EVALUATION OF SOME INSECTICIDES AGAINST OKRA SHOOT AND FRUIT BORER *EARIAS VITTELLA* FAB.

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CERTIFICATE

This is to certify that thesis entitled, **"EVALUATION OF SOME INSECTICIDES AGAINST OKRA SHOOT AND FRUIT BORER *EARIAS VITTELLA* FAB."** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY**, embodies the result of a piece of *bona fide* research work carried out by **TANVEER AHMED SARKER**, Registration no. 05-01605 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.

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Dated: June, 2011
Place: Dhaka, Bangladesh

Prof. Dr. Md. Serajul Islam Bhuiyan
Supervisor

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The Author

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Abstract

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from April to August, 2011 to evaluate of some promising chemical insecticides applied against okra shoot and fruit borer (*Earias vittella* Fab.**)**. The treatments of the experiment were composed of five promising insecticides along with one botanical insecticide and one untreated control viz. T_1 = Neem oil @ 4 ml/L of water sprayed at 7 days interval, T_2 = Caught 10 EC @ 1ml/L of water sprayed at 7 days interval, T_3 = Suntap 50 SP @ 1.2g/L of water sprayed at 7 days interval, T_4 = Marshal 20 EC@ 2ml/L of water sprayed at 7 days interval, T_5 = Dursban 20 EC @ 1ml/L of water sprayed at 7 days interval, T_6 = Diazinon 60 EC@ 1ml/L of water sprayed at 7 days interval, T_7 = Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The data were recorded on shoot infestation at vegetative and fruiting stages; fruit infestation at early, mid and late fruiting stage; plant and yield related attributes as well as yield of okra. Among six treatments, Diazinon 60EC reduced the highest percent of shoot infestation (79% & 86.29%) over control at vegetative and fruiting stage, respectively followed by neem oil (79.68% & 78.06%, respectively), whereas Marshal 20 EC showed the least performance (63.85% & 63.85%, respectively). In case of fruit infestation, Diazinon 60EC reduced the highest percent of fruit infestation by number (84.48%, 86.27% & 89.06%) and weight (79.91%, 82.09% & 83.58%) over control at early, mid and late fruiting stages, respectively followed by neem oil and than other treatments, whereas Marshal 20 EC showed the least performance. Considering plant and yield related attributes, Diazinon 60EC increased the highest percent of plant height (53.35%), number of branch per plant (64.70%), fruit length (43.28%) and girth (9.76%), number of fruit per plant (46.42%) and single fruit weight (41.64%) over control followed by neem oil, Caught 10 EC, Suntap 50 SP, Dursban 20 EC and Marshal 20 EC, where Marshal 20 EC showed the least performance. Similarly, the highest fruit yield (15.44 ton/ha) was also achieved by Diazinon 60 EC with the increase of 14.88% yield over control than neem oil and other insecticides, whereas Marshal 20 EC showed the least performance (13.53 ton/ha) with the lowest percent of yield increase (0.67%). The yield of okra was negative correlated with shoot (r = 0.3813) and fruit (r = 0.3895) infestation, but positively correlated with the yield attributes such as number of branch per plant (r = 0.9192) and length of fruits (r = 0.7612). Considering the economic returns, Diazinon 60EC gave the highest benefit cost ratio (6.90) than Dursban 20EC (5.80), neem oil (4.30) and others, where the lowest BCR (1.28) was achieved by Marshal 20EC. Though neem oil gave third highest BCR (4.30), but produced second highest yield (14.44 ton/ha). Thus neem oil was considered as an economically viable as well as human health hazards free tool effective against okra shoot and borer control.

CHAPTER I

INTRODUCTION

Okra, *Abelmoschus esculentus* (L.) Moench is a member of Malvaceae and known as Lady's finger. It is locally known as "Dherosh'' or "Bhindi". It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Thakur *et al*, 1986). Okra is probably originated in tropical Africa or possibly tropical Asia, and is now widely grown throughout the tropics (Tindall, 1988). The crop is well distributed throughout the Indian Subcontinent and East Asia (Rashid, 1999). Its tender green fruits are popular as vegetables among all classes of people in Bangladesh and elsewhere in the world. Though it is popular, its production is mainly concentrated during the summer. However, now a day's okra is found in the market almost round the year. It is a nutritious and delicious vegetable fairly rich in vitamins and minerals. The edible portion of pod weighing (100g) has moderate levels of vitamins A (0.1 mg) and C (18 mg), calcium (90 mg), phosphorus and potassium. The content of thiamine (0.07 mg), riboflavin (0.08 mg) and niacin (0.08 mg) per 100 g edible portion of pod is higher than that of many vegetable (Rashid, 1999).

In Bangladesh, vegetable production is not uniform round the year. Most of the vegetables are produced in the winter but very low in the summer. Around 30% of the total vegetables are produced in the kharif season (Anon, 1993). Among them okra is very important one. In the year 2009-2010, the total production of okra was about 42000 tons from 10121 hectares of land with an average yield of 4.15 t/ ha (BBS, 2011). The yield is very low compared to that of other developing countries where the yield is as high as 7-12 t/ha (Yamaguchi, 1998). In Bangladesh the yield of okra is very low due to improper management of cultural practices.

Okra production in Bangladesh is affected by many factors, among which 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 of which the fruit borer complex create havoc by causing both quantitative and qualitative loss to the crop. The fruit borers include okra 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). Whereas in general the overall damage due to insect pest accounts to 48.97 percent loss in fruit yield (Kanwar and Ameta, 2007). In Bangladesh okra shoot and fruit borer severely attacked the shoots and fruits of okra and reduced the market value of fruits. The larvae bore into the tender shoots, flower buds, young fruits and feed inside the fruits and damage seeds. As a result affected fruits become unfit for human consumption (Karim, 1992). Srinivasan *et al.* (1959) reported that upto 40-50% damage of okra fruits caused by the okra shoot and fruit borer in some areas of south-east Asian countries. Krishnaiah (1980) observed the attack of fruit borer to the extent of 35% in harvestable fruit of okra in India.

Farmers always desire quick curative action for controlling pests. Since no other control measure against okra shoot and fruit borer is available, chemical insecticides have remained as the most powerful tools for controlling this pest. Insecticides are highly effective, rapid in curative action, adaptable to most situations and relatively economical. Insecticides are the only tool for pest management which is reliable for emergency action when insect pest population approach or exceed the economic threshold level (Prakash, 1988). Chemical insecticides those are applied for controlling brinjal shoot and fruit borer and spotted bollworm have the similar curative action against okra shoot and fruit borer. Because those insecticides are effective against pests having internal feeding behavior, frequent application of insecticides in consecutive cropping season leads to resistance by pests. Kabir *et al.* (1994) reported that some commercially available insecticides like Ripcord 10 EC, Shobicron 425 EC, Cymbush 10 EC, Ralothrin 10 EC, Sunfuran 10 EC an Fenom 10 EC were tested over three consecutive cropping seasons at Gazipur and Jessore against shoot and fruit borer but internal borer showed resistance against those insecticides. Ngo *et al.*, 1999) reported that Proclaim 05 SG showed very little resistance because emamectin benzoate (Proclaim) penetrates the plant cuticle to form a reservoir of active ingredient. The toxic action of cypermethrin and deltamethrin in marketable size fruit persisted for 8 days @ 0.03-0.04 ppm (Agnihotri *et al.*, 1990), whereas that of proclaim persisted for 3 days in okra fruits @ 0.05 mg/kg body weight (El-Aw. 2003). Several management practices have been reported in different parts of the world to control this pest. But in Bangladesh, the control measure of okra shoot and fruit borer is dominated by chemical pesticides. In Bangladesh, attempt to control insect-pest of okra in summer or in winter has been made on a very small scale.

Objectives

Considering the above situation view in mind the present study was, therefore, undertaken considering the following objectives:

- To investigate the level of infestation of okra shoot and fruit borer in okra;
- To evaluate the efficacy of some promising insecticides against the okra shoot and fruit borer, and
- To make the correlation studies among different infestation parameters, yield attributes and yield of okra;
- To analyze the economic returns of different management practices applied against okra shoot and fruit borer.

CHAPTER II

REVIEW OF LITERATURE

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

2.1. Taxonomic position of okra shoot and fruit borer

- Kingdom: Animalia
- Phylum: Arthropoda
- Sub-phylum: Mandibulata
- Class: Insecta
- Order: Lepidoptera
- Family: Noctuidae
- Genus: *Earias*
- Species: *Earias vittella*
- *Earias insulana*

2.2. Distribution of okra shoot and fruit borer

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

2.3. Biology of okra shoot and fruit borer

- Satpute *et al.* (2002) reported that the life cycle of *Earias vittella* is completed within 27-28 days when reared on okra, and within 30-31, 29-30 and 34-35 days when reared on cotton, artificial diet and mesta, respectively.
- The biology of *Earias vittella* on okra (cv. Soumya) was studied by Naresh *et al*. (2004) under laboratory conditions during March-April and June-July 2001 at Mohanpur, Nadia, West Bengal, India. The average fecundity was 199 eggs during Marh-April and 201 eggs during June-July. The egg incubation period was 3.76 and 3.31 days and hatchability was 77.35 and 73.10% in the respective rearing. There were six larval instars during March-April and five during June-July. The larval and pupal stage occupied 12.53 and 7.89 days in the first rearing and 11.12 and 7.66 days in the second rearing respectively. The time required to complete the life cycle (egg to adult) averaged 24.8 days during March-April and 22.09 days during June-July.
- Bhat *et al.* (2005) studied the biology of spotted bollworm, *Earias vittella* (Fab.) on okra. The duration of incubation, larva and pupal period varied from 2.6 to 3.8, 8.2 to 9.0 and 7.8 to 8.6 days during June, July and August compared to 4.4 to 4.8, 9.8 to 12.2 and 9.8 to 10.2 days during September, October and November, respectively. the highest fecundity (206.4 eggs/female) was recorded during September and lowest (187.4 eggs/female) in June.
- Sardana and Tewari (1990) observed the distribution of eggs of *E. vittella* in okra field in Karnatak, India. Result indicates that the border rows tended to receive more eggs than the central rows. Ovipositing females laid most of the eggs on the top of the plants.

