated plot – Management cost in control plot.

Benefit Cost Ratio (BCR):

BCR for each treatment was calculated dividing adjusted net return to total management cost of the respective treatment which may be expressed as:

$$\text{Benefit Cost Ratio} = \frac{\text{Adjusted net return}}{\text{Total management cost}}$$

3.16. Statistical analysis

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 to evaluate the IPM components for suppressing Okra shoot and fruit borer (OSFB) in okra. The efficacy of botanicals and egg parasitoid against the okra shoot and fruit borer was evaluated on the basis of the shoot infestation, bud infestation, fruit infestation, length of healthy and infested fruit, girth of healthy and infested fruits, number of larva per fruit, number of bores per infested fruit, weight of total yield varied significantly with different treatments. The results of the efficiency of the different management practices applied against okra shoot and fruit borer were discussed and possible interpretations were furnished and presented below under headings and sub-headings:

4.1. Effect of management practices on shoot infestation of okra by OSFB

Significant differences were observed among different management practices in terms of percent shoot infestation by number at the vegetative stage, early fruiting stage and late fruiting stage during the management of okra shoot and fruit borer (Table 1).

4.1.1. Shoot infestation at vegetative stage

The highest percent of shoot infestation (25.89 %) was recorded in T_8 (untreated control) which was statistically different from all other treatments (Table 1) and was followed (16.22 %) by T_3 (Spraying of neem leaf extract @ 200g/Litre of water) and T_7 (11.67 %) comprised of spraying of neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval. On the other hand, the lowest percent of shoot infestation (0.87 %) was recorded in T_5 (Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) which was followed (3.01 %) by T_6 (Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval). The intermediate level of infestation was recorded (5.00 %) in T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval) which was followed by T_1 (6.67 %) comprised of spraying of neem oil @ 4 ml/Litre of water at 7 days interval and T_2 (8.27 %) comprised of spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval.

4.1.2. Shoot infestation at early fruiting stage

At early fruiting stage, the highest shoot infestation of 13.67% was observed in control treatment which was followed by the treatment having water based neem leaf extract @ 200g/Litre of water (T_3) that was 10.67 % shoot infestation and T_7 (8.17 %) (Table 1). On the other hand, the lowest shoot infestation (0.5%) was recorded in the plots which was treated with neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval (T_5). The second lowest shoot infestation (2.23 %) observed in T_6 treatment which was statistically similar with T_4 (2.57 %) treatment. The intermediate level of infestation was recorded in T_1 (4.23 %) which was statistically similar with T_2 (4.77 %).

4.1.3. Shoot infestation at late fruiting stage

At late fruiting stage, the highest percent of shoot infestation (11.00%) recorded in control plot which was followed by T_3 (8.17 %) and T_7 (6.22 %) treatment (Table 1). On the other hand, the lowest percent of shoot infestation (0.40 %) was recorded in T_5 (Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (1.60 %). The intermediate level of infestation was recorded in T_4 (2.07 %) treatment which was followed by T_1 (3.00 %) and T_2 (3.08 %) treatment.

During the total cropping season, the lowest shoot infestation (0.59 %) was recorded in the plot which was treated with neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval (T_5). The second lowest shoot infestation was observed in T_6 (2.28 %). On the other hand, the highest shoot infestation (16.85 %) was recorded in control plot (T_8) which was followed by T_3 (11.69 %) and T_7 (8.69 %) treatment. The intermediate level of infestation was recorded in T_4 (3.21 %) followed by T_1 (4.81 %) and T_2 (5.20 %) treatment (Table 1).

Considering the percent reduction of shoot infestation over control, the highest reduction (96.50 %) was recorded in T_5 comprised of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval (Table 1) which was followed by T_6 (86.47 %). On the other hand, the lowest reduction of shoot infestation was recorded in T_3 (30.62 %) followed by T_7 (48.44 %%). The intermediate level of infestation was recorded in T_4 (80.95 %) followed by T_2 (69.14 %) and T_1 (71.45 %).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in reducing the shoot infestation (96.50 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_6 (86.47 %) and T_4 (80.95 %). On other hand, the lowest reduction of shoot infestation was recorded in T_3 (30.62 %) followed by T_7 (48.44 %) and T_2 (69.14 %). It was also revealed that the percent shoot infestation was increased in the vegetative stage of okra and declined by the insect pest during the fruiting stage. As a result the trend of percent reduction of shoot infestation over control caused by okra shoot and fruit borer due to application of different management practices was $T_5 > T_6 > T_4 > T_1 > T_2 > T_7 > T_3$ (Table 1). Shukla *et al*. (1997) reported that before fruiting stage shoot infestation reached at a peak of 8.5%.

4.2. Effect of management practices on the infestation of flower bud

Significant differences were observed among different management practices in terms of percent flower bud infestation by number at the vegetative stage, early fruiting stage and late fruiting stage (Table 2).

4.2.1. Flower bud infestation at vegetative stage

The highest percent of flower bud infestation (6.40 %) was recorded in T_8 (untreated control) which was statistically different from all other treatments and was followed (4.27 %) by T_3 (spraying of neem leaf extract @ 200g/Litre of water) and T_7 (2.79 %) comprised of spraying of neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval (Table 2). On the other hand, the lowest percent of flower bud infestation (0.12 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by (0.93 %) T_6 comprised of spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval. The intermediate level of infestation was recorded (1.30 %)

Table 1: Effect of different management practices on the incidence of okra shoot and fruit borer (OSFB) infestation on shoot at different growth stage of Okra during May-August, 2011

Treatment	% Shoot infestation				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean infestation	% reduction over control
T_1	6.67 de	4.23 d	3.00 d	4.81 d	71.45
T_2	8.27 d	4.77 d	3.08 d	5.20 d	69.14
T_3	16.22 b	10.67 b	8.17 b	11.69 b	30.62
T_4	5.00 e	2.57 e	2.07 d	3.21 e	80.95
T_5	0.87 g	0.5 f	0.40 e	0.59 f	96.50
T_6	3.01 f	2.23 e	1.60 de	2.28 e	86.47
T_7	11.67 c	8.17 c	6.22 c	8.69 c	48.44
T_8	25.89 a	13.67 a	11.00 a	16.85 a	-
$LSD_{(0.01)}$	1.92	1.65	1.42	1.47	-
CV (%)	8.12	11.59	13.19	9.06	-

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

in T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval) followed by T_1 (1.50 %) comprised of spraying of neem oil @ 4 ml/Litre of water at 7 days interval and T_2 (1.80 %) comprised of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval.

