INTENSITY OF INFESTATION AND ECO-SAFE MANAGEMENT PRACTICES AGAINST OKRA SHOOT AND FRUIT BORER IN DIFFERENT VARIETIES OF OKRA

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JUNE 2021

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By

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A Thesis

Submitted to the Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka,

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS)

IN

ENTOMOLOGY

SEMESTER: JANUARY- JUNE, 2021

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CERTIFICATE

This is to certify that thesis entitled, "INTENSITY OF INFESTATION AND ECO-SAFE MANAGEMENT PRACTICES AGAINST OKRA SHOOT AND FRUIT BORER IN DIFFERENT VAREITIES OF OKRA" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of ***MASTER OF SCIENCE (M.S.) in ENTOMOLOGY****, embodies the result of a piece of bona-fide research work carried out by* ***Kabita Sultana, Registration no. 14-06077*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Date: June,2021

Place: Dhaka, Bangladesh

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Dedication

Every challenging work needs self efforts as well as guidance of elder especially those who were very close to our heart.

My humble effort I dedicate to my sweet and loving

Mother,

whose affection, love, encouragement and prays of day and night make me able to get such success and honor,

Along with all hard working and respected

Teachers.

ACKNOWLEDGEMENTS

The author deems it a much privilege to express her enormous sense of gratitude to the Almighty ALLAH for His never ending blessings for the successful completion of the research work.

The author feels proud to express her deep sense of gratitude, sincere appreciation and immense indebtedness to her supervisor ***Prof. Dr. Tahmina Akter****, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, for his continuous guidance, cooperation, constructive criticism and helpful suggestions, valuable opinion in carrying out the research work and preparation of this thesis, without his intense co-operation this work would not have been possible.*

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her co-supervisor ***Asst. prof. Ruhul Amin*** *and all teachers, Department of Entomology, Sher-e- Bangla Agricultural University, Dhaka, for his scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.*

The author expresses her sincere respect to ***Prof. Dr. Md Mizanur Rahman,*** *Chairman, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses her heartfelt thanks to all the teachers of the department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for their valuable teaching, suggestions and encouragement during the period of the study.*

The author expresses her sincere appreciation to her family, brother, sisters, relatives, friends and well-wishers for their inspiration, help and encouragement throughout the study.

Dated: June, 2021

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ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January, 2020 to April, 2020. The experiment was laid out in factorial Randomized Complete Block Design (2 factor) replicated with three times. For this study, factor A- T_1 = Imidacloprid (30 EC was1.5 ml/L of water at 15 days interval); T_2 = Neem oil (5 ml/L of water at 15 days interval); T_3 = Control while factor B- V_1= BARI Dheros-1; V_2= BARI Dheros-2; V_3= Ok-285 V_4= Green finger; V_5= Arko anamika. Results revealed that sustainable management of okra pod borer on different varieties of okra that significantly effect on most of the yield and yield contributing parameters studied in this experiment. Similarly, most of the traits were also affected significantly due to the combination effects. In case of varietal performance, BARI Dheros-1 (V_1) showed best results in terms shoot infestation against pod borer infestations, percentage of infested fruit, fruit infestation at weight basis, fruit length, fruit girth, number of fruit Plant^{-1}, single fruit weight, number of branch plant^{-1}, yield. In case of different treatments, T_1 = Imidacloprid (30 EC was applied at the rate of 1.5 ml/L at 15 days interval) showed outstanding performance of percent reducing the number of fruit borer and which provided better growth and higher yield as compared other treatments. Again, in case of combinations of varieties and different treatments, the number pod borer infestation reduced in T_1V_1 and showed best results in terms of percentage of infested fruit, fruit infestation at weight basis, fruit length, fruit girth, number of fruit Plant^{-1}, single fruit weight, number of branch plant^{-1}, yield. There was negative relationship present in number of pod borer and fruit infestation in weight basis with the yield of okra, i.e. when the number of pod borer and percentage of fruit infestation in weight basis was increased the yield of okra was decreased.

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LIST OF ACRONYMS

AEZ	= Agro-Ecological Zone
BARI	= Bangladesh Agricultural Research Institute
BBS	= Bangladesh Bureau of Statistics
cm	= Centi meter
CV	= Co-efficient variation
DMRT	= Duncans Multiple Range Test
E	= East
EC	= Emulsifiable concentrate
et al.	= And others
FAO	= Food and Agriculture Organization
g	= Gram
ha	= Hectare
IGR	= Insect Growth Regulator
k	= Potash
kg	= Kilogram
LSD	= Least Significant Difference
L	= Litre
mL	= Milliliter
mm	= Millimeter
MP	= Murate of potash
N	= Nitrogen
N	= North
P	= phosphorus
RCBD	= Randomized Complete Block Design
T	=Treatment
TSP	= Triple Super Phosphate
V	= Variety

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CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* L), also known as lady's finger and locally known as 'Bhendi' or 'Dherosh,' is a popular and widely produced annual vegetable crop grown from seed in Bangladesh and other tropical and subtropical countries. It is a member of the Malvaceae family that originated in tropical Africa (Purseglove 1987). Though okra is primarily grown during the kharif season, it may be grown all year (Rashid 1976). In 2007-2008, Bangladesh produced around 38508 metric tons of okra (BBS 2008). India, Nigeria, Sudan, Pakistan, Ghana, Egypt, Saudi Arabia, Mexico, and Cameroon are the largest producers. In terms of area and output, India is leading, followed by Nigeria. Okra is a popular fruit vegetable that is high in nutrients. Vitamins, calcium, potassium, and other minerals are abundant in okra, which are commonly lacking in the diets of underdeveloped countries (Anon. 1990). Moisture 89.6 grams, protein 1.9 grams, fat 0.2 grams, fibre 1.2 grams, phosphorus 56.0 milligrams, sodium 6.9 milligrams, sulphur 30 milligrams, riboflavin 0.1 milligrams, oxalic acid 8 milligrams, minerals 0.7 milligrams, carbohydrates 6.4 milligrams, calcium 66 milligrams, iron 0.35 milligrams, potassium 103 milli (Gopalan *et al.* 2007).

Okra is grown primarily for its immature fruits, which are used as a vegetable. Okra soups and stews are also popular dishes. When ripe, black or brown white eyed seeds are sometimes roasted and used as a substitute for coffee. Tender fruits are utilized in soups and gravies because of their high mucilage content. It serves as a clarifying agent in the manufacturing of jaggery in addition to being a vegetable (Chauhan 1972). Rope is made from crude fiber produced from the stem of the okra plant. The fruits also have some medicinal value. A mucilaginous preparation from the pod can be used for plasma replacement or blood volume expansion (Savello *et al*. 1980).It has also been used to treat ulcers and provide relief from haemorrhoids (Adams 1975).

Okra production in Bangladesh is mainly limited during February to July but its production is severely hampered due to the attack of more than 3 dozens of insect pests from seedling to fruiting stage (Rashid 1995; Nadeem *et al.* 2015). Many of the pests occurring on cotton are found to ravage okra crop. As high as 72 species of insect pests have been recorded on okra (Srinivas and Rajendran 2003). Among them okra pod borer, jassid, whitefly, are the most serious pests. The main causes of poor production are the attack of various pests and diseases & lack of knowledge about cultural practices. Insects damage the crop during their different growth stages, right from germination to harvest & results in getting lower yields (Ewete *et al.* 1983). The yield losses due to insect pests have been reported up to 69 percent. Insect pests not only reduce the growth and production but also transmit pathologic diseases pod borer infestation was proved to be a severe problem in Bangladesh which can alone make the okra cultivation non-profitable.

The systematic works on okra pod borer have not yet been done in Bangladesh. Some sporadic works have been reported to find resistant variety or control measures (Sharaf 1986). Most of the researches so far conducted in Bangladesh were pest survey type where the name of the pest observing field symptoms, the screen of cultivars against the pest under natural conditions was enlisted. There is no effective control measure against the pest in the field if it is established once (Singh 2013). The most effective method of controlling the pest is the cultivation of resistant varieties, but the availability of resistant varieties and sustainability of resistance in okra are rare (Rao *et al.,* 2003). The varieties so far cultivated in Bangladesh are highly susceptible to the pest. By spraying insecticides may be a suitable method of controlling okra pod borer (Gupta *et al.* 2009).

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

- To find out the resistant or tolerant source(s) among different okra varieties/genotypes against okra pod borer.

- To find out efficacy of the different management practices against okra pod borer on different varieties of okra.

- To highlight the establishment of an environmentally safe control measure by growing different resistant varieties of okra.

CHAPTER II

REVIEW OF LITERATURE

A brief assessment of research in connection to the treatment of the okra fruit borer using botanicals and pesticides has been attempted. Okra (*Abelmoschus esculentus*), sometimes known as lady's finger and locally known as 'Bhendi' or 'Dherosh,' is a popular and widely produced annual vegetable crop grown from seed in Bangladesh and other tropical and subtropical countries. This chapter discusses the okra fruit borer. In Bangladesh, only a small amount of insect pest management work on okra (*Abelmoschus esculentus* Moench) has been done in the summer and winter. A brief review of the literature available in Bangladesh and elsewhere related to insect pest control of okra is discussed below:

2.1 General review of okra shoot and fruit borer

2.1.1 Nomenclature

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Noctuidae

Genus*: Helicoverpa*

Species: *Helicoverpa armegera*

2.1.2 Distribution of okra shoot and fruit borer

Waring, Martin and Richard(2003) reported that, This species comprises two sub-species *:* *Helicoverpa armigera* is native and widespread in central and southern Europe, temperate Asia and Africa ; *Helicoverpa armigera* conferta is native to Australia, and Ocenia. The former sub-species has also recently been confirmed to the successfully invaded Brazil (Downes and Anderson 2013) and has since spread across much of south America and reached the Caribbean. It is a migrant species, able to reach Scandinavia and other northern territories.

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

Egg: The eggs are spherical with a ribbed surface and a diameter of 0.4 to 0.6 mm. They start out white and then turn greenish. Females can lay hundreds of eggs, which are laid separately and dispersed throughout the plant. The eggs can hatch into larvae in three days under ideal conditions, and the entire lifecycle can be completed in just over a month.

Larvae: The larvae take 13 to 22 days to develop, reaching up to 40mm long in the six instar. Their coloring is variable, but mostly greenish and yellow to red brown. Three dark stripes extend along the dorsal side and one yellow light stripe is situated under the spiracleson the lateral side. The ventral parts of the larvae are pale. They are rather aggressive occasionally carnivorous and may even cannibalise each other. They fall from the plant and curl up on the ground if disturbed.

Pupae: The pupae develop inside a silken cocoon over 10 to 15 days in soil at a depth of 4-10cm or in cotton bolls or maize ears. Pupation takes place also in leaf and pod.

Adult: Female brownish yellow moth, Male is pale greenish in color with V shaped marking.

2.1.4 Host range of okra pod borer

According to Gautam and Goswami (2004), the okra shoot and fruit borer (*Helicoverpa armigera)* eats a variety of malvaceous plants. Based on average minimum pupal duration, highest fecundity, and maximum pupal and adult weight, Satpute *et al*. (2002) determined that okra was the most favoured host for the development of *Helicoverpa armigera*, followed by cotton, artificial food, and mesta (*Hibiscus sp.).* Under dual choice conditions, Dongre and Rahaller (1992) investigated the relative food plant preference and induction of preference for eating behavior in *Helicoverpa armigera* larvae. Abelmoschus esculentus (okra) was the most popular food plant, while Hibiscus rosa-sinensis was the least. Despite the fact that okra shoot and fruit borer is an oligophagous pest, Butani and Jotwani (1984) discovered it to be an oligophagous pest.

This pest has been found infesting okra, cotton, hollyhock, safflower, indian mallow, *Corchorus sp*, *Hibiscus sp*, *Malvastru Malvass*m *sp*, *Sidasp*, , and *Urena sp*, according to Khan and Verma (1946); Pearson (1958); Butani and Verma (1976); Atwal (1999); David (2001).

Okra and cotton are the most common hosts of the okra shoot and fruit borer, according to Atwal (1976). Sonchal (*Malva parviflora*), gulkhaira (*Althaea officinalis*), holly hock (*Althaea rosea*), and other Malvaceous plants are thought to be its alternate hosts.

When okra shoot and fruit borers were given the choice of different sections of the host plant, Rehman and Ali (1983) found that they favored okra fruit and shoot the best, followed by cotton balls and ball. Deshi cotton (Gossypium) flowers and buds.

