EVALUATION OF SOME CHEMICAL INSECTICIDES IN CONTROLLING MAJOR INSECT PESTS OF OKRA (*Abelmoschus esculentus*)

By

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DECLARATION

I do hereby declare that this thesis entitled "Evaluation of some chemical insecticides in controlling major pests of okra (*Abelmoschus esculentus*)" has been written and composed by myself with my own investigated research data.

I further declare that this thesis has not been submitted anywhere in any form for any academic degree.

December, 2006 **(Sabera Yasmin)**

CERTIFICATE

This is to certify that thesis entitled "Evaluation of some chemical insecticides in controlling major pests of okra (*Abelmoschus esculentus*)" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN ENTOMOLOGY**, embodies the result of a piece of bonafide research work carried out by Sabera Yasmin, Registration no. 26136/00435 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 been duly acknowledged.

Dated:December, 2006
Dhaka, Bangladesh

Md. Mizanur Rahman
Supervisor
Advisory Committee

Dedicated to
My
Beloved Parents &
Sisters

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LIST OF CONTENTS

Chapter No.	Title	Page
	LIST OF TABLES	X
	LIST OF FIGURES	XI
	LIST OF PLATES	XI
	LIST OF APPENDICES	XI
	ACRONYMS	XII
	THESIS ABSTRACT	XIII
I	INTRODUCTION	
II	REVIEW OF LITERATURE	
III	MATERIALS AND METHODS	
IV	RESULTS AND DISCUSSION	
V	SUMMARY AND CONCLUTION	
VI	REFERENCES	
	APPENDICES.	

LIST OF TABLES

Table No	Title	Page
1	Global distribution of whitefly as updated by CAB International Institute of Entomology, London (Cock, 1986)	6
2	Doses of Manures and fertilizers and their methods of application used for this experiment	34
3	Effect of different treatments on the incidence of Jassid population, its reduction and marketable yield over control in Okra	43
4	Effect of different treatments on the incidence of Whitefly population, its reduction and marketable yield over control in Okra	47
5	Effect of different control methods on virus infested plant/plot at different stages of okra plant	50
6	Effect of different control methods on virus infested leaves/plant at different stages of okra plant	50
7	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer infesting shoots of okra plants	53
8	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by number at early fruiting stage	60
9	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by number at mid fruiting stage	62
10	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by number at late fruiting stage	64
11	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer healthy and infesting fruit weight at early fruiting stage	67
12	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer healthy and infesting fruit weight at mid fruiting stage	69
13	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer healthy and infesting fruit weight at late fruiting stage	71
14	Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on fruit length and breadth of Okra	74

LIST OF FIGURES

Figure No	Title	Page
1	Effect of different treatments on plant height of okra measured at maximum vegetative stages of plant	76
2	Effect of different treatments on yield of okra	78

LIST OF PLATES

Plate No	Title	Page
1	Experimental plot of okra at early vegetative stage (A) plot treated with decis 2.5 EC (B) plot treated with fenfen 20 EC	44
2	Experimental plot of okra at early vegetative stage (A) Jassid present undersurface of okra leaf (B) Experimental plot of okra in SAU farm during kharif-2006	45
3	Experimental plot of okra at reproductive stage (A) control plot (B) fenfen 20 EC treated plot	55
4	Shoot and fruit borer (A) Infested shoot of okra (B) Healthy fruit of okra	56
5	Infested fruit of okra showing (A) OSFB feeding outside the fruit (B) OSFB feeding inside the fruit	57

LIST OF APPENDICES

No	Title	Page
1	Monthly average of Temperature, Relative humidity and Total Rainfall of the experiment site during the period from April to July, 2006.	101
2	Company name of chemical insecticides used in the experiment	101

ACRONYMS

ai	=	Active ingredient
et al.	=	And others
cm	=	Centimeter
°C	=	Degree Celsius
df	=	Degree of freedom
EC	=	Emulsifiable Concentrate
WP	=	Wettable Powder
SC	=	Soluble Concentration
g	=	Gram
ha	=	Hectare
kg	=	Kilogram
LSD	=	Least significant difference
LC	=	Median Lethal Concentration
m	=	Meter
μg	=	Microgram
ml	=	Milliliter
RH	=	Relative Humidity
cm^2	=	Square centimeter
m^2	=	Square meter
t	=	Ton
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
UNDP	=	United Nations Development Program
DAS	=	Days After Spray
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
SL	=	Soluble liquid
WG	=	Wettable Granular
ppm	=	Parts per million
MP	=	Murate of Potash
TSP	=	Triple Super Phosphate

EVALUATION OF SOME CHEMICAL INSECTICIDES IN CONTROLLING MAJOR INSECT PESTS OF OKRA
(Abelmoschus esculentus)

By
Sabera yasmin

THESIS ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University (SAU), Dhaka, during April to July, 2006 to evaluate the effectiveness of different chemical insecticides against three major insect pests; Jassid (*Amrasca devastans*), Whitefly (*Bemisia tabaci*) and Okra Shoot and Fruit Borer (OSFB) (*Earias vittella*) of okra, which are serious problem for its production. At vegetative stage against Jassid and Whitefly three treatments comprising Admire 200 SL, Actara 25 WG and control were tested. Lowest number of virus infected plants and leaves and also the lowest average population of Jassid (1.33) and White fly (1.86) were found in Admire 200SL treated plots and the highest in control plots (6.75 and 7.36). For the management of OSFB nine treatments comprising seven insecticides (eg; Cymbush 10 EC, Decis 2.5 EC, Shobicron 425 EC, Karate2.5 EC, Regent 50 SC, Fenfen 20 EC & Suntap 50 WP); mechanical control and untreated control, were evaluated using 'BARI Dherosh-1' laid out in RCBD with 3 replications. Highest infestation of shoot (27.35%) and fruit at early, mid and late reproductive stages (13.82%, 12.64% and 24.60% by number) and (26.06%, 13.78%& 27.67% by weight) was observed in the control plots, which was significantly highest from all other treatments. Fenfen 20 EC @ 0.5 ml/l of water gave the best performance resulting lowest shoot infestation (3.95) and fruit infestation at early, mid & late reproductive stages (1.09%, 1.61% & 4.11 % respectively by number) and (3.92%, 2.29% & 8.37% respectively by weight) and provided highest yield (12.97 ton/ha). Thus the lowest number (0.26, 0.43 & 0.83) and weight (17.13, 11.38 & 32.67gm) of infested fruit per plant, maximum fruit length (15.54, 16.01, 14.10 cm) and breadth (1.89, 1.82 & 1.74 cm) at early, mid & late reproductive stages and maximum height of okra plant (109.88cm) were observed in fenfen 20 EC treated plots . Decis 2.5 EC @ 1ml/of water at 7 days interval also gave statistically similar results for different parameters tested.

Chapter 1
Introduction

CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench), locally known as 'Bhendi' or 'gumbo' or 'Dherosh' also known as lady's finger is a popular and most common annual vegetable crop grown from seed in Bangladesh and in other tropical and subtropical parts of the world. It belongs to the family Malvaceae and originated in tropical Africa (Purseglove, 1987). Though okra is produced mainly in the kharif season it can be grown the year round (Rashid, 1976). About 22 thousand metric tons of okra fruit were produced in 2002-03 in Bangladesh (BBS, 2004). Okra is a tender plant and grown well in warm season. Okra production in Bangladesh is mainly limited during February-July (Rashid, 1995) but its production is severely hampered due to the attack of more than three dozen of insect pests from seedling to fruiting stage (Nayar *et al*., 1976). Among the insect pests of okra, leaf hopper, *Amrasca devastans* ; white fly, *Bemisia tabaci*; okra shoot and fruit borer (OSFB), *Earias vittella F.* are the most serious pests. Okra shoot and fruit borer is the major pest responsible for considerable damage of okra (Butani and Jotwani, 1984). The leaf hopper acts as a major constraint in achieving the potential yield (Faleiro, 1982).The losses in the yield due to this pest have been reported to vary from 32.06 to 40.84 percent (Singh and Brar, 1994)

Amrasca devastans is wide spread in tropical and sub-tropical areas of South and Southeast Asia. Many workers reported that *Amrasca devastans* commonly known as the cotton Jassid, is an important pest infesting cotton, okra, brinjal, potato, tomato, cowpea, cucurbits, castor, rose, sunflower, hollyhock and many other plants. (Butani and Varma, 1978; Gandhi, 1978; Kishore, *et al.,* 1983; Krishnaiah *et al,* 1979;

Sangappa, *et al*. 1978; Sarker and Kulshreshtha, 1978; Singh and Butani, 1963). Jassid attack the crop at early growth stage and reduce the vigor of the plant resulting in drastic reduction in fruit yield. Both the nymphs and adults of Jassid suck the cell sap (Verma, 1985). Jassid is a pest on all plant parts but especially on the leaves. The affected leaves become yellow, curl upwards along the tips and margin and develop necrotic areas which extend to the entire leaf surface, resulting in drying-up of leaves. Finally the affected leaves show "hopper burn symptoms".

Another sucking pest, Whitefly is the serious pest of cotton and okra (Anon, 1989). Recently, the whitefly has become the most economically damaging pest of guava and also to other agricultural and horticultural crops (Gerling, 1985). They also attack cucumber, okra, pumpkin, lablab bean and eggplant (Kajita and Alam, 1996). The damage occurs in various ways, reducing crop yields by sucking plant sap, act as vectors for transmitting viral pathogens, and long delicate nymphal filamentous wax covering the leaves thus reducing the photosynthetic area results yield loss. The heavy colonization of whitefly can cause serious indirect damage to the crop due to honeydue excretion on leaf or fruit surfaces which encourage growth of sooty moulds, and in turn affect the yield both in quantitative and qualitative terms (Byrnee *et al*., 1990; Kajita and Alam, 1996; Basu, 1995).

Okra shoot and fruit borer is commonly known as spotted bollworm of cotton. It is one of the most serious pests of okra in Bangladesh and also other Asian countries. The quantitative and qualitative losses due to this pest brings great economic losses to okra growers of almost all over the world. According to Srinivasan *et al*. (1959), OSFB cause up to 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.

Insecticides are highly effective, rapid in curative action and relatively economical. Recently, a large number of chemicals have been reported to have an effective control of insect pests in Okra (Rai, 1985; Verma *et al.,* 1980). Conventional insecticides like Endosulfan, dimethoate, monocrotophos at recommended doses have been proved effective in brining down the Jassid population to a significantly low level as reported by Bagle and Verma (1991), Singh and Singh (1991), Singh *et al.* (1991) and Verma *et al.*(1994). The synthetic pyrethroids are powerful contact insecticides with a quick knockdown effect, a highly deserved quality to inactivate vector individuals within the period required for virus transmission (Basu, 1995). Kishna (1981) found that foliar sprays of a synthetic pyrethroid reduced the number of nymphs and adults of *B. tabaci* as a chemical measure to curb tomato leaf curl virus disease. Recently, nitroguanidines/neonicotinoids, a new group of insecticides of chloronicotinyl class, such as imidacloprid and thiamethoxam have been found very effective for the control of homopterans attacking okra and cotton (Kumar and Santharam, 1999 and Mohan and Katiyar, 2000). The control of Okra Shoot and Fruit Borer is much difficult for its internal feeding behaviour. Several management practices have been reported to combat this pest. But the control measures of OSFB is dominated by chemical pesticides (Kavadia *et al.,* 1984). The only common method of controlling the pest infestation of okra in Bangladesh is the application of chemical insecticides. Many different insecticides are used to control insect pests of okra to minimize crop losses. A wide range of chemicals have been evaluated and found effective against fruit borer on okra (Krishnaiah *et al.*,1976; Jaganmohan *et al.* 1978). In India, scientists find out that only insecticide applications between 45-75 days after planting increased yield. Application of Cypermethrin or Fenvelerate at 50 gm/ha against OSFB reduced the damage (Pawer *et al.;* 1988; Ratanpara and Bharodia, 1989; David and Kumaraswami 1991; Patil *et al.*, 1991. At present, organophosphates, synthetic pyrethroids and nicotinamides are being widely used to control major pests of Okra. Evidence suggests that the insecticides in use are not rendering sufficient field control which could be the resulting effect of resistant development. To cope with this problem introduction of new insecticides are inevitable. Field screening is one of the best process for selecting a new insecticide against the target pests, which will be safe and more effective.

Considering the importance of okra pests for the production of okra, a research study was undertaken with the following objectives:

1. To investigate the extent of infestation and population of Okra Jassid and Whitefly.
2. To determine the Okra Shoot and fruit Borer damage and asses the losses of okra yield during the study period. and ,
3. To evaluate the efficacy of some chemical insecticides against okra pests.

Chapter 2
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Okra (*Abelmoschus esculentus* L.) is an important vegetable crop in Bangladesh. This crop is infested by large numbers of insect pests that cause considerable yield loss. Among them, okra shoot and fruit borer (*Earias vittella* F), is the most serious pest. Summer is the ideal season for growing okra and the hot dry weather during this period favours the build up of pests. Literature cited below under the following headings and sub-headings reveal some information about this study.

General review of Jassid, Whitefly and Okra Shoot and Fruit Borer

Nomenclature:

The okra jassid, (*Amrasca devastans*) belongs to the order Homoptera and the family Cicadellidae. It's common name is Okra leafhopper and Synonyms are *Amrasca biguttula* (Mats.), *Amrasca biguttula biguttula* (Ishida), *Chlorita biguttula* (Ishida).

Whitefly , (*Bemisia tabaci*) belongs to the order Homoptera and the family Aleyrodidae. Okra Shoot and Fruit Borer (*Earias vittella*) belongs to the order Lepidoptera and family Noctuidae.

Origin and distribution of Jassid, Whitefly and Okra Shoot and Fruit Borer

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, And Central Africa. This pest is also common in Australia (Ghauri, 1963).

The white fly, *Bemisia tabaci*, was first described as a pest of tobacco in Greece in 1889. Outbreaks in cotton in the late 1920's and early 1930's in India and subsequently in Sudan and Iran from the 1950s and 1961 in EL Salvador (Hirano *et al.*, 1993). *Bemisia. tabaci* is widespread in the tropics and subtropics and recorded in many areas outside the previously known range of distribution. The whitefly has been reported as a greenhouse pest in several temperate countries in Europe, viz., Denmark, Finland, France, Norway, Sweden and Switzerland. Besides in greenhouses, the species has been reported on outdoor plants in France and Canada (Basu, 1995). Worldwide distribution of whitefly, *B. tabaci,* was recently updated by CAB International Institute of Entomology, London (Cock, 1986)

Table1. Global distribution of whitefly as updated by CAB International Institute of Entomology, London (Cock, 1986)

Continent/ sub-continent	Countries
Europe	Cyprus, Denmark, Finland, France, Greece, Turkey, Switzerland, Turkey, UK etc.
USSR (Former)	Azerbaijan SSR, Georgian SSR
Africa	Angola, Cape Verde Island, Egypt, Ethiopia, Somalia, Ivory coast, Sierra Leone, South Africa etc.
Asia	Afghanistan, Myanmar, China, India, Indonesia etc.
Pacific Islands and Australia	Australia, Hawaii etc.
North-West Atlantic	Bermuda
America, Northern USA	California, Florida, Texas, etc.
Canada	British Columbia, Quebec etc.
Central America & Caribbean	Barbados, Costa Rica, Puerto Rico etc.
South America	Argentina, Brazil, Venezuela, Colombia

Okra shoot and fruit borer, *Earias vittella* (Fabricius) is widely distributed and is recorded from Pakistan, India, Srilanka, Bangladesh, Burma, Indonesia, New Guinea, and Fiji (Butani and Jatwani, 1984). The pest *E. vittella* is common oriental species found from India and Chaina to North Australia. The genus *Earias* in confined to the old world including Australia (Hill, 1983). Atwal (1976) reported that the species are widely distributed in North Africa, India, Pakistan, and other countries and are serious pest of okra and cotton.