4.2.2. Flower bud infestation at early fruiting stage

At early fruiting stage, the highest percent of flower bud infestation (46.58 %) was observed in T_8 (untreated control) which was statistically different from all other treatments (Table 2) followed by T_3 (37.00 %) and T_7 (30.67 %). On the other hand, the lowest percent of flower bud infestation (11.11 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (16.94 %). The intermediate level of infestation was recorded in T_4 (19.43 %) followed by T_1 (22.00 %) and was statistically similar with T_2 (23.10 %).

4.2.3. Flower bud infestation at late fruiting stage

The highest percent of flower bud infestation (19.91 %) recorded in T_8 (untreated control) which was statistically different from all other treatments (Table 2) and was followed by T_3 (14.83 %) and T_7 (11.83 %). On the other hand, the lowest percent of flower bud infestation (0.91 %) was recorded in T_5 treatment (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) which was followed by T_6 (3.33 %). The intermediate level of infestation was recorded (5.54 %) in T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval) which was statistically similar with T_1 (6.34 %) and T_2 (7.26 %).

During the entire cropping season, the highest flower bud infestation (24.30 %) by OSFB was recorded in T_8 (untreated control) which was statistically different from all other treatments (Table 2) followed by T_3 (18.70 %) and T_7 (15.10 %). On the other hand, the lowest percent of flower bud infestation (4.05 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (7.07 %). The intermediate level of infestation was recorded

(8.76 %) in T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval) followed by T_1 (9.95 %) and T_2 (10.72 %).

Percent reduction of flower bud infestation over control was the highest (83.33 %) in T_5 comprised of spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval (Table 2) followed by T_6 (70.91 %) and T_4 (63.95 %). On the other hand, the lowest reduction of flower bud infestation (23.04 %) was recorded in T_3 treatment comprised of spraying of neem leaf extract @ 200g/Litre of water at 7 days interval followed by T_7 (37.86 %), T_2 (55.88 %) and T_1 (59.05 %).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in reducing the flower bud infestation (83.33 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_6 (70.91 %) and T_4 (63.95 %). On other hand, the lowest reduction of flower bud infestation was recorded in T_3 (23.04 %) followed by T_7 (37.86 %), T_2 (55.88 %). It was also revealed that the bud infestation was increased in the early fruiting stage of okra and declined in the vegetative stage (Table 2). Gahukar (2007) also observed the same trend of results to control lepidopteran pests by using botanicals.

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

Significant differences were observed among different management practices in terms of percent fruit infestation by number at the early fruiting stage, mid fruiting stage and late fruiting stage during the management of okra shoot and fruit borer (Table 3).

4.3.1. Fruit infestation at early fruiting stage

At early fruiting stage of the okra, the highest percent of fruit infestation (9.67 %) was recorded in T_8 (untreated control) which was statistically different from all other treatments (Table 3) and was followed by T_3 (7.50 %) comprised of spraying of neem leaf extract @ 200g/Litre of water at 7 days interval and T_7 (6.27 %) comprised of spraying of neem leaf extract @ 200g/Litre of water at 7 days interval + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval. On the other hand, the lowest percent of fruit infestation (0.33 %) was recorded in T_5 (spraying of neem oil @4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval)

Table 2. Effect of different management practices on the infestation of flower bud by okra shoot and fruit borer (OSFB) at different growth stage of Okra during May-August, 2011

Treatment	% Flower bud infestation				
	Vegetative stage	Early fruiting stage	Late fruiting stage	Mean infestation	% reduction over control
T_1	1.50 de	22.00 d	6.34 d	9.95 de	59.05
T_2	1.80 d	23.10 d	7.26 d	10.72 d	55.88
T_3	4.27 b	37.00 b	14.83 b	18.70 b	23.04
T_4	1.30 e	19.43 de	5.54 d	8.76 e	63.95
T_5	0.12 g	11.11 f	0.91 f	4.05 g	83.33
T_6	0.93 f	16.94 e	3.33 e	7.07 f	70.91
T_7	2.79 c	30.67 c	11.83 c	15.10 c	37.86
T_8	6.40 a	46.58 a	19.91 a	24.30 a	--
$LSD_{(0.01)}$	0.32	4.25	1.86	1.40	--
CV (%)	5.46	6.76	8.75	4.66	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

followed (2.07 %) by T_6 (Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval). The intermediate level of infestation was recorded (2.27 %) in T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval) followed by T_1 (3.23 %) and T_2 (3.77 %).

4.3.2. Fruit infestation at mid fruiting stage

At mid fruiting stage, the highest percent of fruit infestation (20.50 %) was observed in T_8 (untreated control) which was statistically different from all other treatments (Table 3) and was followed by T_3 (10.66 %) and T_7 (6.70 %). On the other hand, the lowest percent of fruit infestation (0.9 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (4.11 %). The intermediate level of infestation was observed in T_4 (4.53 %) which was also followed by T_1 (5.34 %) and was statistically similar with T_2 (5.38 %).

4.3.3. Fruit infestation at late fruiting stage

At late fruiting stage, the highest percent of fruit infestation (10.00 %) recorded in T_8 (untreated control) which was statistically different from all other treatments (Table 3) and was followed (7.77 %) by T_3 (spraying of neem leaf extract @ 200g/Litre of water at 7 days interval) and T_7 (5.67 %). On the other hand, the lowest percent of fruit infestation (1.27 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (3.77 %). The intermediate level of infestation was recorded (4.37 %) in T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval) followed by T_1 (4.62 %) and T_2 (4.65 %).

Considering the mean fruit infestation through the cropping season, the highest fruit infestation (13.39 %) was recorded in T_8 which was statistically different from all other treatments (Table 3) followed by T_3 (8.64 %) and T_7 (6.21 %). On the other hand, the lowest percent of fruit infestation (0.83 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (3.61 %). The rest of the treatments T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval), T_1 (spraying of neem oil @

4ml/Litre of water at 7 days interval) and T_2 (spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval) had the intermediate level of infestation by number (3.72 %, 4.13 % and 4.57 % respectively).

In terms of percent reduction of fruit infestation over control, the highest reduction (93.80 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed (73.04 %) by T_6 (Table 3). On the other hand, the lowest reduction (35.47 %) was recorded in T_3 (spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval) followed by T_7 (53.62 %). The intermediate level of reduction was recorded in T_4 (72.22 %) followed by T_1 (69.16 %) and T_2 (65.87 %).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in reducing the fruit infestation (93.80 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_6 (73.04 %) and T_4 (72.22 %). On other hand, the lowest reduction of fruit infestation was recorded in T_3 (35.47 %) followed by T_7 (53.62 %), T_2 (65.87 %). It was also revealed that the fruit infestation was increased at the mid fruiting stage (Table 3). As a result the trend of percent reduction of fruit infestation over control caused by okra shoot and fruit borer due to application of different management practices was $T_5 > T_6 > T_4 > T_1 > T_2 > T_7 > T_3$ (Table 3). 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.