- The biology of okra shoot and fruit borer was studied on okra in laboratory and field (Singh and Bichoo, 1989). They stated that the egg, larval and pupal stages lasted 3-4, 9-17 and 6-14 days respectively in September-October.
- Sundararaj and David (1987) stated that the percentage survival of okra shoot and fruit borer was higher on okra (68 days), followed by cotton (67 days). Okra and *Abutilon indicum* (16.3days). Okra and cotton had a higher reducing sugar and free amino acid and protein. On the other hand *Abutilon indicum* had lower non reducing sugar.
- Hiremath (1987) found the larval period of *E. vittella* to be 13.7 days and females laid an average of 303.2 eggs in July-August. Krishna (1987) observed higher overall mean fecundity of female okra shoot and fruit borer when larvae reared on okra seeds compared to those reared on whole fruit.
- Butani and Jotwani (1984) reported that the eggs of *Earias vittella* spherical in shape, about half mm in diameter, light bluish green in color and beautifully sculptured having 26 to 32 longitudinal ridges. The alternate ridges project upwards to form a crown thus the eggs look like tiny or miniature poppy fruits. Full grown caterpillars are 18 to 24 mm long, stout, spindle shaped having long stiff setae. Pupae are 13 to 16 mm long and chocolate-brown in color, bluntly rounded and enclosed in inverted boat shaped cocoons. Adults are medium sized moths, 13 to 15 mm long, head and thorax ochreous white; fore wings pale white with a broad wedge shaped horizontal green patch the middle and hind wings silvery creamy white in color. Wing expanse is 30 to 34 mm.

- Butani and Jotwani (1984) also indicated that the moth emerge at dusk; mating takes place 2 to 3 days after emergence and oviposition commences after 1 to 5 days of mating. A female lays on an average 400 eggs (65 to 695). They also reported that incubation, larval and pupal periods last for 3 to 9, 9 to 20 (50 to 60 days during winter), 8 to 12 days, respectively. A single life cycle takes 22 to 25 days extending up to 74 days during winter and there may be 8 to 12 generations in a year. There is no true hibernation but development and activity is considerably slowed down during winter.
- Rehman and Ali (1983) reported that female of *E. vittella* mated for successful insemination and laid 82-378 eggs each in 4-7 days. The egg stage lasted for 3-4 days, the larval stage 5-16 days, the prepupal stage 1 day, the pupal stage 6-13 days and adult life span 8-18 days.
- The biology of *E. vittella* on okra was studied by Sharma *et al.* (1985) in the laboratory using individuals collected from the field of Bihar, India. The borer had 11 generations in a year; the longest life cycle (49 days) was observed during January. While the shortest life cycle of 29 days was found during July.
- Tamhankar *et al.* (1992) studied the growth and development of *Earias vittella* on different artificial diets. They found that the most satisfactory diet consisted of 11% maize semolina, 1.6% wheat bran, 2.4% soyabean powder, 1.4% yeast, 0.9% salt mixture, 0.3% ascorbic acid, 0.9% cellulose, 1.8% agar, 76.7% water and preservatives
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- **2.4. Host range of okra shoot and fruit borer**

- Gautam and Goswami (2004) stated that okra shoot and fruit borer (*Earias vittella)* feeds on many species of malvaceous plants.
- Satpute *et al*. (2002) studied on different hosts of *Earias vittella* and found that okra was most preferred host for the development of the pest, followed by cotton, artificial diet and mesta (*Hibiscus sp.*) based on average minimum pupal period, highest fecundity and maximum pupal and adult weight.
- Dongre and Rahaller (1992) were examined the relative food plant preference and induction of preference for feeding behavior in larvae of *Earias vittella* under dual choice conditions. Out of 5 food plants, *Abelmoschus esculentus* (okra) was the most and *Hibiscus rosa-sinensis* was the least preferred.
- Butani and Jotwani (1984) found okra shoot and fruit borer as an oligophagous pest although okra and cotton are its main hosts. They also found it to feed on a large number of malvaceous plants, both wild as well as cultivated.
- Rehman and Ali (1983) reported that when okra shoot and fruit borer were offered the choice of different parts of host plant they preferred okra fruit and shoot the best followed by cotton balls, ball. Flowers and buds of deshi cotton (*Gossypium arboretum*), buds and flower of kenaf and maize grains, flower of *Abutilon indicum*, flowers of *Hibiscus rosasinensis*, sarson (*Brassica campestris* var *sarson*) , *Malvastrum tricuspidatum*, *Cassia fistula* and ears of pearl millet, pod of jute and soyabean.
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- **2.5. Extent of damage and yield loss okra by okra shoot and fruit borer**
- According to Acharya (2010) 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).

- 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.
- The larvae of okra shoot and fruit borer bore into the tender shoots, flower buds and fruits. As a result, the attacked shootdry 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).

- 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).
- **2.6. Management of okra shoot and fruit borer**
- **2.6.1. Use of chemical insecticides for the management of okra shoot and fruit borer**
- Ramesh and Gupta (2005) studied the effect of spray of different insecticides namely thiodicarp, cartap, diflubenzuron and cypermethrin on okra crop. They observed that cartap exhibit the highest yield, germination percentage and seedling vigour.
- Tzung and Liang (2004) reported that Proclaim (4-deoxy-4-epi-methyl-amino benzoate salt of avermectin BI) has a wide margin of safety because mammalian species are much less sensitive due to lower GABA receptor affinities and relative impermeability of the blood-brain barrier.
- Çhoi *et al.* (2004) studied that the control effects of some insecticides against the stone leek leafminer, *L. chinensis*. They found that among the treatments emamectin benzoate (Proclaim), dimethoate and cartap showed over 87% of larvicidal activity.
- Sale (2004) studied the efficacy of Proclaim (emamectin benzoate of the chemical group Avermectin) for six seasons (from 1999 to 2004) in New Zealand in controlling leafroller on kiwifruits. The results demonstrated that

using Proclaim at the low rate of 2g/l00 litres or 40g/ha recorded an acceptable reduction in leafroller damage.

- El-Aw (2003) studied the toxicity and sub-lethal effects of some insecticides including Proclaim (emamectin benzoate) and reported that the toxic action of Proclaim persisted for 3 days in okra fruits.
- Brickle *et al.* (2001) tested nine insecticides, cypermethrin (Cyperkill 25 EC), carbaryl (Hexavin 50 WP), deltamethrin (Decis 2.8 EC), diflubenzuron (Dimilin 25 WP), endosulfan (Thiodan 35 EC), fenvalerate (Sumicidin 20 EC), fluvalinate (Mavrik 25 EC), monocrotophos (Monocil 36 SL) and quinaiphos (Ekalux 25 EC) against 1 -day-old eggs of *Earias vittella*. All treatments significantly reduced egg-hatch, although diflubenzuron had occured by far the least effect.
- Ngo *et al*. (1999) reported that Proclaim (Emamectin benzoate), a second generation avermectin insecticide, is highly effective against a broad range of Lepidopterous pests. It is most effective when ingested as neurotoxin, but it also demonstrates contact activity. It is not systemic, but through translaminar movement, emamectin benzoate penetrates the plant cuticle to form a reservoir of active ingredient. Emamectin benzoate is highly selective for Lepidopterous larvae and is not disruptive to beneficial arthropods in IPM program.
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- Efficacy of different pesticides and their combination against jassid and borer of okra was studied by Satpathy and Rai (1999). The result indicates that among the treatments in vegetative phase, Monocrotophos + cypermethrin combination reduced the shoot borer damage, significantly to 2.06% and

4.08% during 1996 and 1997 respectively. In the reproductive stage, protection with monocrotophos, cypermethrin, combination of these two insecticides in half doses and combination of neem (2.5 ml/litre) and endosulfan (350 g a.i./ha) were equally effective against fruit borer.

- Residues of cypermethrin in or on okra fruits were analyzed by Bishwajeet *et al.* (1999) at different time intervals by gas liquid chromatography when proprietary and laboratory-prepared cypermethrin formulations were sprayed at recommended field dosages. They observed no phyto-toxicity symptoms in any of the laboratory prepared formulations and the proprietary product at the recommended field dose.
- Badaya *et al*. (1999) studied the efficacy and economics of different insecticides for the control of okra fruit and shoot borer, *Earias vittella* Fab. They found that among several insecticides against *Earias vittella* on okra in Madhya Pradesh, India, fenvalerate at 0.02% was the most effective and profitable treatment, while dimethoate at 0.05% was relatively ineffective.
- Brar *et al.* (1998) reported that among a number of insecticides tested against *Earias spp.* alphamethrin (alpha-cypermethrin), fenvalerate, cyperrnethrin, chlorpyrifos and triazophos at equivalents of 250, 250, 500, 1000 and 1500 ml/ha, respectively, were the most effective, causing 100% mortality 72 h after spraying.
- Dhawan *et al.* (1993) reported in India that cartap (Padan 50 SP) applied at 1.00 kg a.i./ha to control spotted bollworms (*Earias vittella*) on cotton was effective. Higher concentration of cartap (1.25 kg or more) acted as a defoliant.

- A field experiment was conducted by Patil *et al.* (1991) in India for the control of okra fruit and shoot borer (*E. vittella*) with cypermethrin (15 gm/ha), fenvalerate (50gm/ha), acephat (375 gm/ha), quinaphos (250 gm/ha) and endosulfan. (250 gm/ha). All treatments reduced pod damage but cypermethrin treated plants were the least infested gave the best yield.
- David and Kumaraswami (1991) stated that cypermethrin at 0.016%, deltamethrin at 0.003% or 0.002% and fenvalerate at 0.0 1% were the most effective treatments for the control of *Earias spp*. on okra.
- Konar and Rai (1990) found that two applications of malathion at 1000 ml/ha for the control of okra shoot and fruit borer provided significant control of the pest followed by carbaryl.
- Chaudhury and Dadheech (1989) reported that if the insecticidal protection was not given the okra shoot and fruit borer infested fruits were as much as 57.1% with a yield of 9.83 kg/plot. But the plots protected with alternate weekly sprays of 0.03% phosphamidon and 0.05% endosulfan provided yield of 15.65 kg/plot with 10% fruit infestation.
- Chauhan (1989) recommended 2.03% endrin as early as possible in the infested crop for the control of noctuid okra shoot and fruit borer and to be repeated once or twice if necessary.
- Misra (1989) studied the bio-efficacy of some insecticides against the pest complex of okra. The author reported that percent shoot infestation in insecticide treated plots varied from 1.74- 10.03% compared to 15.23% in untreated control plots.
- Sarkar and Nath (1989) conducted a field trial in Tripura, India, and indicated that decamethrin, malathion, endosulfan and carbaryl were effective to

control the okra shoot and fruit borer but fenvalerate (0.5 ml/L and 750 ml/ha)gave the greatest reduction in number of infested fruits.