Host Range of Jassid, Whitefly and Okra Shoot and Fruit Borer

Apart from feeding on okra, the Jassid have a very wide range of host plants, including herbaceous cultivated plants and weeds, chiefly amongst the Malvaceae, Leguminosae and Solanaceae.

Whitefly, *Bemisia tabaci* is highly polyphagous and has been recorded on a wide range of cultivated and wild plants. Greathead (1986) updated the information reported by Mound and Hasley (1978) and listed 506 species of plants belonging to 74 families. It may be pointed out that 50% of the total number host plants belonged to only 5 families, namely, Leguminosae, Malvaceae, Solanaceae and Euphorbiaceae. Junc *et al.* (1983) observed that the whitefly was able to multiply on some alternative food plants, as indicated by the presence of all stages throughout the winter. From early March, whitefly, *Bemisia tabaci* was able to fly from the winter shelters to its more usual food plants, especially vegetables.

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

Rehman *et al.* (1983) reported that when OSFB were offered the choice of different parts of host plant they prefered okra fruit and shoot the best followed by cotton balls, buds of *Gossipium hirsutum*, ball, flowers and buds of Deshi cotton *(G. arboreum*), buds and flower of kenaf, flower of Malvaparviflora and milky maize grains, flower of *Abutilon indicum*, flowers of *Hibiscus rosasinens,* Sarson (*Brassica campestris var. Sarson), Malvastrum tricuspidatum, Cassia fistula* and ears of pearl millet, pod of jute and soyabean.

Nayar and Ananthakrishnan (1983) reported that a part from okra they also infest *Abutilon indicum, Abutilon Hirtum, Althaea rosea, Hibiscus cannabinus, Hibiscus vitifolius* and *Malvastrum coromandelianum.*

Atwal (1976) mentioned that okra and cotton are the most favorite host of OSFB. Plant species including Sonchal (*Malva parviflora*), Gulkhaira (*Althaea officinalis*), holly hock (*Althaea rosea*) and some other Malvaceous plants are appeared to be its alternate hosts.

Whitefly Distribution Within Plants

All developmental stages of *B. tabaci* exhibit aggregation within and between ornamental plants in greenhouses. Whitefly life stages are vertically stratified in a plant with respect to leaf age. Adults, eggs, and first instar nymphs are found on predominantly on young leaves, second and third instar nymphs on middle aged leaves, and fourth instars, pupae, and pupal cases on middle aged and old leaves. Consequently, population estimates can be based on whitefly counts made from leaves in these three age categories. Adult whiteflies can be monitored in greenhouses with yellow sticky cards. Placement of cards five cm above the crop canopy produce the most abundant adult catches. Adults of *B. tabaci* tend to exhibit peak flight activity in the morning and afternoon, respectively.

Status and Nature of Damage of Jassid, Whitefly and OSFB

Okra Jassid, *Amrasca devastans* is one of the key insect pests of okra and is the major factor limiting okra yield in Bangladesh (El-Tom, 1987). This pest can cause more than 50 percent reduction of seed okra yield in some okra genotypes (Bhat *et al.*, 1984). The nymphs and adults of this pest can attack okra leaves at all stages of development. Jassids, particularly the older nymphs, feeding on the small veins appear to affect the functioning of the vascular system so that the leaf changes color from dark yellow to pale green, yellow and then red and brown. Adults and nymphs suck plant sap from the under surfaces of the leaves. The affected leaves show "Hopper burn" symptoms. The edges 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 impaires photosynthesis of okra plants.

Due to the attack of the leafhopper *Amrasca devastans*, the okra leaves become yellow and curl upwards along the tips and margin and develop necrotic areas which extend to the entire leaf surface, resulting in drying up of leaves. The heavily infested plants failed to bear fruits and the less damaged plants were found to produce fruits of different types. The deformed fruits when cooked were fibrous and became unfit for consumption. The infested plants remained stunted in the field.

The Jassid attacked plants are easily identified by the presence of globular, translucent, mucilaginous substances. This might be the plant secretion which had been referred to as "exudates" caused by the Jassid injury. The exudates are 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 number of exudates are found in the younger leaves than in the older ones.

Similarly whitefly (*Bemicia tabaci*) causes severe damage to Okra and it's nature of damage is also similar as Jassid.

Whitefly causes two types of damage to the crops.

Direct feeding damage*:* Whiteflies can cause direct damage to plants as a result of feeding. The whitefly adults and nymphs feed on the plant sap from the underside of the leaves. *B*emisia *tabaci* strain B vectors geminiviruses that cause yellowing and leaf curling in several vegetable crops, and feeding by nymphs can induce physiological disorders such as irregular ripening in tomatoes and silverleaf in curcubits. Vein clearing of foliage and induction of white stems on poinsettia and other ornamentals can occur as a result of feeding by *B. tabaci* strain B. However, the ability of this whitefly to vector viral diseases affecting ornamentals is not a generally recognized problem. *Trialeurodes vaporariorum* vectors closteroviruses that affect cucurbitaceous species, and documented economic losses from viruses vectored by *T. vaporariorum* in ornamental crops are lacking. Feeding by *B. tabaci* strain B on poinsettias can reduce plant height, leaf number, leaf size, and dry weight yields.

Indirect feeding damage: Honeydew deposition on leaves produces a shiny, sticky sheen, and provides an ideal substrate for sooty mold growth (e.g., *Cladosporium* and *Alternaria* spp.). Declines in the aesthetic quality of ornamental plants in greenhouses because of honey dew, black sooty mold contamination, or flying adults are problems associated with high density whitefly populations. Disfigurement of plants in this manner by whiteflies is referred to as indirect damage as it has not resulted from physical damage caused by whitefly feeding and consumer acceptance for ornamental plants with indirect damage is low.

Butani and Jotwani (1984) reported that OSFB lay it's its eggs singly on buds and flowers and occasionally on fruits as well. But in absence of these parts i.e., at the early stage of crop growth, the eggs are laid on shoot tips. 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 plants a bushy appearance. With the formation of buds, flowers and fruits, the caterpillars bore inside those and feed on inner tissue. They move from bud to bud and fruit to fruit thus causing damage to a number of fruiting bodies. 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 and such fruits have hardly get any market value.

Mohan *et. al*. (1983) and Atwal (1976) reported that OSFB bore into tender shoots, Flower buds and Fruits. As a result the attacked shoot dry up while the flower buds and developing fruits dropped prematurely, Affected fruits remain on the plants become unfit for human consumption. Karim (1992) stated that the OSFB bore into shoots and feed inside and damage seeds. Singh and Bichoo (1989) reported that the first symptoms of attack were visible when the crop was 3 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. As soon as fruiting began, the larvae moved to the flower buds, small fruits and even mature pods, causing reduction of yield.

A preliminary note on the control of OSFB was reported by Srinivasan *et al*. (1959) and they found 40-50% damaged okra fruit due to this pest in Madras. In another study Krishnaiah (1980) observed the attack of fruit borer to the extent of 35% in the harvestable fruit of okra.

The damage effects due to *E. vittella* on fruit number and weight in okra genotypes were studied by Sardana and Dutta (1989). In 1986 The results indicate that the least affected genotype (by fruit number) was IC 6653 with only 2.4% infestation compared to those of Bhindi 6 Dhari (2.8%) and Lam Sel-1 (3.8%) with Sel 10 showed the highest infestation (38.7%). In 1987 Bhindi 6 Dhari was least susceptible (2.4%). The infestation was on the basis of fruit weight was lowest in 1986 and 1987 in Bhindi 6 Dhari (1.2%) and Rajen 12 (1.8%) respectively.

Incidence and seasonal distribution of Okra Jassid, Whitefly and OSFB

Incidence and seasonal distribution of Okra Jassid

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

Senapati and Khan (1978) reported that the largest population of Okra Jassid occured from November to February.

Mahmood *et al* (1988) reported that the phonology of the cicadellid 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).

Mahmood *et al.* (1990) reported that abundance of the cicadellid *Amrasca devastans* on Okra was studied in Pakistan's during 1986-87. The pest appeared in June and remained active until the end of the 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 regard to density of the pest.

Neither relative humidity nor rainfall significantly increased or decreased the pest population.

Ali and Karim (1991) conducted an experiment in 3 consecutive kharif and rabi seasons in 1968-88 in Joydebpur, Bangladesh to investigate the influence of cotton plant age on the abundance of *Amrasca devastans*. Cicadellid populations remained below the economic threshold level of 1 insect/leaf for upto 35 days of plant age in kharif cotton and 65 days of plant age in rabi cotton. Most of the Cicadellids were found in 35 to 75 day old cotton plants in kharif season was more vulnerable to insect attack than cotton grown in the rabi season.

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

Incidence and seasonal distribution of Okra Whitefly

In a study in Sudan Kranz *et al.* (1977) found the increase in whitefly population in September and October was directly correlated with the higher relative humidity (80-90%) and increasing temperature (36°-38°).

Gerling *et al.* (1986) observed that the extreme relative humidity, both high and low, were unfavourable for the survival of immature stages. Thus, in Sudan, Horowitz (1986) found significant drop of Whitefly population levels at heavy rainy condition.

Eichelkraut and Cardona (1989) reported that dry conditions were more favourable for Whitefly, *B. tabaci*, than those of high precipitation.

Kuchanwar *et al.* (1989) studied the population dynamics of whitefly in citrus orchards and found three peaks in the emergence of nymphs in the last fortnight of April, the 2nd fortnight of July and last fortnight of December.

Southwood *et al.* (1989) reported that the population suffered very little from natural enemies in the field level, but showed a slow rate of increase after disturbance.

Ozgur *et al.* (1990) reported that whitefly population density remained low until the end of July on cotton and other crops; thereafter it started to increase. With the maturity of the cotton plants, a mass flight began, at this time, the main oviposition on the winter host plants took place.

Salinas and Sumalde (1994) reported that the whitefly was observed throughout the year and the highest population was noted during the month of September and during April to May and November. He further showed that the high temperature and rainfall appeared to have a descriptive effect on the population of Whitefly.

Salinas (1994) reported tha6t temperature, relative humidity, and the number of rainy days had a highly significant correlation with the adult population. A highly significant correlation was also noted between relative humidity and egg counts.

Incidence and seasonal distribution of Okra Shoot and fruit borer

Butani and Jowani (1984) conclude there is no true Hibernation but development and activity is considerably slowed down during winter.

The incidence of *Earias spp* on okra was studied by Dhawan and Sidhu (1984) in Panjub, India, in 1974-77. The maximum damage was counted in fruits (67.7%) and buds (52.4%) in late October. The maximum damage to shoots (1.7%) and flowers (1.5%) occurred in mid- August. In the spring crop the maximum damage to fruits (32.04%) and increased larval population (1.4/plant) were observed in late July. The population of *Earias spp*. Increased slowly up to mid September and rapidly there after. Heavy rainfall adversely affected it's population build up.

In general, the population of insects fluctuates from month to month, season to season, even year to year. Dash *et al.* (1987) reported that the occurance and seasonal abundance of Noctuid *E. vittella* was maximum in shoots from July- October.

Dutta and Saha (1990) observed the lower activity of *E. vittella* during December-January. The higher activity was observed during the increasing temperature from Februaru and a maximum peak in May-June. Khaliq and Yousuf (1986) also reported the increased incidence of *E. Vittella* with the increasing temperature and humidity.

Khurana and Verma (1990) observed lower incidence (12.5%) of *E. vittella* during 1983 in a condition having mean maximum and minimum temperature of 34.3° and 20.5° 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 environmental condition with mean maximum and minimum temperature of 36.3° and 23.2°C, respectively having a mean RH of 64.8%.

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

The root of the cotton plants sprouting in early spring and the fruits of okra left neglected in the field are the two important sources of early infestation and multiplication of this pest (Haque, 1993).

Influence of Temperature, Humidity and Rainfall on Biology of Whitefly

Gerling *et al.* (1986) found that the lower and upper developmental thresholds of temperature are 11°C and 33°C respectively. Rate of development is maximal at 28°C. At that temperature, development from egg to adult takes 20 days. Avidov (1956) considered low humidity as the major mortality factor in Israel, leading to cessation of oviposition and adult mortality. Low humidity of 20% or less during hot weather has been reported to be highly detrimental to the immature stages of whitefly (Avidov 1956;

Gameel, 1978). In Sudan heavy rains were usually followed by a drop in population levels (Khalifa and El-Khidir, 1964; Gamel, 1978). Ohnesorge *et al.* (1981) found that the oviposition was impaired by rain.

Amongst the abiotic factors, relative humidity and sunshine hours were positively and significantly correlated with adult count of the whitefly while maximum temperature, rainfall and wind velocity were negatively and non-significantly associated. The combined effect of abiotic factors explained 72.71% variations in whitefly population. Multiple regression studies revealed that morning relative humidity and sunshine hours were important variables for predicting build up of whitefly population on cotton. Sharma (2004).

Transmission of virus diseases by Whitefly

The non-persistent, semi-persistent are different types of virus vector relationships observed. Besides, these viruses are first broadly grouped as circulative and non-circulative based on duration of infectivity following acquisition of virus. By circulative transmission, virus is absorbed through the midgut inoculated into plants through the virus laden saliva (Basu, 1995). 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 (Basu, 1995).

Effect of Insecticides on Okra Jassid, Whitefly and OSFB

Effect of Insecticides on Okra Jassid

Dahiya *et al.* (1990) studied the efficacy of 16 insecticides against the cicadellid *Amrasca biguttula biguttula* on okra. Cypermethrin, Fenvalerate and Flucythrinate (all at 0.006%), Deltamethrin (0.002%) and Endosulfan (0.07%) were the most persistent and controlled the pest population for 15 days. Fenthion, Diazinon and Phenthoate (all at 0.05%), Malathion (0.075%) and Carbaryl (0.1%) were effective for a week.