2.1.5 Nature of damage

Okra shoot and fruit borer, *Helicoverpa armigera* is one of the key insect pests of okra. The fruit output of okra is reduced by 36-90 percent due to this bug (Misra *et al*., 2002).

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

With the formation of buds, flowers and fruits the caterpillars bore those and feed on the inner tissues. They migrate from one blossom to the next and from one fruit to the next. Damaged buds and blooms wilt and fall to the ground without yielding fruit. Fruits that have been impacted develop deformities in shape and grow slowly (Butani and Jotwani, 1984; Acharya, 2010).

The larvae of okra shoot and fruit bore into the tender shoots, flower buds and fruits. As a result, the attacked the flower buds and developing fruits dropped prematurely. Fruits that are affected stay on the plants and become unfit for human eating (Mohan *et al*. 1983 and Atwal 1976).

The larvae of okra shoot and fruit borer bore into the fruits and feed inside and also damage the seed (Karim 1992). 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).

Srinivasan and Gowder (1959) reported that the pest may cause 40-50% damage of fruit in some areas of south-east Asian countries.

Krishnaiah (1980) observed that the insects attack fruits and cause 35% damage in harvestable fruit in India.

Pareek and Bhargava (2003) reported that fruit borers like *Earias spp*. and *Helicoverpa armigera* cause significant damage to crop to the tune of 91.60 per cent.

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 Caterpillars bore the terminal parts of growing shoots first, then progress down by constructing tunnels inside. As a result, the shoots begin to droop and eventually dry out. Second, the larvae pierce holes in the fruits, rendering them unfit for human eating (Misra *et al*. 2002).

2.1.6. Seasonal abundance of okra pod borer

2.1.6.1. Ecology

The insect was found to occur in high population during hot and humid climate and its number drop in heavy rainfall. The development period of different stages prolonged during winter, the longevity, fecundity and coloration of the adult also fluctuate with environmental temperature and humidity (Schmutterer 1961).

2.1.6.2. Seasonal abundance

Srinivasan and Gowder (1959) reported that 40-50% okra fruit were damaged due to attack of this pest in Madras. In another investigation, Krisnaiah (1980) discovered a 35 percent infestation of fruit borer in harvestable okra fruit. Rana (1983) observed the pick incidence of fruit borer of okra was observed in the last week of August with a range of 34 to 45% damage to fruits.

Dhanwan and Sidhu (1984) reported that the maximum damage occurred in fruits (67.7%) and buds (52.4%) in late October. The maximum in flowers (1.5%) occurred in midAugust. In the spring, the maximum damage to fruits was 32.04 percent, and in late July, there was an increase in larval population of 1.4 per plant. The population of *H. armigera* increased slowly upto mid September and rapidly thereafter. Dhamdhere *et al.* (1984) reported 25.9 to 40.9% damage to fruits in October.

According to Butani and Jotwani (1984), there is no actual hibernation, yet development and activity are significantly delayed throughout the winter. Khaliq and Yousuf (1986) also reported the increased incidence of *H. armigera* with the increasing temperature and humidity.

Dutt and Saha (1990) observed the lower activity of *H. armigera* during DecemberJanuary and the higher activity was observed during the increasing temperature from February and a maximum peak in May-June.

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

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

Pareek *et al*. (2001) reported that the incidence of okra pod borer started in first week of September and maximum fruit infestation recorded in the third week of October.

Yadvendu (2001) recorded that the peak incidence of okra pods borer and maximum fruit infestation in first and fourth week of September, respectively.

The occurrence of okra pod borer began in the fourth week of August, according to Acharya (2002) and Dangi (2004) (6th week after sowing).

Sharma *et al*. (2010) did a field experiment to study the fluctuation of pest population of and their relation with prevailing weather condition at Horticulture Farm in Udaipur, India during Kharif 2005 and 2006. Borer infestation began in the 29th standard week, according to the findings.The peak infestation of plants (91.6 %) was observed in 45th standard week.

The maximum numbers of larvae (7.5 larvae/l0 plants) were recorded in the 42nd standard week. Correlation between pest population and important weather parameters showed that population was negatively correlated with the mean temperature and mean relative humidity but non significantly and negatively correlated withrainfall in terms of larval population and percentage of infested plants.

2.2 Management of okra pod borer

2.2.1 Imidacloprid

Imidacloprid is a systemic, chloro-nicotinyl insecticide with soil, seed and foliar uses for the control of sucking insects including rice hoppers, aphids, thrips, 24 whiteflies, termites, turf insects, soil insects and some beetles.It's most typically used on rice, cereal, maize, potatoes, vegetables, sugar beets, fruit, cotton, hops, and turf, and when administered as a seed or soil treatment, it's highly systemic. The chemical acts by interfering with the insect nervous system's ability to transmit sensations. It creates a blockage in a type of neural pathway known as the nicotinergic system, which is more common in insects than in warm-blooded species (making the chemical selectively more toxic to insects than warmblooded animals). The insect is paralyzed and finally dies as a result of the blockage, which causes a buildup of acetylcholine, an important neurotransmitter. It works both on contact and in the stomach (Kidd and James, 1994). Dustable powder, granular, and seed dressing (flowable slurry concentration) pesticide formulations based on imidacloprid are available.

Dustable powder, granular, seed dressing (flowable slurry concentrate), soluble concentrate, suspension concentrate, and wettable powder insecticide formulations based on imidacloprid are available (Meister 1995). The typical application rate is 0.05-0.125 pounds per acre. These treatment rates are far lower than those of previous, commonly used pesticides. It can be phytotoxic if not used according to the manufacturer's instructions, however when used as a seed treatment to reduce insect pests, it has been demonstrated to be compatible with fungicides (Pike *et al*. 1993).

2.2.1.1 Methods of application

It is most commonly used rice, cereal, maize, potatoes, vegetables, sugar beets, fruit, cotton, 25 hops and turf, and is especially systemic when used as a seed or soil treatment. The chemical acts by interfering with the insect nervous system's ability to transmit sensations. It creates a blockage in a type of neural pathway known as the nicotinergic system, which is more common in insects than in warm-blooded species (making the chemical selectively more toxic to insects than warm-blooded animals). The insect is paralyzed and finally dies as a result of the blockage, which causes a buildup of acetylcholine, an important neurotransmitter. It was also effective on contact and via stomach action (Kidd and James, 1994).

2.2.1.2 Regulatory statuses

Imidacloprid is a general-purpose pesticide that is categorized by the Environmental Protection Agency as a toxicity class II and class III agent, requiring it to be labeled with the words "Warning" or "Caution" (Meister, 1995). Imidacloprid and its metabolites residual tolerances on food/feed additives range from 0.02 ppm in eggs to 3.0 ppm in hops (U.S. Environmental Protection Agency, 1995).

2.2.1.3 Trade or other names : Imidacloprid is found in a variety of commercial insecticides. The products Admire, Condifor, Gaucho, Premier, Premise, Provado, and Marathon all contain imidacloprid as the active ingredient (Meister, 1995).

2.2.1.4 Effect of imidacloprid insecticides in the management of okra okra pod borer

Nazruss alam *et al*. (2008) conducted a field experiment at Ranchi, Bihar, India, to evaluate the efficacy of Multineem [*Azadirachta indica*], NSKE [neem seed kernel extract] and insecticides (endosulfan, imidacloprid and quinalphos), applied alone or in combination, against pod borer on okra. The treatments significantly reduced fruit infestation percentage and increased the yield of okra. Multineem at 1.0 liter/ha + imidacloprid at 150.0 ml/ha (2 sprays) was superior among the treatments, resulting in a benefit cost ratio of 10.50:1.

Praveen *et al.* (2007) tested the effect of seed treatment and foliar spraying of insecticides and neem products on the growth and yield of okra cv. Arka Anamika in Dharwad, Karnataka, India. Imidacloprid (Gauch 600FS) at 12 ml/kg seed, thiamethoxam (Cruiser 70WS) at 10 g/kg seed, neem oil at 80 mg/kg seed, neem cake at 500 kg/ha (soil application), and carbofuran at 15 kg/ha (soil application) were used as seed treatments, as were foliar sprays of imidacloprid (Con Cultural practices that were recommended were adopted. Data were recorded for plant height, number of leaves per plant, days to flower initiation, number of fruits per plant, percentage of fruit damage as well as fruit length, dry fruit weight, percentage of seed damage, 100-seed weight and seed yield. Seed treatment with imidacloprid at 12 ml/kg seed recorded the highest seed yield of 642 kg/ha. Foliar spraying with fenvalerate produced the highest seed yield of 799 kg/ha, followed by neem seed kernel extract (720 kg/ha).

Solangi and Lohar (2007) determined the efficacy of different insecticides against different insect pests and their predators on okra cv. Sabz Pari during the 2005 kharif season in Pakistan. The treatments included four insecticides, i.e. Confidor [imidacloprid], Sundaphos, Polo [diafenthiuron] and Mospilan and their efficacy was checked by a control plot (unsprayed). Pretreatment populations of jassid, thrips, whitefly, mites, spiders, ants, borer and beetles was managed and post-treatment observations were recorded after 24, 48 and 72 h, and 7 and 14 days of insecticidal spray.

Rana *et al*. (2006) conducted experiments during kharif 2003 and 2004, in Karnal, Haryana, India, showed that imidacloprid at 2 ml as well as thiamethoxam and carbosulfan each at 2 g/kg seed were quite effective in controlling pod borer. Imidacloprid at 2 ml, thiamethoxam at 2 g and carbosulfan at 4 g/kg seed were effective in controlling the whitefly (*Bemisiatabaci*). Okra seed yield was higher in thiamethoxam, imidacloprid and carbosulfan treatments.

Insecticidal seed treatment, as demonstrated by Gandhi *et al.* (2006), is a viable alternative to spray and granular applications. It has the ability to protect the crop from germination to reproduction. The use of chemical insecticides on a regular basis destabilizes the ecosystem and promotes the development of pest resistance.

Lal and Sinha (2005) carried out investigation to evaluate four (5, 9, 18, 36 g/kg) doses of imidacloprid seed treatments against the insect pests of okra.But, the treatments having imidacloprid seed treatment at 5 g/kg seed along with two foliar sprays of beta-cyfluthrin or altering of lambda-cyhalothrin and endosulfan were most effective treatments while seed treatment at 36 g/kg was second effective treatment ($p<0.01$) against shoot and fruit borer. However, yield of all the treatments, except highest dose (36 g/kg) of imidacloprid seed treatment gave excellent results.

Beta-cyfluthrin provided maximum protection (4.79% fruit damage) against the fruit borer *Eariasvittella*, while imidacloprid either as seed treatment or as foliar spray was not effective. Variable leaf hopper populations in okra leaves significantly influenced the leaf NAR. Borer damage significantly influenced the healthy fruit yield. Betacyfluthrin treatment significantly reduced the borer damage and recorded maximum economic yield (76.58 q/ha). The imidacloprid treatment was effective for control of leaf hopper population and showed higher leaf NAR, but the yield was less because of high borer infestation (Satpathy *et al.*, 2004).

Nandwana and Arjun (2004) studies were undertaken to determine the effects of seed soaking with chemicals on the multiplication of Meloidogyne incognita and growth of okra. Seeds of okra cv. Parbhani Kranti were soaked with different chemicals (carbosulfan 25 EC, imidacloprid 17.8SL and phosphomidon 85 EC at 0.1% a.i. concentration) for 12 h and thereafter sown in 15-cm earthen pots filled 33 with soil infested with M. incognita. Soaking okra seeds in carbosulfan 25 EC, imidacloprid 17.8SL and phosphomidon 85 EC reduced the severity of root infestation by nematodes in all the treatments. Imidacloprid was the most effective in protecting the plant roots from nematode attack resulting in increased growth of okra plants.

Sunitha *et al.* (2004) conducted field experiments in Bapatla, Andhra Pradesh, India, during the 2002-03 rabi season to assess the relative toxicity of different chemical groups, including dichlorvos, nimbecidine, *Bacillus thuringiensis* (Bt.; Delfin), novaluron (IGR), spinosad and imidacloprid (neonicotinoid), and combinations of dichlorvos Dichlorvos and imidacloprid were shown to be hazardous when used alone rather than in combination with eco-friendly compounds, according to the findings. Coccinellids were found to be relatively safe to the therapies Bt. and nimbecidine.

