EFFECT OF DIFFERENT APPLICATION METHODS OF IMIDACLOPRID ON ABUNDANCE AND MANAGEMENT OF JASSID IN OKRA

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DECEMBER, 2009

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REGISTRATION NO.: 08-03198

A Thesis

Submitted to the Faculty of Agriculture,

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in partial fulfillment of the requirements

for the degree of

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IN

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CERTIFICATE

This is to certify that thesis entitled, "**EFFECT OF DIFFERENT APPLICATION METHODS OF IMIDACLOPRID ON ABUNDANCE AND MANAGEMENT OF JASSID IN OKRA"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried by MD. YASIR ZAMAN, Registration. No. 08-03198 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2009 ....

Place: Dhaka, Bangladesh **Dr. Md. Abdul Latif**

Supervisor

DEDICATED TO MY BELOVED PARENT

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Dated: December, 2009 **The Author**

SAU, Dhaka

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EFFECT OF DIFFERENT APPLICATION METHODS OF IMIDACLOPRID ON ABUNDANCE AND MANAGEMENT OF JASSID IN OKRA

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ABSTRACT

A field study was carried out in the farm of Sher-e-Bangla Agricultural University during May to June, 2009 to investigate the effect of different application methods of imidacloprid on abundance and management of jassid in okra. The population of jassid was gradually increased with the age of the crop and the peak population was found on last week of May and it was remained constant after that. The lowest number of jassid (16.47/plant) was found in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL), which reduced 77.71% population of jassid over control. Plant height, number of fruits/plot and yield per plot were significantly increased under different treatments. The highest plant height (244.8 cm), number of fruits/plant (652) and yield (13.84 t/ha) were observed in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) treated plot. The result of T_4 (seed treatment by Gauchu 70WS + band application of Gauchu 70WS) and T_5 (pre-plant injection by Gauchu 70WS at a depth of 4cm below the seed line + foliar spray with Admire 200SL) were statistically similar with T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) treated plot. The highest benefit cost-ratio (BCR) was obtained in T_1 (23.22) and the highest adjusted net return (Tk. 41,300) was obtained in T_2 which was found as the best treatment in this study. Considering jassid population, plant growth, number of fruits and fruit yield, T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) was the most effective application methods.

CHAPTER I

INTRODUCTION

Okra or lady's finger, *Abelmoschus esculentus* L., is locally known as bhendi, or dheros. It belongs to the family Malvaceae and originated in tropical Africa (Purseglove, 1987). It is a popular and most common vegetable crop grown from seed in Bangladesh and in other tropical and sub-tropical parts of the world. Though okra is produced mainly in the kharif season (Feb-July), it can be grown in year round (Rashid, 1976). About 39 thousands metric tons of okra fruit were produced in 2007-08 in Bangladesh (BBS, 2008).

Production of okra is severely hampered due to the attack of more than three dozen of insect pests from seedling to fruiting stage (Nayar *et al.*, 1976). Among them the cotton jassid (*Amrasca biguttula biguttula* Ishida) is widely distributed in India and is the most destructive pest of American cotton in the North-Western regions. Besides cotton, it also feeds on okra, potato, brinjal and some wild plants, like hollyhock, *kangi buti (Abutilon indicus)*, etc. (Atwal and Dhaliwal, 2007). Distant (1977) stated that *Amrasca biguttula biguttula* is probably universally distributed and is widespread in tropical and sub-tropical areas of South and South-East Asia. Both adults and nymphs suck plant sap from the lower surface of leaves affecting the vegetative and reproductive growth stages of plant. It attacks all plant parts but it has special preference to leaves. The main symptoms are curling of leaf tips, yellowing, burning and sometimes drying of the affected leaves. In leaf tips and margins necrotic areas are developed. Finally, the affected leaves show hopper burn symptoms. The contrasting weather conditions might have an influence on the abundance of okra jassid. This insect has been reported to be the pest of okra throughout the year (Senapati and Khan, 1978). They pointed out that the largest population occurred from November to February, when temperature and relative humidity is low. Rainfall is a major mortality factor for the nymphs and adults of jassid.

Application of chemical insecticide is the only common method of controlling the pest infestation of okra in Bangladesh. Insecticides of different groups are used to control this pest of okra to minimize crop losses. Insecticides are highly effective, rapid in curative action and relatively economic. Considering the seriousness of the pest a wide range of chemicals with various spray formulations have been used in controlling jassid in okra (Nazrussalam *et al*., 2008; Gandhi *et al*., 2006; Swaroop *et al*., 2005). Conventional insecticides like endosulfan, dimethoate, monocrotovos at recommended doses have been used to bring down the jassid population, but none of them have proved effective to reduce the pest population significantly.

Recently many researcher have been reported that imidacloprid, which is found in different formulations in the market as Gauchu 70WS, Admire 200SL, etc, are very effective to combat this pest (Parveen *et al*., 2007; Solangi and Lohar, 2007; Lal and Sinha, 2005). Imidacloprid is the principal representative of a new pesticide class, the neonicotinoid insecticides. These insecticides are designed to act on nicotine receptors to control insect pests. The toxicology database supports the success of this strategy for imidacloprid, with signs of nicotinic stimulation (e.g. tremor) evident only at relatively high levels of exposure. It is not mutagenic or carcinogenic (Krieger, 2001). Furthermore, it is not a primary embryonic toxicant or a reproductive toxicant, nor it is teratogenic due to its high insecticidal potency and relatively low mammalian toxicity. It has very high margin of safety.

Considering above facts the present research work was undertaken to investigate the incidence of abundance of okra jassid and to determine the efficacy of different application methods of imidacloprid in controlling okra jassid at tolerable level with the following objectives:

- To evaluate the effect of different application method of imidacloprid on the abundance of okra jassid.
- To find out the effectiveness of different application method of imidacloprid for the management of jassid in okra.

CHAPTER II

REVIEW OF LIERATURE

Okra (*Abelmoschus esculentus* L.) an important vegetable crop in Bangladesh is infested by large numbers of insect pests that cause considerable yield loss. Among them okra jassid (*Amrasca biguttula biguttula* Ishida) is a serious pest occurring either sporadically or as outbreak every year, wherever the crop is grown affecting okra cultivation adversely. Literatures cited below under the following headings and sub-headings reveal some information about this study.

2.1 General review of okra jassid, *A. biguttula biguttula* (Ishida)

2.1.1 Nomenclature

The okra jassid, *A. biguttula biguttula* belongs to the order Homoptera and the family Cicadellidae.

Synonym

Amrasca biguttula (Mats.)

Amrasca biguttula biguttula (Ishida)

Chlorita biguttula (Ishida)

Common name: Okra leafhopper

2.1.2 Origin and distribution

Okra jassid is a versatile and widely distributed insect. It has been recorded in India, China, Pakistan, Iran, Syria, Greece, Spain, Argentina, Brazil and USA. It is distributed widely throughout Eastern, Western, Southern and Central Africa. This pest is also common in Australia (Ghauri, 1963).

2.1.3 Host range

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

2.1.4 Status and nature of damage

Okra jassid, *A. devastans* is one of the key insect pests of okra and is the major factor limiting okra yield in Bangladesh (El-Tom, 1987). This pest can cause more than 50 percent reduction of seed okra yield in some okra genotypes (Bhat *el al*., 1984). The nymphs and adults of this pest can attack okra leaves at all stages of development. Jassids, particularly the older nymphs, feeding on the small veins appear to affect the functioning of the vascular system so that the leaf of edge changes color from dark to pale green, yellow and then red and brown. Adults and nymphs suck plant sap from the under surfaces of leaves. The affected leaves shown hopper burn symptoms (Plate 1, B). The whole leaf of susceptible okra varieties can desiccate and shed. The edges of leaves curl downwards if attacked leaves have not fully expanded. Growth of young plants may be completely stopped. They also introduce a toxin that impairs photosynthesis of okra plants.

Due to attack of the jassid, the okra leaves became yellow and curled upward. The leaves finally turned brown at the tips and dried up. The heavily infested plants failed to bear fruits and the less damaged plants were found to produce fruits of different type. The deformed fruits when cooked were fibrous and became unfit for consumption. The infested plants remained stunted in the field. The jassid attacked plants are easily identified by the presence of globular, translucent, mucilaginous substances. This might be the plant secretion which had been referred to as “exudates” caused by the jassid injury (Plate 1, C). The exudates were present mostly on the under surface of the leaf, a few in the leaf petiole and stem. The jassid damaged the plants at all stages of their growth. The maximum numbers of exudates were found in the younger leaves than in the older ones (El-Tom, 1987).