- Dhamdhere *et al.* (1988) stated that 0.15% thiodicarp was more effective than the other carbamate tested for the control of okra shoot and fruit borer on the basis of percent fruit infestation, yield and economic considerations and was as effective as 0.03% oxydemeton methyl.
- Pawer *et al.* (1988) reported that single spray of endosulfan at 500 gm/ha followed by 3 applications of cypermethrin (fenvalerate) at 50 gml/ha at 14 days intervals were the most effective for the control of *E. vittella* of okra. Application of fenvalerate at 0.015% for the control of okra shoot and fruit borer gave lowest infestation levels and highest yield (Ratanpara and Bharodia, 1989).
- Sardana and Tewari (1987) reported that dipping the pupae of okra shoot and fruit borer in diflubenzuron suspension of 125 ppm or more for 30 second resulted in pupal mortality. The effectiveness of the chemicals decreased with increase of pupal age.
-
- Treatment with endosulfan at 500 g/ha sprayed 15 days after germination followed by 3 app1ications of fenvalerate at 50 g/ha 40, 55 and 70 days after germination were most cost effective is controlling insect pests of okra (*E. vittella*) for summer and winter (Krishnakumar and Srinivasan, 1987).
- A significant reduction in *E. vittella* on okra was obtained with fenvalerate, cypermethrin and deltamethrin at 50, 30 and 10 gm/ha, respectively when applied at 25 days intervals compared to those applied at 35 days intervals. There was no significant difference in marketable yield among the

treatments applied at 25 and 35 days intervals suggesting a possibility of extending the spray interval (Krishnakumar and Srinivasan, 1985).

- The economics of pest management of okra shoot and fruit borer were studied by (Srinivasan and Krishnakumar, 1983) in Karnatak, India for 3 growing seasons. Disulfoton granules at 1 kg a.i/ha applied at the time of sowing, followed by carbaryl sprays at 40, 50 and 60 days after germination in the rainy and late summer growing seasons, or 40 and 55 days after germination in the winter season, gave the maximum crop yield and net income.
- Gopalan *et al.* (1974) reported that the best result can be achieved to control the noctuid fruit and shoot borer *E. vittella* of okra with two application of sevimol 1%, monocrotophos 0.1% or endosulfan 0.9% at the 45 and 60 days after sowing the crop.
- Venkatanarayanan *et al.* (1974) tested different insecticides in combination with urea in controlling okra shoot and fruit borer and reported that urea at 2% and 3% concentration could be safely mixed with 0.07% endosulfan, 0.1% sevimol and 0.1% nuvacron without affecting their insecticidal properties. However, urea at 4% and 6% with or without insecticides scorched the leaves.
- **2.6.2. Use of botanical insecticides for the management of okra shoot and fruit borer**
- Mudathir and Basedow (2004) found that different preparations of neem significantly reduced okra shoot and fruit borer infestation in okra.
- 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.

- Ambekar *et al.* (2000) evaluated the efficacy of neem-based formulations and synthetic insecticides against okra shoot and fruit borer. They found that all treatments significantly reduced fruit borer infestation over the untreated control. However, cypermethrin at 0.1% was the most effective and recorded the lowest infestation of 6.57%.
- 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).
- Adult pairs of males and females of *Earias vittella*, a pest of cotton and okra, were released in breeding chambers in different sets, containing the odours of the leaves of neem, *Azadirachta indica*; tulsi, *Ocimum basilicum*; eucalyptus, *Eucalyptus rosfrata*; lantana, *Lantana camara*; bulbs of garlic, *Allium sativum* and one control set with no odour. Adult longevity did not differ significantly among the treatments. All the treatments significantly reduced the egg output as compared to the control (172 eggs). Similarly, all the odours significantfy reduced egg hatching compared to the control (90.81%). The lowest number of eggs (128) and hatching (68.15%) were recorded with *Azadirachta* leaves odour (George, 1997).
- 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).

- Numerous plant species have been reported to possess pest control properties but only a few seem to be ideally suited to practical utilization. Among these, neem (*Azadirachta indica* A. Juss) and bakain (*Melia azedarach* L) are the most promising plants from the entomological perspective (Schmutterer 1990 and 1995).
- Neem 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).
- Weekly application of neem (*Azadirachta indica*) oil at 2% was effective for controlling *E. vittella* on okra (Sardana and kumar, 1989). They observed that the plots having lower fruit damage and increased yields in treated plots as compared those of untreated ones. Neem oil was found as effective as monocrotophos at 0.05% and can therefore, be recommended for the use in an integrated control scheme for the pest.
- 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).
- Maximum reduction in bollworm infestation (65.7%) was observed in garlic treated plot. Garlic extract and NSKE both at 10 per cent were found to be superior. Lowest bollworm incidence was observed with NSKE (10.3%), datura and neem oil emulsion (Anon. 1987).
- Sardhana and Krishna Kumar (1989) studied the efficacy of neem oil, karanj oil (both at 0.5, 1.0 and 2.0%) and garlic oil (0.25, 0.5 and 1.0%) in comparison with monocrotophos (0.05%). Among the oils, neem oil and karanj oil offered effective control against okra fruit borers. It was

concluded that weekly application of neem oil at two per cent concentration was effective in controlling fruit borer in okra and was safe to natural enemies.

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

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

CHAPTER III

METERIALS AND METHODS

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from April to August 2011 to find out the efficacy of five promising chemical insecticides and one botanical product applied against okra shoot and fruit borer on the reduction of infestation level of okra shoot and fruit borer. The details of different experimental materials and methodologies followed during the course of the investigation are described under the following sub-headings:

3.1 Description of the experimental site

3.1.1. Location and duration

The research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the *kharif* season from April to August 2011.

3.1.2. Soil of the experimental site

The soil of the experimental site is a medium high land belonging to the Modhupur Tract under the Agro Ecological Zone (AEZ) 28. The soil texture was silty loam with a pH 6.7. Soil samples of the experimental plot was collected from a depth of 0 to 30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI), Farmgate, Dhaka. Details of the mechanical analysis of soil sample are shown in Appendix I.

3.1.3. Climate

The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to August, 2011) and scantly in the Rabi season (October to March, 2011). There was no rain fall during the month of December, January and February. The average maximum temperature during the period of experiment was 35.10°C and the average minimum temperature was 30.40°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the period of the experiment were collected from Bangladesh Meteorological Department, Agargoan, Dhaka and have been presented in (Appendix II).

3.1.4. Preparation of the field

The selected land for the experiment was first opened on 27 March 2011 by power tiller and expose to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and laddering to obtain good tilth followed each ploughing. Weeds and stubble's were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. After removal of the weeds, stubble's and dead roots, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the design, and the edge around each unit plot was raised to check run out of the nutrients. The target land was leveled and the experimental plot was divided into 28 equal plots with a plot size of 3.0 m x 2.0 m and plot to plot distance 0.6 m; block to block distance 0.5 meter.

3.1.5. Application of fertilizers

The entire quantity of cowdung (10 ton/ha) was applied before final land preparation. Urea was applied as per treatment in each plots of $6m^2$. Triple Super Phosphate (TSP) and Muriate of Potash (MP) were applied at the rate of 100kg/ha and 150kg/ha respectively. Full dose of TSP and cowdung were applied to the soil at the final land preparation. Urea and MP were applied as side dressing (ring method) in 3 equal installments at 15, 30 and 45 days after germination.

3.1.6. Design of the experiment and layout

The experiment consisting 7 treatments was laid out in RCBD with four replications. The whole field was divided into four blocks, where each block further divided into 7 plots (Plate1). Altogether, there were 28 unit plots in each experiment and required 245 m^2 land. Each unit plot was 6 m^2 (3 m ×2 m) in size. The distance between plots was 0.50m, plant to plant distance was 60cm and row to row distance was 50cm.

Plate 1. The experimental field of Okra laid out in farm of SAU, Dhaka

3.2. Treatments

There were six insecticides from different groups and one untreated control evaluated in this study applied against okra shoot and fruit borer, where each insecticide was treated as individual treatment to explore their efficacy. The group wise insecticides with their specific dose applied as treatment were given below:

Treatment	Insecticides ®	Dose	Insecticide group
T_1	Neem oil	@ 4 ml//Litre of water	Botanical
T_2	Caught 10 EC	@ 2 ml/Litre of water	Cypermethrin
T_3	Suntap 50 SP	@1.2gm//Litre of water	Organocarbamate
T_4	Marshal 20 EC	@ 2 ml/Litre of water	Organocarbamate
T_5	Dursban 20 EC	@ 1 ml//Litre of water	Organophosphate
T_6	Diazinon 60 EC	@ 1 ml//Litre of water	Organophosphate
T_7	Untreated control	No control measure	

3.3. Detail procedure of the study

The detail procedure considering the materials used and methodology followed in the study were furnished in below:

3.3.1. Okra variety used in the study

The okra variety "BARI Dherosh-1'' was used in the present study. It is an open pollinated high yielding variety developed by the Vegetable Section of Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Gazipur. The seeds of the selected variety were collected from Vegetable Section of BARI, Gazipur.

3.3.2. Seed sowing

Seeds were sown on 28 April, 2011. In each plot, seeds were sown in rows and there were three rows in each plot. In the rows, plant to plant distance was 60 cm and row to row distance was 50 cm. the seeds were covered with fine soil by hand. The field was irrigated lightly immediately after sowing.

3.3.3. Intercultural operation

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

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

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

Weeding: Four weeding were done manually at 15, 30, 45 and 60 DAS to keep the plots free from weeds.

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

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

3.3.4. Application of the treatments

The selected treatments comprising different insecticides with their assigned doses were started to apply in their respective plots when the moths of okra shoot and fruit borer were first seen in the okra field. The first incidence of moths of okra shoot and fruit borer was determined by the utilization of light trap (Plate 2) in the okra field. Therefore, considering the first appearance of the moths in the field, treatment applications were started at 60 days after sowing (DAS) of the okra seeds. The treatments were applied at 7 days interval and continued. In case of untreated control, only fresh water was sprayed for respective plots.

Plate 2. Use of light trap to identify the first incidence of adult moth in the okra field

3.4. Data collection and calculation

Infestated shoot and fruit of okra was monitored during vegetative and reproductive stages respectively. Infested shoots were counted and recorded at 7 days intervals after observing the bores and excreta in both vegetative and reproductive stage of the okra plants, but fruit infestation was counted and recorded at every harvesting time of the fruits that was followed at every alternate day.

Eight plants per plot were selected randomly and tagged for data collection. Data collection on shoot infestation was started at 60 DAS. All data were collected before the application of treatment. After the completion of data collection, insecticides were sprayed according to schedule. The data were collected on the number of total and infested shoots per plant, number of total and infested fruits per plant, weight of total and infested fruits per plant and plot**,** plant height (cm)**,** number of branch per plant**,** length and girth of fruits**,** yield (t/ha) of fruits.