Waryam-Singh *et al.* (1991) evaluated five insecticides against *Amrasca biguttula biguttula (A. devastans)* on Okra in Jammu and Kashmir, India, in 1986-87. Endosulfan at 0.053, 0.07 and 0.87% a.i. and Decamethrin (Deltamethrin) at 0.0014, 0.0028 and 0.0042% a.i. were the most effective treatments 3, 7 and 14 after spraying. Malathion at 0.05, 0.067 and 0.084% a.i. was intermediate in effectiveness. Quinalphos and Chlorpyriphos were relatively ineffective.

Ali *et al.* (1993) conducted experiments during 1988-89, 1989-90, and 1990-91 in 3 major cotton areas of Bangladesh to determine the most effective management practice for *Amrasca devastans.* The effectiveness of 14-day interval calender-based fixed sprays currently recommended (Monocrotophos, Azodrin 40 WAC) was compared with sprays at 2 population threshold (0.67 Jassid/leaf and one Jassid /leaf and 2 damage thresholds (0.5 Jassid damage grade/ plant, (i.e. leaf edge curled with discoloration on 50 % of leaves). The fixed spray treatments required up to 8 calender sprays during the season. The mean benefit cost (b/c) ratio in this treatment was the lowest (3.1) and was not cost effective. The 0.5 Jassid damage grade threshold, treatment also required many sprays, with a low b/c ratio of 9.0 and was also not cost effective. The one Jassid/leaf threshold treatment requied only 2-4 sprays, had the highest BC ratio of 16.6 and was the most cost effective treatment, followed by the 0.67 Jassid/leaf threshold, with a BC ratio of 12.5 and the one Jassid damage grade threshold with a BC ratio of 12.2.

Pawer and Lawande (1993) conducted field studies in Maharastra, India, during 1987-89 to determine the economic threshold for *Amrasca devastans* and *Earias vittella* infesting Okra. The results suggested that sprays of Endosulfan (at 0.05%) could be given when the density of *A. devastans* reached 2.5 nymphs /leaf. This resulted in fewer insecticide applications and a higher crop yield and profit.

Radadia and Patel (1993) noticed that in case of Jassid, treatments of Monocrotophos, Permethrin, Endosulfan and Fenthion were found equally effective compared with the treatment of fenvelerate and they were significantly superior to the rest of the treatments.

Ali *et al.* (1994) carried out a field experiment in Bangladesh, spraying of Dimethoate or Oxydemeton-methyl at 2 ml/litre water or 1.2 litres/ha against *Amrasca devastans* in cotton at threshold levels of 0.75, 1.0, 1.5, 2.0, and 3.0 Cicadellids/leaf was compared with recommended calender- based fixed sprays. For 3 seasons, the spraying threshold of 1 Cicadellid/ leaf required a minimal number of sprays, conserved arthropod natural enemies of cotton pests in the field and gave maximum profit compared with other spray treatments in cotton. A flexible 3 tier-spraying threshold level (0.75 Cicadellid/leaf during pre-flowering, 1.0 Cicadellids/leaf during post-flowering and 1.5 Cicadellids/leaf during ball maturity stages was suggested for *A. devastans* on cotton in Bangladesh.

Ali and Karim (1994) evaluated six new chemical insecticides for their biological efficacy against *Amrasca devastans*. Azodrin 40 WSC (Monocrotophos) @ 2ml/l water, Tamaron 40 SL (Methamidophos) @ 2ml/l water and Talstar 2.5 EC (Bifenthrin) @ 0.25 ml/l water were very effective against the pest, causing 91 to 97.53 % mortality on the second day post-treatment and were effective up to the 30th day post-treatment causing 73.27 to 79.17% mortality. The Dimethoate formulations (Polygor 40 EC, and Sunagor 40 EC) @ 2 ml/l water were relatively less effective causing 56.5 to 72.37% mortality on the second day post-treatment and 65.79 to 70.54% mortality on the 30th day post-treatment. Furadan 5 G (Carbofuran) @ 2 kg a.i./ha was not effective on the second day post-treatment causing only up to 8.72% mortality but was effective during the subsequent post treatment counts showing up to 68.68% mortality on the 30th day post-treatment. All insecticides were toxic to non target arthropod parasitoid and predators of cotton pests even on the 30th day post treatment.

Borah (1994) tested 8 insecticide schedules against *Amrasca biguttula biguttula* [*A. devastans*] on okra in Assam, India, 0.05% Malathion applied at 15 DAG followed by 0.03% dimethoate at 25 and 30 DAG resulted in the highest yield.

Variable exposures to feeding by *Amrasca biguttula* (0,10,20,30 and 40 days after its appearance on the crop) were investigated for their effect on different parameters of seed yield of okra. There was an increase in the Cicadellid population the longer the exposure period. The seed yield, plant height, number of fruits per plant and fruit length had an inverse relationship with the Cicadellid population, which contributed an average of 28.30 to 47.30% in reducing these parameters. The unexposed plants and those exposed to Cicadellid feeding for up to 10 days were longer, bore longer and more fruits, possessed more seeds per fruit and yielded more than those exposed for more than 30 days. At 10 days' feeding exposure, the reduction in seed yield was very low (4.06%) and insecticide sprays at this level proved economical. (Mahal *et al.*, 1994)

Yadgirwar *et al.* (1994) tested synthetic pyrithroid (Cypermethrin and Deltamethrin) and organophosphate insecticides (Dimethoate and Phosphamidon) alone and in combination to control *Amrasca biguttula biguttula (A. devastans)* on cotton in

Mararashtra, India. Among all 9 tretments, the combination of Deltamethrin 0.0025%+ Dimethoate 0.03% was the most effective.

Afzal *et al*. (1996) showed that the efficacy of five different dosages of Tamaron 600SL viz., 150, 180, 240, 300 as well as 360 ml a.i./ acre against the cotton Jassid, *Amrasca devastans*. All of those doses were found to be equitoxic against this pest. On numeral basis, however, a dose of 360 ml a.i. /acre was found to be the most effective.

Khorsheduzzaman *et al*. (1997) found that the percent reduction over control was highest (78.54%) in Cymbush 10 EC treatment than untreated control.

Jamil *et al*. (1998) studied the efficacy of a Carbofuran formulation with polythylene-polyvinyl acetate co-polymer for the control of the Cicadellid, *Amrasca devastans*, the Noctuids *Earias insulana* and *E. fabae*, the Gelechiid, *Pectinophoira gossypiella* and the Aleyrodid, *Bemisia tabaci* on cotton in Pakistan. 14C- Carbofuran with polyetylene-polyvinyl acetate was applied to pots containing cotton seeds (at 9.6 Carbofuran mg/pot). Some protection was observed following treatment and for 3 months treated cotton plants appeared to be healthier than untreated plants. After this time their resistance to pest attack decreased in comparison to untreated plants. It is suggested that a higher dosage would be more effective.

Kumar *et al*. (2001) evaluated some insecticides against cotton Jassid on okra and noticed that Endosulfan was effective in controlling Jassid.

Alam *et al*. (2001) conducted an experiment and observed that seasonal mean number of Jassid population per leaf was 3.29/ plant in Cymbush 10 EC @ 2ml/ l of water up to last harvest at 15 days interval, 3.30/ plant in Neem oil, 3.89/ plant in Furadan 5 G @ 30 kg treated plots.

Field experiments were conducted by Bhargava *et al*. (2001) to study the bioefficacy of insecticides against two major pests of okra (cv. Arka Anamika), viz. jassid (*Amrasca* *biguttula biguttula*) and fruit borer (*Earias vittella*). Sprays of Monocrotophos at 500 g a.i./ha were significantly superior in reducing Jassid population, where as all three rates of Beta-Cyfluthrin (50, 75 and 100 g a.i./ha) showed resurgence of Jassid population after three days of application. Among different insecticides, Endosulfan and Quinalphos at 500 g a.i./ha gave superior protection to fruits.

Kumar *et al.* (2001) studied the efficacy of Imidacloprid and Thiamethoxam was evaluated on okra leafhopper, *Amrasca biguttula biguttula*. Thiamethoxam (Actara 25 WG) was on par with Imidacloprid (Gaucho 600FS) seed treatment at 12 ml/kg of seed in reducing leafhopper infestation. Lower concentrations of Imidacloprid seed treatment were less effective. All the doses of Imidacloprid and Thiamethoxam had no phytotoxic effect on okra. The utility of Imidacloprid and Thiamethoxam had no phytotoxic effect on okra. The utility of Imidacloprid for the control of okra leafhopper is dicussed.

Shakharappa and Patil (2001) studied that the efficacy of Silafluofen 20 EC, a new insecticide of Slanecophanes group, for the control of leafhopper in transitional cotton cv. DCH-32 belt. Silafluofen 20 EC was tested at 2 concentrations, i.e. 50 and 100 g a.i./ha and compared with other insecticides, Methyl Dometon 25 EC, Phosphamidon 85 WSC, Neem gold and untreated control. The crop was sprayed 4 times during September- October. The pretreatment population of leafhopper ranged from2.67 to 2.86 in the experimental plots. The lowest population of 2.20 leafhoppers/leaf was recorded in the treatment Silafluofen 20 EC at 100 g a.i. /ha which was on par with Methyl Demeton 25 EC with 2.24 leafhoppers per leaf. Both treatments were significantly superior to the rest of the treatments. The next best treatments were Phosphomidon and Silafluofen at 50 g a.i. /ha.

Singh *et al.* (2001) tested the efficacy of Fenvelerate at 75g a.i./ha, ethion at 300 g a.i./ha, Cartap hydrochloride at 500 g a.i./ha, Fluvalinate at 75 g a.i./ha and Endosulfan at 500 g a.i./ha against okra jassid (*A. biguttula biguttula*) infesting okra cv. Pusa Sawani. Pesticide applications were made twice; the first spray was applied one month after crop germination and the second was applied at the initiation of flowering. Jassid populations were recorded before treatment and 1, 7 and 15 days after each treatment. All the treatments were superior to the untreated control in the management of the pest up to 7 days after the first treatment. Fenvalerate showed good control of the pest throughout the experiment.

Kaur (2002) observed that seed treatment with 5 g/kg Imidacloprid/ha +foliar spray with 500 g a. i. Monocrotophos/ha + 30 g a. i. Cypermethrin/ ha resulted in lowest mean population of cotton Jassid in 1999 (1.78) and 2000 (1.45).

Misra and Senapati (2003) contucted an experiment during the rainy season of 1999 and summer 2000 at Bhubaneshwar, Orissa, India to evaluate new generation insecticides and found that Thiamethoxam at rates ranging from 25 to 50 g a.i./ha and Imidacloprid at 25 g ai/ha gave significant excellent control of the Jassid (83.3-100%) and increased the marketable fruit yied of okra.

Alam (2005) found that Jassid infestation varied in different growth stages of Okra plants and hampered okra production severely. The chemical insecticide Milfan 20EC was the most effective against Okra Jassid. Besides this, Chloroced 20EC and Sumithion 50 EC also showed better result.

Anon. (2005) conducted an experiment to control Jassid population on Lady's finger and found that Admire, Koranda, Corofen, Neembicidine had significant effect in controlling Jassid.

Effect of Chemical insecticide on Whitefly

From the early period of control against Whitefly with resin soda (Thomas, 1932) and fish-oil resin soap sprays (Husain *et al.*, 1939; Pruthi, 1946), the chemical control has come a long way. The advent of DDT after the second world war ushered in a revolution in the sphere of insect control.

In a laboratory study Butler and Rao (1990) of India reported that 0.5% sprays of 3 commercial neem oil formulations, namely, Neemguard, Newark and Neempon to single eggplant leaves against Whitefly resulted 97% fewer eggs and 87% fewer immatures compared to those on untreated leaves.

The effectiveness of 19 insecticides and insecticide combinations against the Aleyrodid, *Bemisia tabaci* were evaluated in Venezuela by Marcano *et al.* (1993) and they observed that the most effective insecticides against eggs and nymphs of the pest were: Imidacloprid (91.67 and 78.61 litres/ha); Mineral oil + Imidacloprid (88.85 and 71.33) litres/ha); Cyfluthrin + Methamidophos (87.85 and 69.08 litres/ha); Buprofezin (86.1 and 53.19 litres/ha); Lambda-cyhalothrin (86.1 and 47.47 litres/ha); Profenofos + Cypermethrin (85.93 and 70.18 litres/ha); and Bifenthrin (85.82 and 70.21 litres/ha).

The efficacy of Phorate, Endosulfan, Phosphamidon, Dimethoate, Methyl demeton [demeton-methyl], Monocrotophos, Phosalone, Acephate, Fenvalerate, Neem seed extract and Neem oil for the control of *Bemisia tabaci* on cotton was studied by Nimbalkar *et al.* (1993) in the field in Maharashtra, India. Monocrotophos, Fenvalerate and Phorate applied at a depth of 10 cm at sowing were the most effective.

Singh *et al.* (1994) found that Cotton leaf curl bigeminivirus (CLCuV) occurred widely in parts of north western India on *Gossypium hirsutum* during 1994, its incidence varying from 1 to 97% on differant varieties. A greater build-up of the vector population was observed in cotton during October. Ethion 50 EC at 800 ml and Triazophos 40 EC at 600 ml/acre were both effective against the vector.

The efficacy of Imidacloprid (Bay NTN 33893), applied on *P. ixocarpa* seeds, roots (before transplanting) and/or on the neck of the plant (a few days after transplanting), in controlling *Bemisia tabaci* was evaluated in a field experiment conducted in Totolapan, Morelos, Mexico by Alatorre *et al.* (1995) The treatments which proved to be efficient in controlling *B. tabaci* were: seed applications + root applications and a combination of all the application methods. Imidacloprid (applied every 7-10 days) was more effective in controlling the pests than metamifidos.

Increase of trap catches with the increase of day temperature indicates the thermophilic nature of Whiteflies. Unlike Cotton, insecticidal control of *B. tabaci* has generally been aimed at curbing the spread of viral diseases rather than the direct injury by whitefly (Basu, 1995).

Imidachloprid (a systemic chloronicotinyl insecticide) gained major importance for control of *B. tabaci* in both field and protected crops, in view of extensive resistance to Organophosphorus, Pyrethroid and Cyclodiene insecticides (Cahil *et al.*, 1995).

Cahil *et al.* (1996) cautioned that the application of Imidacloprid must be carefully handled to avoid rapid resistance selection since *B. tabaci* has the genetic potential to become resistant to this insecticide.

Haider (1996) found that grafted Tomato plants sprayed with Ripcord was the very effective in managing the virus disseminating whitefly.

Kabir *et al.* (1996) observed that Chess, Nogos and Fenom as effective on the reduction of blackfly, *Aleurocanthus woglumi* Ashby after 7 days of application.

