INTENSITY OF INFESTATION AND MANAGEMENT PRACTICES OF JASSID ON DIFFERENT OKRA VARIETIES

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INTENSITY OF INFESTATION AND MANAGEMENT PRACTICES OF JASSID ON DIFFERENT OKRA VARIETIES

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CERTIFICATE

*This is to certify that thesis entitled, "**INTENSITY OF INFESTATION AND MANAGEMENT PRACTICES OF JASSID ON DIFFERENT OKRA VAREITIES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in ENTOMOLOGY**, embodies the result of a piece of bona-fide research work carried out by **FARZANA AFRIN NISHI, Registration no. 14-06083** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Date: June, 2021
Place: Dhaka, Bangladesh

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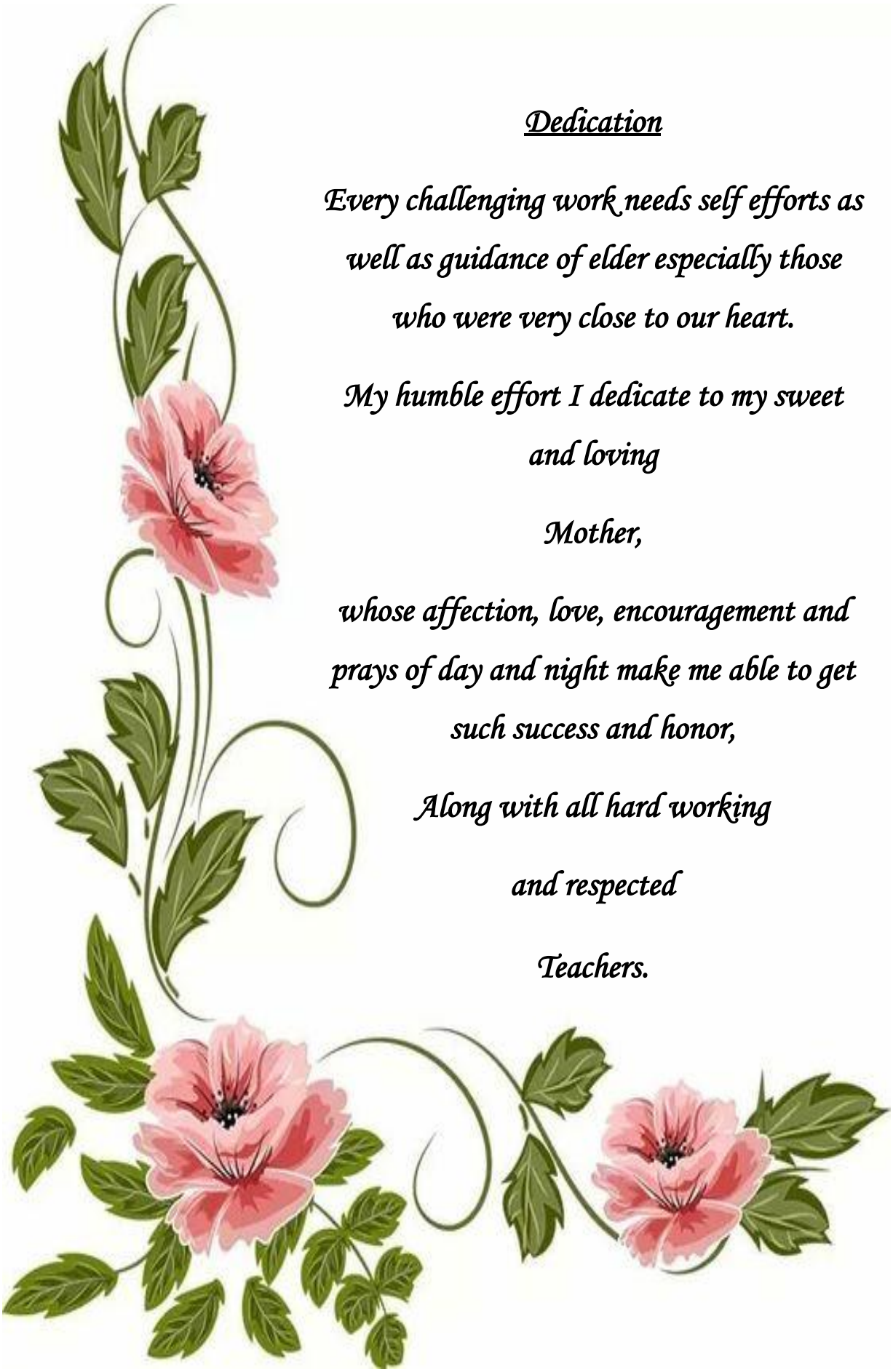

Dedication

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

My humble effort I dedicate to my sweet and loving

Mother,

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

Along with all hard working

and respected

Teachers.

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Dated: December, 2021

SAU, Dhaka ***The Author***

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ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October, 2019 to February, 2020. The experiment was laid out in Randomized Complete Block Design (2 factor) replicated with three times. For this study, factor A- T1 = Bumper 20SL was applied at the rate of 1.5 ml/L at 15 days interval); T2 = Neem oil (applied at the rate of 5 ml/L at 15 days interval); T3 = Control and factor B- V1= BARI Dheros-1; V2= BARI Dheros-2; V3= Ok-285 V4= Green finger; V5= Arko anamika. Results revealed that sustainable management of jassid on different varieties of okra that significantly effect on most of the yield and yield contributing parameters studied in this experiment. Similarly, most of the traits were also affected significantly due to the combination effect. In case of varietal performance, BARI Dheros-1 (V1) showed best results in terms of the number jassid infestation, percentage of infested fruit, fruit infestation at weight basis, fruit length, fruit girth, number of fruit Plant-1, single fruit weight, number of branch plant-1, yield. In case of different treatments, T1 = Bumper (20SL was applied at the rate of 1.5 ml/L at 15 days interval) showed outstanding performance for percent reducing the number of insect pests and getting the better growth and higher yield compared to those of other treatments. Again in case of combinations of varieties and different treatments, the number jassid infestation was reduced in T1V1 and T1V1 showed best results in terms of percentage of infested fruit, fruit infestation at weight basis, fruit length, fruit girth, number of fruit Plant-1, single fruit weight, number of branch plant-1, yield. There was negative relationship present in number of jassid and percentage of fruit infestation in weight basis with the yield of okra, i.e. when the number of jassid and percentage of fruit infestation in weight basis was increased the yield of okra was decreased.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Full word	Abbreviations	Full word	Abbreviations
Agriculture	Agric.	Milliequivalents	Meqs.
Agro-Ecological Zone	AEZ	Triple super phosphate	TSP
And others	*et al.*	Milligram(s)	mg
Applied	App.	Millimeter	mm
Asian Journal of Biotechnology and Genetic Engineering	AJBGE	Mean sea level	MSL
Bangladesh Agricultural Research Institute	BARI	Metric ton	MT
Bangladesh Bureau of Statistics	BBS	North	N
Biology	Biol.	Nutrition	Nutr.
Biotechnology	Biotechnol.	Randomized Complete Block Design	RCBD
Botany	Bot.	Regulation	Regul.
Centimeter	Cm	Research and Resource	Res.
Cultivar	cv.	Review	Rev.
Degree Celsius	°C	Science	Sci.
Department	Dept.	Society	Soc.
Development	Dev.	Soil plant analysis development	SPAD
Dry Flowables	DF	Soil Resource Development Institute	SRDI
East	E	Technology	Technol.
Editors	Eds.	Tropical	Trop.
Emulsifiable concentrate	EC	Thailand	Thai.
Entomology	Entomol.	United Kingdom	UK
Environments	Environ.	University	Univ.
Food and Agriculture Organization	FAO	United States of America	USA
Gram	G	Wettable powder	WP
Horticulture	Hort.	Serial	Sl.
International	Intl.	Percentage	%
Journal	J.	Number	No.
Kilogram	Kg	Microgram	µ
Least Significant Difference	LSD		
Liter	L		
Milliliter	ml		

CHAPTER-I

INTRODUCTION

Okra (*Abelmoschus esculentus* L.), also known as lady's finger and locally known as *'Bhindi'* or *'Dherosh'* ,is a popular and widely planted vegetable crop in Bangladesh and other parts of the world. Okra is primarily grown in Bangladesh during the kharif season, but it can be grown all year (Rashid 1976). It is a popular vegetable crop in the tropical and subtropical climates (Osekita 2009). It is said to have originated in tropical Africa or Asia, and is currently widely planted across the tropics (Ali *et al*., 2012). The crop can be found all over the Indian subcontinent and East Asia (Rashid 1999). Bangladesh produces 38,508 metric tons of okra every year from 9786 hectares of land (BBS 2009), with an average output of 3.93 tons per hectare (BBS 2009). When compared to the yields of other affluent countries (9.7-10 t ha), the yield is extremely low. (Thomson and Kelly 1979).

Okra is a multipurpose crop. The tender okra pods are eaten fresh, canned, and dried. In Turkey, okra seeds are roasted, ground, and used as a coffee substitute. It is a healthy and tasty vegetable that is high in vitamins and minerals (Khushk *et al.*, 2003). The edible portion (100g) of the pod contains moderate amounts of vitamin A (375 IU), vitamin C (21.1 mg), calcium (81mg), phosphorus (63mg), and potassium (303mg) (USDA National Nutrient Database) .Thiamine (0.07mg), riboflavin (0.08mg), and niacin (0.08mg) content per 100g edible portion is higher than that of many vegetables (Rashid 1999). Tender fruits contain a high amount of mucilage and are used in soups and gravies. Okra fruits and stems contain crude fiber and gummy material, which are used in the production of confectionary and glace paper. Aside from being a vegetable, it also serves as a clarifying agent (Chauhan 1972). The fruits are also medicinal in nature. A mucilaginous preparation derived from the pod can be used to replace plasma or increase blood volume (Savello *et al.*, 1980). Tender fruits are used as vegetables or as sliced and dried pieces in culinary preparations. Because of its high mucilage content, it is also used to thicken gravies and soups. Okra roots and stems are used to clean cane juice. Matured fruits and stems containing crude fiber are used in the paper industry. Its tender green fruits are used as a vegetable and are typically sold fresh, but can also be found canned or dehydrated. Its

fruits can be prepared in a variety of ways. It can be fried in butter or oil and then cooked with the appropriate ingredients.

Okra is a nutritious vegetable that helps to meet the country's vegetable demand when vegetables are scarce in the market. Okra mucilage has medicinal and industrial applications. Vegetable production in Bangladesh is not consistent throughout the year. The majority of vegetables are grown in the winter, with very little produced in the summer. In the kharif season, approximately 30% of total vegetables are produced (Anon. 1993), with okra playing a significant role. In 2009-2010, the total okra production was approximately 42000 tons from 10121 hectors of land, with an average yield of 4.15t/ha (BBS 2011). The yield is very low in comparison to other developing countries, where yields can reach 7-12 t/ha (Yamaguchi 1998).

One of the major constraints identified for okra production is the increasing incidence of insect pests, which can result in significant yield losses. From the seedling to the fruiting stage, okra is vulnerable to insect attack (Vyas and Patel 1991). Many insect species attack this crop, including the okra shoot and fruit borer (OSFB), okra jassid, cut worm, white fly, aphids, and others. Among these due to favorable environmental conditions *Amrasca devastans*, or Jassid, is a major pest in the tropics and subtropics. It is one of the most important sucking insects that attack and cause significant damage to the okra crop. (Dhandapani *et al*., 2003; Jamshaid *et al*., 2008). Jassid and whitefly are the most serious sucking insect pests (Atwal, 1994), causing 35-40% crop yield losses and eventually increasing the level of damage to 60-70% in optimal conditions (Salim 1999). Jassid nymphs and adults both cause damage by sucking cell sap and inserting toxic saliva into plant cells. Their saliva contains protease and lipase, which aid in the digestion of proteins and lipids. Toxins found in saliva cause tissue necrosis and phytotoxemia in host plants. The insect not only reduces the farmer's profit but also spreads a variety of pathogenic diseases. The color of the leaves changes from green to yellow brown, turning downward, which is a characteristic feature of sucking insects, particularly jassid, the margins of the leaves become grayish, plant growth is stunted, it weakens, the photosynthetic area decreases, and the plant eventually dies (Bhatangar and Sharma, 1991; Lohar 2001; Asi *et al*., 2008).

To mitigate losses caused by this pest and control okra jassid, our farmers use a variety of chemical insecticides in large quantities. However, this indiscriminate and non-judicious use of chemical insecticides is causing insecticide resistance, insecticidal residues, phytotoxicity, and the death of beneficial insects. Again, the residual effect of insecticides causes agro-ecosystem imbalance (Sarker and Nath 1989). Fruits harvested at short intervals of insecticide spraying are likely to retain unavoidably high levels of insecticide residues, which may pose a high risk to consumers (Sardana *et al*., 2006). To mitigate the threat of food contamination, host plant resistance and a variety of bio-insecticide sources are being sought to replace synthetic insecticides. Host plant resistance is a more bio-rational approach to integrated pest management that can suppress insect pest populations (Ashfaq *et al*., 2010). Cultivation of resistant varieties is one of the most effective, economical, and eco-friendly tactics which proves to be the most promising approach to enhance okra production (Khan *et al.,* 2010). Plant derivatives, which are eco friendly, having a high potential as insecticides (Grainge and Ahmad, 1988; Dhingra *et al*., 2008). Furthermore, these are not harmful to humans or other non-target organisms. Botanicals have a variety of properties, including insecticidal and insect growth regulatory activity against a wide range of insect and mite pests (Prakash *et al*., 1990). Unfortunately, there is very little information available on botanical management of this pest, and no attempt has been made in our country to manage this pest using resistant varieties and bio-rationales, specifically extracted microbe products.

Objectives:

Considering the importance of eco-friendly approaches to manage the okra jassid, the present study has been intended to fulfill the following objectives:

- To know the infestation level of Jassid (*Amarsaca devastans*) on okra leaf and fruit

- To find out efficacy of the different management practices and to establish of an environmentally safe control measure against jassid

CHAPTER-II

REVIEW OF LITERATURE

Okra (*Abelmoschus esculentus* L.) Okra is a major vegetable crop in Bangladesh, but it is infested by a plenty of insect pests that cause significant yield loss. Okra jassid, *Amrasca devastans*, is a notorious pest that occurs sporadically or in epidemic form throughout Bangladesh every year. Damage caused by *Amrasca biguttula biguttula* from young seedling to mature crops results in a 50% yield loss (Halder *et al.*, 2016) and 40-56 percent losses (Krishnnaiah 1980). During the day, the pests prefer to rest on the underside of the leaves. In Bangladesh, only a small amount of work has been done on insect pest management of okra in the summer and winter. A brief review of the literature available in Bangladesh and elsewhere related to insect pest control of okra is discussed below:

2.1. General review of okra jassid (*Amrasca devastans*)

2.1.1. Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Sub-phylum: Mandibulata

Class: Hexapoda

Order: Hemiptera

Sub-Order: Homoptera

Family: Cicadillidae/Jassidae

Genus: *Amrasca*

Species: *Amrasca devastans*

Common name: Okra leafhopper/ Okra Jassid

2.1.2. Origin & Distribution:

Okra jassid is a versatile and widespread insect. It has been recorded in India, China, Pakistan, Iran, Syria, Greece, Spain, Argentina, Brazil and the United States. It is widely

distributed throughout Eastern, Western, Southern, and Central Africa, as well as Australia (Rahman *et al.,* 2014). This pest is also very common in Bangladesh.

2.1.3. Environment effects on outbreak of okra jassid

Jassid population is controlled by their inherent capability to expand, over the influence of various external environmental parameters. Different environmental factors such as temperature, relative humidity, and rainfall are thought to be important reasons for population fluctuations. The Punjab region has a large jassid population due to favorable environmental conditions. Environmental factors have an impact on the existence, growth, and development of jassids, as well as their reproductive capacity. Temperature is one of the most important environmental factors on which insects rely for management. The various environmental parameters influence the development, life cycle, spread, and jassid outbreaks to such an extent that they are forced to acclimate. The nymphal population begins to grow during the second week after seedling emergence. After 2001, the overall status of jassids on okra decreased, owing primarily to the increased use of neonicotinoid seed treatment chemicals. Jassids become a pest during the months of July and August, sometimes threatening crop stand (Iqwal *et al*., 2010). Devi *et al.* (2018) also found a link between temperature, rainfall, evening relative humidity, and evaporation.

2.1.4. Description of life stages

Biology of Jassid

2.1.4.1. Egg: The eggs are curved, greenish-yellow eggs (0.7-0.9 X 0.15-0.2 mm) that are oviposited deeply implanted in the midrib or a large vein on either surface of the leaf, a petiole, or a young stem but never in the leaf lamina (Vennila *et al.,* 2007). Depending on the species, 29-60 eggs can be laid singly, and they hatch in four to eleven days.

2.1.4.2. Nymph: Nymphs are flattened, pale yellowish green (Vennila *et al.,* 2007), wedge-shaped, 0.5-2.0 mm long, move diagonally, and are confined to the underside of the leaves during the day, but can be found anywhere on the leaves at night. Depending on food availability and temperature, the nymphal period ranged from 2 to 21 days. In India,

a generation lasts 3-4 weeks during the summer, and a jassid has 11 generations in a year (Iqbal *et al* 2008).

2.1.4.3. Adult: Jassid adults are tiny insects that are oval in shape and have four wings that are about 3.5 mm long. Their bodies are elongate and pale green in color. Male adults are smaller than females. The black spots can be found in both the forewings and the vertex (Vennila *et al*., 2007). Adults are very active with sideways movement, but they hop quickly. (Singh *et al.,* 2003).

2.1.4.4. Host range

Apart from okra, the jassid feed on a diverse range of host plants, including herbaceous cultivated plants and weeds, primarily from the Malvaceae, Leguminosae, and Solanaceae families. Jassid is a polyphagous insect that infests okra, cotton, potato, tomato, hollyhock, sunflower brinjal, beans, castor, rose, cucurbits, and other plants. Jassid infests approximately 17 host plant species from 8 different families (Rahman *et al.,* 2014).

2.1.4.5. Monitoring :

On the undersides of the leaves, nymphs and adults can be seen. When disturbed, nymphs tend to move sideways, whereas adults can fly easily, and both nymphs and adults follow an aggregated distribution (Shivalingaswamy *et al.,* 2002). Sharma *et al.* (1997) studied the biology of jassid (*Amrasca*) on okra varieties; pusa swani revealed that the insect had a 6.27-day incubation period. Jassid egg hatchability was 91.9 percent, and nymphal instars lasted 1.5, 1.1, 1.2, 1.5, and 2.0 days. The average pre-mating, pre-observation, oviposition, and post-oviposition periods were 2.55, 3.45, 16.57, and 3.90 days respectively. The average fecundity was 17.5 eggs per female. The adult life span was between 21 and 30 days. The females dominated over males in numbers in the field

2.1.5. Okra jassid damage to okra plant and fruits

The pest jassid is one of the most common sucking insects, because it attacks the okra crop causing significant losses (Iqbal *et al.,* 2008). Jassid and whitefly are more serious sucking insect pests that transmit plant viral infections (Atwal 1994). They suck the plant

sap, causing yellowing of the leaves and yield losses of up to 35-40%, which can climb to 60-70% in an ideal environment. (Sultana *et al.,* 2016).