3.4.1. Data on shoot infestation

Eight plants from each plot were selected randomly for data collection. The infestations of shoot (Plate 3)by okra shoot and fruit borer were recorded by direct visual observation. Total numbers of shoots as well as the number of infested shoots were recorded at two days interval from 8 tagged plants in each treatment. The percent shoot infestation and percent reduction of shoot infestation over control were calculated with the following formula (Khosla, 1997):

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

$$\% \text{ reduction of shoot infestation over control} = \frac{\text{Mean value of untreated plot - Mean value of treated plot}}{\text{Mean value of untreated plot}} \times 100$$

Plate 3. Healthy (left) and **o**kra shoot and fruit borer infested (right) shoots of okra

3.4.2. Data on fruit infestation

The data on the number of total and infested fruits (Plate 4) by number and weight were recorded from 8 tagged plants for each treatment. The percent fruit infestation and percent reduction of fruit infestation over control were calculated with the following formula:

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

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

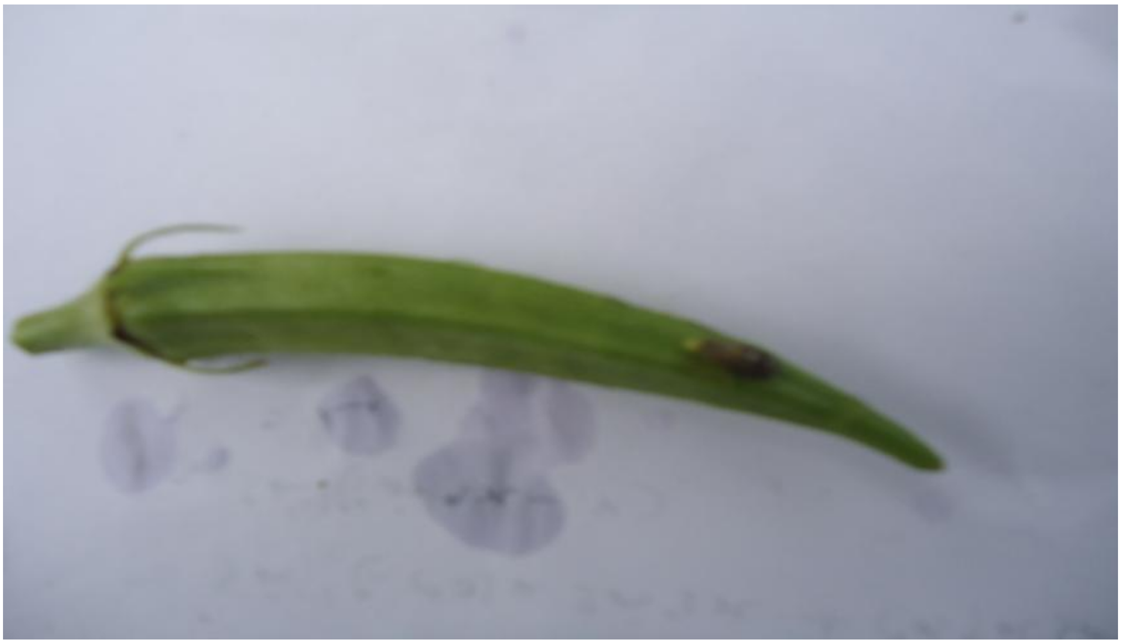

Plate 4. Okra fruit showing infestation symptom caused by OSFB

3.4.3. Length and girth of fruit

Length and girth of fruits from randomly selected 8 plants was taken and then averaged for each treatment separately. The percent increase of fruit length and girth over control were calculated with the following formula:

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

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

3.4.4. Height of plant

Height of plant from randomly selected 8 plants was taken and then averaged for each treatment separately. The percent increase of fruit length and girth over control were calculated using the above mentioned formula.

3.4.5. Number of branch per plant

Number of branch (Plate 5) from randomly selected 8 plants was taken and then averaged for each treatment separately. The percent increase of branch over control was calculated using the above mentioned formula.

Plate 5. An okra plant showing branches and flowers

3.4.6. Weight of single fruit

Mean weight of fruits from randomly selected 8 plants were measured for each plot of the experiment for each treatment separately. The percent increase of single fruit over control was calculated using the above mentioned formula.

3.4.7. Yield of okra

Total yield of okra per plot was recorded in kg/plot separately for each treatment. From the yield of okra per plot was then converted into yield in ton/ha for each treatment. Effect of different treatments on the increase and decrease of okra yield over control was also then calculated using the following formula:

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

3.5. Economic analyses of the treatments

Economic analysis in terms of benefit cost ratio (BCR) was analyzed on the basis of total expenditure of the respective management practice along with the total return from that particular treatment for a hectare of land.

3.5.1. Treatment wise management cost/variable cost:

The cost was calculated by adding all costs incurred for labours and inputs for each management treatments including untreated control during the entire cropping season. The plot yield (kg/plot) of each treatment was converted into ton/ha.

3.5.2. Gross return (GR):

The yield in terms of money that was measured by multiplying the total yield by the unit price of okra (Tk 25/kg).

3.5.3. Net return (NR):

The net return was calculated by subtracting treatment wise management cost and production cost from gross return.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Adjusted net return}}{\text{Total management cost}}$$

3.6. Statistical analysis

The collected data on various parameters were statistically analyzed MSTAT-C computer software package program. The mean for all the treatments were calculated and analyses of variance for all the characters were performed by F-variance test. The significance of difference between the pairs of treatment mean was compared by the Duncan's Multiple Range (DMRT) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results on the effectiveness of various treatments including untreated control for the management of okra shoot and fruit borer (*Earias vittella*) have been described and discussed with following sub headings:

4.1. Effect of insecticides on shoot infestation at vegetative stage

Significant differences were observed among different insecticides in terms of percent shoot infestation by number at the vegetative stage during the management of okra shoot and fruit borer (Table 1). The highest percent of shoot infestation (9.47 %) was recorded in T_7 (untreated control) which was statistically different from all other treatments (Table 1) and it was followed by T_4 (3.42 %) comprised of spraying Marshal 20 EC @ 2ml/L of water at 7 days interval and T_3 (3.02 %) comprised of spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval.On the other hand, the lowest percent of shoot infestation (1.72 %) was recorded in T_6 comprised of Diazinon 60 EC @ 1.0 ml/L of water at 7 days interval and followed by T_1 (1.92%) comprised of Spraying of neem oil @ 4ml/L of water at 7 days interval and T_2 (2.32 %) comprised of spraying Caught 10 EC @ 1 ml/L of water at 7 days interval.

Considering the percent shoot infestation reduction over control, the highest reduction (81.79%) was observed in T_6 and the lowest reduction (63.85%) was observed in T_4 Marshal 20 EC @2 ml/L of water (Table 1).

Table 1. Efficacy of different insecticides on shoot infestation during the management of okra shoot and fruit borer at vegetative stage

Treatment	Shoot infestation (%)	% reduction of hoot infestation over control
T_1	1.93 cd	79.68
T_2	2.33 c	75.46
T_3	3.03 b	68.07
T_4	3.43 b	63.85
T_5	3.03 b	68.07
T_6	1.73 d	81.79
T_7	9.48 a	-
LSD $_{(0.05)}$	0.45	-
CV (%)	8.42	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

4.1.2. Efficacy of different insecticides on shoot infestation at fruiting stage

More or less similar trend of results were also observed among different insecticides in terms of reduction of shoot infestation at fruiting stage during the management of okra shoot and fruit borer. The highest shoot infestation (7.41%) was recorded in T_7 (untreated control) followed by T_4 (2.83%), T_5 (2.33%), T_3 (2.23%). On the other hand, the lowest shoot infestation (1.02%) at fruiting stage was recorded in T_6 followed by T_1 (1.63%) and T_2 (2.03%). Considering the shoot infestation reduction over control at fruiting stage, the highest reduction 86.29% was achieved in T_6 followed by T_1 (78.06%), T_2 (72.65%), T_3 (69.95%) and the lowest reduction (61.85%) was achieved in T_4 followed by T_5 (68.60%).

Table 2. Efficacy of different insecticides on shoot infestation during the management of okra shoot and fruit borer at fruiting stage

Treatment	Shoot infestation (%)	% reduction of shoot infestation

		over control
T_1	1.63 e	78.06
T_2	2.03 d	72.65
T_3	2.23 c	69.95
T_4	2.83 b	61.85
T_5	2.33 c	68.60
T_6	1.02 f	86.29
T_7	7.41 a	-
LSD $_{(0.05)}$	0.14	-
CV (%)	3.33	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

From the above findings it was revealed that among the different insecticides the T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in terms of percent shoot infestation reduction and the T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7days interval was least performer in reducing percent shoot infestation reduction over control during the management of okra shoot and fruit borer. As a result, the trend of different management practices in terms of shoot infestation reduction was T_6> T_1> T_2> T_3,T_5> T_7. About similar results were also observed by different researchers. Shukla *et al.* (1997) reported that before fruiting stage shoot infestation reached a peak of 8.5%. Choi in Hu *et al.* (2004) reported that Proclaim showed 87% shoot infestation reduction. Islam *et al.* (1999) observed the minimum acceptable level of shoot infestation reduction over control was 80%.

4. 3. Efficacy of different insecticides on fruit infestation by number at early fruiting stage

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

Table 3. Efficacy of different insecticides on fruit infestation by number at early fruiting stage during the management of okra shoot and fruit borer

Treatment	Fruit infestation (%)	% reduction of fruit infestation over control
T_1	3.03 e	82.12
T_2	4.93 c	70.89
T_3	5.03 c	70.30
T_4	5.73 b	66.16
T_5	4.43 d	73.84
T_6	2.63 f	84.48
T_7	16.92 a	-
LSD $_{(0.05)}$	0.14	-
CV (%)	1.52	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications
[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7 = Untreated control]

The highest percent of fruit infestation (16.92 %) was recorded in T_7 (untreated control) which was statistically different from all other treatments (Table 3) and followed by T_4 (5.73 %) comprised of spraying Marshal 20 EC @ 2ml/L of water at 7 days interval and T_3 (5.03 %) comprised of spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval and spraying of Dursban 20 EC @ 1 ml/L of water at 7 days interval On the other hand, the lowest percent of fruit infestation (2.63 %) was recorded in T_6 comprised of Diazinon @ 1.0 ml/L of water at 7 days interval and it was followed (3.03%) by T_1 comprised of Spraying of neem oil @ 4ml/L of water at

7 days interval and T_5 (4.43 %) comprised of spraying Dursban 20 EC @ 1 ml/L of water at 7 days interval.

Considering the percent fruit infestation reduction over control, the highest reduction (84.45%) was observed in T_6 and the lowest reduction (66.16%) was observed in T_4 Marshal 20 EC @2 ml/L of water (Table 3).

