EFFECT OF BOTANICALS ON OKRA (*Abelmoschus esculentus* L.) ATTACKING INSECT PEST

NAZMUL HUDA

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

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BY

NAZMUL HUDA

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Approved By:

Prof. Dr. Mohammed Sakhawat Hossain **Supervisor** Department of Entomology Sher-e-Bangla Agricultural University	**Prof. Dr. Md. Abdul Latif** **Co-Supervisor** Department of Entomology Sher-e-Bangla Agricultural University

Dr. S. M. Mizanur Rahman
Chairman
Examination Committee

DEPARTMENT OF ENTOMOLOGY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that thesis entitled, "**EFFECT OF BOTANICALS ON OKRA (*Abelmoschus esculentus* L.) ATTACKING INSECT PEST**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **NAZMUL HUDA, Registration No.12-04857** 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: June, 2018

Dhaka, Bangladesh

Prof. Dr. Mohammed Sakhawat Hossain

Supervisor

Department of Entomology

Sher-e-Bangla Agricultural University

Dhaka-1207

DEDICATED TO

MY

BELOVED PARENTS

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EFFECT OF BOTANICALS ON OKRA (*Abelmoschus esculentus* L.) ATTACKING INSECT PEST

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ABSTRACT

The experiment was conducted in the field of Sher-e-Bangla Agricultural University, Dhaka during the period from mid April to August 2017 to find out the efficacy of different management against different okra pest. The treatments comprised four botanical products. These treatments are T_1 =untreated control ,T_2 = Spraying of Neem oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of 10ml garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The data were recorded on fruit and plant infestation by number, weight and length of individual fruit at early, mid and late fruiting stages; and yield related attributes as well as yield of okra. Spraying of Neem oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval reduced highest aphid infestation at both vegetative (51.1%) and fruiting stages (54.1%). Highest reduction of plant infestation was (80.4%), highest shoot and fruit borer infestation reduction at different fruiting stage was (61.1%), highest jassid infestation at both vegetative and fruiting stages reduction was (47.2%) and (49.2%) respectively, highest white fly infestation at both vegetative and fruiting stages were (59.6%) and (59.8%) respectively. On the other hand it increased length of individual healthy fruit (16%), weight of individual healthy fruit (26.8%), and final yield of okra (41.2%). Considering Benefit Cost Ratio (BCR) and environment aspect, it may be suggested that neem oil may be suitable option than other control.

CHAPTER I

INTRODUCTION

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Okra (*Abelmoschus esculentus* L.) is a polyploidy vegetable. It is belonging to the family Malvaceae. Its chromosome number is 2n = 2x =72 or 144. It is the only vegetable crop in the Malvaceae family (Santos, 2012). It is self-pollinated crop; occurrence of out crossing to an extent of 4 to 19% with the maximum of 42.2% is noticed with the insect assisted pollination (Kumar, 2006). This self-pollinating crop is an example that requires a separation between varieties to maintain purity (Tripathi *et al.*, 2011).

It is an important vegetable crop grown in the tropical and sub-tropical parts of the world (Raju *et al.*, 2008) and commonly known as “lady’s finger or okra” (Anwar *et al.*, 2011). It is a warm season vegetable (Voss and Bell, 2007; Reddy *et al*., 2012) and can tolerant more heat and drought (Phathizwe, 2011).

Okra is native to North Eastern Africa in the area of Ethiopia and Sudan (Santos, 2012). It is cultivated in various tropical, subtropical and Meditterean regions of the world (Kamalpreet *et al.*, 2013). It is age old cultivated crop and extensively disseminated from Africa to Asia, Southern Europe and America and currently grown in many countries.

It is grown for fresh table use or for processing (Voss and Bell, 2007; Reddy *et al.*, 2012), its tender green fruits for consumption as a fried or boiled vegetable (Pradip *et al.*, 2010; Anwar *et al.*, 2011). It is rich source of vitamins and other nutrients for the rural population. It is mainly cultivated for its tender immature fruits, which are largely used as fresh vegetable. Okra fruits contain water (89 g), protein (2-4 g), fat (0.3), carbohydrate (7.6 g), calcium (92 mg), phosphorus (51 mg), iron (0.6 mg) and potassium (249 mg) per gram fresh weight. It is also a rich source of iron and vitamin A, B and C**.**

The fruits have various medicinal properties too. It is useful in fever, chronic dysentery, and irritable states of genitor. It is good for people suffering from renal colic, leucorrhoea, spermatorrhoea, chronic dysentery and general weakness. Due to high iodine content fruits are considered useful for control of goiter. The stem of the plant is used for cleaning of sugarcane juice and for the extraction of fibers in paper mills. Okra is specially valued for its tender and delicious fruits in different part of the country. Moreover, to a limited extent, it is canned, dehydrated to preserve, and also used as in frozen form.

Okra crop is suffering from number of biotic and abiotic factors, including insect pests and diseases (Jiskani, 2006). It is attacked by a number of phytophagous insects, diseases and mites during different growth stages (Gulati, 2006). The most important insect pest of okra crop are Aphid, Jassid, Whitefly, Thrip, Mites Shoot and fruit borer, Whitefly, *Bemisia tabaci* (Genn.). These pests are damaging crop by sucking the sap directly and by transmitting a large number of viral diseases indirectly (Basu, 1995). Jassid found a very damaging sucking insect pest of many crops in the majority areas of the growing countries of the world and has been found damaging many crops in the world. It has been observed that, both adults and nymphs cause damage while sucking sap of plants. Due to sucking, the color becomes grayish or injecting toxic saliva into the plant tissues of okra crops (Crinkling) is the characteristic feature of jassid attack (Lohar, 2001).

Srinivasan *et al.* (1959) reported that the okra shoot and fruit borer is responsible for 40-50% damage of okra fruit in some areas of South East Asian countries. Krishnaiah (1980) observed the attack of fruit borer to the extent of 35% in harvestable fruit of okra. In Madras 40-50% fruit were also found damaged by this pest (Srinivasan and Gowder, 1959). The attack of fruit borer, *Earias vittella* on okra starts 4-5 weeks after the germination both in the kharif and summer seasons. The attacked top tender shoots dry up while flowers, buds and developing fruit fall down pre-maturely. Larvae of *Earias vittella* enter the shoot tips of young plants and bore into fruits. The affected fruits are unfit for human consumption.

The species of Aphididae, Coccidae and Pseudococcidae families such as *Aphid gossypii* (Glover), *Cocci ceriferus* (Fabricius) and *Pseudococci solenopsis* (Tinsley) cause damage to crops by various ways attacking on leaves, steams, fruits and roots (Prishanthini, 2009). Predatory spiders are found effective controlling agent and suggested for controlling jassids (Bukhari *et al*. 2012). The effective method at present for the control of these pests is, however, by the use of synthetic insecticides that are widely used since a long time, but recent investigations have proved that the use of synthetic pesticides is hazardous to human health and have long residual effects. Beside these, the chemicals create harmful effects over the population of predatory spiders, ants and lady bird beetles (Lohar, 2007). The natural bio-pesticides in commercial agriculture and horticulture is being practiced since long to circumvent the problems associated with indiscriminate use of pesticides are earning reputation among the researchers and growers (Kalidhar, 2003).

The bio-pesticides offer desirable alternative derived from animals, plants, bacteria and certain minerals. Bio-pesticides are less toxic to non-targeted natural enemies and generally affect only the target pest (Shukla, 2009). Bio pesticides are effective even in small quantities and often decompose quickly resulting in lower exposures and less effects of pollution problems. The seeds of neem tree (*Azadirachta indica*) have numerous effects on pests and have minimal toxicity to non-target organisms (Blackwell, 1993). The use of botanical products e.g. tobacco extract, neem oil and extract, found cheap and it is in the reach of rural areas people which can be easily collected in rural areas, and also found promising and useful for pest control (Roy, Amin, and Uddin, 2005).

