INCIDENCE OF MAJOR INSECT PESTS OF OKRA AND THEIR MANAGEMENT

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INCIDENCE OF MAJOR INSECT PESTS OF OKRA AND THEIR MANAGEMENT

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CERTIFICATE

This is to certify that thesis entitled ***"INCIDENCE OF MAJOR INSECT PEST OF OKRA AND THEIR MANAGEMENT"*** *submitted to the* ***Faculty of Agriculture,*** *Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) IN ENTOMOLOGY,*** *embodies the result of a piece of bona fide research work carried out by* ***JANNATUL FERDUS, Registration no. 16-07572*** *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.

Dated: December, 2017
Place: Dhaka, Bangladesh

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ABSTRACT

The experiment was conducted in the field of Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during October 2017 to January 2018. The experiment consists of eight treatments such as T_1= Actara 25 WG @ 1g/Litre of water sprayed; T_2= Neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed; T_3= Water based neem seed kernel extract @ 5g/Litre of water sprayed; T_4= Bioneem plus 1.0EC @ 1ml/Litre of water sprayed; T_5= Ostad 10 EC @ 2ml/Litre of water sprayed; T_6= Sevin 85 WP @ 1.2g/ Litre of water sprayed; T_7= Marshal 100EC @ 1.5ml/ Litre of water sprayed; T_8=Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The result indicates that Actara 25 WG (T_1) treatment decreased the incidence of insect pests of okra compared to other treatments. The highest reduction over control caused by jassid (78.34%), whitefly (86.73%), okra shoot and fruit borer for shoot (100%) as well as for fruit (100%), aphid (91.92%), mealybug (92.72%) in T_1 treatment. In case of leaf infestation, the lowest percent leaf infestation was caused by whitefly (47.92%), jassid (47.35%) in T_1 treatment. Beside this, natural enemies also observed in the research field such as, the highest lady bird beetle (5.33), staphylinid beetle (5.00), spider (4.67), ant (3.67), ground beetle (3.00) were recorded in T_8 treatment and the lowest lady bird beetle (1.00), staphylinid beetle (1.00), spider (1.00), ant (1.00), ground beetle (1.33) were recorded in T_1 treatment during the study period . The highest okra yield (3.86 ton/ha) was produced in T_1 treatment. These findings illustrated that, the Actara 25 WG ($T_{1)}$ treatment was more effective for the reduction of incidence of major insect pests of okra.

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CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is one of the most common summer vegetables grown in Bangladesh. It is also known as lady's finger and locally called "*Dharos*" or “*Vendi*” which belongs to the family Malvaceae. It is an economically important vegetable grown in tropical and sub-tropical parts of the world (Saifullah and Rabbani, 2009; Arapitsas, 2008). Though okra is produced mainly in the Kharif season it is cultivated even in dry areas and almost available throughout the year (Rashid, 1999, Norman, 1992) for favourable climatic conditions (Memon *et al.,* 2004). Total production of okra was about 44000 metric tons from 26000 acres of land in Bangladesh with an average yield of nearly 4.6 t/ha in the year 2012-2013 (BBS, 2013), which is much lower in compare with the yield ranges from 7-12 t/ha in the developed countries (Yamaguchi, 1998).

Lady’s finger plays an important role to meet the demand of vegetables of the country when vegetables are scanty in the market (Ahmed, 2011 and Rashid, 1999). Okra contains carbohydrate, proteins and vitamin C in large quantities (Dilruba *et al*., 2009), and plays a vital role in human diet (Saifullah and Rabbani, 2009; Kahlon *et al*., 2007). The immature pods are the edible part of this plant and are consumed as a vegetable. Fruits can be boiled, fried or cooked (Akintoye *et al*., 2011). Due to its high iodine contents, the “okra” fruit is considered to be useful for the control of goiter.

Okra production in Bangladesh is affected by many factors, among them insect pest and diseases are the major. Okra is susceptible to the attack of various insects from seedling to fruiting stage such as okra shoot and fruit borer, okra jassid, cut worm, white fly, aphids, mealybug, red cotton bug etc. Among the insect pests, whitefly, *Bemisia tabaci*, shoot and fruit borer (SFB), *Earias vittella* F. jassid, *Amrasca biguttula biguttula,* mealybug, *Ferrisia virgata* are the most serious.

The nymphs and adults of Jassid suck sap usually from the under surface of the leaves and inject toxins causing curling of leaf edges and leaves turn red or brown called as 'Hopper Burn' (Patel and Patel 1996). The yield loss due to jassid desapping in okra amounts to 54 to 66% (Satpathy *et al*., 2004). Similarly, nymphs and adults of whitefly suck the sap usually from the under surface of the leaves and excrete honeydew. Leaves appear sickly and get coated with sooty mold (Jayaraj *et al.,* 1986). Apart from their direct damage by sucking plant sap, it is also known as the vector for deadly 'yellow vein mosaic virus'. It was estimated that if insecticidal umbrella was not provided, there would be a net yield loss of 54.04 to 76% (Hafeez and Rizvi, 1994 and Choudhary and Dadheech, 1989). Okra shoot and fruit borer larvae cause damage both in vegetative and reproductive phase of the crop. It is reported that about 69% losses in marketable yield due to attack of this insect pest.In Bangladesh okra sucking pest likely aphid and mealybug severely attack the leaves of okra and reduce the yield of okra.

Management practices of aphid on okra in Bangladesh and other countries are still limited to frequent spray of toxic chemical pesticides (Rathod *et al*. 2002, Chitra et al., 1997, Patel *et al*., 1996, Iyyappa 1994, Patil *et al*., 1990 Deshmukh and Barle 1976). Beside the chemical; plant product mixed with animal product is used to reduce the aphid (Ukey *et al*. 1999). Jassid population including adult and nymph may also be reduced through use of plant materials (Natarajan *et al.*, 2000, Rosaiah (2001**a**). Whitefly and mealybug population was also reduced through chemical insecticide as well as plant materials (Tatagar 2002, Chandrashekharappa 1995, Ahmad *et al.* 1995, Gopali 1992, Nandihalli *et al.* 1990, Jayaraj *et al.* 1986). Various control strategies have been adopted against these insect pest, one common method being the use of synthetic insecticides, which can be environmentally disruptive and can result in the accumulation of residues in the harvested produce creating health hazards (Chinniah *et al*. 1998).

Farmers always desire quick curative action for controlling pests. Since no other control measure against okra sucking pests is available, chemical insecticides have remained as the most powerful tools for controlling this pest. Insecticides are highly effective, rapid in curative action, adaptable to most situations and relatively economical. Insecticides are the only tool for pest management which is reliable for emergency action when insect pest population approach or exceed the economic threshold level (Parkash, 1988).

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

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

- To know the infestation level of major insect pests in okra;
- To evaluate the effectiveness of some selected synthetic insecticides and botanical product against different major insect pests;
- To show the relationship among different infestation parameters of yields attributes and yield of okra.

CHAPTER II

REVIEW OF LITERATURE

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

Table 1. List of major insect pests of okra

Common name	**Scientific Name**	**Order**	**Family**	**Crop growth stage**
Jassid	*Amrasca biguttula biguttula*	Homoptera	Cicadellidae	Flowering initiation-fruiting
Whitefly	*Bemisia tabaci*	Homoptera	Aleyrodidae	Peak vegetative-fruiting
Okra shoot and fruit borer	*Earias vittella*	Lepidoptera	Noctuidae	Peak vegetative-fruiting
Aphid	*Aphis gossypii*	Homoptera	Aphididae	Fruiting
Mealybug	*Ferrisia virgate*	Homoptera	Pseudococcidae	Flowering initiation-fruiting

2.1 Jassid

2.1.1 Biology of jassid

Curved, greenish-yellow eggs (0.7-0.9 × 0.15-0.2 mm) are laid deeply embedded in the midrib or a large vein on the either surface of the leaf or in a petiole or young stem but never in the leaf lamina. Depending on species, 29-60 eggs can be laid singly and they hatch in 4-11 days (Sharma, 1997). Nymphs are pale green, wedge-shaped, 0.5-2.0 mm long, having carb like sideways movement characteristics when disturbed (Kochhar, 1986). They are confined to the under surface of leaves during the daytime,but can be found anywhere on the leaves at night (Evans, 1965). The nypmphal period can vary from 2 to 21 days depending on food supplies and temperature (Hussain *et al.*, 1979). A generation likes 3-4 weeks in the summer Amrasca devastans is estimated to have 11 generations in a year in India (Iqbal, 2008). Adults are small, elongate and wedge-shaped, about 2.5 mm long, semitransparent plae green body, shimmering wings, very active, having a sideways walk like the nymphs, but quick to hop and fly when disturbed. (Singh *et al.*, 2003; Kakar and Dobra1988). They have a life span of up to 2 months (Evans, 1965).

2.1.2 Incidence of jassid

Singh *et al.* (2013) recorded that the incidence of leafhopper commenced from 2nd week after sowing i.e. the fourth week of August. Thereafter the peak pest population was recorded during the fourth week of September.

Boopathi *et al.* (2011) observed that the incidence of A. biguttula biguttula was active from last week of May to till the final harvest i.e. first week of August. The peak level of incidence was noticed during first week of July.

Anitha and Nandihalli (2008) revealed that population of leafhopper on Kharif crop started appearing from first week of August, 2006. Peak incidence of leafhopper was noticed during last week of October, 2006.

2.1.3 Management of jassid

2.1.3.1 Management by botanicals

Karn Adilakshmi *et al.* (2008) reported that NSKE (5%) registered minimum population of leafhopper over all other neem based botanical insecticides like Neemazal T/S (1%), Neemazal F (5%), Niconeem (0.03%), Neemol (0.03%) and Neem oil and chemical as endosulfon and Control. Fruit yield was also relatively more in NSKE (5%) treated plot.

Shabozoi *et al.* (2011) reported the minimum mean population of jassid (1.65/leaf) was recorded in Biosal or neem oil, whereas the maximum pest population (2.39/leaf) was found in control.

Harischandra Naik *et al.* (2012) revealed that Neemazol @ 3.5%, neem oil @ 2% and NSKE @ 5% were found superior against leafhopper than other botanicals like Vitex negundo leaf extract @ 5%, chilly garlic leaf extract @ 5% and Neemazol + chilly garlic leaf extracts.

2.1.3.2 Management by chemicals

Among the imidacloprid formulations, imidacloprid 17.8 SL at 25 g a.i./ha was found superior against leafhoppers and this was on par with acephate 75 SP, thiamethoxam 25 WG, acetamiprid 20 SP, imidacloprid 17.8 SL at 20 g a.i./ha and imidacloprid 70 WG at 25 g a.i./ha (Honnappagouda *et al.*, 2011).

Sujay Anand *et al.* (2013) reported that the thiamethoxam and acetamiprid resulted in the effective management of leafhopper in okra followed by buprofezin and pymetrozine. Hence these biorationals offers as a good alternative to neonicotinoids. The spiromesifen was very effective in managing the whitefly in okra.

Results showed that imidacloprid @ 2 ml, thiamethoxam and carbosulfan @ 2 g/kg seed were found effective in controlling okra leafhopper (*A. devastans*). Seed yield was higher in thiamethoxam, imidacloprid and carbosulfan treatments. (Rana *et al.,* 2006).

2.2 Whitefly

2.2.1 Biology of whitefly

According to Schmutterer (1969), whiteflies are known to reproduce bisexually or parthenogenetically, and hence numerous generations can occur during the year. Both adults and nymphs suck the plant sap. Eggs are tiny (about 0.2 mm long) and pear-shaped. They stand upright on the leaves, being anchored at the broad end by a short stalk inserted into the leaf. They are laid usually in arcs or circles, on the undersides of young leaves.Hatching occurs after 5-10 days at 30 °C depending on species, temperature and humidity (Martin, 1999). On hatching, the first instar nymph is the only mobile nymphal stage. It moves to a suitable feeding location on the lower leaf surface where it settles.