4. 4. Efficacy of different insecticides on fruit infestation by number at mid fruiting stage

More or less similar trend of results were also observed among different insecticides in terms of reduction of fruit infestation at mid fruiting stage during the management of okra shoot and fruit borer. The highest fruit infestation (14.02%) was recorded in T_7 (untreated control) followed by T_4 (4.93%), T_3 (4.03%), T_5 (3.93%) (Table 4). On the other hand, the lowest fruit infestation (1.93%) at mid fruiting stage was recorded in T_6 followed by T_1 (2.23%) and T_2 (3.83%). Considering the fruit infestation reduction over control at mid fruiting stage, the highest reduction 86.27% was achieved in T_6 followed by T_1 (84.13%), T_2 (72.72%), T_5 (72.00%) and the lowest reduction (64.87%) was achieved in T_4 followed by T_3 (68.6071.29%) .

Table 4. Efficacy of different insecticides on fruit infestation by number at mid fruiting stage during the management of okra shoot and borer

Treatment	Fruit infestation (%)	% reduction of fruit infestation over control
T_1	2.22 d	84.13
T_2	3.83 c	72.72

T_3	4.03 c	71.29
T_4	4.93 b	64.87
T_5	3.93 c	72.00
T_6	1.93 e	86.27
T_7	14.02 a	-
LSD $_{(0.05)}$	0.23	-
CV (%)	3.1	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

4. 5. Effect of different insecticides on fruit infestation at late fruiting stage

More or less similar trend of results were also observed among different insecticides in terms of reduction of fruit infestation at late fruiting stage during the management of okra shoot and fruit borer. The highest fruit infestation (13.02%) was recorded in T_7 (untreated control) followed by T_4 (4.66%), T_5 (3.63%), T_3 (3.43%). On the other hand, the lowest fruit infestation (1.43%) at late fruiting stage was recorded in T_6 followed by T_1 (2.03%) and T_2 (2.43%) (Table 5). Considering the fruit infestation reduction over control at late fruiting stage, the highest reduction 89.06% was achieved in T_6 followed by T_1 (84.45%), T_2 (81.38%), T_3 (73.69%) and the lowest reduction (64.09%) was achieved in T_4 followed by T_5 (72.19%)

Table 5. Efficacy of different insecticides on fruit infestation by number at late fruiting stage during the management of okra shoot and fruit borer

Treatment	Fruit infestation (%)	% reduction of fruit infestation over control
T_1	2.03 d	84.45
T_2	2.42 d	81.38

T_3	3.43 c	73.69
T_4	4.68 b	64.09
T_5	3.63 c	72.16
T_6	1.43 e	89.06
T_7	13.02 a	-
LSD $_{(0.05)}$	0.51	-
CV (%)	7.78	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

From the above findings it was revealed that among the different insecticides the T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in terms of percent fruit infestation reduction and the T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7days interval was least performer in reducing percent fruit infestation reduction over control during the management of okra shoot and fruit borer. As a result , the trend of different management practices in terms of fruit infestation reduction was T_6> T_1> T_5> T_2,T_3> T_7. About similar results were also observed by different researchers. Shukla *et al.* (1997) reported that before fruiting stage shoot infestation reached a peak of 8.5%. Krishna (1987) obtained 41.23% and Chaudhury (2001) recorded 29.84% fruit infestation in untreated control plot at late fruiting stage in okra.

4. 6. Efficacy of different insecticides on fruit infestation by weight at early fruiting stage

Significant differences were observed among different management practices in terms of percent fruit infestation by weight at the early fruiting stage during the management of okra shoot and fruit borer (Table 6).

Table 6. Efficacy of different insecticides on fruit infestation by weight at early fruiting stage during the management of okra shoot and fruit borer

Treatment	Fruit infestation (%)	% reduction of fruit by weight over control
T_1	7.39 e	77.72
T_2	8.34d e	74.88
T_3	10.61 d	68.04
T_4	23.87 b	28.10
T_5	15.40 c	53.61
T_6	6.67 e	79.91
T_7	33.20 a	-
LSD $_{(0.05)}$	2.67	-
CV (%)	11.93	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications
[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

The highest percent of fruit infestation (33.20%) was recorded in T_7 (untreated control) which was statistically different from all other treatments (Table 6) and followed by T_4 (23.87 %) comprised of spraying Marshal 20 EC @ 2ml/L of water at 7 days interval and T_5 (15.40%) comprised of spraying of Dursban 20 EC @ 1 ml/L of water at 7 days interval andT_3 spraying of Suntap 50 SP @ 1.2 g/L of water at 7 days interval On the other hand, the lowest percent of fruit infestation (6.67 %) was recorded in T_6 comprised of Diazinon @ 1.0 ml/L of water at 7 days interval and it was followed (7.39) by T_1 comprised of Spraying of neem oil @ 4ml/L of water at 7 days interval and T_2 (8.34 %) comprised of spraying Caught 10 EC @ 1 ml/L of water at 7 days interval.

Considering the percent fruit infestation reduction over control,the highest reduction (79.92%) was observed in T_6 and the lowest reduction (28.10%) was observed in T_4 Marshal 20 EC @2 ml/L of water (Table 6).

4. 7. Efficacy of different insecticides on fruit infestation by weight at mid fruiting stage

More or less similar trend of results were also observed among different insecticides in terms of reduction of fruit infestation at late fruiting stage during the management of okra shoot and fruit borer. The highest fruit infestation (31.95%) was recorded in T_7 (untreated control) followed by T_4 (22.63%), T_5 (14.21%), T_2 (7.15%). On the other hand, the lowest fruit infestation (5.72%) at mid fruiting stage was recorded in T_6 followed by T_1 (6.30%) and T_2 (7.15%). Considering the fruit infestation reduction over control at mid fruiting stage, the highest reduction (82.09%) was achieved in T_6 followed by T_1 (80.27%), T_2 (77.62%), T_3 (70.66%) and the lowest reduction (29.17%) was achieved in T_4 followed by T_5 (55.52%).

Table 7. Efficacy of different insecticides on fruit infestation by weight at mid fruiting stage during the management of okra shoot and fruit borer

Treatment	Fruit infestation (%)	% reduction of fruit weight over control
T_1	6.30 e	80.27
T_2	7.15 de	77.62
T_3	9.38 d	70.66
T_4	22.63 b	29.17
T_5	14.21 c	55.52

T_6	5.72 e	82.09
T_7	31.95 a	-
LSD $_{(0.05)}$	2.62	-
CV (%)	12.68	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

4. 8. Effect of different insecticides on fruit infestation by weight at late fruiting stage

More or less similar trend of results were also observed among different insecticides in terms of reduction of fruit infestation at late fruiting stage during the management of okra shoot and fruit borer. The highest fruit infestation (30.98%) was recorded in T_7 (untreated control) followed by T_4 (21.67%), T_5 (13.30%), T_3 (8.42%). On the other hand, the lowest fruit infestation (5.09%) at late fruiting stage was recorded in T_6 followed by T_1 (5.47%) and T_2 (6.23%). Considering the fruit infestation reduction over control at late fruiting stage, the highest reduction 83.58% was achieved in T_6 followed by T_1 (82.35%), T_2 (79.89%), T_3 (72.81%) and the lowest reduction (30.05%) was achieved in T_4 followed by T_5 (57.07%).

Table 8. Efficacy of different insecticides on fruit infestation by weight at late fruiting stage during the management of okra shoot and fruit borer

Treatment	% Fruit infestation by weight	% reduction of fruit infestation by weight over control
T_1	5.47 e	82.35
T_2	6.23 de	79.89
T_3	8.42 d	72.81
T_4	21.67 b	30.05
T_5	13.30 c	57.07
T_6	5.09 e	83.58

T_7	30.98 a	-
LSD $_{(0.05)}$	0.51	-
CV (%)	13.33	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications
[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

From the above findings it was revealed that among the different insecticides the T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in terms of percent fruit infestation reduction and the T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7days interval was least performer in reducing percent fruit infestation reduction over control during the management of okra shoot and fruit borer. As a result, the trend of different management practices in terms of fruit infestation reduction was T_6> T_1 $T_{2,}$> T_3>T_5>T_7. About similar results were also observed by different researchers . Shukla *et al.* (1997) reported that before fruiting stage shoot infestation reached a peak of 8.5%. Krishna (1987) obtained 41.23% and Chaudhury (2001) recorded 29.84% fruit infestation in untreated control plot at late fruiting stage in okra.

4. 9 Efficacy of different insecticides on the plant related yield attributes of okra

Significant differences were observed among different insecticides in terms of plant height (cm) and number of branch per plant during the management of okra shoot and fruit borer (Table 9). The highest plant height (cm) (100.40cm) was recorded in T_6 (Diazinon 60EC @ 1.0 ml/L of water at 7 days interval) which was statistically different from all other treatments (Table 9) and it was followed T_1 (95.36cm) comprised of spraying of neem oil @ 4ml/L of water at 7 days interval and T_2 (90.47cm) comprised of spraying Caught 10 EC @ 1 ml/L of water at 7 days interval and T_5 (81.43cm) spraying of Dursban 20 EC @ 1 ml/L of water at 7 days interval. On the other hand, the lowest plant height(cm) (65.47cm) was recorded in T_7 (untreated control) and it was followed (72.72cm) by T_4 comprised of Spraying Marshal 20 EC @ 2ml/L of water at 7 days interval and T_3 (77.93cm) comprised of Suntap 50 SP @ 1.2 g/L of water at 7 days interval.

Considering the plant height increased reduction over control, the highest reduction (11.07%) was observed in T_4 and the lowest reduction (53.35%) was observed in T_6 (Table 9).

More or less similar trend of results were also observed among different management practices in terms of number of branches per plant due to different spray of insecticides during the management of okra shoot and fruit borer. The present study revealed that there was a highly significant effect of insecticide on number of branches per plant of okra the highest (4.71) from Diazinon 60EC @ 1.0 ml/L of water at 7 days interval and the lowest (2.86) from control treatment at harvest.

Considering the no. branch increase over control, the highest reduction 64.70% was achieved in T_6 followed by T_1 (35.34%), T_2 (23.76%), T_3 (18.54%) and the lowest reduction (6.96%) was achieved in T_4 followed by T_5 (16.10%).

Table 9. Efficacy of different insecticides on plant related yield attributes of okra during the management of okra shoot and fruit borer

Treatment	Plant height (cm)	% increase of plant height over control	No of Branch plant^{-1}	% increase of branch over control
T_1	95.36 b	45.65	3.87 b	35.34
T_2	90.47 c	38.19	3.54 c	23.76
T_3	77.93 e	19.03	3.39 d	18.54
T_4	72.72 f	11.07	3.06 e	6.96
T_5	81.43 d	24.38	3.32 d	16.10

T_6	100.40 a	53.35	4.71 a	64.70
T_7	65.47 g	-	2.86 f	-
LSD $_{(0.05)}$	0.015	-	0.15	-
CV (%)	5.67	-	8.9	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

4. 10. Efficacy of different insecticides on fruit related yield attributes of okra

Significant variations were observed among different management practices in terms of fruit related yield attributes of okra during management of okra shoot and fruit borer (Table 10).