2.1.5.1. Feeding injury

Okra jassid sucks the plant cell sap, causing reddening and yellowing of the leaves, as well as a reduction in the photosynthetic zone. By injecting its toxic saliva into plant tissues, it caused damage to both nymphs and adults. The most severe damage was reported in the middle of the season, resulting in lower yields. (Sahito *et al.,* 2017).

2.1.5.2. Symptomps of Plant damages

- Tender leaf become yellowish
- Leaves margin shows curling downwards and reddening
- During severe infestation, leaves become browning, which is a common "hopper burn" symptom
- Leaf margins broke and crumbled into pieces when crushed
- Leaves dried up and shed down, stunting growth

ET: 50 nymphs/adults per leaf or yellowing and curling from the middle to upper portion of the plant in 25% of field plants

2.1.5.3. Indirect Damages due to Okra jassid

The accumulation of honeydew produced by the jassid causes indirect damage, on leaves and fruit, this honeydew serves as a substrate for the growth of black sooty mold. The mold reduces photosynthesis, lowering the plant's market value or rendering it unmarketable (Berlinger 1986). Mandahar and Singh (1972) investigated how the Okra Yellow Vein Mosaic Virus affects the host. They found that *Hibiscus esculentus* infection resulted in a 62-82 percent reduction in total chlorophyll and a 56.61 percent reduction in total photosynthesis, while infected tissue respiration increased by 8.33 percent. Carbohydrates were found to be transported from healthy to diseased leaves, where they

accumulated, possibly explaining why infected plants did not bear fruit. Infection with the Okra Yellow Vein Mosaic Virus reduced chlorophyll a and b content in okra leaves while increasing chlorophyll enzyme activity, according to Ramiah *et al.* (1972). The amount of carotene and xanthophylls in the food was also reduced.

2.1.5.4. Status and Nature of damage

The okra jassid, *A. devastans*, is one of the most important insect pests of the okra plant and is a major factor limiting okra yield in Bangladesh (Eltom 1978). In some okra genotypes, this pest can reduce seed okra yield by more than half (Bhat *et al*., 1984). This pest's nymphs and adults can eat okra leaves at any stage of development. Jassid, particularly older nymphs, feeding on small veins appears to affect the vascular system's functioning, causing the edge leaf to change color from dark to pale green, yellow, and finally red and brown. Plant sap is sucked by adults and nymphs from the undersides of leaves. Hopper burn symptoms were visible on the affected leaves. The entire leaf of susceptible okra varieties can dry out and fall off. If the attacked leaves haven't fully expanded, their edges curl downward. Young plants' growth can be completely stopped. They also introduce a toxin that prevents okra plants from photosynthesis. The okra leaves turned yellow and curled upward as a result of the jassid's attack. The leaves eventually dried up and turned brown at the tips. Plants that were heavily infested failed to bear fruit, while those that were less damaged produced a variety of fruits.

When cocked, the deformed fruits became fibrous and unfit for consumption (Kochhar 1986). In the field, the infested plants remained stunted. The presence of globular, translucent, mucilaginous substances on jassid-attacked plants can easily be identified. The exudates were mostly found on the leaf's underside, with a few in the leaf petiole and stem. The jassid harmed the plants at every stage of their development. The younger leaves had the most exudates, while the older leaves had the least (Eltom 1987).

2.1.5.5. Incidence and seasonal distribution of okra jassid

During the kharif seasons of 2005 and 2006 in Kanpur, Uttar Pradesh, India, the population dynamics of jassid on okra cv. Azad bhindi-1 were studied in relation to weather factors. In 2005, Jassid began actively working on a 3-week-old crop in the first week of August. In 2006, jassid infestation on shoots began in the fourth week of July at the 7 leaf stage and lasted until the third week of September (Yadav *et al.*, 2007). In 2005, the highest population of jassid was discovered on 8-week-old plants in the second week of September. (Yadav *et al.*, 2005).

In 1998-99, Inee *et al.* (2000) investigated the seasonal abundance of jassid on okra in Assam, India. The findings indicate that meteorological parameters played an important role in the growth of the cotton jassid population. The population of jassid was at its peak in the last week of May, 1998 (37.53 nymphs per leaf) and in the middle of April, 1999 (30.00 nymphs / leaf).

Kumawat *et al.* (2000) discovered the seasonal incidence of jassid (*Amrasca devastans*) on Okra crop during kharif 1996 in Rajasthan semi-arid region, India. The jassid invasion begins in the fourth week of July and peaks in the 2nd and 4th weeks of September, respectively.

Mahmood *et al.* (1990) investigated the abundance of Cicadellidae, jassid on okra in Pakistan from 1986 to 1987. Pests appeared in June and remained active throughout the crop season. Temperature was the most important environmental factor of all. In terms of density, there was a positive correlation between the highest and lowest temperatures.

Mahmud *et al.* (1988) reported phonology of the Cicadellidae, jassid on okra in Pakistan in another study. For about five weeks after germination, the pest population remains below the economic threshold level. The population passed the threshold in early June and remained constant until late August.

Senapati and Khan (1978) discovered that the most okra jassid appeared from November to February. According to Pawar *et al.* (1996), sowing on the 15th and 1st of June had a lower incidence of *Amrasca devastans* and a higher yield of marketable fruits (22.9 q/ha).

According to Atwal *et al.* (1969), the population peaked in August and September, with temperatures ranging from 28.2 to 30°C.

Ali *et al.* (1991) conducted an experiment in Joydebpur, Bangladesh, over 3 consecutive kharif and rabi seasons to investigate the effect of plant age on jassid abundance. Cicadellid populations remained below the economic threshold level of one insect/leaf for up to 35 days in kharif and 65 days in rabi. The majority of the cicadellids were found in plants that were 35 to 75 days old in the kharif season and 65 to 130 days old in the rabi season. Plants grown during the kharif season were more susceptible to insect attack than plants grown during the rabi season (Yadav *et al.*, 2008).

Tomar and Rana (1994) found that the spring sowing dates of 20 February and 5 March, and the rainy season sowing dates of 2 April and 5 June, had the lowest incidence of jassid nymphs. (Yadav *et al*., 2001).

2.1.6. Management tactics

2.1.6.1. Use of botanical extracts

Botanical pesticides are becoming incredibly popular, and they are now being used to control a wide range of insect pests. It was discovered that botanical substances can be used to control the Lepidopteran insect.

Patel and Patel (1996) discovered that spraying a 5% neem seed kernel suspension on okra had an inhibitory effect on *Amrasca devastans*, resulting in the production of abnormal adults and a lower emergence of normal adults. Umamaheshwari *et al.* (1999) found that neem oil had a significantly higher percent mortality of jassid and other sucking pests on okra than achook and nimbecidine. Castor oil outperformed the untreated control but fell short of neem products. However, dicofol (0.2 %) outperformed all other neem products.

Natarajan *et al*. (2000) investigated the efficacy of botanicals such as NSKE, garlic kerosene extract, and Vitex extract against the jassid, *A. devastans*, on okra and discovered that garlic kerosene extract had the fewest jassid.

Pawar *et al.* (2000) conducted a field trial to evaluate the bio-efficacy of organic products against jassid and aphids on okra and discovered that cow urine, *Lantana camara* L., and *Azadirachta indica, A. Juss* were effective.

Except in terms of jassid incidence, the treatments outperformed monocrotophos. The leaf extracts of Annona, reticulat, and jatropa were highly effective against the bhendi jassid. Spraying neem oil + garlic extract, garlic extract + chilli extract, garlic extract + cow urine, and NSKE + cow urine on okra reduced the incidence of aphids and jassids. (Jayakumar 2002).

The laboratory studies were carried out to test the joint action potential of NSKE methanolic extract in combination with methanolic extracts of two other botanicals, sweet flag and pungum, against *Amrasca devastans* on okra at 1:1:1, 2:1:1, and 3:1:1 (v/v) ratios. When compared to other combinations and NSKE alone, the first combination had the lowest settling response and the highest mortality of jassids. Under field conditions, the combination at 0.42 percent concentration also provided superior pest control after methyl demeton (0.05 percent) (Srinivasa Rao and Rajendran, 2002). According to Mani *et al.* (2005), botanical pesticides such as neem oil, azadirachtin (300 ppm), and (1500 ppm), mahua and pungum oil significantly reduced jassid population on okra.

A field trial was conducted to determine the effectiveness of traditional pest control measures against major rice pests. The results showed that the brown jassid population was suppressed (6.96 hoppers/hill) in plots treated with a mixture of asafetida leaves followed by a waste tobacco leaf extract. The treatment with rice bran and kerosene resulted in the lowest jassid population, whereas plots sprayed with lime + ash and green chilli extract resulted in the least leaf folder damage (Bhaskaran 1995).

Under laboratory conditions, Narayanasamy (1999) investigated the insecticidal activity of 23 selected traditional pest control practices (plant extracts) against rice pests such as jassid and leafhopper. The most effective practices against jassid was spraying the extract

of garlic + kerosene (39.29% mortality) followed by neem oil and rice bran + kerosene. Garlic (21.35/plant) and Margosa (2.94/plant) treated plots had the lowest jassid population on tea plants, followed by Margoeconeem (3.47/plant) (Baisen and Ghosh Hajra 2001). Rosaiah (2001) discovered that spraying monocrotophos in brinjal was more effective than other methods of reducing jassid incidence. However, neem oil (0.5%) outperformed NSKE in terms of reducing jassid and whitefly populations, as well as shoot and fruit borer damage (5 percent). The effectiveness of Annona, Calotropis, and Jatropa leaf extracts against the pests of brinjal was poor (Rosaiah (2001).

Hanumantappa (2003) investigated the efficacy of botanicals against the sunflower jassid, *A. devastans*, and discovered that among the botanicals tested, NSKE (5%) was superior to neem oil, pongamia oil, and commercial neem formulation.

Deshmukh and Barle (1976) investigated the insecticidal activities of 20 plant extracts and suspensions against jassid. *Spodopetra litura* Oriental Leaf worm Moth was much more sensitive to plant extracts than Jassid. Some indigenous extracts, such as neem, garlic, tobacco straw wash, and a soap-kerosene mixture, were used as repellents against mustard jassid *Lipaphis erysimi* K. and all of the extracts showed a reduction in infestation as well as an increase in yield (Kabir and Mia 1987).

Cold alcoholic extracts of Calamus, *Azadirachta indica*, *Butea sp.*, *Calotropis sp.*, *Datura alba* (Nees.), *Ipomea carnea* (Jacq.), and *Parthenium hysterophorous* L. were checked against *Dactynotus carthami* (HRL) and *A. devastans*. The cold alcoholic extract of *P. hysterophorous* appeared to be more toxic against both insects, followed by *A. indica* (Patil *et al*. 1990).

According to Iyyappa (1994), spraying 1% lemon juice reduced the jassid population on okra. The dried tobacco waste soaked in water for two days and the extract mixed with neem oil and cow urine when sprayed against sucking pests like jassid and whitefly was

found extremely effective. Samanthbhai and Dharmanbhai made a similar observation about the effectiveness of lemon juice on jassid population in okra (1994).

At Tirupathi, petroleum ether extract of neem, garlic derivatives, bullock's heart leaves, Mexican prickly poppy, and neem oil (margosa) were tested against the okra jassid, *A. devastans*. All of the leaf extracts performed similarly and reduced the jassid population by 88.81 to 90.06 percent. *Annona squamosa* (sugar apple) and Neem guard were the most effective, with reductions of 84.43 and 82.45 percent, respectively, while garlic extract was the least effective (Chitra *et al*. 1997).

Jassid populations were drastically reduced in plots treated with neem cake (86.92 %), *Pongamia pinnata* (Indian Beech or Pongam Oiltree) (85.50 percent), NSKE (84.48 %), and Lantana (84.48 %) (83.50%). The dimethoate treatment produced the highest seed yield, followed by Pongamia (14.32 q/ha) and Lantana (14.14 q/ha). It was recommended to use botanical extracts such as NSKE (5%), neem cake (5%), *Pongamia pinnata* (5%), and Lantana (5%), taking into account cost economics and ecosystem and environmental factors (Mallapur *et al.,* 2001).

Rathod *et al.* (2002) investigated the bioefficacy of various herbal products against the mustard jassid, *L. erysimi*, and discovered a lower number of jassid population in aripple leaf extract (21.94), sadabahar leaf extract (21.34), and a mixture of garlic + green chilli + kerosene (22.50) after 10 days of spraying.

Patel *et al.* (2003) investigated the efficacy of cow urine and botanicals against sucking pests of okra and discovered that, while applying cow urine (20%) alone was effective in reducing the jassid population, the insecticidal effects of cow urine could be further enhanced by enriching it with other botanical products such as 'Nikuchhi,' a leaf extract of neem, custard apple, jatropa, and lantana.

Patel *et al.* (2003) investigated the bio-efficacy of arni (*Clerodendron multiflorum* F.), lantana (*L. camara*), mint (*Mentha piperata* L.), ardusa (*Alicantehus excels* R.), naffitia

(*Ipomoea fistulosa* M.), and kaner (*Nerium indicum* Mill.) leaf extracts (10%) against *A. devastans* under laboratory conditions. The results showed that *A. devastans* died at a significantly higher rate (34.93 percent) when treated with NSKE, followed by neem (32.39 percent). Plants treated with ardusa leaf extract died at a rate of 27.39 percent, which was comparable to neem, naffatia, and lantana. Mint, kaner, and axni leaf extracts were all about equally effective, with mortality rates ranging from 20% to 22%. Ratanjyot leaf extract was unable to control the jassid population. Field evaluation studies also revealed that NSKE outperformed all other treatments by having the lowest jassid population (35.98 jassid/plant). Natural enemies *of A. devastans* were found to be unaffected by the botanicals.

According to Nonita Devi *et al.* (2003), among the various plant extracts tested, Artemesia vulgaris (Linn.) (@ 0.0645 percent) had the highest mortality rate of 70.65% against okra jassid.

Balikai and Lingappa (2005) investigated the bioefficacy of various botanicals on rabi sorghum against jassid, *Melanaphis sacchari* (Zhentner). Among the plant products tested, *Catheranthes (Vinca) rosea* L. leaves at 5%, *Pongamia pinnata* (L.) kernels at 2%, *Pongamia pinnata* leaves at 5%, A. indica kernels at 5%, *Vitex negundo* L. leaves at 5%, and *Adhatoda vasica* Nees leaves at 5% had the same insecticidal value as endosulfan 35 EC at 0.07% against jassid . With the exception of *V. negundo* and *A. vasica*, this resulted in higher grain and fodder yields comparable to endosulfan. *V. rosea*, *P. pinnata*, *A. indica, V. negundo*, and *A. vasica* plant products can be effectively used for its management as an eco-friendly management tactic. (Balikai and Lingappa 2005).

2.1.6.2. Chemical Control

In Karnatak, India, Kumar *et al.* (1989) investigated the critical time of insecticidal application for control of *A. devastans* on okra. Insecticide application 21-42 days after germination resulted in the lowest pest infestation and the highest benefit-cost ratio.

In the chilli ecosystem, Babu and Santaram (2000) found that imidacloprid 200 SL had a 23-day effect on aphids and a 31-day effect on leafhoppers.

Verma (1989) tested Sumithion 50 EC, Lindane, endosulfun (Thiodan 35 EC), methyl-O-demton, monocrotophose (Azodrin 400), and other chemicals on okra in the field in India against the cicadellid, *A. devastans*. He advised a 50% mortality concentration within 4.0 days.

To determine the most effective treatment, a schedule of insecticide sprays using sumithion 50 EC and systoate 400 on 35, 45, 55, and 65 days after planting was investigated in Benin. Sumithion 50 EC, malathion 8F, quinalphos 25 EC or monocrotophos or endosulfan 35 EC would be highly effective if applied during flowering and then again during pod setting. However, at lower infestation levels, insecticide application would be uneconomical (Atachi and Sourkou, 1989).

During kharif 2003 and 2004, Rana *et al.* (2006) conducted experiments in Karnal, Haryana, India, and discovered that admire 200SL at 2 ml, as well as thiamethoxam and carbosulfan each at 2g/kg seed, were quite effective in controlling jassid and whitefly. Treatments resulted in higher okra seed yield. It was also cost effective and significantly reduced the amount of insecticide used.

Gandhi *et al.* (2006) demonstrated that insecticidal seed treatment is a viable alternative to spraying and granular applications. Lal and Sinha (2005) conducted research to evaluate four (5,9,18, 36, g/kg) doses of Admire (imadacloprid) treatments against okra sucking pests. The studies revealed that the seeds yield of all treatments, with the exception of the highest dose (36g/kg) of Admire treatment, produced excellent results.

Dey *et al.* (2005) conducted filed experiment during the 1998 and 1999 to evaluate the efficacy of imidacloprid 70WS, Admire 200SL, against jassid, *Aphis gossypii* and *Bemisia tabaci* of okra and their natural enemies. Admire 20SL was applied as foliar spray at 20 and 40 days after sowing. It was effective against jassid and others sucking pests.

Anoh, (2005) conducted an experiment to control jassid population on lady's finger and found that admire 200 SL had significant effect in controlling jassid.

2.1.6.3. Efficacy of new promising molecules against okra pests and natural enemy complex

Kumar *et al.* (1999) investigated the bio-efficacy of Admire 200 SP, a new insecticidal compound, against okra aphid and jassid in comparison to monocrotophos, acephate, and oxydemeton methyl. Based on the results of two seasons of testing, acetamiprid proved superior to the conventional insecticides in controlling pests at all tested doses. The chemical, applied at a rate of 10 g a.i./ha, provided consistent control of the target pests over an extended period of time.

During 1997 and 1998, Dhawan and Simwat (2000) studied the effect of indoxacarb on the population of sucking pests such as aphids and jassids. In both years, the population had significantly lower levels of indoxacarb and admire than cypermethrin and the untreated control. According to Ramesh Babu and Santaram (2000), the effect of admire 200 SL lasted 23 days against jassid and 31 days against sucking pests like jassid in the ecosystem.

Katole and Patil (2000) investigated the activities of natural enemies in imidacloprid seed treatments and foliar sprays (70 WS for seed treatment and 17.8 SL for foliar spray). Though there was no statistically significant difference in the occurrence of natural enemies (Coccinellids and Chrysoperla grubs), the plots with seed treatments had higher populations of natural enemies than the foliar sprays. Acetamiprid 20 SP @ 30 g a.i./ha recorded the fewest jassids (0.92/leaf) and aphids (0.65/leaf) in cotton after 7 days of application when compared to monocrotophos (1.68 jassid and 11.10 aphids/leaf) (Patil *et al.* 2001).