2.2.2 Incidence of whitefly

Pal *et al.* (2013) studied the incidence of insect pests infesting okra (cv. Indam-9) in Sriniketan, West Bengal, India, during summer (March to June) of 2009. The incidence of whitefly occurred at the early crop periods. The maximum and minimum temperatures, relative humidity, rainfall and sunshine were positively correlated with the incidence of the insect pest.

Hasan *et al*. (2008) conducted a field experiment in Uttar Pradesh, India, in 2005 and 2006, to determine the spatial distribution of *B.tabaci* on different okra cultivars. The results showed significant differences on the pest density at different stages of crop growth i.e. 30, 45 and 60 days after planting. The peak population was recorded on 60 days old crop, while the lowest was on 30 days old crop in 2005 & 2006. Population density was higher (3.2 to 6.7 adult/ leaf) during kharif season 2006 than that in 2005 (2.1 to 4.2 adult/ leaf). *B.tabaci* followed a regular distribution, while aggregated distribution pattern was also recorded when the population was low in 2005.

It causes three types of damage namely direct damage, indirect damage and virus transmission (Berlinger, 1986). Direct damage is caused by piercing and sucking of sap from the foliage of plants. Heavy infestation of adult and their progeny can cause the death of seedling, reduce the plant growth rate and yield due to sap removal. When adult and immature whiteflies feed, they excrete honeydew, a sticky excretory waste that is largely composed of plant sugars. It may also cause leaf chlorosis, leaf withering and premature dropping of leaves that eventually results in plant death. Indirect damage results in the accumulation of honeydew produced by the whiteflies. This honeydew serves as a substrate for growth of black sooty mould on leaves and fruiting bodies. The mould reduces photosynthesis and lessens the value of the plant or yields rendering them unmarketable (Berlinger, 1986). The third type of damage is caused by vectoring of plant viruses by the whitefly. It is considered as the most common and important vector of plant viruses worldwide. *B.tabaci* transmits plant viruses of seven distinct virus groups including: geminiviruses, oviruses, carlaviruses, potyviruses, nepoviruses, loteoviruses and DNA-containing rod-shaped viruses (Duffus, 1996).

2.2.3 Management of whitefly

2.2.3.1 Management by botanicals

Adilakshmi *et al.* (2008) reported that NSKE (5%) registered minimum population of whitefly over all other neem based botanical insecticides like Neemazal T/S (1%), Neemazal F (5%), Niconeem (0.03%), Neemol (0.03%) and Neem oil and chemical as endosulfon and Control. Fruit yield was also relatively more in NSKE (5%) treated plot.

Harischandra Naik *et al.* (2012) revealed that Neemazol @ 3.5%, neem oil @ 2% and NSKE @ 5% were found superior against whiteflies than other botanicals like Vitex negundo leaf extract @ 5%, chilly garlic leaf extract @ 5% and Neemazol + chilly garlic leaf extracts.

Harischandra *et al*., 2012. Performance of botanical and fungal formulation for pest management in organic okra production system. Journal of Biopesticides, 5 (Supplementary): 12-16.

Adilakshmi, *et al.,* 2008. Bio- efficacy of some botanical insecticides against pests of okra. Karnataka Journal of Agriculture Sciences, 21(2): 290-292.

2.2.3.2 Management by chemical

Raghuraman and Gupta (2005) reported that acetamiprid 40 g a.i/ha and imidaclopird 100 g a.i./ha were the most effective treatments against B. tabaci and 48 and 45% increase in seed cotton yield over control, respectively. They suggested acetamiprid and imidacloprid are good substitute for conventional insecticides in vogue, which could use in formulating a successful management strategy for B. tabaci.

According to Kale *et al.* (2005), seed treatment with thiamethoxam @ 5 g a.i./ha followed by alphamethrin 0.05% spray was the most effective in reducing whitefly populations in okra with higher yield and cost benefit ratio.

2.3 Okra shoot and fruit borer

2.3.1 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.Eggs are laid singly or in small groups on young shoots, underside of the leaves, flower buds or young pods. Depending on the species, 82-378 eggs are laid in each 4-7days and they hatch in 3-4 days in warm weather and 8-9 days under cold weather (Rehman and Ali, 1983). The larvae undergo 4-5 molts. Larval duration varies from 9-

20 days in warm weather and 50-60 days in winter (Rahman and Ali, 1983). The pod borer pupates on top of the soil layer or on the plant, often on dried shoots and pods. The pupal period lasts from a few days to more than months depending upon the climate. The average pupal period being 1-3 weeks (Rehman and Ali, 1983). It has 11 generations in a year. The longest life cycle (49 days) was observed during January while the shortest life cycle (29 days) was found during July (Sharma *et al.*, 1985).

2.3.2 Incidence of okra shoot and fruit borer

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

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

A field experiment was conducted by Sharma *et al*. (2010) to study the fluctuation of pest population of E. vittella Fab. and their relation with prevailing weather condition at Horticulture Farm in Udaipur, India during Kharif 2005 and 2006. The results revealed that borer incidence commenced in the 29th standard week. The peak infestation of plants (91.6 %) was observed in 45th standard week.

2.3.3 Management of okra shoot and fruit borer

2.3.3.1 Management by botanical

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

Antifeedant effect of neem in combination with sweet flag and pangram extracts on okra shoot and fruit borer was studied by the Rao *et al.* (2002) which gave 43.12 to 80.00 percent mortality protection over control. Mudathir and Basedow (2004) found that different preparations of neem significantly reduced okra shoot and fruit borer infestation in okra.

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

Mudathir. M. and Basedow. T. (2004). Field experiments on the effects of neem products on pests and yields of okra *Abelmoschus esculentus* in the Sudan.

2.3.3.2 Management by biological

Biological control agents (spider, ant, lady bird beetle, Orius, myrid bug, Laius, Chrysoperla, Trichogramma etc.), botanicals (neem oil or biosal and tobacco extracts) and microbial control (*Bacillus thuringiensis*) should be integrated for economic management of insect pests (Abro *et al.,* 2004 and Memon *et al.,* 2004; Arora *et al*., 1996).

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

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

2.3.3.3 Management by chemicals

Ramesh and Gupta (2005) studied the effect of spray of different insecticides namely thiodicarp, cartap, diflubenzuron and cypermethrin on okra crop. They observed that cartap exhibit the highest yield, germination percentage and seedling vigour.

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

Bhargava *et al.* (2001) found that endosulfan and quinalphos @ 500 g a.i./ha gave superior protection to fruits of okra against shoot and fruit borer in okra fields.

2.4 Aphid

2.4.1 Biology of aphids

No sexual forms of Aphids species are known in the tropics so reproduction is most probably exclusively parthenogenetic. Many generations occur during the year; only three to five days at 28-30 °C and 10-12 days at 25-28 °C are required to complete the development from the first nymphal instar to the adult. The number of nymphs, which are produced by one female under favourable conditions may reach 150 (Schmutterer, 1969).

2.4.2 Incidence of aphids

Singh *et al.* (2013) reported that the incidence of aphid commenced from fourth week after sowing that is, second week of September. The aphid population gradually increased and reached the peak level during the second week of October. Thereafter declined trend was observed and population of aphid reached its lowest level in third week of November.

Boopathi *et al*. (2011) reported that the incidence of *A. gossypii* commenced from first week of June i.e. seventh week after sowing on all the cultivars. *A. gossypii* population reached the peak infestation level at third week of June i.e., ninth week after sowing.

2.4.3 Management of aphids

2.4.3.1 Management by botanical

Harischandra Naik *et al*. (2012) revealed that Neemazol @ 3.5%, Neem oil @ 2%, NSKE @ 5% was found superior against aphids than other botanicals like Vitex negundo leaf extract @ 5%, chilly garlic leaf extract @ 5% and Neemazol + chilly garlic leaf extracts.

Adilakshmi *et al*. (2008) reported that NSKE (5%) registered minimum population of aphid over all other neem based botanical insecticides like Neemazal T/S (1%), Neemazal F (5%), Niconeem (0.03%), Neemol (0.03%) and Neem oil and chemical as endosulfon and Control. Fruit yield was also relatively more in NSKE (5%) treated plot.

According to Dhanalakshami (2006) among the indigenous materials tested, NSKE + GCK + CU (5.11 aphids/2 leaves) was found to be most effective with 81.25 per cent reduction in okra aphid (A. gossypii) which was followed by GCK + CU + CD (8.94 aphid/2 leaves) and GCK + CU (8.99 aphids/2 leaves).

2.4.3.2 Management by chemical

Wadnekar *et al.* (2004) reported that, mean number of aphid (0.4, 0.83 and 1.17 aphids/leaf after 2, 7 and 14 DAS, respectively) was found to be significantly low in thiamethoxam 25 WG @ 150 g a.i/ha. Thiamethoxam 25 WG @ 100 g and thiamethoxam 25 WG @ 75 g a.i/ha recorded 4.95 and 5.9 aphids per leaf, respectively.

Misra (2002) evaluated some newer insecticides like thiamethoxam (Actra 25 WG), imidacloprid (confider 200 SL) and profenophos + cypermethrin (Rocket 44 EC) along with conventional insecticides like dimethoate (Rogar 30 EC), cypermethrin (super killer 10 EC), profenophos (Curacron 50 EC) against okra aphid, A. gossypii and leafhopper, A. biguttula biguttula. The results revealed that imidacloprid and thiamethoxam, both belonging to nitroguanidine group used @ 25 g a.i/ha proved significantly superior in controlling aphids and leafhoppers on okra compared to other conventional insecticides.

2.5 Mealybug

Reproduction is mostly parthenogenetic but some species such as *M. hirsutus* are bi-parental. The mature female lays eggs in an egg sac of white wax, usually in clusters on the twigs, branches, or bark of the host plant but sometimes on the plant's leaves and terminal ends. Each egg sac may contain as many as 600 eggs, majority of which are female resulting in explosive outbreak. Some species such as *D. brevipes* are ovoviviparous i.e. the eggs hatch within the female and give births live larvae. Egg development takes between 3 and 9 days. Eggs hatch into nymphs called crawlers and are very mobile. In appearance, nymphs of both sexes resemble female adults. There are three nymphal instars in female and four in males which lasts for 22–25 days. The last instar of the male is an inactive stage with wing buds within a cocoon of mealy wax. Individual mealybugs may take as long as 30 days to grow through all the nymphal stages under normal conditions. There may be as many as 15 generations per year.

2.5.1 Incidence of mealybug

Shahid *et al*. (2013) studied the seasonal activity of *Phenacoccus solenopsis* (Tinsley) which revealed that mealy bug remains active throughout the year on various plant species. Its activity was at the peak during the months of August and September. Population of mealy bug was maximum on Verbenaceae and Malvaceae, during the summer but on Euphorbiaceae during winter season. The winter season host plant species and ever green plants served as carryover of *P. solenopsis* to the summer economic crop (*Gossypium hirsutum*).

Jat *et al*. (2014) found maximum population of mealy bug, *P. solenopsis* on tobacco from 4th week of November (47th standard week) and continued up to 3rd week of January (3rd standard week). The population of mealy bug between this period was 236.7 to 235.1 mealy bugs per plant. At this stage the plant vigor and morning relative humidity were suitable for fast multiplication of mealy bugs.

Nalini (2015) studied the field incidence of mealybugs and its parasitization on cotton, sunflower, brinjal, tomato, bhendi, mesta, guava and china rose. The results revealed that incidence of *Phenacoccus solenopsis* incidence was high on *Gossypium hirsutum* (55.10) and *Hibiscus rosa-sinensis* (59.20) during August, 2009. Its parasitoid *Aenasius bambawalei* was recorded with high per cent parasitization on *G. hirsutum* (August, 2008) and *H. rosa-sinensis* (July, 2009).

2.5.2 Management of mealybug

2.5.2.1 Management by botanicals

Tatagar (2002) conducted an experiment to study the efficacy of different plant extracts against leaf curl caused by thrips and mealybug in chilli. The least leaf curl index was found in Vitex leaf extract which was at par with the recommended package. The pod yield obtained from Vitex leaf extract (5%), neem oil (5 ml/l) and recommended package were on par with each other.