2.1.5 Life history

Egg: Curved, greenish-yellow eggs (0.7-0.9 X 0.15-0.2 mm) are laid deeply embedded in the midrib or a large vein on either surface of the leaf or in a petiole or young stem but never in the leaf lamina. Depending on species, 29-60 eggs can be laid singly and they hatch in 4-11 days.

Nymph: Nymphs are pale green, wedge-shaped, 0.5-2.0 mm long, have a characteristic crab-1ike, sideways movement when disturbed. They are confined to the under surface of leaves during the daytime, but can be found anywhere on the leaves at night (Evans, 1965). The nymphal period can very from 7 to 21 days depending on food supplies and temperature. A generation likes 3-4 weeks in the summer *Amrasca devastans* is estimated to have 11 generations in a year in India (Plate 2. A).

Adult: Adults are small, elongate and wedge-shaped, about 2.5 mm long, body pale green with semi-transparent, shimmering wings, very active, having a sideways walk like the nymphs, but quick to hop and fly when disturbed. They have a life span of up to 2 months (Plate 2. B) (Evans, 1965).

Plate 1

A. Healthy okra plant
B. Jassid infested okra plant with leaf burn (hopper burn) symptom
C. Jassid (nymphs and adult) feeding on lower surface of leaves

A

B

Plate 2.

A. Nymph of okra jassid

B. Adult of okra jassid

Monitoring: Nymphs and adults can be found on the undersides of leaves. Nymphs tend to move sideways when disturbed, adults can fly readily and both nymphs and adults follow an aggregated distribution.

Sharma and Sharma (1997) observed the biology of *Amrasca biguttula biguttula* on okra variety; Pusa Sawani revealed that the insect had an incubation period of 6.27 days. The egg hatchability was 91.9%. The nymphs were observed to pass through five instars and the duration of each instars was 1.5, 1.1, 1.2, 1.5 and 2.0 days for instars I, II, III, IV and V respectively. The nymphal period averaged 7.3 days. Mean pre-mating, pre oviposition, oviposition and post-oviposition period 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 ranged from 21 to 30 days. The females dominated over males in numbers in the field. Rearing of nymphs on different cultivars showed poor survival, longer developmental period and smaller size on cv. IC 7l94 as compared to days cvs MR 12, MR 10-1 and Pusa Sawani.

2. 2 Incidence and seasonal distribution of okra jassid

Yadav *et al*. (2007) studied the population dynamics of jassid (*Amrasca biguttula biguttula*), on okra cv. Azad bhindi-1 in relation to weather factors, during kharif seasons in 2005 and 2006 at Kanpur, Uttar Pradesh, India. Jassid activity started from the first week of August on 3-week-old crop and continued until the third week of September on 12-week-old crop during 2005. In 2006, jassid infestation on shoots started from the fourth week of July on 7-leaf-stage until the third week of September. The maximum population of jassid was observed during 2005 in the second week of September on 8-week-old plants.

The seasonal abundance of cotton jassid, *Amrasca biguttula biguttula*, on okra was investigated by Inee and Dutta (2000) in Jorhat, Assam, India during 1998-99. Results revealed that meteorogical parameters played an important role in the population build up of cotton jassid. The jassid population was maximum in the last week of May in 1998 (37.53 nymphs per leaf) and middle of April in 1999 (30.00 nymphs per leaf). High temperature (30-36 degrees C), evening relative humidity (below 80%) and low rainfall period coupled with bright sunshine hours favoured the development of cotton jassid population.

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

Mahmood *et al*., (1990) studied the abundance of the Cicadellid, *Amrasca devastans* on okra in Pakistan during 1986-87. The pest appeared in June and remained active until the end of the crop season. Among various environmental factors the only significant factor in both years of the study was temperature. A positive correlation was found between maximum and minimum temperature with regarding to density of the pest. Neither relative humidity nor rainfall significantly increased or decreased the pest population.

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

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

Pawar *et a*l., (1 996) showed that the crop sown on 15th May and 1st June had a lower incidence of *A. devastans* with a good yield of marketable fruits (22.9 q/ha).

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

Ali and Karim (1991) conducted an experiment in 3 consecutive kharif and rabi seasons of 1968- 88 in Joydebpur, Bangladesh to investigate the influence of cotton plant age on the abundance of *Amrasca biguttula biguttula*. Cicadellid populations remained below the economic threshold level of one insect/leaf for up to 35 days of plant age in kharif cotton and 65 days of plant age in rabi cotton. Most of the cicadellids were found in 35 to 75 days old cotton plants in kharif and 65 to 130 days old cotton plants in the rabi season. Cotton grown in the kharif season was more vulnerable to insect attack than cotton grown in the rabi season.

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

2. 3 Imidacloprid insecticides

2. 3. 1 Imidacloprid

Imidacloprid is a systemic, chloro-nicotinyl insecticide with soil, seed and foliar uses for the control of sucking insects including rice hoppers, aphids, thrips, whiteflies, termites, turf insects, soil insects and some beetles. It is most commonly used on rice, cereal, maize, potatoes, vegetables, sugar beets, fruit, cotton, hops and turf, and is especially systemic when used as a seed or soil treatment. The chemical works by interfering with the transmission of stimuli in the insect nervous system. Specifically, it causes a blockage in a type of neuronal pathway (nicotinergic) that is more abundant in insects than in warm-blooded animals (making the chemical selectively more toxic to insects than warm-blooded animals). This blockage leads to the accumulation of acetylcholine, an important neurotransmitter, resulting in the insect's paralysis, and eventually death. It is effective on contact and via stomach action (Kidd and James, 1994).

Imidacloprid based insecticide formulations are available as dustable powder, granular, seed dressing (flowable slurry concentrate), soluble concentrate, suspension concentrate, and wettable powder (Meister, 1995). Typical application rates range from 0.05-0.125 pounds/acre. These application rates are considerably lower than older, traditionally used insecticides. It can be phytotoxic if it is not used according to manufacturer's specifications, and has been shown to be compatible with fungicides when used as a seed treatment to control insect pests (Pike *et al*., 1993).

2. 3. 2 Methods of application

Imidacloprid is a systemic, chloro-nicotinyl insecticide with soil, seed and foliar uses for the control of sucking insects including rice hoppers, aphids, thrips, whiteflies, termites, turf insects, soil insects and some beetles. It is most commonly used rice, cereal, maize, potatoes, vegetables, sugar beets, fruit, cotton, hops and turf, and is especially systemic when used as a seed or soil treatment. The chemical works by interfering with the transmission of stimuli in the insect nervous system. Specifically, it causes a blockage in a type of neuronal pathway (nicotinergic) that is more abundant in insects than in warm-blooded animals (making the chemical selectively more toxic to insects than warm-blooded animals). This blockage leads to the accumulation of acetylcholine, an important neurotransmitter, resulting in the insect's paralysis, and eventually death. It was also effective on contact and via stomach action (Kidd and James, 1994).

2. 3. 3 Regulatory statuses

Imidacloprid is a general use pesticide, and is classified by EPA as both a toxicity class II and class III agent, and must be labeled with the signal word "Warning" or "Caution" (Meister, 1995). There are tolerances for residues of imidacloprid and its metabolites on food/feed additives ranging from 0.02 ppm in eggs, to 3.0 ppm in hops (U.S. Environmental Protection Agency, 1995).

2. 3. 4 Trade or other names

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

2. 4 Effect of imidacloprid insecticides in the management of okra jassid

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

Praveen *et al*. (2007) conducted field trial at Dharwad, Karnataka, India, to evaluate the effect of seed treatment and foliar spraying of insecticides and neem products on the growth and yield of okra cv. Arka Anamika. Treatments consisted of seed treatment of imidacloprid (Gauch 600FS) at 12 ml/kg seed, thiamethoxam (Cruiser 70WS) at 10 g/kg seed, neem oil at 80 mg/kg seed, neem cake at 500 kg/ha (soil application) and carbofuran at 15 kg/ha (soil application) as well as foliar sprays of imidacloprid (Confider 200SL) at 0.25 ml/litre, thiamethoxam (Actara 25WG) at 0.40 g/litre, fenvalerate (Fenval) at 0.5 ml/litre and neem seed kernel extract at 5%. Recommended cultural practices were adopted. Data were recorded for plant height, number of leaves per plant, days to flower initiation, number of fruits per plant, percentage of fruit damage as well as fruit length, dry fruit weight, percentage of seed damage, 100-seed weight and seed yield. Seed treatment with imidacloprid at 12 ml/kg seed recorded the highest seed yield of 642 kg/ha. Foliar spraying with fenvalerate produced the highest seed yield of 799 kg/ha, followed by neem seed kernel extract (720 kg/ha).