Patil *et al.* (2002) compared imidacloprid 17.8 percent SL to conventional insecticides for its relative efficacy against sucking pest complex of chilli, namely aphid (*A. gossypii*), thrips (*Scitothrips dorsalis* Hood), and jassids (*A. devastans devastans*). Imidacloprid 17.8 SL at 125 and 150 ml/ha was found to be more effective than monocrotophos and dimethoate against the sucking pest complex in chilli. The treatment with imidacloprid 17.8 SL @ 150 ml/ha yielded significantly more than the treatments with imidacloprid 17.8 SL @ 125 and m100 ml/ha, monocrotophos 36 WSC (650 ml/ha), and dimethoate 30 EC (750 ml/ha).

Subhadra Acharya *et al*. (2002) studied the efficacy of newer insecticides such as acetamiprid, thiamethoxam, imidacloprid and abamectin and, other commonly used insecticides like dicofol, ethion and dimethoate against okra jassid, *A. devastans* devastans and found that acetamiprid @ 20 g a.i./ha and thiamethoxam and imidacloprid (both @ 25 g a.i/ha) proved quite effective followed by abamectin @ 20 g a.i./ha. All the newer insecticides were found to be safe to lady bird beetle. Isacc and Svetlana (2002) compared the bioefficacy of emamectin benzoate 5 SG to abamectin against Western flower thrips, Frankliniella occidentalis (Pergade), in the laboratory and in the field. The results showed that emamectin benzoate had nearly ten times the activity on thrips as abamectin.

According to Misra (2002), imidacloprid 70 WS and thiomethoxam 20 WG @ 25 g a.i. proved significantly superior in controlling jassids on okra. Imidacloprid was a very effective neonecotinoid, next best to thiamethoxam, against A. devastans devastans 3rd instar nymphs, with an LC50 value of 0.000813 per cent (Ravikumar *et al.* 2003).

Pawar *et al.* (2003) tested the efficacy of newer molecules against okra sucking pests, including imidacloprid 17.8 SL, acetamiprid 20SP, and thiamethoxam 20WG. The results showed that imidacloprid and acetamiprid were the most effective at reducing pest populations, followed by thiamethoxam. Jayewar *et al.* (2003) conducted a field experiment to assess the bioefficacy of acetamiprid 20SP against sucking pests of chilli.

Acetamiprid at doses of 80 and 40 g a.i./ha was found to be very effective in reducing jassid and thrips populations, resulting in maximum green chilli yield.

Khedkar and Ukey (2003) studied the efficacy of newer insecticides against jassids on okra and noticed that acetamiprid was the most effective molecule in terms of jassid population reduction (to the extent of 92.16 at 10 DAS) and appeared to be the most effective treatment against jassids. In Thailand, two applications of emamectin benzoate 5 SG (proclaim) at seven-day intervals provided competitive control of *Scirtothrips* sp. on beans. In Indonesia, emamectin benzoate was found to be effective against *Thrips palmi* L. on potato 7 days after spraying. Furthermore, the chemical effectively controlled mites on okra (Anon., 2003).

According to Siddegowda *et al.* (2003), spinosad 45 SC at higher dosages (50 g a.i./ha) significantly reduced pod damage and increased grain yield in pigeonpea. However, when compared to endosulfan at 700 g a.i./ha, the lower dosage (56 g a.i./ha) resulted in less pod damage and higher grain yield.

2.1.6.4. Effect of Detergent on Plant:

Bokary *et al*. conducted a thesis in 2004 and found that anionic surfactants in laundry detergent were used to test their effects on plant growth via irrigation water. In a pot experiment, lettuce and okra were grown and irrigated with distilled water containing domestic detergent at three different concentrations: low concentration (LC) of 0.1 g L-1, normal concentration (NC) of 1.0 g L-1, and high concentration (HC) of 5.0 g L-1, with distilled water (DW) used as a control. The experiment was carried out in a green house in Ouagadougou, Burkina Faso, for three months from July to October. At harvest, lettuce leaves, okra fruits, and both crop shoots were weighed as dry and/or fresh weights. To assess the effects of watering, soil pH and electrical conductivity (EC) were analyzed. The concentration of detergent in irrigation solutions increased soil pH and EC. There was no

statistically significant difference in okra fruit growth (fresh and dry weight) between the DW, LC, and NC treatments. Plants in HC, on the other hand, died 20 days after planting (DAP). Similarly, there was no significant difference in lettuce shoots (dry weight) between the LC, NC, and DW treatments, but lettuce in the HC died 12 DAP. After harvest, the EC of irrigated soils increased significantly for all treatments, whereas pH showed no significant difference. According to the study, using more than 1.0 g L-1 of laundry detergent can inhibit plant growth, and using high concentration grey water on detergent can exacerbate soil salinity.

2.1.6.5. Effect of different varieties on jassid population:

Gangopadhyay *et al.* (2016) reported that the wild species in general is considered to be the reservoir of genes especially for biotic and abiotic stresses. In okra, the predominant biotic stresses are yellow vein mosaic disease (YVMD), shoot and fruit borer and leaf hopper. Sixty eight (68) accessions belonging to four wild *Abelmoschus* species [*Abelmoschus caillei* (A. Chev.) Stevels, *Abelmoschus manihot* (L.) Medik., *Abelmoschus moschatus* (L.) Medik. and *Abelmoschus tuberculatus* Palet Singh] and eight okra varieties were characterized and evaluated for phenological characters including biotic stresses under natural epiphytotic condition. The wild species examined consisted of 18 accessions (16 exotic and 2 indigenous) of *A. caillei*, 29 accessions of *A. manihot*, 16 accessions of *A. moschatus* and 5 accessions of *A. tuberculatus*. All the wild *Abelmoschus* species exhibited high diversity (as measured by Shannon Diversity Index) for 3 qualitative characters viz. intensity of stem colour, leaf shape, epicalyx shape, 13 quantitative characters and 3 biotic stress parameters. Among the wild species, *A. caillei* and *A. tuberculatus* showed maximum and minimum diversity for qualitative characters, respectively. There was significant variation for 19 out of 24 quantitative characters studied. Inter-species diversity pattern as estimated through Ward's Minimum Variance Dendrogram and Principal Component Analysis revealed clear

differentiation among the species with minimum overlapping indicating close association between geographical origins and clustering pattern. Intra-species diversity indicated role of specific adaptation in sub-clustering. Resistance to YVMD was found in accessions belonging to three wild species viz. *A. caillei*, *A. manihot* and *A. moschatus* while resistance to shoot and fruit borer and leaf hopper was found in accessions of all the four wild species. The resistant accessions can further be used for introgressing biotic stress resistance through pre-breeding into cultivated okra species.

Khadija *et al.* (2016) observed effect of jassid population on different okra varieties on the time frame at different life stages of the plant and effect of physio-morphic characters. Linear mixed models and growth curves were used by keeping plants effect random to account repeated measures data and cubic trend interaction with verities was found to be significant using AIC, BIC and deviance criteria of model selection. Nested designs were used for the area within each plant. Results revealed Arka Anamika (6.96 insects/plant) to be the most resistant cultivar among all the five tested cultivars followed by Super Green (8.11 isnects/plant). Ambika (13.3 insect/plant) was least resistant cultivar among all the five tested cultivars. Host plant resistance was enhanced by the hair density on plant leaves of okra cultivars; cultivars having high density of trichomes showed high resistance towards the jassid infestation. Leaf area differences drive the insect population was also calculated.

Chandani *et al.* (2015) reported that *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae) is polyphagous pest of many agricultural and nonagricultural plants. It sucks the cell sap from leaves, flowers, fruits and tender stems and affects the growth of crop plants adversely. It also creates sooty mould on crop leaves which affect photosynthesis, growth and yield of the crops. *A. biguttula biguttula* attacked Cotton (*Gossypium hirsutum* L.), Brinjal (*Solanum melongena* L.) and Okra (*Abelmoschus esculentus* L.) throughout the year. It was also found attacking Sunflower *Helianthus annus* L., Cowpea *Vigna*

unguiculata L., China Rose (*Hibiscus rosasinensis* L.), Pigeon pea (*Cajanus cajan* Millsp.) and several grasses including durva lawns (*Cynodon dactylon* L.). Occurrence of the Jassid and its damage to different plants is discussed in the paper.

Rehman *et al*. (2015) suggested that the leaf hopper, *Amarasca bigutulla bigutulla* Ishida is an important sucking pest of okra causing huge losses. The present study was aimed to study the incidence and population dynamics of *Amarasca bigutulla bigutulla* on four okra (*Abelmoschus esculentus* L.) varieties in Southern Punjab Pakistan. The results revealed non significant difference in the mean population of *A. bigutulla bigutulla* on different okra varieties. However, maximum population was observed on Green star and minimum population on Pusa sawani. The leaf hopper population varies in different dates throughout the season with maximum population observed in the first week of July, 2012. Host Plant Susceptibility Indices (HPSI,s) of various genotypes were also observed. HPSI, s of durga (32%) was maximum toward leaf hopper followed by Green star and arka anamika (25% each) and minimum in Pusa sawani (18%). Correlation with different environmental variables showed negative correlation with maximum temperature and positive significant correlation with relative humidity at morning 8 AM. The study will be helpful in the management of jassid on okra under agro-climatic conditions of Southern Punjab.

Dilbar *et al.* (2014) studied genotypes of okra against jassid were conducted under semi natural conditions. The data on antibiosis (mating period, number of nymphs emerged, nymphal period, number of nymphs reaching to adult stage and survival of nymphs (%), antixenosis (preference/non preference) and tolerance studies based on fruit yield per plant were conducted. The genotype Pusa Swani showed highest mating period (19.67 minutes), number of nymphs emerged (19.33 per female), number of nymphs reaching to adult stage (17.67), nymphal survival (91.36%) and the lowest nymphal period (7.33 days) proved to be comparatively susceptible and the genotype Sanum was found to be comparatively resistant which showed mating period of 11.67 minute, number of nymphs emerged per

female 8.00 per female, nymphal period 10.67 days, number of nymphs reaching to adult stage 3.33 and nymphal survival of 41.66%. Lower trend of jassid after feeding on genotype, Sanum observed individuals in the range of 2.67 per plant whereas, Pusa Swani was found to be the most preferred having 9.67 individual per plant. Tolerance study revealed that Sanum resulted in the highest fruit yield (148.73g / plant) and was statistically at par with those of recorded on Sanum (145.13 g/plant) and Okra-7080 (143.74 g/plant). The genotype Pusa Swani resulted in minimum yield i.e. 112.92 g/plant.

Khuhro (2014) revealed that the results in the case of IPM set-I. The seasonal population of insect pests total mean thrip (0.14 ± 0.03/leaf), jassid (1.10±0.24/leaf), whitefly (2.38±0.38/leaf), aphid (0.15 ±0.01 / leaf) and spotted bollworm (0.57±0.04/plant) was recorded under the conditions of set I on okra crop. However, beneficial insects spider (3.19±0.07/plant), seven spotted beetle (0.31±0.07/plant), eleven spotted beetle (0.03±0.01/plant) and zigzag beetle (0.56±0.01/plant) was recorded on okra crop in the set I strategy. The results further indicated that in case of IPM set-II the insect pests and beneficial insects were recorded. Total mean population of thrips (2.27±0.32/leaf), Jassid (1.33±0.26/leaf), Whitefly (3.58± 0.63/leaf), aphid (2.59± 0.41/leaf) and spotted bollworm (1.45± 0.25/plant) was recorded in under the case of IPM set II on okra crop. However, the beneficial insect population such as, spider (3.84±0.68/plant), seven spotted beetle (0.72±0.14/plant), eleven spotted beetle (0.26±0.07/plant) and zigzag beetle (0.93±0.19) was recorded in set II. However, the results depicted, under IPM practices Set-III (untreated or control) the insect pests and benifical insects was recorded. The population of sucking insect pest thrip (5.13±0.30/leaf), jassid (4.57± 0.20/leaf), whitefly (17.79± 0.78/leaf), aphid (1.8o± 0.05) and (2.48± 0.07/plant) was recorded in under the case of IPM set III. However, the benifical insect population such as, seven spotted beetle (2.89± 0.03/plant), eleven spotted beetle (1.18± 0.04/plant), zig zag beetle (0.68± 0.03/plant) was also recorded in under the case of IPM set III. The results showed that IPM Set-I found superior in relation to IPM set-II, as compared IPM set III on okra eco-system. However,

in set I okra trap with maize crop, release of natural enemies and spray of neem leaf extract with neem oil product caused greater reduction of insect pests as compared IPM set II, okra trapped with sunflower, marigold, and spray of only neem leaf extract. While the population of beneficial insects was more in IPM set III on okra crop due to more population of insect pests.

Muhammad *et al.* (2014) evaluated relative plant resistance/susceptibility of different cultivars of brinjal against the jassid during summer 2009 at PARS, Faisalabad, Pakistan. Fourteen cultivars of brinjal viz. Pusa Purple Round (PPR), Rubi, Vrib-01, Vrib-02-F1, Dilnasheen, Vrib-0401, Vrib-04, Bemissal, Vrib-9901, Nirala, Qaisar, JK_Kajal, Cluster King and Purple QL were tested for their susceptibility against jassid. All the tested cultivars showed significant differences ($P \leq 0.05$) for the tested parameters viz. pest preference, host plant susceptibility indices (HPSI) as well as yield/plot. The peak infestation time of the pest after sowing of crop was 1st week of June after which it gradually declined. The cultivars Nirala, Bemissal and Vrib-04 appeared as comparatively susceptible showing high population of jassid/leaf while Vrib-9901, Vrib-0401, and Vrib-02-F1 appeared as intermediate and Rubi, Vrib-01 and Cluster King were observed comparatively as resistant ones with least number of jassid/leaf. The cultivar Bemissal proved the most susceptible varietyamong the tested ones showing maximum level of HPSI (18%) and minimum fruit yield (44.66 kg/plot) while Rubi proved the most resistant cultivar with minimum HPSI (7%) and a maximum fruit yield (81.0 kg/plot).

Mari (2013) reported that effect of trap crops on jassid population in ladys finger was carried out at Latif experimental farm, Sindh Agriculture University, Tandojam during summer of 2008. Monitoring jassid population indicated that it increase its highest value of 11.35/ leaf on October 29 when vegetative development and succulence of leaves was at its top, and then decreased to reach its lowest value of 1.46/ on December 13. When evaluating the effect of mixed cropping on the pest population, jassid population was

highest (7.87 insects/leaf) on okra (mono crop), followed by okra with sunflower (5.50 insects /leaf), okra with maize (4.89 insects leaf) and okra with garden pea (4.00 insects /leaf). It was concluded that okra is the major host plant of jassid. The infestations of jassid started one month after germination and continued till harvesting of the okra crops. The trap crops i.e sunflower, maize, garden pea can also attract jassid population in presence of okra. However, jassid had preference for okra in the presence of other trap crops. Thus, jassid resistant cultivers could be the best approach for manage of jassid.

Solangi *et al*. (2013) carried out field studies on evaluation of biopesticides against jassid, *Amrasca biguttula biguttula* (Ishida) in okra crop at the experimental area of Habib Farm, District Hyderabad, during the year 2012. The crop was sown on well preapred seedbed keeping 45 cm distance between ridges to ridge, after thinning a plant to plant distance of 22.5 cm in CRB design. During the present study four replications and five treatments i.e. T_1 (Neem Powder), T_2 (Tobacco leaves), T_3 (Neem Oil), T_4 (Neem oil + Beneficial micro-organism B.M), T_5 (Control) were used. The pre-treatment observations were taken 24 hours before spray whereas post-treatment observations were taken at the intervals of 24, 48 and 72 hours and after one and two weeks. Relative neem oil + BM displayed greater reduction of jassid population (78.47%), followed by neem oil (76.57%), whereas, neem powder (65.46%) and tabacco leaves (63.16%) were less effective in reducing the population of jassid in field. However, during 2nd and 3rd spray the efficacy of all products remained the same altough it was higher as compared to 1st spray. The average performance of three sprays was maximum in case of (Neem oil + B.M) (81.28%), followed by neem oil (79.40%), neem powder (72.93%) and tabacco leaves (69.00%) respectively. The present study strongly suggests that the use of bio-pesticides may be helpfull to reduce the effect of pesticides in the environment.

Yajuvendra *et al*. (2013) reported that the okra crop was found infested with sucking insect pests, these are, whitefly, leafhopper and aphid (*A. gossypii*) during 2008. A

thorough knowledge of seasonal activity of different insect pests determines the predisposing climatic factors affecting their population dynamics. The study was carried out in the Rajaula Farm of Mahatama Gandhi Chitrokoot Gramodya Vishwvidyalay (MGCGV), Chitrakoot, Satna, M. P. The observations on aphid, whitefly and leafhopper and natural enemy incidence was carried out simultaneously on 5 randomly selected plants per plot, taking 6 leaves, that is, 2 each from upper, middle and lower strata. Aphid population showed negative correlation with minimum and mean temperature, rainfall and maximum and minimum relative humidity whereas, positive correlation with maximum temperature and coccinellids. Aphidophagous predators like coccinellids appeared more or less with aphid population. The coccinellids showed negative correlation with maximum, minimum and mean temperature, rainfall and maximum and minimum relative humidity. Whitefly and leafhopper population showed negative correlation with maximum, minimum and mean temperature and maximum and minimum relative humidity whereas positive correlation with rainfall.

Investigated the seasonal incidence of jassid (*Amrasca biguttula biguttula*) and whitefly (*Bemisia tabaci*) populations on okra and their correlation with abiotic factors were carried out in the semi-arid region of Rajasthan, India. The infestation of jassids and whiteflies started in the fourth week of July and reached peaks in the second and fourth weeks of September, respectively. Correlation of these insect-pests with abiotic factors viz., minimum and maximum temperature, relative humidity and rainfall was also assessed. Maximum temperature was significantly correlated with whitefly density.

Saif *et al.* (2012) evaluated the role of physico characters of five okra genotypes Sharmeeli, Pusa Green,Anokhi, Arka Anamika and Sabz Pari against jassid, the results shows that all tested cultivers differed significantly in relation to leaf hopper population density. Same pattern was observed for morphological characters except hair density on leaf veins. Cultivers Arka Anamika had low population1.61 ± 0.31 hoppers/leaf) and

found comparatively more resistant to jassid's attack. In contrast, genotype Anokhi proved as highly susceptible with maximum jassid population3.07 ± 0.56 hoppers/leaf). The leaf hopper population continuously increased from third week of June to 2nd week of July. Correlation co-efficients between populations of okra jassid and different morphic characters of okra revealed highly significant, strong and negative correlation for hair density on lamina and fruit yield per plant while non-significant, weak and negative correlation for hair density on midrib, leaf area and dry shoot weight. The output implies the identification of resistant source against Jassid which can be exploited for plant genetic improvement and sowing of okra crop where pest causes substantial yield losses.