Thus it is revealed from Table 1 and 3 that the rate of infestation is higher in fruits than the shoots which are in consistence with the findings reported by Maleque (1998) who also observed that the caterpillars preferred the fruits to shoots during the fruiting stage.

Table 3. Effect of different management practices on the infestation of fruit by okra shoot and fruit borer by number at different growth stage of Okra during May-August, 2011

Treatment	% Fruit infestation				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean infestation	% reduction over control
T_1	3.23 de	5.34 cd	4.62 cd	4.13 de	69.16
T_2	3.77 d	5.38 cd	4.65 cd	4.57 d	65.87
T_3	7.5 b	10.66 b	7.77 b	8.64 b	35.47
T_4	2.27 e	4.53 d	4.37 cd	3.72 e	72.22
T_5	0.33 f	0.9 e	1.27 e	0.83 f	93.80
T_6	2.07 e	4.11 d	3.77 d	3.61 e	73.04
T_7	6.27 c	6.70 c	5.67 c	6.21 c	53.62
T_8	9.67 a	20.50 a	10.00 a	13.39 a	--
$LSD_{(0.01)}$	1.23	1.43	1.39	0.72	--
CV (%)	11.55	8.12	10.88	5.29	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

4.4. Effect of management practices on the infestation of fruit by weight

Significant differences were observed among different management practices in terms of percent fruit infestation by weight at the early fruiting stage, mid fruiting stage and late fruiting stage during the management of okra shoot and fruit borer (Table 4).

4.4.1. Fruit infestation at early fruiting stage

At early fruiting stage, the highest percent of fruit infestation (8.63 %) was recorded in T_8 (untreated control) which was statistically different from all other treatments (Table 4) followed (6.33 %) by T_3 (spraying of neem leaf extract @ 200g/Litre of water at 7 days interval) and T_7 (5.72 %) comprised of spraying of neem leaf extract @ 200g/Litre of water at 7 days interval + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval. On the other hand, the lowest percent of fruit infestation (0.50 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed (2.47 %) by T_6 (spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval). The intermediate level of fruit infestation was recorded (3.40 %) in T_4 comprising *Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval followed by T_1 (3.77 %) comprising spraying of neem oil @ 4 ml/Litre of water at 7 days interval and T_2 (4.37 %) comprising spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval.

4.4.2. Fruit infestation at mid fruiting stage

Considering the percent fruit infestation by okra shoot and fruit borer (OSFB) at mid fruiting stage, the highest percent of fruit infestation (21.31 %) was observed in T_8 (untreated control) which was statistically different from all other treatments (Table 4) which was followed by T_3 (17.72 %) and T_7 (12.08 %). On the other hand, the lowest percent of fruit infestation (4.12 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (6.91 %). The intermediate level of infestation was observed in T_4 (8.05 %) which was statistically similar with T_1 (8.58 %), followed by T_2 (8.83 %).

4.4.3. Fruit infestation at late fruiting stage

At late fruiting stage, the highest percent of fruit infestation (13.33 %) recorded in T_8 which was statistically different from all other treatments (Table 4) and was followed by T_3 (8.32 %) and T_7 (5.14 %). On the other hand, the lowest percent of fruit infestation (1.05 %) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (2.23 %). The intermediate level of infestation was observed in T_4 (3.21 %) which was statistically similar with T_1 (3.35 %) and was followed by T_2 (3.83 %).

During the entire cropping season, the highest fruit infestation (14.43 %) by weight was recorded in T_8 which was statistically different from all other treatments (Table 4) which was followed by T_3 (10.79 %) and T_7 (7.65 %). On the other hand, the lowest percent of fruit infestation (1.89 %) by weight was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) which was followed by T_6 (3.87 %). The rest of the treatments T_4 (*Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval), T_1 (spraying of neem oil @ 4ml/Litre of water at 7 days interval) and T_2 (spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval) had the intermediate level of infestation by weight (4.89 %, 5.23 % and 5.68 % respectively).

Considering the percent reduction of fruit infestation over control, the highest reduction (86.90 %) was recorded in T_5 comprised of spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval (Table 4) which was followed by T_6 (73.18 %). On the other hand, the lowest reduction (25.22 %) was recorded in T_3 comprised of spraying of neem leaf extract @ 200g/Litre of water followed by T_7 (46.98 %). The intermediate level of reduction of fruit infestation by weight was recorded in T_4 (66.11 %) followed by T_2 (60.64 %) and T_1 (63.76 %).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in reducing the fruit infestation (86.90 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_6 (73.18 %) and T_4 (66.11 %). On other hand, the lowest reduction of fruit infestation was recorded in T_3

(25.22 %) followed by T_7 (46.98 %), T_2 (60.64 %). It was also revealed that the percent fruit infestation by weight was increased in the fruiting stage of okra and declined there after (Table 4). Ambekar *et al.* (2000) reported similar results to the present study where as bio-pesticide performed best in reducing fruit infestation by OSFB.

Table 4. Effect of different management practices on the infestation of fruit by okra shoot and fruit borer (OSFB) by weight at different growth stage of Okra during May-August, 2011

Treatment	% Fruit infestation by weight				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean infestation	% reduction over control
T_1	3.77 cd	8.58 de	3.35 d	5.23 de	63.76
T_2	4.37 c	8.83 d	3.83 cd	5.68 d	60.64
T_3	6.33 b	17.72 b	8.32 b	10.79 b	25.22
T_4	3.40 d	8.05 de	3.21 d	4.89 e	66.11
T_5	0.50 f	4.12 f	1.05 e	1.89 g	86.90
T_6	2.47 e	6.91 e	2.23 de	3.87 f	73.18
T_7	5.72 b	12.08 c	5.14 c	7.65 c	46.98
T_8	8.63 a	21.31 a	13.33 a	14.43 a	--
$LSD_{(0.01)}$	0.90	1.79	1.55	0.74	--
CV (%)	8.40	6.73	12.63	4.47	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

4.5. Effect of different treatments on the yield contributing character of Okra

Significant differences were observed among different management practices in terms of length of healthy fruit and infested fruit during the management of okra shoot and fruit borer (Table 5).

4.5.1. Length of healthy fruit

Length of healthy fruit was significantly influenced by different treatments during the management of okra shoot and fruit borer (Table 5). The highest fruit length (13.37 cm) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval) which was statistically different from all other treatments and followed (12.78 cm) by T_6 (spraying of water based neem seed kernel @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval). On the other hand, the lowest fruit length (10.34 cm) was recorded in T_8 (untreated control) and there was no significant difference between T_3 (11.33 cm) comprised of Spraying of neem leaf extract @ 200g/Litre of water at 7 days interval, T_7 (11.77 cm) comprised of T_3 + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval, T_2 (11.55 cm) comprised of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval, T_1 (11.62 cm) comprised of spraying of neem oil @ 4ml/Litre of water at 7 days interval and T_4 (11.77 cm) comprised of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval. But among the treated plots, T_3 showed the lowest fruit length (11.33 cm).