The agriculture workers are highly vulnerable to these pesticides during handling and usage. It was mentioned that two million people became affected and 40,000 died due to insecticide poisoning (Rajput, 2004). Therefore, for controlling over pest it is necessary to go through ecological factors. In this present scenario, people are facing very difficulties to overcome insect pests of crops. Thus, it is need have today that, for controlling pests necessary to acquire best controlling methods which considered safe for human beings as well as environment. By above facts avoid to use most health hazardous insecticides and to use bio control measurements for the betterment of environmental protection. Hence, botanical insecticides, and their essential oils, are among the most efficient botanicals (Regnault-Roger, 1997).

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

• To know the infestation level of Aphid, Jassid, Okra Shoot and Fruit Borer (OSFB) and white fly in okra ecosystem;

• To evaluate the effectiveness of selected four botanical product against Aphid, Jassid, Okra Shoot and Fruit Borer (OSFB) and white fly;

• To find the relationship among different infestation parameters yields attributes and yield of okra.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

In Bangladesh very few works of insect pest management of okra (*Abelmoschus esculentus*) in summer or winter have been done. A short review of the literature available in Bangladesh and elsewhere related to insect pest control of okra is discussed below:

2.1. General review of aphid *(Aphis gossypii)*

Nomenclature:

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Family: Aphididae

Genus: *Aphis*

Species: *Aphis gossypii*

2.1.1. Distribution of Aphid

Aphids originated in the late Cretaceous about 100 million years ago, but the Aphidinae which comprises about half of the 4700 described species and genera of aphids alive today come from their most recent radiation which occurred in the late Tertiary less than 10 Mya.

Wegierek (2017) revealed that aphids are distributed worldwide, but are most common in temperate zones. In contrast to many taxa, aphid species diversity is much lower in the tropics than in the temperate zones.

Berry (1968) reported that they can migrate great distances, mainly through passive dispersal by winds. Winged aphids may also rise up in the day as high as 600 m where they are transported by strong winds.

For example, Hill (2012) stated that the currant-lettuce aphid, *Nasonoviari bisnigri*, is believed to have spread from New Zealand to Tasmania around 2004 through easterly winds.

Margaritopoulos *et al.* (2009) mentioned that aphids have also been spread by human transportation of infested plant materials, making some species nearly cosmopolitan in their distribution.

2.1.2. Host range of okra aphid

2.1.3. Nature of damage

Capinera (2001) revealed that the cotton aphid has a very wide host range with at least 60 host plants being known in Florida and perhaps 700 worldwide. Among cucurbit vegetables, it can seriously affect watermelons, cucumbers, cantaloupes, squash and pumkin. Other vegetable crops attacked include pepper, eggplant, okra,and asparagus. It also affects citrus, cotton and hibiscus.

Direct Damage

Capinera (2007) stated that direct damage to plants occurs from the feeding activity of aphid nymphs and adults. Aphids pierce the plant tissue and extract sap, which results in a variety of symptoms, including decreased growth rates and reduced vigor; mottling, yellowing, browning, or curling of leaves; and wilting, low yields, and plant death. Saliva injected into plants by aphids can cause leaves to pucker, curl, or become distorted. Curled and distorted leaves can protect aphids from natural enemies or applied treatment materials. Aphids feeding on flower buds and fruit can cause malformed flowers or fruit.

Indirect Damage

Natwick *et al.* (2009) revealed that indirect damage can be caused by deposits of honeydew. Honeydew is the sticky, sugary liquid waste produced by aphids as a result of feeding on plant sap. Honeydew can attract other insects, such as ants, that will feed on the honeydew. Ants can aggressively defend aphids (and their honeydew food source) from predators and parasites, and interfere with the control of aphids by natural enemies. Honeydew deposits that accumulate on the plant can also create a growth substrate for sooty molds. Sooty molds are dark fungi comprised of a complex of several fungal species. Sooty mold growth on leaves and other plant parts blocks light and can reduce photosynthesis.

Indirect damage is also caused by the ability of some aphid species to serve as virus vectors. Aphids alone generally do not cause major economic losses in cucurbit crops. However, the viruses transmitted by aphids can cause severe losses. Several mosaic diseases are caused by aphid-transmitted viruses, including cucumber mosaic virus (CMV), watermelon mosaic virus (WMV), zucchini yellow mosaic virus (ZYMV), and papaya ring-spot virus (PRSV). Virus diseases often have distinctive symptoms and result in reduced growth and yield. The symptoms of virus infection include mottling, yellowing or curling of leaves, and stunting of plant growth. Under favorable conditions, these viruses can cause a high rate of crop failure and severe economic losses.

Transmission of virus

Transmission of viruses by aphids is generally of two types: non-persistent and persistent. Aphids acquire non-persistently transmitted viruses after just a few seconds of feeding or probing virus-infected plant tissues with their mouthparts, and can transmit virus to another plant immediately. However, the persistence of the virus in the aphid is very short-lived—only a few minutes. Acquisition of persistently-transmitted viruses requires 10–60 minutes of feeding and, following a 12-hour incubation period, aphids will remain infective for up to their entire life span. In most cases, the green peach aphid and the melon aphid acquire virus by probing or feeding on weeds or other cucurbit crops that are infected. The insects then probe or feed on non-infected crops and transmit the virus. The higher the aphid population, the more rapid the virus spread.

2.1.4. Management of Aphids in Okra

The pest management goal in okra production systems is to design the system so that pests do not find plants, are controlled by natural enemies (biological control), or their damage is kept to a minimum. Vigorous, healthy plants are more able to withstand damage caused by arthropods and disease. Therefore, a “plant positive” (as opposed to “pest negative”) approach to managing the system for beneficial processes and cycles and creating healthy soil and plants, is the foundation of integrated pest management in organic systems.

Cultural Control of Aphids in Okra

A crop rotation plan to proactively manage pests is the foundation of okra production. Rotating between crop families can help minimize crop-specific insect pests. Late-season fields should be planted as far away from existing okra as possible. Later plantings and long-season okra is generally most affected by aphid-transmitted mosaic viruses because aphid populations are higher and virus-infected host plants are more available, resulting in more aphids carrying virus. Weeds such as burdock, pokeweed, and other perennial broadleaf weeds can serve as reservoirs for Cucumber Mosaic Virus and Watermelon Mosaic Virus, and should be eliminated.

Plants should be grown with appropriate soil fertility levels. Excessive nitrogen favors aphid reproduction. Application of less soluble forms of nitrogen, in small portions throughout the season rather than all at once, is less likely to promote aphid infestations.

Plants should be inspected for signs and symptoms of an aphid infestation. Special attention should be given to susceptible plant parts where aphids are most likely to establish, such as the undersides of leaves, stems, and buds or tip growth. Also look for honeydew, sooty mold, leaf yellowing, distortion of leaves and new growth, and cast skins produced by molting nymphs. Locations in the field or greenhouse where aphids are found should be flagged, so that population development can be monitored and management efforts evaluated.

Physical Control of Aphids in okra

Many vegetables are most susceptible to aphid damage during the seedling stage. Older plants are more tolerant of aphid feeding. Losses can be reduced by growing seedlings in a greenhouse or under protective covers, such as floating row cover. Protective covers will also prevent transmission of aphid-transmitted viruses. Check transplants for aphids and remove them before planting or destroy infested plants by dropping the plant or infested plant part in a bucket of soapy water, and dispose of them away from the field.

Biological Control of Aphids on Okra

Biological control by natural enemies (predators, parasitoids, and pathogens) can have a significant impact on aphid populations. Natural enemies can be conserved through refraining from using broad-spectrum pesticides that kill both pest and beneficial insects. Natural enemy populations can be conserved by creating habitats that provide resources (farm scaping). Farm scaping methods include the use of insectary plants, hedgerows, cover crops, and water reservoirs to attract and support populations of beneficial organisms such as insects, spiders, amphibians, reptiles, bats, and birds that parasitize or prey upon insect pests. Keeping dust down also encourages parasitism and predation.

Beneficial insects will be attracted to plants with moderate to heavy aphid infestations. These natural enemies may eat large numbers of aphids but the reproductive capability of aphids may be so great that the impact of the natural enemies will not be enough to keep the aphids at or below acceptable levels. Even if aphid populations are reduced to an acceptable level, if virus is present, it may be spread by the few remaining aphids.