Sandeep and Kaur (2002) conducted field trials in Ludhiana, Punjab, India, from 1998 to 2000 to examine how effective various seed treatments and foliar sprays were at eradicating cotton jassid (*A. biguttula biguttula*) and spotted bollworm (*Earias sp*.) infested okra cv. Arka Anamika. T1: seed treatment with 5 g/kg imidacloprid/ha + foliar spray with 500 g a.i. monocrotophos/ha + 30 g a.i. cypermethrin/ha (T2), 15 g a.i. lambdacyhalothrin/ha (T3), 800 g a.i.profenofos/ha (T4) (T7). In 1998, T4 had the lowest mean population of cotton jassid (5.22),In 1999 (1.78) and 2000, T1 produced the lowest mean population of cotton jassid (1.45). T1 had the least leaf harm owing to jassid infestation. The spotted bollworm caused the least amount of fruit damage (31.54 percent) on T3. T1 had the highest average fruit output (21.39 q/ha).

Uptake and dissipation of imidacloprid in okra was studied by treating the seeds with Gaucho at 9 g a.i./kg seed and spraying okra crop at the fruiting stage with Confidor 200SL at 0.3 and 0.6 ml/liter. The plant absorbed imidacloprid from its seed treatment, and residues remained in the plant for more than 30 days after germination. Fruits collected 50, 55, and 60 days after germination, on the other hand, had no leftovers. In two consecutive seasons, imidacloprid residues evaporated rapidly with time after foliar treatment, with a half-life of 2-4 days. The residues, however, became non-detectable 10 days after treatment at lower concentration and 15 days after treatment at higher concentration (Indumathi *et al*. 2001).

2.2.2 Cultural control

OSFB can be reduced through clean cultivation and the eradication of alternate host plants, according to Atwal (1976). When cotton is not grown in a region, Kashyap and Verma

(1987) indicated that management of OSFB might be achieved through field hygiene, early sowing, and resistant types.

Kumar and Urs (1988) investigated the influence of nitrogen, phosphate, and potassium fertilizers on the incidence of noctuid *E. vittella* on okra in the field in Karnataka, India. The areas treated with 250 and 30 kg of nitrogen and potassium per hectare, respectively, had the most infestations. There was a link between the plant's nitrogen uptake and the presence of *E. vittella*. However, there was a link between the plants' potassium uptake and their infection.

2.2.3 Neem oil

Neem , *Azadirachta indica* oil contains at least 100 biologically active compounds and the major constituents are triterpenes, limonoids and azadirachtin (Scudeler and Santos 2013, Scudeler *et al*.2013, Scudeler *et* al. 2014, Chandramohan *et al*. 2016). These bitter alkaloids have a contact and systemic effect on insect pests. Neem oil and its derivatives have broad-spectrum insecticidal components that restrict insect eating, disrupt hormone function in juvenile stages, diminish ecdysone, deregulate growth, and suppress development and reproduction (Brahmachari 2004).

The triterpenoid azadirachtin ($C_{35}H_{44}O_{16}$) was first isolated from the seeds of the tropical neem tree by Butterworth and Morgan (1968). Kraus et al. and Bilton et al. eventually explained its definite structural formula, which parallels that of ecdysone, in 1985. Azadirachtin is a limonoid alleliochemical (Butterworth and Morgan, 1968; Broughton *et al*., 1986) present in the fruits and other tissues of the tropical neem

tree (*Azadirachta indica*). The fruit is the most important aspect of neem that affects 13 insects in various ways.The leaves, which can also be utilized for pest management, can grow up to 30 cm in length.

Adilakshmi *et al.* (2008) reported that neembased insecticides were more effective in suppressing the fruit borer population and registered significantly low incidencethan untreated check.

Botanical extracts and oils have toxic effect on insect pests, and incapacitate their growth and reproduction (Ahad *et al*. 2016, Mazumder *et al*. 2016).

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

Antifeedant effect of neem in combination with sweet flag 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.

Lakshmanan (2001) found that neem extract, alone or in combination with other plant extracts, was efficient in controlling *E. vittella*, *Chilo partellus Swinhoe*, *H. armigera*, and *S. litura*, lepidopteran pests.

Morale *et a*l. (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.*

Neem oil worked as an antifeedant, growth inhibitor, and oviposition deterrent against insect pests of okra and cotton after being sprayed (Ahmed *et al*., 1995).

2.2.3.1 Mode of action of neem

2.2.3.1.1 Settling Behavior

In M. persicae, crude neem extracts inhibit settling and diminish feeding (Griffiths et al. 1978 and 1989).

2.2.3.1.2 Oviposition Behavior: Under laboratory conditions, females of various lepidopterous insects are repelled by neem products on treated plant parts or other substrates and will not lay eggs on them.

2.2.3.1.3 Feeding Behavior

Azadirachtin is a potent insect antifeedant. Antifeedancy is the result of effects on deterrent and other chemoreceptors. The antifeedant effects of azadirachtin have been reported for many species of insects. Reduction of feeding was also observed after topical application or injection of neem derivatives, including AZA and alcoholic neem seed kernel extract. This suggests that the reduction in food intake by insects is regulated not just by gustatory organs in the mouth, but also by non-gustatory organs. These two phagodeterrent/antifeedant effects were called primary and secondary (Schmutterer 1985).

2.2.3.1.4 Metamorphosis

Depending on the dose used, azadirachtin has a variable effect on insect metamorphosis, causing various morphogenetic abnormalities as well as mortality. The IGR impact of neem derivatives such methanolic neem leaf extract and azadirachtin in insect larvae and nymphs was first detected in Heteroptera and Lepidoptera in 1972 (Leuschner 1972).

Molting, if it occurred, was incomplete, and the insects tested died as a result. Botanicals have a variety of qualities, including insecticidal and insect growth-regulating properties, which make them effective against a variety of insect pests and mites (Rajasekaran and Kumaraswami, 1985; Prakash and Rao, 1986 and 1987; Prakash et al., 1987; 1989 and 1990). Plant products have several advantages over synthetic chemicals, including low mammalian toxicity, no reported development of resistance to their production thus far, less hazardous to non-target organisms, no pest resurgence problem, no adverse effect on plant growth, negligible application risks, low cost, and easy availability. Neem, sweet flag, cashew, custard apple, sugar apple, derris, lantana, tayanin, indian privet, agave, crow plant, and other plant species with pest management properties were mentioned by Ahmed (1984).There are 1005 plant species with biological properties against insect pests, including 384 species that act as antifeedants, 297 species that act as repellents, 97 species that act as attractants, and 31 species that act as growth inhibitors. According to (Schmutterer, 1995), about 413 different species/sub-species of insect pests are vulnerable to neem products. The listed species/sub-species come from a variety of insect orders, with the majority of them belonging to the Lepidoptera (136) and Coleopteran families (79).

CHAPTER III

MATERIALS AND METHODS

The pot experiment was conducted during the period from January to April 2020 at the experimental field of Sher-e-Bangla Agricultural University, Dhaka. The experiment was designed to study the intensity of infestation and sustainable management of okra pod borer on different varieties of okra. The materials and methods followed in this experiment are presented in this chapter under the following headlines-

3.1 Location

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The location of the experimental site was 23074//N latitude and 90035//E longitude and an elevation of 8.2 m from the sea level (Anon., 1989).

3.2 Climate

The study site was under the subtropical climate, characterized by three distinct seasons, the Rabi from November to February and the Kharif- I, pre-monsoon period or hot season from March to April and the Kharif- II monsoon period from May to October (Edris *et al*., 1979). The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from weather yard, Bangladesh Meteorological Department, Agargaon, Dhaka -1207.

3.3 Soil

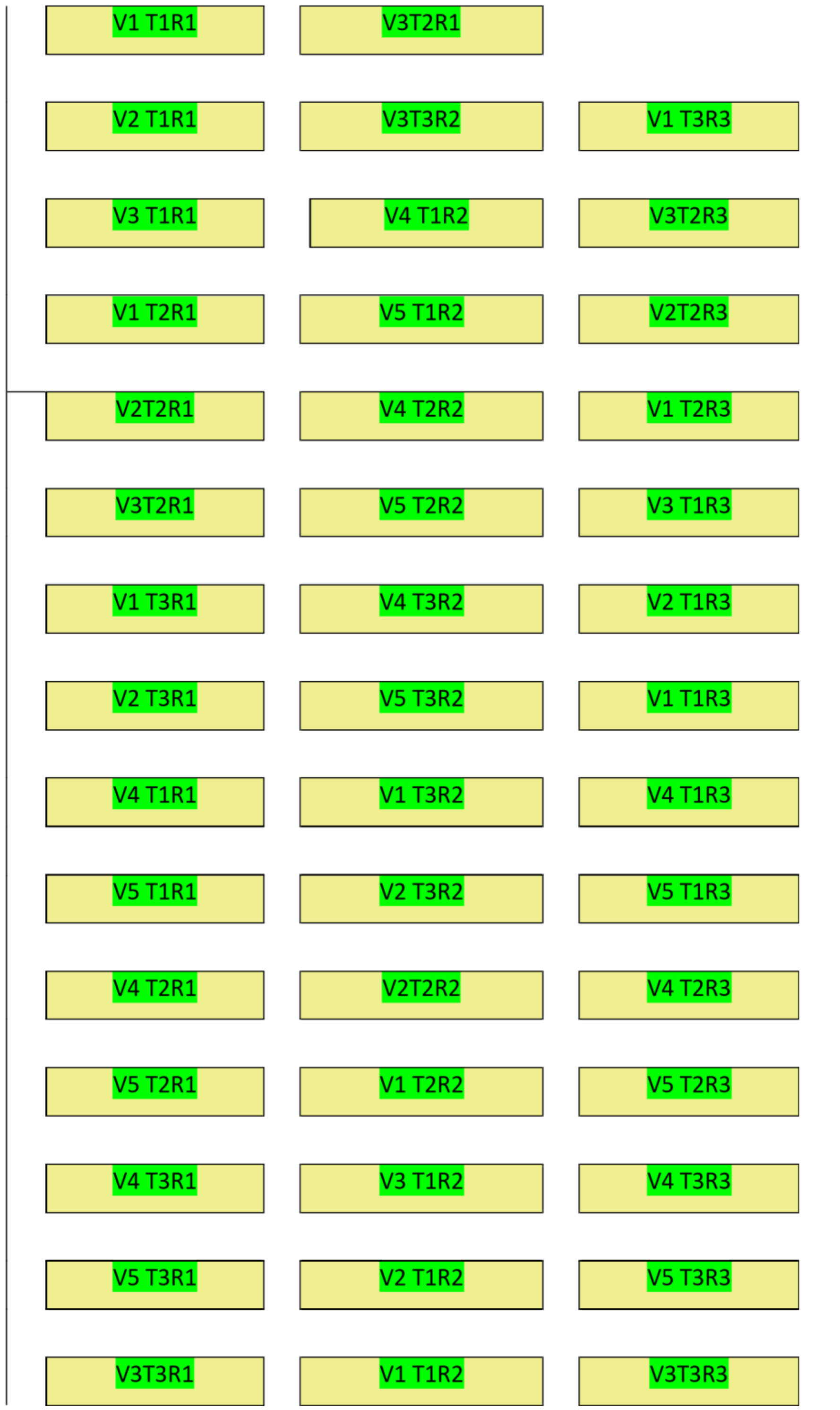
Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, CEC-25.28 22 (Haider *et al*., 1991). The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). Details of the mechanical analysis of soil sample.

3.4 Seed collection

The seeds of okra variety BARI Dheros-1 and BARI Dheros-2 were collected from BARI and Green finger, Ok-285, Arko anamika were collected from Green life nursery, Agargaon, Dhaka.

3.5 Experimental design and layout

The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. The experimental field was divided into three blocks maintaining 0.75m block to block distance and each block was subdivided into 15 plots treatments each maintaining 2.5 m x 2 m plot size. Thus the total number of plots was 45. The plot to plot distance was 0.5 m was kept to facilitate different intercultural operations. The layout of the experiment is shown in Figure 1.



Legend

Varities:

V1 = BARI Dheros-1

V2 = BARI Dheros-2

V3 = Green finger

V4 = Ok-285

V5 = Arko anamika

Treatments: 03

Block to block 0.75m

Plot size= 2.5 m x 2 m

Plot to plot 0.5m

Replications:3

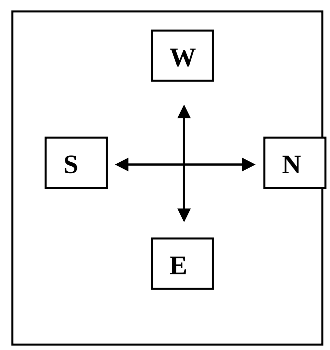


Figure 1. Layout of the experimental field

3.6 Land preparation

The experimental plot was opened in the first week of January 2020 with a power tiller and was exposed to the sun for a week, after which the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and thus the land was prepared for the experiment. The field layout and design of the experiments were followed immediately after land preparation.