Solangi and Lohar (2007) determined the efficacy of different insecticides against different insect pests and their predators on okra cv. Sabz Pari during the 2005 kharif season in Pakistan. The treatments included four insecticides, i.e. Confidor [imidacloprid], Sundaphos, Polo [diafenthiuron] and Mospilan and their efficacy was checked by a control plot (unsprayed). Pretreatment populations of jassid, thrips, whitefly, mites, spiders, ants and beetles was managed and post-treatment observations were recorded after 24, 48 and 72 h, and 7 and 14 days of insecticidal spray. In controlling jassid, all the insecticides were significantly effective but Confidor proved to be more effective compared to Sundaphos, Polo and Mospilan, where jassid mean population was 1.20 /plant compared to pretreatment population of 7.78 /plant, thrips 1.16 /plant compared to pretreatment population of 6.52 /plant, whitefly 1.18 /plant compared to pretreatment population of 8.31 /plant, mites controlled to the level of 2.42 /plant compared to 8.56 /plant (control). All the insecticides were almost equal in effect on the spiders and the mean spider population was 0.31, 0.30, 0.31, and 0.38 /plant in plots sprayed with Confidor, Sundaphos, Polo and Mospilan, respectively. Similar results were obtained with population of ants where the mean population was 0.33, 0.38, 0.35 and 0.35 /plant in plots sprayed with Confidor, Sundaphos, Polo and Mospilan, respectively. All the insecticides were harmful for the beetles and the mean population of beetles was 0.03, 0.06, 0.03 and 0.07 /plant in plots sprayed with Confidor, Sundaphos, Polo and Mospilan, respectively. However, Confidor and Polo were more harmful to beetles compared to Sundaphos and Mospilan. All the insecticides were effective against jassid, thrips, whitefly and mites, but Confidor proved to be most equally effective against all the insect pests under study compared to Sundaphos, Polo and Mospilan. Confidor also proved better than the other insecticides, because the population of predators, i.e. spiders, ants and beetles was less affected by Confidor application compared to Sundaphos, Polo and Mospilan.

Rana *et al*. (2006) conducted experiments during kharif 2003 and 2004, in Karnal, Haryana, India, showed that imidacloprid at 2 ml as well as thiamethoxam and carbosulfan each at 2 g/kg seed were quite effective in controlling jassid. Imidacloprid at 2 ml, thiamethoxam at 2 g and carbosulfan at 4 g/kg seed were effective in controlling the whitefly (*Bemisia tabaci*). Okra seed yield was higher in thiamethoxam, imidacloprid and carbosulfan treatments. Management of sucking pests of okra with the use of insecticides as seed treatment provided an opportunity to minimize the quantity of the insecticide.

Gandhi *et al*. (2006) showed that insecticidal seed treatment is an alternative method to spray and granular applications. It can protect the crop right from germination to reproductive stage. Recurrent use of chemical insecticides destabilizes the ecosystem and enhances the development of resistance in pest population. Use of biopesticides like neem oil (NO) is a promising one in this situation. Two field experiments were conducted to test the efficacy of NO as a seed dresser (20 ml/kg) and the effect was compared with systemic chemical insecticides imidacloprid (7 g/kg) and carbosulfan (7 g/kg) and *Pseudomonas fluorescens* (10 g/kg). Field studies revealed that the neem oil 60EC (C) [(NO 60EC (C)] had the minimum population of sucking pests, leafhopper (*Amrasca biguttula biguttula* Ishida) and aphids (*Aphis gossypii* Glover), i.e., below the ETL (2 number per leaf) up to 45 days after sowing and provided better yield compared to control. Although the systemic chemical insecticide imidacloprid performed better by recording 11280 and 11580 kg/ha of marketable fruit yield, NO 60EC (C) also increase twofold marketable fruit yield 11,000 and 10,620 kg/ha, respectively, in 2001 and 2002 experiments. Results of this study suggest that NO could be used as a potential seed dresser for managing sucking pests in okra.

Lal and Sinha (2005) carried out investigation to evaluate four (5, 9, 18, 36 g/kg) doses of imidacloprid seed treatments against the insect pests of okra. Studies revealed that seeds treated with imidacloprid afforded an effective protection of okra crop against the management of leafhoppers and their populations remained below the economic threshold level throughout the experiment. But, the treatments having imidacloprid seed treatment at 5 g/kg seed along with two foliar sprays of beta-cyfluthrin or altering of lambda-cyhalothrin and endosulfan were most effective treatments while seed treatment at 36 g/kg was second effective treatment ($p<0.01$) against shoot and fruit borer. However, yield of all the treatments, except highest dose (36 g/kg) of imidacloprid seed treatment gave excellent results.

Dey *et al*. (2005) conducted field experiments during the 1998 and 1999 summer season to evaluate the efficacy of imidacloprid formulations (70WS, water dispersible powder for slurry treatment; 20SL, soluble liquid) against the sucking pest complex (*Aphis gossypii, Thrips tabaci, Amrasca biguttula biguttula* and *Bemisia tabaci*) of okra (cv. Vijaya) and their natural enemies. Imidacloprid 70WS was used for seed treatment at the time of sowing and imidacloprid 20SL was applied as foliar spray at 20 and 40 days after sowing. Imidacloprid 70WS at 5-10 g/kg seed provided effective control of early sucking pest complex of okra.

Imidacloprid 20SL at 100-125 ml/ha was also equally effective against the sucking pest complex of okra. Comparative data on the mean number of *Aphis gossypii, Thrips tabaci*, *Amrasca biguttula biguttula* and *Bemisia tabaci* per leaf; mean germination percentage; mean plant height; mean number of predatory coccinellid grubs per plant; mean percentage of *Aphis gossypii* parasitized by *Aphidius spp*. and yield were also tabulated.

Two new systemic insecticides belonging to nitroguanidine group, imidacloprid and acetamiprid, were evaluated and compared with currently recommended methyl demeton for the control of the jassid, *Amrasca biguttula biguttula*, on okra for two cropping seasons, 2002 and 2003, at Durgapura, Jaipur, Rajasthan, India. The pooled data for two years revealed that imidacloprid formulation, Confidor 350SC at 75 ml/ha, was the most effective treatment in reducing the jassid incidence to a seasonal mean of 10.65 per 5 plants, and recording the maximum fruit yield of 87.4 q/ha. In comparison, treatments with methyl demeton (1000 ml/ha) and acetamiprid formulation (Pride 20 SP; 50 ml/ha) recorded significantly lower fruit yield of 40.25 and 35.69 q/ha, respectively, but were better than the control (29.02 q/ha) (Swaroop *et al*., 2005).

The efficacy of different groups of chemicals alone and in combinations was evaluated by Sunitha *et al.* (2005) against okra sucking pests (*Aphis gossypii* and *Amrasca biguttula biguttula*) in a field experiment in Bapatla, Andhra Pradesh, India, during rabi 2002-03. There were 14 insecticidal treatments involving dichlorvos at 0.1%, imidacloprid at 0.006%, Nimbecidine at 1%, Bacillus thuringiensis (Delfin) at 0.2%, novaluron at 0.01% and spinosad at 0.015% alone;

and imidacloprid at 0.003%, dicglorvos at 0.005% and spinosad at 0.0075% in combination with novaluron at 0.005% and Delfin at 0.1%. Two sprays were given at 15 days interval. The population counts of aphids and leafhoppers were recorded one day before the spraying as pre-treatment count and at 1, 5, 10 and 15 days after spraying (DAS) for the post-treatment counts. Imidacloprid at 0.006% was the most effective treatment in reducing the aphid population at 5 and 10 DAS. Novaluron at 0.005% + imidacloprid at 0.003% and Delfin at 0.1% + imidacloprid at 0.003% were also effective, recording 95.26 and 83.17% reductions, respectively. Among the other treatments, dichlorvos at 0.1% was the next treatment with 77.57% reduction, but it was on par with novaluron at 0.005% + dichlorvos at 0.05%(71.91%), and this was followed by Delfin at 0.1%+ dichlorvos at 0.05%(60.01%). The combination treatments novaluron+Delfin, novaluron+imidacloprid and novaluron+dichlorvos did not show synergistic effect over individual treatments of novaluron, imidacloprid and dichlorvos, respectively. It was concluded that two sprays of imidacloprid at 0.006% could be sprayed at 15 days interval to minimize the sucking pest population on okra.

Anon. (2005) conducted an experiment to control jassid population on lady's finger and found that admire, koranda, corofen, neembicidine had significant effect in controlling jassid.