Mallapur and Lingappa (2005) evaluated indigenous materials against chilli pests and the results revealed that the least leaf curl index (LCI) against both thrips (0.4 LCI) and mealybug (0.8 LCI) was observed in garlic chilli kerosene extract (0.5%) + nimbecidine. The next best treatments included turmeric + cow urine (2.5%) and GCK (1%) alone. The highest yield was obtained in GCK + nimbecidine treatment followed by insecticide application and GCK alone.

2.5.2.2 Management by chemical

Patel *et al.* (2010) obtained more than 95 per cent reduction in mealy bug population over control after 3 DAS in buprofezin in all the three doses (250, 312.5 and 625 g. a. i. /ha). The efficacy of buprofezin against early and later instar nymphs of *P. solenopsis* under laboratory condition was also found to be dose dependent and it was more toxic to early instars than later instar nymphs. It was most effective against early as well as later instars nymphs at highest dose (625 g a.i/ha). At the two lower doses (250 g a.i/ha and 312.5 g a.i/ha), its effectiveness was comparable to chlorpyriphos 400 g a.i/ha and Carbaryl 1000 g a.i/ha.

Sharma and Kaushak (2010) reported that spinosad 45 SC along with six cheical insecticides viz., emamectin benzoate 5 WSG, cypermethrin 10 EC, quinalphos 25 EC, endosulfan 35 EC, lambda cyhalothrin 5 EC, chlorpyrifos 20 EC was evaluated against and also against natural enemies (Encarsia lutea, C. carnea and ladybird beetles) on eggplant (Cv., BR-112 and plant growth parameters). Spinosad @ 162.5 ml/h was most effective against mealy bug (*P. solenopsis*) but was safe to natural enemies whereas the other chemical insecticides proved toxic to them.

CHAPTER III

MATERIALS AND METHODS

The present study regarding incidence of major insect pests of okra and their management had been conducted during October 2017 to January 2018 in the experimental field of Sher-e-Bangla Agricultural University, Dhaka. Required materials and methodology are described below under the following sub-headings.

3.1 Location

The experiment was conducted in the experimental farm 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 sea level (Anon., 1989).

3.2 Climate

The climate of 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 and presented in Appendix I.

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 are shown in Appendix II.

3.4 Seed collection

The seeds of okra variety BARI Dheros-1 were collected from Kustia seed store, Mirpur, 11, 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 8 plots for 8 treatments each maintaining 3 m x 2 m plot size.Thus the total number of plots was 24. 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.

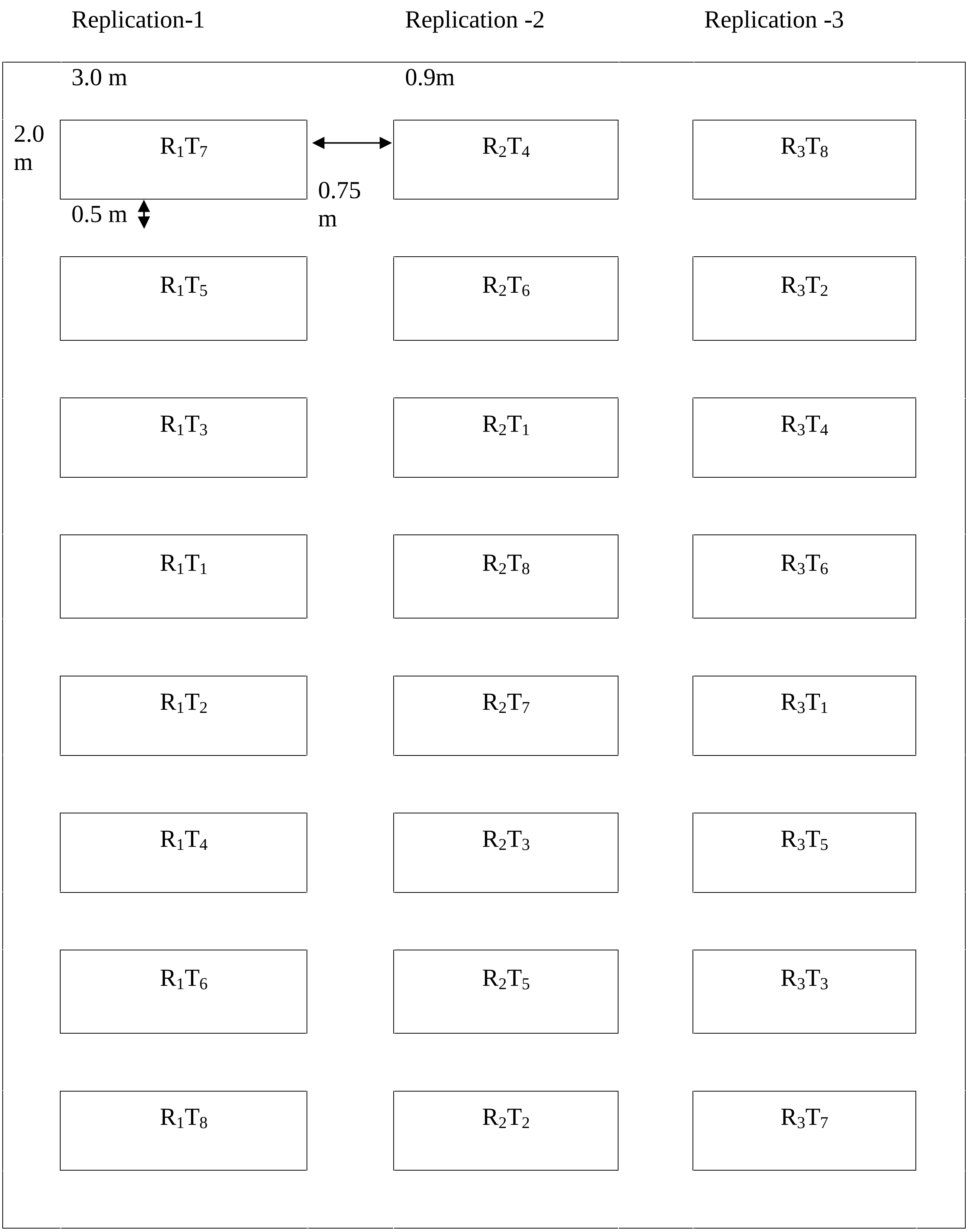

Figure 1. Field lay-out of the experiment

3.6 Land preparation

The experimental plot was opened in the first week of October 2017 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 exprement. 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 5 October, 2017. 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.

Table 2. Doses of manures and fertilizers and their methods of application used for this experiment (Haque, 1993)

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

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

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

3.9 Cultural practices

3.9.1 Gap filling: Dead, injured and weak seedlings were replaced by new vigor okra seedlings which were 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 other seedlings were 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 and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings. When the soil moisture level was very low. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet. 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. Green fruit harvesting was started from 27 November, 2017 and was continued up to January 10, 2018.

3.10 Treatments

Therefore, treatments of this experiment were as follows:

Table 3. List of treatments used in the study

Treatment	Name	Dose
T_1	Actara 25 WG	1g/Litre of water sprayed at 7 days interval
T_2	Neem oil	3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval
T_3	Neem seed kernel extract	10% aquous extract of neem seed kernel
T_4	Bioneem plus 1.0EC	1ml/Litre of water at 7 days interval
T_5	Ostad 10 EC	2ml/Litre of water at 7 days interval
T_6	Sevin 85 WP	1.2g/ Litre of water at 7 days interval
T_7	Marshal 100EC	1.5ml/ Litre of water at 7 days interval
T_8	Untreated control	Only water was sprayed

Plate 1. The experimental plot during the study period

3.11 Preparation of the pesticides used as treatments

3.11.1 Neem oil

For proper management of okra insect pests 3 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 3m x 2m area.

3.11.2 Neem seed kernel extract

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

3.12 Application of the treatments

Spraying was done at 12.00 pm to avoid moisture on leaves. First application was done after 30 days of germination. Treatments were applied at 7 days interval. Spraying was done by knapsack sprayer having a pressure of 4.5 kg/cm^2.

3.13 Monitoring of insect pest and data collection

For data collection five plants per plot were randomly selected and tagged. Data collection was started at 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.

The following parameters were considered during data collection.

- Incidence of insect pests per plant: The number of jassid, whitefly, aphid and mealybug per five tagged plants per plot.
- Leaf infestation (%): Number of infested leaves by whitefly and jassid per five tag plants per plot as well as number of total leaves per five tagged plants per plot.
- Okra shoot and fruit borer infestation: Number of okra shoot and fruit borer infested shoot as well as fruits per five randomly selected tagged plants per plot.
- Incidence of beneficial arthropods per plot: Number of lady bird beetle, field spider, ant, staphylinid beetle, ground beetle per randomly selected plants per plot through visual inspection.
- Diversity of arthropods community per plot: Number of lady bird beetle, field spider, ant, staphylinid beetle, ground beetle per plot through pitfall trap.
- Yield contributing characters: Height of plants, length and girth of fruit, weight of fruit, per five randomly selected plants per plot.
- Total edible yield (ton/ha): Weight of edible fruit per plot.

3.13.1 Incidence of okra insect pests per okra plant

Data were collected on the number of jassid, whitefly, aphids, mealybug per plant at vegetative as well as early, mid and late fruiting stage of okra.

3.13.2 Leaf infestation (%)

Number of infested leaves was counted from total leaves per plant and percent leaves infested by okra insect pests were calculated as follows:

$$\% \text{ Leaf infestation} = \frac{\text{No. of infested leaves}}{\text{Total no. of leaves per plant}} \times 100$$

3.13.2.1 Reduction leaf infestation over control

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

Leaf infestation (%) reduction over control=

$$\frac{\% \text{ infested leaves in control} - \% \text{ infested leaves in the treatment}}{\% \text{ infested leaves in control}} \times 100$$

Plate 2. Jassid on the lower surface of the leaf (green colour)

Plate 3. Jassid infested plant

Plate 4. Whitefly on the lower portion of the leaf

Plate 5. Leaves infected by Okra yellow vein clearing mosaic virus

Plate 6. Larva of Okra shoot and fruit borer showing infestation

Plate 7. Pupa of Okra shoot and fruit borer

Plate 8. Adult of Okra shoot and fruit borer

Plate 9. Mealybug on the lower surface of the leaf

Plate 10. Aphid on the lower surface of the leaf

3.13.3 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=

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

Fruit infestation (%) reduction over control=

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

3.13.4 Incidence of beneficial arthropods per plot

Data were collected on the incidence of natural enemies like lady bird beetle, staphylinid beetle, spider, ant, ground beetle etc. per plot and counted separately for each treatment through visual observation in the field.

Plate 11. Lady bird beetle adult on the leaf

Plate 12. Lady bird beetle feeding mealybug

Plate 13. Staphylinid beetle on the lower side of okra leaf

Plate 14. Ground beetle on the okra plot

Plate 15. Ant on the lower portion of okra leaf

Plate 16. Predatory field spider on the lower portion of okra leaf

3.13.5 Diversity of arthropods community per plot

3.13.5.1 Pitfall trap method

This method was used for the species that roam on the soil surface such as ground beetles, spiders, staphylinid beetle etc. Small plastic pots having 6 cm diameter and 8 cm depth were used as pitfall traps each of which was half filled with water. Two traps were placed in soil in each of the plots at early, mid and late fruiting stages of okra to trap the insects. The trap mouth of the pot was kept at the ground level so as not to obstruct insect movement. After 48 hours of setting traps, insects were collected from each plot/treatment and kept separately. On the basis of phenotypic similarity, trapped insects were identified to family in which they belong and data were recorded against each treatment.

Plate 17. Pitfall trap for capturing soil inhibiting arthropod in okra field

3.13.5.2 Measurement of diversity index and equitability

To assess both the abundance pattern and the species richness, Simpson's diversity index was used (Simpson, 1949).