It is recommended that an action threshold of damage level 1-3 (i.e. presence of adults and eggs to appearance of nymphs and 500-1000 individuals/leaf) should be adopted (Rodriguez *et al.*, 1996)

Rushtapakornchai *et al.* (1996) investigated three granular insecticides (Fipronil 0.3% G, Carbosulfan 5.0% G and Carbofuran 3.0% G) and 10 foliar insecticides (Bifenthrin 2.5% EC, Fenpropathrin 10.0% EC., Acephate 75.0% SP, Pyriproxyfen 10.0% EC, Fipronil 5.0% SC, Imidacloprid 10.0% SL, Carbosulfan 20.0% e.c., Methamidophos 60.0% SL, Cypermethrin / Phosalone 28.8% e.c. and *Beauveria bassiana*). The effectiveness of these insecticides to control *Bemisia tabaci* on tomato (cv. VF-134-1-2) was tested in Petchaburi Province (Thailand) between November and December, 1995. At 18 days after transplanting (DAT) the occurrence of yellow leaf curl symptoms on tomato plants was 5.0, 3.3 and 6.7% in treatments of the 3 granular insecticides, respectively, and between 1.7 and 15.0% in foliar insecticide treatments. At 32 and 45 DAT, the abundance of yellow leaf curl symptoms ranged from 21.7 to 55.0% and 36.7 to 71.7%, respectively, in Bifenthrin, Imidacloprid, Fenpropathrin, Fipronil and Cypermethrin / Phosalone treatments. The abundance of symptoms in untreated plots was 65.0 and 91.7%, respectively.

Azam *et al.* (1997) conducted an experiment during 1993-95 with some insecticides (Carbofuran, Endosulfan, Dimethoate, Buprofezin and Triazophos) for the control of *B. tabaci* and yellow leaf curl bigeminivirus (TYLCV) and found that Endosulfan had the most affect to control *Bemisia tabaci.*

In the Dominican Republic, several applications of Imidachloprid starting after transplantation were used to control TYLCV (Polston &Anderson, 1997).

Naimatullah *et al.* (1998) tested (Endosulfan, Methamidophos, Talstar [Bifenthrin], M-Pede [an organic insecticide based on potassium salts of fatty acids], Incegar (insect growth regulator) and Surfactan (surf+cotton seed oil) individually and in various combinations in a field experiment in Faisalabad, Punjab, Pakistan, to determine the most effective control of *B. tabaci* infesting cotton cultivars CIM-1100 and S-12. The combination of Methamidophos + Talstar proved to be the most effective in decreasing the egg hatchability (32.41 and 37.40%), adult emergence (50.30 and 54.50%), adult population (2.34 and 2.15/leaf) and cotton leaf curl virus (2.4 and 1.11 mean number of scoring) on S-12 and CIM-1100, respectively, as against 97.47 and 94.34% egg hatching, 96.39 and 96.37 adult emergence and 10.99 and 9.93 per leaf adult population on the two cultivars in the untreated control

The Chloronicotinyl insecticide imidacloprid is widely used in soil application, seed treatment and as a foliar spray. Its systemic properties are well-known. It is more or less completely metabolised, depending on the method of application, plant species and time. In the present work, Nauen *et al.* (1999) demonstrate that the olefine metabolite and two hydroxy metabolites of Imidacloprid are active against the cotton Whitefly, *Bemisia tabaci*, in oral ingestion bioassays (sachet test). The 4-hydroxy metabolite is as active as Imidacloprid and the Olefine compound c10 times more active. The two hydroxy metabolites were also active against biotypes from Almeria, Spain and a B-type strain from California.

Manson *et al.* (2000) observed that proportion of viruliferous Whiteflies surviving the acquisition on treated plants appeared similar to that of insects fed on untreated plants, suggesting that Thiamethoxam activity in preventing TYLCV transmission by *B. tabaci* was simply due to its killing activity, and anti-feeding or repellent actions can be excluded. Viruliferous whiteflies exposed to Thiamethoxam-treated plants stopped feeding before acquiring enough virus to subsequently inoculate plants.

Nuvacron 40SL (Monocrotophos) and Cymbush 10 EC had significant effect on lower incidence of Whitefly as well as viral infection. (Anon., 2001)

Zabel *et al.* (2001) investigated the efficacy of a new class of insecticide (Chloronicotinyl) Mospilan 20 SP (a.i. Acetamiprid), compared with Lannate 90 SL (a.i. Methomyl) and Applaud WP 25 (a.i. Buprofezin), in glasshouse control of Whitefly (*Trialeurodes vaporariorum*). All investigated insecticides significantly decreased the number of whitefly larvae, compared with untreated plots where population density grew during the trial. Based on statistical analysis, efficacy of all insecticides on Whitefly larvae were in the same category. Some differences occurred 7 days after the third treatment. Deposited egg number was significantly different between controls and each insecticide plot. Efficacy of investigated insecticides, evaluated according to deposited egg number, was also good and in the same category.

Aneja *et al.* (2002) reported that *Bemisia tabaci* population reduced when treated with Nuvacron 36 SL (Monocrotophos, 500 ml/ 10 L of water).

Berlinger *et al.* (2002) found that Tomato yellow leaf curl virus (TYLCV) is the most frequently occurring virus in the Middle East, and the most harmful. It is transmitted solely by the whitefly, *Bemisia tabaci*. Within 4-6 h of inoculative feeding, a whitefly can transmit TYLCV to a healthy plant with 80% probability. The symptoms are apparent after two to three weeks whereupon fruit set is effectively terminated.

A study was conducted by Abdullah *et al.* (2004) as a part of a research work on insecticide hormoligosis in *B. tabaci* to investigate the changes in biological parameter of this pest in response to repeated application of insecticides. Five commonly used insecticides on cotton in Punjab (India), i.e. Quinalphos (250, 375 and 500 g), Carbaryl (625, 938 and 1250 g), Acephate (750, 1125 and 1500 g), Endosulfan (438, 656 and 875 g) and Fenvalerate (25, 38 and 50 g a.i./ha), were repeatedly sprayed on potted plants of cotton. The maximum reduction was recorded in all doses of Endosulfan, followed by higher doses of other insecticides. In general, low doses of insecticides caused lower reduction in longevity compared with higher doses. The results indicated that no hormoligosis was induced in longevity of the Whitefly by the tested insecticides.

The toxicity of Thiamethoxam and Imidacloprid and their efficacy against Whitefly were studied by Torres *et al.* (2004). Thiamethoxam and Imidacloprid showed significant control of Whitefly in comparison with untreated plants up to 40 days after treatment in potted plants. Whitefly population had low density over time in the field with no differences between treatments and only at day 64 higher whitefly population was observed on untreated plants and plants treated with 0.5 mg (a.i.) of Thiamethoxam per plant. Untreated and treated plants with 0.5 mg of Thiamethoxam showed infestation of 68.7 and 31.2%, respectively, at this time. Thiamethoxam and Imidacloprid used in cotton for whitefly control can be more successful when they are used at doses bellow 1 mg (a.i.) per plant due to shorter residual effect.

Significantly the lowest whitefly infestation was occured when seed bed netting and Imidacloprid was applied simultaneously (Anon, 2005).

The plots treated with seed bed netting and two spray of of Imidacloprid 200 SL had lowest number of Whitefly and it was statistically similar with the treatment seed bed netting with the spraying Neembicidine and seed treatment only (Anon, 2005).

Effect of chemical's on OSFB

Borer is the major pest of okra, committing colossal losses to okra growers. Although various measures have been reported for controlling the pests, there is not a single such method that successfully be adopted to suppress the incidence and damage of the pests. This perhaps, is mainly due to the oligophagous nature of this pest that helps their year round population build up. However, a through search of review reveals that the approaches that had ever been made in controlling this pest comprise mainly the use of chemicals. Though various management approaches are practiced for this pest suggested by different workers, insecticides are found very effective which are cited below.

David and Kumaraswami (1991) stated that Cypermethrin at 0.016%, Deltamethrin at 0.003% or 0.002% and Fenvelerate at 0.01% were the most effective treatments for the control of *Earias spp.*on okra.

A field experiment was conducted by Patil *et al.* (1991) in India for the control of the Okra Fruit and Shoot Borer *(E. vittella)*. They treated okra plants with Cypermethrin (15gm/ha), Fenvelerate (50 gm /ha), Acephate (375 gm/ha), Quinalphos (250 gm/ha and Endosulfan (250 gm/ha). All treatments reduced pod damage but Cypermethrin treated plants were the least infested and gave the best yield.

Samuthiravelu *et al.* (1991) tested Neem oil (at 0.1, 0.3 and 0.5%) alone and with Endosulfan (0.035 and 0.07%) for the control of *Earias vittella* on okra in Tamil Nadu, India. Applications of Neem oil and Endosulfan, alone and together, reduced damage and the maximum yield was obtained with 0.07% Endosulfan.

The plots treated with Ralothrin 10 EC, Neem plus, Aimcocyper 10 EC (Cypermethrin), Sumitox 20 EC (Fenvelerate) all had significantly lower percentage of fruit infestations than the untreated control. Though the percentage of fruits bored were very low (range 3.69-8.16), none of this insecticides had exceeded the standard level of 80% reduction of infestation over control (highest was 54.78 treated with Aimcocyper 10 EC) (Anon, 1992).

The efficacy of different insecticides such as Ralothrin 10 EC, Arrivo 10 EC, Peskil 10 EC, Chemocarb 50 EC, Shobicron 42.5 EC, Sumitox 20 EC, Fastac 2 EC, Decis 2.5 EC and found that the percentages of infested fruits between treatments were statistically identical. Because of low incidence of OSFB (less than 2%) the effectiveness of the tested insecticides were not clear, yield did not vary significantly between treatments. However, Sumitox treated plots offered the highest yield (23.33 t/ha) (Anon, 1992).

Screening of insecticides for the control of okra Shoot and Fruit Borer were studied by Anon., 1993, at RARS, Jessor during kharif 1993.Cymbush 10 EC @1ml, Sunmerin 10 EC @ 1ml, Ripcord 10 EC @ 1ml, Sumithion %0 EC @ 2ml, Nogos 100 Ec @ 2 ml and Fyfanon 50 Ec @ 2 ml were applied where first application was made at fruit initiation stage and the second one after 30 days of the fruits. It was found that Because of low incidence of shoot and fruit borer (5%) the effectiveness of the tested insecticides was not clear but Sunmerin treated plots offered the highest yield (19.52t/ha).

Borah (1995) tested several insecticides against *Earias vittella* on okra in Assam, India, in 1993, Malathion 0.05% applied 15 days after germination in combination with Dimethoate 0.03% applied 25 and 30 days after germination was the most effective treatment against the pest and also gave the maximum yield, followed by Dimethoate 0.03% applied 15 and 30 days after germination.

Mishra *et al.* (1996) reported that Fenvelerate (0.005%) offered best protection from *Earias vittella* in top growing shoots followed by Deltamethrin 0.0015%, Cypermethrin 0.005%, Monocrotophos 0.04%. Fenvelerate was found to be most effective (2% damage) treatment for borer control followed by Deltamethrin where the percent infestation was 3.4.

Haque (1997) conducted an experiment on the management of okra shoot and fruit borer and found that a foliar spray of Ripcord 10 EC @ 1.5ml/l of water showed significantly the lowest level of shoot and fruit infestation (7.68%, 1.13% respectively).

Mathur *et al.* (1998) tested several chemical and biological control treatments against *Earias spp* in a field experiment in 1996 in Rajasthan with okra. The combined application of Monocrotophos 36 SL (1.0 litre/ha), followed by two sprays of *Bacillus thuringiensis* subsp. Kurstaki (Btk) (Dipel-8L, 1.0 litre/ha) + Methomyl 40 SP (0.625 kg/ha) produced the lowest fruit damage (4.21%) and the highest fruit yield (4.07 t/ha).

Sarode *et al.* (1998) showed that out of 13 insecticidal treatments against *Earias vittella*, Endosulfan at 0.06% was the most effective. Neem [*Azadirachta indica*] seed kernel extract was relatively ineffective at controlling the pest.

Field studies were conducted by Tomar (1998) to determine the control efficacy of *Bacillus thuringiensis* subsp. Kurstaki (Dipel) mixed with lower concentrations of Endosulfan, Fenvalerate, Multineem [neem extract], Carbaryl or Acephate for the control of *Earias vittella* infesting okra. Dipel + Endosulfan and Dipel + Fenvalerate were very effective, reducing the percentage shoot and fruit infestation. The maximum yield of healthy fruits was obtained using Dipel + Fenvalerate, which also gave the highest profit and cost benefit ratio, followed by Dipel + Acephate and Dipel + Endosulfan.

Rahman *et al.* (2000) noticed that Diazinon applied at 15 days interval completely eradicated OSFB shoot infestation while Diazinon applied alone or in combinations with Thiovin and Bavistin at 15 days interval significantly reduced OSFB fruit and seed infestation. The number of fruits/plant, number of seeds/fruits, and seed yield/plot increased with application of Bavistin+Thiovit+Diazinon at 15 days interval.

The mean percent pod borer infestation was the lowest (9.31%) in Shobicron 425 EC which was statistically similar to that of Hill dherosh (15.81%) followed by Furadan 5 G (20.60%), BARI Dherosh-1 (29.71%) compared to untreated control (62.27%). Only Shobicron 425 EC achieved more than 80% infestation reduction over control with significantly higher yield (Anon, 2001).

Gowri *et al.* (2002) found that Endosulfan (0.07%) and Nimbecidine (1.0%), were most effective in controlling the fruit borer, *E. vittella* and gave higher yield of okra (cv. Parbhani kranthi) fruits.

The Beta-Cyfluthrin was the most effective insecticide, recording LC50 value of 0.00537, 0.00574 and 0.00629% and relative toxicity of 12.4990, 13.4907 and 14.7519 to 3, 6 and 9 days old larvae, respectively. This was followed by Profenofos and Ethion. Nain *et al.* (2004).

Chapter 3
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The present study for evaluating some chemical insecticides against Okra Jassid (*Amrasca devastans*), Whitefly (*Bemisia tabaci*) and Okra Shoot and Fruit borer (QSFB) (*Earias vittella*) was carried out using a variety of BARI Dherosh-1 in the experimental farm of Sher-e-Bangla Agricultural Universuty (SAU), Sher-e-Banglanagar, Dhaka, during April to July, 2006. The materials and methods adopted in the study are discussed under the following sub-headings:

Description of the field experimental site

3.1 Experimental site

The experimental field was located at 90°335′E longitude and 23°774′N latitude at an altitude of 9 meter above the sea level. The land was in Agro-ecological Zone of "Madhupur Tract" (AEZ No. 28). The field experiment was set up on the medium high land of the experimental farm.

3.2 Soil

The soil of the experimental site was clay loam in texture having pH 5.47-5.63.

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 detailed record of monthly total rainfalls, temperature, humidity during the period of experiment were noted from the Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212and has been presented in Appendix I.

3.4 Design of the experiment and Layout

The study was conducted considering two treatments including a control for Jassid and whitefly at early stage and 9 treatments for controlling Okra Shoot and Fruit Borer at vegetative and reproductive stages. The experiment was laid out in a Randomized Complete Block Design (RCBD). The entire experimental field was divided into three blocks. The each experimental blocks was divided into nine plots. Two adjacent unit plots and blocks were seperately by 1m and 1.5 m apart respectively. Each experimental plot comprised the area about 6 sq. m. So, the total area covered by the experiment was 162 sq.m. (6 x 27). Each treatment plots were allocated randomly and replicated three times.