Seed treatment of okra with imidacloprid at 3 g/kg and subsequent application of monocrotophos at 500 g a.i./ha at 55 and 70 days after sowing offered maximum protection against the leaf hopper *Amrasca biguttula biguttula* (0.53 nymphs/plant) throughout the crop growth stage in Uttar Pradesh, India. Foliar application of imidacloprid (200SL) at 18.5 g a.i./ha and monocrotophos (36.6EC) at 500 g a.i./ha also protected the crop from the leaf hopper (0.86 and 1.96 nymphs/plant, respectively). The pooled leaf net carbon assimilation rate (NAR) over four crop growth stages varied from 16.66 micro mol CO< sub>2</ sub> m-2 s-1 in untreated plots to 34.40 micro mol CO< sub>2</ sub> m-2 s-1 in monocrotophos and cypermethrin treated plots. The treatments manifesting less leaf hopper (0.53-2.41 nymphs/plant) population recorded higher rate of leaf NAR (27.78-33.28 micro mol CO< sub>2</ sub> m-2 s-1). A drastic reduction of pooled leaf NAR to 16.66 micro mol CO< sub>2</ sub> m-2 s-1 was recorded when leaf hopper population was 6.68 nymphs/plant. Beta-cyfluthrin provided maximum protection (4.79% fruit damage) against the fruit borer *Earias vittella*, while imidacloprid either as seed treatment or as foliar spray was not effective. Variable leaf hopper populations in okra leaves significantly influenced the leaf NAR. Borer damage significantly influenced the healthy fruit yield. Beta-cyfluthrin treatment significantly reduced the borer damage and recorded maximum economic yield (76.58 q/ha). The imidacloprid treatment was effective for control of leaf hopper population and showed higher leaf NAR, but the yield was less because of high borer infestation (Satpathy *et al*., 2004).

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

Sunitha *et al.* (2004) conducted field experiments during the 2002-03 rabi season in Bapatla, Andhra Pradesh, India, to study the relative toxicity of different groups of chemicals, viz. dichlorvos, nimbecidine, *Bacillus thuringiensis* (B.t.; Delfin), novaluron (IGR), spinosad and imidacloprid (neonicotinoid) and combination of dichlorvos, spinosad and imidacloprid with novaluron and B.t. against predatory coccinellid beetles *Cheilomenes sexmaculata* and *Micraspis univittata*. The results indicated that dichlorvos and imidacloprid alone were found to be toxic compared to their combination with eco-friendly chemicals. The treatments B.t. and nimbecidine were found to be relatively safe to coccinellids.

Misra and Senapati (2003) conducted experiment during the rainy season of 1999 and summer of 2000 at Bhubaneshwar, Orissa, India to evaluate new generation insecticides such as thiamethoxam 25WG at 12.5, 25.0, 37.5 and 50.0 g ai/ha, imidacloprid 200SL at 25.0 g ai/ha, profenofos 50EC at 250.0 g ai/ha along with potential conventional insecticides dimethoate 30EC at 300.0 g ai/ha, monocrotophos 36SC at 400.0 g ai/ha and a botanical insecticide azadirachtin at 3.0 g ai/ha against the okra jassid (*A. biguttula biguttula*). Thiamethoxam at the rates of 25 to 50 g ai/ha and imidacloprid at 25.0 g ai/ha gave significant excellent control of the jassid (83.3-100.00%) during both the test seasons and increased the marketable fruit yield (32.40-35.44%) of okra (*Hibiscus esculentus* [*Abelmoschus esculentus*]) compared to conventional insecticides, *azadirachtin* and untreated control.

Ravikumar *et al*. (2003) studied the toxicity of two neonicotinoids (thiamethoxam and imidacloprid) and few commonly used insecticides (oxydemeton-methyl, dimethoate, fenvalerate, monocrotophos and malathion) against the third instar nymphs of *A. biguttula biguttula* (Hisar strain) on okra under screenhouse condition. The respective LC< sub>50</ sub> values (%) were 0.000314, 0.000813, 0.005927, 0.006273, 0.008110, 0.025100 and 0.02690, respectively. Thiamethoxam was 85.95 times more toxic than Malathion, the least toxic one.

The residue level and dissipation rate of imidacloprid in okra (cv. Arka Anamika) was studied in a field experiment conducted in Tamil Nadu, India during March 2001. The treatments comprised of 10 g imidacloprid 70WS/kg seed; 100 and 200 ml imidacloprid 200SL/ha foliar spray; and a combination of seed and foliar spray treatments. The mean recovery was 91.20% from fortified samples at 1 and 2 micro g/g. Imidacloprid residue was below the detectable limit in fruit samples collected during the first 3 harvests (42-48 days) from all the treatments. Dissipation studies on the combined seed and foliar treatments showed that 5 g imidacloprid 70WS /kg + 100 ml imidacloprid 200SL /ha had an initial residue deposit of 2.56 mg/kg on okra leaves, while 10 g imidacloprid 70WS /kg + 200 ml imidacloprid 200SL /ha had an initial residue deposit of 3.77 mg/kg. The dissipation of the initial deposits from 17.13 to 25.00% after one day of treatment reached below the detectable limit on the seventh day at 100 and 200 ml/ha. The half-life values for 100 and 200 ml/ha were 2.61 and 2.95%, respectively, and the suggested waiting periods after spraying were 4 and 6 days, respectively (Ilango and Devaraj, 2003).

Kaur (2002) observed that seed treatment with 5 g/kg imidacloprid/ha +foliar spray with 500 g a.i., monocrotophos/ha + 30 g a.i. cypermethrin/ha resulted in lowest mean population of cotton jassid in 1999 (1 .78) and 2000 (1 .45).

Sandeep and Kaur (2002) field experiments were conducted in Ludhiana, Punjab, India during 1998-2000 to determine the efficacy of various seed treatments and foliar sprays in controlling cotton jassid (*A. biguttula biguttula*) and spotted bollworm (*Earias sp.*) infesting okra cv. Arka Anamika. The treatments comprised seed treatment with 5 g/kg imidacloprid/ha + foliar spray with 500 g a.i. monocrotophos/ha + 30 g a.i cypermethrin/ha (T_1), seed treatment with 5 g/kg chlorpyrifos/ha + folair spray with 500 g a.i. monocrotophos/ha + 30 g a.i. cypermethrin/ha (T_2), 15g a.i. lambda-cyhalothrin/ha (T_3), 800 g a.i. profenofos/ha (T_4), 625 g a.i. carbaryl/ha (T_5), 800 g a.i. carbaryl/ha (T_6) and 500 g a.i. monocrotophos/ha (T_7). T4 resulted in the lowest mean population of cotton jassid in 1998 (5.22), whereas T1 resulted in the lowest mean population of cotton jassid in 1999 (1.78) and 2000 (1.45). Leaf injury due to jassid infestation was lowest with T_1. T_3 resulted in the lowest mean fruit damage (31.54%) by the spotted bollworm. Mean fruit yield was highest (21.39 q/ha) in T_1.

The efficacy of new insecticides viz., acetamiprid, thiamethoxam, imidacloprid, NACLFMOA and abamectin against the *A. biguttula biguttula* infesting okra cv. Utkal Gaurav, was evaluated in a field experiment conducted in Bhubaneswar, Orissa, India during the summer of 2001. Nitroguanidines viz., acetamiprid (20 g.a.i./ha), and thiomethoxam and imidacloprid (25 g.a.i./ha) were most effective in controlling okra jassids, followed by the fermentation metabolites, NACLFMOA, and abamectin both at 20 g.a.i./ha. Out of 10 pesticides evaluated, nitroguanidines gave 77.2-86.0% reduction of jassid population 21 days after application followed by the fermentation metabolites which gave 66.8-70.9% reduction in pest population. The new molecules evaluated were safer to lady bird beetle (Subhadra *et al*., 2002).

Misra (2002) evaluated some newer insecticides like thiomethoxam (Actara 25WG), imidacloprid (Confider 200SL) and profenofos + cypermethrin (Rocket 44EC) along with conventional insecticides like dimethoate (Rogor 30EC), cypermethrin (Superkiller 10EC), profenofos (Curacron 50EC) and a plant product, *azadirachtin* (Neemarin 1500 ppm) against okra cv. Utkal Gourav aphids (*Aphis gossypii*) and jassids (*Amrasca biguttula biguttula*) in Orissa, India, during kharif season of 2000. The results revealed that imidacloprid and thiomethoxam, both belonging to nitroguanidine group used at 25 g a.i./ha proved significantly superior in controlling aphids and jassids on okra. Dimethoate at 300 g a.i./ha and cypermethrin at 100 g a.i./ha followed the above two treatments. The plant product *azadirachtin* at 3 g a.i./ha was effective against aphids but not against jassids.