Simpson's Index, $$D = \frac{1}{\sum_{i=1}^{S} Pi^2}$$

Where, Pi is the proportion of individual for the ith insect family and S is the total number of insect family in the community (i.e., the richness). The value of index depends on both the richness and the evenness (equitability) with which individuals were distributed among the families. Equitability was quantified by expressing Simpson's index, D as a proportion of the maximum possible value of D.

Equitability, $$E = \frac{D}{D\ max} = \frac{1}{\sum_{i=1}^{S} Pi^2} \times \frac{1}{S}$$

3.13.6 Yield contributing characters of okra

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

3.13.6.1 Height of fruit

The height of fruit was recorded in centimeter (cm) during harvest time from each experimental plot. The height of every fruit was measured by a meter scale and mean values were recorded.

3.13.6.2 Girth of fruit

The girth of fruit was recorded in centimeter (cm) during harvest time from each experimental plot. The girth of every fruit was measured by a slide caliperse and mean values were recorded.

3.13.6.3 Weight of fruit

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

3.13.6.4 Harvesting

As the seeds were sown in the field at times, the crops were harvested at different times. Fruits were harvested at two days interval when they attained edible stage. Fruit harvesting was started from 27 November, 2017 and was continued up to 10 January, 2018.

Plate 18. Healthy fruit

3.13.7 Yield per hectare

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

3.14 Statistical analysis of data

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

CHAPTER IV

RESULTS AND DISCUSSION

The results on incidence of major insect pests have been presented by using different tables and graphs and discussed with possible interpretations have been given under the following sub-headings:

4.1 Occurrence of insect pests in the okra field

A number of insect pests were recorded in the field of okra, of when they are occurred. The jassid and whitefly occurred in the vegetative stage when 6-8 leaves are form and continued upto late fruiting stage. In case of okra shoot and fruit borer, it occurred in the early to late fruiting stage. Aphids occurred in the early flowering, and mid flowering stage. Mealybug occure in the early to late fruiting stage.

Table 4: List of insect pests found in okra field during October, 2017 to January, 2018

Insect pests	**Growth stage**						
	Seed ling	**2-4 Leaves**	**6-8 Leaves**	**Flowe ring**	**Early fruiting**	**Mid fruiting**	**Late fruiting**
Jassid							
Whitefly							
Okra shoot and fruit borer							
Aphids							
Mealybug							

Light grey area: occurrence of insect pests

4.2 Incidence of major insect pests of okra

4.2.1 Incidence of jassid

Number of jassid per plant was recorded at vegetative as well as early, mid and late fruiting stage and statistically significant variation was observed among the treatments applied for controlling major insect pests of okra (Table 5).

At the vegetative stage of okra, significant variations were observed in different treatments in case of number of jassid per plant. Results showed that, the lowest number of jassid (0.87) was recorded in T_1 treated plot which was statistically different from other treatments. On the other hand, the highest number of jassid (25.89) was recorded in T_8 treated plot, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the treatments applied against jassid per plant at the vegetative stage including untreated okra in terms of reducing number was $T_8 > T_3 > T_7 > T_2 > T_5 > T_4 > T_6 > T_{1.}$

At the early fruiting stage of okra, significant variations were observed in different treatments in case of number of jassid per plant. Results showed that, the lowest number of jassid (5.57) was recorded in T_1 treated plot which was statistically different from other treatments. On the other hand, the highest number of jassid (12.93) was recorded in okra (T_8) treatment, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the reducing number was $T_1 > T_3 > T_2 > T_6 > T_4 > T_5 > T_7 > T_8$.

In the mid fruiting stage of okra, significant variations were observed among the treatments in terms of jassid per plant. From the results it was revealed that, the lowest number of jassid (2.17) was recorded in T_1 treated plot. The highest number of jassid (12.57) was recorded in T_8 which was significantly different from all other treatments. As a result, the order of rank of efficacy of the treatments applied against jassid per plant at the mid fruiting stage including untreated okra in terms of reducing number was $T_1 > T_4 > T_6 > T_3 > T_2 > T_7 > T_5 > T_8$.

At the late fruiting stage of okra, number of jassid per plant was also varied significantly due to different types of treatments. Results showed that, the lowest number of jassid (0.53) was recorded in T_1 treatment, which was significantly different from all other treatments. On the other hand, the highest number of jassid (13.13) was recorded in (T_8) which was statistically different from all other treatments. As a result, the trend of rank of efficacy of the treatments applied against jassid per plant at the late fruiting stage including untreated okra in terms of the reducing number was $T_1 > T_4 > T_6 > T_2 > T_3 > T_5 > T_7 > T_8$.

Table 5: Effect of different management practices on the incidence of jassid infestation on leaf at different growth stages of okra

Treatment	Incidence of jassid (No./plant)					
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% reduction over control
T_1	0.87 g	5.57 c	2.17 e	0.53 e	2.79 e	78.34
T_2	8.27 d	8.20 b	7.07 cd	5.10 cd	6.79 c	47.28
T_3	16.22 b	8.00 b	6.37 d	6.63 bc	7.00 c	45.65
T_4	5.00 e	8.87 b	4.63 d	3.07 d	5.42 d	57.92
T_5	6.67 de	9.70 b	9.70 b	8.20 b	9.20 b	28.57
T_6	3.01 f	8.53 b	5.37 d	3.30 d	5.73 d	55.51
T_7	11.67 c	9.93 b	9.07 bc	8.43 b	9.14 b	29.04
T_8	25.89 a	12.93 a	12.57 a	13.13 a	12.88 a	-
LSD (0.01)	1.92	1.91	2.32	2.21	0.31	-
CV (%)	8.12	8.78	13.39	15.00	2.21	-

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

Percent reduction of leaf infestation over control was the highest (78.34 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 5) followed by T_4 (57.92 %) and T_6 (55.51 %). On the other hand, the lowest reduction of leaf infestation (28.57 %) was recorded in T_5 treatment comprised of spraying Ostad 10 EC @ 2ml/Litre of water at 7 days interval of followed by T_7 (29.04 %), T_3 (45.65 %) and T_2 (47.28 %).

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in reducing leaf infestation (78.34 %) caused by jassid due to application of different management practices followed by T_4 (57.92 %) and T_6 (55.51 %) and the lowest reduction of leaf infestation was recorded in T_5 (28.57 %) followed by T_7 (29.04 %), T_3 (45.65 %). It was also revealed that leaf infestation was increased in the early fruiting stage of okra and declined in the vegetative stage (Table 5).

This result agrees with the findings of Singh *et al.* (2013) recorded that the incidence of leafhopper commenced from 2nd week after sowing.

4.2.2 Incidence of whitefly

Number of whitefly per plant was recorded at vegetative as well as early, mid and late fruiting stage and statistically significant variation was observed among the treatments applied for controlling major insect pests of okra (Table 6).

At the vegetative stage of okra, significant variations were observed in different treatments in case of number of whitefly per plant. Results showed that, the lowest number of whitefly (1.60) was recorded in T_1 treated plot which was statistically different from other treatments. On the other hand, the highest number of whitefly (4.98) was recorded in T_8 treated plot, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the treatments applied against jassid per plant at the vegetative stage including untreated okra in terms of reducing number was $T_1 > T_6 > T_4 > T_7 > T_5 > T_3 > T_2 > T_8$.

At the early fruiting stage of okra, significant variations were observed in different treatments in case of number of whitefly per plant. Results showed that, the lowest number of whitefly (1.40) was recorded in T_1 treated plot which was statistically different from other treatments. On the other hand, the highest number of whitefly (7.50) was recorded in okra (T_8) treatment, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the reducing number was $T_1 > T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_8$.

In the mid fruiting stage of okra, significant variations were observed among the treatments in terms of whitefly per plant. From the results it was revealed that, the lowest number of whitefly (0.50) was recorded in T_1 treated plot. The highest number of whitefly (7.57) was recorded in T_8 which was significantly different from all other treatments. As a result, the order of rank of efficacy of the treatments applied against jassid per plant at the mid fruiting stage including untreated okra in terms of reducing number was $T_1 > T_4 > T_6 > T_3 > T_2 > T_7 > T_5 > T_8$.

At the late fruiting stage of okra, number of whitefly per plant was also varied significantly due to different types of treatments. Results showed that, the lowest number of whitefly (0.27) was recorded in T_1 treatment, which was significantly different from all other treatments. On the other hand, the highest number of whitefly (6.87) was recorded in (T_8) which was statistically different from all other treatments. As a result, the trend of rank of efficacy of the treatments applied against whitefly per plant at the late fruiting stage including untreated okra in terms of reducing number was $T_1 > T_6 > T_4 > T_2 > T_3 > T_7 > T_5 > T_8$.

Percent reduction of leaf infestation over control was the highest (86.73 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 6) followed by T_4 (72.03 %) and T_6 (70.04 %). On the other hand, the lowest reduction of leaf infestation (39.53 %) was recorded in T_5 treatment comprised of spraying Ostad 10 EC @ 2ml/Litre of water at 7 days interval of followed by T_7 (42.13 %), T_3 (56.09 %) and T_2 (58.14 %).

Table 6: Effect of different management practices on the incidence of whitefly infestation on leaf at different growth stages of okra.

Treatment	Incidence of whitefly (No./plant)					
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% reduction over control
T_1	1.60 h	1.40 e	0.50 e	0.27 e	0.97 e	86.73
T_2	3.97 b	3.59 cd	3.40 c	2.20 cd	3.06 c	58.14
T_3	3.80 d	3.86 bcd	3.20 c	2.57 c	3.21 c	56.09
T_4	2.38 f	2.96 d	1.67 d	1.50 d	2.04 d	72.03
T_5	3.74 c	4.69 b	4.73 b	3.83 b	4.42 b	39.53
T_6	2.02 g	3.22 d	1.87 d	1.47 d	2.19 d	70.04
T_7	2.85 e	4.36 bc	4.70 b	3.63 b	4.23 b	42.13
T_8	4.98 a	7.50 a	7.57 a	6.87 a	7.31 a	-
LSD (0.01)	0.35	0.91	0.84	0.74	0.36	-
CV (%)	4.75	10.42	10.02	10.93	4.37	-

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in reducing leaf infestation (86.73 %) caused by whitefly due to application of different management practices followed by T_4 (72.03 %) and T_6 (70.04 %) and the lowest reduction of leaf infestation was recorded in T_5 (39.53 %) followed by T_7 (42.13 %), T_3 (56.09 %). It was also revealed that leaf infestation was increased in the early fruiting stage of okra and declined in the vegetative stage (Table 6). Pal *et al.* (2013) reported that the incidence of whitefly occurred at the early crop periods. The maximum and minimum temperatures, relative humidity, rainfall and sunshine were positively correlated with the incidence of the insect pest.

4.2.3 Incidence of aphid

Number of aphids per plant was recorded at early, mid and late fruiting stage and statistically significant variation was observed for different types of treatments applied for controlling major insect pests of okra (Table 7).

At the early fruiting stage of okra, significant variations were observed in different treatments in case of number of aphids per plant. Results showed that, the lowest number of aphid (0.37) was recorded in T_1 treated plot which was statistically different from other treatments. On the other hand, the highest number of aphid (4.43) was recorded in okra (T_8) treatment, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the reducing number was $T_1 > T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_8$.

In the mid fruiting stage of okra, significant variations were observed among the treatments in terms of aphid per plant. From the results it was revealed that, the lowest number of aphid (0.33) was recorded in T_1 treated plot. The highest number of aphid (4.23) was recorded in T_8 which was significantly different from all other treatments. As a result, the order of rank of efficacy of the treatments applied against aphid per plant at the mid fruiting stage including untreated okra in terms of reducing number was $T_1 > T_4 > T_6 > T_3 > T_2 > T_7 > T_5 > T_8$.

In the late fruiting stage, no of aphids was recorded in zero.