4.5.2. Length of infested fruit

In case of infested fruit length, the highest fruit length (8.69 cm) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval) which was significantly different from all other treatments (Table 5) and followed (6.03 cm) by T_6 that was statistically similar (6.70 cm) with T_4 (6.03 cm). On the other hand, the lowest fruit length (3.06 cm) was recorded in T_8 (untreated control) followed (3.55 cm) by T_3 which was statistically similar with T_7 (3.78 cm). There was no significant difference between T_2 (4.26 cm) and T_1 (4.31 cm). But among the treated plots, T_3 (Neem leaf extract @ 200g/Litre of water) showed the lowest fruit length (3.55 cm).

Percent increase of fruit length over control was the maximum (183.99 %) in T_5 (Table 5) comprised of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval and followed by T_6 (118.95 %) and T_4 (97.06 %). On the other hand, the minimum increase of fruit length (16.01 %) was recorded in T_3 comprised of neem leaf extract @ 200g/Litre of water at 7 days interval followed by T_7 (23.53 %), T_2 (39.21 %) and T_1 (40.85 %).

From the above finding it was revealed that among the different management practices T_5 (neem oil @ 4ml/Litre of water + *Trichogramma evanescens* @ 0.25g/6m^2 at 7 days interval) performed as the best treatment in terms of percent increase of fruit length (183.99 %) over control followed by T_6 (118.95 %). On the other hand, T_3 was the least performer in terms of percent increase of fruit length (23.53 %) over control (Table 5). 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.

4.6. Effect of yield contributing character of Okra on yield

Significant differences were not observed among different management practices in terms of girth of healthy fruit and infested fruit during the management of okra shoot and fruit borer (Table 6).

4.6.1. Girth of healthy fruit

In case of fruit girth, the highest fruit girth (5.75 cm) was recorded in the plot treated with neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval (T_5) which was not significantly different from all other treatments (Table 6) and was followed (5.64 cm) by T_6 (spraying of water based neem seed kernel @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval) which was statistically identical with T_4 (5.64 cm) comprised of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval. On the other hand, the lowest fruit girth (4.77 cm) was recorded in the control plot (T_8) followed by T_3 (5.09 cm) comprised of Spraying of neem leaf extract @ 200g/Litre of water at 7 days interval which was statistically identical with T_7 (5.09 cm) comprised of T_3 + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval. The intermediate level of

Table 5. Management practices on yield contributing characters of okra

Treatment	Length of healthy fruit (cm)	Length of infested fruit (cm)	% increase over control
T_1	11.62 c	4.31 c	40.85
T_2	11.55 c	4.26 c	39.21
T_3	11.33 c	3.55 cd	16.01
T_4	11.77 c	6.03 b	97.06
T_5	13.37 a	8.69 a	183.99
T_6	12.78 b	6.70 b	118.95
T_7	11.55 c	3.78 cd	23.53
T_8	10.34 d	3.06 d	--
$LSD_{(0.01)}$	0.41	0.95	--
CV (%)	1.42	7.72	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

fruit girth was recorded in T_2 (5.40 cm) comprised of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval followed by T_1 (5.48 cm) comprised of spraying of neem oil @ 4ml/Litre of water at 7 days interval.

4.6.2. Girth of infested fruit

In case of infested fruit girth, the highest fruit girth (4.50 cm) was recorded in T_5 (neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval) which was statistically similar with T_6 (4.23) treatment (Table 6). On the other hand, the lowest fruit girth (1.81 cm) was recorded in T_8 (untreated control) and followed (2.02 cm) by T_3 (spraying of neem leaf extract @ 200g/Litre of water at 7 days interval).

In terms of percent increase of fruit girth over control, the maximum increase of fruit girth (148.62 %) was recorded in T_5 treatment (Table 6) which was followed by T_6 (133.70 %) and T_4 (101.10 %). On the other hand, the minimum increase of fruit length (11.60 %) was recorded in $T_{3,}$ followed by T_7 (51.38 %), T_2 (86.74 %) and T_1 (89.50 %).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in terms of percent increase of fruit girth over control (148.62 %) due to application of different management practices followed by T_6 (133.70 %) and T_4 (101.10 %). On other hand, the minimum increase of fruit girth was recorded in T_3 (11.60 %) followed by T_7 (51.38 %), T_2 (86.74 %) (Table 6).

More or less similar works were done by 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 6. Effect of different management practices on yield contributing characters of Okra

Treatment	Girth of healthy fruit (cm)	Girth of infested fruit (cm)	% increase over control
T_1	5.48 ab	3.43 b	89.50
T_2	5.40 bc	3.38 b	86.74
T_3	5.09 c	2.02 d	11.60
T_4	5.64 ab	3.64 b	101.10
T_5	5.75 a	4.50 a	148.62
T_6	5.64 ab	4.23 a	133.70
T_7	5.09 c	2.74 c	51.38
T_8	4.77 d	1.81 d	--
$LSD_{(0.01)}$	0.31	0.57	--
CV (%)	2.37	7.20	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescence* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescence* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescence* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescence* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

4.7. Effect of management practices on infestation intensity

Significant differences were observed among different management practices in terms of infestation intensity during the management of okra shoot and fruit borer (Table 7).

4.7.1. Effect on infestation intensity per fruit

The effects of different treatments on the infestation intensity per fruit was expressed in terms of infestation intensity corresponding to any of 3 scales such as Scale 1 (low infestation intensity; 1 bore/fruit), Scale 2 (moderate infestation intensity; 2-3 bores/fruit), Scale 3 (high infestation intensity; >3 bores/fruit) were presented in Table 7. In case of percent fruit infestation intensity those belonging to scale 1 (having 1 bore/fruit), the highest number of bore/fruit was recorded (19.67 bore/fruit) in T_8 (untreated control) which was statistically different from all other treatments followed (14.50 bore/fruit) by T_3 (spraying of neem leaf extract @ 200g/Litre of water at 7 days interval) which was statistically similar with T_7 (13.33 bore/fruit) comprised of T_3 + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval. On the other hand, the lowest number of bore (4.47 bore/fruit) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval) which was statistically similar with T_6 (5.50 bore/fruit) comprised of spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval. The intermediate level of infestation intensity was recorded (7.50 bore/fruit) in T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval) followed (10.17 bore/fruit) by T_1 comprising the spraying of neem oil @ 4ml/Litre of water at 7 days interval and was statistically similar with T_2 (11.00 bore/fruit) comprising the spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval.