3.7 Sowing of seeds

Seeds were sown in the experimental plots on 6 January, 2020. The row to row and plant to plant spacing was maintained at 45 cm and 40 cm respectively. The field was irrigated lightly immediately after sowing. At least three seeds were sown in each pit of the plot to avoid the risk of germination failurity of the seeds.

3.8 Manure and fertilizer

The fertilizers N, P, K in the form of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP) respectively and as an organic manure, Cow dung were applied.

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

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

Plate 01: Vegetative stage of okra plant in the experimental field during the study periods.

Plate 02: Reproductive stage of okra plant with flower and fruits in the experimental field during the study periods.

3.9 Cultural practices

3.9.1 Gap filling: Dead, injured and weak seedlings were replaced by new vigor okra seedlings grown in extra area of the main field.

3.9.2 Thinning: When the seedlings were established, one healthy seedling in each pit was kept and others removed from the pit.

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

3.9.4 Harvesting: As the seeds were sown in the field at times, the crops were harvested at different times. Green fruits were harvested at two days interval when they attained edible stage and was continued up to April 15, 2020.

3.10 Treatments

Treatments of this experiment were as follows:

The experiment consisted of two factors as mentioned below: Factor

A: Organic insecticides

- T_1 = Spraying Imidacloprid @1.5 ml/L of water at 15 days interval
- T_2 = Spraying Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval.
- T_3 = Control Factor B: Varieties
- V_1= BARI Dheros-1
- V_2= BARI Dheros-2
- V_3= Ok-285
- V_4= Green finger

- V_5= Arko anamika

Treatment combinations were 15 as:

T_1V_1, T_1V_2, T_1V_3, T_1V_4, T_1V_5, T_2V_1, T_2V_2, T_2V_3, T_2V_4, T_2V_5, T_3V_1, T_3V_2, T_3V_3, T_3V_4, T_3V_5.

3.11 Preparation of the pesticides used as treatments

3.11.1 Imidacloprid

Imidacloprid 30 EC was applied at the rate of 1.5 ml/L water at 15 days intervals.

3.11.2 Neem oil

For proper management of okra insect pests 5 ml neem oil was poured in 1 Litre of water and then 10 ml trix was mixed to obtain fine droplet of aqueous suspension to spray 2.5m x 2m area.

3.12 Application of the treatments

Spraying was done at 3.00-4.00 pm to avoid moisture on leaves. First application was done after 30 days of germination. Treatments were applied at 15 days interval. Spraying was done by knapsack sprayer having a pressure of 4.5 kg/cm^2.

3.13 Monitoring of insect pest and data collection

For data collection five plants per plot were randomly selected and tagged. Data were collected from seedling stage to fruiting stage. The results are presented as an average value of the five tagged plants. The data were recorded on different parameters.

- No. of shoot infestated at different growing stages
- No. of fruit infestated at different fruiting stages
- No. of healthy fruit at different fruiting stages
- Fruit infestated at different fruiting stage in weight basis
- Fruit length
- Fruit girth
- No. of fruit $Plant^{-1}$
- Single fruit weight
- No. of branch $plant^{-1}$

- Yield (kg/plot)
- Yield (ton/ha)

3.14 Determination of infested shoot in number

All the fruits were counted from randomly 5 selected plants from middle rows of each plot and examined. The collected data were vegetative stage. The healthy and infested fruits were counted and calculated the percent infested fruit.

3.15 Determination of fruit infested and healthy fruit in number

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

3.15.1 Okra shoot and fruit borer infestation

The number of infested shoot as well as fruit, total okra shoot as well as fruit and untreated control plot were recorded for each treated plot and the reduction of infestation in number basis was calculated using the following formulae:

Shoot infestation (%) reduction over control=

$$\frac{\text{\% infested shoot in control} - \text{\% infested shoot in the treatment}}{\text{\% infested shoot in control}} \text{ X100}$$

Fruit infestation (%) reduction over control=

$$\frac{\text{\% infested fruit in control} - \text{\% infested fruit in the treatment}}{\text{\% infested fruit in control}} \text{ X 100}$$

Plate 03: Healthy fruits with plant of BARI Dheros-1 (V_1) variety .

Plate 04: Healthy fruits with plant of BARI Dheros-2 (V_2) variety .

Plate 05: Healthy fruits with plant of Ok-285 (V_3) local variety harvesting.

Plate 06: Healthy fruits with plant of Green finger (V_4) variety after harvesting

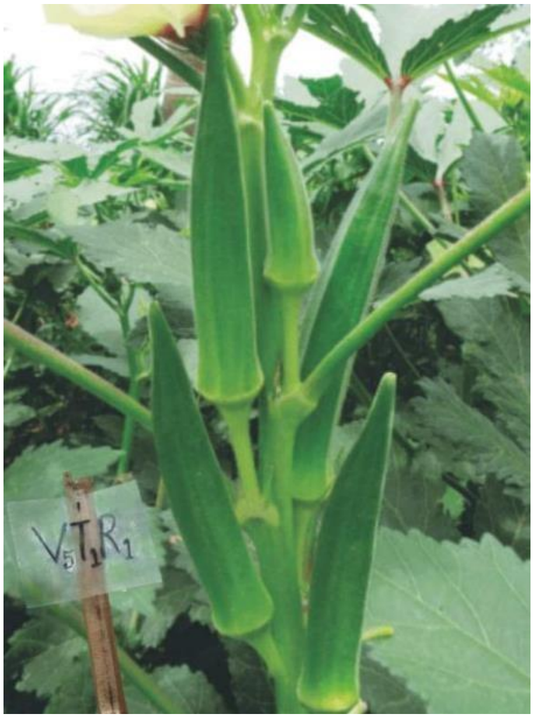


Plate 07: Healthy fruits on plant of Arko anamika

	
Plate 08: Okra fruit infested by OSFB larva	Plate 09:iI:Infested okra fruit with OSFB larva

3.16 Determination of infested fruit and healthy fruit (weight basis)

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

3.17 Yield contributing characters of okra

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

3.17.1 Length of fruit

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

3.17.2 Girth of fruit

The girth of fruit was recorded in centimetre (cm) during harvesting from each experimental plot. The girth of every fruit was measured by a slide calipers and mean values were recorded.

3.17.3 Weight of fruit

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

3.17.4 Yield per hectare

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

3.18 Statistical analysis

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

Plate10: Infested okra fruits after harvesting during the study period.

Plate 11: Healthy okra fruits after harvesting during the study period.

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CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the study "Intensity of infestation and eco-safe management practices of okra shoot and fruit borer on different varieties of okra" have been presented and discussed in this chapter. Treatments effect of insecticides levels on all the studied parameters have been presented in various tables and figures and discussed below under the following sub-headings.

4.1 Incidence of okra shoot and fruit borer

4.1.1 Percentage of shoot infestated at different growing stages

4.1.1.1 Effect of management practices

Significant variation at 5 % level on percentage of shoot infestation was found at different growing stages influenced by different treatments (Table 1) Among the treatment Imidacloprid (T_1) showed significantly the lowest shoot infestation percentage (2.62, 1.52, 1.51, 1.37 and 1.74 at vegetative, early fruiting, mid fruiting, late fruiting stages and mean, respectively) which was statistically different from Neem oil (T_2). Significantly the highest shoot infestation percentage (22.16, 11.09, 8.95, 8.10 and 12.58 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in control treatment (T_3). The results consistent with the findings of Roy *et al*. (2016), Islam *et al*. (2015) and Bisne *et al.* (2008) who observed shoot infestation significantly among the treatments.

4.1.1.2 Effect of Variety

Effect of management practices showed a significant variation at 5 % level on percentage of shoot infestation was found at different growing stages influenced by different varieties (Table 1) Among the varieties BARI Dheros-1 (V_1) showed significantly the lowest shoot infestation percentage (8.08, 3.79, 3.60, 3.00 and 4.62 at vegetative, early fruiting, mid fruiting, late fruiting stages and mean, respectively) which was statistically different from BARI Dheros-2 (V_2) followed by Green finger (V_4) varieties. Significantly the highest shoot infestation percentage (14.05, 7.19, 6.22, 6.63 and 8.27 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

Table1. Effect of management practices and variety on percentage of shoot infestation at different growing stages

Treatments	% Shoot infestation				
	Vegetative stage	**Early fruiting stage**	**Mid fruiting stage**	**Late fruiting stage**	**Mean**
T_1	2.62 c	1.52 c	1.51c	1.37 c	1.74 c
T_2	7.77 b	3.61 b	3.43 b	2.76 b	4.39 b
T_3	22.16 a	11.09 a	8.95 a	8.10 a	12.58 a
$LSD_{(0.05)}$	**0.48**	**0.38**	**0.19**	**0.18**	**0.40**
Varieties					
V_1	8.08 e	3.790 e	3.60 e	3.00 e	4.62 d
V_2	9.44 d	4.793 d	4.01 d	3.52 d	5.41 c
V_3	11.87 b	5.737 b	4.85 b	4.30 b	6.69 b
V_4	10.82 c	5.510 c	4.48 c	3.93 c	6.20 b
V_5	14.05 a	7.193 a	6.22 a	5.63 a	8.27 a
$LSD_{(0.05)}$	**0.62**	**0.49**	**0.24**	**0.24**	**0.52**
CV (%)	**5.94**	**9.47**	**5.39**	**6.03**	**8.58**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2=Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.1.3 Interaction effect

Interaction effect of intensity of infestation and management practices decrease gradually advance of growth stage in respect of shoot infestation (Table 2).

Table 2. Interaction effect of intensity of infestation and management practices on percentage of shoot infestation at different growing stages

Treatments combination	% Shoot infestation				
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean
T_1V_1	1.25 l	0.40 j	0.33 k	0.25 k	0.56 l
T_1V_2	2.21 kl	1.02 j	1.01 j	0.99 j	1.31 kl
T_1V_3	3.25 jk	2.01i	2.00i	1.92 hi	2.30 j
T_1V_4	2.86 jk	1.95i	1.85 hi	1.68i	2.09 jk
T_1V_5	3.55 j	2.21 hi	2.4 h	2.02 hi	2.55 ij
T_2V_1	5.25 i	3.02 gh	2.93 g	2.21 gh	3.35 hi
T_2V_2	6.85 h	3.12 fg	3.01 g	2.54 fg	3.88 gh
T_2V_3	8.23 g	3.95 ef	3.71ef	2.98 e	4.72 g
T_2V_4	7.25 gh	3.85 e-g	3.48 f	2.85 ef	4.36 g
T_2V_5	11.25 f	4.22 e	4.01 e	3.21 e	5.67 f
T_3V_1	17.75 e	7.95 d	7.53 d	6.55 d	9.95 e
T_3V_2	19.25 d	10.24 c	8.01 c	7.03 c	11.13 d
T_3V_3	24.12 b	11.25 b	8.85 b	8.01 c	13.06 b
T_3V_4	22.35 c	10.85 bc	8.12 c	7.25 b	12.14 c
T_3V_5	27.35 a	15.15 a	12.25 a	11.65 a	16.60 a
$LSD_{(0.05)}$	**1.08**	**0.86**	**0.42**	**0.41**	**0.90**
CV (%)	**5.94**	**9.47**	**5.39**	**6.03**	**8.58**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 =Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

The infestation rate was much higher in the vegetative stage of growing period. After that the increasing rate was much slower up to late fruiting stage. However, the least percentage of shoot infestation (1.25, 0.40, 0.33, 0.25, and 0.56 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in the treatment combinationT_1V_1which was statistically different from all other treatments. The highest percentage of shoot infestation (27.35, 15.15, 12.25, 11.65, and 16.60 at vegetative, early fruiting, mid fruiting, late fruiting stages and mean, respectively) was obtained from the treatment combination of $T_3V_{5.}$

4.1.2 Percentage of fruit infestation at different fruiting stages

4.1.2.1 Effect of management practices

Significant variation at 5 % level on percentage of fruit infestation was found at different growing stage influenced by different treatments (Table 3). Among the treatment Imidacloprid (T_1) showed significantly the minimum fruit infestation percentage (13.44, 14.21, 15.11 and 14.05 at early fruiting, mid fruiting, late fruiting stages and mean, respectively) which was statistically different from Neem oil (T_2). Significantly the maximum fruit infestation percentage (36.39, 39.10, 43.80, and 39.76 at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in (T_3) untreated control treatment.

Fruit infestation reduction over control in was estimated and the highest value was found from the treatment T_1 (64.66%) and the minimum reduction over control from T_2 (42.30%) treatment.