4.10.1. Effect on length of fruit

In case of fruit length, the highest fruit length (13.43 cm) was recorded in T_6 treated with Diazinon 60EC @ 1.0 ml/L of water at 7 days interval which was significantly different from all other treatments (Table 10) and was followed (12.94 cm) by T_1 (of neem oil @ 4ml/L of water at 7 days interval). On the other hand, the lowest fruit length (9.37 cm) was recorded in T_7 (untreated control). More or less similar works were done by Butani and Jotwani (1984) and Thakur *et al.* (1986) and reported that the length of the okra fruit affected by the Okra shoot and fruit borer.

4.10.2. Effect on girth of fruit

In case of infested fruit girth, the highest fruit girth (1.80 cm) was recorded in T_6 treated with Diazinon 60EC @ 1.0 ml/L of water at 7 days interval (Table 10). On the other hand, the lowest fruit girth (9.37 cm) was recorded in T_7 (untreated control). 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.

4.10.3. Effect on number of fruit per plant

Different insecticides showed highly significant variation on the fruit yield per plant. The maximum fruit yield per plant (24.35) was recorded in T_6 (Diazinon 60EC @ 1.0 ml/L of water at 7 days interval), whereas the lowest fruits yield (16.63) was obtained in T_7 (untreated control) (Table 10).

4.10.4. Effect on single fruit weight (g)

Significant variation was observed due to the effect of insecticides on individual fruit weight. The maximum fruit weight (13.64g) was obtained in T_6 (Diazinon 60EC @ 1.0 ml/L of water at 7 days interval), and the minimum fruit weight (9.63) as obtained in T_7 (untreated control) (Table 10).

Table 10. Efficacy of different insecticides on fruit related yield attributes of okra during the management of okra shoot and fruit borer

Treatment	Fruit length (cm)	% increase of fruit length over control	Fruit girth (cm)	% increase of fruit girth over control	No. of fruit per plant	% increase of fruit number over control	Single fruit weight (gm)	% increase of single fruit weight over control
T_1	12.94 b	38.06	1.73 b	5.49	22.49b	35.24	12.58b	30.63
T_2	12.25 c	30.69	1.70 c	3.66	20.99c	26.22	12.28c	27.52
T_3	11.29 d	20.45	1.70 c	3.66	19.68d	18.34	11.22d	16.51
T_4	11.00 f	17.36	1.70 c	3.66	16.49f	0.84	10.80e	12.15
T_5	11.15 e	18.96	1.73 b	5.49	18.73e	12.63	11.19d	16.20
T_6	13.43 a	43.28	1.80 a	9.76	24.35a	46.42	13.64a	41.64
T_7	9.37 g	-	1.64 d	-	16.63f	-	9.63f	
LSD $_{(0.05)}$	0.05	-	-	-	0.92	-	0.05	-
CV (%)	4.50	-	3.80	-	3.10	-	5.30	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

4.11. Efficacy of different insecticides on the yield of okra

More or less similar trend of results were also observed among different insecticides in terms of reduction of yield increased during the management of okra shoot and fruit borer. The highest yield increased (14.88%) was recorded in T_6 (Diazinon 60EC @ 1.0 ml/L of water at 7 days interval) followed by T_4 (21.67%), T_5 (13.30%), T_3 (8.42%). On the other hand, the lowest yield increased (0.67%) was recorded in T_4 followed by T_1 (5.47%) and T_2 (6.23%). Considering the fruit infestation reduction over control at late fruiting stage, the highest reduction 83.58% was achieved in T_6 followed by T_1 (82.35%), T_2 (79.89%), T_3 (72.81%) and the lowest reduction (30.05%) was achieved in T_4 followed by T_5 (57.07%).

Table 11. Efficacy of different insecticides on the yield of okra during the management of okra shoot and fruit borer

Treatment	Yield (kg/plot)	Yield(t/ha)	% increase of okra yield over control
T_1	8.80 ab	14.66 ab	9.08
T_2	8.49 ab	14.14 ab	5.21
T_3	8.17 b	13.60 b	1.19
T_4	8.13 b	13.53 b	0.67
T_5	8.51 ab	14.18 ab	5.51
T_6	9.27 a	15.44 a	14.88
T_7	8.07 b	13.44 b	-
LSD $_{(0.05)}$	0.83	1.38	-
CV (%)	6.55	6.55	-

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of four replications

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

4.11.1. Fruit yield per plot

A significant variation in different insecticide showed on the fruit yield per plot. The maximum fruit yield per plot (9.27 kg) was recorded in T_6 (Diazinon 60EC @ 1.0 ml/L of water at 7 days interval), whereas the lowest fruits yield (8.07 kg) was obtained T_7 (untreated control) followed by (8.13kg) Marshal 20 EC @ 2ml/L of water at 7 days interval (Table 11).

4.11.2. Yield per hectare

Different insecticide showed a highly significant variation on the fruit yield per hectare. The maximum fruit yield per hectare (15.44 tons) was recorded in T_6 (Diazinon 60EC @ 1.0 ml/L of water at 7 days interval). Whereas, the lowest fruits yield (8.065 tons) was obtained from T_7 (untreated control) (Table 11). Choi in Hu *et al*. (2004) observed that proclaim exhibit the highest fruit yield of okra.

4.13. Relationship between shoot infestation and yield of okra among different management practices

Correlation study was done to establish the relationship between the incidences of shoot infestation 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 = -0.0458x + 14.71 gave a good fit to the data and the co-efficient of determination (R^2 = 0.3813) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the yield (t/ha) of okra was negatively correlated with the incidence of shoot infestation.

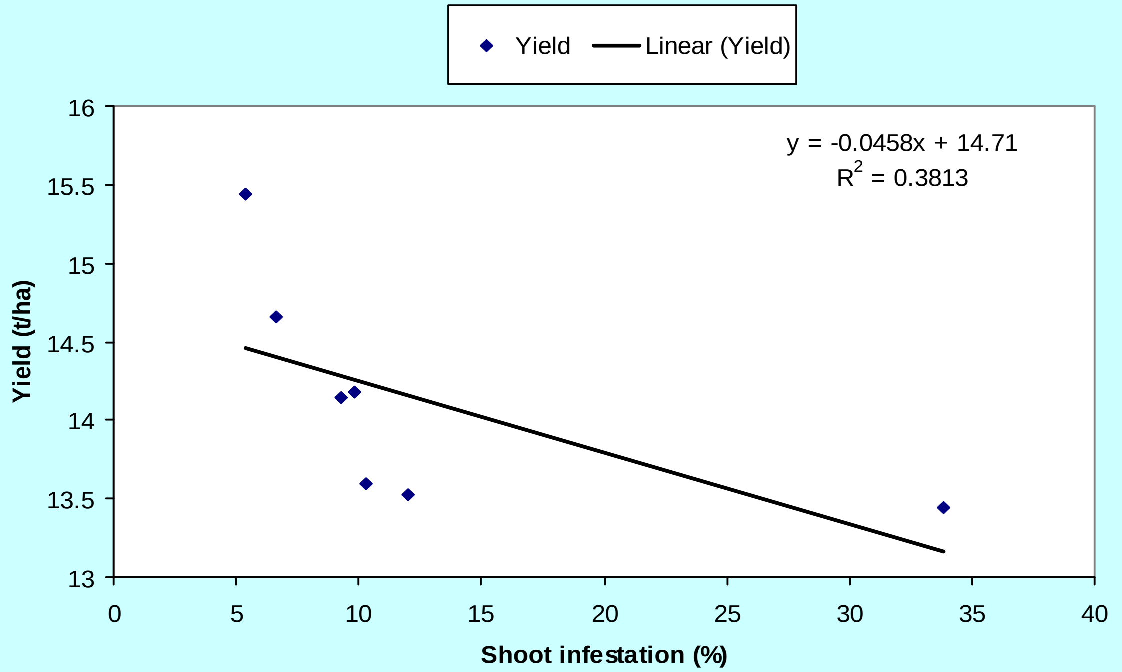

Figure 1. Relationship between shoot infestation and yield of okra

4.14. Relationship between fruit infestation and yield of okra among different management practices

Correlation study was done to establish the relationship between fruit infestation by number 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 = -0.0348x + 14.68 gave a good fit to the data and the co-efficient of determination (R^2 = 0.3895) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the yield (t/ha) of okra was negatively correlated with the incidence of fruit infestation.

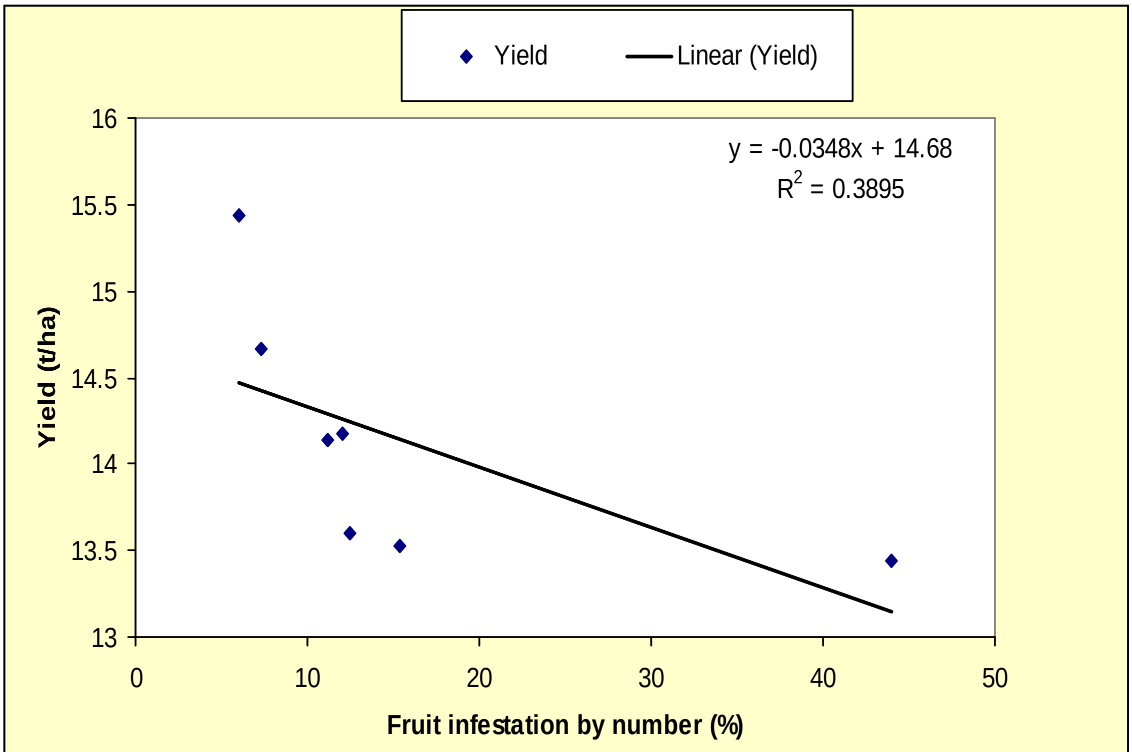

Figure 2. Relationship between fruit infestation by number and yield of okra

4.15. Relationship between number of branch per plant and yield of okra among different management practices

Correlation study was done to establish the relationship between number of branch per plant and yield of okra among different management practices. From the Figure 3 it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = 1.1317x + 10.14 gave a good fit to the data and the co-efficient of determination (R^2 = 0.9192) 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 positively correlated with number of branch per plant.