Almost same trend was observed in case of scale 2 and also in scale 3 with considerably decreasing value in all these treatments. Where lowest number of bores was found in T_5 which was statistically similar with T_6 treatment.

Considering the mean intensity through the cropping season, the highest infestation intensity (12.03 bore/fruit) was recorded in T_8 which was statistically different from all other treatments (Table 7) followed by T_3 (8.48 bore/fruit) and T_7 (7.85 bore/fruit). On the other hand, the lowest percent infestation intensity (2.71 bore/fruit) was recorded in T_5 followed by T_6 (3.39 bore/fruit), T_4 (4.56 bore/fruit) and T_1 (5.83 bore/fruit).

In terms of percent reduction of bores per fruit over control, the highest reduction (77.47 %) was recorded in T_5 (Table 7) followed by T_6 (71.82 %) and T_4 (62.09 %). On the other hand, the lowest reduction (29.51 %) was recorded in $T_{3,}$ followed by T_7 (34.75 %), T_2 (46.55 %) and T_1 (51.54 %).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in terms of reducing the number of bores per fruit (77.47 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_6 (71.82 %) and T_4 (62.09 %). On other hand, the lowest reduction of number of bores per fruit was recorded in T_3 (29.51 %) followed by T_7 (34.75 %), T_2 (46.55 %) (Table 7). More or less similar finding was observed by Dhingra *et al.* (2008) which was conformity with the present study.

Table 7. Effect of different treatments on infestation intensity of fruits infested by Okra shoot and fruit borer during May-August, 2011

Treatment	Infestation intensity (%)				
	Scale-1 (1 bore/fruit)	Scale-2 (2-3 bore/fruit)	Scale-3 (>3 bore/fruit)	Mean intensity (%)	% reduction over control
T_1	10.17 c	5.13 d	2.20 cd	5.83 d	51.54
T_2	11.00 c	5.75 cd	2.53 c	6.43 d	46.55
T_3	14.50 b	7.50 b	3.43 b	8.48 b	29.51
T_4	7.50 d	3.83 e	2.33 cd	4.56 e	62.09
T_5	4.47 e	2.43 f	1.23 e	2.71 g	77.47
T_6	5.50 e	2.87 ef	1.80 de	3.39 f	71.82
T_7	13.33 b	6.80 bc	3.42 b	7.85 c	34.75
T_8	19.67 a	11.17 a	5.27 a	12.03 a	--
$LSD_{(0.01)}$	1.27	1.14	0.63	0.62	--
CV (%)	4.87	8.27	9.36	4.02	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

4.8. Effect of different treatments on the incidence of larvae per fruit of okra

Significant differences were observed among different management practices in terms of the incidence of larvae of okra shoot and fruit borer during the management of okra shoot and fruit borer (Table 8).

The highest no. of larva per fruit in number (1.60 larvae/fruit) was recorded in T_8 (untreated control) treatment which was statistically different from all other treatments. Among the treated plot, the highest no. of larvae per fruit (1.06 larvae/fruit) was observed in T_3 (spraying of neem leaf extract @ 200g/Litre of water at 7 days interval) which was statistically similar (0.95 larvae/fruit) with T_7 (spraying of neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval). On the other hand, the lowest no. of larvae per fruit (0.32 larvae/fruit) was recorded in T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) followed by T_6 (0.50 larvae/fruit) comprised of spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval and there was no significant difference between T_1 (0.55 larvae/fruit), T_2 (0.59 larvae/fruit) and T_4 (0.64 larvae/fruit).

In terms of percent reduction of larvae per fruit over control, the highest reduction (80.00 %) was recorded in T_5 (Table 8) followed by T_6 (68.75 %) and T_1 (65.62 %). On the other hand, the lowest reduction of larvae per fruit was recorded in T_3 (33.75 %) followed by T_7 (40.62 %), T_4 (60.00 %) and T_2 (63.12 %).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in terms of reducing the number of larvae per fruit over control (80.00 %) due to application of different management practices followed by T_6 (68.75 %) and T_1 (65.62 %). On other hand, the lowest reduction of number of larvae per fruit was recorded in T_3 (33.75 %) followed by T_7 (40.62 %), T_2 (63.12 %).

Table 8. Effect of different treatments on the number of larva per fruit during May-August, 2011

Treatment	Number of larvae per fruit	% reduction over control
T_1	0.55 c	65.62
T_2	0.59 c	63.12
T_3	1.06 b	33.75
T_4	0.64 c	60.00
T_5	0.32 d	80.00
T_6	0.50 c	68.75
T_7	0.95 b	40.62
T_8	1.60 a	--
$LSD_{(0.01)}$	0.15	--
CV(%)	8.08	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

4.9. Effect of different treatments on the yield of okra

Significant differences were observed among different treatments in terms of total fruit yield per plot in kg, total fruit yield in ton/ha and percent increase over control during the entire cropping season (Kharif-2), presented in Table 9.

In case of total fruit yield per plot, the maximum fruit yield was recorded (7.50 kg/plot) in T_5 treatment (spraying of neem oil @ 4 ml/Litre of water at 7 days interval + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) which was statistically similar with T_6 (7.02 kg/plot) comprised of spraying of water based neem seed kernel extract @ 50 g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval (Table 9). On the other hand, the lowest fruit yield was recorded (3.76 kg/plot) in T_8 treatment (untreated control) followed (4.60 kg/plot) by T_3 treatment (spraying of neem leaf extract @ 200 g/Litre of water at 7 days interval) which was statistically similar (4.78 kg/plot) with T_7 treatment (spraying of neem leaf extract @ 200 g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval). The intermediate level of fruit yield was recorded in T_4 treatment (5.99 kg/plot) comprised of *Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval which was statistically similar with T_1 (5.77 kg/plot) and T_2 (5.62 kg/plot).

In terms of percent increase of total fruit yield over control, the highest yield was recorded (99.37 %) in T_5 (Table 9) followed by T_6 (86.60 %), T_4 (59.17 %) and T_1 treatment (53.43 %). On the other hand, minimum increase of total fruit yield over control was recorded in T_3 (22.33 %) followed by T_7 (27.11 %) and T_2 (49.44 %) treatment.

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in terms of increasing the yield of okra over control (99.37 %) due to application of different management practices followed by T_6 (86.60 %) and T_4 (59.17 %). On other hand, the minimum increase of fruit yield over control was recorded in T_3 (22.33 %). Sasikala *et al.* (1999) and Rabindra *et al.* (2007) also found that biological control agents were effective against okra shoot and fruit borer as well as increased yield which support the present study findings.