Alam *et al.* (2010) carried out experiments in the Field Laboratory of Entomology, Bangladesh Agricultural University, Mymensingh, during February to May, 2008 to investigate the population abundance and to determine the efficacy of three botanical oils (Neem, Mahogani, Karanja) and one synthetic insecticide (Admire 200 SL) against Okra Jassid, Amrasca devastans. The Jassid was first noticed in early March just 7 days after germination and attacked the crop seriously. The highest mean number of Jassid leaf-1 (34) was found in April, 2008. In evaluating the effectiveness of the insecticide and botanical oils to control Okra Jassid, three times applications were made at 7 days interval. The Jassid population varied significantly with the application of insecticide and botanicals. Admire 200 SL give the best result among the treatment. Out of three botanicals Karanja repelled 93.33%, where as Mahogoni and Neem repelled 86.66 and 63.33%.The effectivity of botanicals and synthetic insecticides was found in the following order: Admire 200 SL> Karajan oil >Mahogani oil >Neem oil.

Iqbal *et al*. (2010) revealed that the data on jassid population per leaf obtained from varietals trials in 2006-2007 at various dates of observation were correlated with the ambient weather conditions such as maximum, minimum and average temperatures, average relative humidity and rainfall. The coefficient of determination values were

observed to find the role of weather effects on population fluctuation of jassid, *Amrasca biguttula biguttula* (Ishida) on okra. Minimum temperature during 2007 and on cumulative basis of 2006 and 2007 had significant and positive correlation with the jassid population and the other factors were not effective on jassid population. Rainfall showed maximum contribution *i.e.* 12% in population fluctuation of jassid during 2006 followed by maximum temperature, average temperature and relative humidity. Minimum temperature showed maximum contribution *i.e*. 20.5% in population fluctuation of jassid during 2007 followed by rainfall, relative humidity, maximum temperature and average temperature. On an average of two years data, rainfall was found to be the most important effects which contributed maximum *i.e.* 13.4% in population fluctuation of jassid on okra.

Anitha and Nandihalli (2009) experiment was conducted in Dharwad, Karnataka, India, during the kharif of 2006 to study the response of okra hybrids (Shagun, AROH-218, Anokhi, Suruchi, Bhendi No.10 and NS-503) and Arka Anamika (control) to leafhopper (*Amrasca biguttula biguttula*) and aphid (*Aphis gossypii*). Bhendi No. 10 recorded the lowest leafhopper population (11.86 per 3 leaves) at 45 days after sowing (DAS), but remained inferior to Arka Anamika (9.63 per 3 leaves). The remaining hybrids were on a par with each other with regard to leafhopper population. A similar trend was observed at 60 DAS. Among the hybrids evaluated against the aphid, Bhendi No.10 had the lowest aphid population (19.67 per 3 leaves); this hybrid was on a par with NS-503 and AROH-218 at 45 DAS, but inferior to Arka Anamika. A similar trend was observed at 60 DAS. Leafhopper and aphid populations were negatively correlated with the number of hairs on the leaf lamina and number of hairs on the leaf midrib, but positively correlated with the thickness of the midrib.

Hasan *et al*. (2009) conducted as screening trials on 30 genotypes of okra for resistance against the jassid, *Amrasca biguttula biguttula*, during 2006. From preliminary screening trials three genotypes showing comparatively susceptible responses (Pusasawani, Dera

local and Okra-3), three showing intermediate (Karam-5,durga and Clean spineless) and three showing resistant response (Makhmali, Punjab selection and Green wonder) to jassids were selected for final screening trials during 2007. Host plant susceptibility indices were also calculated to determine the contribution of each selected genotype towards susceptibility during 2006, 2007 and on average of 2006-07. Differences were found to be significant among genotypes of okra during both the study years regarding jassid numbers per leaf. The trend in selected genotypes towards susceptibility/resistance against jassid was found to be similar to those observed during preliminary screening trials. Pusasawani showed maximum Host Plant Susceptibility Index (HPSI) (18% on average population of jassid per leaf recorded during 2006 and 2007.

Prabu *et al.* (2009) evaluated ten Abelmoschus esculentus cultivars and 21 wild lines belonging to nine Abelmoschus species for resistance to jassid (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*) and shoot and fruit borer (*Earias spp*.) in naturally infested fields for three seasons (summer and Kharif 2004 and summer 2005) at Rahuri. The results of screening for three seasons revealed that wild *A. moschatus* lines 1,2,3,4 and 5 were found to have least jassid (nymph) population per leaf while *A. moschatus* lines 1,2,3,4 and 5 and A. angulosus were found to have minimum mean whitefly (adult) population per leaf. Therefore, the above wild species were found resistant to jassid and whitefly incidence, respectively. Further, the study revealed that *A. tuberculatus* lines 1,2 and 3 were found immune to fruit borer infestation while *A. tuberculatus* lines 1,2 and 3, *A. tetraphyllus* lines 2,3,4 and 5 and *A. manihot spp. tetraphyllus* were found completely free from shoot borer infestation. However, none of the cultivated *A. esculentus* cultivars screened for three seasons was found resistant to above pests of okra.

CHAPTER III

MATERIALS AND METHODS

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

3.1 Location

The experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The location of the experimental site was 23°74''N latitude and 90°35''E longitude and an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Climate

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

3.3 Soil

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

3.4 Seed collection

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

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

3.6 Land preparation

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

3.7 Sowing of seeds

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

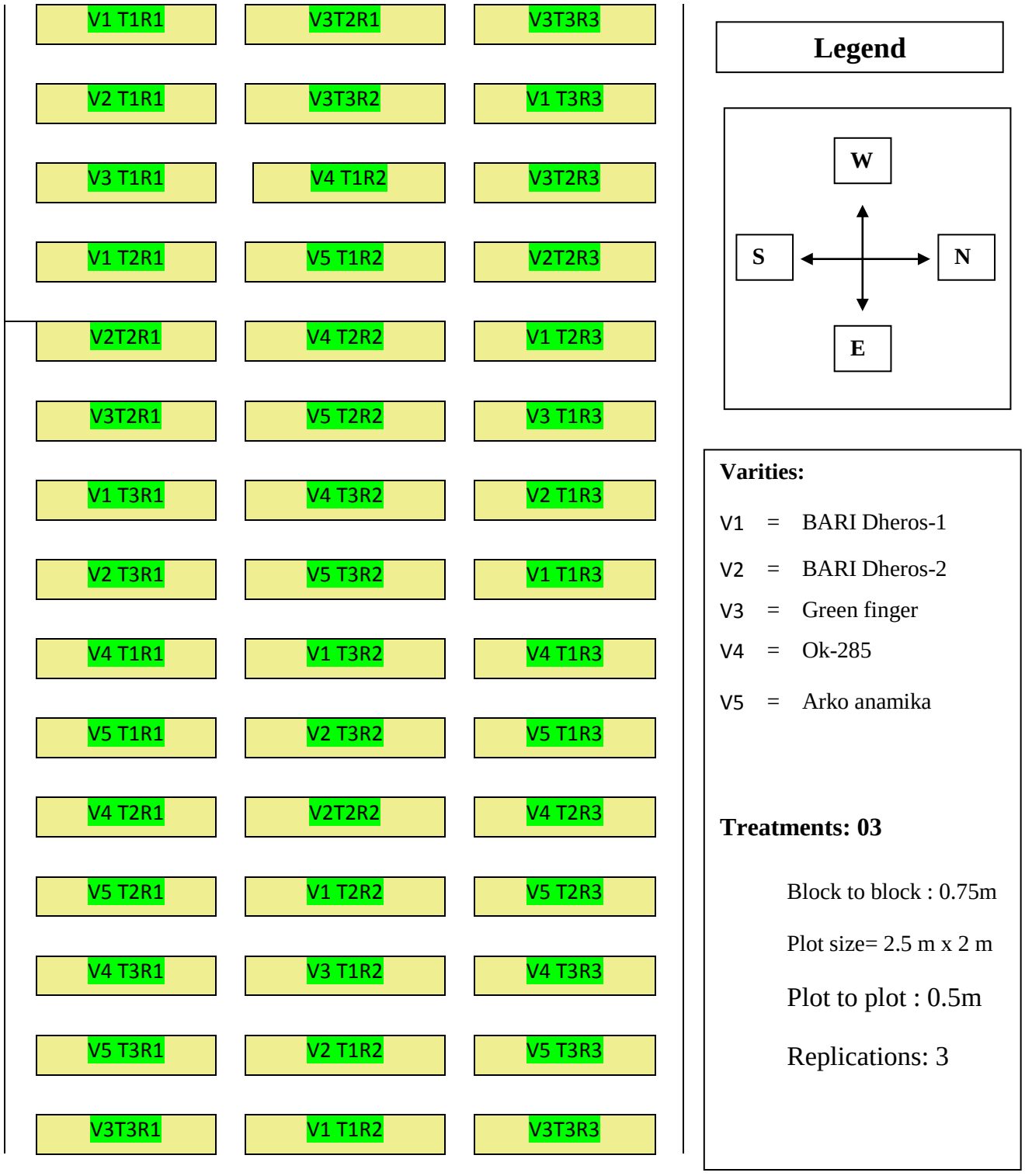


Figure 1. Layout of the experimental field

3.8 Manure and fertilizer

The fertilizers N, P, K in the form of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP) respectively and as an organic manure, Cow dung were applied. Entire amount of cow dung, TSP and MP were applied during final land preparation. The entire amounts of urea were applied as top dressing in two equal splits at 25, 45 days after seed sowing.

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

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

3.9 Cultural practices

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

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

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

3.9.4 Harvesting: As the seeds were sown in the field at times, the crops were harvested at different times. Green fruits were harvested at two days interval when they attained edible stage. Green fruit harvesting was started from 27 November, 2017 and was continued up to April 15, 2020.

3.10 Treatments

Therefore, treatments of this experiment were as follows:

The experiment consisted of two factors as mentioned below:

Factor A: Organic manure

- T_1 = Spraying Imidaclorpid @1.5 ml/L at 15 days interval
- T_2 = Spraying Neem oil @ 2 ml/Litre of water mixed with 10 ml of trix liquid sprayed at 15 days interval.
- T_3 = Control

Factor B: Variety

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

Treatment combinations were as: 15

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

Plate 01: Experimental Okra field during the study period

Plate 02: Seedling of Okra in nursery bed during the study period

Plate 03: Healthy Okra plant with fruit in the Experimental field during the study period.

Plate 04: Jassid infested Okra leaf in the Experimental field during the study period

3.11 Preparation of the pesticides used as treatments

3.11.1 Bumper

Bumper 30SL was applied at the rate of 1.5 ml/L at 15 days interval.

3.11.2 Neem oil

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

3.12 Application of the treatments

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

3.13 Monitoring of insect pest and data collection

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

- No. of leaves infestation at different fruiting stage
- Percentage of infested Fruit at different fruiting stage
- Fruit infestation at different fruiting stage in weight basis
- No. of Jassid at different fruiting stage
- Fruit length
- Fruit girth
- No. of fruit $Plant^{-1}$
- Single fruit weight
- No. of branch $plant^{-1}$
- Yield (kg/plot)
- Yield (ton/ha)

Plate 05: Healthy fruits of BARI Dheros-1 (V_1) variety after harvesting

Plate 06: Healthy fruits of BARI Dheros-2 (V_2) variety after harvesting

Plate 07: Healthy fruits of Green finger (V_4) variety after harvesting

Plate 08: Healthy fruits of Arko anamika (V_5) variety after harvesting

Plate 09: Healthy fruits of Ok-285 (V_3) local variety after harvesting.

3.14. Number of jassid:

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

$$\% \text{ reduction of jassid} = \frac{\text{Number of jassid before control- Number of jassid after control}}{\text{Total number of jassid before control}} \times 100$$

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

3.15 Determination of no. of leaves infestation at different fruiting stage

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

3.16 Determination of fruit infested and healthy fruit in number

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

3.17 Method of recording

3.17.1 Leave infestation

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

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

3.17.2. Number of Fruit

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

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

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

3.17.3 Okra shoot and fruit infestation

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

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

Shoot infestation (%) reduction over control=

$$= \frac{\text{Infested shoot in control} - \% \text{ infested shoot in the treatment}}{\text{Infested shoot in control}} \times 100$$

$$\text{Fruit infestation (\%) reduction over control} = \frac{\text{Infested fruit in control} - \% \text{ infested fruit in the treatment}}{\text{Infested fruit in control}} \times 100$$

3.18 Determination of fruit infested and healthy fruit in weight basis

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

3.19 No. of Jassid at different fruiting stage

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

3.20 Yield contributing characters of okra

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

3.20.1 Length of fruit

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

3.20.2 Girth of fruit

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

3.20.3 Weight of fruit

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

3.20.4 Yield per hectare

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

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

3.21. Statistical analysis of data

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

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Incidence of Jassid

4.1.1 Number of leaves infestation plant^{-1} at different growing stage

4.1.1.1 Effect of sustainable management

Significant variation at 5 % level on number of leaves infestation plant^{-1} was found at different growing stage influenced by different treatment (Table 1) Among the treatment Bumper 30SL (T_1) showed significantly the lowest leaves infestation plant^{-1} (3.84, 4.44, 5.38, 6.17 and 4.94 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from neem oil (T_2). Significantly the highest leaves infestation plant^{-1} (8.73, 11.16, 12.75, 14.21 and 11.71 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Control (Without pesticide) (T_3) treatment. The results consistent with the findings of Cook *et al*. (2017), Islam *et al*. (2015) and John *et al.* (2010) who observed leaves infestation significantly among the treatments.

4.1.1.2 Effect of Variety

Effect of sustainable management showed a significant variation at 5 % level on number of leaves infestation plant^{-1} was found at different growing stage influenced by different varieties (Table 1) Among the varieties BARI Dheros-1 (V_1) showed significantly the least leaves infestation plant^{-1} (5.67, 7.04, 7.86, 8.76 and 7.34 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the highest leaves infestation plant^{-1} (7.17, 8.95, 10.17, 11.60 and 9.47 at vegetative, early

fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

Table1. Effect of variety and management practices on number of leaves infestation plant^{-1} at different growing stage

Treatments	Leaves infestation Plant^{-1}				
	Vegetative stage	**Early fruiting stage**	**Mid fruiting stage**	**Late fruiting stage**	**Mean**
T_1	3.84 c	4.44 c	5.38 c	6.17 c	4.94 c
T_2	7.13 b	8.66 b	9.19 b	10.08 b	8.77 b
T_3	8.73 a	11.16 a	12.75 a	14.21 a	11.71 a
$LSD_{(0.05)}$	**0.56**	**0.53**	**0.73**	**0.50**	**0.62**
Variety					
V_1	5.67 b	7.04 b	7.86 b	8.76 d	7.34 c
V_2	6.54 a	7.63 b	8.50 b	9.54 c	8.00 bc
V_3	6.84 a	8.37 a	9.53 a	10.42 b	8.82 a
V_4	6.62 a	8.37 a	9.49 a	10.46 b	8.74 ab
V_5	7.17 a	8.95 a	10.17 a	11.60 a	9.47a
$LSD_{(0.05)}$	**0.73**	**0.68**	**0.94**	**0.65**	**0.81**
CV(%)	**11.44**	**8.73**	**10.71**	**6.64**	**9.84**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.1.3 Interaction effect

Interaction effect of intensity of infestation and management practices decrease gradually advance of growth stage in respect of number of leaves infestation plant^{-1} (table 2). The infestation rate was much slower in the vegetative stage of growing period. After that the increasing rate was much higher up to late fruiting stage. However, the least number of leaves infestation plant^{-1} (2.20, 3.10, 4.20, 5.25, and 3.69 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in the treatment combination

T_1V_1 which was statistically different from all other treatments. The highest number of leaves infestation plant^{-1} (9.25, 12.25, 14.25, 16.75, and 13.13 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was obtained from the treatment combination of T_3V_5.

Table 2. Interaction effect of variety and management practices on number of leaves infestation plant^{-1} at different growing stage

Treatment combination	Leaves infestation Plant^{-1}				
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean
T_1V_1	2.20 f	3.10 h	4.20 h	5.25 h	3.69 h
T_1V_2	3.50 e	3.70 h	4.80 gh	5.90 gh	4.48 gh
T_1V_3	4.50 e	4.90 g	5.80 gh	6.20 gh	5.35 g
T_1V_4	3.95 e	5.20 g	6.10 g	6.85 g	5.53 g
T_1V_5	4.75 e	5.10 g	6.00 g	6.65 g	5.63 g
T_2V_1	6.71 d	7.68 f	8.12 f	8.52 f	7.76 f
T_2V_2	6.95 cd	8.25 ef	8.35 f	9.25 f	8.20 ef
T_2V_3	7.35 b-d	8.98 de	9.75 d-f	10.75 e	9.21 c-e
T_2V_4	7.15 cd	8.90 de	9.52 ef	10.52 e	9.02 d-f
T_2V_5	7.50 b-d	9.50 cd	10.25 de	11.40 de	9.66 cd
T_3V_1	8.12 a-b	10.35 bc	11.25 cd	12.50 cd	10.56 bc
T_3V_2	8.50 ab	10.95 b	12.35 bc	13.48 bc	11.32 b
T_3V_3	8.99 a	11.25 ab	13.05 ab	14.32 b	11.90 ab
T_3V_4	8.77 a	11.02 b	12.85 a-c	14.01 b	11.66 b
T_3V_5	9.25 a	12.25 a	14.25 a	16.75 a	13.13 a
$LSD_{(0.05)}$	**1.26**	**1.18**	**1.63**	**1.19**	**1.39**
CV(%)	**11.44**	**8.73**	**10.71**	**6.64**	**9.84**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.2 Number of Jassid plant^{-1} at different growing stage

4.1.2.1 Effect of management practices

Significant variation at 5 % level on number of jassid plant^{-1} was found at different growing stage influenced by different treatment (Table 3) Among the treatment (T_1) Bumper 30SL showed significantly the lowest number of jassid plant^{-1} (2.06, 4.17, 2.81, 2.28 and 2.83 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from neem oil (T_2). Significantly the highest number of jassid plant^{-1} (19.61, 9.36, 9.70, 9.74 and 12.10 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Control (Without pesticide) (T_3) treatment.

Number of jassid plant^{-1} reduction over control in sustainable management was estimated and the highest value was found from the treatment T_1 (76.61%) and the minimum reduction over control from T_2 (55.26%) treatment

4.1.2.2 Effect of Variety

Effect of sustainable management showed a significant variation at 5 % level on number of jassid plant^{-1} was found at different growing stage influenced by different varieties (Table 3) Among the varieties BARI Dheros-1 (V_1) showed significantly the least number of jassid plant^{-1} (6.73, 5.67, 5.04, 4.39 and 5.45 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties.Significantly the highest number of jassid plant^{-1} (11.83, 8.89, 8.01, 8.16 and 9.23 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

Number of Jassid plant^{-1} reduction over control in variety was estimated and the highest value was found from the variety V_1 (40.94%) which was followed by V_2 (34.68%) and V_4 (30.31%) varieties and the minimum reduction over control from V_3 (26.52%) variety.