Parasitoids (sometimes called parasites) do not usually eat their hosts directly. Adult parasitoids lay their eggs in, on, or near their host insect. When the eggs hatch, the immature parasitoids use the host as food, ultimately killing the host. The parasitized aphid forms a mummy that appears bloated and tan, light brown, or white. When the weather is warm, the generation time of most parasitoids is quite short.

Chemical Control of Aphids in Okra

Seaman *et al.* (2009) mentioned that products should not be relied upon as a primary method of insect control. Scouting is important for detecting infestations at an early stage. When conditions warrant an application, proper choice of materials, proper timing, and excellent spray coverage are essential.

Only when all non-chemical practices are insufficient to prevent or control crop pests, may a biological or botanical material allowed. Application of broad-spectrum foliar insecticides will also kill beneficial insects, and allow aphid populations to rebound. This is because most aphids are females that don't need to mate to produce new aphids. The reproduction of natural enemies is slower, often requiring time for mating, egg-laying, and egg hatch.

Insecticidal soaps, azadirachtin, and certain oils are acceptable for use in organically grown crops. Rosemary oil is less disruptive of beneficial than soaps and narrow range oils. They require direct contact with the insects and leave no residual effect.

2.2. General review of okra shoot and fruit borer

2.2.1. Nomenclature

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

2.2.2. Distribution of okra shoot and fruit borer

According to Jotwani (1984) *Earias vittella* (Fabricius) is widely distributed.

Hill (1983) recorded that distribution of OSFB in Pakistan, India, Sri Lanka, Bangladesh, Burma (Myanmar), Indonesia, New Guinea and Fiji. This pest is common oriental species found from India and China to North Australia.

Atwal (1976) mentioned North Africa, Pakistan, India, and other countries for widely distribution of okra shoot and fruit borer.

2.2.3. Host range of okra shoot and fruit borer

Gautam and Goswami (2004) stated that okra shoot and fruit borer (*Earias vittella)* feeds on many species of malvaceous plants.

Satpute*et al*. (2002) studied on different hosts of *Earias vittella* and found that okra was most preferred host for the development of the pest, followed by cotton, artificial diet and mesta (*Hibiscus sp.*) based on average minimum pupal period, highest fecundity and maximum pupal and adult weight.

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

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

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

Atwal (1976) mentioned that okra and cotton is the most favorite host of OSFB. Plant species including sonchal (*Malvaparvi flora*), gulkhaira (*Althaea officinalis*), holly hock (*Althaea rosea*) and some other Malvaceous plants are appear to be its alternate hosts. Rahman and Ali (1983) reported that when okra shoot and fruit borer were offered the choice of different parts of host plant they preferred okra fruit and shoot the best followed by cotton balls, ball. Flowers and buds of deshi cotton (*Gossypium arboretum*), buds and flower of kenaf and maize grains, flower of *Abutilon indicum*, flowers of *Hibiscus rosa sinensis*, sarson (*Brassica campestris* var. *sarson*), *Malvastrum tricuspidatum*, *Cassia fistula* and ears of pearl millet, pod of jute and soyabean.

2.2.4. Nature of damage

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

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

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

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

Karim (1992) revealed that the larvae of OSFB bore into the shoots and feed inside and also damage the seed.

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

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

2.2.5 Seasonal abundance of okra shoot and fruit borer

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

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

Srinivasan and Gowder (1959) reported that 40-50% okra fruit were damaged due to attack of this pest in Madras.

In another study Krisnaiah (1980) observed the attack of fruit borer to the extent of 35% in the harvestable fruit of okra.

Rana (1983) observed the pick incidence of shoot and fruit borer of okra was observed in the last week of August with a range of 34 to 45% damage to fruits.

Dhanwan and Sidhu (1984) studied the incidence of *Earias* spp. on okra. They reported that the maximum damage occurred in fruits (67.7%) and buds (52.4%) in late October. The maximum in shoots (1.7%) and flowers (1.5%) occurred in mid-August. In spring, the maximum damage to fruits was 32.04% and increased larval population 1.4/plant was observed in late July. The population of *Earias spp* increased slowly upto mid-September and rapidly thereafter.

Dhamdhere *et al.* (1984) reported 25.9 to 40.9% damage to fruits in October.

Butani and Jotwani (1984) reported that there is no true hibernation but development and activity is considerably slowed down during winter.

Khaliq and Yousuf (1986) also reported the increased incidence of *E. vittella* with the increasing temperature and humidity.

In general, the population of OSFB fluctuates from month to month, season to season, even year to year.

Dash *et al.* (1987) reported that the occurrence and seasonal abundance of noctuid *E. vittella* was maximum in shoots from July to October.

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

Khurana and Verma (1990) observed lower incidence (12.5%) of *E. vittella* during 1983 in a condition having mean maximum and minimum temperature of 34.30 C and 20.50 C, respectively with a mean RH of 73%, frequent rainfall between May and September. But they found comparatively higher incidence (20.5%) of the pest during 1987, in an environment condition with mean maximum and minimum temperatures of 36.3 C and 23.2 C, respectively having a mean RH of 64.8%.

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

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

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

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

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

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

A field experiment was conducted by Sharma *et al.* (2010) to study the fluctuation of pest population of *Earias vittella* (Fab.) and their relation with prevailing weather condition at Horticulture Farm in Udaipur, India during Kharif 2005 and 2006. The results revealed that borer incidence commenced in the 29th standard week. The peak infestation of plants (91.6 %) was observed in 45th standard week. The maximum numbers of larvae (7.5 larvae/l0 plants) were recorded in the 42nd standard week.

Correlation between pest population and important weather parameters showed that *Earias* population was negatively correlated with the mean temperature and mean relative humidity but none significantly and negatively correlated with rainfall in terms of larval population and percentage of infested plants.

2.2.6. Management of okra shoot and fruit borer

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

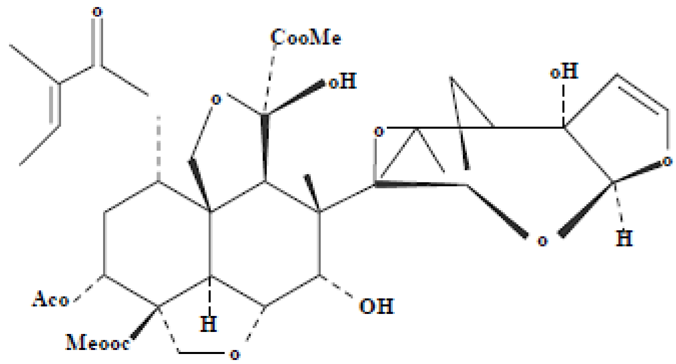

Figure A. Structural formula of azadirachtin

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

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

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

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

George (1997) conducted an experiment and revealed that adult pairs of males and females of *Earias vittella*, a pest of cotton and okra, were released in breeding chambers in different sets, containing the odours of the leaves of neem, *Azadirachta indica*; tulsi, *Ocimum basilicum*; eucalyptus, *Eucalyptus rosfrata*; lantana, *Lantana camara*; bulbs of garlic, *Allium sativum* and one control set with no odour. Adult longevity did not differ significantly among the treatments. All the treatments significantly reduced the egg output as compared to the control (172 eggs). Similarly, all the odours significantfy reduced egg hatching compared to the control (90.81%). The lowest number of eggs (128) and hatching (68.15%) were recorded with *Azadirachta* leaves odor.

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

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

2.3. General review of jassid (*Amrasca devastans*)

Jassid is the major insect pest of different vegetables including okra, which causes significant damage to crop every year. The incidence of this pest occurs sporadically or in epidemic from throughout Bangladesh and affecting adversely the quality and yield of the crop.