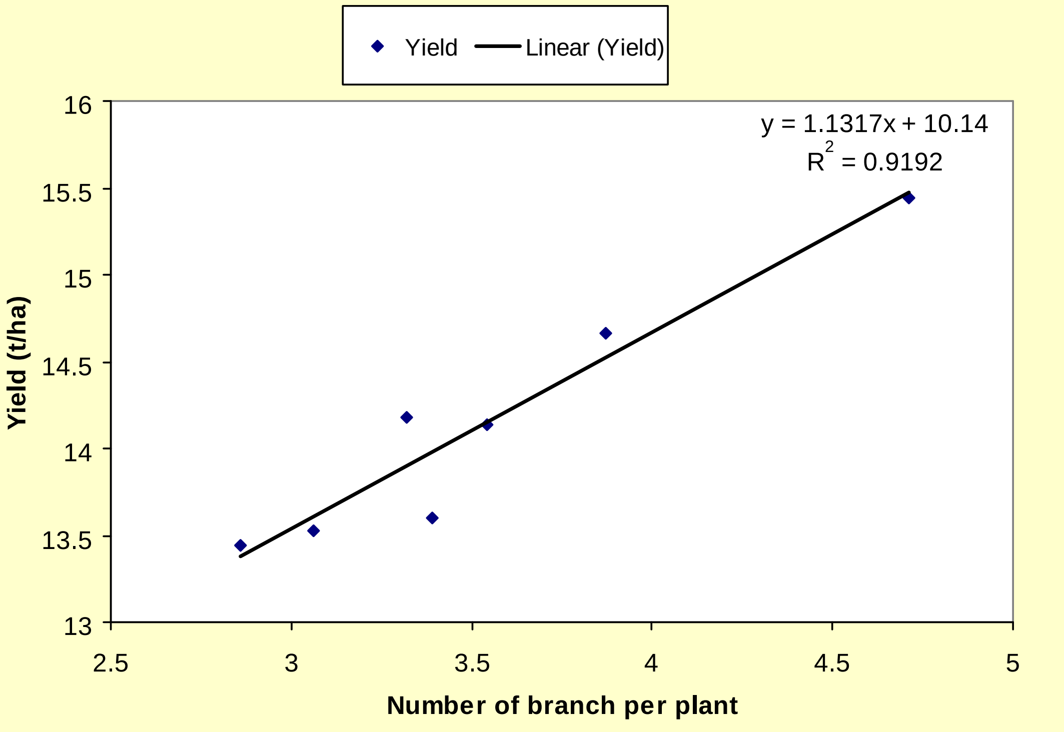

Figure 3. Relationship between number of branch per plant and yield of okra

4.16. Relationship between length of fruit and yield of okra among different management practices

Correlation study was done to establish the relationship between length of fruit and yield of okra among different management practices. From the Figure 4 it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = 0.46x + 8.79 gave a good fit to the data and the co-efficient of determination (R^2 = 0.7612) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the yield (t/ha) of okra was moderately as well as positively correlated with the length of fruit.

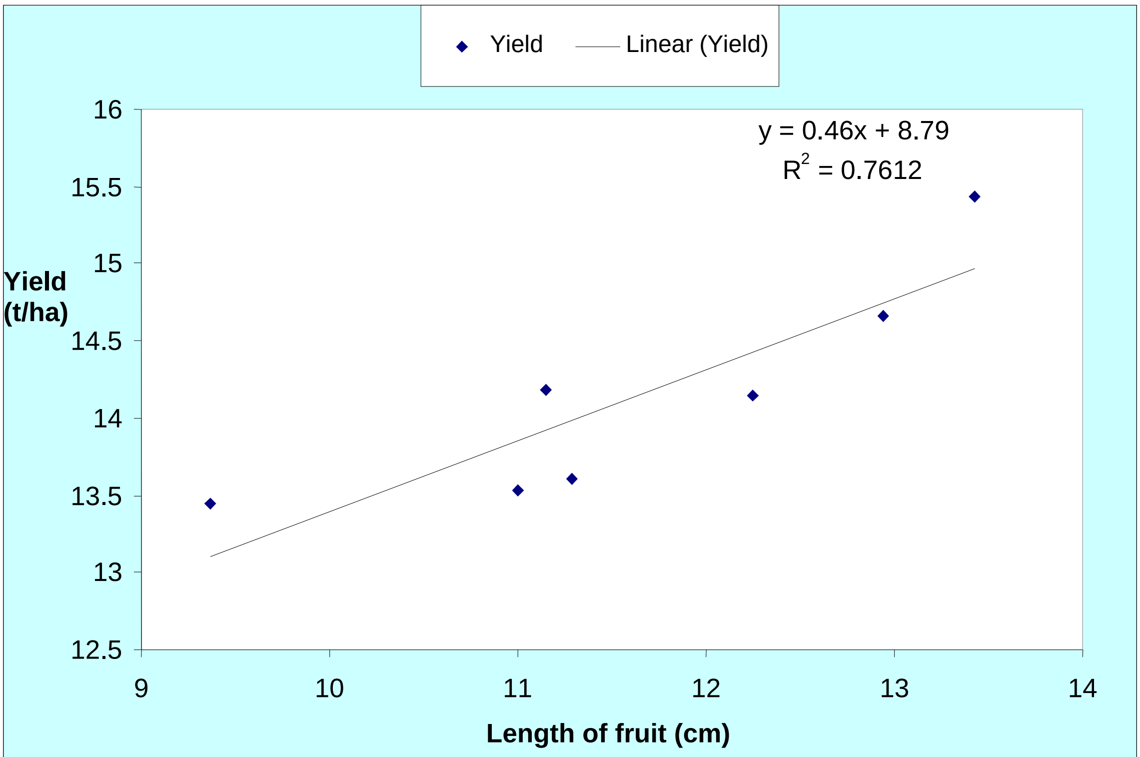

Figure 4. Relationship between length of fruit and yield of okra

4. 12. Economic analysis of different insecticides applied against okra shoot and fruit borer

Economic analysis of different insecticidal treatments applied against okra shoot and fruit borer infestation on okra is presented in Table 12. The T_7 (untreated control) did not incur any pest management cost. The labor costs were involved in all treatments for spraying insecticides except T_7. For insecticide treatments (T_2 to T_6), cost of chemical insecticides and for neem oil treatment (T_1) cost of neem oil were also involved (Appendix III). Thus the highest benefit cost ratio (6.90) was obtained in the T_6 (Diazinon 60EC@ 1.0ml/L of water) treated plot. The second highest benefit cost ratio (5.80) was found in T_5 (Dursban 20EC @ 1ml/L of water) treated plot. More or less similar benefit cost ratio was observed in T_1 (4.30) comprising of spraying of neem oil @ 4 ml/Litre of water at 7 days interval. The lowest benefit cost ratio (1.28) found in T_4 (Marshal 20EC@ 2ml/L of water) treated plot followed by T_3 (2.70) comprising of spraying of Suntap 50 SP @ 1.2g/L of water (Table 12).

Table 12. Economic analysis of different management practices applied against okra shoot and fruit borer in okra field during April to August, 2011

Treatments	No. of spray	Cost of pest management (TK)			Yield (t/ha)	Gross return (Tk.)	Net return (Tk.)	Adjusted return (Tk.)	Benefit cost ratio (BCR)
		Insecticides (Tk)	Labour	Total					
T_1	7	8400	2100	10500	14.66	366500	265130	45000	4.3
T_2	7	6300	2100	8400	14.14	353500	254230	34100	4.1
T_3	7	5670	2100	7770	13.60	340000	241360	21230	2.7
T_4	7	10500	2100	12600	13.53	338250	234780	14650	1.2
T_5	7	4305	2100	6405	14.18	354500	257225	37095	5.8
T_6	7	7350	2100	9450	15.44	386000	285680	65550	6.9
T_7	0	0	0	0	12.44	311000	220130	-	-

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

Cost of botanical and chemical insecticides: Neem oil @ TK40/100ml; Caught 10 EC @ Tk 120/100ml; Suntap 50 SP @ Tk 90/100ml; Marshall 20 EC@ Tk. 100/100 ml; Dursban 20 EC @ Tk. 82/100ml and Diazinon 60 EC@ 140/100ml
Market price of okra: TK 25/kg

From the above mentioned findings it was revealed that the T_6 performed as the best treatment in terms of benefit cost ratio (6.90) followed by T_5 (5.80). On other hand, the lowest benefit cost ratio was recorded in T_4 (0.78) followed (0.98) by T_3 (Table 12).

CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was conducted at the field laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April to August, 2011 to find out the efficacy of five promising chemical insecticides and one botanical product against okra shoot and fruit borer, *Earias vittella* on okra. The treatments are comprised with one botanical product, five synthetic chemical insecticides and one untreated control and these are T_1 = Neem oil @ 4ml/L of water at 7 days interval, T_2= Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Dursban 20 EC @ 1ml/L at 7 days interval, T_6 = Diazinon 60 EC@ 1.0ml/L at 7 days interval, and T_7= Untreated control. The experiment was laid out in single factor Randomized Complete Block Design (RCBD) with four replications.