3.5 Land preparation

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

3.6 Manures, Fertilizer and their methods of Application

Manures and fertilizers with their doses and their methods of application followed in this study was recommended by Haque (1993) and are shown in Table 2:

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

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

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

3.7 Collection and sowing of seeds

Seeds were collected from the BARI, Joydebpur, Gazipur and sown in the experimental plots at the rate of 54 seeds/ plot (three seeds per pit and 18 pits per plot). Seeds were sown on 2 April, 2006.

3.8 Plant spacing

The plant spacing was maintained at 60x50 cm (row to row and plant to plant distance respectively).

3.9 Cultural operations

After sowing seeds light irrigation was given to each plot. Supplementary irrigation was applied at an interval of 2-3 days. Dead or damaged seedlings were replaced immediately by new one from the stock. Weeding was done four times to break the soil crust and to keep the plots free from weeds. Stagnant water was drained out at the time of heavy rain. The urea was top dressed in 2 splits as mentioned earlier.

4.0 Procedure of the study

To investigate the population of Jassid, Whitefly and to determine the Okra Shoot and Fruit Borer damage the following procedures were followed during studies.

4.1 Treatment for control measures

The comparative effectiveness of the following three treatments for Okra Jassid and Whitefly and nine treatments for okra Shoot and fruit borer was evaluated on the basis of reduction of those pests. The individual control measure under each treatment as well as standard practice and control are described and discussed below

4.2 Details of the treatments for Jassid and Whitefly at vegetative stage

Admire 200 SL @ 0.5 ml/l of water at 7days interval

Acrata 25 WG @ 1 g/l of water at 7days interval

control

4.3 Details of the treatments for OSFB

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= control

4.4 Insecticides application

The test treatments comprised of two insecticides Admire 200 SL and Actara 25 WG and control for the management of sucking pests, Jassid and Whitefly. Spraying was done at 11.00 am to avoid moisture on leaves. First application was done after 14 days of germination. Treatments were applied at 7 days interval for sucking pests and treated three times. Other treatments for the control of okra shoot and fruit borer (Cymbush 10 EC, Decis 2.5 EC, Shobicron 425 EC, Karate 2.5 EC, Regent 50 SC, Fenfen 20 EC, Suntap 50 WP, mechanical control and untreated control) were applied at seven days. To get complete coverage of plants spraying was done uniformly on the entire plant with special care.

All the time the mixture of insecticides in the sprayer was shaken well and sprayed by a Knapsack sprayer. Before spraying, volume was calibrated to find out the required quantity of spray materials for the same replicated plots. The required quantity was measured as 6 litres.

5.0 Data Collection

5.1 Okra Jassid and Whitefly Population

The Population of Okra Jassid and Whitefly was recorded at 7 days intervals which started from the first initiation of the pest attack (after 13 days of germination). The selected plants were observed regularly for detection of population at different treatments. The counting was started from the very beginning of Okra Jassid and Whitefly infestation. Ten infested plants were randomly selected from each plot by tagging and from the under surface of the top five leaves both Jassid and Whitefly nymphs and adults were counted visually at early in the morning. For pest management decision making, leaf-turn (visual) method was more reliable to assess the adult population Munir Ahmed *et al.* (2002).The data were converted to mean Jassid and whitefly population per 20 leaves.

5.2 Assesment of Treatment Effects

Percent reduction of population : The effect of treatments on Jassid and Whitefly was determined by counting the number of pests per plant before and after applicaton of treatments. The percent reduction of Jassid and Whitefly per plant was calculated using the following way-

$$\% \text{ Reduction} = \frac{\text{Number of treated plot - Number of control plot}}{\text{Number of control plot}} \times 100$$

5.3 Virus Infestation

Number of OkYVMV infected leaves per plants and number of infested plants per plot were counted at 7 days interval that started from the first incidence of yellow leaf curling leaves and continued up to vegetative stage of the crop.

5.4 Incidence of Okra Shoot and Fruit borer

For data on Okra Shoot and Fruit Borer infestation, the following parameters were recorded from 10 randomly selected plants from each plot.

Number of infested shoots: The total number of shoots and the number of shoots infested by the OSFB was recorded at weekly intervals from each plot for each treatment during the period from April to July, 2006 and the percent shoot infestation and its reduction over control were calculated for all the treatments. In mechanical control the infested shoots were clipped, removed and destroyed after counting.percent infestation of shoot was calculated using the following procedure:

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

Number of fruits per plant: Data were collected on the basis of the number of harvested fruits per plant in each treatment. The marketable fruits were harvested at every alternate day intervals at some early, mid and late fruiting stages.

Number of healthy and infested fruits: Number of healthy fruits (HF) and infested fruits (IF) harvested at early, mid and late fruiting stages of the plant. There were 10 Harvest at early, 12 harvest at mid and 7 harvest at late fruiting stages respectively. In total 29 harvests were done throughout the fruiting period (May to July, 2006). Infestation rate (by number and weight) of okra fruits caused by OSFB at early, mid and late fruiting stages in different treatments and its reduction over control were calculated.

Weight of healthy and infested fruit: The weight of healthy and infested fruits at early, mid and late fruiting stages of Okra plants were taken separately per plot for each treatment.

Fruit infestation percent: The infested fruits were calculated at all reproductive stages using the following procedure:

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

$$\text{\% Infestation of fruit by Weight} = \frac{\text{Weight of infested fruit}}{\text{Total Weight of fruit}} \times 100$$

Plant height (cm): Average height of 10 plants at maximum vegetative stage was measured.

Fruit length (cm): The mean length of fruits excluding peduncle of 20 randomly selected fruits from each unit plot were measured at all stages.

Fruit breadth (cm): The mean diameter of fruits at middle part of 20 randomly selected fruits from each plot at all stages.

Fruit yield per plant: After each harvest, the weight of healthy and infested fruits per plant was recorded in each treatment.

Yield per hectare: The 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 in case of Jassid and Whitefly.

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

6.0 Statistical Analysis of Data

The recorded data were complied and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT. The treatment means were separated by Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) when necessary (Gomez, 1984).

Chapter 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

To evaluate the effectiveness of different treatments comprising two nicotinoids, Admire 200 SL and Actara 25 WG and an untreated control were applied in reducing the infestation of okra Jassid and Whitefly. Another seven chemical insecticides, mechanical control and untreated control measures were applied for suppressing Okra Shoot and Fruit Borer (OSFB). Effectiveness of these treatments on population incidence, extent of damage and yield were presented and discussed under following sections. Experimental plot of Okra located at SAU farm during Kharif-2006 was shown in Plate 1 & 2.

Incidence of Okra Jassid and marketable yield

The incidence of Jassid population per plant, various treatment effects on their percent reduction over control, marketable yield and percent increase of marketable yield using chemicals are presented in the Table 3. The Mean number of Jassids per plant differed significantly among the treatments. Significantly the lowest number of Jassid infestation per plant (1.33) was observed in Admire 200 SL treated plots. The mean number of Jassid population was 2.12 per plant when treated with Actara 25 WG. Jassid population was found 1.39 per leaf when treated with Admire. (Anon., 2005). Again, the highest number of Jassid infestation per plant (6.75) was observed in untreated control plots. Similarly the percent Jassid population reduction over control was exceeded 50% in both the chemical treatments The Jassid population reduction was the highest (80.30%) when treated with admire 200 SL, and 68.59% when treated with Actara 25 WG (Table 3).

The marketable yield was statistically similar among the treatments. It was the highest (12.62 t/ha) in Admire 200 SL treated plots followed by Actara 25 WG (11.79 t/ ha). The lowest marketable yield (10.32) was found from untreated control plots. The marketable yield increase over control 22.29% in Admire 200 SL treated plots that was higher than Actara treated plots (14.24%) over control.

Misra (2002) reported that at 15 Days After Spraying the number of Jassids/leaf on the insecticidal treatment plots was significantly lower than unsprayed control plots. Among the treatments, Imidacloprid recorded significantly the lowest number of Jassids (0.22/leaf) followed by Thiamethoxam (0.49/leaf) and untreated control (5.90/leaf). Imidaclopdid recorded the highest reduction in Jassid population (96.27%).

Misra and Senapati (2003) also reported that thiamethoxam and imidacloprid performed significantly better against the Jassids than other test compounds. Jassid population/leaf was 0.67 and 0.00 after 7 days of spray and also percent reduction over control was 83.33% and 88.33% of Thiamethoxam 25 WG @ 50.0 g ai/ha and Imidacloprid 200 SL @25 g ai/ha respectively in rainy season. the highest Jassid population was found in control plots 5.33 after 7 days. Fruit yield was found 3.37, 3.29 and 2.56 tonnes/ha in thiamethoxam, imidacloprid and control plots respectively where okra variety 'Utkal Gaurav' was used. The results also showed that increase in yield over control was 31.74% and 28.54% when thiamethoxam and imidacloprid wee used.

Divakar (1997) reported increase in fruit yield of okra with imidacloprid seed treatment, followed by foliar spray with the same insecticide.

Anon. (2005) reported that before spraying, Jassid population /leaf was 2.40 but after spraying Admire on the 7^{th} day it was 1.39 /leaf and yield obtained was 6256.25 kg/ha.

Alternate sprays of endosulfan 35 EC and Malathion 50 EC, at 0.05%, were applied in another experiment by Kumawat *et al.* (2004). The fruit yield was maximum (26.80 and 37.60 q/ha, respectively) in 1996 and 1997 at a density of 2 jassid nymphs/leaf. The weekly nymphal population increased by 0.60/day per leaf. Based on the economic injury levels and rate of density increase, the economic threshold level was estimated as 1.00 nymph /leaf. (Kumawat *et al.*, 2004)

Singh *et al.* (1991) repoted that plots treated with decamethrin and endosulfan at all the test dosages were effective at 7 days after spraying and showed 1.0-2.9 Jassids per plant. Differences in fruit yield during 1986 were not significant, but during 1987, plots treated with insecticides yielded 38.50-45.27q/ha as compared with 28.83 q/ha in the untreated control.

Patel *et al.* (1997) also found that average number of Jassid per leaf was1.81 after 7 days of spray of Endosulfan (0.035%) EC.

Table 3. Effect of different treatments on the incidence of jassid population and marketable yield its reduction over control in okra

Treatment	Mean number of jassid population /plant	Jassid population reduction over control (%)	Marketable Yield (t/ha)	Marketable yield increase over control (%)
Admire 200 SL	1.33 c	80.30	12.62 a	22.29
Actara 25 WG	2.12 b	68.59	11.79 ab	14.24
Control	6.75 a	--	10.32 b	--
$LSD_{0.05}$	0.759	--	1.709	--
Level of significance	**	--	*	--
CV (%)	9.85	--	6.51	--

In a column, numeric data represents the mean value of 3 replications from 30 plants
** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Plate 1.Experimental plot of Okra at vegetative stage
(A) Plot treated with decis 2.5 EC
(B) Plot treated with fenfen 20 EC

Plate 2. Experimental plot of Okra at vegetative stage
(A) Jassid present under surface of okra leaf.
(B) Experimental plot of Okra in SAU farm during kharif-2006

Incidence of Okra Whitefly

Significantly the lowest number of whitefly population per plant was recorded (1.86) from the plots treated with Admire 200 SL followed by Actara 25 WG (2.04). The highest number of Whitefly infestation (7.36) was found in untreated control plots. Maleque *et al*. (2001) recorded the highest whitefly incidence (3.46/plant) in tomato plants and Whitefly population reduction over control was never exceeded 50% in any treatment. The Whitefly population reduction was 74.73% in Admire 200 SL and 72.28% in Actara 25 WG. The marketable yield was significantly highest (12.82 t/ha) from the Admire 200 SL treated plots while Actara 25 WG treated plots gave 11.03 t/ha yield. The lowest marketable yield (10.45 t/ha) was obtained from control plots followed by Actara 25 WG treated plots which was 11.03 t/ha. The Marketable yield over control increase 22.68% when treated with Admire 200 SL but it increase only 5.55% in Actara 25 WG treated plots (Table 4).

Ganapathy and Karuppiah (2004) also recorded that whitefly population of 1.7, 7.7 & 20.0 per 10 mungbean plant at 25 DAS, 35 DAS and 50 DAS in seed treated with Imidacloprid @ 5 g/kg seed. The population of Whitefly of 2.9, 5.7 & 13.6 obtained when seed treated with Thiamethoxam @ 5g/g seed. It was 4.2, 8.3 & 19.3 with Imidacloprid sprayed at 15 DAS @ 0.25 ml/l and 0.5, 4.4 & 11.4 with Thiamethoxam spray at 15 DAS @ 0.2g/l.

Thiamethoxam 0.01 percent spray on 15^{th} and 25^{th} DAS reduced the whitefly population over control by 75% in blackgram and 57.1% in greengram (Karthikeyan, 2002)

Table 4. Effect of different treatments on the incidence of white fly population and marketable yield its reduction over control in okra

Treatment	Mean number of white fly population /plant	Whitefly population reduction over control (%)	Marketable Yield (t/ha)	Marketable yield increase over control (%)
Admire	1.86 b	74.73	12.82 a	22.68
Actara	2.04 b	72.28	11.03 b	5.55
Control	7.36 a	--	10.45 b	--
$LSD_{0.05}$	0.296	--	1.619	--
Level of significance	**	--	*	--
CV (%)	4.52	--	6.25	--

In a column, numeric data represents the mean value of 3 replications from 30 plants
** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Incidence of virus infected plants and leaves at different stages

Different treatments affect the incidence of virus infected plants per plot at various growth stages of okra plant significantly. The number of virus infected plants and virus infected leaves per plant recorded at vegetative, early fruiting, mid fruiting and late fruiting stages of okra for two chemical treated and control plots are shown in Table 5 and 6.

At vegetative stage significantly lower number of virus infected plant per plot (0.33) was observed in the treatment utilizing Admire 200 SL compared to Actara 25 WG treated plots (1.00) and control plots (6.33). At early fruiting stage occurance of virus infected plants was also significantly lower (0.67) than that of control plots (6.67). At mid fruiting stage virus infected plants were higher in untreated control plots (7.33) which were lowest in Admire 200 SL treated plots (1.00). Similarly at late fruiting stage virus infected plants were higher (8.33) in control plots which was comparatively very lower in Admire 200 SL treated plots (1.33).

In case of virus infected leaves, the Admire 200 SL treated plots had lower number of infected leaves at vegetative stage (1.33) compared to untreated control plants (8.67). Similarly at early fruiting stage Admire 200 SL greatly reduced the virus infection on leaves. In Actara 25 WG treated plots virus infected leaves was lower than control plots. At mid fruiting stage virus infected leaves were significantly lowest in Admire 200 SL treated plants than control plants. At late fruiting stage highest number of virus infected leaves were found in control plots (16.67). In Admire 200 SL treated plots it was lowest. Actara 25 WG treatment had also some effect on lowering infection of virus leaves than control plants.