Table 9. Effect of different management practices on yield of Okra during May-August, 2011

Treatment	Yield (kg/plot)	Yield (ton/ha)	(%) increase over control
T_1	5.77 b	9.62 b	53.43
T_2	5.62 b	9.37 b	49.44
T_3	4.60 c	7.67 c	22.33
T_4	5.99 b	9.98 b	59.17
T_5	7.50 a	12.50 a	99.37
T_6	7.02 a	11.70 a	86.60
T_7	4.78 c	7.97 c	27.11
T_8	3.76 d	6.27 d	--
$LSD_{(0.01)}$	0.84	1.40	--
CV(%)	6.13	6.68	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

4.10. Relationship between % shoot infestation and yield of okra among different management practices during May-August, 2011

Correlation study was done to establish the relationship between the % shoot infestations and yield of okra among different management practices.

From the figure 1, it was revealed that negative correlation was observed between the parameters. It was evident that the equation y = -0.363x + 11.81 gave a good fit to the data and the co-efficient of determination (R^2 = 0.8974) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that yield (t/ha) of okra was strongly as well as negatively correlated with % shoot infestation.

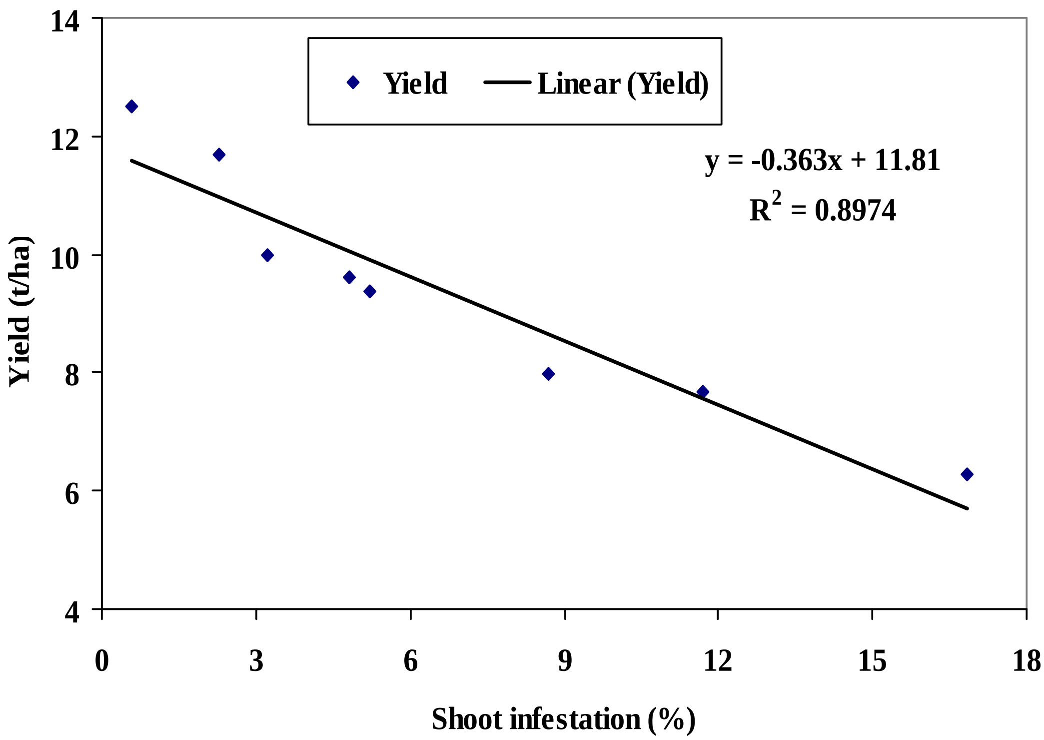

Figure 1. Relationship between % shoot infestation and yield of okra among different management practices

It was revealed that when the shoot infestation (0.59 %) decreased the yield (12.5 t/ha) of okra was increased. On the contrary, when the shoot infestation (16.85 %) was increased then the yield (6.27 t/ha) of okra was decreased. So, it can be said that there was strongly negative correlation between shoot infestation and yield of okra.

4.11. Relationship between incidence of flower bud infestation and yield of okra among different management practices during May-August, 2011

Correlation study was done to establish the relationship between the incidences of flower bud infestation and yield of okra among different management practices.

From the Figure 2, it was revealed that negative correlation was observed between the parameters. It was evident that the equation y = -0.2817x + 12.8 gave a good fit to the data and the co-efficient of determination (R^2 = 0.9207) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that yield (t/ha) of okra was strongly as well as negatively correlated with the incidence of flower bud infestation.

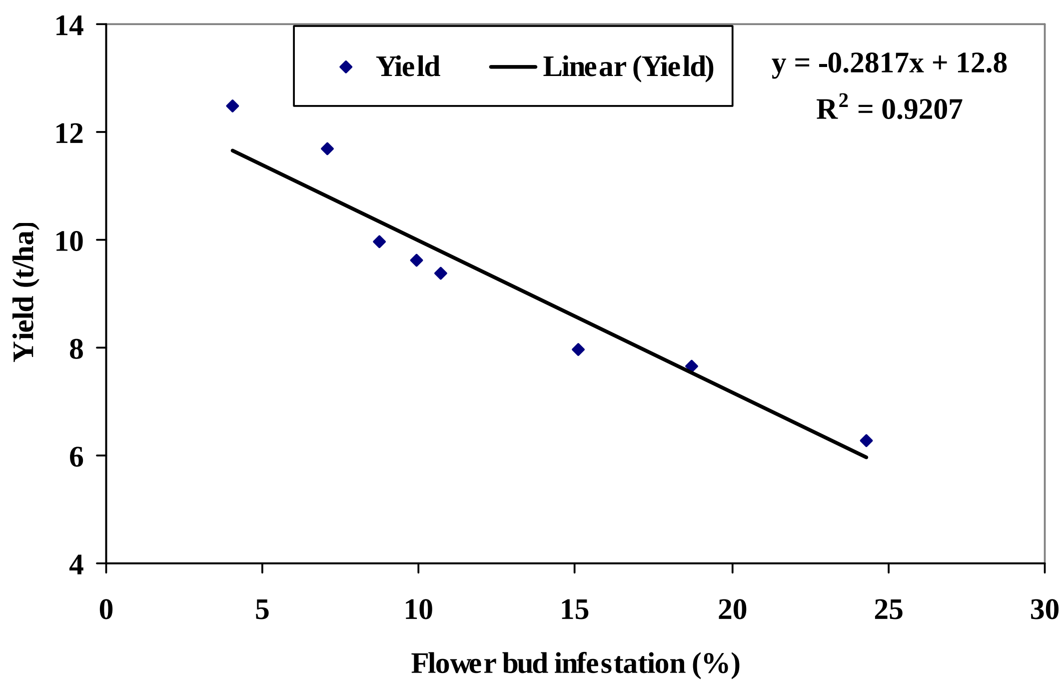

Figure 2. Relationship between incidence of flower bud infestation and yield of okra among different management practices

It was revealed that when the flower bud infestation (4.05 %) decreased the yield (12.5 t/ha) of okra was increased. On the contrary, when the flower bud infestation (24.3 %) was increased then the yield (6.27 t/ha) of okra was decreased. So, it can be said that there was strongly negative correlation between flower bud infestation and yield of okra.