Percent reduction of leaf infestation over control was the highest (91.92 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 7) followed by T_4 (73.44 %) and T_6 (57.74 %). On the other hand, the lowest reduction of leaf infestation (27.48 %) was recorded in T_5 treatment comprised of spraying Ostad 10 EC @ 2ml/Litre of water at 7 days interval of followed by T_7 (36.26 %), T_3 (40.42 %) and T_2 (47.8 %).

Table 7: Effect of different management practices on the incidence of aphid infestation on leaf at different growth stages of okra.

Treatment	Incidence of aphid (No./plant)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% reduction over control
T_1	0.37 h	0.33 f	0	0.35 g	91.92
T_2	2.46 e	2.05 cd	0	2.26 d	47.81
T_3	2.88 d	2.28 bc	0	2.58 cd	40.42
T_4	1.15 g	1.14 e	0	1.15 f	73.44
T_5	3.63 b	2.65 b	0	3.14 b	27.48
T_6	2.01 f	1.64 de	0	1.83 e	57.74
T_7	3.25 c	2.27 bc	0	2.76 c	36.26
T_8	4.43 a	4.23 a	0	4.33 a	-
LSD (0.01)	**0.25**	**0.51**	**NS**	**0.36**	**-**
CV (%)	**4.13**	**10.16**	**NS**	**6.40**	**-**

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in reducing leaf infestation (91.92 %) caused by aphid due to application of different management practices followed by T_4 (73.44 %) and T_6 (57.74 %) and the lowest reduction of leaf infestation was recorded in T_5 (27.48 %) followed by T_7 (36.26 %), T_3 (40.42 %). It was also revealed that leaf infestation was increased in the early fruiting stage of okra and declined in the mid fruiting stage (Table 7).

Singh *et al.* (2013) reported that the aphid population gradually increased and reached the peak level during the second week of October. Thereafter declined trend was observed and population of aphid reached its lowest level in third week of November.

4.2.4 Incidence of mealybug

Number of mealybugs per plant was recorded at early, mid and late fruiting stage and statistically significant variation was observed among the treatments applied for controlling major insect pests of okra (Table 8).

At the early fruiting stage of okra, significant variations were observed in different treatments in case of number of mealybugs per plant. Results showed that, the lowest number of mealybug (0.67) was recorded in T_4 treated plot which was statistically different from other treatments. On the other hand, the highest number of mealybug (1.41) was recorded in okra (T_8) treatment, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the reducing number was $T_4 > T_6 > T_2 > T_3 > T_7 > T_1 > T_5 > T_8$.

In case of the mid fruiting stage of okra, significant variations were observed among the treatments in terms of mealybug per plant. From the results it was revealed that, the lowest number of mealybug (0.17) was recorded in T_1 treated plot which was significantly different from all other treatments. Accordingly, the highest number of mealybug (1.55) was recorded in T_8 which was also significantly different from all other treatments. As a result, the order of rank of efficacy of the treatments applied against mealybug per plant at the mid fruiting stage including untreated control in terms of reducing number was $T_1 > T_4 > T_6 > T_3 > T_2 > T_7 > T_5 > T_8$.

Table 8: Effect of different management practices on the incidence of mealybug infestation on leaf at different growth stages of okra.

Treatment	Incidence of mealybug (No./plant)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% reduction over control
T_1	0.67 e	0.17 e	0.12 e	0.12 e	92.72
T_2	0.45 d	0.43 d	0.42 d	0.42 d	74.55
T_3	0.46 d	0.45 d	0.43 d	0.43 d	73.94
T_4	0.41 d	0.39 d	0.38 d	0.38 d	76.97
T_5	0.67 b	0.65 b	0.63 b	0.63 b	61.82
T_6	0.43 d	0.41 d	0.31 d	0.31 d	81.21
T_7	0.57 c	0.55 c	0.54 c	0.54 c	67.27
T_8	1.41 a	1.55 a	1.65 a	1.65 a	-
LSD (0.01)	0.08	0.08	0.08	0.08	-
CV (%)	4.28	4.19	4.21	4.21	-

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

At the late fruiting stage of cabbage, number of mealybug per plant was also varied significantly due to different types of treatments. Results showed that, the lowest number of mealybug (0.12) was recorded in T_1 treatment, which was significantly different from all other treatments. On the other hand, the highest number of mealybug (1.65) was recorded in (T_8) which was statistically different from all other treatments. As a result, the trend of rank of efficacy of the treatments applied against mealybug per plant at the late fruiting stage including untreated okra in terms of reducing number was $T_1 > T_6 > T_4 > T_2 > T_3 > T_7 > T_5 > T_8$.

Percent reduction of leaf infestation over control was the highest (92.72 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 8) followed by T_6 (81.21 %) and T_4 (76.97 %). On the other hand, the lowest reduction of leaf infestation (61.82 %) was recorded in T_5 treatment comprised of spraying Ostad 10 EC @ 2ml/Litre of water at 7 days interval of followed by T_7 (67.27 %), T_3 (73.94 %) and T_2 (74.55 %).

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in reducing leaf infestation (92.72 %) caused by mealybug due to application of different management practices followed by T_6 (81.21 %) and T_4 (76.97 %) and the lowest reduction of leaf infestation was recorded in T_5 (61.82 %) followed by T_7 (67.27 %), T_3 (73.94 %). It was also revealed that leaf infestation was increased in the early fruiting stage of okra and declined in the late fruiting stage (Table 8).

The results agree with the findings of Jat *et al*. (2014) who found maximum population of mealy bug, *P. solenopsis* on tobacco from 4th week of November (47th standard week) and continued up to 3rd week of January (3rd standard week).

4.3 Leaf infestation of okra

4.3.1 Leaf infestation caused by whitefly

The significant variations were observed among the different treatments used for the management practices in terms of percent leaf infestation by number due to attack of whitefly during the study period, which is shown in Table 9.

The highest number of leaf per plant (6.88) was recorded in T_1 treatment, which was statistically different from all other treatments. Accordingly, the lowest number of leaves (5.51) was recorded in T_8 treatment, which was statistically similar to T_5 (5.94) treatment.

Again, considering the number of infested leaves per plant, the lowest number of infested leaves (3.00) caused by whitefly was recorded in T_1 treatment, which was statistically different from all other treatments. Accordingly, the highest number of infested leaves per plant (5.01) was recorded in T_8 which was significantly different from all other treatments.

Table 9: Effect of treatment on leaf infestation of okra caused by whitefly during the study period.

Treatment	Leaf infestation by whitefly during the study period of okra			
	Total number of healthy leaves per plant	No. of infested leaves per plant	% leaf infestation	(%) increase over control
T_1	6.88 a	3.00 g	47.92 g	48.97
T_2	6.35 b	4.18 de	54.33 f	42.15
T_3	6.20 b	4.31 cd	60.25 e	35.84
T_4	6.40 b	3.70 f	64.74 d	31.06
T_5	5.94 bc	4.61 b	72.55 c	22.75
T_6	6.29 b	3.94 e	75.98 c	19.09
T_7	6.33 b	4.44 bc	80.75 b	14.01
T_8	5.51 c	5.01 a	93.91 a	-
LSD (0.01)	0.47	0.24	3.48	-
CV (%)	3.07	2.39	2.08	-

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

Again, considering the level of infestation, the lowest leaf infestation (47.92%) caused by whitefly was observed in T_1 treatment, which was significantly different from all other treatments. Accordingly, the highest infestation (93.91%) was recorded in T_8 which was statistically different from all other treatments.

Considering the reduction of leaf infestation caused by whitefly, the highest reduction of leaf infestation over okra was observed 48.97% in T_1 treatment; whereas, the lowest reduction of leaf infestation over okra was observed in T_5 (14.01%) treatment.

4.3.2 Leaf infestation caused by jassid

The significant variations were observed among the different treatments used for the management practices in terms of percent leaf infestation by number due to attack of jassid during the study period, which is shown in (Table 10).

The highest number of leaf per plant (6.88) was recorded in T_1 treatment, which was statistically different from all other treatments. Accordingly, the lowest number of leaves (5.51) was recorded in T_8 treatment, which was statistically similar to T_5 (5.94) treatment.

Again, considering the number of infested leaves per plant, the lowest number of infested leaves (3.26) caused by jassid was recorded in T_1 treatment, which was statistically different from all other treatments. Accordingly, the highest number of infested leaves per plant (5.27) was recorded in T_8 which was significantly different from all other treatments.

Again, considering the level of infestation, the lowest leaf infestation (47.35%) caused by jassid was observed in T_1 treatment, which was significantly different from all other treatments. Accordingly, the highest infestation (95.57%) was recorded in T_8 which was statistically different from all other treatments.

Considering the reduction of leaf infestation caused by jassid, the highest reduction of leaf infestation over okra was observed 50.46% in T_1 treatment; whereas, the lowest reduction of leaf infestation over okra was observed in T_5 (17.79%) treatment.

Table 10: Effect of treatments on leaf infestation of okra caused by jassid during the study period

Treatment	Leaf infestation by jassid during the study period of okra			
	Number of healthy leaves per plant	No. of infested leaves per plant	% leaf infestation	(%) increase over control
T_1	6.88 a	3.26 f	47.35 f	50.46
T_2	6.35 b	4.19 cd	66.00 cd	30.94
T_3	6.20 b	4.37 bc	70.46 c	26.27
T_4	6.40 b	3.77 e	58.88 e	38.39
T_5	5.94 bc	4.67 b	78.57 b	17.79
T_6	6.29 b	4.00 de	63.76 de	33.28
T_7	6.33 b	4.57 b	72.22 c	24.43
T_8	5.51 c	5.27 a	95.57 a	-
LSD (0.01)	0.47	0.33	6.29	-
CV (%)	3.07	3.13	3.75	-

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 20EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

4.4 Okra shoot and fruit borer infestation

4.4.1 Shoot infestation

Number of infested shoot per plant was recorded at early, mid and late fruiting stage and statistically significant variation was observed among the treatments (Table 11).

At the early fruiting stage, no shoot infestation was occurred.

At the mid fruiting stage, significant variations were observed among the treatments in case of percent of shoot infestation per plant.Lowest percent of shoot infestation (0.00) was recorded in T_1 treated plot which was statistically similar to T_4 (0.04), T_6 (0.05), T_2 (0.05), T_3 (0.09) treatments respectively. On the other hand, the highest percent of shoot infestation (0.60) was recorded in okra (T_8) treatment, which was significantly different from all other treatments. As a result, the trend of rank of the reducing number was $T_1 > T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_8$.

Table 11: Effect of different management practices on the incidence of okra shoot and fruit borer (OSFB) infestation on shoot at different growth stages of okra.

Treatment	% Shoot infestation				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean Infestation	% reduction over control
T_1	0	0.00 d	0.00 d	0.00 e	100
T_2	0	0.05 d	0.07 cd	0.07 cde	76.67
T_3	0	0.09 cd	0.08 cd	0.09 cd	70
T_4	0	0.04 d	0.04 cd	0.04 de	86.67
T_5	0	0.33 b	0.27 b	0.30 b	0
T_6	0	0.05 d	0.05 cd	0.05 cde	83.33
T_7	0	0.16 c	0.09 c	0.13 c	56.67
T_8	0	0.60 a	0.53 a	0.30 b	-
LSD (0.01)	NS	0.08	0.08	0.08	-
CV (%)	NS	18.65	19.24	15.55	-

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

In the late fruiting stage of okra, significant variations were observed among the treatments in terms of percent shoot infestation per plant. From the results it was revealed that, the lowest number of aphid (0.00) was recorded in T_1 treated plot which was statistically similar to T_4 (0.04), T_6 (0.05), T_2 (0.07), T_3 (0.08) treatments respectively. The highest percent of shoot infestation (0.53) was recorded in T_8 which was significantly different from all other treatments. As a result, the order of rank of efficacy of the treatments applied against aphid per plant at the mid fruiting stage including untreated okra was $T_1 > T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_8$.