Table3. Effect of management practices and variety on number of jassid plant^{-1} at different growing stage

Treatments	Number of Jassid plant^{-1}					
	Vegetative stage	**Early fruiting stage**	**Mid fruiting stage**	**Late fruiting stage**	**Mean**	**%reduction over control**
T_1	2.06 c	4.17 c	2.81 c	2.28 c	2.83 c	76.61
T_2	4.25 b	6.73 b	5.39 b	5.26 b	5.41 b	55.26
T_3	19.61 a	9.36 a	9.70 a	9.74 a	12.10 a	--
$LSD_{(0.05)}$	**0.57**	**0.42**	**0.31**	**0.44**	**0.56**	**--**
Variety						
V_1	6.73 d	5.67 c	5.04 c	4.39 d	5.45 d	40.94
V_2	7.66 c	6.15 bc	5.22 c	5.07 c	6.02 cd	34.68
V_3	8.72 b	6.66 b	5.97 b	5.77 b	6.78 b	26.52
V_4	8.27bc	6.41 b	5.67 b	5.42 bc	6.43 bc	30.31
V_5	11.83 a	8.89 a	8.01 a	8.16 a	9.23 a	--
$LSD_{(0.05)}$	**0.73**	**0.54**	**0.39**	**0.57**	**0.73**	**--**
CV(%)	**8.80**	**8.28**	**6.85**	**10.32**	**11.09**	**--**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.2 .3 Interaction effect

Interaction effect of intensity of infestation and management practices decrease gradually advance of growth stage in respect of number of Jassid plant^{-1} (table 4). The infestation rate was much higher in the early fruiting stage of growing period. After that the increasing rate was much lower up to late fruiting stage. However, the least number of Jassid plant^{-1} (0.71, 3.25, 2.01, 0.38 and 1.59at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in the treatment combination T_1V_1 which was statistically different from all other treatments. The highest number of Jassid plant^{-1} (27.5, 14.25, 14.35, 15.25, and 17.90 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was obtained from the treatment combination of T_3V_5.

Interaction effect of intensity of infestation and management practices on percentage of number of jassid plant^{-1} reduction over control was estimated and the highest value was found from the combination T_1V_1 (91.12%) and the minimum reduction over control from T_3V_3 (37.32%) combination.

Table 4. Interaction effect of intensity of infestation and sustainable management on number of Jassid plant^{-1} at different growing stage

Treatment combination	Number of Jassid plant^{-1}					
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%reduction over control
T_1V_1	0.71 h	3.25 i	2.01 g	0.38 g	1.59 h	91.12
T_1V_2	1.72 gh	3.75 hi	2.22 g	2.02 f	2.43 gh	86.42
T_1V_3	2.75 fg	4.55 gh	3.35 f	3.05 ef	3.43 fg	80.84
T_1V_4	2.25 g	4.12 hi	2.95 f	2.75 e	3.02 fg	83.13
T_1V_5	2.90 fg	5.21 g	3.52 f	3.23 e	3.72 ef	79.22
T_2V_1	3.74 ef	6.25 f	4.85 e	4.75 d	4.90 df	72.63
T_2V_2	3.90 ef	6.55 ef	4.98 e	4.85 d	5.07d	71.68
T_2V_3	4.47 e	6.90 d-f	5.75 cd	5.65 cd	5.69 d	68.21
T_2V_4	4.31 e	6.77 d-f	5.26 de	5.06 cd	5.35 d	70.11
T_2V_5	4.85 e	7.21 de	6.15 c	6.01 c	6.06 d	66.15
T_3V_1	15.75 d	7.52 cd	8.25 b	8.05 b	9.89 c	44.75
T_3V_2	17.35 c	8.15 bc	8.45 b	8.35 b	10.58 bc	40.89
T_3V_3	18.95 b	8.52 b	8.80 b	8.60 b	11.22 b	37.32
T_3V_4	18.24 bc	8.35 bc	8.65 b	8.45b	10.92 bc	38.99
T_3V_5	27.75 a	14.25 a	14.35 a	15.25a	17.90 a	--
$LSD_{(0.05)}$	**1.27**	**0.94**	**0.68**	**0.99**	**1.26**	**--**
CV(%)	**8.80**	**8.28**	**6.85**	**10.32**	**11.09**	**--**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.3 Percentage of fruit infestation at different fruiting stage

4.1.3.1 Effect of management practices

Significant variation at 5 % level on percentage of fruit infestation was found at different growing stage influenced by different treatment (Table 5) Among the treatment Bumper 30SL (T_1) showed significantly the minimum fruit infestation percentage (4.13, 4.94, 4.74 and 4.60 at early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from neem oil (T_2). Significantly the maximum fruit infestation percentage (17.97, 18.64, 18.89, and 18.50 at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Control (Without pesticide) (T_3) treatment.

Percentage of fruit infestation reduction over control in management practices was estimated and the highest value was found from the treatment T_1 (75.11%) and the minimum reduction over control from T_2 (49.17%) treatment.

4.1.3.2 Effect of Variety

Effect of sustainable management showed a significant variation at 5 % level on percentage of fruit infestation was found at different growing stage influenced by different varieties (Table 5) Among the varieties BARI Dheros-1 (V_1) showed significantly the least fruit infestation percentage (8.69, 9.38, 9.04 and 9.04 at early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the highest fruit infestation percentage (12.54, 13.74, 14.36 and 13.55 at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

Percentage of fruit infestation reduction over control in variety was estimated and the highest value was found from the variety V_1 (33.26%) which was followed by V_2 (27.11%) and V_4 (22.01%) varieties and the minimum reduction over control from V_3 (17.66%) variety.

Table 5. Effect of management practices and variety on percentage of fruit infestation at different growing stage

Treatments	Percentage of fruit infestation				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%reduction over control
T_1	4.13 c	4.94 c	4.74 c	4.60 c	75.11
T_2	9.15 b	9.66 b	9.39 b	9.40 b	49.17
T_3	17.97 a	18.64 a	18.89 a	18.50 a	--
$LSD_{(0.05)}$	**0.41**	**0.63**	**0.68**	**0.63**	**--**
Variety					
V_1	8.69 e	9.38 d	9.04 d	9.04 d	33.26
V_2	9.58 d	10.10 cd	9.94 c	9.87 c	27.11
V_3	11.00 b	11.37 b	11.09 b	11.15 b	17.66
V_4	10.28 c	10.81 bc	10.60 bc	10.56 bc	22.01
V_5	12.54 a	13.74 a	14.36 a	13.55 a	--
$LSD_{(0.05)}$	**0.53**	**0.81**	**0.87**	**0.81**	**--**
CV(%)	**5.24**	**7.56**	**8.23**	**7.73**	**--**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.3.3 Interaction effect

Interaction effect of intensity of infestation and sustainable management decrease gradually advance of growth stage in respect of percentage of fruit infestation (Table 6). The infestation rate was slower in the early fruiting stage of growing period. After that the increasing rate was little bit increase up to late fruiting stage. However, the least percentage of fruit infestation (2.65, 3.89, 3.44 and 3.33 at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in the treatment combination T_1V_1 which was statistically different from all other treatments. The highest percentage of fruit infestation (18.5, 18.50, 18.15 and 18.30 at early fruiting, mid fruiting, late fruiting stage and mean respectively) was obtained from the treatment combination of T_3V_5.

Interaction effect of intensity of infestation and management practices on percentage of fruit infestation reduction over control was estimated and the highest value was found from the combination T_1V_1 (86.41%) and the minimum reduction over control from T_3V_3 (25.31%) combination.

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

Treatment combination	Percentage of fruit infestation				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%reduction over control
T_1V_1	2.65 k	3.89 h	3.44 i	3.33 i	86.41
T_1V_2	3.65 j	4.35 h	4.33 hi	4.11 hi	83.22
T_1V_3	4.75 hi	5.25 gh	5.02 gh	5.01 gh	79.55
T_1V_4	4.25 ij	5.15 gh	5.03 gh	4.81gh	80.37
T_1V_5	5.36 h	6.04 g	5.90 g	5.77 g	76.45
T_2V_1	8.01 g	8.62 f	8.25 f	8.29 f	66.16
T_2V_2	8.36 fg	8.95 f	8.75 ef	8.69 f	64.53
T_2V_3	10.01 e	10.36 e	10.11 df	10.16 e	58.53
T_2V_4	9.25 ef	9.75 ef	9.52 d-f	9.51 ef	61.18
T_2V_5	10.14 e	10.66 e	10.33 d	10.38 e	57.63
T_3V_1	15.42 d	15.65 d	15.45 c	15.51 d	36.69
T_3V_2	16.75 c	17.00 cd	16.75 bc	16.83 cd	31.31
T_3V_3	18.25 b	18.50 b	18.15 b	18.30 b	25.31
T_3V_4	17.35 bc	17.55 bc	17.2 b	17.38 bc	29.06
T_3V_5	22.12 a	24.52 a	26.85 a	24.50 a	--
$LSD_{(0.05)}$	**0.91**	**1.40**	**1.52**	**1.40**	**--**
CV(%)	**5.24**	**7.56**	**8.23**	**7.73**	**--**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.4 Fruit infestation plant^{-1} at different fruiting stage in weight basis

4.1.4.1 Effect of management practices

Significant variation at 5 % level on percentage of fruit infestation plant^{-1} was found at different growing stage influenced by different treatment (Table 7) Among the treatment Bumper 30SL (T_1) showed significantly the minimum fruit infestation plant^{-1} in weight basis (4.93 g, 7.18 g, 5.70 g and 5.94 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from neem oil (T_2). Significantly the maximum fruit infestation plant^{-1} in weight basis (16.13 g, 17.98 g, 14.49 g and 16.20 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Control (Without pesticide) (T_3) treatment.

Percentage of fruit infestation plant^{-1}in weight basis reduction over control in sustainable management was estimated and the highest value was found from the treatment T_1 (63.33%) and the minimum reduction over control from T_2 (46.45%) treatment.

4.1.4.2 Effect of Variety

Effect of sustainable management showed a significant variation at 5 % level on percentage of fruit infestation plant^{-1} in weight basis was found at different growing stage influenced by different varieties (Table 7) Among the varieties BARI Dheros-1 (V_1) showed significantly the least fruit infestation plot^{-1} in weight basis percentage (8.07 g, 9.23 g, 7.50 g and 8.27 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) which was statistically different from BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. Significantly the highest fruit infestation plant^{-1} in weight basis (14.59 g, 18.84 g, 14.57 g and 16.03 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3).

Percentage of fruit infestation plant^{-1}in weight basis over control in variety was estimated and the highest value was found from the variety V_1 (48.34%) which was followed by V_2 (46.43%) and V_4 (43.34%) varieties and the minimum reduction over control from V_3 (40.82%) variety.

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

Treatments	% Fruit infestation plant^{-1} (g)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%reduction over control
T_1	4.93 c	7.18 c	5.70 c	5.94 c	63.33
T_2	8.69 b	9.55 b	7.77 b	8.67 b	46.45
T_3	16.13 a	17.98 a	14.49 a	16.20 a	--
$LSD_{(0.05)}$	**0.67**	**0.63**	**0.75**	**0.71**	**--**
Variety					
V_1	8.07 d	9.23 c	7.50 c	8.27 c	48.34
V_2	8.49 cd	9.43 c	7.79 bc	8.57 bc	46.43
V_3	9.46 b	10.46 b	8.49 b	9.47 b	40.82
V_4	8.99 bc	9.90 bc	8.26 bc	9.05 bc	43.43
V_5	14.59 a	18.84 a	14.57 a	16.03 a	--
$LSD_{(0.05)}$	**0.86**	**0.81**	**0.96**	**0.91**	**--**
CV(%)	**9.03**	**7.27**	**10.70**	**9.20**	**--**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.4.3 Interaction effect

Interaction effect of intensity of infestation and management practices decrease gradually advance of growth stage in respect of fruit infestation plot^{-1} in weight basis (Table 8). The infestation rate was slower in the early fruiting stage of growing period. After that the increasing rate was little bit increase up to late fruiting stage. However, the least

percentage of fruit infestation (4.22 g, 6.68 g, 5.01 g and 5.30 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in the treatment combination T_1V_1 which was statistically different from all other treatments. The highest percentage of fruit infestation (29.33 g, 38.75 g, 29.33 g and 32.47 g at early fruiting, mid fruiting, late fruiting stage and mean respectively) was obtained from the treatment combination of T_3V_5.

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

Treatment combination	% Fruit infestation plant^{-1} (gm)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	%reduction over control
T_1V_1	4.22 f	6.68 e	5.01 g	5.30 e	83.68
T_1V_2	4.85 f	6.98 e	5.25 g	5.69 e	82.48
T_1V_3	5.25 f	7.45 e	6.15 e-g	6.28 e	80.66
T_1V_4	5.01 f	7.15 e	5.75 fg	5.97 e	81.61
T_1V_5	5.40 f	7.65 e	6.35 d-g	6.47 e	80.07
T_2V_1	8.25 e	9.15 d	7.25 c-f	8.22 d	74.68
T_2V_2	8.52 e	9.20 d	7.79 c-e	8.50 d	73.82
T_2V_3	8.92 e	9.85 d	7.98 cd	8.92 d	72.53
T_2V_4	8.75 e	9.45 d	7.82 cd	8.67 d	73.30
T_2V_5	9.05 e	10.14 d	8.02 c	9.07 d	72.07
T_3V_1	11.75 d	11.85 c	10.25 b	11.28 c	65.26
T_3V_2	12.12 cd	12.13 c	10.35 b	11.53 c	64.49
T_3V_3	14.21 b	14.08 b	11.35 b	13.21 b	59.32
T_3V_4	13.25 bc	13.11 bc	11.21 b	12.52 bc	61.44
T_3V_5	29.33 a	38.75 a	29.33 a	32.47 a	--
$LSD_{(0.05)}$	**1.50**	**1.41**	**1.67**	**1.58**	**--**
CV(%)	**9.03**	**7.27**	**10.70**	**9.20**	**--**

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

Interaction effect of intensity of infestation and sustainable management on percentage of fruit infestation plot^{-1} in weight basis reduction over control was estimated and the highest value was found from the combination T_1V_1 (83.68%) and the minimum reduction over control from T_3V_3 (59.32%) combination.

4.1.5 Yield Contibuting Characters

4.1.5.1 Effect of management practices

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

In the term of number of branch plant^{-1}, among the treatment Bumper 30SL (T_1) showed significantly the highest number of branch plant^{-1} (4.80) which was statistically different from Neem oil (T_2). Significantly the least number of branch plant^{-1} (2.86) was found in Control (Without pesticide) (T_3) treatment.

In the term of number of fruit plant^{-1}, among the treatment Bumper 30SL (T_1) showed significantly the highest number of branch plant^{-1} (24.60) which was statistically different from Neem oil (T_2). Significantly the least number of fruit plant^{-1} (20.20) was found in Control (Without pesticide) (T_3) treatment.

In consider of fruit length (cm) and fruit girth (cm), among the treatment Bumper 30SL (T_1) showed significantly the highest number of branch plant^{-1} (14.90 and 1.54) which was

statistically similar from Neem oil (T_2). Significantly the least fruit length (cm) and fruit girth (cm) (14.50 and 1.53) was found in Control (Without pesticide) (T_3) treatment.

In consider of Single fruit weight (g), among the treatment Bumper 30SL (T_1) showed significantly the highest single fruit weight (13.36 g) which was statistically different from Neem oil (T_2). Significantly the least single fruit weight (10.49 g) was found in Control (Without pesticide) (T_3) treatment

4.1.5.2 Effect of Variety

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

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

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

[T_1 = Spraying Bumper 30SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/Lof water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

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

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

4.1.5.3 Interaction effect

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

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

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

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

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

Table 10. Interaction effect of variety and management practices on yield Contributing Characters at different growing stage

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

[T_1 = Spraying Bmper20SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.6 Production of okra

4.1.6.1 Effect of management practices

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

In the term of yield (kg/plot), among the treatment Bumper 20SL (T_1) showed significantly the highest number of yield (kg/plot) (8.04) which was statistically different from Neem oil (T_2). Significantly the least yield (kg/plot) (4.76) was found in Control (Without pesticide) (T_3) treatment.

In the term of yield (ton/ha), among the treatment Bumper 20SL (T_1) showed significantly the highest yield (ton/ha) (16.07) which was statistically different from neem oil (T_2). Significantly the least yield (ton/ha) (9.52) was found in Control (Without pesticide) (T_3) treatment.

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

4.1.6.2 Effect of Variety

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

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

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

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

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

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

[T_1 = Spraying Bumper 20SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.1.6.3 Interaction effect

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

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

Yield (ton/ha) increase over control in management practices was estimated and the highest value was found from the combination T_1V_1 (158.70%) and the minimum increase over control from T_3V_3 (33.42%) treatment.

Table 12. Interaction effect of variety and management practices on yield Contributing Characters at different growing stage

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

[T_1 = Spraying Bumper 20SL @1.5 ml/L at 15 days interval, T_2 = Spraying Neem oil @ 2 ml/L of water mixed with 10 ml of trix liquid sprayed at 15 days interval, T_3 = Control]

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

4.2. Interaction with the numbers of Jassid and yield of okra

4.2.1. In case of different management practices

Correlation study was done to establish the relationship between number of Jassid per plant^{-1} and yield (t/ha) of okra in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the numbers of jassid caused by plant^{-1}and yield of okra (Figure 1). It was evident from the Figure 1 that the regression equation y = -0.6914x + 17.798gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9927) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the number of jassid caused by plant^{-1}and yield of okra, i.e., the yield decreased with the increase of the number of jassid caused by plant^{-1}of okra in case of the performance of different treatments.