4.12. Relationship between incidence of fruit infestation and yield of okra among different management practices during May-August, 2011

Correlation study was done to establish the relationship between the incidences of fruit infestation and yield of okra 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 = -0.4487x + 11.81 gave a good fit to the data and the co-efficient of determination (R^2 = 0.8307) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the yield (t/ha) of okra was strongly as well as negatively correlated with the incidence of fruit infestation.

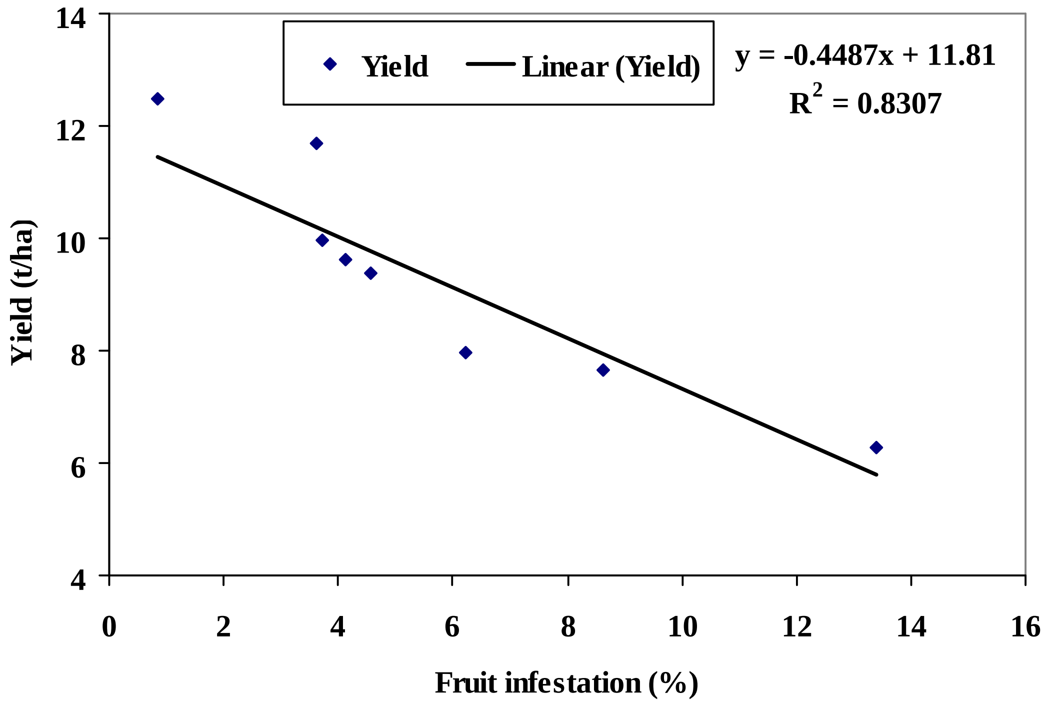

Figure 3. Relationship between incidence of fruit infestation and yield of okra

It was revealed that when the fruit infestation (0.83 %) decreased the yield (12.5 t/ha) of okra was increased. On the contrary, when the fruit infestation (13.39 %) was increased then the yield (6.27 t/ha) of okra was decreased. So, it can be said that there was strongly negative correlation between fruit infestation and yield of okra.

4. 13. Benefit cost ratio analysis

The highest benefit cost ratio (6.46) was obtained in the T_5 (spraying of neem oil @ 4 ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) treated plot. The second highest benefit cost ratio (5.62) was found in T_6 (spraying of water based neem seed kernel extract @ 50 g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) treated plot. More or less similar benefit cost ratio was observed in T_4 (4.98) comprising of releasing of *Trichogramma evanescens* egg parasitoid @ 0.5 g/plot at 7 days interval, T_1 (4.73) comprising of spraying of neem oil @ 4 ml/Litre of water at 7 days interval and T_2 (4.43) comprising of spraying of water based neem seed kernel extract @ 50 g/Litre of water at 7 days interval. The lowest benefit cost ratio (0.78) found in T_7 (spraying of neem leaf extract @ 200 g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25 g/plot at 7 days interval) treated plot followed by T_3 (0.98) comprising of spraying of neem leaf extract @ 200 g/Litre of water at 7 days interval (Table 10).

Similarly the net return was also the highest in T_5 treated plot i.e. Tk. 233300/ha followed by T_6 treated plot which is Tk. 217600/ha. On the other hand, the lowest net return found in T_3 treatment which includes Tk. 139300 followed by T_7 (140300 Tk.).

From the above mentioned findings it was revealed that the T_5 performed as the best treatment in terms of benefit cost ratio (6.46) followed by T_6 (5.62). On other hand, the lowest benefit cost ratio was recorded in T_7 (0.78) followed (0.98) by T_3 (Table 10).

Table 10. Economic analysis of different management practices for managing okra shoot and fruit borer during May-August, 2011

Treatments	Cost of pest management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net return (Tk.)	Adjusted return (Tk.)	Benefit cost ratio (BCR)
T_1	11700	9.62 b	192400	180700	55300	4.73
T_2	11400	9.37 b	187400	176000	50600	4.43
T_3	14100	7.67 c	153400	139300	13900	0.98
T_4	12400	9.98 b	199600	187200	61800	4.98
T_5	16700	12.50 a	250000	233300	107900	6.46
T_6	16400	11.70 a	234000	217600	92200	5.62
T_7	19100	7.97 c	159400	140300	14900	0.78
T_8	--	6.27 d	125400	125400	125400	--
$LSD_{(0.01)}$	--	1.40	--	--	--	--
CV(%)	--	6.68	--	--	--	--

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

T_1 = Spraying of neem oil @ 4ml/Litre of water at 7 days interval;

T_2 = Spraying of water based neem seed kernel extract @ 50g/Litre of water at 7 days interval;

T_3 = Spraying of water based neem leaf extract @ 200g/Litre of water at 7 days interval;

T_4 = Release of *Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval;

T_5 = Spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_6 = Spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_7 = Spraying of water based neem leaf extract @ 200g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval;

T_8 = Untreated control.

CHAPTER V

SUMMARY

The present study was carried out at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from May 2011 to August 2011 to evaluate performance of IPM tools for the development of an IPM package against okra shoot and fruit borer in okra.