Percent reduction of shoot infestation over control was the highest (100 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 11) followed by T_4 (86.67 %) and T_6 (83.33 %). On the other hand, the lowest reduction of shoot infestation (0 %) was recorded in T_5 treatment comprised of spraying Ostad 10 EC @ 2ml/Litre of water at 7 days interval of followed by T_7 (56.67 %), T_3 (70 %) and T_2 (76.67 %).

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in reducing shoot infestation (100 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_4 (86.67 %) and T_6 (83.33 %) and the lowest reduction of leaf infestation was recorded in T_5 (0 %) followed by T_7 (56.67 %), T_3 (70 %). It was also revealed that shoot infestation was increased in the mid fruiting stage of okra and declined in the late fruiting stage (Table 11). Shukla et al. (1997) reported that before fruiting stage shoot infestation reached at a peak of 8.5%.

4.4.2 Fruit infestation

At the early fruiting stage of okra, no fruit infestation was occurred.

At the mid fruiting stage of okra, significant variations were observed in different treatments in case of percent of fruit infestation per plant. Results showed that, the lowest percent of shoot infestation (0.00) was recorded in T_1 treated plot which was statistically similar to T_4 (0.04), T_6 (0.05), T_2 (0.07), T_3 (0.08) treatments respectively.

On the other hand, the highest percent of shoot infestation (0.53) was recorded in okra (T_8) treatment, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the reducing number was $T_1 > T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_8$.

At the late fruiting stage of okra, also no fruit infestation was occurred.

Table 12: Effect of different management practices on the incidence of okra shoot and fruit borer (OSFB) infestation on fruit at different growth stages of okra.

Treatment	% Fruit infestation (No./plant)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean infestation	% reduction over control
T_1	0	0.00 d	0	0.00 c	100
T_2	0	0.07 cd	0	0.02 bc	98
T_3	0	0.08 cd	0	0.03 bc	97
T_4	0	0.04 cd	0	0.01 bc	99
T_5	0	0.27 b	0	0.09 b	91
T_6	0	0.05 cd	0	0.02 bc	98
T_7	0	0.09 c	0	0.03 bc	97
T_8	0	0.53 a	0	0.18 a	-
LSD (0.01)	NS	0.08	NS	0.08	-
CV (%)	NS	19.24	NS	14.47	-

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 20 EC @ 1ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

Percent reduction of fruit infestation over control was the highest (100 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 12) followed by T_4 (99 %) and T_6 (98 %). On the other hand, the lowest reduction of shoot infestation (91 %) was recorded in T_5 treatment comprised of spraying Ostad 20 EC @ 1ml/Litre of water at 7 days interval of followed by T_7 (97 %), T_3 (97 %) and T_2 (98 %).

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in reducing fruit infestation (100 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_4 (99 %) and T_6 (98 %) and the lowest reduction of fruit infestation was recorded in T_5 (91 %) followed by T_7 (97 %), T_3 (97 %). It was also revealed that fruit infestation was only occur in the mid fruiting stage. (Table12).

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

4.5 Incidence of natural enemies

In terms of number of natural enemies per plot in okra field, the significant variations were observed among the different treatments used for the management practices which have been shown in Table 13.

In case of lady bird beetle, ant, predatory field spider, staphylinid beetle and ground beetle the highest number per plot such as 5.33, 3.67, 4.67, 5.00, and 3.00 respectively were obtained from T_8 treatment.While the lowest numbers of lady bird beetle (1.00), ant (1.00), predatory field spider (1.00), staphylinid beetle (1.00) and ground -beetle (1.33) per plot were recorded in T_1 treatment.

Table 13: Effect of treatment on the incidence of natural enemies in okra field during the study period

Treatment	Number of natural enemies per plot				
	Lady bird beetle	Ant	Predatory field spider	Staphylinid beetle	Ground beetle
T_1	1.00 e	1.00 d	1.00 d	1.00 f	1.33 bc
T_2	3.33 bc	2.33 b	2.67 c	3.67 b	2.00 b
T_3	3.00 bc	2.00 bc	2.00 c	2.67 cd	1.67 bc
T_4	3.67 b	2.67 b	3.67 b	4.00 b	2.00 b
T_5	2.00 d	1.33 cd	2.00 c	2.00 e	1.00 c
T_6	2.67 cd	2.00 bc	2.00 c	3.00 c	1.67 bc
T_7	2.00 d	1.33 cd	2.33 c	2.00 de	1.00 c
T_8	5.33 a	3.67 a	4.67 a	5.00 a	3.00 a
LSD (0.01)	0.84	0.86	0.82	0.65	0.77
CV (%)	12.00	17.32	13.23	9.16	18.62

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

4.6 Diversity of insect community

Trends in diversity pattern of insects under different treatments using relative methods viz. pitfall trap at the early, mid and late fruiting stages of okra growth are shown after combining the data from collected samples in Appendix III-V and Table 14.

Pitfall trap method

Diversity index of an insect community under different treatment using pitfall method at the early, mid and late fruiting stages of okra is presented in Table 14.

At the early fruiting stage, the highest number of insect species (18) and also the highest diversity index (5.34) per plot were observed in T_1 treatment, whereas the lowest number of insect species (7) was observed in T_8 treatment and the lowest diversity index (1.92) per plot was recorded from T_5 treatment. On the other hand, the highest equitability (0.91) per plot was observed in T_7 treatment and the lowest equitability (0.38) per plot was recorded from T_5 treatments.

At the mid fruiting stage, the highest number of insect species (20) and also the highest diversity index (5.41) per plot were observed in T_1 treatment, while the lowest number of insect species (9) and lowest diversity index (3.59) per plot was recorded from the T_8 treatment. Again, the highest equitability (0.95) per plot was observed in T_2 treatment and the lowest equitability (0.81) per plot was recorded from T_8 treatment.

At the late fruiting stage, the highest number of insect species (23) and also the highest diversity index (8.28) per plot was observed in T_1 treatment, whereas the lowest number of insect species (11) was observed in T_8 treatment and lowest diversity index (3.03) per plot was obtained from T_2 treatment, and the highest equitability (1.38) per plot was observed in T_1 treatments and the lowest equitability (0.51) per plot was observed from T_2 treatment.

Table 14. Diversity index and equitability of insect community of different families under different treatment using pitfall trap method at early, mid and late fruiting stage of okra

Treatment	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	No. of insect species per plot	Diversity index (D)	Equitability (E)	No. of insect species per plot	Diversity index (D)	Equitability (E)	No. of insect species per plot	Diversity index (D)	Equitability (E)
T_1	18 a	5.43	0.76	20 a	5.41	0.9	23 a	8.28	1.38
T_2	12 bc	3.57	0.71	14 bc	4.73	0.95	16 bc	3.03	0.51
T_3	12 bc	2.64	0.66	15 bc	4.33	0.87	15 bc	3.68	0.92
T_4	14 b	4.22	0.84	16 b	4.38	0.88	18 b	4.63	0.93
T_5	10 cd	1.92	0.38	12 cd	4.72	0.94	14 c	4.73	0.95
T_6	13 bc	4.33	0.87	16 b	4.52	0.9	17 bc	3.87	0.97
T_7	11 bc	4.57	0.91	13 bc	4.33	0.87	15 bc	4.16	0.83
T_8	7 d	3.24	0.81	9 d	3.59	0.81	11 d	3.98	0.71

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

4.7 Yield contributing characters of okra

Significant variation was found in different treatments in case of height of plant as well as number, length, girth, weight of fruit which were measured as the yield contributing character of okra shown in Table 15.

4.7.1 Height of plant

The height of okra plant showed significant variation among the treatments. The maximum height of plant (37.83 cm) was recorded in T_1 treatment, which is statistically similar to T_4 (32.86 cm) and T_7 (32.82 cm) treatment. On the other hand, the minimum height of plant (25.10 cm) was recorded in T_8 treatment, which were statistically different for all other treatments.

4.7.2 Number of fruits

In case of the number of fruits showed significant variation among the treatments. The maximum number of fruit (3.85) was recorded in T_1 treatment, which is statistically different from all other treatments. On the other hand, the minimum number of okra (2.04) was recorded in T_8 treatment, which were statistically similar to T_5 (2.16), and T_3 (2.46) treatments respectively.

4.7.3 Length of fruit

In case of the length of okra showed significant variation among the treatments. The maximum length of fruit (6.66 cm) was recorded in T_2 treatment, which were statistically similar to T_7 (6.31 cm) treatment. On the other hand, the minimum length of fruit (5.62 cm) was observed in T_3 treatment, which was significantly similar to T_1 (5.63 cm), T_4 (5.65 cm), T_5 (5.97 cm), T_8 (6.02 cm), and T_6 (6.04 cm) treatments respectively. Butani and Jotwani (1984) and Thakur *et al.* (1986) reported that the length of the okra fruit affected by the Okra shoot and fruit borer.

4.7.4 Girth of fruit

In case of the girth of okra showed significant variation among the treatments. The maximum length of fruit (3.97 cm), which are statistically different from all other treatments. On the other hand, the minimum length of fruit (3.14 cm) was observed in T_5 and T_4 treatment, which was significantly similar to T_7 (3.25 cm), T_8 (3.44 cm), T_3 (3.45 cm) treatments respectively.

More or less similar works were done by Butani and Jotwani (1984) and Thakur *et al*. (1986) reported that the girth of the okra fruit affected by the Okra shoot and fruit borer.

Table 15: Effect of different management practices on yield contributing characters of okra.

Treatment	Height per plant	Number of fruits per plant	Length of fruit per plant	Girth of fruit per plant	Weight of fruit per Plant
T_1	37.83 a	3.85 a	5.63 c	3.41 b	10.44 a
T_2	31.97 b	2.62 cd	6.66 a	3.97 a	6.52 bc
T_3	31.05 b	2.46 de	5.62 c	3.45 bc	6.43 bc
T_4	32.86 ab	3.13 b	5.65 c	3.14 c	7.51 b
T_5	29.57 bc	2.16 e	5.97 bc	3.14 c	6.10 bc
T_6	31.87 b	2.93 bc	6.04 bc	3.56 b	7.56 b
T_7	32.82 ab	2.67 cd	6.31 ab	3.25 bc	5.77 c
T_8	25.10 c	2.04 e	6.02 bc	3.44 bc	3.17 d
LSD (0.01)	5.01	0.40	0.58	0.32	1.34
CV (%)	6.63	6.15	3.93	3.79	8.25

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

T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

4.7.5 Weight of fruit

In case of the girth of okra showed significant variation among the treatments. The maximum length of fruit (10.44 cm), was observed in T_1 treatment which are statistically different from all other treatments. On the other hand, the minimum length of fruit (3.17 cm) was observed in T_8 treatment, which was significantly different from all other treatment.

4.8 Yield

Effect of different treatments on the yield of okra Significant differences were observed among the treatments in terms of total fruit yield per plot in kg, total fruit yield in ton/ha and percent increase over control during the entire cropping season, presented in Table 16.

Table 16: Effect of different management practices on the yield of Okra during October 5 to January 10.

Treatment	Yield (kg/plot)	Yield (ton/ha)	(%) increase over control
T_1	2.31 a	3.86 a	229.91
T_2	1.18 bcd	1.97 bcd	68.38
T_3	0.95 bcd	1.58 bcd	35.04
T_4	1.43 b	2.38 b	103.42
T_5	0.85 cd	1.41 cd	20.51
T_6	1.43 b	2.38 b	103.42
T_7	1.34 bc	2.23 bc	90.50
T_8	0.70 d	1.17 d	-
LSD (0.01)	0.50	0.83	-
CV (%)	16.18	16.19	-

[In column, means containing same letter indicate significantly similar under DMRT at 1% level of significance. Values are the means of three replications]. T_1=Spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval; T_2=Spraying of neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval; T_3=Spraying of water based neem seed kernel extract @ 5g/Litre of water at 7 days interval; T_4=Spraying of Bioneem plus 1.0EC @ 1ml/Litre of water at 7 days interval; T_5=Spraying of Ostad 10 EC @ 2ml/Litre of water at 7 days interval; T_6=Spraying of Sevin 85 WP @ 1.2g/ Litre of water at 7 days interval; T_7=Spraying of Marshal 100EC @ 1.5ml/ Litre of water at 7 days interval; T_8=Untreated control]

In terms of percent increase of total fruit yield over control, the highest yield was recorded (229.91%) in T_1 followed by T_4 (103.42 %), and T_6 (103.42 %). On the other hand, minimum increase of total fruit yield over control was recorded in T_5 (20.51 %) followed by T_7 (35.04 %) and T_2 (68.38 %) treatment.