4.1.2.2 Effect of Variety

Effect of management practices showed a significant variation at 5 % level on percentage of fruit infestation was found at different growing stages influenced by different varieties (Table 3)Among the varieties BARI Dheros-1 (V_1) showed significantly the least fruit infestation percentage (20.55, 20.66, 21.71 and 20.64 at early fruiting, mid fruiting, late fruiting stages and mean, respectively) which was statistically different from BARI Dheros-2(V_2) and following by Green finger (V_4) varieties. Significantly the highest fruit infestation percentage (28.13, 31.49, 38.11 and 32.54 at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

Percentage of fruit infestation reduction over control in variety was estimated and the highest value was found from the variety V_1 (36.57%) which was followed by V_2 (31.22%) and V_4 (21.54%) varieties and the minimum reduction over control from V_3 (17.49%) variety.

Table 3. Effect of management practices and variety on percentage of fruit infestation at different growing stages

Treatments	% Fruit infestation				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%Reduction over control
T_1	13.44 c	14.21 c	15.11 c	14.05 c	64.66
T_2	21.67 b	22.86 b	24.36 b	22.94 b	42.30
T_3	36.39 a	39.10 a	43.80 a	39.76 a	--
$LSD_{(0.05)}$	**1.27**	**0.46**	**0.60**	**1.06**	**--**
Variety					
V_1	20.55 c	20.66 e	21.71 e	20.64 d	36.57
V_2	21.07 c	22.32 d	23.73 d	22.38 c	31.22
V_3	25.47 b	26.84 b	28.23 b	26.85 b	17.49
V_4	23.94 b	25.65 c	27.02 c	25.53 b	21.54
V_5	28.13 a	31.49 a	38.11 a	32.54 a	--
$LSD_{(0.05)}$	**1.64**	**0.60**	**0.77**	**1.37**	**--**
CV (%)	**7.15**	**2.44**	**2.88**	**5.53**	**--**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.2.3 Interaction effect

Interaction effect of intensity of infestation and management practices decrease gradually advance of growth stage in respect of percentage of fruit infestation (Table 4). The infestation rate was slower in the early fruiting stage of growing period. After that the increasing rate was little bit increase up to late fruiting stage. However, the least percentage of fruit infestation (10.95, 11.25, 11.98 and 11.39at early fruiting, mid fruiting, late fruiting stage and mean, respectively) was found in the treatment combination T_1V_1 which was statistically different from all other treatments. The highest percentage of fruit infestation (44.25, 50.54, 67.25 and 54.01 at early fruiting, mid fruiting, late fruiting stages and mean, respectively) was obtained from the treatment combination of T_3V_5.

Interaction effect of intensity of infestation and sustainable management on percentage of fruit infestation reduction over control was estimated and the highest value was found from the combination T_1V_1 (78.91%) and the minimum reduction over control from T_3V_3 (27.14%) combination.

Table 4. Interaction effect of intensity of infestation and management practices on percentage of fruit infestation at different growing stages

Treatments combination	% Fruit infestation				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%Reduction over control
T_1V_1	10.95 gh	11.25 l	11.98 l	11.39 k	78.91
T_1V_2	11.52 h	12.35 k	12.99 l	12.29jk	77.24
T_1V_3	14.15 gh	15.63 j	16.73 jk	15.50 hi	71.30
T_1V_4	13.21 h	14.85 j	15.85 k	14.64ij	72.89
T_1V_5	14.36 gh	16.98 i	18.02 ij	16.45 hi	69.54
T_2V_1	16.21 fg	17.78 i	19.12 i	17.70gh	67.23
T_2V_2	18.25 f	19.36 h	21.12 h	19.58 g	63.75
T_2V_3	24.85 e	25.37 g	26.85 g	25.69ef	52.43
T_2V_4	23.25 e	24.85 g	25.68 g	24.59 f	54.47
T_2V_5	25.45 e	26.96 f	29.05 f	27.15 e	49.73
T_3V_1	31.48 d	32.95 e	34.02 e	32.82 d	39.23
T_3V_2	33.45 cd	35.25 d	37.09 d	35.26 c	34.72
T_3V_3	37.42 b	39.52 b	41.11 b	39.35 b	27.14
T_3V_4	35.35 bc	37.25 c	39.52 c	37.37bc	30.81
T_3V_5	44.25 a	50.54 a	67.25 a	54.01 a	--
$LSD_{(0.05)}$	**2.85**	**1.04**	**1.34**	**2.37**	**--**
CV (%)	**7.15**	**2.44**	**2.88**	**5.53**	**--**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.3 Percentage of healthy fruit at different fruiting stages

4.1.3.1 Effect of management practices

Significant variation at 5 % level on percentage of healthy fruit was found at different growing stage influenced by different treatments (Table 5). Among the treatment Imidacloprid (T_1) showed significantly the maximum healthy fruit percentage (87.16, 85.78, 84.89 and 85.95at early fruiting, mid fruiting, late fruiting stages and mean, respectively) which was statistically different from Neem oil (T_1). Significantly the minimum healthy fruit percentage (63.61, 60.89, 56.20, and 60.24 at early fruiting, mid fruiting, late fruiting stages and mean, respectively) was found in T_3 untreated control treatment.

Percentage of healthy fruit increase over control in sustainable management was estimated and the highest value was found from the treatment T_1 (42.68%) and the minimum increase over control from T_2 (27.92%) treatment.

4.1.3.2 Effect of Variety

Effect of management practices showed a significant variation at 5 % level on percentage of healthy fruit was found at different growing stage influenced by different varieties (Table 5). Among the varieties BARI Dheros-1 (V_1) showed significantly the maximum healthy fruit percentage (80.45, 79.34, 78.29 and 79.36 at early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically similar from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the minimum healthy fruit percentage (71.98, 68.51, 61.89 and 67.46 at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

Percentage of healthy fruit increase over control in variety was estimated and the highest value was found from the variety V_1 (17.64%) which was followed by V_2 (15.06%) and V_4 (10.38%) varieties and the minimum increase over control from V_3 (8.43%) variety.

Table 5. Effect of management practices and variety on percentage of healthy fruit at different growing stages

Treatments	% Healthy Fruit				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Increase over control
T_1	87.16 a	85.78 a	84.89 a	85.95 a	42.68
T_2	78.40 b	77.40 b	75.64 b	77.06 b	27.92
T_3	63.61 c	60.89 c	56.20 c	60.24 c	--
$LSD_{(0.05)}$	**1.62**	**1.39**	**2.42**	**2.10**	**--**
Varieties					
V_1	80.45 a	79.34 a	78.29 a	79.36 a	17.64
V_2	78.93 a	77.68 a	76.27 a	77.62 a	15.06
V_3	74.53 b	73.60 b	71.77 b	73.15 b	8.43
V_4	76.06 b	74.35 b	72.98 b	74.47 b	10.38
V_5	71.98 c	68.51 c	61.89 c	67.46 c	--
$LSD_{(0.05)}$	**2.09**	**1.80**	**3.13**	**2.71**	**--**
CV (%)	**4.83**	**6.49**	**4.48**	**6.33**	**--**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.3.3 Interaction effect

Interaction effect of intensity of infestation and management practices decrease gradually advance of growth stage in respect of percentage of healthy fruit (Table 6). The infestation rate was increase in the early fruiting stage of growing period. After that the increasing rate was little bit slower up to late fruiting stage. However, the highest percentage of healthy fruit (89.05, 88.75, 88.02 and 88.61at early fruiting, mid fruiting, late fruiting stages and mean, respectively) was found in the treatment combinationT_1V_1which was statistically different from all other treatments. The lowest percentage of healthy fruit (55.75, 49.46, 32.75 and 45.99 at early fruiting, mid fruiting, late fruiting stages and mean, respectively) was obtained from the treatment combination of $T_3V_{5.}$

Interaction effect of intensity of infestation and sustainable management on percentage of healthy fruit increase over control was estimated and the highest value was found from the combination T_1V_1 (92.67%) and the minimum reduction over control from T_3V_5 (31.88%) combination.

Table 6. Interaction effect of intensity of infestation and management practices on percentage of healthy fruit at different growing stages

Treatments combination	% Healthy Fruit				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%Increase over control
T_1V_1	89.05 a	88.75 a	88.02 a	88.61 a	92.67
T_1V_2	88.48 a	87.65 ab	87.01 ab	87.71 ab	90.72
T_1V_3	85.85 ab	84.37 c	83.27 a-c	84.50 a-d	83.74
T_1V_4	86.79 ab	85.15 bc	84.15 a-c	85.36 a-c	85.61
T_1V_5	85.64 ab	83.02 cd	81.98 bc	83.55 b-d	81.67
T_2V_1	83.79 bc	82.22 cd	80.88 c	82.30 cd	78.95
T_2V_2	81.75 c	80.64 d	78.88 cd	80.42 d	74.86
T_2V_3	75.15 d	74.63 e	73.15 e	74.31 e	61.58
T_2V_4	76.75 d	75.15 e	74.32 de	75.41 e	63.97
T_2V_5	74.55 d	73.04 e	70.95ef	72.85 e	58.40
T_3V_1	68.52 e	67.05 f	65.98fg	67.18 f	46.08
T_3V_2	66.55ef	64.75fg	62.91gh	64.74fg	40.77
T_3V_3	62.58 g	60.48 h	58.89 h	60.65 g	31.88
T_3V_4	64.65fg	62.75gh	60.48 h	62.63fg	36.18
T_3V_5	55.75 h	49.46i	32.75i	45.99 h	--
$LSD_{(0.05)}$	**3.61**	**3.11**	**5.42**	**4.69**	**--**
CV(%)	**4.83**	**6.49**	**4.48**	**6.33**	**--**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.4 Fruit infestation plot^{-1} at different fruiting stages (weight basis)

4.1.4.1 Effect of management practices

Significant variation at 5 % level on percentage of fruit infestation plot^{-1}was found at different growing stage influenced by different treatments (Table 7). Among the treatments Imidacloprid (T_1) showed significantly the minimum fruit infestation plot^{-1} in weight basis (62.20 g, 239.00 g, 167.80 g and 156.34 g at early fruiting, mid fruiting, late fruiting stages and mean, respectively) which was statistically different from Neem oil (T_2). Significantly the maximum fruit infestation plot^{-1} in weight basis (95.45 g, 556.60 g, 304.40 g and 318.82 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in T_3 untreated control treatment.

Percentage of fruit infestation plot^{-1} in weight basis reduction over control in sustainable management was estimated and the highest value was found from the treatment T_1 (50.96%) and the minimum reduction over control from T_2 (21.69%) treatment.

4.1.4.2 Effect of Variety

Effect of management practices showed a significant variation at 5 % level on percentage of fruit infestation plot^{-1} in weight basis was found at different growing stage influenced by different varieties (Table 7). Among the varieties BARI Dheros-1 (V_1) showed significantly the least fruit infestation plot^{-1} in weight basis percentage (72.17 g, 376.67 g, 215.33 g and 221.39 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the highest fruit infestation plot^{-1} in weight basis (83.50 g, 459.33 g, 266.67 g and 269.83 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok285 (V_3).

Percentage of fruit infestation plot^{-1} in weight basis over control in variety was estimated and the highest value was found from the variety V_1 (17.95%) which was followed by V_2 (14.32%) and V_4 (10.55%) varieties and the minimum reduction over control from V_3 (9.49%) variety.

Table 7. Effect of management practices and variety on fruit infestation plot^{-1}(g) on weight basis at different growing stages

Treatments	Fruit infestation plot^{-1} (g)				
	Early fruiting stage	**Mid fruiting stage**	**Late fruiting stage**	**Mean**	**% Reduction over control**
T_1	62.20 c	239.00 c	167.80 c	156.34 c	50.96
T_2	74.55 b	433.00 b	241.40 b	249.65 b	21.69
T_3	95.45 a	556.60 a	304.40 a	318.82 a	--
$LSD_{(0.05)}$	**1.17**	**3.48**	**4.14**	**4.41**	**--**
Varieties					
V_1	72.17 d	376.67 d	215.33 d	221.39 d	17.95
V_2	74.58 c	388.33 c	230.6 c	231.19 c	14.32
V_3	79.00 b	413.00 b	240.67 b	244.22 b	9.49
V_4	77.75 b	410.33 b	236.00 bc	241.36 b	10.55
V_5	83.50 a	459.33 a	266.67 a	269.83 a	--
$LSD_{(0.05)}$	**1.51**	**4.49**	**5.35**	**5.66**	**--**
CV (%)	**5.02**	**2.13**	**2.33**	**2.56**	**--**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.4.3 Interaction effect

Interaction effect of intensity of infestation and management practices decrease gradually advance of growth stage in respect of fruit infestation plot^{-1} in weight basis (Table 8). The infestation rate was slower in the early fruiting stage of growing period. After that the increasing rate was little bit increase up to late fruiting stage. However, the least percentage of fruit infestation (55 g, 215 g, 152 g and 140.67 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in the treatment combinationT_1V_1which was statistically different from all other treatments. The highest percentage of fruit infestation (102 g, 605 g, 350 g and 352.33 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was obtained from the treatment combination of $T_3V_{5.}$

Interaction effect of intensity of infestation and sustainable management on percentage of fruit infestation plot^{-1} in weight basis reduction over control was estimated and the highest value was found from the combination T_1V_1 (60.07%) and the minimum reduction over control from T_3V_5 (9.84%) combination.