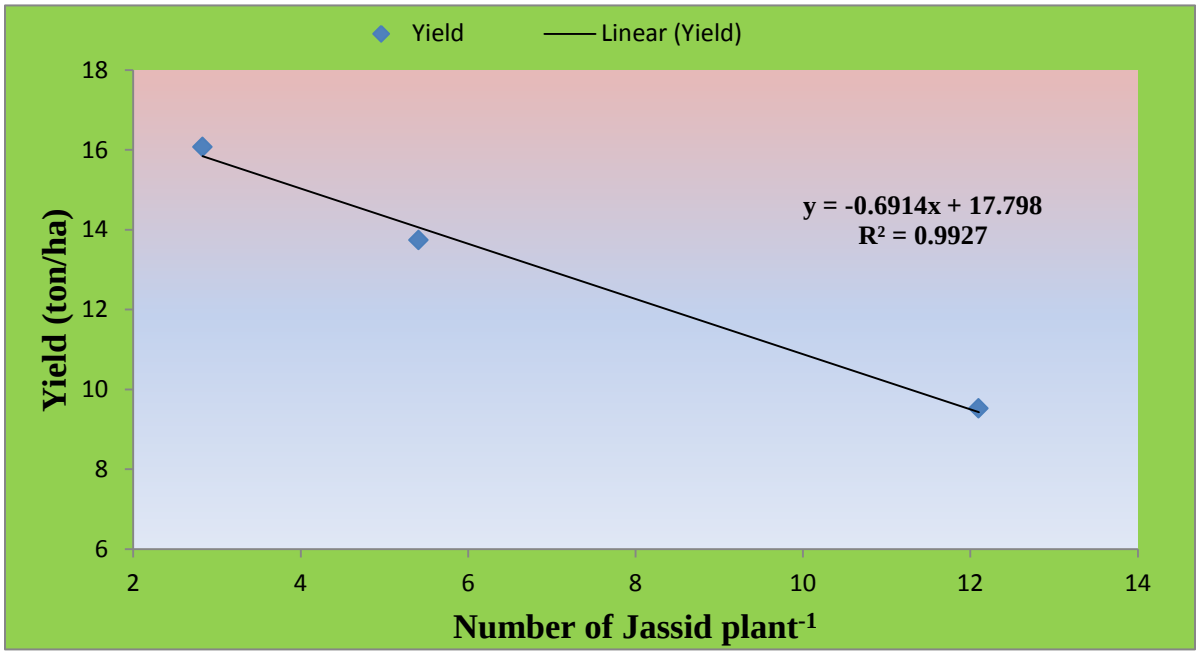


Figure 2: Correlation between the number of Jassid per plant^{-1} and yield (t/ha) of okra in case of different management practices

4.2.2. In case of varieties

Correlation study was done to establish the relationship between number of jassid caused by plant^{-1}and yield (t/ha) of okra in case of varietal performance. From the study it was revealed that significant correlation was observed between the numbers of jassid caused by plant^{-1}and yield of okra (Figure 2). It was evident from the Figure 2 that the regression equation y = -0.909x + 19.275gave a good fit to the data, and the co-efficient of determination (R^2 = 0.8135) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the number of jassid caused by plant^{-1}and yield of okra, i.e., the yield decreased with the increase of the number of jassid caused by plant^{-1}of okra in case of varietal performance.

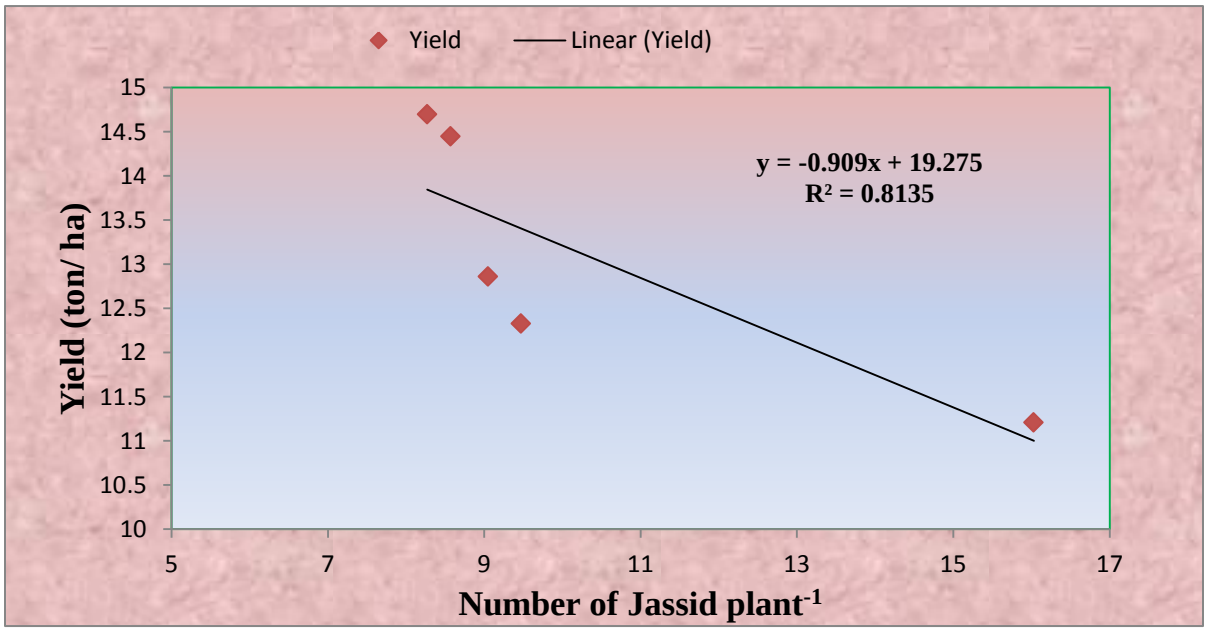


Figure 3: Correlation between the number of Jassid per plant^{-1} and yield (t/ha) of okra in case of different varieties

4.2.3. In case of combination of varieties and management practices

Correlation study was done to establish the relationship between number of jassid caused by plant^{-1}and yield (t/ha) of okra in case of the combination of varieties and treatments. From the study it was revealed that significant correlation was observed between the numbers of jassid caused by plant^{-1}and yield of okra (Figure 3). It was evident from the Figure 3 that the regression equation y = -0.9995x + 21.58gave a good fit to the data, and the co-efficient of determination (R^2 = 0.8252) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the number of jassid caused by plant^{-1}and yield of okra, i.e., the yield decreased with the increase of the number of jassid caused by plant^{-1}okra in case of the combination of varieties and treatments.

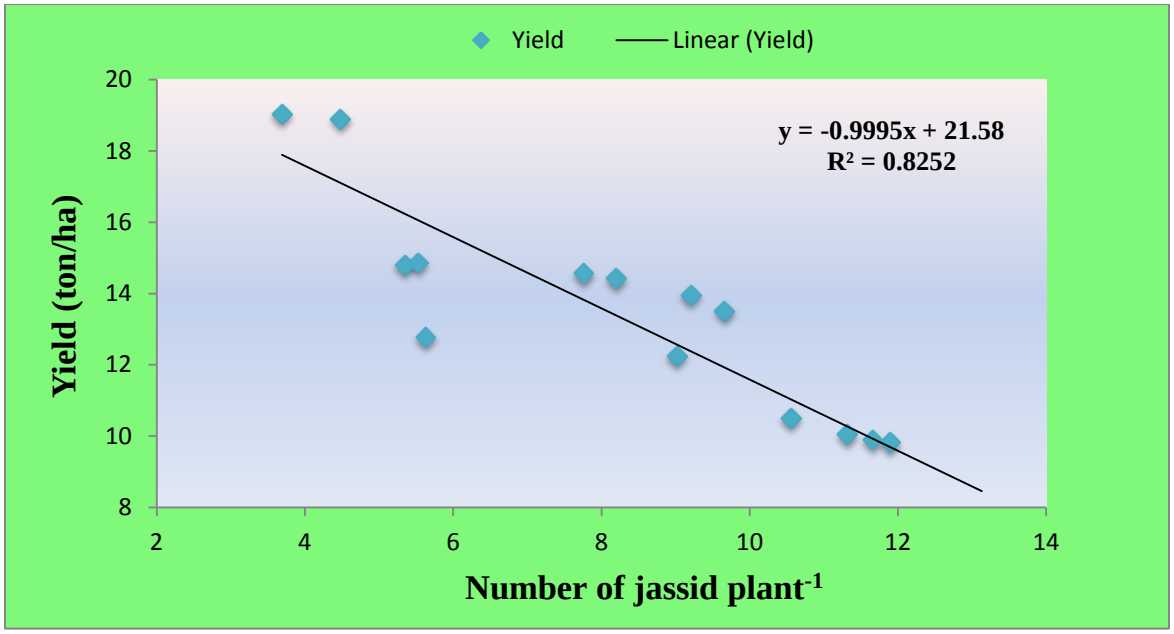


Figure 4: Correlation between the number of Jassid per plant^{-1} and yield (t/ha) of okra in case of different management practices and varieties

4.3. Interaction with the percentage fruit infestation plant^{-1} (g) and yield of okra

4.3.1. In case of different mangement practices

Correlation study was done to establish the relationship between percentage fruit infestation plant^{-1} (g) and yield (t/ha) of okra in case of the performance of different treatments. From the study it was revealed that significant correlation was observed between the percentage fruit infestation plant^{-1} (g) and yield of okra (Figure 4). It was evident from the Figure 4 that the regression equation y = -0.6218x + 19.496 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9903) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the percentage fruit infestation plant^{-1} (g)and yield of okra, i.e., the yield decreased with the increase of the percentage fruit infestation plant^{-1} (g)of okra in case of the performance of different treatments

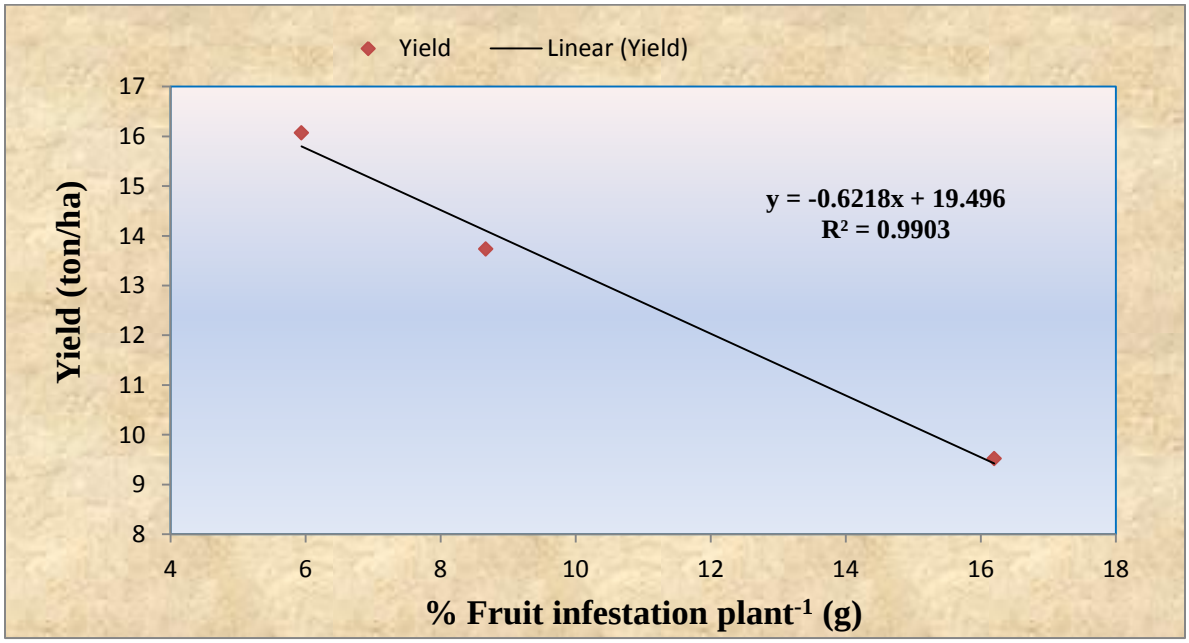


Figure 5: Correlation between the percentage fruit infestation plant^{-1} (g) and yield (t/ha) of okra in case of different management practices

4.2.2. In case of varieties

Correlation study was done to establish the relationship between percentage fruit infestation plant^{-1} (g) and yield (t/ha) of okra in case of varietal performance. From the study it was revealed that significant correlation was observed between the percentage fruit infestation plant^{-1} (g) and yield of okra (Figure 5). It was evident from the Figure 5 that the regression equation y = -0.3667x + 16.879gave a good fit to the data, and the co-efficient of determination (R^2 = 0.6594) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the percentage fruit infestation plant^{-1} (g) and yield of okra, i.e., the yield decreased with the increase of the percentage fruit infestation plant^{-1} (g) of okra in case of varietal performance.

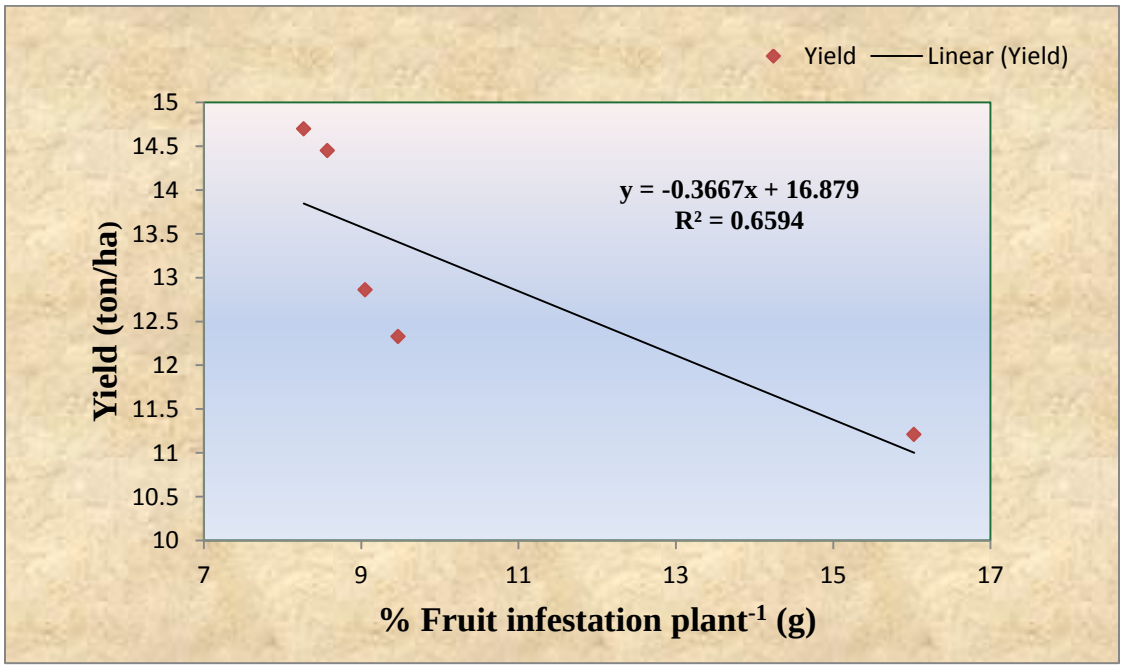


Figure 6: Correlation between the percentage fruit infestation plant^{-1} (g) and yield (t/ha) of okra in case of different varieties.

4.2.3. In case of combination of varieties and treatments

Correlation study was done to establish the relationship between percentage fruit infestation plant^{-1} (g) and yield (t/ha) of okra in case of the combination of varieties and treatments. From the study it was revealed that significant correlation was observed between the percentage fruit infestation plant^{-1} (g) and yield of okra (Figure 6). It was evident from the Figure 6 that the regression equation y = -0.3655x + 16.866gave a good fit to the data, and the co-efficient of determination (R^2 = 0.5481) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between the percentage fruit infestation plant^{-1} (g)and yield of okra, i.e., the yield decreased with the increase of the percentage fruit infestation plant^{-1} (g)okra in case of the combination of varieties and treatments.

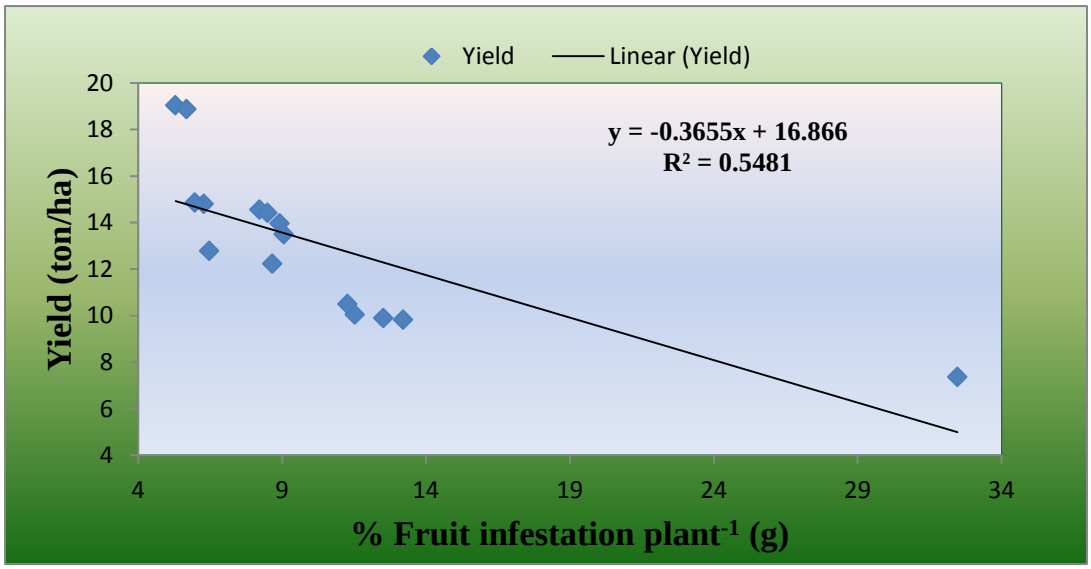


Figure 7: Correlation between the percentage fruit infestation plant^{-1} (g) and yield (t/ha) of okra in case of different management practices and varieties.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from January to April, 2020 to study the Intensity of infestation and sustainable management of jassid on different varieties of okra using botanicals and chemical. The treatments are comprised with different varieties, one synthetic chemical insecticide, one botanical insecticide and one untreated control and these are T_1 = Bumper 20SL @ 1.5 ml/L at 15 days interval; T_2 = Neem oil @ 5 ml/L of water mixed with 10ml of trix liquid sprayed at 7 days interval; T_3 = Untreated control; V_1= BARI Dheros-1, V_2= BARI Dheros-2, V_3= Ok-285, V_4= Green finger, V_5= Arko anamika. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. Considering the efficiency of different management practices, the findings of the results have been summarized as follows:

In terms of number of leaves infestation plant^{-1} was found at different growing stage influenced by different varieties, among the varieties BARI Dheros-1 (V_1) showed significantly the least leaves infestation plant^{-1} (5.67, 7.04, 7.86, 8.76 and 7.34 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) and following by BARI Dheros-2(V_2) & Green finger (V_4) varieties. Significantly the highest leaves infestation plant^{-1} (7.17, 8.95, 10.17, 11.60 and 9.47 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) was found in Arko anamika (V_5) variety which followed by Ok-285 (V_3). As a result, in order of the trend of different varieties in terms of leaves infestation plant^{-1} was V_1 (BARI Dheros-1) < V_2 (BARI Dheros-2) < V_4 (Green finger) < V_3 (Ok-285) < V_5 (Arko anamika).

In terms of Interaction effect of variety and management practices on number of leaves infestation plant-1 throughout the growing period of okra during the management of okra jassid at the different days after sowing , T_1V_1 comprising Bumper 20SL @ 1.5 ml/L at 15 days interval with BARI Dheros-1, performed best result showing least number of leaves infestation plant^{-1} (2.20, 3.10, 4.20, 5.25, and 3.69 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively) followed by T_1V_2 and T_1V_3 treatments respectively, whereas T_3V_5 comprising untreated control & Arko anamika was showed the least performance showing highest number of leaves infestation plant^{-1} (9.25, 12.25, 14.25, 16.75, and 13.13 at vegetative, early fruiting, mid fruiting, late fruiting stage and mean respectively)which is followed by T_3V_4.