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in terms of increasing the yield of okra over control (229.91 %) due to application of different management practices. On other hand, the minimum increase of fruit yield over control was recorded in T_5 (20.51 %). Different management practices ensure the optimum vegetative growth and other yield contributing characters as well as maximum yield per hectare. Choi In Hu *et al*. (2004) observed that proclaim exhibit the highest fruit yield of okra.

4.9 Relationship between leaf infestation and yield

4.9.1 Leaf infestation caused by whitefly

Correlation study was done to establish the relationship between the percent leaf infestation caused by whitefly at harvesting stage and yield (ton/ha) of okra. From the study it was revealed that, significant correlation was observed between the percent leaf infestation caused by whitefly and yield of okra. It was evident from the Figure 2 that the regression equation $y = - 0.0343x + 4.4803$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.3775$) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a strongly negative relationship between percent leaf infestation caused by whitefly and yield of okra, i.e., the yield decreased with the increase of the infestation of leaf caused by whitefly during the study period of okra.

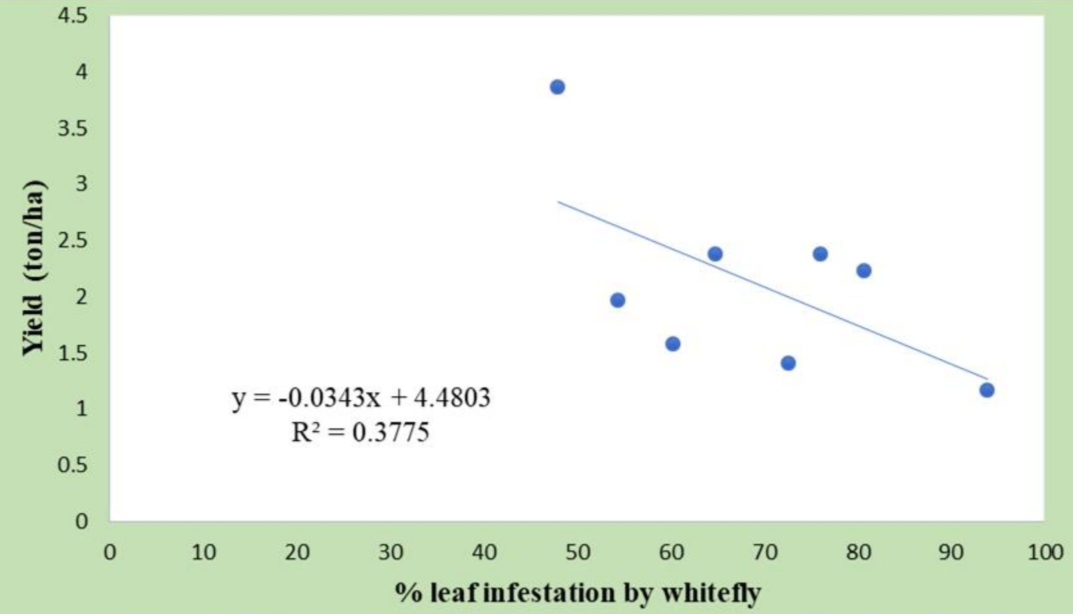

Figure 2: Relationship between percent leaf infestation by whitefly and okra yield during the study period

4.9.2 Relationship between leaf infestation caused by jassid and yield of okra

Correlation study was done to establish the relationship between the percent leaf infestation caused by jassid at harvesting stage and yield (ton/ha) of okra. From the study it was revealed that, significant correlation was observed between the percent leaf infestation caused by jassid and yield of okra. It was evident from the Figure 3 that the regression equation y = - 0.052x + 5.7145 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.7824) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a strongly negative relationship between percent leaf infestation caused by jassid and yield of okra, i.e., the yield decreased with the increase of the infestation of leaf caused by jassid during the study period of okra.

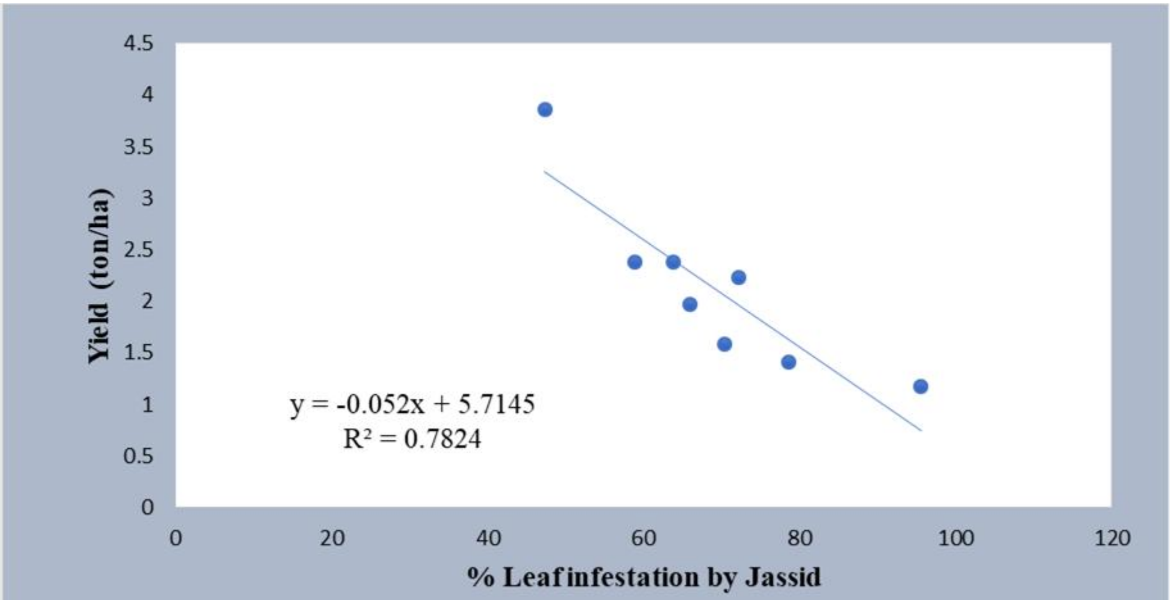

Figure 3: Relationship between percent leaf infestation by jassid and okra yield at during the study period

4.10 Relationship between shoot as well as fruit infestation and yield

4.10.1 Relationship between shoot infestation caused by okra shoot and fruit borer and yield of okra

Correlation study was done to establish the relationship between the percent shoot infestation caused by okra shoot and fruit borer at different stage and yield (ton/ha) of okra. From the study it was revealed that, significant correlation was observed between the percent shoot infestation caused by okra shoot and fruit borer and yield of okra. It was evident from the Figure 4 that the regression equation y = -5.5546x + 2.8029 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.5921) 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 percent shoot infestation caused by okra shoot and fruit borer and yield of okra, i.e., the yield decreased with the increase of the infestation of shoot caused by okra shoot and fruit borer at different stage.

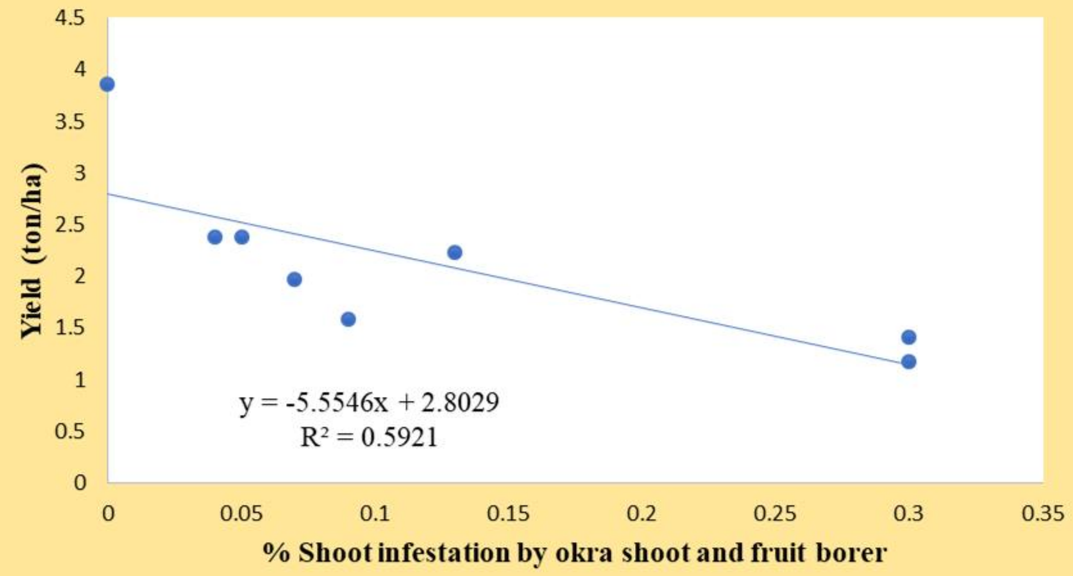

Figure 4: Relationship between percent shoot infestation by okra shoot and fruit borer and okra yield during the study period

4.9.2 Relationship between fruit infestation caused by okra shoot and fruit borer and yield of okra

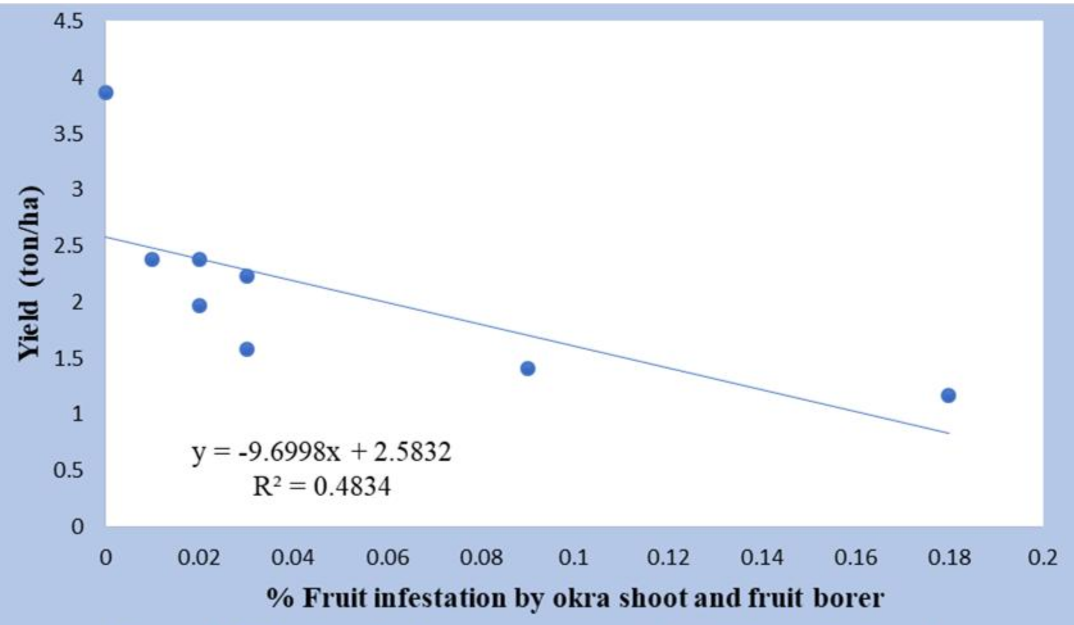

Figure 5: Relationship between percent fruit infestation by okra shoot and fruit borer and okra yield during the study period

Correlation study was done to establish the relationship between the percent fruit infestation caused by okra shoot and fruit borer at different stage and yield (ton/ha) of okra. From the study it was revealed that, significant correlation was observed between the percent fruit infestation caused by okra shoot and fruit borer and yield of okra. It was evident from the Figure 5 that the regression equation $y = -9.6998x + 2.5832$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.4834$) 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 percent fruit infestation caused by okra shoot and fruit borer and yield of okra, i.e., the yield decreased with the increase of the infestation of fruit caused by okra shoot and fruit borer at different stage.