Bhargava and Ashok (2001) evaluated two formulations of imidacloprid, 600FS and 70WP, as seed dressers on okra at 5 and 9 ml/kg seeds and 5, 7.5 and 10 g/kg seeds, respectively, for the control of sucking pests during kharif season. Both formulations had no adverse effect on the seed germination of okra. Imidacloprid

600FS at 9 ml/kg seeds and 70WP at 10 g/kg seeds were found to be promising against jassid (*Amrasca biguttula biguttula*) and whitefly (*Bemisia tabaci*). Higher yields were recorded for these treatments. Imidacloprid 70WP at 10 g/kg seeds was at par with the lower rates with respect to almost all parameters. No treatment caused any phytotoxic symptoms on okra. Plant growth characters, viz., plant height, greenness of leaves, leaf area, number of fruits per plant, and yield were superior in plots treated with both formulations of imidacloprid compared with plots with the recommended monocrotophos and untreated control. Considering the overall effectiveness of imidacloprid against sucking pests and yield, 9 ml of imidacloprid 600FS and 5 g of imidacloprid 70WP per kg seeds appeared to be the optimum rate.

Insecticides are proving ineffective against the adults of *A. biguttula biguttula* on okra cv. Varsha Uphar at Hisar, Haryana, India. Toxicity of various insecticides viz., malathion, oxydemeton-methyl, phosphamidon, dimethoate, thiamethoxam, endosulfan, and monocrotophos was studied against this leafhopper in Hisar, Haryana, India [date not given], and the LC< sub>50</ sub> values (%) were 1.097, 0.126, 0.112, 0.178, 0.000447, 0.063, and 0.063, respectively. Thiamethoxam was the most toxic i.e. 2454 times more toxic than malathion which was least toxic. Imidacloprid gave more than 80 per cent mortality of this pest at 4 times lower the normal concentration (0.000225%) while fenvalerate could not bring about even 20 per cent mortality at 30 times the normal concentration (0.15%) indicating development of resistance in leafhopper to the commonly recommended insecticides (Kalra *et al*., 2001).

Uptake and dissipation of imidacloprid in okra was studied by treating the seeds with Gaucho at 9 g a.i./kg seed and spraying okra crop at the fruiting stage with Confidor 200SL at 0.3 and 0.6 ml/litre. Imidacloprid was taken up by the plant from its seed treatment and the residues persisted in plant for more than 30 days after germination. However, residues could not be detected in fruits harvested at 50, 55 and 60 days after germination. Imidacloprid residues dissipated exponentially with time following foliar application with a half-life of 2-4 days in two consecutive seasons. The residues, however, became non-detectable 10 days after treatment at lower concentration and 15 days after treatment at higher concentration (Indumathi *et al*., 2001).

Efficacy of imidacloprid and thiamethoxam was evaluated by Kumar *et al.* (2001) on okra leafhopper, *Amrasca biguttula biguttula*. Field experiments were conducted in Bangalore, Karnataka, India on okra cv. Arka Anamika during the kharif and summer seasons of 1999 and 2000, respectively. Thiamethoxam (Actara 25WG) was on par with imidacloprid (Gaucho 600FS) seed treatment at 12 ml/kg of seed in reducing leafhopper infestation. Lower concentrations of imidacloprid seed treatment were less effective. All the doses of imidacloprid and thiamethoxam had no phytotoxic effect on okra. The utility of imidacloprid for the control of okra leafhopper is discussed.

CHAPTER III

MATERIALS AND METHODS

The present study was conducted to evaluate the effect of different application methods of imidacloprid on abundance and management of jassid (*Amrasca biguttula biguttula)* in the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka during March to June, 2009. The materials and methods adopted in the study are discussed under the following sub-heading:

3.1. Experimental site

The experimental field was located at 90º335´E longitude and 23º774´N latitude at an altitude of 9 meter above the sea level. The field experiment was set up on the medium high land of the experimental farm.

3. 2 Soil

The soil of the experiment site was a medium high land, clay loam in texture and having P^H 5.47-5.63. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below-

AEZ No.: 28

Soil Series: Tejgaon

General Soil: Non-calcareous dark grey

3. 3 Climate

The climate of the experimental site is sub tropical characterized by heavy rainfall during March to June and sporadic during the rest of the year. The detail record of monthly total rainfalls, temperature, and humidity during the period of experiment were noted from the Bangladesh Meteorological Department (climate division), Agargaon, Dhaka-1212 and has been presented in Appendix 1.

3. 4 Land preparation

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

3. 5 Manures, fertilizer and their methods of application

Manures and fertilizers applied as per recommendation of Haque (1993) for okra cultivation. The doses of manures and fertilizer and application methods are given below:

Table 1. Doses of manures and fertilizer and their methods of application used for this experiment (Haque, 1993)

Manure/Fertilizer	Dose (kg ha^{-1})	Basal dose (kg ha^{-1})	Top dressing (kg ha^{-1})	
			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. 6 Design of the experiment and layout

The study was conducted including five treatments along with one untreated control. The experiment was laid out in a Randomized Complete Block Design (RCBD). The entire experimental field was divided into four blocks. The each experimental block was divided into six plots. Two adjacent unit plots and blocks were separated by 1m apart. Each experimental plot comprised the area about 3 x 4.2 m^2. So, the total area covered by the experiment was 326.4 (20.4 x 16) m^2. Each treatment was allocated randomly within the block and replicated four times.

3. 7 Collection and sowing of seeds

Seeds of BARI Derosh 1 variety was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and sown in the experimental plots at the rate of 72 seeds/plot (three seeds per pit and 24 pits per plot). Seeds were sown on 23 March, 2009.

3. 8 Plant spacing

The plant spacing was maintained at 60 x 50 cm (row to row and plant to plant distance respectively (Anon, 2006).

3. 9 Cultural operations

After sowing seeds light irrigation was given to each plot for proper germination of seed. Supplementary irrigation was applied at an interval of 2-3 days. Weeding was done five times to break the soil crust and to keep the plot free from weeds. Stagnant water was drained out at the time of heavy rain. Urea was top dressed in two splits as mentioned earlier.

3. 10 Treatments for control measures

The comparative effectiveness of the following six treatments for jassid was evaluated on the basis of reduction of jassid population. The individual control measure under each treatment as well as standard practice and control methods are described and discussed below.

3. 11 Details of the treatments for jassid

T_1 = Seed treatment by Gauchu 70WS @ 5 g/kg seed

T_2 = Seed treatment by Gauchu 70WS @ 5 g/kg seed + foliar spray with Admire 200SL @ 0.5 ml/l of water

T_3 = Band application of Gauchu 70WS @ 2 g/l of water

T_4 = Seed treatment by Gauchu 70WS @ 5 g/kg seed + band application of Gauchu 70WS @ 2 g/l of water

T_5 = Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line @ 2g/l of water + foliar spray with Admire 200SL @ 0.5 ml/l of water

T_6 = Control

For seed treatments 5 g Gauchu 70WS @ was dissolved in pure water. Then 500 g okra seeds were soaked and kept for two hours. Band application of Gauchu 70 WS was done by making circular band around the plants and 2 g Gauchu 70WS was applied in each band.

3. 12 Insecticides application

Spraying was done at 11.00 am to avoid drift of insecticides with moisture of leaves. First application was done 15 days after germination of seeds. Treatments were applied at 7 days interval. Spraying was done by knapsack sprayer having a pressure of 4.5 kg/cm^2. To get complete coverage of plant, spraying was done uniformly on the entire plant with special care. All the time the mixture of insecticides in the sprayer was shaken well. Before spraying, volume was calibrated to find out the required quantity of spray materials for the same replicated plots.

3. 13 Data collection

Data were collected on jassid population, plant height, no. of fruits, fruit weight and yield of okra fruit. The population of jassid was counted at 7 days interval starting from 14 days after germination when first incidence of jassid was noticed. Twelve plants were randomly selected from each plot and tagged properly. Both nymphs and adults of jassid were counted from the lower surface of the top five leaves of the selected plants. The counting was done visually at early in the morning. Mean population per plant was calculated from these recorded data. The height of selected twelve plants was measured at 15, 30 and 45 days after germination. The mean plant height was calculated from these data. Fruits were harvested at every alternate date throughout fruiting season. The number and weight of fruits per plot were recorded after each harvest. A total of 20 harvests were done throughout the fruiting period (April-June). From these data the average number of fruits/plot was calculated for each treatment.