Table 8. Interaction effect of intensity of infestation and management practices on fruit infestation plot^{-1}(g) on weight basis at different growing stages

Treatment combination	Fruit infestation plot^{-1} (g)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% Reduction over control
T_1V_1	55 l	215 m	152 l	140.67 i	60.07
T_1V_2	59 k	225 l	159 kl	147.67 i	58.09
T_1V_3	65 j	239 k	175 j	159.67 h	54.68
T_1V_4	64 j	268 i	168 jk	166.67 h	52.69
T_1V_5	68 i	248 j	185 i	167.00 h	52.60
T_2V_1	70 hi	385 h	215 h	223.33 g	36.61
T_2V_2	72 gh	402 g	235 g	236.33 f	32.92
T_2V_3	76 fg	435 e	255 f	255.33 e	27.53
T_2V_4	74.25 f	418 f	237 g	243.08 f	31.01
T_2V_5	80.5 e	525 d	265 e	290.17 d	17.64
T_3V_1	91.5 d	530 d	279 d	300.17c	14.80
T_3V_2	92.75 cd	538 c	298 bc	309.58 bc	12.13
T_3V_3	96 bc	565 b	292 c	317.67 b	9.84
T_3V_4	95 b	545 c	303 b	314.33 b	10.79
T_3V_5	102 a	605 a	350 a	352.33 a	--
$LSD_{(0.05)}$	**2.62**	**7.77**	**9.27**	**9.86**	**--**
CV(%)	**5.02**	**2.13**	**2.33**	**2.56**	**--**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.5 Yield Contributing Characters

4.1.5.1 Effect of management practices

Significant variation was observed in number of branch plant^{-1}, number of fruit plant^{-1}, fruit length (cm), fruit girth (cm) and Single fruit weight (g) at total growing period for the intensity of infestation and management practices of okra pod borer on different varieties of okra (Table 9).

In the term of number of branch plant^{-1}, among the treatment Imidacloprid (T_1) showed significantly the highest number of branch plant^{-1} (4.80) which was statistically different from Neem oil (T_2). Significantly the least number of branch plant^{-1} (2.86) was found in untreated control (T_3).

In the term of number of fruit plant^{-1}, among the treatment Imidacloprid (T_1) showed significantly the highest number of branch plant^{-1} (24.60) which was statistically different from Neem oil (T_2). Significantly the least number of fruit plant^{-1} (20.20) was found in Control treatment (T_3).

In consider of fruit length (cm) and fruit girth (cm), among the treatment Imidacloprid (T_1) showed significantly the highest number of branch plant^{-1} (14.90 and 1.54) which was statistically similar from Neem oil (T_2). Significantly the least fruit length (cm) and fruit girth (cm) (14.50 and 1.53) was found in T_3 untreated control treatment.

In consider of Single fruit weight (g), among the treatment Imidacloprid (T_1) showed significantly the highest single fruit weight (13.36 g) which was statistically different from Neem oil (T_2). Significantly the least single fruit weight (10.49 g) was found in control treatment (T_3).

4.1.5.2 Effect of Variety

Significant variation was observed in number of branch plant^{-1}, number of fruit plant^{-1}, fruit length (cm), fruit girth (cm) and Single fruit weight (g) at total growing period for the intensity of infestation and management practices of okra shoot and fruit borer on different varieties of okra (Table 9).

Table 9. Effect of management practices and variety on yield Contributing Characters at different growing stages

Treatments	Yield Contributing Characters				
	No. of branch plant^{-1}	No. of fruit Plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Single fruit weight (g)
T_1	4.80 a	24.60 a	14.90 a	1.54	13.36 a
T_2	4.08 b	22.60 b	14.85 a	1.56	12.64 b
T_3	2.86 c	20.20 c	14.50 b	1.53	10.49 c
$LSD_{(0.05)}$	**0.23**	**0.19**	**0.22**	**0.11**	**0.64**
Varieties					
V_1	4.22 a	25.67 a	19.50 a	1.52 b	13.41 a
V_2	4.09 a	25.00 b	18.17 b	1.49 b	13.23 a
V_3	3.77 bc	20.33 d	11.75 d	1.73 a	11.19 c
V_4	3.97 ab	21.33 c	12.83 c	1.52 b	12.18 b
V_5	3.52 c	20.00 e	11.50 d	1.44 b	10.82 c
$LSD_{(0.05)}$	**0.30**	**0.24**	**0.28**	**0.14**	**0.82**
CV (%)	**7.89**	**1.10**	**1.98**	**9.49**	**7.49**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

In the term of number of fruit plant^{-1}, among the variety was estimated and the highest value was found from the variety V_1 (25.67) which was followed by V_2 (25.00) and V_4 (21.33) varieties and the minimum number of fruit plant^{-1}from V_5 (20.00) variety which was followed by V_3 (20.33) variety.

In consider of Single fruit weight (g), among the variety was estimated and the highest value was found from the variety V_1 (13.41 g) which was followed by V_2 (13.23 g) and V_4 (12.18 g) varieties and the minimum number of fruit plant^{-1}from V_5 (10.82) variety which was followed by V_3 (11.19) variety.

4.1.5.3 Interaction effect

Significant variation was observed in number of branch plant^{-1}, number of fruit plant^{-1}, fruit length (cm), fruit girth (cm) and Single fruit weight (g) at total growing period for the intensity of infestation and management practices of okra shoot and fruit borer on different varieties of okra (Table 10).

In the term of number of branch plant^{-1}, among the combination value was estimated and the highest value was found from the combination T_1V_1 (5.25) and the minimum value from T_3V_5 (2.35) combination.

In the term of number of fruit plant^{-1}, among the combination value was estimated and the highest value was found from the combination T_1V_1 (30) and the minimum value from T_3V_5 (18) combination.

In consider of fruit length (cm) and fruit girth (cm), among the combination value was estimated and the highest value was found from the combination T_1V_1 (20 and 1.5) and the minimum value from T_3V_5 (12 and 1.4) combination.

In consider of Single fruit weight (g), among the combination value was estimated and the highest value was found from the combination T_1V_1 (14.55 g) and the minimum value from T_3V_5 (8.25 g) combination.

Table10. Interaction effect of intensity of infestation and management practices on yield Contributing Characters at different growing stages

Treatments combination	No. of branch plant^{-1}	No. of fruit Plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Single fruit weight (g)
T_1V_1	5.25 a	30 a	20 a	1.5 b-c	14.55 a
T_1V_2	5.12 a	28 b	18 e	1.48 cd	14.21 a
T_1V_3	4.45bc	21 g	11.75 hi	1.75 a	12.1 c-e
T_1V_4	4.90 ab	23 e	13 f	1.5 b-c	13.21 a-c
T_1V_5	4.28 cd	21 g	11.5i	1.45 d	12.75 b-d
T_2V_1	4.25 cd	25 d	19 c	1.55 a-d	14.15 ab
T_2V_2	4.15 cd	26 c	18.5 d	1.50 b-d	14.02 ab
T_2V_3	4.02 cd	20 h	11.5i	1.70 a-c	11.5ef
T_2V_4	4.08 cd	21 g	12.5 g	1.56 a-d	12.35 c-e
T_2V_5	3.92 d	21 g	11 j	1.48 cd	11.45 d-f
T_3V_1	3.15 e	22 f	19.5 b	1.52 a-d	11.52 d-f
T_3V_2	3.02 e	21 g	18 e	1.5 b-d	11.45 d-f
T_3V_3	2.85ef	20 h	12 h	1.74 ab	10.25 f
T_3V_4	2.95 e	20 h	13 f	1.5 b-d	11ef
T_3V_5	2.35 f	18i	12 h	1.4 d	8.25 g
$LSD_{(0.05)}$	**0.52**	**0.41**	**0.49**	**0.24**	**1.42**
CV (%)	**7.89**	**1.10**	**1.98**	**9.49**	**7.49**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.6 Yield of okra

4.1.6.1 Effect of management practices

Significant variation was observed in yield (kg/plot), Yield (ton/ha) total growing period for the intensity of infestation and management practices of okra shoot and fruit borer on different varieties of okra (Table 11).

In the term of yield (kg/plot), among the treatment Imidacloprid (T_1) showed significantly the highest number of yield (kg/plot) (8.04) which was statistically different from Neem oil (T_2). Significantly the least yield (kg/plot) (4.76) was found in untreated control treatment (T_3).

In the term of yield (ton/ha), among the treatment Imidacloprid (T_1) showed significantly the highest yield (ton/ha) (16.07) which was statistically different from Neem oil (T_2). Significantly the least yield (ton/ha) (9.52) was found in T_3 untreated control treatment (T_3).

Yield (ton/ha) increase over control in management practices was estimated and the highest value was found from the treatment T_1 (68.75%) and the minimum increase over control from T_2 (44.23%) treatment.

4.1.6.2 Effect of Variety

Significant variation was observed in yield (kg/plot), Yield (ton/ha) total growing period for the intensity of infestation and sustainable management of okra pod borer on different varieties of okra (Table 11).

In the term of yield (kg/plot), among the variety was estimated and the highest value was found from the variety V_1 (7.35) which was followed by V_2 (7.22) and V_4 (6.43) varieties and the minimum number of fruit plant^{-1}from V_5 (5.61) variety which was followed by V_3 (6.17) variety.

In the term of yield (ha/ton), among the variety was estimated and the highest value was found from the variety V_1 (14.70) which was followed by V_2 (14.45) and V_4 (12.86) varieties and the minimum number of fruit plant^{-1}from V_5 (11.21) variety which was followed by V_3 (12.33) variety.

Yield (ton/ha) increase over control in variety was estimated and the highest value was found from the variety V_1 (31.13%) which was followed by V_2 (28.90%) and V_4 (14.72%) varieties and the minimum increase over control from V_3 (9.99%) variety.

Table 11. Effect of management practices and variety on yield Contributing Characters at different growing stages

Treatments	**Yield Contributing Characters**		
	Yield (kg/plot)	**Yield (ton/ha)**	**% Increase yield over control**
T_1	8.04	16.07 a	68.75
T_2	6.89	13.74 b	44.23
T_3	4.76	9.52 c	--
$LSD_{(0.05)}$	**0.35**	**0.76**	**--**
Varieties			
V_1	7.35 a	14.70 a	31.13
V_2	7.22 a	14.45 a	28.90
V_3	6.17 b	12.33 b	9.99
V_4	6.43 b	12.86 b	14.72
V_5	5.61 c	11.21 c	--
$LSD_{(0.05)}$	**0.45**	**0.98**	**--**
CV (%)	**7.04**	**7.70**	**--**

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.1.6.3 Interaction effect

Significant variation was observed in yield (kg/plot), Yield (ton/ha) total growing period for the intensity of infestation and management practices of okra shoot and fruit borer on different varieties of okra (Table 12).

In the term of number of Yield (ton/ha), among the combination value was estimated and the highest value was found from the combination T_1V_1 (9.52) and the minimum value from T_3V_5 (3.68) combination.

Yield (ton/ha) increase over control in sustainable management was estimated and the highest value was found from the combination T_1V_1 (158.70%) and the minimum increase over control from T_3V_5 (33.42%) treatment.