2.3.1 Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Sub-phylum: Mandibulata

Class: Insecta

Order: Homoptera

Family: Cicadillidae

Genus: Amrasca

Species: Amras cadevastans

2.3.2. Origin and distribution

Okra Jassid is a versatile and widely distributed insect. It has been recorded in India, China, Pakistan, Iran, Syria, Greece, Spain, Argentina, Brazil and USA. It is distributed widely throughout Eastern, Western, Southern, Central Africa and Australia. This pest is also common in Bangladesh. 2.2.3. Host range: Apart from feeding on okra, the jassid have a very wide range of the host plants, including herbaceous cultivated plants and weeds, chiefly amongst the Malvaceae, Legunmiosae and Solanaceae.

2.3.3. Status and nature of damage okra jassid

Eltom (1978) revealed that *A. devastans is* one of the key insect pests of okra and is the major factor limiting okra yield in Bangladesh.

Bhat et al. (1984) stated that this pest can cause more than 50 percent reduction of seed okra yield in some okra genotypes.

Kochhar (1986) mentioned that the nymphs and adults of this pest can attack okra leaves at all stages of development. Jassid, particularly the older nymphs, feeding on the small veins appear to affect the functioning of the vascular system so that the leaf of edge changes color from dark to pale green, yellow and then red and brown. Adults and nymphs suck plant sap from the under surfaces of leaves. The affected leaves show hopper burn symptoms. The whole leaf of susceptible okra varieties can desiccate and shed. The edge of leaves curl downwards if attacked leaves have not fully expanded. Growth of young plants may be completely stopped. They also introduce a toxin that impairs photosynthesis of okra plants. Due to attack of the jassid, the okra leaves became yellow and curled upward. Then the leaves finally turned brown at the tips and dried up. The heavily infested plants failed to bear fruits and the less damaged plants were found to produce different types of fruits. The deformed fruits when cocked were fibrous and become unfit for consumption.

Eltom (1987) reported that the infested plants remained stunted in the field. The jassid attacked plants are easily identified by presence of globular, translucent, mucilaginous substances. The exudates were present mostly on the under surface of the leaf, a few in the leaf petiole and stem. The jassid damaged the plants at all stages of their growth. The maximum numbers of exudates were found in the younger leaves than in the older ones.

2.3.4. Distribution of okra jassid

Yadav et al. (2007) studied the population dynamics of jassid (*Amrasca devastans*), on okra cv. Azad bhindi-1 in relation to weather factors, during kharif seasons in 2005 and 2006 at Kanpur, Uttar Pradesh, India. Jassid actively started from first week of \august on 3-weekold crop in 2005. In 2006, jassid infestation on shoots started from the fourth week of July on 7 leaf-stage until the third week of September.

Yadav *et al.* (2005) revealed that the maximum population of jassid was observed in 2005 in the second week of September on 8 week-old plants.

Inee and Dutta (2000) reported that the seasonal abundance of jassid, *Amrasca devastans*, on okra was investigated by in Jorhat, Assam, India during 1998-99. Result revealed that meteorological parameters played an important role in the population build up of cotton jassid. The jassid population was maximum in the last week of May in 1998 (37.53 nymphs per leaf) and middle of April in 1999 (30.00 nymphs per leaf).

Yadav *et al.* (2004) mentioned that high temperature (30-36 degree C), evening relative humidity (bellow 80%) and low rainfall period with bright sunshine hours favored the development of jassid population.

Kumawat *et al.* (2000) investigated the seasonal incidence of jassid (*Amrasca devastans*) on Okra during kharif 1996 in the semi-arid region of Rajasthan, India. The infestation of jassid started in the fourth week of July and reached in peak in the second and fourth weeks of September, respectively.

Mahmood *at el.* (1990) studied the abundance of the Cicadellidae, *Amrasca devastans* on okra in Pakistan during 1986-1987. The pest appeared in June and remained active until the end of crop season. Among various environmental factors the only significant factor in both years of the study was temperature. A positive correlation was found between maximum and minimum temperature with regarding to density of the pest. Neither relative humidity nor rainfall significantly increased or decreased the pest population.

In another study, Mahmood *at el.* (1988) reported that phonology of the Cicadillidae, *Amrasca devastans* on okra in Pakistan. The population of the pest remained below the economic threshold level for about 5 weeks after germination of the okra crop. The population then crossed over the threshold level in early June and remained at the same level until late August. The population of the pest peaked in late July (27.8 individuals per leaf).

Senapati and Khan (1978) reported that the largest population of okra jassid occurred from November to February.

Pawar *et al.* (1996) showed that the crop sown on 15th May and 1st June had a lower incidence of *Amrasca devastans* with a good yield of marketable fruits (22.9 q/ha).

Atwal *et al.* (1969) reported that the population reached its peak in August and September ranged between 28.2-30 ℃ .

Ali and Karim (1991) conducted an experiment in 3 consecutive kharif and rabi seasons in Joydebpur, Bangladesh to investigate the influence of plant age on the abundance of *Amrasca devastans*. Cicadellid populations remained below the economic threshold level of one insect/leaf for up to 35 days of plant age in khraif and 65 days of plant age in rabi. Most of the cicadellids were found in 35 to 75 days old plants in kharif and 65 to 130 days old plants in rabi season.

Yadav *et al.* (2008) revealed that plants growth in the kharif season was more vulnerable to insect attack than plant grown in the rabi season.

Tomar and Rana (1994) reported that among the sowing dates, 20 February and 5 march for spring sow in and 2 April and 5 June for rainy season sowing gave the least incidence of *Amrasca devastans* nymphs.

2.3.5. Management of Okra Jassid

Botanical Control:

Hugar *et al.* (1990) revealed that spraying of neem oil, neem seed, neem leaf extract, neem seed kernel extract against jassid, whiteflies, thrips and aphids was very effective. In addition to this many plant products like *Annona squamosa* L., *Chrysanthemum* spp. and *Rotenone* spp. were used as insect repellents and antifeedants in managing the pests attacking many crops.

Kanvarjibhai (1993) experimented with the extract prepared by using, neem, green chilli and garlic which is mixed with water in the proportion of 1:2 and sprinkled over many crops infested by Jassid and other aphid. He observed the consistent efficacy of the mixture for more than five years.

Thomas (1994) found that hot water extract of highly pungent chilli along with few bits of asafetida (the brownish gum resin of various plants; has strong taste and odor;

formerly used as an antispasmodic) to be quite effective against leafhopper and mite pests. Garlic bulbs were (200 g) crushed and soaked in kerosene (200 ml) for 24 h and then mixed with ground chilli (25 g) along with 10 ml of soap solution. When 20 ml of the extract was diluted in one liter of water and sprayed on the crops gave good control of the Jassid.

Chemical control

Kumar *et al.* (1998) evaluated the critical time of insecticidal application for control of *Amrasca devastans* on okra was investigated in Karnatak, India. Application of insecticide 21-42 days after germination resulted in the lowest infestation of both pests and the highest benefit-cost ratio.

Babu and Santaram (2000) reported that the effect of imidacloprid 200 SL persisted for 23 days against aphids, 31 days against leafhopper in chilli ecosystem.

Verma (2001) tested Sumithion 50 EC, Lindane, endosulfun (Thiodan 35 EC), methyl-Odemton, monocrotophose (Azodrin 400) and some others chemical against cicadellid *Amrasca devastans* on okra in the field in India. He recommended 50% mortality concentration within 4.0 days.

Atachi and Sourkou (1989) revealed that a schedule of insecticide sprays using sumithion 50 EC and systoate 400 on 35, 45, 55 and 65 days after planting was investigated in Benin to determine the most effective treatment. Application of sumithion 50 EC, malathion 8F, quinalphos 25 EC or monocrotophos or endosulfan 35 EC one at flowering and then at pod setting stage would be highly effective. However, at lower infestation, insecticide application would not be economically advisable.

Rana *et al.* (2006) conducted experiments during kharif 2003 and 2004, in Karnal, Haryana, India, showed that admire 200SL at 2 ml as well as thiamethoxam and carbosulfan each at 2g/kg seed were quite effective in controlling jassid and whitefly. Okra seed yield was higher in treatments. And it was cost effective and minimized quantity of insecticide in a very significant level.

Gandhi *et al.* (2006) showed that insecticidal seed treatment is an alternative method to spray and granular applications.