3. 14 Percent reduction of population

The effect of treatments on jassid was determined by calculating the number of jassid per plant. The percent reduction of jassid per plant was calculated using the following formula:

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

3.15 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:

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

3. 16 Benefit cost ratio analysis

For benefit cost analysis, records of the costs incurred for labour, insecticides, application of insecticides in each treatment and that of control without insecticide were maintained. The untreated control (T_6) did not require any pest management cost. The price of the marketable healthy fruit of each treatment and that of control was calculated at market rate. The result of Benefit-Cost analysis was expressed in terms of Benefit-Cost Ratio (BCR)

3. 17 Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTATC program. The treatment means were separated by Duncan's Multiple Range Test (DMRT) (Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present research work was conducted to investigate the efficacy of different application methods of imidacloprid on okra jassid (*Amrasca biguttula biguttula* Ishida) in okra crop. The efficacy of imidacloprid insecticides against the jassid in the fields was evaluated on the basis of the number of nymphs and adults per plot, plant height, number of total fruit and total yield varied significantly with different treatments.

4.1 Incidence of okra jassid in control plot

The population trend of jassid at untreated (control) plot at different weeks after germination is shown in Figure 1. The graph expressed that the jassid population was higher at 3rd week after germination then declined at 4th, 5th and 6th week. It was again increased from the 7th week after germination. The similar population trend was observed in relation to cropping season of the year. It was observed that jassid population was higher at the mid April then declined and it was again increased from the 3rd week of May (Figure 2). The peak population was obtained at the 4th week of May and remained at the same level in June. It is clear that the population of the jassid was remained low up to middle of the May.

These results support the findings of Mahmood *et al.* (1988) who reported that the jassid population remained below the economic threshold level for about five weeks after germination of the okra crop. The population crossed over the threshold level in June and remained at the same level until late August. Ali and

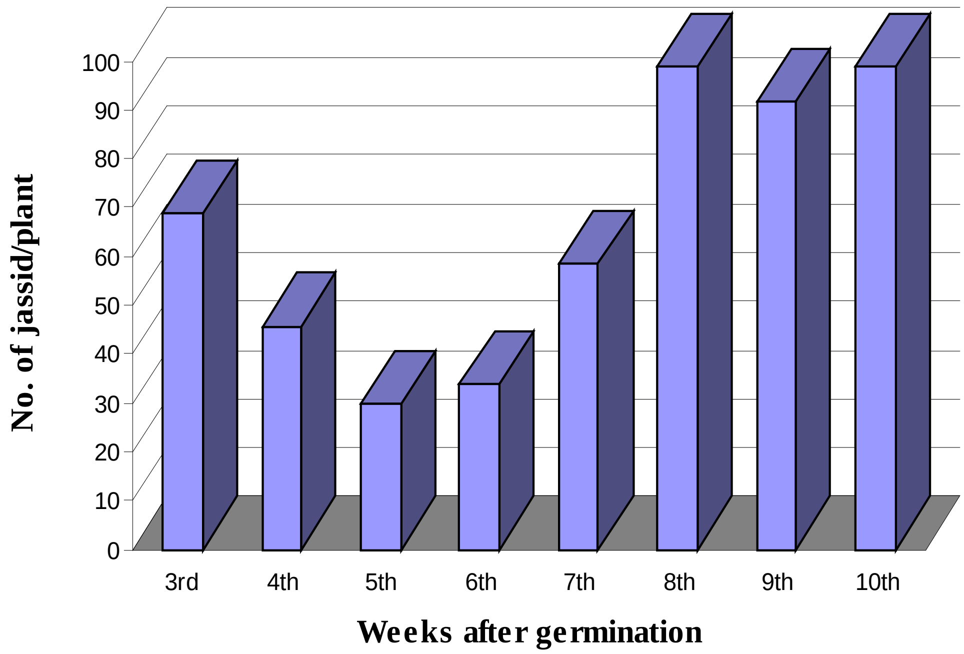

Figure 1. Population trend of jassid at untreated plot at different weeks after germination.

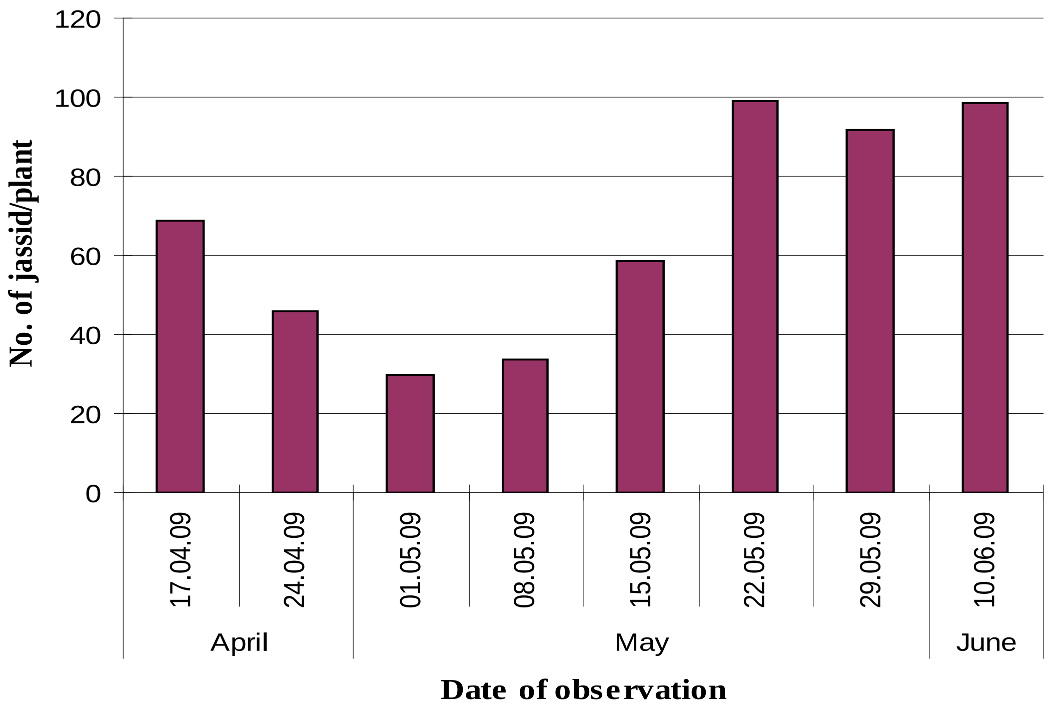

Figure 2. Population trend of jassid at untreated plot during 17 April to 10 June 2009.

Karim (1991) found the similar trend of jassid population on cotton plants in Kharif season.

4.2 Efficacy of imidacloprid in controlling okra jassid

The effect of different application methods of imidacloprid insecticides on application of jassid in okra is shown in Table 2. A significant effect was observed on the jassid population at different times after treatments application.

At first observation, the lowest number of jassid population (33.75) was observed in T_1 followed by 40.75 and 39.00 in T_2 and $T_{5,}$ respectively having no significantly difference among them. The highest number of jassid (68.75/plant) was observed in control plot which significantly higher than all other treated plot. Similarly, the highest number of jassid population (45.75/plant) was observed in control plot at second observation. On the other hand, no significant relation was observed among the population of jassid in other treatments.

There was significant variation of jassid population among the different application methods of imidacloprid insecticides at third observation. The lowest number of jassid population (9.5/plant) was observed in T_4 (seed treatment by Gauchu 70WS + band application of Gauchu 70WS). The second lowest number of jassid was found in T_5 which was statistically similar with T_3 and T_2 treated plot. Here the highest number of jassid population (30.0/plant) was observed in control plot.

The number of jassid population was significantly influenced by the imidacloprid insecticides with different application methods at fourth observation after treatment application. It was observed that the lowest number of jassid (4.75/plant) was observed in T_4 plot (seed treatment by Gauchu 70WS + band application of Gauchu 70WS), which was significantly similar with the T_3 plot. The moderate number of jassid population was observed in T_2 which was not statistically similar with T_5 treatment. The highest number of jassid (33.75/plant) was observed in control. At fifth observation, the lowest number of jassid (6.0/plant) was observed in T_2 plot (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL), which was more or less similar with T_4 (seed treatment by Gauchu 70WS + band application of Gauchu 70WS) plot, then the lowest number of jassid population was observed in T_5 and T_1 treated plot which was significantly similar with each other. The highest number of jassid population (58.5/plant) was found in control plot.

At sixth observation, the lowest number of jassid (7.00/plant) was observed in T_2 plot (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL). The second lowest number of jassid population (10.25/plant) was observed in T_5 plot (pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line + foliar spray with Admire 200SL), which was significantly similar with each other. T_5 was also significantly similar with T_4 and T_3. The highest number of jassid (99.00/plant) was observed also in control plot. The number of jassid population was significantly influenced by the imidacloprid insecticides with different application methods at seventh observation after treatment application. Here the lowest number of jassid (7.50/plant) was observed in T_2 plot (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL). Then the second lowest number of jassid population was observed in T_5, which was statistically similar with T_3 and T_4 treated plot. The highest number of jassid (91.75/plant) was found in control plot.