In terms of number of jassid plant^{-1} reduction over control in sustainable management was estimated. Among the treatments highest value was found from the treatment T_1 (76.61%) comprising Bumper 20SL @ 1.5 ml/L at 15 days interval and the minimum reduction over control was found from T_2 (55.26%) treatment comprising Neem oil @ 5 ml/L of water mixed with 10ml of trix liquid sprayed at 7 days interval. As a result, order the trend of different management practices in terms of present jassid plant^{-1} reduction was T_1 (Bumper 20SL) > T_2 (Neem oil) > T_3 (Untreated control) .

In terms of number of jassid plant^{-1} reduction in variety was estimated. Among the varieties, highest value was found from the variety $V_{1,}$BARI Dheros-1(40.94%)which was followed by $V_{2,}$ BARI Dheros-2(34.68%) and V_4,Green Finger (30.31%) varieties and the minimum reduction fromV5,Arko Anamika(20%) which was followed by V_3,Ok-285 (26.52%) variety. As a result, order the trend of different varieties in terms of present jassid plant^{-1} reduction was V_1 (BARI Dheros-1) > V_2 (BARI Dheros-2)> V_4 (Green Finger) > V_3 (OK-285) >V_5 (Arko Anamika).

In terms of Interaction effect of intensity of infestation and management practices on percentage of fruit infestation reduction over control was estimated and the highest value was found from the combination T_1V_1 (91.12%) comprising Bumper 20 SL@ 1.5 ml/L at 15 days interval & BARI Dheros-1, followed by T_1V_2 and T_1V_4 treatments respectively. Minimum reduction combination over control from combination T_3V_5 (37.32%) comprising untreated control and Arko anamika was showed the least performance which was followed by T_3V_3 &T_3V_4.

In terms of percentage of fruit infestation reduction over control in sustainable management was estimated. Among the treatments highest value was found from the treatment T_1 (75.11%) comprising Bumper 20SL @ 1.5 ml/L at 15 days interval and the minimum reduction over control was found from T_2 (49.17%) treatment comprising Neem oil @ 5 ml/L of water mixed with 10ml of trix liquid sprayed at 7 days interval. As a result, order the trend of different management practices in terms of fruit infestation reduction was T_1 (Bumper 20SL) > T_2 (Neem oil) > T_3 (Untreated control)

In terms of number of fruit infestation reduction in variety over control was estimated. Among the varieties, highest value was found from the variety V_1,BARI Dheros-1(33.26%)which was followed by V_2, BARI Dheros-2(27.11%) and V_4,Green Finger (22.01%) varieties and the minimum reduction fromV5,Arko Anamika which was followed by V_3,Ok-285 (17.66%) variety. As a result, order the trend of different varieties in terms of present jassid plant^{-1} reduction was V_1 (BARI Dheros-1) > V_2 (BARI Dheros-2)> V_4 (Green Finger) > V_3 (OK-285) >V_5 (Arko Anamika).

In terms of Interaction effect of variety and sustainable management on percentage of fruit infestation reduction over control was estimated and the highest value was found from the combination T_1V_1 (86.41%) comprising Bumper 20SL @ 1.5 ml/L at 15 days

interval & BARI Dheros-1, followed by T_1V_2 and T_1V_4 treatments. Minimum reduction combination over control from combination T_3V_5comprising untreated control & Arko anamika was showed the least performance which was followed by T_3V_3 &T_3V_4.

In terms of percentage of fruit infestation plant^{-1} reduction on weight basis over control in sustainable management was estimated. Among the treatments highest value was found from the treatment T_1 (63.33%) comprising Bumper 20SL @ 1.5 ml/L at 15 days interval and the minimum reduction over control was found from T_2 (46.45%) treatment comprising Neem oil @ 5 ml/L of water mixed with 10ml of trix liquid sprayed at 7 days interval. As a result, order the trend of different management practices in terms of fruit infestationplant^{-1} reduction on weight basis was T_1 (Bumper 20SL) > T_2 (Neem oil) > T_3 (Untreated control).

In terms of number of fruit infestationplant^{-1} reduction on weight basis in variety over control was estimated. Among the varieties, highest value was found from the variety V_1,BARI Dheros-1(48.34%)which was followed by V_2, BARI Dheros-2(46.43%) and V_4,Green Finger (43.43%) varieties and the minimum reduction fromV_5, Arko Anamika which was followed by V_3,Ok-285 (17.66%) variety. As a result, order the trend of different varieties in terms of fruit infestationplant^{-1} reduction on weight basis was V_1(BARI Dheros-1) > V_2 (BARI Dheros-2)> V_4 (Green Finger) > V_3 (OK-285) >V_5 (Arko Anamika).

In terms of Interaction effect of variety and sustainable management on percentage of fruit infestationplant^{-1} reduction on weight basis over control ,the highest value was found from the combination T_1V_1 (83.68%) comprising Bumper 20 SL @ 1.5 ml/L at 15 days interval & BARI Dheros-1, followed by T_1V_2 and T_1V_4 treatments. Minimum reduction combination over control from combination T_3V_5comprising untreated

control & Arko anamika was showed the least performance which was followed by T_3V_3 &T_3V_4.

It was also found that T_1(Bumper 20SL) performed as the best treatment showing the highest number of branch plant^{-1}(4.80), number of fruit plant^{-1}(24.60), fruit length (14.90cm), fruit girth (1.54cm) and Single fruit weight (13.36g).On the other hand the lowest number of branch plant^{-1}(2.86), number of fruit plant^{-1}(20.20), fruit length (14.50cm), fruit girth (1.53cm) and Single fruit weight (10.49g) were recorded in T3(Untreated Control).

V_1(BARI Dheros-1)performed as the best variety showing the highest number of fruit plant^{-1}(25.67),Single fruit weight (13.41g).On the other hand minimum number of fruit plant^{-1} (20.00), Single fruit weight (10.82g) were recorded in V_5 (Arko anamika).

In terms of Interaction effect of variety and sustainable management,T_1V_1 performed best showing the highest number of branch plant^{-1}(5.25), number of fruit plant^{-1}(30.00), fruit length (20.00cm), fruit girth (1.5cm) and Single fruit weight (14.55g).On the other hand the lowest number of branch plant^{-1}(2.35), number of fruit plant^{-1}(18.00), fruit length (12.00cm), fruit girth (1.40cm) and Single fruit weight (8.25g) were recorded in T_3V_5.

From the above findings, It is revealed that T_1 performed as the best treatment in terms of increasing the yield of okra over control(68.75%) whereas the minimum increase of fruit yield over control was recorded in T_2 (44.23%).

It is also revealed that the highest increase of fruit yield (ton/ha) increase over control was found from the variety V_1 (31.13%) which was followed by V_2 (28.90%) and V_4 (14.72%) varieties and the minimum increase over control from V_3 (9.99%) variety.

In terms of Interaction effect of variety and sustainable management on fruit yield (ton/ha) increase over control, the highest value was found from the combination T_1V_1 (158.70%) followed by T_1V_2 (156.52%) & T_1V_4 (101.90%) and the minimum increase over control from T_3V_3 (33.42%) treatment.

CONCLUSION

The present study revealed that the increased yield per hectare of okra with decreased percent infestation of shoot, plant, flower, as well as fruit infestation caused by jassid and treatment Bumper 20 SL (T_1) and combination T_1V_1 showed best performance for controlling this insect pest. From the above result it can be concluded that in terms of overall performance, the variety BARI Dheros-1 (V_1) performed the highest healthy fruit yield whereas the highest total yield was found from BARI Dheros-1 (V_1) which was statistically close to BARI Dheros-2 (V_2) and following by Green finger (V_4) varieties. So, comparing insect infestation status, Arkoanamika (V_5) may be considered as the best among the experimental okra varieties.

The chemical insecticide Bumper 20SL @ 1.5 ml/L at 15 days interval with BARI Dheros-1variety is the most effective against jassid. Among botanical treatments, Neem oil @ 5 ml/L of water mixed with 10ml of trix liquid sprayed at 7 days interval with BARI Dheros-1 performed better to control jassid in okra, which might be chosen as the alternative approach.

RECOMMENDATION

However, from this experiment followings are some important recommendations-

- Experiment should be repeated for confirmation the activity of the major pests in other regions of Bangladesh to reach any concrete conclusion.
- Further trials should be carried out in consecutive years in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

REFERENCE

Anitha, K.R. and Nandihalli, B.S. (2009). Evaluation of some okra hybrids against leafhopper and aphid. Karanataka, *J. Agric. Sci*, **22**: 718-719.

Ali, M.I., Khan, M., Rashid, A., and Sajid, M. (2012). Epidemiology of okra yellow vein mosaic (OYVMV) and Its management through tracer, mycotol and imidacloprid. *American J. Pl. Sci*. **3**:1741-1745

Ali, M.I. and Karim, M.A. (1991). Rational insecticide use for the control of the cotton jassid, *Amrasca biguttula* (Shir) (Cicadellidae, Homopters) and the spotted bollworm, *Earias vittella* (F.) (Noctuidae, Lepidoptera) on cotton in Bangledesh. *Trop. Pest Manag*. **37** (1):66-70.

Anonymous (1993). Research and development of vegetable crops. Paper presented in the workshop on importance of okra as summer vegetable on March 9-10, IPSA, Gazipur.pp.1-07.

Anonymous (2005). Development of management approach against jassid infestation on lady's finger (*Abelmoschus esculentus*). Annual Research Report, Entomology Division. *BARI*, Gazipur, Bangladesh. pp. 46-48.

Ashfaq, M., Noor-ul-Aen, M., Zia K., Nasreen A., and Mansoor-ul-Hasan. (2010). The correlation of abiotic factors and physico-morphic charateristics of (*Bacillus thuringiensis*) Bt transgenic cotton with whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae) and jassid, *Amrasca devastans* (Homoptera: Jassidae) populations. *African J. Agric. Res.* **5**(22): 3102-3107.

Atwal, S.N. (1994). Agricultural pests of India and South-East Asia Kalyani Publishers, New Delhi, India, pp. 52

Atwal, A.S., Chaudhary, J.P. and Sohi, B.S. (1969). Effect of temperature and humidity on development and population of jassids, *Empoasca devastants* Distant. *J. Res*. (PAU), **6**(1): 255-261.

Babu, R.K. and Santaram, G. (2000). Persistence toxicity of imidacloprid to aphid and leafhoppers on groundnut. *Pestology*, **24** : 23-25.

BBS. (2009). Ministry of Planning, Government of Peoples Republic of Bangladesh. *Year book of Agric. Stat. Bangladesh*. Dhaka.

BBS. (2011). Ministry of Planning, Government of Peoples Republic of Bangladesh. *Year book of Agric. Stat. Bangladesh*. Dhaka.

Balikai, R.A. and Lingappa, S. (2005). Management of aphid, *Melanaphis sacchari* (Zehntner) on rabi sorghum through botanicals. In Sustainable Insect Pest Management (Eds. S. Ignacimuthu and S. Jayaraj) Narosa Publishing House, New Delhi, pp.204-209.

Berlinger, M.J. (1986). Host Plant Resistance to *Bemisia tabaci*. *Agric. Ecosystems Environ.***17**: 69-82

Bhat, M.G. Joshi, A.B. and Singh, M. (1984). Relative losses of seed cotton yield by jassid and bollworm in some cotton genotypes (*Gossypium hirsutum* L.), *Indian J. Entomol.* **46**(1): 169-173.

Bhaskaran, S. (1995). Studies on traditional pest control practices of Tamil Nadu. M. Sc. (Agri.) Thesis, Annamalai University, Annamalainagar, p. 120.

Chauhan, D.V.S. (1972). Vegetable production in India. 3rd Edn. Ram Prasad Sons, *Agra*. Pp. 28-30.

Chitra K.C., Rao S.J., Rao P.K. (1997). Efficacy of plant extracts for controlling cotton aphid (Aphis gossypii). *Indian J. Agric. Sci*. **63**:134-135.

Devi, Y.K., Kumar V. and Gill R.S. (2018). Effect of nitrogen fertilizers and weather parameters on the incidence of jassid *Amrasca biguttula biguttula* (Ishida) in Bt, non-Bt and Desi cotton, *Indian Journal of Entomology,* **80** (3), 741-747

Dey, R., Pal, K.K. Bhatt, D.M. and Chauhan, S.M.(2005). Growth promotion and yield enhancement of peanut okra by application of plant growth. Microbiol. Res. 159, 371–394.

Deshmukh, S. D. and Barle, M.N.(1976). Studies on the insecticidal property of indigenous plant extracts. *Indian J. Entomol*. **3** : 11-18.

Dhawan, A. K. and Simwat, G.S.(2000). Evaluation of indoxacarb for the control of bollworm complex and its impact on population of sucking pests. *Pestology,***15** : 20- 25.

Dhandapani, N., Shelkar, U.R., Murugan, M. (2003). Bio-intensive pest management (BIPM) in major vegetable crops: an Indian perspective. *Food Agric. Envir*. **2**:333-339.

Dhingra, S., Walia, S., Kumar, J., Singh, S., Singh, G., Parmar, B.S.(2008). Field efficacy of azadirachtin-A, tetrahydroazadirachtin-A, neemazal and endosulfan against key pests of okra (*Abelmoschus esculentus*). *Pest. Manag. Sci*.**64**: 1187-1194.

Dilbar, H., Sultana, S., Sultana, T., Jabeen, F., Akhter, M. and Ali. A. (2014). Antibiosis Studies on okra genotypes against *A. biguttula biguttula* (Ishida). *J. of Entomol. and Zool. Studies*. **2** (4): 78-81.

El-Tom, H.A. (1987). Integrated Pest Management for Cotton in Bangladesh (Terminal Report). FAO/UNDP Cotton Improvement Program. Cotton research Station, Rangpur, Bangladesh. 4p.

Gandhi,V.P. and Namboodiri,N.V.(2006). The adoption and economics of Bt cotton in India: Preliminary results from a study (Working paper number 2006-09-04). Ahmedabad, India: Indian Institute of Management.

Grainge, M. and Ahmad, S. (1988). Handbook of Plants with Pest Control Properties. John Wiley and Sons, 470 p.

Gangopadhyay, K. K., Singh, A., Kumar Bag, M., Ranjan, P., Prasad, T.V., Roy A. and Dutta, M. (2016). Diversity analysis and evaluation of wild *Abelmoschus* species for agro-morphological traits and major biotic stresses under the north western agro-climatic condition of *Indian. J. Entomol*.**54** (4): 215-220.

Halder, J., Sanwal, S. K., Deb, D., Rai, A. B. and Singh, B.(2016). Mechanisms of physical and biochemical basis of resistance against leaf-hopper (*Amrasca biguttula biguttula*) in different okra (*Abelmoschus esculentus*) genotypes. *Indian J. Agril. Sci.* **86**(4), pp.481-484.

Hanumantappa, M.(2003). Bioecology and management of leafhopper, *Amrasca biguttula biguttula* (Ishida) (Homoptera : Cicadellidae) on sunflower. *M. Sc. (Agri.) Thesis,* University of Agricultural Sciences, Dharwad.

Hasan, M., Ashfaq, M., Iqbal, J. and Sagheer, M. (2009). Varietal resistance against Jassid, *A. biguttula biguttula* (Ishida) on Okra under Faisalabad ecological conditions. In: Feldmann F, Alford D. V, Furk C: Crop Plant Resistance to Biotic and Abiotic Factors, pp.138-145.

Iqbal J. and Ashfaq, M. (2010). Influence of abiotic factors on population fluctuation of leaf hopper, *Amrasca biguttula biguttula* (Ishida) on Okra. *Pakistan J. Zool*. 42, pp. 615-621.

Inee-Gogoi, B. C., Dutta and Gogoi,I., (2000). Seasonal abundance of cotton jassid, (*Amrascabiguttula biguttula*) Ishida. On *okra*.*J.Agric*.*Sci*.,*Society*-of-North-East India.**13**(1):22-26.

Isacc, I. and Svetlana, K.A., (2002). Emamectin a novel insecticide for the control of field crop pests. *Pest Management Science*. **58** : 1091-1098.

Iyyappa, V.R. (1994). Plant Protection Practices. *Honey Bee*, **1**: 13.

Iqbal, J., Mansoor, H., Muhammad, A., Shahbaz, T. and Amjad, A. (2008). Screening of okra genotypes against jassid, *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae). *Pak. J. Agril. Sci*. **45**(4): 448 - 451.

Iqbal, J., Ashfaq, M., ul Hasan, M., Sagheer, M., and Nadeem, M. (2010). Influence of abiotic factors on population fluctuation of leaf hopper, *Amrasca biguttula biguttula* (Ishida) on Okra. *Pak. J. Zool.***42**(5).

Jamshaid, I., Hasan. M., Ashfaq, M., Sahi, S.T. and Ali, A. (2008). Screening of okra genotypes against jassid, *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae). *Pak. J. Agril. Sci.***45**(4):448-451.

Jayakumar, R. (2002). Survey of indigenous practices for the management of pests in Raichur district and evaluation of few practices against okra. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Kabir, K.H. and Mia, M.D.(1987). Effectiveness of some indigenous materials as repellent against the mustard aphid. *Bangladesh J. Zool*.**15** : 87-88.

Katole, S.R. and Patil, P.J.(2000). Biosafety of imidacloprid and thiamethoxam as seed treatment and foliar sprays to some predators. *Pestology*, **24**: 11-13.

Khadija, J., Muhammad, A.R., Munawar, A., Hussain, K. and Javed., H. (2016). Varietal and physico-morphic resistance of okra cultivars against *Amrasca biguttula biguttula* (Homoptera: Cicadellidae). *J. Entomol. and Zool. Stu.***14** (5) : 313-317.

Khuhro, S.A.(2014). Integrated pest management of insect pest population through different technique strategies in Okra agroeco-system. Internal knowledge Sharing Plateform **4** (8): 221-225.

Khan, M.A., Akram, W., Khan, H.A.A., Asghar, J., Khan, T.M. (2010). Impact of Bt- cotton on whitefly, Bemisia tabaci (Genn.) population. *Pak. J. Agri. Sci*. **47**(4): 327-332.

Khedkar, J. R. and Ukey, S.P. (2003), Efficacy of newer insecticide against jassids, *Amrasca devastans* State Level Seminar on Pest Management for Sustainable Agriculture, February 6-7, 2003, MAU, Parbhani, pp. 199-192.

Khushk, A. M., Usman, S. M. and Memon, M. A. (2003). The cultivation of okra in Sindh and its economic view, PARC Technology transfer institute, *Tandojam. Sindh Zarat*, 136, 17-18.