Lal and Sinha (2005) carried out investigation to evaluate four (5, 9, 18, 36, g/kg) doses of Admire (imadacloprid) treatments against sucking pests of okra. Studies revealed that seeds yield of all the treatments, except highest dose (36g/kg) of Admire treatment gave excellent results.

Dey *et al.* (2005) conducted filed experiment during the 1998 and 1999 to evaluate the efficacy of imidacloprid 70WS, Admire 200SL, against jassid, *Aphis gossipy* and *Bemisia tabaci* of okra and their natural enemies. Admire 20SL was applied as foliar spray at 20 and 40 days after sowing. It was effective against jassid and others sucking pests Anoh, (2005) conducted an experiment to control jassid population on lady's finger and found that admire 200 SL had significant effect in controlling jassid.

2.4 General review of whitefly

Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Sub order: Sternorrhyncha

Superfamily: Aleyrodoidea

Family: Aleyrodidae

Genus: *Bemisia*

Species: *Bemisia tabaci*

2.4.1 Origin and Distribution of whitefly

Gennadius (1889) revealed that okra whitefly (*Bemisia tabaci* Genn.) is the most important insect pest of okra in Bangladesh and acts as the vector of Okra yellow vein clearing mosaic virus (OkYVCMV) on okra. *Bemisia tabaci* was first described in 1889 as a pest of tobacco in Greece and named as *Aleyrodes tabaci*, the tobacco whitefly.

Cock (1986) stated that from 1926 to 1981, *B. tabaci* was reported as sporadic pest and was the most important vector of plant viruses in subtropical, tropical and temperate zones where winters are mild enough to permit year round survival.

However, Brown *et al.* (1995) mentioned that whitefly related problems have historically occurred after the introduction of intensive cropping regimes that require relatively high inputs of fertilizers and pesticides.

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

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

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

2.4.2. Host range of whitefly

Greathead (1986) revealed that the sweet potato whitefly has an extremely wide host range. It attacks more than 500 species of plants from 63 plant families.

Mau and Tsuda (1991) reported that in Hawaii, the sweet potato whitefly has been found on the following crop plants: annona (cherimoya, atemoya, sugarapple), avocado, broccoli, cauliflower, Chinese cabbage, Chinese wax gourd, cucumber, *Dendrobium* (flowers), edible gourds, eggplant, fig, green bean, guava, hibiscus, hyotan, lettuce, luffa, plumeria, poinsettia, pumpkin, rose, soy bean, squash, sweet potato, togan, tomato, ung-choi, watermelon, yard long beans and zucchini. Although not yet reported in the state, other crop hosts include cabbage, chrysanthemum, beans, bitter melon, dishrag squash, pepper, pea, and radish.

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

2.4.3. Nature of damage

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

Berlinger (1986) reported that whitefly, *B. tabaci* damaging the plants in three means that were as discussed below:

2.4.4. Direct damage

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

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

2.4.5. Indirect damage

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

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

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

2.4.6. Transmission of virus

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

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

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

2.4.7. Management of whitefly by botanicals

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

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

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

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

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

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

Similarly, in a field trial, Ahmad *et al.* (1995) observed the ovipositional deterrence of neem oil against *B. tabaci* on cotton.

Srinivasamurthy and Sharma (1997) reported some of the traditional pest management practices followed by farmers to manage whiteflies infesting cotton. Neem oil (2%), castor seed oil (5%), *Madhuca latifolia* (J. F. Gmel.) oil (0.5%), tobacco leaf extract

(0.5%), fish oil rosin soap (0.2%) and nicotine sulphate (0.2%) helped to reduce the pesticide dumping in cotton ecosystem.

As reported by Singh *et al.* (1999), spraying neem seed extract (5%) and neem oil (5%) resulted in considerable reduction of whitefly population on cotton.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1. Location of the experimental plot

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from mid April to August 2017. The site is 230 46’ N and 900 24’ E Latitude and at Altitude of 9m from the sea level.

3.2. Characteristics of soil

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

3.3. Climate

The climate of the experimental site is sub-tropical characterized by heavy rainfall during April to July and sporadic during the rest of the year. The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to September, 2017) and scantly in the Rabi season (October to March, 2017). The average maximum temperature during the period of experiment was 37.8 °C and the average minimum temperature was 19 °C. Details of the meteorological data in respect of temperature, rainfall and relative humidity the period of the experiment were collected from Bangladesh Meteorological Department, Agargaon, Dhaka- 1207, Dhaka and have been presented in (Appendix II).

3.4. Design and layout of the experiment

The study was conducted with five treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD). The field was divided into 20 equal sub plots maintaining 1m x 5.5 m plot size, 1 meter block to block distance. 0.5 meter plot to plot distance, where each block was used for each replication and each treatment was randomly assigned in each plot.

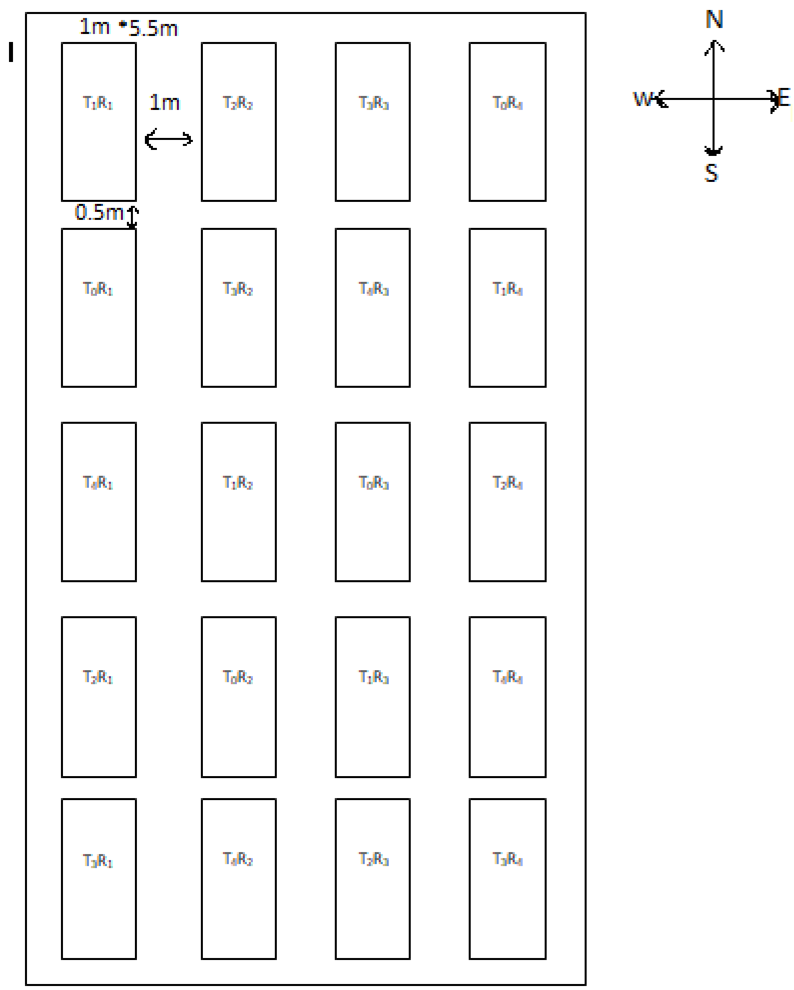

Plate1: Layout of okra field

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

3.5. Land preparation

The selected land for the experiment was first opened on 27th March 2017 by power tiller and expose to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and laddering to obtain good tilth followed each ploughing. The stubbles of the crops and uprooted weeds were removed from the field and the land was properly leveled. The field layout was done on accordance to the design, immediately after land preparation.

3.6. Manure and fertilizer application

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

Table 1. Doses of manures and fertilizer and their methods of application used for this experiment

Manure/Fertilizer	Dose per ha (kg)	Basal (kg/ha)	Top dressing(kg/ha)	
			First*	Second**
Cow dung	5000	Entire amount	-	-
Urea	150	50	50	50
TSP	120	Entire amount	-	-
MP	110	Entire amount	-	-

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

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

3.7. Collection and sowing of seeds

Seeds of okra (Choice) were collected from Siddik bazaar Dhaka. The seed company name was Lal Teer Seed Ltd. Seeds were sown in the experimental plots on 19 April, 2017 at the rate of 72 seeds/plot (three seeds per pit and 24 pits per plot).