SUMMARY

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

In terms of percent shoot infestation by number at the vegetative stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in terms of percent shoot infestation reduction (81.79%) over control followed by T_1 (79.68%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (75.46%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 (63.85%) comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7days interval was showed the least performance (63.85%) in reducing percent shoot infestation at vegetable stage over control. As a result, order the trend of different management practices in terms of percent shoot infestation reduction was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

In terms of percent shoot infestation by number at fruiting stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in terms of percent shoot infestation reduction (86.29%) over control followed by T_1 (78.06%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (72.65%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 (61.85%) comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7days interval was showed the least performance (63.85%) in reducing percent shoot infestation reduction over control. As a result, order the trend of the efficiency of different management practices and untreated control in terms of percent reduction of shoot infestation at fruiting stage was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

In case of fruit infestation by number at early fruiting stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in reducing the highest percent fruit infestation (84.48%) over control followed by T_1 (82.12%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (70.89%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (66.16%) in reducing the lowest percent of fruit infestation over control. As a result, order the trend of the efficiency

of different management practices and untreated control in terms of percent reduction of fruit infestation at fruiting stage was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

In case of fruit infestation by number at mid fruiting stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in reducing the highest percent fruit infestation (86.27%) over control followed by T_1 (84.13%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (72.72%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (64.87%) in reducing the lowest percent of fruit infestation over control. As a result, order the trend of the efficiency of different management practices and untreated control in terms of percent reduction of fruit infestation at fruiting stage was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

In case of fruit infestation by number at late fruiting stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in reducing the highest percent fruit infestation (89.06%) over control followed by T_1 (84.45%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (81.38%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (64.09%) in reducing the lowest percent of fruit infestation over control. As a result, order the trend of the efficiency

of different management practices and untreated control in terms of percent reduction of fruit infestation at fruiting stage was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

In case of fruit infestation by weight at early fruiting stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in reducing the highest percent fruit infestation (79.91%) over control followed by T_1 (77.72%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (74.88%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (28.10%) in reducing the lowest percent of fruit infestation over control. As a result, order the trend of the efficiency of different management practices and untreated control in terms of percent reduction of fruit infestation at fruiting stage was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

In case of fruit infestation by weight at mid fruiting stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in reducing the highest percent fruit infestation (82.09%) over control followed by T_1 (80.27%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (77.62%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (29.52%) in reducing the lowest percent of fruit infestation over control. As a result, order the trend of the efficiency

of different management practices and untreated control in terms of percent reduction of fruit infestation at fruiting stage was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

In case of fruit infestation by weight at late fruiting stage, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in reducing the highest percent fruit infestation (83.58%) over control followed by T_1 (82.35%) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (79.89%) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (30.05%) in reducing the lowest percent of fruit infestation over control. As a result, order the trend of the efficiency of different management practices and untreated control in terms of percent reduction of fruit infestation at fruiting stage was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

Considering the plant related yield attributes, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in increasing the highest percent of plant height (53.35%) and number of branch per plant (64.70%) over control followed by T_1 (45.65% & 35.34%, respectively) comprising spraying oil @ 4 ml/L of water at 7 days interval and T_2 (38.19% & 23.76%, respectively) comprising spraying of Caught 10 EC @ 1.0 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (11.07% & 6.96%, respectively) in increasing the lowest percent of plant height and number of branch per plant over control. As a result, order the trend of the efficiency of different management practices and untreated control in terms of percent increase of plant height and number of branch per plant was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

Considering the fruit related yield attributes of okra, T_6 comprising spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in increasing the highest percent of fruit length (43.28%), fruit girth (9.76%), number of fruit per plant (46.42%) and single fruit weight (41.64%) over control followed by T_1 (38.06%, 5.49%, 35.24% & 30.63%, respectively) comprising spraying neem oil @ 4 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (17.36%, 3.66%, 0.84% & 12.15%, respectively). As a result, order the trend of the efficiency of different management practices and untreated control in terms of percent increase of fruit length, fruit girth, number of fruit per plant and single fruit weight was T_6 (Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

Considering the yield of okra, T_6 comprising the spraying of Diazinon 60EC @ 1.0ml/ L of water at 7 days interval performed best result in increasing the highest percent fruit yield (14.88%) over control followed by T_1 (9.08%) comprising spraying oil @ 4 ml/L of water at 7 days interval, whereas T_4 comprising spraying Marshal 20 EC @ 2.0ml/L of water at 7 days interval was showed the least performance (0.67%). As a result, order the trend of the efficiency of different management practices and untreated control in terms of the percent increase of fruit yield of okra was T_6

(Diazinon 60 EC) > T_1 (Neem oil) > T_2 (Caught 10 EC) > T_3 (Suntap 50 SP), T_5 (Dursban 20 EC) > T_4 (Marshal 20 EC) > T_7 (Untreated control).

Yield of okra was negative correlated with shoot ($r^2 = 0.3813$) and fruit infestation ($r^2 = 0.3895$), but positively correlated with the number of branch per plant ($r^2 = 0.9192$) and length of fruits ($r^2 = 0.7612$).

In case of economic returns among different management practices, the highest benefit cost ratio (6.90) was achieved by T_6 comprising Diazinon 60EC @ 1.0ml/L of water followed by T_5 (5.80) comprising Dursban 20EC @ 1ml/L of water and T_1 (4.30) comprising neem oil @ 4 ml/Litre of water. The lowest BCR (1.28) was achieved by T_4 (Marshal 20EC@ 2ml/L of water). Though neem oil gave third highest BCR (4.30), but produced second highest yield (14.44 ton/ha). Thus neem oil was considered as an economically viable and human health hazards free tool effective against okra shoot and borer control.

CONCLUSION

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

- In case of shoot infestation reduction, Diazinon 60EC @ 1.0ml/ L of water at 7 days interval reduced the highest shoot infestation (79% & 86.29%) at vegetative and fruiting stage, respectively over control followed by neem oil (79.68% & 78.06%, respectively), whereas Marshal 20 EC @ 2.0ml/L of water showed the least performance (63.85% & 63.85%, respectively).

- In case of fruit infestation reduction by number, Diazinon 60EC reduced the highest fruit infestation (84.48%, 86.27% & 89.06%) at early, mid and late fruiting stages, respectively over control followed by neem oil (82.12%, 84.13% & 84.13%, respectively), whereas Marshal 20 EC showed the least performance (66.16%, 64.87% & 64.09%, respectively).

- In case of fruit infestation reduction by weight, Diazinon 60EC reduced the highest fruit infestation (79.91%, 82.09% & 83.58%) at early, mid and late fruiting stages, respectively over control followed by neem oil (77.72%, 80.27% & 82.35%, respectively), whereas Marshal 20EC showed the least performance (28.10%, 29.52% & 30.05%, respectively).

- In case of plant related yield attributes, Diazinon 60EC increased the highest percent of plant height (53.35%) and branch per plant (64.70%) over control followed by neem oil, caught 10 EC, whereas Marshal 20 EC showed the least performance (11.07% & 6.96%, respectively).

- In case of fruit related yield attributes, Diazinon 60EC increased the highest percent of fruit length (43.28%) and girth (9.76%), number of fruit per plant (46.42%) and single fruit weight (41.64%) over control than neem oil and other insecticides, whereas Marshal 20 EC showed the least performance (17.36%, 3.66%, 0.84% & 12.15%, respectively).

- In case of yield of okra, Diazinon 60EC also increased the highest percent fruit yield (14.88%) over control than neem oil and other insecticides, whereas Marshal 20 EC showed the least performance (0.67%).

- Yield of okra was negative correlated with shoot (r^2 = 0.3813) and fruit infestation (r^2 = 0.3895), but positively correlated with the number of branch per plant (r^2 = 0.9192) and length of fruits (r^2 = 0.7612).

- In case of economic returns, Diazinon 60EC @ 1.0ml/L of water gave the highest BCR (6.90) than Dursban 20EC (5.80), neem oil (4.30) and others, the lowest BCR (1.28) was achieved by Marshal 20EC.

- Though neem oil gave third highest BCR (4.30), but produced second highest yield (14.44 ton/ha). Thus neem oil may be considered as an economically viable and human health hazards free tool effective against okra shoot and borer control.

RECOMMENDATIONS

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

1. Diazinon 60EC @ 1.0ml/L of water spraying at 7 days interval may be recommended as an effective control measure applied against okra shoot and fruit borer infestation on okra;
2. Neem oil @ 4 ml/L of water spraying at 7 days may be as considered as effective and human health hazards free control measures.
3. Further intensive studies based on different doses of Diazinon and Neem oil should be done.
4. More chemicals and botanicals with their derivatives should be included in further elaborative research for controlling okra shoot and fruit borer.

CHAPTER VI

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APPENDICES

Appendix I. Physiological properties of the initial soil

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

Appendix II: Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from April 2011 to August, 2011

Date/Week	Temperature		Relative humidity (%)	Rainfall (mm) (Total)
	Maximum	Minimum		
April	33.5	23.2	64	123
May	33.4	24.6	76	235
June	32.6	26.3	80	314
July	32.3	26.7	79	356
August	31.1	26.5	82	409
September	32.4	26.4	77	207

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

Appendix III. cost incurred per hectare in different management practices applied against okra shoot and fruit boerer

Treatment	Items of expenditure	Cost (TK)
T_1	Total no. of labours for spraying insecticides 14×150.00[a]	2100.00
	Neem oil 21000 ml (for 7 prays)×0.4[b]	8400.00
	Total cost	**10500.00**
T_2	Total no. of labours for spraying insecticides 14×150.00[a]	2100.00
	Caught 10 EC 5250 ml (for 7 prays)×1.2[c]	6300.00
	Total cost	**8400.00**
T_3	Total no. of labours for spraying insecticides 14×150.00[a]	2100.00
	Suntap 50 SP 6300 ml (for 7 prays)×0.90[d]	5670.00
	Total cost	**7770.00**
T_4	Total no. of labours for spraying insecticides 14×150.00[a]	2100.00
	Marshal 20 EC 10500 ml (for 7 prays)×1.00[e]	10500.00
	Total cost	**12600.00**
T_5	Total no. of labours for spraying insecticides 14×150.00[a]	2100.00
	Dursban 20 EC 5250 ml (for 7 prays)×0.82[f]	4305.00
	Total cost	**6405.00**
T_6	Total no. of labours for spraying insecticides 14×150.00[a]	2100.00
	Diazinon60 EC 5250 ml (for 7 prays)×1.40[g]	7350.00
	Total cost	**9450.00**
T_7	No management cost	**0.00**

[T_1 = Spraying of neem oil @ 4ml/L of water at 7 days interval, T_2 = Spraying of Caught 10 EC @ 1ml/L of water at 7 days interval, T_3 = Spraying of Suntap 50 SP @ 1.2g/L of water at 7 days interval, T_4 = Spraying of Marshal 20 EC@ 2ml/L at 7 days interval, T_5 = Spraying of Dursban 20EC @ 1ml/L at 7 days interval, T_6 = Spraying of Diazinon 60EC@ 1.0ml/L at 7 days interval, T_7= Untreated control]

a=Labour cost @ 150.00 Tk/day
b=Neem oil @ Tk 40/100ml
c=Caught 10 EC @ Tk 120/100ml
d=Suntap 50 SP @ Tk 90/100ml
e=Marshall 20 EC@ Tk. 100/100ml
f=Dursban 20EC @ Tk. 82/100ml
g=Diazinon60EC@ Tk 140/100ml