Table12. Interaction effect of intensity of infestation and management practices on yield Contributing Characters at different growing stages

Treatments combination	Yield (kg/plot)	Yield (ton/ha)	% increase yield over control
T_1V_1	9.52 a	19.04 a	158.70
T_1V_2	9.44 a	18.88 a	156.52
T_1V_3	7.40 b	14.8 b	101.09
T_1V_4	7.43 b	14.86 b	101.90
T_1V_5	6.39 cd	12.78 cd	73.64
T_2V_1	7.28 b	14.56 b	97.83
T_2V_2	7.21 b	14.42 bc	95.92
T_2V_3	6.98 bc	13.96 bc	89.67
T_2V_4	6.12 d	12.24 d	66.30
T_2V_5	6.75 b-d	13.5 b-d	83.42
T_3V_1	5.25 e	10.5 e	42.66
T_3V_2	5.02 e	10.04 e	36.41
T_3V_3	4.91 e	9.82 e	33.42
T_3V_4	4.95 e	9.9 e	34.51
T_3V_5	3.68 f	7.36 f	--
$LSD_{(0.05)}$	**0.77**	**1.69**	--
CV (%)	**7.04**	**7.70**	--

[T_1 = Imidacloprid @1.5 ml/L at 15 days interval; T_2 = Spraying Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

[V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika]

4.2. Interaction with percentage of shoot infestation and yield of okra

4.2.1. In case of different treatments

Correlation between percentage of shoot infestation due to treatments and yield (t/ha) of okra. It was revealed that significant correlation was observed between the percentage of shoot infestation and yield of okra (Figure 1). Results evident from that the regression equation y = -0.5832x + 16.747 and the co-efficient of determination (R^2 = 0.9852) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the percentage of shoot infestation and yield of okra, i.e., the yield decreased with the increase of the percentage of shoot infestation of okra in case of the performance of different treatments.

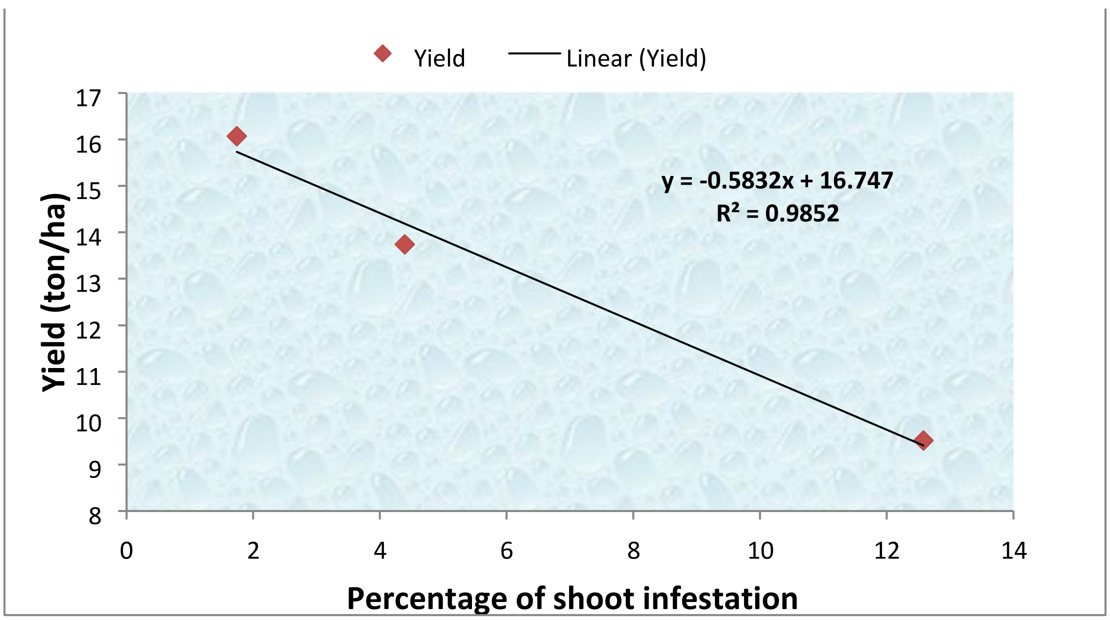

Figure 1: Correlation between the percentage of shoot infestation due to treatments and yield of okra

4.2.2. In case of varieties

Correlation between percentage of shoot infestation due to varieties and yield (t/ha) of okra. It was revealed that significant correlation was observed between the percentage of shoot infestation and yield of okra (Figure 2). Results evident from the Figure 2 that the regression equation y = -1.0324x + 19.55 and the co-efficient of determination (R^2 = 0.9462) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the percentage of shoot infestation and yield of okra, i.e., the yield decreased with the increase of the percentage of shoot infestation of okra in case of varietals performance.

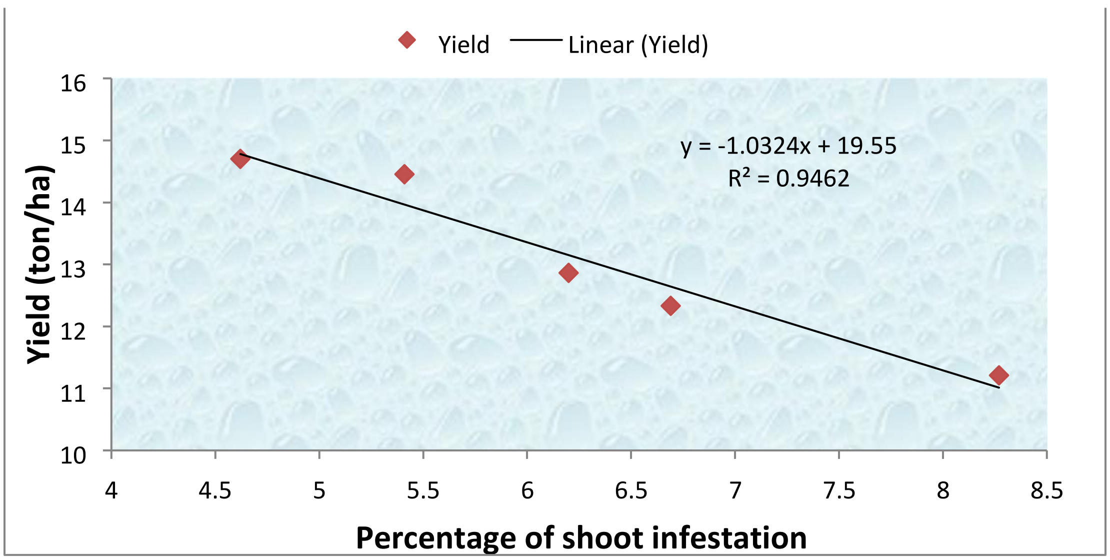

Figure 2: Correlation between the percentage of shoot infestation due to varieties and yield of okra

4.2.3. In case of combination of varieties and treatments

Correlation between percentage of shoot infestation due to treatments and varieties and yield (t/ha) of okra. It was revealed that significant correlation was observed between percentage of shoot infestation and yield of okra (Figure 3). Results evident from the Figure 3 that the regression equation y = -0.5943x + 16.822 and the coefficient of determination ($R^2 = 0.8207$) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the percentage of shoot infestation and yield of okra, i.e., the yield decreased with the increase of the percentage of shoot infestation okra in case of the combination of varieties and treatments.

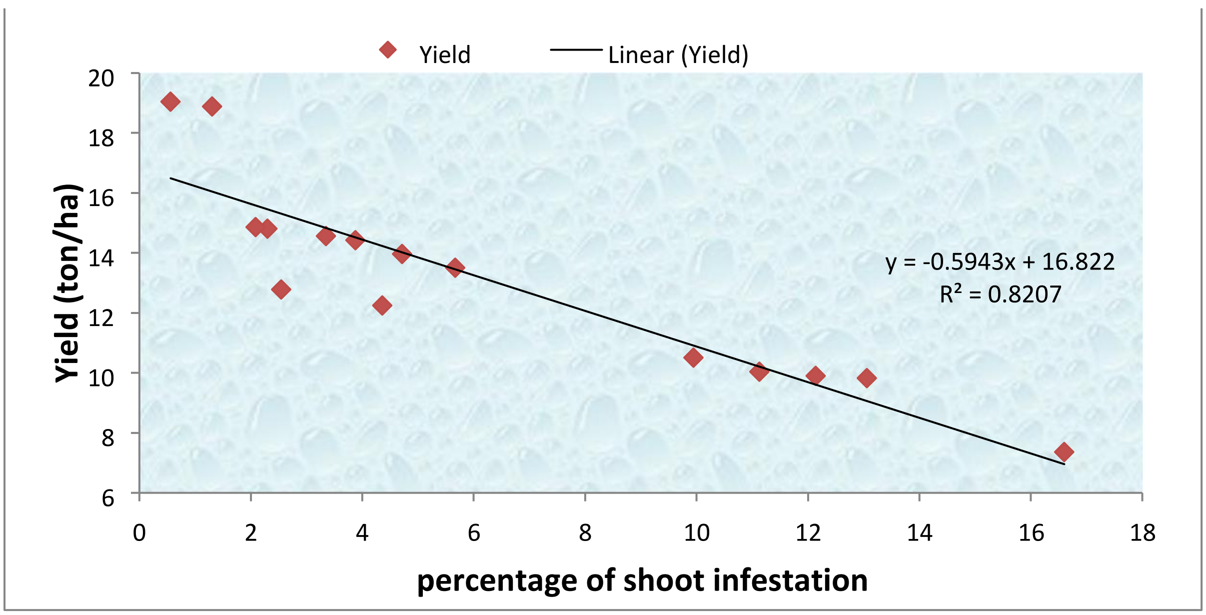

Figure 3: Correlation between the percentage of shoot infestation due to varieties and treatments and yield of okra

4.3. Interaction with percentage of healthy fruit and yield of okra

4.3.1. In case of different treatments

Correlation between percentage of healthy fruit due to treatments and yield (t/ha) of okra. It was revealed that significant correlation was observed between the percentage of healthy fruit and yield of okra (Figure 4). Results evident from the Figure 4 that the regression equation y = 0.2543x - 5.8112 and the co-efficient of determination (R^2 = 0.9999) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a positive relationship between the percentage of healthy fruit and yield of okra, i.e., the yield decreased with the increase of the percentage of healthy fruit of okra in case of the performance of different treatments.

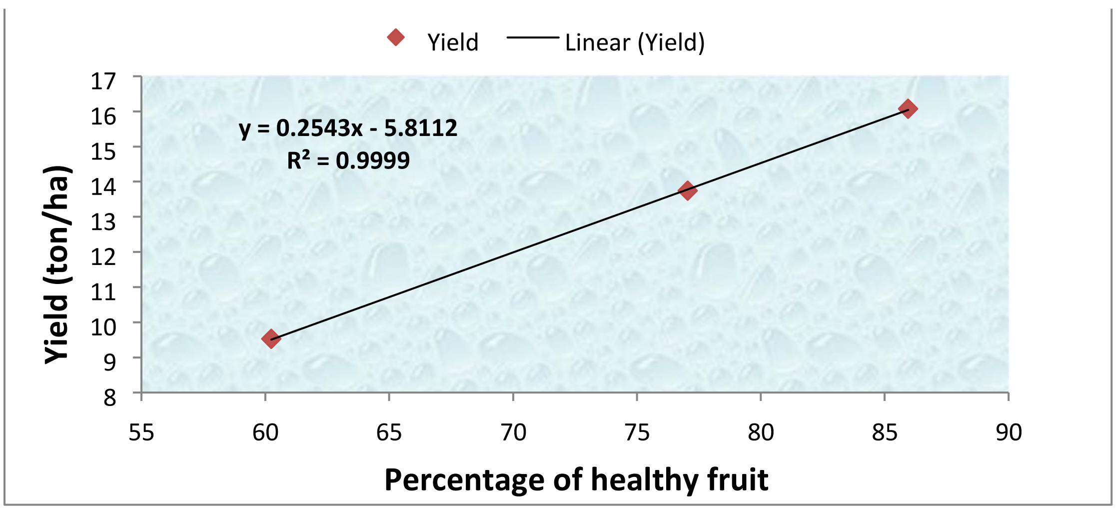

Figure 4: Correlation between the percentage of healthy fruit due to treatments and yield of okra

4.3.2. In case of varieties

Correlation study was done to establish the relationship between percentage of healthy fruit and yield (t/ha) of okra in case of varietals performance. From the study it was revealed that significant correlation was observed between the percentage of healthy fruit and yield of okra (Figure 5). It was evident from the Figure 5 that the regression equation y = 0.311x - 10.035 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9523) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a positive relationship between the percentage of healthy fruit and yield of okra, i.e., the yield decreased with the increase of the percentage of healthy fruit of okra in case of varietals performance.