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

The field was irrigated lightly immediately after sowing.

Plate 2: Sowing of okra seeds

3.8. Intercultural operations

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

3.9. Inter-Cultural practices

3.9.1. Gap filling

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

3.9.2. Thinning

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

3.9.3. Irrigation

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

Plate 3: Watering the okra field

3.9.4. Drainage

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

3.10. Harvesting

As the seeds were sown in the field at times, the crops were harvested at different times. Green pods were harvested at four days interval when they attained edible stage. Green pod harvesting was started from 27 May and was continued up to 11 August, 2017.

3.11. Treatments

The comparative effectiveness of the following five treatments for okra insect complex were evaluated on the basis of reduction of the pest.

T_1 =untreated control

T_2 = Spraying of Neem oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval;

T_3 = Spraying of 10ml garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval;

T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval;

T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval

Note: The botanicals were collected from hatkhola bazaar, Dhaka

3.12. Application of the treatments

Spraying was done at 12.00 pm to avoid moisture on leaves. The selected botanicals with their assigned doses were started to apply in their respective plots after 45 days of germination. Treatments were applied at 7 days interval. Spraying was done by knapsack sprayer having a pressure of 4.5 kg/cm^2. To get complete coverage of plant spraying was done uniformly on the entire plant with special care. In case of untreated control, nothing was sprayed for respective plots.

Plate 4: Application of the treatments on okra plants

3.13. Data collection

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

3.14. Collection of data on yield and yield contributing character

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

3.15. Data recorded

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

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

Yield contributing characters

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

3.16.1. Method of recording percent infestation of shoots and fruits

3.16.1.1. Shoot infestation

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

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

3.16.1.2. Fruit infestation

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

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

3.16.2. Percent of fruit infestation

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

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

3.16.3. Weight of single fruit

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

3.16.4. Yield per hectare

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

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

3.17. Statistical analysis of data

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance (ANOVA) was done with the help of computer package Statistix 10. The treatment means were separated by Least Significant Difference (LSD) test.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was done in the research field of Sher-e-Bangla Agricultural University, Dhaka. It was conducted during Kharif I 2017 to find out the efficacy of four botanicals insecticides applied against major insect pest of okra. The results of the present study have been interpreted and discussed under the following sub-headings:

4.1. Efficacy of different Botanicals against Aphid infesting okra at the vegetative stage

The effect of selected treatments against is presented in the table 2. Highest percent infestation (17.7%) was observed in T_1 (untreated control) treatment which was closely followed by T_5 (15.8%) and T_4 (14.6%) treatments respectively. On the other hand the lowest percent of infestation (8.7%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_3 (13.8%) treatment (spraying of 4ml/L water mix with 10ml of garlic oil sprayed at 7 days interval).

In T_2 treatment vegetative infestation percentage over control was estimated the highest value (51.1%) and lowest value (10.7%) from T_5 treatment (Table 2). From the findings it was revealed that T_2 performed the lowest percentage of infestation at the vegetative stage. Whereas in control treatment (T_1) the situation was reverse.

Table 2: Efficacy of different Botanicals against Aphid infesting okra at the vegetative stage

Treatments	% of vegetative stage infestation			Mean	% reduction over control
	At 1st spray	At 2nd spray	At 3rd spray		
T_1	17.4 a	18.1 a	17.6 a	17.7 a	0
T_2	7.1 c	9.3 c	9.6 b	8.7 d	51.1
T_3	13.7 b	13.6 b	14.1 a	13.8 c	22.1
T_4	14.6 ab	14.4 b	14.8 a	14.6 bc	17.5
T_5	15.7 ab	15.9 ab	15.9 a	15.8 b	10.7
CV (%)	11.5	7.3	13.8	5.6	_
LSD (5%)	3.6	2.4	4.5	1.8	_

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

4.2. Efficacy of different Botanicals against Aphid infesting okra at the Fruiting stage

The effect of selected treatments against is presented in the table 3. Highest percentage infestation (10.3%) was observed in T_1 (untreated control) treatment which was closely followed by T_5 (7.9%) and T_4 (7.1%) treatments respectively. On the other hand the lowest % of infestation (4.7%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_3

(6.4%) treatment (spraying of 4ml/L water mix with 10ml of garlic oil sprayed at 7 days interval).

Table 3: Efficacy of different Botanicals against Aphid infesting okra at the Fruiting stage

Treatments	% of fruiting stage infestation			Mean	% reduction over control
	Days after third spray				
	At 1st spray	At 2nd spray	At 3rd spray		
T_1	9.4 a	9.8 a	11.6 a	10.3 a	0
T_2	4 c	4.9 c	5.1 d	4.7 e	54.1
T_3	6.2 b	6.8 b	6.2 cd	6.5 d	37.3
T_4	6.7 b	7.2 b	7.1 bc	7.1 c	31.7
T_5	7.3 b	8.1 b	8.5 b	7.9 b	22.8
CV (%)	10.7	7.8	9.3	3.2	-
LSD (5%)	1.6	1.3	1.6	0.5	-

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

[T1 =untreated control T2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

In T_2 treatment vegetative infestation percentage over control was estimated the highest value (54.1%) and lowest value (22.8%) from T_5 treatment (Table 3). From the findings it was revealed that T_2 performed the lowest % of infestation at the vegetative stage. Whereas in control treatment (T_1) the situation was reverse.

In the year of 2009 Seaman *et al.* recommended the insecticidal soaps, azadirachtin, and certain oils as acceptable for use in organically grown crops. Rosemary oil is less disruptive of beneficial than soaps and narrow range oils. They require direct contact with the insects and leave no residual effect.

Plate 5. Okra flower showing infestation symptom caused with Aphid

4.3. Efficacy of different botanicals against okra shoot and fruit borer (OSFB) throughout the growing period

The effect of selected treatments against is presented in the table 4. Highest % plant infestation (16.9%) was observed in T_1 (untreated control) treatment which was closely followed by T_3 (8.7%) and T_5 (8.1%) treatments respectively. On the other hand the lowest % of plant infestation (3.3%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_4 (6.7%) treatment (spraying of 4ml/L water mix with 10ml of black seed oil sprayed at 7 days interval).

In T_2 treatment vegetative infestation percentage over control was estimated the highest value (80.4%) and lowest value (52.4%) from T_5 treatment (Table 4). From the findings it was revealed that T_2 performed the lowest % of plant infestation. Whereas in control treatment (T_1) the situation was reverse.

Table 4: Percent plant infestation by number throughout the growing period of Okra by Okra shoot and fruit borer during the management of okra Insect pest by botanicals

Treatments	% plant infestation by number					%reduction over control
	45 DAS	52 DAS	66 DAS	73 DAS	Mean	
T_1	10.7 a	16.7 a	19.2 a	21.0 a	16.9 a	0.00
T_2	1.9 b	1.9 b	3.3 c	6.0 b	3.3 b	80.4
T_3	4.9 ab	6.5 b	11.7 ab	11.7 ab	8.7 b	48.4
T_4	2.8 ab	4.193 b	9.2 bc	10.3 b	6.6 b	60.5
T_5	5.6 ab	6.942 b	9.442 bc	10.692 b	8.0 b	52.4
CV (%)	73.1	57.1	31.6	35.8	35.7	
LSD (5%)	8.6	9.3	7.5	9.6	7.1	

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

4.4. Efficacy of different Botanicals against okra shoot and fruit borer (OSFB) at different fruiting stage

The effect of selected treatments against is presented in the table 5. Highest % infestation (11.5%) was observed in T_1 (untreated control) treatment which was closely followed by T_4 (7.4%) and T_5 (7.3%) treatments respectively. On the other hand the lowest % of infestation (4.4%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_3 (5.9%) treatment (spraying of 4ml/L water mix with 10ml of garlic oil sprayed at 7 days interval).