The lowest whitefly incidence (1.61, 1.70 &1.56/plant) was obtained in yellow sticky trap, Nuvacron 40 SL and Cymbush 10 EC treated plots where viral infection was 9.42, 8.33 & 10.15% but in the control plots the highest whitefly incidence was 3.46/plant and the viral infection was 18.40% (Anon., 2001).

Significantly the lowest whitefly infestation /20 leaves was (5.97) with the lowest TYLCV infection of 27.77% and the yield of 28.37 t/ha observed in seed bed netting + imidacloprid 200 SL treated plots. While the highest whitefly infestation/20 leaves was 30.96 with TYLCV infection of 67.93% and the lowest yield of 20.15 t/ha was observed in control plots (Anon, 2005).

Torres *et al.* (2004) reported that Thiamethoxam and imidacloprid showed significant control of whitefly in comparison with untreated plants up to 40 days after treatment in potted plants.

Dipangkar *et al.* (2004) reported that in overall field condition, the percentage of infected plants increased gradually from the date of seed sowing upto the last harvest under both sprayed and non sprayed conditions, but the rate of increase in the number of infected plants was higher in non-sprayed condition as compared to sprayed condition.The highest percentage of infected plants (77.5%) was observed in non-sprayed condition whereas 58.75% infection was found in sprayed condition. The number of infected plants was positively correlated with the number of whitefly. Moreover, the insecticide spray was found responsible to delay the virus infection on the plant and thus the infection rate.

Table 5. Effect of different control methods on virus infested plant/plot at different stages of okra plants

Treatment	Number of virus infested plant/plot at stage			
	Vegetative	Early fruiting	Mid fruiting	Late fruiting
Admire 200 SL	0.33 c	0.67 c	1.00 c	1.33 c
Actara 25 WG	1.00 b	1.33 b	1.67 b	2.00 b
Control	6.33 a	6.67 a	7.33 a	8.33 a
$LSD_{0.05}$	0.258	0.487	0.551	0.257
Level of significance	**	**	**	**
CV (%)	9.25	5.65	4.76	5.63

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

Table 6. Effect of different control methods on virus infested leaves/plant at different stages of okra plants

Treatment	Number of virus infested leaves/plant at stage			
	Vegetative	Early fruiting	Mid fruiting	Late fruiting
Admire 200 SL	1.33 c	1.67 c	2.67 c	3.33 c
Actara 25 WG	3.33 b	4.00 b	4.33 b	8.33 b
Control	8.67 a	10.33 a	13.00 a	16.67 a
$LSD_{0.05}$	1.151	0.789	1.953	2.527
Level of significance	**	**	**	**
CV (%)	14.29	7.13	6.90	4.08

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

Extent of OSFB infestation (%) on Okra Shoot due to treatment application

The incidence of OSFB on shoots (%) is presented in Table 7. The effect of different treatments had significantly affected the incidence of OSFB in shoots and fruits of Okra. However, the highest infestation was recorded in the shoots of control plants (27.35%) and was significantly different from those of other treatments. The lowest infestation of shoot (3.95%) in plants of Fenfen 20 EC sprayed plots (T_6) and was statistically similar to Decis 2.5 EC treated plots and Cymbush 10 EC treated plants (10.45%).

There was no significant difference among the treatments fenfen 20 EC, Decis 2.5 EC, Cymbush 10 EC and Shobicron 425 EC for number of healthy shoots per plant. However, numerically higher number of healthy shoots per plant was recorded (2.76) in plants sprayed with fenfen 20 EC at the rate of 0.5 ml. Similar findings of other workers may be narrated to support the present findings.

During the late non-cotton season (late March to July), the spotted bollworm was likely to continue their life cycle as a major part on okra which is grown widely in Bangladesh during the non-cotton period (Alam, 1969). The spotted bollworm prefers okra much more to cotton (Ali and Karim, 1990.)

It was observed that the attack of OSFB on okra shoot initiated during vegetative stage and continued up to maturity of the plants and occurred on the apical part of the plant. Butani *et al.* (1984) also reported that the infestation was generally found on terminal branches of the plant.

Ahmed and Rizvi (1994) also reported the similar results that fenvelerate (0.015%) was most effective followed by cypermethrin (0.0075%), deltamethrin (0.0015%) and permethrin (0.015%). The results were 4.94%, 5.11%, 5.63% & 6.21% shoot infestation, respectively from those treatments.The highest shoot infestation was in control plots (23.11%). These results confirmed the findings of Nimbalkar and Ajri (1981), Sinha and Chakarbarti (1982), Jagan Mohan *et al.* (1979), Kale *et al.* (1982), Krishna Kumar and Srinivasan (1983) and Ramesh Babu and Azam (1981).

Misra and Singh (1996) also observed that fenvelerate (0.005%) offered best protection from *Earias Vittella* in top growing shoots followed by deltamethrin (0.0015%), cypermethrin (0.005%). Fenvelerate was found to be most effective (1.74% damage) followed by Deltamethrin (4.00% damage) and Cypermethin (5.94% damage).

Table 7. Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer infesting shoots of okra plants

Treatment	Number of shoots/plant			
	Healthy	Infested	% Infestation	% reduction over control
T_1	2.57 ab	0.300 e	10.45 e	61.79
T_2	2.72 a	0.133 f	4.68 f	82.89
T_3	2.58 ab	0.377 d	12.81 d	53.16
T_4	2.32 cd	0.600 c	20.61 c	24.64
T_5	2.47 bc	0.420 d	14.56 d	46.76
T_6	2.76 a	0.113 f	3.95 f	85.56
T_7	2.34 cd	0.660 b	21.99 c	19.60
T_8	2.25 cd	0.713 b	24.05 b	12.07
T_9	2.19 d	0.823 a	27.35 a	--
$LSD_{0.05}$	0.197	0.055	1.786	--
Level of significance	**	**	**	--
CV (%)	4.70	4.87	6.61	

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= untreated control

Infested shoots per plant

Table 7 showed that there was no significant difference between infested shoots per plant of Fenfen 20 EC treated plots and those of Decis 2.5 EC treated plots (0.133). The highest number of infested shoot per plant was found in control plots (0.823). Similarly, there was no significant difference among the healthy shoots per plant in the plots treated with Fenfen 20 EC, Decis 2.5 EC, Cymbush 10 EC, Shobicron 425 EC. However, numerically higher number of healthy shoots/ plant was recorded (2.47) in plants sprayed with Fenfen 20 EC at the rate of 0.5 ml/l of water at 7 days interval and lower (2.19) in control plots followed by mechanical control and Suntap 50WP. Haque *et al.* (1997) recorded the number of healthy shoot 2.47 and infested shoot 0.16 per plant and percent shoot infestation 7.68 when treated with ripcord 10 EC.

Percent Shoot Infestation reduction over control with different treatments

The maximum percent shoot infestation reduction over control was observed in Fenfen 20 EC treated plots (85.56%) followed by Decis 2.5 EC (82.89%). The lowest percent shoot infestation reduction over control was found in mechanical control followed by Suntap 50 WP and Karate 2.5 EC treated plants. Cymbush 10 EC and Shobicron 425 EC treatments showed greater than 50 % reduction over control (Table 7).

Plate 3. Experimental plot of Okra at reproductive stage
(A) Control plot at reproductive stage
(B) Fenfen 20 EC treated plot at reproductive stage

Plate 4. Shoot and fruit (A) Infested shoot of Okra due to okra shoot and fruit borer (B) Healthy fruit of Okra

Plate 5. Infested fruit of Okra showing (A) OSFB feeding outside the fruit
(C) OSFB feeding inside the fruit

Effect of different treatments on number of Healthy fruit and OSFB Infested fruit per plant

The Table 8, 9 and 10 illustrate the number of healthy fruit of okra, OSFB infested fruits, infestation percent and Percent reduction over control at early, mid and late fruiting stages, respectively.

At early fruiting stage the percent of fruit infestation (by number) among the treatments varied significantly (Table 8). The untreated control plots (T_9) had the highest fruit infestation (13.82%), which differed significantly from all other treatments. The second highest fruit infestation was 11.83% for mechanical control followed by Suntap 50 WP(T_7) (9.89%) and Karate 2.5 EC (8.55%) treated plots (T_4) and they were statistically identical.

The lowest fruit infestation (by number) was obtained from the T_6 plots where fenfen 20 EC @ 0.5 ml/ l water of water was used (1.09%) which was statistically similar with T_2 treatment where Decis 2.5 EC was used (1.52%). In cymbush 10 EC treated plots, fruit infestation was 4.42% followed by Shobicron 425 EC (5.64%) and Regent 50 SC (5.89%) treatments. In respect of healthy fruit production, fruits harvested from the plots treated with T_1, T_2, T_3, T_5, and T_6 were statistically similar. The highest number of healthy fruits were harvested from Fenfen 20 EC (T_6) treated plots (23.27) and the lowest number of healthy fruits were harvested from untreated control plots (T_9) (19.07) followed by mechanical control (T_8) and Suntap 50 WP (T_7) treated plots (Table 8). Significant variation was observed in respect of number of fruits infestation by OSFB at early stage (Table 8). The maximum number of fruit infestation (3.06) was occured in the control plots (T_9) which was statistically different from that of all other treatments. The minimum number of fruit infestation (0.26) was recorded in plants applied with

Fenfen 20 EC (T_6) which was statistically similar to Decis 2.5 EC (0.36). The cymbush 10 EC treated plots also had lower fruit infestation (1.02). The plants which were treated with Shobicron 425 EC and Regent 50 SC had reasonable effect on borer infestation compared to that of untreated control and mechanical control plots (Table 8). The highest fruit infestation reduction over control (by number) was recorded from plots having treatment Fenfen 20 EC (T_6) (92.11%) followed by treatment with Decis 2.5 EC (T_2) (88.64%), Treatment with Cymbush 10 EC (T_1) (68.02%). Patil *et al.* (1991) used chemicals against OSFB and found cypermethrin as the best material to reduce borer infestation. On the other hand Haque *et al.* (1997) recorded number of healthy fruit (20.39), infested fruit (0.43) per plant and % fruit infestation by borer (1.13) when treated with ripcord 10 EC.

Table 8. Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by number at early fruiting stage

Treatment	Number of fruits/plant			
	Healthy	Infested	% Infestation	% reduction over control
T_1	22.17 abc	1.02 f	4.42 e	68.02
T_2	22.84 ab	0.36 g	1.57 f	88.64
T_3	21.37 abcd	1.27 e	5.64 de	59.19
T_4	20.93 bcde	1.96 d	8.55 c	38.13
T_5	21.32 abcd	1.33 e	5.89 d	57.38
T_6	23.27 a	0.26 g	1.09 f	92.11
T_7	20.37 cde	2.23 c	9.89 c	28.44
T_8	19.79 de	2.65 b	11.83 b	14.40
T_9	19.07 e	3.06 a	13.82 a	--
$LSD_{0.05}$	1.801	0.232	1.365	--
Level of significance	**	**	**	--
CV (%)	4.90	8.64	11.32	--

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= Untreated control

On the other hand at mid fruiting stage, the percent of fruit infestation by number varied significantly among treatments (Table 9). Plots having treatment T_6 gave the lowest fruit infestation by number (1.61%) which was statistically identical with treatment T_2 (2.64%). The third lowest fruit infestation by number (4.04%) was obtained in Cymbush 10 EC treated plots which was followed by Shoobicron 425 EC (4.90%) treated ones. Similar to early stage, the highest fruit infestation by number (12.64) was obtained from untreated control plots (T_9) followed by treatment with mechanical control (T_8) (10.76%) and treatment Suntap 50 WP (T_7) (7.98%), respectively. At this stage, there was no significant difference among the chemical treatments in respect of healthy fruits. The lowest number of healthy fruits were obtained from untreated control plots (20.50) followed by mechanical control plots (22.04%) having no significant difference between them.

Significantly the lowest number of OSFB infested fruits were harvested from Fenfen 20 EC treated plots (0.43). The second lowest fruit infestation was obtained from Treatment T_2 treated plants (0.72) followed by treatment T_1 (1.12) and treatment T_3 (1.34), respectively having no significant difference between them. The highest number of infested fruit was obtained from untreated control (2.97) followed by treatment T_8 (2.67). The highest reduction in fruit infestation by number (87.26%) was obtained from T_6 followed by T_2 (79.11%), T_1 (68.04%), T_3 (61.23%), T_5 (58.94%) (Table 9).

Sarker and Nath (1989) also found that fenvelerate (0.5ml/l) caused the greatest reduction in numbers of infested fruits which was similar to Ratanpara and Bharodia's (1989) observations. Misra and Singh (1996) also reported that percent infestation of fruit by OSFB was lowest in fenvelerate treated plots (2.06%) followed by Deltamethrin and cypermethrin (3.45% & 8.22% fruit damage by number, respectively). The highest fruit damage was obtained in control plots (19.01%).

Table 9. Effect of different chemicals and a mechanoical control method applied against okra shoot and fruit borer on healthy and infesting fruit by number at mid fruiting stage

Treatment	Number of fruits/plant			
	Healthy	Infested	% Infestation	% reduction over control
T_1	26.68 a	1.12 f	4.04 e	68.04
T_2	26.52 a	0.72 g	2.64 f	79.11
T_3	25.92 a	1.34 ef	4.90 e	61.23
T_4	26.81 a	1.85 d	6.46 d	48.89
T_5	26.10 a	1.43 e	5.19 e	58.94
T_6	26.42 a	0.43 h	1.61 f	87.26
T_7	25.72 a	2.23 c	7.98 c	36.87
T_8	22.04 b	2.64 b	10.76 b	14.87
T_9	20.50 b	2.97 a	12.64 a	--
$LSD_{0.05}$	1.553	0.251	1.147	--
Level of significance	**	**	**	--
CV (%)	3.56	8.81	10.60	--

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= Untreated control

At late fruiting stage, significantly the highest fruit infestation by number was observed in untreated control plots, T_9 (24.60%), which was statistically different from other treatments (Table 10). The lowest fruit infestation was recorded in T_6 (4.11%) followed by T_2 (4.46%) which was statistically similar. No significant difference was found among the treatments in case of healthy fruits except the fruits of untreated control plots but numerically the highest number of healthy fruits were harvested from the treatment T_6 (19.51). The lowest number of healthy fruits were harvested from untreated control plots. In contrary the highest number of infested fruits were obtained from untreated control plots (4.82) followed by the treatment T_8 (18.08). The lowest number of infested fruit was recorded in the treatment T_6 (0.83) which was statistically similar to those harvested from treatment T_2 plots (0.92). The treatment T_1 had also reasonable effect in respect of infested fruit (by number) (1.37), followed by treatment T_3 (1.73), T_4 (1.97), and T_5 (1.87), respectively.

Similar to early and mid fruiting stages, the highest fruit infestation reduction over control by number was recorded in the treatment T_6 (83.29%) at late fruiting stage followed by the treatment T_2 (81.87%).