Kochhar, S.L. (1986). Tropical Crops. A Text Book of Economic Botany. Macmillan Indian Ltd. pp.263-264.

Krishnaiah, N. V. & Kalode, M. B. (1984). Evaluation of neem oil, neem cake and other non-edible oil cakes against rice pests. *Ind. J. Pl. Protec.* **12**(2), 101-107.

Kumar, V. D.V.N.H., Subramanian, R. and Natarajan, P.(1999). Evaluation of acetamiprid a new chemical insecticidal compound against cotton aphids, *Aphis gossypii* and jassids, *Amrasca biguttula biguttula. Pestology*, **23** : 28-33.

Kumar, N. K. K., Srinivasan, K. and Sardana, H. R. (1989). Evaluation of time of insecticidal application on the control of leafhopper, *Amrasca biguttula biguttula* Ishida (Cicadellidae: Homoptera) and aphid, *Aphis gossypii* Glover (Aphididae: Homoptera) on okra. Insect Sci. and its Applic. **10**(3): 333-339.

Kumawat, R.L., B.L. Pareek and B.L. Meena. (2000). Seasonal incidence of jassid and whitefly on okra and their correlation with abiotic factors. *Annals. of Biol.***16** (2): 167-169.

Lal, O.P.; Sinha, S.R. and Srivastava, Y.N. (2005). Evaluation of some promising insecticides against mustard aphid, *Lipaphis erysimi* Kalt. on cabbage under field condition. *J. entomol. Res*., **26**(2): 169-173.

Mahmood, T., Khokar, K.M., Banaras, M. and Ashraf, M. (1990). Effect of environmental factors on the density of leafhopper, *Amrasca devastans* (Distant) on okra. *Crop Pest Manage.* **36**:279-284.

Mahmood, T., Mahmood, K. and Niazi, Z.M.(1988). Density variation of leafhopper on okra at Islamabad. *Pakistan J. Agril. Res.***9**(2):195-197.

Mallapur, C.P., Hulihalli, U.K. and Kubsad, V.S.(2001). Safflower aphid management through botanical insecticides. *Karnataka J. Agric. Sci*., **14** : 321-325.

Mandahar, C.L. and Singh, J.S. (1972). Effect of bhendi yellow vein mosaic on its host. *Acta. Acad. Sci*. Hungaricae **7**: 187-191.

Mari, J.M. (2013). Impact of trap crops on the population of jassid (A*mrasca devastans* (dist.) in okra. *Wudpecker J. Agril. Res*. **2**(9): 252-255.

Misra, H. P.(2002). Field evaluation of some newer insecticides against aphids (*Aphis gossypii*) and jassids (*Amrasca biguttula biguttula*) on okra. *Indian J. Entomol.*, **64**: 80-84.

Muhammad, A., A. Muhammad, N. Rana, S.H. Muhammad, A. Muhammad and A. Muhammad. (2014). The susceptibility study of some aubergine (*Solanum melongena* L.) cultivars against jassid (*Amrasca biguttula biguttula)* (Ishida*) Pak. J. Agri. Sci*., **51** (3) : 679-683.

Natarajan, R., Subramanian, P. and Santaram, G., (2000). Efficacy of some botanicals against okra leafhopper, *Amrasca biguttula biguttula* (Ishida). *Annals of Plant Protection Sci*., **8** :18-21.

Narayansamy, P. (1999). Traditional pest management for sustainable agriculture. Proceeding of Biopesticides in Insect Pest Management, Rajmundry. pp.225-231.

Nonita Devi, M., Singh, T.K. and Chitradevi, L. (2003). Efficacy of certain botanical insecticides against cotton aphid, *Aphis gossypii* Glover on brinjal. *Pestology*, **27**: 6-9.

Osekita, B. A. (2009). Correlation and path coefficient analyses of seed yield attributes in okra (*Abelmoschus esculentus* L.) Moench. *African J. Biotech.* , 1330-1336.

Patel, P. S., Shukla, N.P. and Patel, G.M.(2003). Enhancing insecticidal properties of cow urine against sucking pests of cotton. **In** : Proceedings of the National Symposium on Frontier Areas of *Entomol. Res.*, November 5-7, 2003, p. 471.

Patel, Z. P. and Patel, Z.R.(1996). Effect of botanicals on behavioural response and growth of jassids, *Amrasca biguttula biguttula*. *Indian J. Plant Prot*. **24**: 28-32.

Pawar, D.B., Lawande, D.E., Warade, S.D.(1996). Effects of different sowing dates on the incidence of leafhopper, mite and fruit borer of okra. *J. Mahrashtra Agri*l. Univ., **21**(3): 375-377.

Pawar, D. R., Warad, S.D., Patil, S.K. and Barve, H.S.(2000). Preliminary studies on the efficacy of organic product on aphid, *Aphis gossypii Glover* (Aphididae: Homoptera) and leafhopper, *Amrasca devastans* Dis (Cicadellidae : Homoptera) of okra. Insect Environment, **6**: 111-112.

Patil, A. S., Patil, P.D. and Patil, R.S., (2002). Efficacy of different schedule doses of imidacloprid against sucking pest complex of chilli (*Capsicum annum L*.). *Pestology*, **26**: 31-33.

Patil, B. V., Bhemanna, M. Badriprasad, P.R., Gowdar, S.B. and Kuamr, N.H., (2001). Bioefficacy of acetamiprid 20SP against early sucking pests in irrigated cotton. Pestology, **25**: 29-33. Page 81.

Patil, K. S., Deshkar, M.M., Rane, A.E. and Nimbalkar, S.A.(1990). Some indigenous plant materials against *A. gossypii* and *Dactynotus carthami* H. R. L. **In**: Botanical Pesticides in Integrated Pest Management, Ed. Chari M. S. and Ram Prasad G. *Indian Soc. Toba*. *Sci*., Rajamundri, p. 238- 241.

Pawar, S. A., Walunj, A.R., Mote, U.N. and Charan, A.P.(2003). Efficacy of PI-0111 a new molecule for control of sucking pests of cotton. **In:** Proceedings of the National Symposium on Frontier Areas of *Entomol. Res*., November 5- 7, 2003, p. 170.

Prabu, T., Warade, S.D., Saidiand, M.H. and Baheti, S. (2009). Screening wild and cultivated okra species for resistance to important pests. *J. of Plant Sci.*, **98** (1) : 987-993.

Prakash, A., Rao, J., Jevari, S.N. and Gupta, S.P. (1990). Rice agro ecosystem management by pesticides and its consequences Nat con. Publ. in Growth Development and Natural Resources Conservations. pp. 131-137.

Rashid, M.M. (1976). Vegetables of Bangladesh (in Bengali). Bangla Academy, Dhaka, pp- 494.

Rashid, M.M. (1999). Shabji Biggan (in Bengal). Rashid Publishing House, 94 Old DOHS, Dhaka-1206. P.49.

Rahman, A. (2014). Development of management practices against jassid (*Amrasca devastans*) in okra (Doctoral dissertation, Department of Entomology, Sher-E-Bangla Agricultural University, Dhaka).

Rahman, M.A., Uddin, M.M., Haque, M.A., Rahman, M.M. (2014). Varietal preference of okra shoot and fruit borer, *Earias vittella* (Fab.) under field condition in Bangladesh. *Acad. Res. J .Agric. Sci. Res.* **3**(1): 8-12.

Rahman, A. (2014). Development of management practices against jassid (*Amrasca devastans*) in okra (Doctoral dissertation, Department of Entomology, Sher-E-Bangla Agricultural University, Dhaka.).

Ramiah, M., Vidhyasekaran, P. and Kandaswamy, T.K.(1972). Changes in photosynthetic pigments of bhendi infected by yellow vein mosaic disease. *Madras Agril. J.* **59**:402-404.

Rehman A.U., Razaq, M. and Wali, M. (2015). Incidence and population dynamics of leaf hopper, *Amrasca bigutulla bigutulla* (Cicadellidae:Homoptera) on four varieties of okra (*Abelmoschus esculentus*) crop in Multan, Pakistan. *Pak. J. Zool.***47**(3): 763-767.

Rana, J. (2006). Response of Coccinella septempunctata and Menochilus sexmaculatus (Coleoptera: Coccinellidae) to their aphid prey, *Lipaphis erysimi (*Hemiptera: Aphididae) in Rapeseed-mustard. *European. J. Ent.***103**: 81-84.

Rathod, A.T., Tandale, M.B., Aherkar, S.K. and Lande, G.K., (2002). Bioefficacy of herbal products against mustard aphid, *Lipaphis erysimi* (Kalt) and its parasite, *Diaeretiella rapae*. *Pestology*, **26** : 17-19.

Ravikumar, S.S., Chillar, B.S. and Rohilla, H.R. (2003). Toxicity of Nitroguanidines/ Neonicotinoids and conventional insecticides against leaf hoppers, *Amrasca biguttul*a on okra under screen house. *Indian J. Entomol*. **65** : 268-272.

Saif, U.H., Javed and Aziz, M.A.(2012). Role of physico-morphic characters of different okra genotypes in relation to population of jassid, *Amrasca biguttula biguttula Ishida. J. Agric. Res.* **50** (2): 217-224.

Sarkar, H.B., Nath, S.C. (1989). Field evaluation of various insecticides against fruit borer, *Earias vittella* (Fab.) and effect on yield of lady's finger seed. *Pestology*, **13**: 19-21.

Sardana, H.R., Bambawale, O.M., Singh, D.K. and Kadu, L.N. (2006). Conservation of natural enemies through IPM in brinjal *(Solanuum melongena* L.) fields. *Entomol.* **31**(2): 83-88.

Singh, A.K. and Kumar, M. (2003). Efficacy and economics of neem based products against cotton jassid, *Amrasca biguttulla biguttulla* Ishida in okra. *Crop Res.-Hisar*. **26**(2), 271-274.

Sahito, H.A., Shah, Z.H., Kousar, T., Mangrio, W.M., Mallah, N.A., Jatoi, F.A. and Kubar, W.A. (2017). Comparative efficacy of novel pesticides against jassid, *Amrasca biguttula biguttula* (Ishida) on cotton crop under field conditions at Khairpur, Sindh–Pakistan. *Singapore J. of Sci. Res*., 1- 8.

Sultana, P., Alam, M.J., Das, K., Azad, M.A. K. and Islam, M.T. (2016). Eco-friendly control of okra jassid using botanicals from jute (*Corchorus capsularis*). *Bangladesh J.of Entomol.* **30**: 65-70.

Savello, P.A., Mortin, F.W. and Hill, J.M. (1980). Nutritional composition of okra seed meal. *Agricultural and Food Chemistry*. **28**: 1163-1166

Subhadra Acharya, H.P., Mishra, H.P. and Dash, D. (2002). Efficacy of insecticides against okra jassid, *Amrasca biguttula biguttula* Ishida. *Annals Plant Protec. Sci*. **10**: 230-232.

Senapati, B. & Khan, S.R. (1978). note on population fluctuation of *Amrasca biguttula biguttula* (Ishida) at Bhubaneswar. *Indian J. of Agril. Res*. **12**; 97-98.

Shivalingaswamy, T.M., Satpathy, S., Singh, B., & Kumar, A. (2002). Predator-prey interaction between jassid (*Amrasca biguttula biguttula*, Ishida) and a staphylinid in okra. *Veg.Sci*., **29**(2), 167- 169.

Samanthabhai and Dharmanbhai, D. (1994). Lemon juice for aphid control. *Honey Bee*, **1**: 17.

Siddegowda, D.K., Suhas Yelshetty and Patil, B.V. (2003). Spinosad 45 SC : An effective insecticide against pigeon pea pod borer, *Helicoverpa armigera* (Hub.). *Pestology*, **17** : 21-22.

Srinivasa Rao, N. and Rajendran, R. (2002). Joint action potential of neem with other plant extracts against the leaf hoppers, *Amrasca devastans* (Distant) on okra. *Pest Manag.and Eco.Zoo.,***10** : 131-136.

Thomson, H.C. and Kelly, W.C. (1979). Vegetable Crops (3rd ed.). McGraw Hill Co. New York. P. 562.

Tomar, S.K. and Rana, O.S. (1994). Incidence of jassid in relation to variety and time of sowing in cotton (Gossypium Spp.). *Ind. J. Agric. Sci*., **64** (11): 10-37.

Umamaheshwari, T., Sharmila, Bharathi, C., Kanagarajan, R., Arvindainambi, S. and Selvanarayana, V. (1999). Neem formulation and castor oil – a safe way to manage okra red spider mite. *J. Aca.,***14** : 77-79

Vennila, S., Biradar, V.K., Sabesh, M. and Bambawale, O.M. (2007). Know Your Cotton Insect Pest Jassids. *Entomol.* **32**(2):42-48.

Verma, S. (1989). Efficacy and persistence of some insecticides against jassids infesting okra *(Abelmoschus esculentus). Pl. Protect. Bull*. **41**(1-2): 1-5.

Vyas, S.H., Patel, J.R. (1990). Relative susceptibility of some okra cultivars to *Earias vittella* (Fabricius). *Indian J. Pl. Protec*. **18**: 115-118

Yadav, S.K., Dhankhar, B.S., Deswal, D.P. and Tomer. R.P.S. (2001). Effect of sowing date and plant geometry on seed production and quality of okra, *Abelmoschus esculentus* L. (Moench) cv. *Varsha Uphar. Seed Res*., **30**: 240-243.

Yadav, S.K., Dhankhar, B.S., Deswal, D.P. and Tomer, R.P.S.(2005). Effect of sowing date and plant geometry on seed production and quality of okra, *Abelmoschus esculentus* L. (Moench) cv. *Varsha Uphar. Seed Res*., **29**: 149-152.

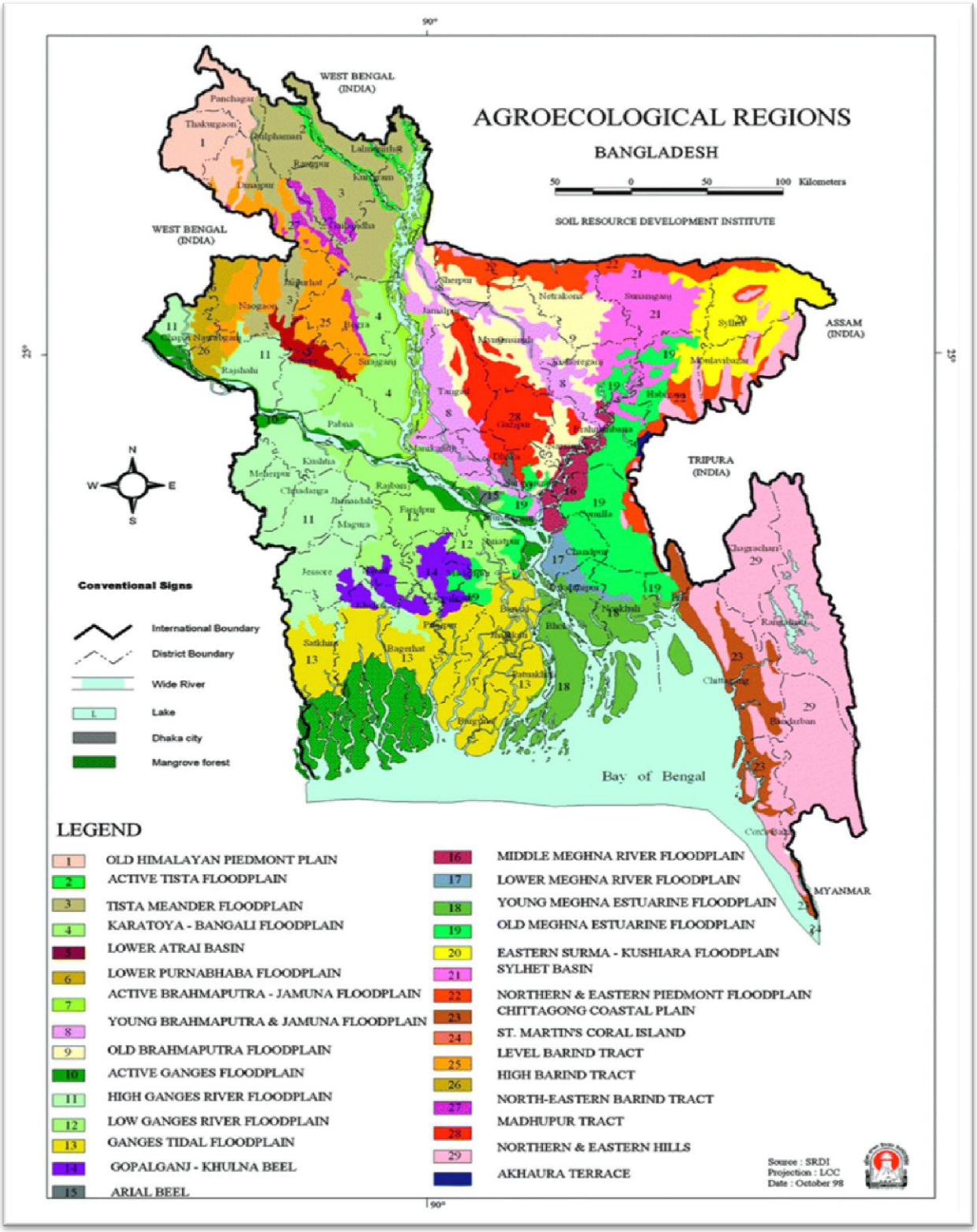
Yadav, J.B., Singh, R.S. and Tripathi, R.A. (2007). Effect of weather parameters on the incidence of pest complex of okra. *Annal. Pl. Protec.Sci.***15**(2):477-478.

Yadav, J.B., Singh, R.S. and Tripathi, R.A.(2008). Evaluation of biopesticides against pest complex of okra. *Annal. Pl. Protec. Sci*.**16**:58-61.

Yajuvendra. S.A. Jha, Verma1, S., Mishra,V. K. and Singh, S.S. (2013). Population dynamics of sucking insect pests and its natural enemies on okra agro-ecosystem in Chitrakoot region. Indian Institute of vegetable Research, Varanasi (U. P.) India. **8**(28): 381-382.

Yamaguchi, M. (1998). World Vegetables : Principles, Production and Nutritive Values. Van Nostrand Reiduction. New York, USA. pp. 415.

Appendix I. Agro-Ecological Zones of Bangladesh



Appendix II. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from October 2019 to March 2020

Month	Average air temperature (°C)	Average relative humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
October, 2013	34.8	77	227	5.8
November, 2013	29.7	65	5	6.4
December, 2013	26.9	68	0	7.0
January, 2014	24.6	66	0	5.5
February, 2014	33.7	69	185	7.8
March, 2014	36.7	70	205	7.7

Source: Bangladesh Meteorological Department (Climate & weather division), Agargaon. Dhaka – 1212

Appendix III. Characteristics of Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
Ph	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (mel 1 00 g soil)	0.10
Available S (ppm)	45

Source : SRDI, 2019