In T_2 treatment fruit infestation percentage over control was estimated the highest value (61.1) and lowest value (35.7%) from T_4 treatment (Table 5). From the findings it was revealed that T_2 performed the lowest % of fruit infestation. Whereas in control treatment (T_1) the situation was reverse.

Similar study was carried out by Misra in 1989 and he revealed that percent shoot infestation in insecticide treated plots varied from 1.74- 10.03% compared to 15.23% in untreated control plots. Again George (1997) conducted an experiment and stated that adult pairs of males and females of *Earias vittella*, a pest of cotton and okra, were released in breeding chambers in different sets, containing the odours of the leaves of neem, *Azadirachta indica*; tulsi, *Ocimum basilicum*; eucalyptus, *Eucalyptus rosfrata*; lantana, *Lantana camara*; bulbs of garlic, *Allium sativum* and one control set with no odour. Adult longevity did not differ significantly among the treatments. All the treatments significantly reduced the egg output as compared to the control (172 eggs). Similarly, all the odours significantfy reduced egg hatching compared to the control (90.8%). The lowest number of eggs (128) and hatching (68.1%) were recorded with *Azadirachta* leaves odor. Moreover, Ambekar *et al.* (2000) evaluated the efficacy of neem-based formulations and synthetic insecticides against okra shoot and fruit borer. They found that all treatments significantly reduced fruit borer infestation over the untreated control. However, cypermethrin at 0.1% was the most effective and recorded the lowest infestation of 6.5%.

Table 5: Efficacy of different Botanicals against Okra shoot and fruit borer infesting at different fruiting stage

Treatments	% fruit infestation				% reduction over control
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	
T_1	11.4 a	11.8 a	12.9 a	11.5 a	0
T_2	2.9 b	4.7 b	5.7 b	4.4 b	61.1
T_3	4.8 ab	6.6 ab	6.4 b	5.8 b	49.0
T_4	6.5 ab	7.5 ab	8.0 ab	7.4 b	35.7
T_5	5.9 ab	7.9 ab	8.0 ab	7.2 b	36.7
CV (%)	55.7	36.2	29.7	19.9	-
LSD (5%)	7.9	6.3	5.5	3.3	-

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

Plate 6. Healthy Okra plants, flower and fruits

Plate 7. Okra fruit showing infestation symptom caused with OSFB larvae

4.5. Efficacy of different Botanicals against Jassid infesting okra at the vegetative stage

The effect of selected treatments against is presented in the table 6. Highest percent infestation (22.1%) was observed in T_1 (untreated control) treatment which was closely followed by T_5 (17.3%) and T_3 (16.1%) treatments respectively. On the other hand the lowest percentage of infestation (11.6%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_4 (15.7%) treatment (spraying of 4ml/L water mix with 10ml of black oil sprayed at 7 days interval).

Table 6: Efficacy of different Botanicals against Jassid infesting okra at the vegetative stage

Treatmens	% infestation at vegetative stage			Mean	% reduction over control
	1st spray	2nd spray	3rd spray		
T_1	20.6 a	21.9 a	23.7 a	22.1 a	0
T_2	9.8 c	11.4 c	13.7 b	11.6 c	47.2
T_3	14.4 b	15.7 bc	18.383 a	16.1 b	26.8
T_4	15.3 b	15.6 bc	16.2 ab	15.7 bc	28.8
T_5	16.9 ab	17.3 ab	17.7 ab	17.3 b	21.4
CV (%)	12.2	15.4	20.2	10.9	-
LSD (5%)	4.2	5.7	8.1	4.1	-

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

In T_2 treatment infestation percentage over control was estimated the highest value (47.22) and lowest value (21.42%) from T_5 treatment (Table 6). From the findings it was revealed that T_2 performed the lowest % of fruit infestation. Whereas in control treatment (T_1) the situation was reverse.

4.6. Efficacy of different Botanicals against Jassid infesting okra at the Fruiting stage

The effect of selected treatments against is presented in the table 7. Where is highest percent infestation (17.7%) was observed in T_1 (untreated control) treatment which was closely followed by T_5 (14.2%) and T_4 (12.7%) treatments respectively. On the other hand the lowest % of infestation (9.2%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_3 (12.6%) treatment (spraying of 4ml/L water mix with 10ml of garlic oil sprayed at 7 days interval).

In T_2 treatment infestation percentage over control was estimated the highest value (49.22) and lowest value (20.41%) from T_5 treatment (Table 7). From the findings it was revealed that T_2 performed the lowest % of fruit infestation. Whereas in control treatment (T_1) the situation was reverse.

Table 7: Efficacy of different Botanicals against Jassid infesting okra at the Fruiting stage

Treatments	% infestation at fruiting stage			Mean	% reduction over control
	Days after third spray				
	1	5	10		
T_1	17.8 a	17.7 a	17.6 a	17.7 a	0
T_2	8.9 b	10.0 b	8.7 b	9.2 c	49.2
T_3	13.6 a	13.1 ab	11.1 b	12.6 bc	29.4
T_4	14.1 a	12.2 b	12.1 ab	12.7 bc	28.6
T_5	15.3 a	13.6 ab	13.6 ab	14.2 ab	20.4
CV (%)	13.8	15.1	20.0	12.7	-
LSD (5%)	4.3	4.5	5.7	3.8	-

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

Hugar *et al.* conducted an experiment in 1990 and revealed that spraying of neem oil, neem seed, neem leaf extract, neem seed kernel extract against jassid, whiteflies, thrips and aphids was very effective. In addition to this many plant products like *Annona squamosa* L., *Chrysanthemum* spp. and *Rotenone* spp. were used as insect repellents and antifeedants in managing the pests attacking many crops. Again, Kanvarjibhai (1993) experimented with the extract prepared by using, neem, green chilli and garlic which is mixed with water in the proportion of 1:2 and sprinkled over many crops infested by Jassid and other aphid. He observed the consistent efficacy of the mixture for more than five years. Thomas (1994) found that hot water extract of highly pungent chilli along with few bits of asafetida (the brownish gum resin of various plants; has strong taste and odor; formerly used as an antispasmodic) to be quite effective against leafhopper and mite pests. Garlic bulbs were (200 g) crushed and soaked in kerosene (200 ml) for 24 h and then mixed with ground chilli (25 g) along with 10 ml of soap solution. When 20 ml of the extract was diluted in one liter of water and sprayed on the crops gave good control of the Jassid.

Plate 8. Okra leaves showing infestation symptom caused with Jassid

4.7. Efficacy of different Botanicals against whitefly infesting okra at the vegetative stage

The effect of selected treatments against is presented in the table 8. Where is highest percent infestation (11.7%) was observed in T_1 (untreated control) treatment which was closely followed by T_5 (8.9%) and T3 (7.9%) treatments respectively. On the other hand the lowest percentage of infestation (4.7%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_4 (12.4%) treatment (spraying of4ml/L water mix with 10ml of black seed oil sprayed at 7 days interval).

Table 8: Efficacy of different Botanicals against Whitefly infesting okra at the vegetative stage

Treatments	% infestation at vegetative stage			Mean	% reduction over control
	1st spray	2nd spray	3rd spray		
T_1	11.9 a	12.8 a	10.3 a	11.7 a	0
T_2	4.8 c	3.7 c	5.5 a	4.7 c	59.6
T_3	7.9 bc	7.2 bc	8.6 a	7.9 bc	32.1
T_4	8.5 ac	7.5 bc	6.2 a	7.4 bc	36.5
T_5	9.1 ab	9.1 b	8.8 a	8.9 ab	23.4
CV (%)	19.9	20.8	35.5	18.9	-
LSD (5%)	3.8	3.8	6.3	3.4	-

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

In T_2 treatment infestation percentage over control was estimated the highest value (59.6%) and lowest value (23.4%) from T_5 treatment (Table 8). From the findings it was revealed that T_2 performed the lowest % of fruit infestation. Whereas in control treatment (T_1) the situation was reverse.