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

A field experiment was carried out in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, to investigate the incidence of major insect pest and their management during the period from October 2017 to January 2018. The eight treatments were T_1: Actara 25 WG; T_2: Neem oil; T_3: Neem seed kernel extract; T_4: Bioneem plus 1.0EC; T_5: Ostad 10 EC; T_6: Sevin 85 WP; T_7: Marshal 100EC; T_8: Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data was collected on insect incidence, leaf infestation, shoot infestation, fruit infestation, incidence of natural enemy, diversity index and equitability of insect community through pit fall trap methods, yield contributing characters. Statistically significant variation was recorded at vegetative as well as early, mid and late fruiting stages for the incidence of insect pest. At vegetative stage, the lowest number of jassid (0.87), whitefly (1.60), per plant were recorded from T_1 (Actara 25 WG) treatment, whereas the highest numbers were recorded in T_8 treatment (25.89 and 4.98 respectively). At early fruiting stage, the lowest number of jassid (5.57), whitefly (1.40), aphids (0.37), mealybug (0.67) per plant were recorded from T_1 treatment, whereas the highest numbers were recorded in T_8 treatment (12.93, 7.50, 4.43, 1.41 respectively). At the mid fruiting stage, the lowest number of jassid (2.17), whitefly (0.50), aphids (0.33), and mealybug (0.17) per plant were recorded from T_1 treatment, whereas the highest numbers were recorded in T_8 treatment (12.57, 7.56, 4.23 and 1.55 respectively). At the late fruiting stage, the lowest number of jassid (0.53), whitefly (0.27), and mealybug (0.12) per plant were recorded from T_1 treatment, whereas the highest numbers were recorded in T_8 treatment (13.13, 6.87 and 1.65 respectively). In case of percent leaf infestation at harvesting stage, the lowest percent leaf infestation caused by whitefly (47.92%) were recorded from T_1 treatment, whereas the highest percent leaf infestation was recorded in T_8 treatment (93.91%) as well as the lowest percent leaf infestation caused by jassid (47.35%) was recorded from T_1 treatment, whereas the highest percent leaf infestation was recorded in T_8 treatment (95.57%). In case of okra shoot and fruit borer infestation, the reduced highest shoot infestation (100%) was recorded from T_1 treatment, as well as the reduced highest fruit infestation (100%) was recorded from T_1 treatment. In case of beneficial arthropods, the highest number of natural enemies like as lady bird beetle (5.33), staphylinid beetle (5.00), spider (4.67), ant (3.67) and ground beetle (3.00) were recorded from T_8 treatment, while the lowest number of lady bird beetle (1.00), staphylinid beetle (1.00), spider (1.00), ant (1.00), and ground beetle (1.33) per plot were recorded in T_1 treatment by visual observation. However, for the diversity index of insect community significant variations were also noticed in cases of pit fall trap method. For pit fall trap method, the highest number of insect species and the highest diversity index were observed in T_1 treatment (5.34, 5.41 and 8.28) in early, mid and late fruiting stages respectively, whereas the lowest number of insect species was observed in T_8 treatment and the lowest diversity index were recorded from T_5 treatment (1.92) in early fruiting stage, T_8 treatment (3.59) in mid fruiting stage and T_2 treatment (3.03) in late fruiting stage. In term of okra yield (ton/ha), the highest yield was recorded from T_1 treatment (3.86 ton/ha), where the lowest yield was recorded in case of T_8 treatment (1.17 ton/ha).

CONCLUSION

From the study the following conclusions may be drawn:

- Incidence of major insect pests of okra was less in T_1 treatment that was comprised with Actara 25 WG @ 1g/Litre of water at 7 days interval as compared with other treatments.

- In T_1 treatment, the infestation reduction over control was 78.34% for jassid, 86.73% for whitefly, 100% for okra shoot and fruit borer in case of shoot and fruit, 91.92% for aphid, and 92.72% for mealybug. In case of leaf infestation, the lowest percent leaf infestation was caused by whitefly (47.92%), jassid (47.35%) also in T_1 treatment. The highest okra yield (3.86 ton/ha) was produced in T_1 treatment.
- These findings illustrated that, the T_1 treatment was more effective for the reduction of incidence of major insect pests of okra.

RECOMMENDATION

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

- Application of Actara 25 WG @ 1g/Litre of water at 7 days interval may be recommended as an effective control measure applied against major insect pests infested okra.
- Further intensive studies based on different doses of Actara may be conducted.
- More chemicals and botanicals with their derivatives should be included in further elaborative research for controlling major insect pests of okra.

CHAPTER VI

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CHAPTER VII

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October, 2017 to January 2018

Month	Air temperature		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
October, 2017	26.7	16.7	80	10
November, 2017	25.8	16.0	78	00
December, 2018	22.4	13.5	74	00
January, 2018	24.5	12.4	68	00

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1207.

Appendix II. Characteristics of the soil of experimental field by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Expeimental Field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%Clay	30
Textural class	Silty-clay
Ph	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix III. Diversity and equitability of insect community of different families using pit fall trap method at early fruiting stage of okra

Treatment	Insect families	No. of individual	Proportion of individual (Pi)	Pi2	Diversity index (D)	Equitability (E)
T_1	Formicidae	5	0.28	0.0784	5.34	0.76
	Coccinellidae	2	0.11	0.0121		
	Muscidae	4	0.22	0.0484		
	Arachnida	3	0.17	0.0289		
	Chrysomelidae	1	0.06	0.0036		
	Carabidae	1	0.06	0.0036		
	Staphylinidae	2	0.11	0.0121		
T_2	Carabidae	1	0.08	0.064	3.57	0.71
	Formicidae	3	0.25	0.0625		
	Coccinellidae	2	0.17	0.0289		
	Arachnida	3	0.25	0.0625		
	Muscidae	3	0.25	0.0625		
T_3	Coccinellidae	1	0.08	0.064	2.64	0.66
	Muscidae	2	0.17	0.0289		
	Arachnida	4	0.33	0.1089		
	Formicidae	5	0.42	0.1764		
	Carabidae	1	0.07	0.0049	4.22	0.84
	Formicidae	3	0.21	0.0441		

T_4	Coccinellidae	2	0.14	0.0196		
	Muscidae	4	0.29	0.0841		
	Arachnida	4	0.29	0.0841		
T_5	Muscidae	3	0.3	0.39	1.92	0.38
	Arachnida	2	0.2	0.04		
	Formicidae	2	0.2	0.04		
	Coccinellidae	1	0.1	0.01		
	Staphylinidae	2	0.2	0.04		
T_6	Muscidae	4	0.31	0.0961	4.33	0.87
	Formicidae	3	0.23	0.0529		
	Coccinellidae	1	0.08	0.0064		
	Arachnida	3	0.23	0.0529		
	Staphylinidae	2	0.15	0.0225		
T_7	Formicidae	3	0.27	0.0729	4.57	0.91
	Coccinellidae	1	0.09	0.0081		
	Carabidae	2	0.18	0.0324		
	Muscidae	3	0.27	0.0729		
	Arachnida	2	0.18	0.0324		
T_8	Formicidae	3	0.43	0.1849	3.24	0.81
	Coccinellidae	1	0.14	0.0196		
	Muscidae	2	0.29	0.0841		
	Staphylinidae	1	0.14	0.0196		

Appendix IV. Diversity and equitability of insect community of different families using pit fall trap method at mid fruiting stage of okra

Treatment	Insect families	No. of individual	Proportion of individual (Pi)	Pi2	Diversity index (D)	Equitability (E)
T_1	Formicidae	5	0.25	0.0625	5.41	0.9
	Coccinellidae	2	0.1	0.01		
	Muscidae	3	0.15	0.0225		
	Arachnida	4	0.2	0.04		
	Carabidae	2	0.1	0.01		
	Staphylinidae	4	0.2	0.04		
T_2	Staphylinidae	3	0.21	0.0441	4.73	0.95
	chrysomilidae	2	0.14	0.0196		
	Formicidae	4	0.29	0.0841		
	Carabidae	2	0.14	0.0196		
	Muscidae	3	0.21	0.0441		
T_3	Carabidae	1	0.07	0.0049	4.33	0.87
	Formicidae	4	0.27	0.0729		
	Coccinellidae	3	0.2	0.04		

	Muscidae Arachnida	3 4	0.2 0.27	0.04 0.0729		
T_4	Carabidae Formicidae Coccinellidae Arachnida Muscidae	2 5 2 3 4	0.13 0.31 0.13 0.19 0.25	0.0169 0.0961 0.0169 0.0361 0.0625	4.38	0.88
T_5	Muscidae Formicidae Coccinellidae Arachnida Staphylinidae	2 3 2 2 3	0.17 0.25 0.17 0.17 0.25	0.0289 0.0625 0.0289 0.0289 0.0625	4.72	0.94
T_6	Formicidae Coccinellidae Carabidae Muscidae Arachnida	4 2 2 4 4	0.25 0.13 0.13 0.25 0.25	0.0625 0.0169 0.0169 0.0625 0.0625	4.52	0.9
T_7	Muscidae Arachnida Formicidae Coccinellidae Staphylinidae	3 3 4 1 2	0.23 0.23 0.31 0.08 0.15	0.0529 0.0529 0.0961 0.0064 0.0225	4.33	0.87
T_8	Chrysomilidae Carabidae Muscidae Arachnida	2 1 3 3	0.22 0.11 0.33 0.33	0.0484 0.0121 0.1089 0.1089	3.59	0.81

Appendix V. Diversity and equitability of insect community of different families using pit fall trap method at late fruiting stage of okra

Treatment	Insect families	No. of individual	Proportion of individual (Pi)	Pi2	Diversity index (D)	Equitability (E)
T_1	chrysomilidae Carabidae Muscidae Arachnida Staphylinidae Coccinellidae Formicidae	2 1 5 4 3 3 5	0.09 0.04 0.22 0.17 0.13 0.13 0.31	0.0081 0.0016 0.0484 0.0289 0.0169 0.0169 0.0961	8.28	1.38
	Carabidae Formicidae Coccinellidae	1 5 3	0.06 0.31 0.19	0.0036 0.0961 0.0361	3.03	0.51

T_2	Muscidae Arachnida	3 4	0.19 0.25	0.0361 0.0625		
T_3	Coccinellidae Muscidae Arachnida Formicidae	2 4 4 5	0.13 0.27 0.27 0.33	0.0169 0.0729 0.0729 0.1089	3.68	0.92
T_4	Muscidae Formicidae Coccinellidae Arachnida Staphylinidae	4 5 2 3 4	0.22 0.28 0.11 0.17 0.22	0.0484 0.0784 0.0121 0.0289 0.0484	4.63	0.93
T_5	Carabidae Formicidae Coccinellidae Arachnida Muscidae	2 4 2 3 3	0.14 0.29 0.14 0.21 0.21	0.0196 0.0841 0.0196 0.0441 0.0441	4.73	0.95
T_6	Arachnida Formicidae Coccinellidae Staphylinidae	5 5 3 4	0.29 0.29 0.18 0.24	0.0841 0.0841 0.0324 0.0576	3.87	0.97
T_7	Formicidae Coccinellidae Carabidae Muscidae Arachnida	4 2 1 4 4	0.27 0.13 0.07 0.27 0.27	0.0729 0.0169 0.0049 0.0729 0.0729	4.16	0.83
T_8	Muscidae Formicidae Coccinellidae Arachnida Staphylinidae	3 4 1 1 2	0.27 0.36 0.09 0.09 0.18	0.0729 0.1296 0.0081 0.0081 0.0324	3.98	0.71