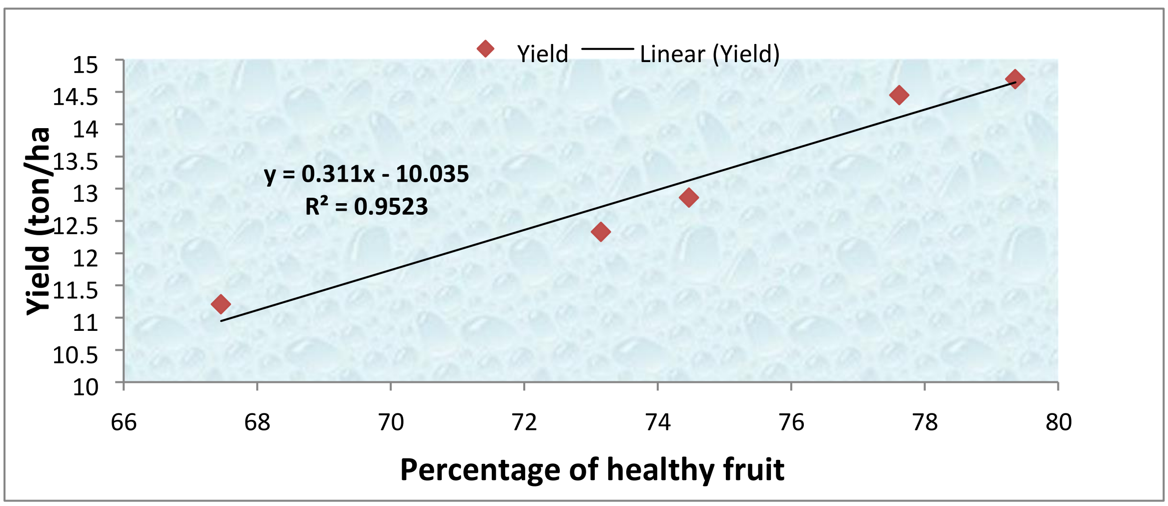

Figure 5: Correlation between the percentage of healthy fruit due to varieties and yield of okra

4.3.3. In case of combination of varieties and treatments

Correlation between percentage of healthy fruit due to varieties and treatments and yield (t/ha) of okra. Results revealed that significant correlation was observed between the percentage of healthy fruit and yield of okra (Figure 6). It was evident from the Figure 6 that the regression equation y = 0.2452x - 5.1385 and the co-efficient of determination (R^2 = 0.8268) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a positive relationship between the percentage of healthy fruit and yield of okra, i.e., the yield decreased with the increase of the percentage of healthy fruit okra in case of the combination of varieties and treatments.

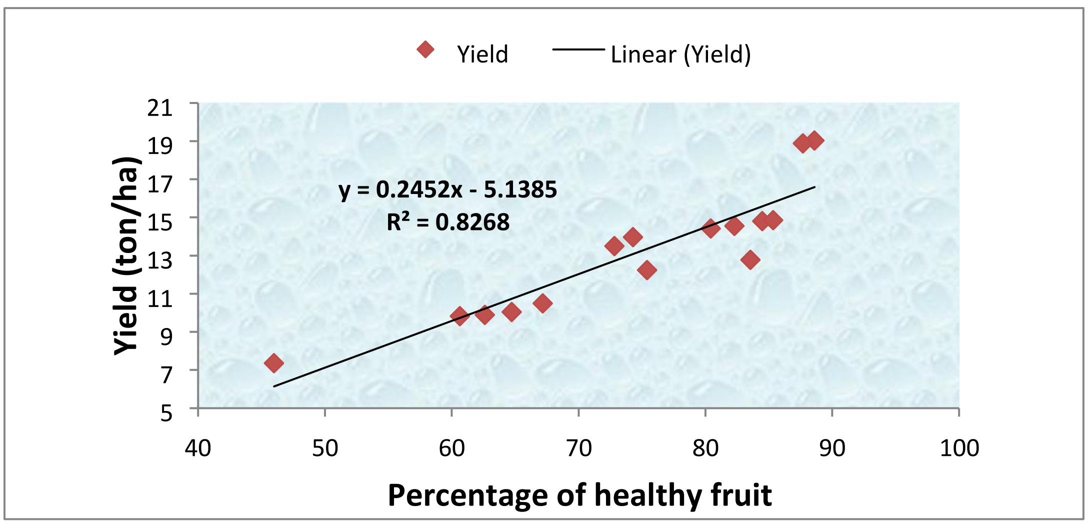

Figure 6: Correlation between the percentage of healthy fruit due to varieties and treatments and yield of okra

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Present study was conducted to investigate insect pest infestation status in "Intensity of infestation and eco-safe management practices against okra shoot and fruit borer in different varieties of okra". Study revealed that incidence of insect pests was found during the study period in the experimental field. The experiment consists of control measures and plant extract varietals combination.

Results showed that the significant variations were observed among different stage okra in term of percentage of shoot infestation, percentage of fruit infestation, percentage of healthy fruit, fruit infestation plot^{-1}(g) on weight basis, yield contributing characters and yield (t/ha) of okra.

In case of varieties: In term of percentage of shoot infestation, among the varieties BARI Dheros-1 (V_1) showed significantly the least shoot infestation which was statistically different from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the highest shoot infestation percentage was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

In term of percentage of fruit infestation, among the varieties BARI Dheros-1 (V_1) showed significantly the least fruit infestation which was statistically different from BARI Dheros2 (V_2) and following by Green finger (V_4) varieties. Significantly the highest fruit infestation percentage was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

In term of percentage of healthy fruit, among the varieties BARI Dheros-1 (V_1) showed significantly the maximum healthy fruit percentage which was statistically similar from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the minimum healthy fruit percentage was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

In term of percentage of fruit infestation plot^{-1} in weight basis, among the varieties BARI Dheros-1 (V_1) showed significantly the least fruit infestation plot^{-1} in weight basis percentage which was statistically different from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the highest fruit infestation plot^{-1} in weight basis was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

In the term of number of fruit plant^{-1}, among the variety was estimated and the highest value was found from the variety V_1 (25.67) which was followed by V_2(25.00) and V_4 (21.33) varieties and the minimum number of fruit plant^{-1}from V_5 (20.00) variety which was followed by V_3 (20.33) variety.

In consider of Single fruit weight (g), among the variety was estimated and the highest value was found from the variety V_1 (13.41 g) which was followed by V_2 (13.23 g) and V_4 (12.18 g) varieties and the minimum number of fruit plant^{-1}from V_5 (10.82) variety which was followed by V_3 (11.19) variety.

In the term of yield (kg/plot), among the treatment Imidacloprid (T_1) showed significantly the highest number of yield (kg/plot) (8.04) which was statistically different from Neem oil (T_2). Significantly the least yield (kg/plot) (4.76) was found in Control (Without pesticide) (T_3) treatment.

In the term of yield (ton/ha), among the treatment Imidacloprid (T_1) showed significantly the highest yield (ton/ha) (16.07) which was statistically different from Neem oil (T_2). Significantly the least yield (ton/ha) (9.52) was found in untreated control T_3 treatment (Without insecticide).

In case of management practices: In term of percentage of shoot infestation, among the treatment Imidacloprid (T_1) showed significantly the lowest shoot infestation percentage which was statistically different from Neem oil (T_2). Significantly the highest shoot infestation percentage was found in untreated control T_3 treatment (Without insecticide).

In term of percentage of fruit infestation, among the treatment Imidacloprid (T_1) showed significantly the minimum fruit infestation percentage which was statistically different from Neem oil (T_2). Significantly the maximum fruit infestation percentage was found in untreated control T_3 treatment (Without insecticide).

In term of percentage of healthy fruit, among the treatment Imidacloprid (T_1) showed significantly the maximum healthy fruit percentage which was statistically different from Neem oil (T_2). Significantly the minimum healthy fruit percentage was found in untreated control T_3 treatment (Without insecticide).

In term of percentage of fruit infestation plot^{-1} in weight basis, among the treatment Imidacloprid (T_1) showed significantly the minimum fruit infestation plot^{-1} in weight basis which was statistically different from Neem oil (T_2). Significantly the maximum fruit infestation plot^{-1} in weight basis was found in Control (Without pesticide) (T_3) treatment.

In the term of number of branch plant^{-1}, among the treatment Imidacloprid (T_1) showed significantly the highest number of branch plant^{-1} (4.80) which was statistically different from Neem oil (T_2). Significantly the least number of branch plant^{-1} (2.86) was found in untreated control T_3 treatment (Without insecticide).

In the term of number of fruit plant^{-1}, among the treatment Imidacloprid (T_1) showed significantly the highest number of branch plant^{-1} (24.60) which was statistically different from Neem oil (T_2). Significantly the least number of fruit plant^{-1} (20.20) was found in untreated control T_3 treatment (Without insecticide).

In consider of fruit length (cm) and fruit girth (cm), among the treatment Imidacloprid (T_1) showed significantly the highest number of branch plant^{-1} (14.90 and 1.54) which was statistically similar from Neem oil (T_2). Significantly the least fruit length (cm) and fruit girth (cm) (14.50 and 1.53) was found in Control (Without pesticide) (T_3) treatment.

In consider of Single fruit weight (g), among the treatment Imidacloprid (T_1) showed significantly the highest single fruit weight (13.36 g) which was statistically different from Neem oil (T_2). Significantly the least single fruit weight (10.49 g) was found in untreated control T_3 treatment (Without insecticide).

In the term of yield (kg/plot), among the treatment Imidacloprid (T_1) showed significantly the highest number of yield (kg/plot) (8.04) which was statistically different from Neem oil (T_2). Significantly the least yield (kg/plot) (4.76) was found in untreated control T_3 treatment (Without insecticide).

In the term of yield (ton/ha), among the treatment Imidacloprid (T_1) showed significantly the highest yield (ton/ha) (16.07) which was statistically different from Neem oil (T_2). Significantly the least yield (ton/ha) (9.52) was found in Control (Without pesticide) (T_3) treatment.

In case of interaction effect: In term of percentage of shoot infestation, the infestation rate was much higher in the vegetative stage of growing period. After that the increasing rate was much slower up to late fruiting stage. However, the least percentage of shoot infestation was found in the treatment combination T_1V_1 which was statistically different from all other treatments. The highest percentage of shoot infestation was obtained from the treatment combination of T_3V_5.

In term of percentage of fruit infestation, the infestation rate was slower in the early fruiting stage of growing period. After that the increasing rate was little bit increase up to late fruiting stage. However, the least percentage of fruit infestation was found in the treatment combination T_1V_1 which was statistically different from all other treatments.

The highest percentage of fruit infestation was obtained from the treatment combination of T_3V_5.

In term of percentage of healthy fruit, the infestation rate was increase in the early fruiting stage of growing period. After that the increasing rate was little bit slower up to late fruiting stage. However, the highest percentage of healthy fruit was found in the treatment combination T_1V_1 which was statistically different from all other treatments. The lowest percentage of healthy was obtained from the treatment combination of T_3V_5.

In term of percentage of fruit infestation plot^{-1} in weight basis, the infestation rate was slower in the early fruiting stage of growing period. After that the increasing rate was little bit increase up to late fruiting stage. However, the least percentage of fruit infestation was found in the treatment combination T_1V_1 which was statistically different from all other treatments. The highest percentage of fruit infestation was obtained from the treatment combination of T_3V_5.

In the term of number of branch plant^{-1}, among the combination value was estimated and the highest value was found from the combination T_1V_1 (5.25) and the minimum value from T_3V_5 (2.35) combination.

In the term of number of fruit plant^{-1}, among the combination value was estimated and the highest value was found from the combination T_1V_1 (30) and the minimum value from T_3V_5 (18) combination.

In consider of fruit length (cm) and fruit girth (cm), among the combination value was estimated and the highest value was found from the combination T_1V_1 (20 and 1.5) and the minimum value from T_3V_5 (12 and 1.4) combination.

In consider of Single fruit weight (g), among the combination value was estimated and the highest value was found from the combination T_1V_1 (14.55 g) and the minimum value from T_3V_5 (8.25 g) combination.

In the term of number of Yield (ton/ha), among the combination value was estimated and the highest value was found from the combination T_1V_1 (9.52) and the minimum value from T_3V_5 (3.68) combination.

CONCLUSION

From the above result it can be concluded that in terms of overall performance, the variety BARI Dheros-1 (V_1) performed the highest healthy fruit yield whereas the highest total yield was found from BARI Dheros-1 (V_1) which was statistically close to BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. So, comparing insect infestation status, Arko anamika (V_5) may be considered as the lowest and BARI Dheros-1 (V_1) as the best among the experimental okra varieties. Also treatment Imidacloprid (T_1) and combination T_1V_1 showed best performance.

RECOMMENDATION

However, from this experiment following are some important recommendations-

- Experiment should be repeated for confirmation the activity of the major pests in other regions of Bangladesh to reach conclusion.
- Further trials should be carried out in consecutive years.

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