4.8. Efficacy of different Botanicals against Whitefly infesting okra at the Fruiting stage

The effect of selected treatments against is presented in the table 9. Where is highest % infestation (10.8%) was observed in T_1 (untreated control) treatment which was closely followed by T_5(8.3%) and T_4(7.1%) treatments respectively. On the other hand the lowest % of infestation (4.3%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_3 (6.7%) treatment (spraying of4ml/L water mix with 10ml of garlic oil sprayed at 7 days interval).

Table 9: Efficacy of different Botanicals against Whitefly infesting okra at the Fruiting stage

Treatments	% infestation at fruiting stage			Mean	% reduction over control
	Days after third spray				
	1st spray	2nd spray	3rd spray		
T_1	8.9 a	11.1 a	12.4 a	10.8 a	
T_2	3.2 b	4.6 b	5.1 b	4.3 b	59.8
T_3	5.8 ab	6.6 ab	7.8 ab	6.7 ab	37.3
T_4	7.2 a	6.2 ab	7.7 ab	7.1 ab	34.7
T_5	8.8 a	8.4 ab	7.8 b	8.3 ab	22.5
CV (%)	25.8	33.3	31.4	25.8	
LSD (5%)	3.9	5.5	5.8	4.3	

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

In T_2 treatment infestation percentage over control was estimated the highest value (59.8%) and lowest value (22.5%) from T_5 treatment (Table 9). From the findings it was revealed that T2 performed the lowest % of fruit infestation. Whereas in control treatment (T_1) the situation was reverse.

In 2001, Rosaiah reported that neem oil 0.5% was significantly superior in reducing the whitefly population and shoot and fruit borer damage on okra followed by NSKE (5%). Again, Jayaraj *et al.* (1986) reported that NSKE (5%) and neem oil (5%) caused 93.7 and 90.3 per cent mortality of nymphal stage of *B. tabaci* at seven days after spraying, respectively. Similarly as reported by Natarajan *et al.* (1986), *B. tabaci* population was suppressed effectively by neem oil (0.5%) when the pest population was 5 to 10 per leaf. According to Nandihalli *et al.* **(**1990) two neem products, Neemax and Neem guard (3 ml/l) when combined with sub-lethal dose of monocrotophos (0.086%) gave effective control of nymphal and adult population of *B. tabaci* on cotton followed by application of NSKE (5%) and neem seed oil (5%). The efficacy was on par with insecticides like monocrotophos (0.1%) and phosphamidon (0.1%). Patel *et al.* (1994) conducted an experiment and revealed that the effectiveness of a neem based product, Neemax as ovipositional deterrent was tested in the lab against *B. tabaci* on cotton in Gujarat. Only 30.39 eggs/plant were deposited on plants treated with (0.5%) Neemax as against 62.61 eggs/plant in case of control plants.

Plate 9: Okra leave showing yellow mosaic virus disease symptom which is caused by whitefly

4.9. Efficacy of different Botanicals on Individual fruit length and Individual fruit weight

From table 10 we can get individual fruit size is highest in case of treatment T_2 (16.1 cm) followed by T_5 control (14.3 cm). T_1 treatment is cause of lowest individual fruit size 12.9 cm followed by T_4 (13.7) is the second lowest treatment. In case of individual fruit weight is highest in case of treatment T_2 (26.8 g) followed by T_4 control (25.1 gm). T_5 (22.9 g) treatment is cause of lowest individual fruit size followed by T_1 (23.9) is the second lowest treatment.

Table 10: Efficacy of different Botanicals on Individual fruit length and Individual fruit weight

Treatments	Individual Fruit size (cm)	Individual Fruit weight (g)
T_1	12.9	23.9
T_2	16.1	26.8
T_3	13.8	24.1
T_4	13.7	25.1
T_5	14.3	22.9
CV (%)	4.1	3.8
LSD (5%)	1.3	2.1

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

Plate 10: Harvested healthy okra fruits

Plate 11: Infested Okra fruits

4.11. Average yield of okra for different management practices

In Table 12 we can get that individual fruit weight is highest in case of treatment T_2 (4.9 kg/plot) followed by T_3 control (4.4 kg/plot). T_1 (3.5 kg/plot) treatment is cause of lowest individual fruit size followed by T_5 (3.7 kg/plot) is the second lowest treatment.

Table 11: Average yield of okra for different management practices

Treatments	Fruit yield (kg/plot)	% increase over control
T_1	3.5 c	0
T_2	4.9 a	41.2
T_3	4.4 b	27.3
T_4	4.3 b	25.2
T_5	3.7 c	5.7
CV (%)	4.9	-
LSD (5%)	0.4	-

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

[T_1 =untreated control T_2 = Spraying of Neem oil 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Spraying of garlic oil@ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_4 = Spraying of 10ml black seed oil @ 4 ml/Litre of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_5 = Spraying of turmeric powder @ 200g/L of water at 7 days interval]

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

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

To control okra aphid, in term of percent infestation at the vegetative and fruiting stage, the lowest percentage of infestation (vegetative 8.6% and fruiting 4.7%)) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment. The rank order of different management practices in terms of present aphid infestation reduction both vegetative and fruiting stage was T_2 (Neem oil)> T_3 (Garlic oil)>T_4 (Black seed oil)> T_5 (turmeric powder)>T_1 (untreated control).

The lowest percentage of plant infestation (3.3%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment which was closely followed by T_4 (6.6%) treatment (spraying of 4ml/L water mix with 10ml of black seed oil sprayed at 7 days interval).The rank order of different management practices for plant infestation reduction was T_2 (Neem oil)> T_4 (black seed oil)> T_5 (turmeric powder)> T_3 (garlic oil) >T_1 (untreated control).

In case of okra shoot and fruit borer, lowest percentage of infestation at different fruiting stage was observed in T_2 (4.4%) (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment. The rank order of different management practices in terms of present okra shoot and fruit borer infestation reduction at different fruiting stage was T_2 (Neem oil)> T_3 (Garlic oil)> T_5 (Turmeric powder)> T_4 (Black seed oil)>T_1 (untreated control).

In term of percent jassid infestation at the vegetative and fruiting stage, the lowest percentage of infestation (vegetative 11.6% and fruiting 9.2%) was observed in T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment. The rank order of different management practices in terms of present jassid infestation reduction at vegetative stage T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval)and at fruiting stage was T_2 (Neem oil)> T_3 (Garlic oil)> T_4 (Black seed oil)> T_5 (turmeric powder) >T_1 (untreated control).

For whitefly infestation both at vegetative and fruiting stage, T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) was showed the lowest infestation level and at percent level they were 4.7% and 4.3% respectively. The rank order of white fly infestation reduction both at vegetative and fruiting stage T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval).

For highest fruit size an, weight with total weight, T_2 (spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval) treatment was the most effective management practice for every aspect.

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

Spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval reduced highest aphid infestation at both vegetative 51.1% and fruiting stages 54.1%, highest reduction of plant infestation was 80.4%, highest shoot and fruit borer infestation reduction at different fruiting stage was 61.1%, highest jassid infestation at both vegetative and fruiting stages reduction was 47.2%and 49.2%, highest white fly infestation at both vegetative and fruiting stages were 59.6%and 59.8%. On the other it increased length of individual healthy fruit (16.1%), weight of individual healthy fruit (26.8%), and yield of okra (41.2%).

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

- Spraying of 4ml/L water mix with 10ml of neem oil sprayed at 7 days interval may be recommended as an effective control measure applied against aphid, Okra Shoot and Fruit Borer (OSFB), jassid and whitefly infested okra.

- More botanicals with their derivatives should be included in further elaborative research for controlling aphid, Okra Shoot and Fruit Borer (OSFB), jassid and whitefly.

CHAPTER VI

REFERENCES

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APPENDICES

Appendix I. Physiological properties of the initial soil

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

Appendix II: Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from April 2017 to August, 2017

Months	Temperature		Average Relative humidity (%)	Rainfall (mm) (Total)
	Maximum	Minimum		
April	36 °C	19 °C	75	175
May	37.8 °C	24.4	71	255
June	33.8	26.2	81	370
July	33.1	26.5	79	415
August	32.3	26.2	83	413
September	32.0	26.5	76	298

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