Among eight treatments, it was observed that, T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval) was the most effective treatment for reducing shoot infestation over control at vegetative stage and different fruiting stage of okra plant. Hence the lowest shoot infestation was 0.87%, 0.50% and 0.40% in T_5 at vegetative stage, early fruiting stage and late fruiting stage respectively, followed by T_6 (spraying of water based neem seed kernel extract @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval), T_4 (*Trichogramma evanescens* egg parasitoid @ 0.5g/plot at 7 days interval), T_1 (spraying of neem oil @ 4ml/Litre of water sprayed at 7 days interval) and T_2 (water based neem seed kernel extract @ 50 g/Litre of water sprayed at 7 days interval) treatment. On the other hand, the highest shoot infestation 25.89%, 13.67% and 11.00% were recorded in T_8 (untreated control) at vegetative stage, early fruiting stage and late fruiting stage respectively followed by T_3 (spraying of neem leaf extract @ 200g/Litre of water at 7 days interval) and T_7 (T_3 + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval). It is also observed that T_5 ensured significantly the highest reduction in shoot infestation (96.50%) over the control followed by T_6, T_4, T_1, T_2, T_7 and T_3 is the least performer.

In case of flower bud infestation, the lowest percent of flower bud infestation was recorded in T_5 i.e. 0.12 %, 11.11%, and 0.91 % at vegetative stage, early fruiting stage and late fruiting stage respectively followed by T_6, T_4, T_1 and T_2. On the contrary, the highest percent of flower bud infestation was recorded in T_8 i.e. 6.40%, 46.58% and 19.91% at vegetative stage, early fruiting stage and late fruiting stage respectively followed by T_3 and T_7. In case of percent reduction of flower bud infestation over control, the highest reduction (83.33 %) was recorded in T_5 and the lowest reduction (23.04 %) was recorded in $T_{3.}$

Considering the percent fruit infestation, it was observed that T_5 (spraying of neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitiod @ 0.25g/plot at 7 days interval) was the best treatment in terms of reduction of fruit infestation by number which was 93.80 % over control. It was also revealed that the trends of results regarding reduction of fruit infestation was $T_5 > T_6 > T_4 > T_1 > T_2 > T_7 > T_3$. It was also shown that the percent fruit infestation by weight was increased in the fruiting stage of okra and declined there after but performance of different management practices in reducing fruit infestation by weight over control was shown same trends as before where highest reduction of fruit infestation (86.90 %) by weight was observed in T_5 treatment.

It was also found that T_5 performed as the best treatment in terms of fruit length and fruit girth of healthy fruit and also of infested fruit. In terms of percent increase of fruit length over control, the maximum increase of fruit length (183.99%) was recorded in T_5 where T_3 was the least performer in terms of percent increase of fruit length (23.53 %) over control. The maximum increase of fruit girth (148.62 %) was also recorded in T_5 treatment.

Out of eight treatments, T_5 performed as the best treatment in terms of reducing the number of bores per fruit (77.47 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_6 (71.82 %) and T_4 (62.09 %). On other hand, the lowest reduction of number of bores per fruit was recorded in T_3 (29.51 %) followed by T_7 (34.75 %), T_2 (46.55 %).

It was also revealed that the trends of results regarding reduction of incidence of larva was $T_5 > T_6 > T_4 > T_1 > T_2 > T_7 > T_3 > T_{8.}$ The highest reduction (80.00 %) was recorded in T_5 and the lowest reduction (33.75 %) was recorded in $T_{3,}$ followed (40.62 %) by T_7, T_4 (60.00 %) and T_2 (63.12 %).

From the above finding, it is revealed that T_5 performed as the best treatment in terms of increasing the yield of okra over control (99.37 %) followed by T_6 (86.60 %) and T_4 (59.17 %). where the minimum increase of fruit yield over control was recorded in T_3 (22.33 %) followed by T_7 (27.11 %), T_2 (49.44 %).

In case of relationship between percent shoot infestation and yield of okra among different management practices, it was shown that negative correlation was observed between the parameters i.e., the yield of okra decreased with the increase of incidence of shoot infestation. Same trends were observed in relationship between the incidence of flower bud infestation and yield of okra and also in relationship between the incidence of fruit infestation and yield of okra among different management practices.

It is also revealed that T_5 performed as the best treatment in terms of benefit cost ratio (6.46) followed by T_6 (5.62). On other hand, the lowest benefit cost ratio was recorded in T_7 (0.78) which was very close to T_3 treatment (0.98).

CONCLUSION AND RECOMMENDATION

The present study revealed that the increased yield per hectare of okra with decrease rate of shoot, flower bud and fruit infestation and the reduced weight of infested fruits might be obtained by applying neem oil @ 4ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval (T_5). Treatment T_6 consists of neem seed kernel @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval might be chosen as the alternative approach.

It was revealed that treatment T_5 having neem oil @ 4 ml/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval ensured minimum rate of shoot, flower bud and fruit infestation with increased yield. Treatment T_6 consisting of neem seed kernel @ 50g/Litre of water + *Trichogramma evanescens* egg parasitoid @ 0.25g/plot at 7 days interval could be the second effective tactics for controlling okra shoot and fruit borer. These two treatments could be integrated with the judicious use of selective chemicals and non-chemicals approaches for combating this obnoxious pest. On the other hand, T_4 and T_1 also have significant effect in suppressing this pest and it might be tested with other chemical and non-chemical components (i.e. pheromone, mechanical control, cultural control, biological control etc.) to combat this pest. It can be said that bio-control agents and botanicals are not only effective against okra shoot and fruit borer but also environmentally safe and requires more research on it. However, further study of this experiment is needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI

REFERENCES

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CHAPTER VII

APPENDIX

Appendix 1. Cost incurred per hactare in different management practices against OSFB on okra during May-August, 2011

Treatment	Item of expenditure/ha	Cost in (Taka)
T_1	14 Labors @150 Tk./labor	2100
	Neem oil @40 Tk./100 ml	9600
T_2	30 Labors @150 Tk./labor	4500
	Neem seed kernel @20 Tk./kg	6900
T_3	14 Labors @150Tk./labor	2100
	Neem Leaf @10Tk./kg	12000
T_4	16 Labors @150 Tk./labor	2400
	Trichogramma evanescens @0.5gm/plot	10000
T_5	14 Labors @ 150 Tk./labor	2100
	Neem oil @40 Tk./100ml	9600
	Trichogramma evanescens @0.25gm/plot	5000
T_6	30 Labors @150 Tk./labor	4500
	Neem seed kernel @20 Tk./kg	6900
	Trichogramma evanescens @0.25gm/plot	5000
T_7	14 Labors @150 Tk./labor	2100
	Neem Leaf @10 Tk./kg	12000
T_8	--	--