Anon. (2001) reported that The mean percent pod borer infestation was (9.31%) found in shobicron 425 EC and (20.60%) furadan 5G treated plots and shobicron 425 EC achieved 65.16% infestation reduction over control.

Ahmed *et al.* (1994) also observed that the lowest percent of fruit infestation was in fenvelerate treated plots (3.20%) followed by deltamethrin (5.30%) and cypermethrin (5.40%). The maximum fruit infestation was in control plots (35.84%)

Table 10. Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by number at late fruiting stage

Treatment	Number of fruits/plant			
	Healthy	Infested	% Infestation	% reduction over control
T_1	19.10 a	1.37 e	6.72 e	72.68
T_2	19.13 a	0.92 f	4.46 f	81.87
T_3	18.52 a	1.73 d	8.57 d	65.16
T_4	18.51 a	1.97 cd	9.63 cd	60.85
T_5	18.67 a	1.87 cd	9.09 cd	63.05
T_6	19.51 a	0.83 f	4.11 f	83.29
T_7	18.62 a	2.22 c	10.63 c	56.79
T_8	16.92 a	3.73 b	18.08 b	26.50
T_9	14.82 b	4.82 a	24.60 a	--
$LSD_{0.05}$	0.201	0.337	1.512	--
Level of significance	*	**	**	--
CV (%)	7.65	9.00	8.20	--

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= Untreated control

Effect of different treatments on weight of Healthy fruit and OSFB Infested fruit per plant

The effect of various treatments on the weight of healthy and infested fruit, percent fruit infestation at early, mid and late fruiting stages of okra and its infestation reduction over control are presented in Tables 11-13.

At early fruiting stage the mean percentages of fruit infestation (by weight) among the treatments varied significantly (Table 11). The control plots had the highest fruit infestation (26.06%), which differed significantly from all other treatments. The second highest fruit infestation was 20.42 % obtained from the treatment T_8 which was followed by T_7 (10.52%). The lowest fruit infestation (by weight) was obtained from treatment T_6 (3.92%) followed by T_2 (5.22%). The fruit infestation was obtained from the plots with the treatment T_1 (6.49%), followed by treatment T_3 (8.30%), T_5 (8.82%) and T_4 (9.37%) respectively (Table 11).

The weight of healthy fruits was statistically similar in some chemical treatments at early stage. However, the highest amount of healthy fruit weight was observed in treatment T_6 (419.02 g) followed by the treatment T_2 (411.36 g), T_1 (406.76g), T_5 (396.51 g) respectively. The lowest amount of weight of healthy fruit was recorded in control plots (281.33 g) which was statistically similar to mechanical control (299.11 g). Suntap 50 WP (T_7) and Karate 2.5 EC (T_4) treatment effect on fruit weight was statistically identical (387.47g and 392.70g respectively) (Table 11).

The weight of infested fruit differed significantly in control plots compared to other treatments. The highest amount of infested fruit weight was recorded in control plots (99.12 g) followed by the treatment T_8 (76.72 g) and T_7 (45.55 g), respectively. The lowest quantity of infested fruit weight was obtained from Fenfen 20 EC treated plots (17.13g). The second lowest quantity of OSFB infested fruit weight was observed in treatment T_2 (22.59g) followed by the treatment T_1 (28.09 g), respectively. The highest fruit infestation reduction over control (by weight) was recorded from the treatments T_6 (84.96%) followed by treatment T_2 (79.97%), T_1 (75.10%), T_3 (68.15%), T_5 (66.16%), T_4 (64.04%), T_7 (59.63%) and T_8 (21.64%), respectively (Table 11).

Table 11. Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by weight at early fruiting stage

Treatment	Weight of fruits (g) /plant			
	Healthy	Infested	% Infestation	% reduction over control
T_1	406.76 ab	28.09 e	6.49 e	75.10
T_2	411.36 ab	22.59 f	5.22 ef	79.97
T_3	394.24 ab	35.62 d	8.30 d	68.15
T_4	392.70 b	40.42 cd	9.37 cd	64.04
T_5	396.51 ab	38.36 d	8.82 d	66.16
T_6	419.02 a	17.13 g	3.92 f	84.96
T_7	387.47 b	45.55 c	10.52 c	59.63
T_8	299.11 c	76.72 b	20.42 b	21.64
T_9	281.33 c	99.12 a	26.06 a	--
$LSD_{0.05}$	22.84	5.231	1.355	--
Level of significance	**	**	**	--
CV (%)	3.50	6.74	7.11	--

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= Untreated control

At mid fruiting stage, the percent of fruit infestation by weight varied significantly among the treatments (Table 12). The treatment T_6 gave the lowest fruit infestation by weight (2.29%). The second lowest fruit infestation by weight in treatment T_2 (3.82%) followed by the treatment T_1 (4.79) were recorded. The highest quantity of fruit infestation was observed in the untreated control plots (13.78%) by weight followed by the treatment T_8 (12.46%).

There was no significant difference among the chemical treatments in respect of healthy fruits by weight exceptTreatment T_7. However, numerically the highest quantity of healthy fruits were obtained from the treatment T_6 (486.66 g) followed by treatment T_2 (487.36 g) and treatment T_1(486.15 g), respectively. The lowest quantity of healthy fruit was obtained from untreated control plots (403.60 g) which was statistically similar to that of treatment T_8 (403.63 g) followed by treatment T_7 (442.66 g). The highest quantity of infested fruit by weight was obtained from control plots (64.53 g) followed by Mechanical control plots (57.49 g). The lowest quantity of infested fruit weight was observed in Fenfen 20 EC treated plots (11.38 g). The second lowest infested fruit weight was recorded to Decis 2.5 EC treated plots (19.33 g) followed by Cymbush 10 EC treated plots (24.43 g).The highest reduction in fruit infestation by weight was recorded from T_6 (83.38%) followed by T_2 (72.28%, T_1 (65.24%), T_3 (57.69%), T_5 (55.22%), T_4 (44.27%), T_6 (28.30%) and T_8 (9.58%), respectively. (Table 12). The yield of healthy fruit did not vary significantly among the treatments (Table 12) (Anon., 1993). Weight of healthy fruit was 17.67 t/ha and infested fruit 0.57 t/ha in fenom 10 EC treated plots followed by cymbush 10 EC, sumicidin 10 EC, sumithion 50 EC and ripcord 10 EC (17.39, 17.08, 16.92 and 16.22 t/ha healthy fruits) and infested fruit (0.38, 0.48, 0.47 and 0.63 t/ha infested fruits). These results have some similarity with findings of the present study.

Table 12. Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by weight at mid fruiting stage

Treatment	Weight of fruits (g) /plant			
	Healthy	Infested	% Infestation	% reduction over control
T_1	486.15 a	24.43 f	4.79 fg	65.24
T_2	487.36 a	19.33 g	3.82 g	72.28
T_3	469.92 a	29.07 ef	5.83 ef	57.69
T_4	484.42 a	40.24 d	7.68 d	44.27
T_5	472.71 a	31.10 e	6.17 e	55.22
T_6	486.66 a	11.38 h	2.29 a	83.38
T_7	442.66 b	48.50 c	9.88 c	28.30
T_8	403.63 c	57.49 b	12.46 b	9.58
T_9	403.60 c	64.53 a	13.78 a	--
LSD0.05	25.76	5.521	1.082	--
Level of significance	**	**	**	--
CV (%)	3.24	8.80	8.44	--

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= Untreated control

At late fruiting stage, significantly the highest fruit infestation by weight was observed in control plot (27.67%), which was statistically differed with other treatments. the second highest fruit infestation was recorded from the treatment T_8 (22.13%). The lowest fruit infestation was in treatment T_6 (8.37%) followed by plots of T_2 (10.49%) and T_1 (11.48%). Other treatments gave the intermediate level of infestation (Table 13).

Like early and mid stages, the highest weight of healthy fruits was observed in T_6 (360.15g) treated plots which was statistically similar to that of treatment T_2, (342.89g) ,T_1 (342.89g) and T_3 (338.42 g) respectively. Lowest weight of healthy fruit was recorded in untreated control plots (251.83g) followed by treatment T_8 (286.02 g). Other treatments gave intermediate level of healthy fruit by weight.

On the other hand weight of infested fruit was higher in untreated control plots, (T_9) (96.35g) which differed significantly from others. The second highest infested fruit by weight was found from mechanical control plots (T_8). Significantly lowest quantity of infested fruit by weight was recorded from T_6 (32.67g) treated plots. The second lowest infested fruit by weight was observed in T_2 (41.43g) followed by T_1 (44.34g) treated plots having no significant difference between them.

The highest fruit infestation reduction over control by weight was recorded in T_6 (69.75%) at late fruiting stage. The plots with T_1 also accounted 62.09% fruit infestation reduction over control and this was followed by T_1 (58.51%), T_6 (56.85%), T_5 (51.97%), T_4 (46.66%), T_7 (37.69%) and T_8 (20.02%), respectively.

Table 13. Effect of different chemicals and a mechanical control method applied against okra shoot and fruit borer on healthy and infesting fruit by weight at late fruiting stage

Treatment	Weight of fruits (g) /plant			
	Healthy	Infested	% Infestation	% reduction over control
T_1	342.89 abc	44.34 fg	11.48 fg	58.51
T_2	353.85 ab	41.43 g	10.49 g	62.09
T_3	338.42 abc	45.82 f	11.94 f	56.85
T_4	311.58 cd	54.23 d	14.82 d	46.44
T_5	326.22 bc	49.99 e	13.29 e	51.97
T_6	360.15 a	32.67 h	8.37 h	69.75
T_7	310.89 cd	64.73 c	17.24 c	37.69
T_8	286.02 d	81.24 b	22.13 b	20.02
T_9	251.83 e	96.35 a	27.67 a	--
$LSD_{0.05}$	30.72	3.616	1.108	--
Level of significance	**	**	**	--
CV (%)	5.54	3.68	4.20	--

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= Untreated control

Fruit length, breadth :

The variation in fruit length and breadth at early, mid and late reproductive stages of Okra plant have been shown in Table 14. At early fruiting stage, the plants under fenfen 20 EC (T_6) produced fruits of numeically higher fruit length (15.54 cm) and were statistically similar to that of T_2 (15.43 cm), T_1 (15.31 cm), T_3 (15.09), T_5 (15.02 cm) treatments respectively. The plants of coltrol plots produced fruits with a minimum length of 14.52 cm followed by Mechanical control (14.67 cm) and Suntap 50 WP (14.73cm) treated plots. The fruits of control plots were shorter (1.74cm) followed by Mechanical control (1.77 cm) and Suntap 50 WP (1.78 cm). The beadth of fruit was higher in Fenfen 20 EC (T_6) treated plants (1.89 cm) and was statistically similar to that obtained in Decis 2.5 EC (1.86 cm), Cymbush 10 EC (1.85 cm), Shobicron 425 EC (1.84 cm), Regent 50 SC (1.82 cm) treated plots.

At mid fruiting stage, like early fruiting stage, higher fruit length (16.01cm) and fruit breadth (1.82cm) was observed in fenfen 20 EC (T_6) treated plants followed by T_1, T_2, T_3, and T_5 treatments respectively.

At late fruiting stage higher fruit length (14.10 cm) was found from fenfen 20 EC (T_6) treated plots which was statistically similar to T_1 and T_2 treated plots but the lower fruit length was obtained from control plots (12.96 cm) which was followed by T_7, T_8, T_4 treatments. Similarly the breadth of fruit was higher in fenfen 20 EC (T_6) treated plots (1.74 cm) which was statistically similar to T_2 (1.70 cm) and T_1 (1.63 cm) treated plots but this time the fruit length was comparatively lower than early and mid stages. Statistically similar and higher diameter of individual fruit was found in T_6, T_2, T_3, T_1, T_5 treated plots. Lower fruit diameter (1.49) was found in control plots. But the treated plots including fenfen 20 EC the percent fruit infestation at certain level was comparable to that of control treatments. This results higher fruit length and breadth in the treated plots is not uncommon. Butani and Jotwani (1984) and Thakur *et al.* (1986) reported that the length and breadth of the okra fruit affected the infestation of OSFB. This was because of the deformation of fruit and retardation of its growth. Haque *et al.* (1997) reported that individual fruit length and breadth were 14.69 and 1.41 cm when ripcord was used.

Table 14. Effect of different chemicals and a mechanical control method appied against okra shoot and fruit borer on fruit length and fruit breadth of okra at different stages

Treatment	Fruit length (cm) at different fruiting stage			Fruit breadth (cm) at different fruiting stage		
	Early	Mid	Late	Early	Mid	Late
T_1	15.31 ab	15.68 ab	13.95 ab	1.85 ab	1.78 ab	1.63 bc
T_2	15.43 a	15.76 ab	14.09 a	1.86 ab	1.78 ab	1.70 ab
T_3	15.09 abc	15.49 abc	13.33 bc	1.84 abc	1.75 abc	1.65 ab
T_4	14.90 bcd	15.23 bcd	13.24 c	1.79 cde	1.70 bc	1.53 cde
T_5	15.02 abcd	15.32 abcd	13.35 bc	1.82 bcd	1.76 ab	1.60 bcd
T_6	15.54 a	16.01 a	14.10 a	1.89 a	1.82 a	1.74 a
T_7	14.73 cd	15.06 bcd	13.05 c	1.78 cde	1.70 bc	1.53 cde
T_8	14.67 cd	14.90 cd	13.18 c	1.77 de	1.70 bc	1.52 de
T_9	14.52 d	14.69 d	12.96 c	1.74 e	1.67 c	1.49 e
$LSD_{0.05}$	0.474	0.650	2.72	0.055	0.077	0.095
Level of significance	**	**	**	**	**	**
CV (%)	7.82	2.45	2.72	5.81	2.74	3.32

In a column, numeric data represents the mean value of 3 replications from 10 plants
** Significant at 0.01 level of probability

T_1= Cymbush 10 EC @ 1.2 ml/l of water at 7days interval

T_2= Decis 2.5EC @ 1ml/l of water at 7days interval

T_3= Shobicron 425 EC @ 2ml/l of water at 7days interval

T_4= Karate 2.5EC @ 1ml/l of water at 7days interval

T_5= Regent 50 SC @ 1ml/l of water at 7days interval

T_6= Fenfen 20 EC @ 0.5ml/l of water at 7days interval

T_7= Suntap 50 WP @ 1.2g/l of water at 7days interval

T_8= Mechanical control (comprising removal and destruction of infected shoots & fruits)

T_9= Untreated control

Plant Height:

Plant height was measured at maximum vegetative stage. The tallest plant was obtained (109.88 cm) in Fenfen 20 EC treated plots (T_6) which was statistically identical with those of plants treated with Decis 2.5 EC (108.51 cm) and Cymbush 10 EC (105.52 cm) (Figure 1). The plant height was significantly lower (92.97cm) in untreated control plots (T_9) and was statistically similar to that of Mechanical control (95.87 cm) and Suntap 50 WP (96.32 cm) treated plots. The lowest plant height in control plants was due to heavy virus infestation and borer infestation.The findings of other workers have some similarity to those found in the present study.