There was significant variation of jassid population also among the different application methods of imidacloprid insecticides at eighth observation. It was observed that, the lowest number of jassid (8.00/plant) was found in T_2 plot (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL). The second lowest number of jassid population was found in T_4 followed by T_5 plot which was statistically not different with each other. The highest number of jassid (91.75/plant) was observed in control plot.

Considering the average population of jassid during cropping season, the lowest population was found in T_2, which was statistically similar with T_5, but different from other treatments. The intermediate level of jassid was found in T_4, T_3 and T_1 having no significant different between T_3 and T_4. However, significant difference was observed between T_1 and T_3. The higher number of jassid (65.78/plant) was found in T_6 (untreated control) whish was significantly higher than all treated plots.

Figure 3 revealed that all application methods significantly reduced the jassid population over control although none of the treatments failed to reach the standard level of population reduction (80%). However T_2 showed the last performance in reducing the jassid population which reduced 77.71% jassid population over control. T_5 also gave the similar results in reduction of jassid population. T_4 and T_3 showed the moderate performance in reduction of jassid population and T_1 gave the lowest efficacy regarding this parameter.

In the present study it was found that seed treatments by Gauchu 70WS in combination to foliar spray with Admire 200SL gave the best result against jassid population. The result is similar to the findings of Lal and Sinha (2005) who revealed that seeds treated with imidacloprid afforded an effective protection of okra crop against the management of leafhoppers and their populations remained below the economic threshold level throughout the experiment. Satpathy *et al*. (2004) found that foliar application of imidacloprid (200SL) and monocrotophos (36.6EC) protected the crop from the leaf hopper. The result is also similar to the findings of Rana *et al*. (2006) who stated that management of sucking pests of okra with the use of insecticides as seed treatment (imidacloprid) provided an opportunity to minimize the quantity of the insecticide.

Table 2. Average population of jassid per plant during the cropping period under different treatments

Treatments	Average number of jassid plant^{-1}								Grand Mean
	*1st	*2nd	*3rd	*4th	*5th	*6th	*7th	*8th	
T_1	33.75 c	23.75 b	15.25 b	14.00 b	13.25 c	20.75 b	30.75b	29.25b	22.60 b
T_2	40.75bc	28.5 b	13.5 bc	8.50 c	6.00 b	7.00 d	7.50 d	8.00 d	14.66 e
T_3	47.75 b	23.25 b	13.25bc	7.25cd	15.75bd	16.25bc	19.00c	22.5bc	20.60 bc
T_4	44.00 b	21.00 b	9.50 c	4.75 d	7.75 cd	14.75bc	20.25c	15.00c	18.72 cd
T_5	39.00bc	18.50 b	11.50 b	9.50bc	11.00bc	10.25cd	16.25c	15.75c	16.47 de
T_6	68.75 a	45.75 a	30.00 a	33.75a	58.50 a	99.00 a	91.75a	98.75a	65.78 a
LSD $_{0.05}$	0.167	0.1507	0.1718	0.1965	0.2077	0.2131	0.1581	0.2383	3.552
CV (%)	4.66	7.22	9.79	12.98	12.27	11.36	11.36	11.91	8.90

In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance.
* Indicate time of observation of jassid population.
T_1 = Seed treatment by Gauchu 70WS
T_2 = Seed treatment by Gauchu 70WS + foliar spray with Admire 200SL
T_3 = Band application of Gauchu 70WS
T_4 = Seed treatment by Gauchu 70WS + band application of Gauchu 70WS
T_5 = Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line + foliar spray with Admire 200SL
T_6 = Control

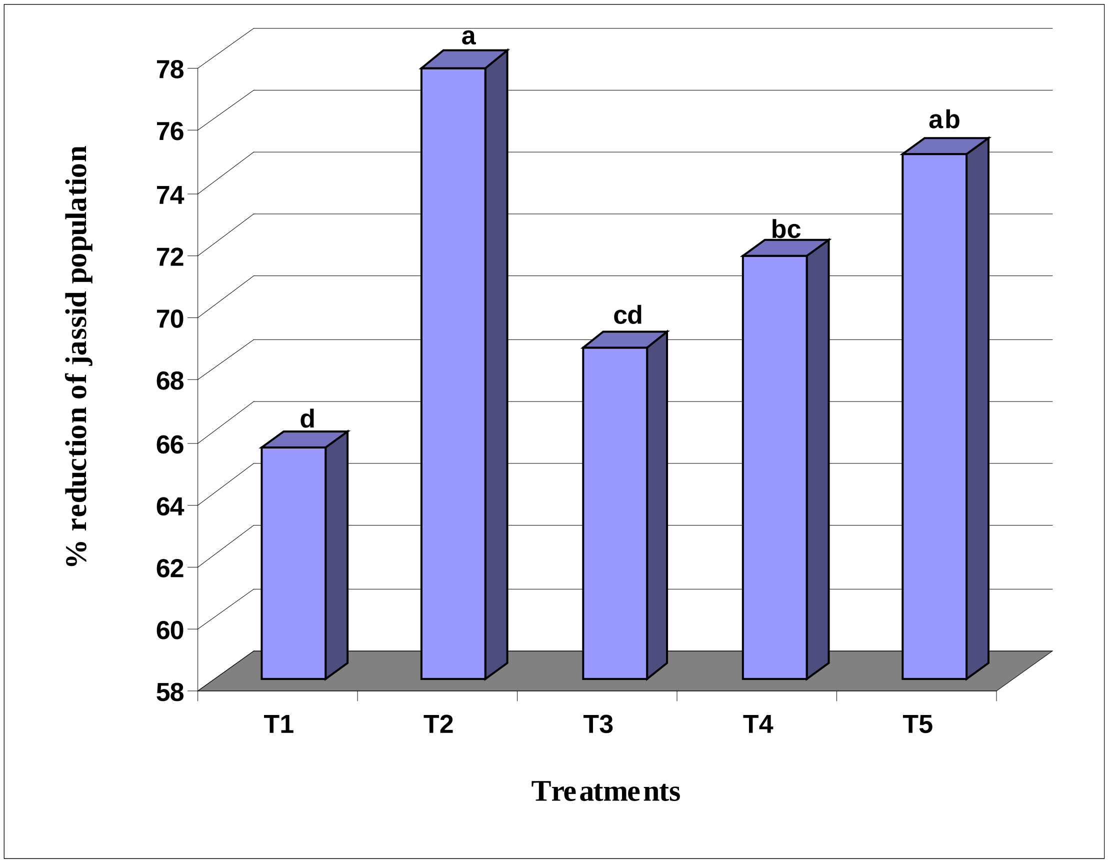

Figure 3. Percent (%) reduction of jassid population over control

T_1 = Seed treatment by Gauchu 70WS
T_2 = Seed treatment by Gauchu 70WS + foliar spray with Admire 200SL
T_3 = Band application of Gauchu 70WS
T_4 = Seed treatment by Gauchu 70WS + band application of Gauchu 70WS
T_5 = Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line + foliar spray with Admire 200SL

4. 3 Incidence of okra jassid in the best performed treatment plot

The number of jassids per plant at different weeks after germination was counted from the most effective treated plots (T_2 = seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) is presented in Figure 4. The lowest number of jassid per plots was observed during 7^{th} week followed by 8^{th}, 9^{th} and 10^{th} weeks respectively after germination. The highest number of jassid per plots was observed during 3^{rd} week followed by 4^{th} and 5^{th} weeks after germination. From the above results it reveals that the infestation by okra jassid in best performed treatment plot was highest at vegetative to flowering stage and lowest during flowering to fruiting stage and remains until the cropping season (Figure V).

The population of jassid was initially high and gradually decreased to below economic threshold level in the best treated plot. It was remained constant upto last harvest.

4. 4 Plant height as influenced by jassid control

Plant height was not adequate in untreated plot as found in the treated plots due to the infestation of okra jassid. In the control plot the maximum height was 105.2 cm but it was 244.8 cm in the T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) plot. Significant variation was found in plant height at different ages of plant at different treatments (Table 3). Plant height was ranged from 13.49 to 20.35 cm, 16.15 to 39.00 cm, 25.69 to 72.18 cm, 32.05 to 128.3 cm, 69.80 to 181.8 cm, 89.03 to 220.53 cm and 105.2 to 244.83 cm at 15, 30, 45, 60, 75, 90 and 105 days of plant age, respectively.