Haque *et al.* (1997) reported that plant height was 103.60 cm in ripcord treated plots.

Misra and Singh (1996) also observed that highest average plant height was in fenvelerate treated plots (131.80 cm) followed by deltamethrin and cypermethrin treated plots (107.13 & 105.80 cm) and lowest plant height was in control plots (88.93 cm).

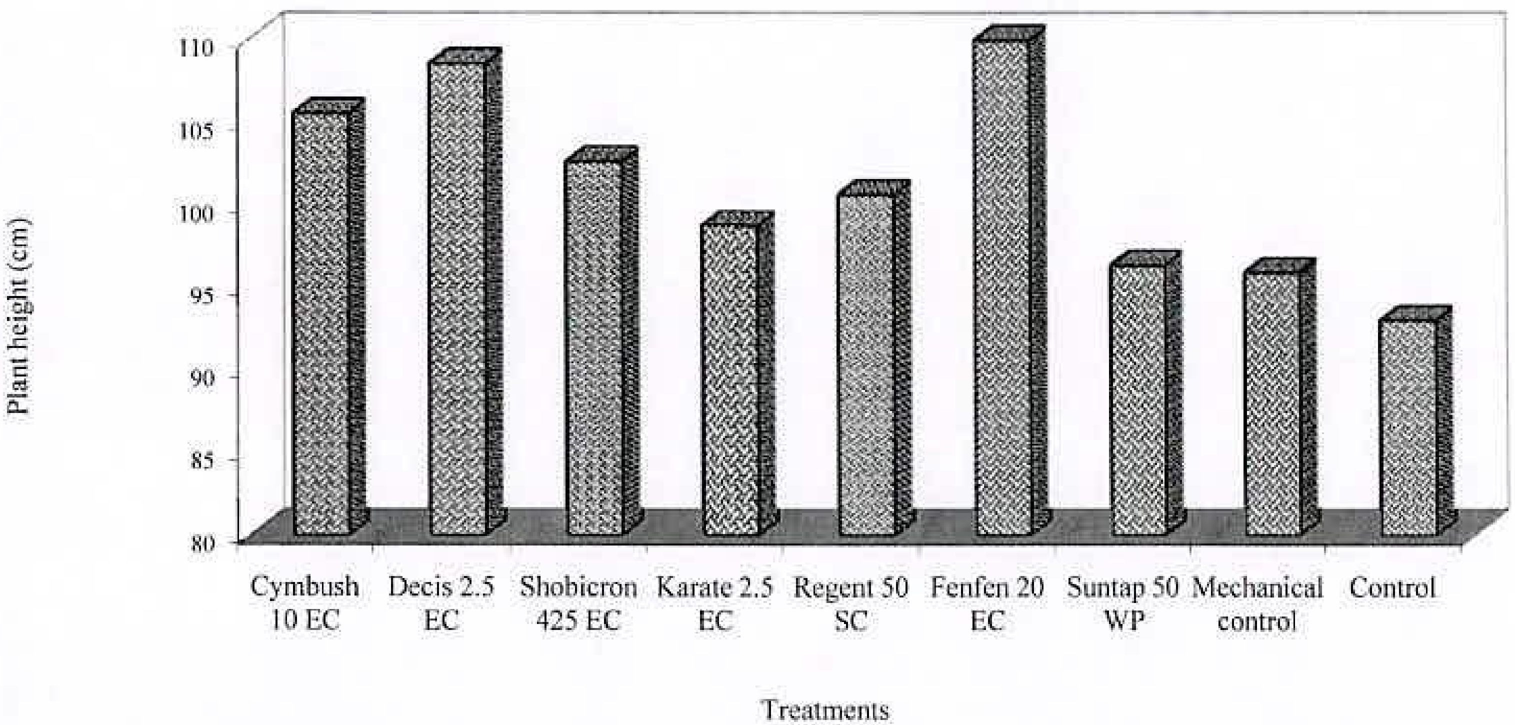

Figure 1. Effect of different treatments on plant height of orka measured at maximum vegetative stage of plant

Fruit Yield

The highest quantity of fruits were harvested from the Fenfen 20 EC treated plots (12.97 t/ha) followed by the treatment Decis 2.5 EC (12.47 t/ha), Cymbush 10 EC (12.64 t/ha), Karate 2.5 EC (12.35t/ha), Shobicron425 EC (12.27 t/ha) and Regent (12.27 t/ha) treated plots respectively (figure2). Yield was lowest in untreated control plots (11.33 t/ha). Similarly it was lower in the plots applied with mechanical control (11.95 t/ha) and Suntap 50WP treated plots (11.98 t/ha). The overall results indicated that the chemical insecticides used in this study gave almost comparable control against OSFB and provided better yield. Almost similar yield (13.33 t/ha) was obtained by Haque *et al.* (1997) when ripcord was used.

Yield of 1406.83 kg/ha was obtained in Sumitox treated plots and 1325.23 kg/ha in Ralothrin sprayed plots (Anon., 1992). In 2001, 8.75t/ha of yield was found in Shobicron 425 EC treated plots (Anon., 2001). Rao *et al.* obtained fruit yield of 106.7q/ha from Endosulfan 0.07% spray alternated with Carbaryl 0.15% spray.

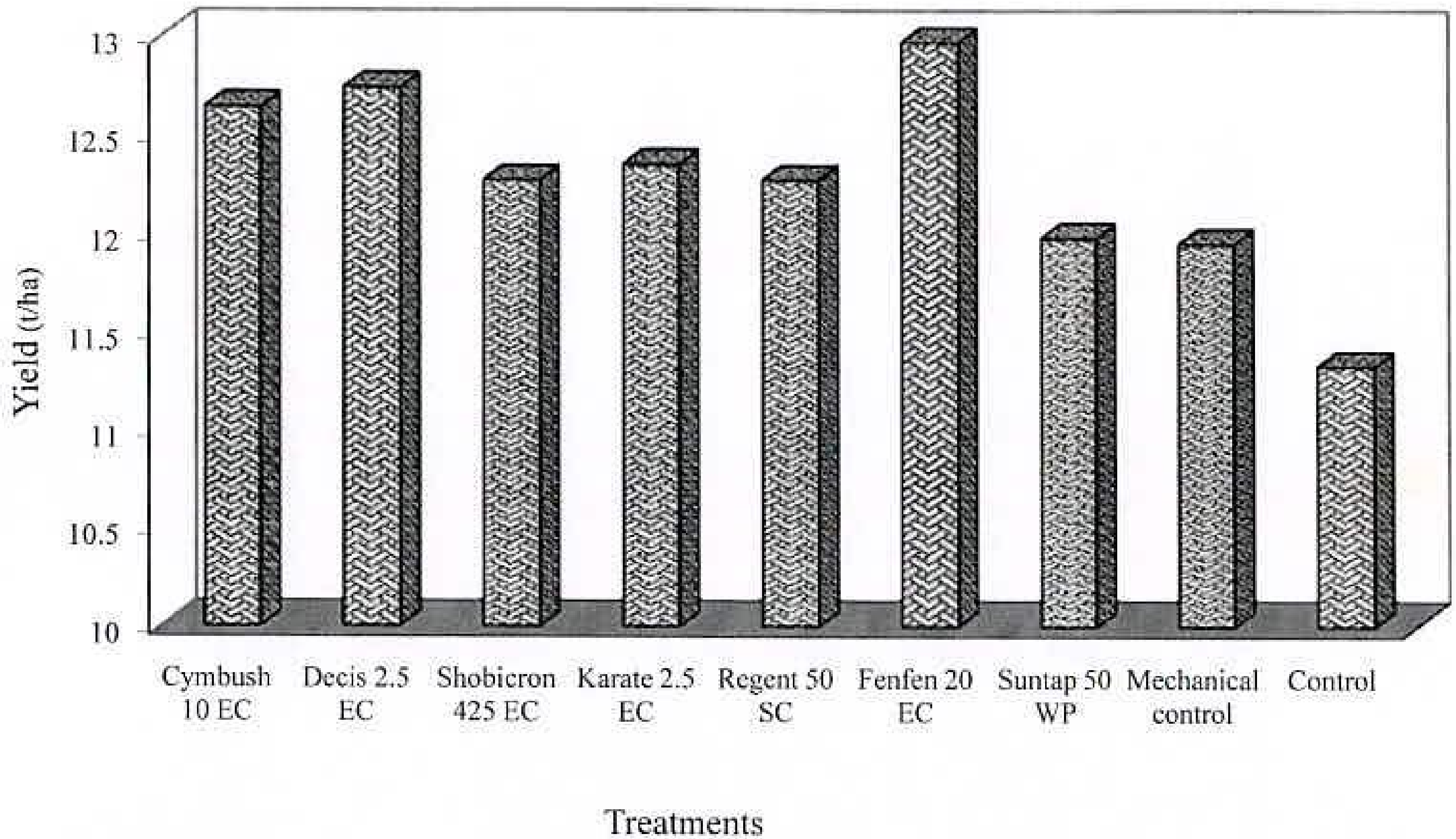

Figure 2. Effect of different treatments on yield of okra

Chapter 5
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The current study was carried out at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from April to July, 2006 to evaluate the effect of some synthetic insecticides to suppress the okra shoot and fruit borer over a cropping season. To meet the objectives, two chemical treatments, Admire 200 SL and Actara 25 WG along with an untreated control, for management of Jassid and Whitefly and nine treatments consisting of seven chemical insecticides (Cymbush 10 EC, Decis 2.5 EC, Shobicron 425 EC, Karate 2.5 EC, Regent 50 SC, Fenfen 20 EC, Suntap 50WP), mechanical control and untreated control for the management of okra shoot and fruit borer (OSFB) at different doses and time intervals were tested.

Experimental results showed that the mean number of Jassid population was significantly different with the application of different treatments. The highest number of Jassid per plant was found in the untreated control plots but the lowest number of Jassid was observed in Admire 200 SL treated plots and also the treatment showed the highest reduction of Jassid (80.30%) over control which confirmed 12.62 ton yield per ha where marketable yield increased 22.29% over control.

Similarly Admire 200 SL showed the lowest whitefly population (1.86) per plant and maximum population was found in untreated control plots (7.36). Admire 200 SL reduced 74.73% whitefly population over control as a result yield obtained 12.82 ton per ha and marketable yield increased 22.68% over control. At vegetative, early, mid and late fruiting stages of plant, the number of virus infested plants (0.33, 0.67, 1.00 and

1.33, respectively) per plot and leaves (1.33, 1.67, 2.67, 3.33, respectively) per plant, were lowest when Admire 200 SL was used but were highest in untreated control plots.

In case of okra shoot and fruit borer, significantly the lowest percent shoot infestation (3.95%) per plant was obtained from the Fenfen 20 EC (T_6) @ 0.5 ml/l of water treated plots which was followed by Decis 2.5 EC (T_2), (4.68%) @ 1 ml/l of water, Cymbush 10 EC (T_1) @ 1.2 ml/l of water and Shobicron 425 EC (T_3) @ 2 ml/l of water. Significantly the highest percent shoot infestation was obtained in the control plots.

At early fruiting stage, significantly the highest fruit infestation (13.82%) by number and weight (26.06%) was obtained from control plots, which was statistically different from others. Significantly the lowest fruit infestation was obtained from the Fenfen 20 EC (T_6) treated plots both by number (1.09%) and weight (3.92%) and was followed by Decis 2.5 EC (T_2) treated plots. Similar results were also evident at mid and late fruiting stages by number of infestation. At early and mid fruiting stage, Fenfen 20 EC exceeded the standard level of 80% reduction of fruit infestation over control both by number and weight but at late fruiting stage, Fenfen 20 EC exceeded the standard level of 80% reduction of fruit infestation only by number.

At early fruiting stage, the highest healthy fruits both by number and weight were obtained from Fenfen 20 EC treated plots (23.27) and (419.02g), respectively which were staistically identical to T_2, T_1, T_3 and T_5 treatments respectively. At mid fruiting stage, the number and weight of healthy fruits were statistically similar in chemical treated plots except in suntap 50 WP which differed only by weight. At late fruiting stage, the number of healthy fruits in different chemical treated plots did not varied significantly except control plots but at both stages the highest healthy fruits were obtained from Fenfen 20 EC treated and the lowest healthy fruits were obtained from untreated control plots both by number and weight. The infested fruits varied significantly in all the treated plots both by number and weight at all reproductive stages. However, the highest infested fruits were observed from control plots followed by mechanical control both by number and weight and the lowest infested fruits were recorded in Fenfen 20 EC treated plots both by number and weight followed by Decis 2.5 EC.

At all reproductive stages of okra plants under treatment Fenfen 20 EC (T_6), produced the maximum fruit length, breadth and plant height which were statistically similar to that of treatment T_2, T_1 and T_3 respectively. Untreated control plots produced the minimum length, breadth and plant height. In case of fruit breadth, the results from untreated control plots were statistically similar with treatment T_8 and T_7 respectively.

The highest yield was obtained from Fenfen 20 EC treated plots (12.97 t/ha) which was statistically similar to T_2, T_1, T_4, T_3 and T_5, treated plots respectively. The lowest yield was obtained from control plots (11.33 t/ha).

From the present study, it may be concluded that the lower incidence of Jassid and Whitefly was found in plots spraying with Admire 200 SL and also the decreased rate of shoot and fruit infestation and increased yield of fruit of summer okra were observed in plots spraying with Fenfen 20 EC and Decis 2.5 EC. Cymbush 10 EC also has significant effect in suppressing the borer and it might be tested with other management tactics. However, it could be advised to use Admire for controlling Okra Jassid and Whitefly and Fenfen 20 EC against okra shoot and fruit borer when the population appear to damage though further on-station and /or on-farm trials may be undertaken in order to confirm the validity of these results.

Chapter 6
References

CHAPTER VI

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LIST OF APPENDICES

Appendix I. Monthly average of Temperature, Relative humidity and Total Rainfall of the experiment site during the period from April to July, 2006

Year	Months	Air temperature (°C)			Relative humidity (%)	Total Rainfall (mm)
		Maximum	Minimum	Mean		
2006	April	33.74	23.81	28.77	68.92	179
	May	33.66	24.95	29.39	72.74	184
	June	32.39	26.08	29.23	79.82	562
	July	32.38	26.68	29.53	80.43	331

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka-1212.

Appendix II. Company name of chemical insecticides used in the experiment

Chemical Insecticides	Company name
Admire 200 SL	Bayer Crop Science Ltd
Actara 25 WG	Syngenta Bd Ltd
Cymbush 10 EC	Syngenta Bd Ltd
Decis 2.5 EC	Bayer Crop Science Ltd
Shobicron 425 EC	Syngenta Bd Ltd
Karate 2.5 EC	Syngenta Bd Ltd
Regent 50 SC	BASF Bd Ltd
Fenfen 20 EC	Alpha Agro Ltd
Suntap 50 WP	McDonald Bd (Pvt) Ltd

Source: Plant protection Wing, DAE.