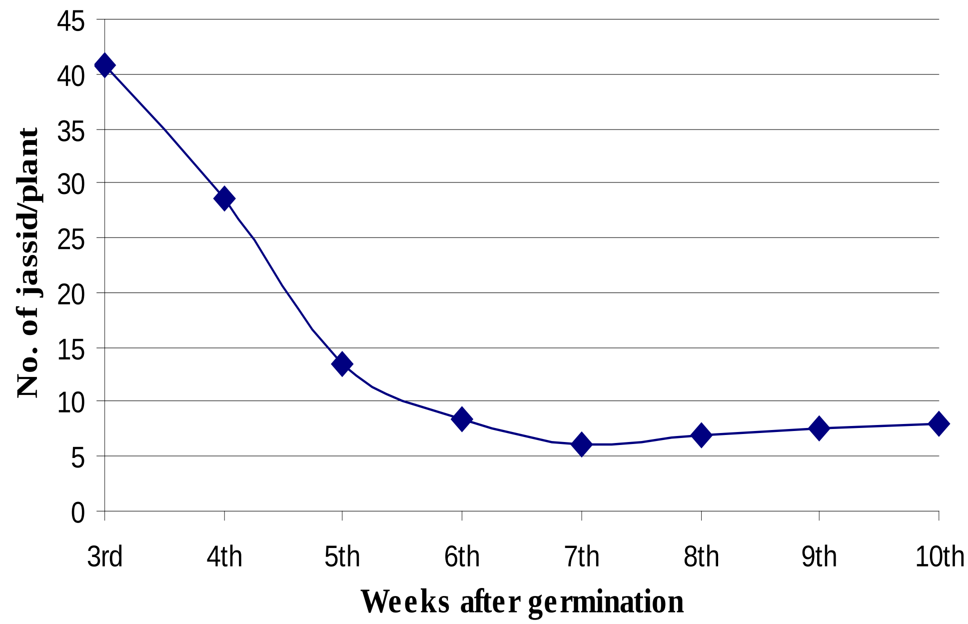

Figure 4. Population trend of jassid at the best treated plot at different weeks after germination.

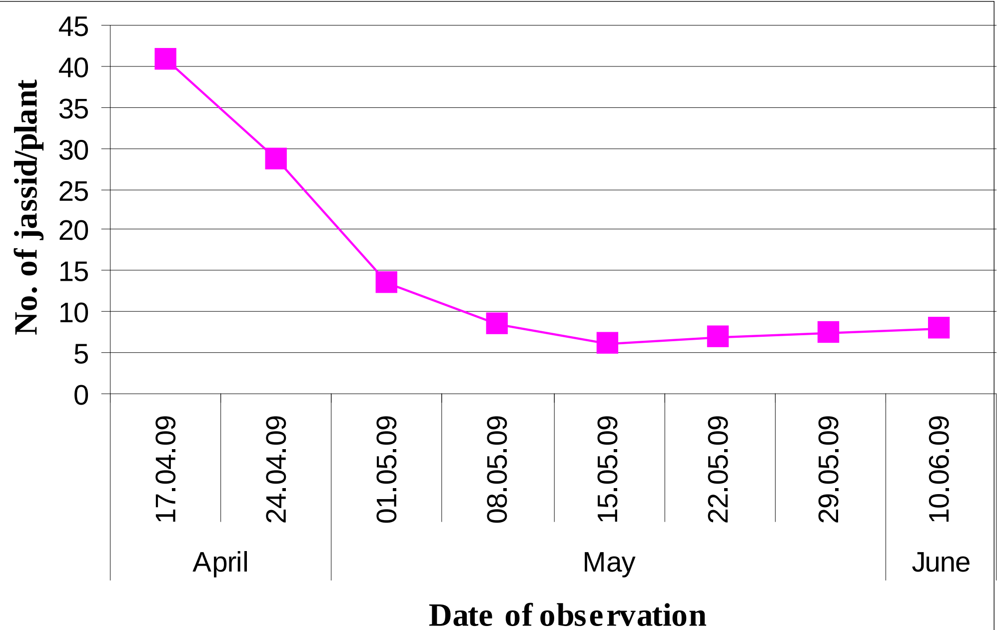

Figure 5. Population trend of jassid at the best treated plot at different dates of obsrevation.

After 15 days of plant age, the highest height (20.35 cm) was observed in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) plot. The second highest height (17.70 cm) was found in T_4 followed by T_1 (17.02 cm) plot. Then the height of T_5 and T_3 was significantly similar with each other. The lowest height (13.49 cm) was observed in the control plot. There was significant variation in plant height among the different treatments at the spray of 30 days after germination. The highest height (39.00 cm) was observed in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) plot. The 2nd and 3rd highest (36.53 cm and 35.07 cm) height was found in T_4 and T_5 plot. The minimum height was observed in control plot.

At 45 days of plant age, the highest height (72.18 cm) was found in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) plot. The 2nd and 3rd highest (65.60 cm and 61.05 cm) height were found in T_4 and T_5 plot. The lowest height (25.69 cm) was observed in the control plot. At 60 days of plant age, the highest height (128.3 cm) was found in T_2 (seed treatment by Gauchu 70 WS + foliar spray with Admire 200SL) plot. The 2nd and 3rd highest (119.0 cm and 110.6 cm) height was found in T_4 and T_5 plot. The lowest height (32.05 cm) was observed in the control plot. The plant height was significantly influenced by the different application methods of imidacloprid at 75 days of plant age after germination. Here the highest height (181.8 cm) was found in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) plot. The 2nd and 3rd highest

(172.5 cm and 160.5 cm) height was found in T_4 and T_5 plot. The lowest height (69.80 cm) was observed in the control plot.

There was significant variation among the different treatments at 90 days of plant age after germination. The highest height (220.53 cm) was found in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) plot. The 2nd and 3rd highest (209.7 cm and 199.9 cm) was found in T_4 and T_5 plot. T_1 and T_3 treated plot was statistically similar. Here the lowest plant height (89.03 cm) was found in the control plot. At 105 days of plant age, the highest height (244.83 cm) was found in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) plot. The 2nd and 3rd highest (234.1 cm and 223.6 cm) was found in T_4 and T_5 plot. The lowest height (105.2 cm) was observed in the control plot.

From this study it was evident that all the treated plots had significantly different from that of the control plot. Seed treatment by Gauchu 70WS + Foliar spray with Admire 200SL (T_2 plot) was the best among the other treatments. This result indicates that application of imidacloprid decreased the population of jassid and caused normal growth of the okra crop. Seed treatment by Gauchu 70WS + Foliar spray with Admire 200SL (T_2) caused maximum growth of the crop. This result is support the findings of Bhargava and Ashok (2001), who stated that plant growth characters, viz., plant height, greenness of leaves, leaf area, number of fruits per plant, and yield was superior in plots treated with both formulations of imidacloprid compared with untreated control.

Table 3. Efficacy of different application methods of imidacloprid on the plant height of okra due to jassid infestation

Treatments	Plant height in cm at different ages (days)						
	15	**30**	**45**	**60**	**75**	**90**	**105**
T_1	17.02c	28.64e	54.08d	101.2d	155.0d	193.7d	220.1d
T_2	20.35a	39.00a	72.18a	128.3a	181.8a	220.5a	244.8a
T_3	16.51d	34.05d	50.75e	97.04e	152.0e	189.8e	214.1e
T_4	17.70b	36.53b	65.60b	119.0b	172.5b	209.7b	234.1b
T_5	16.54d	35.07c	61.05c	110.6c	160.5c	199.9c	223.6c
T_6	13.49e	16.15f	25.69f	32.05f	69.80f	89.03f	105.2f
$LSD_{0.05}$	0.1846	0.9532	0.1581	0.2335	0.2860	0.1581	0.2077
CV (%)	0.73	0.19	0.19	0.16	0.13	0.06	0.07

In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance.

T_1 = Seed treatment by Gauchu 70WS
T_2 = Seed treatment by Gauchu 70WS + foliar spray with Admire 200SL
T_3 = Band application of Gauchu 70WS
T_4 = Seed treatment by Gauchu 70WS + band application of Gauchu 70WS
T_5 = Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line + foliar spray with Admire 200SL
T_6 = Control

4. 5 Efficacy of different application methods of imidacloprid on mean mumber of fruits

Okra fruit production was seriously affected due to infestation of jassid. The data (Table 4) revealed that the highest number of fruits per plot (652.0) was obtained in T_2 which was significantly higher than all other treatments. The second highest number of fruits (641.3) was harvested from T_4 followed by 623.8 in T_5 having significant difference between the two treatments. The lowest number of fruits (502.0) was found in control which was significantly lower than all other treatments. Consequently T_2 increased 29.88% fruit length over control. Therefore T_2 performed the best regarding the length of fruit against jassid attack. This result supports the findings of Kaur (2002) who observed that seed treatment with imidacloprid foliar spray resulted lowest population of jassid in cotton. Sandeep and Kaur (2002) also found the similar results by seed treatments with foliar spray.

4. 6 Efficacy of different application methods of imidacloprid on fruit yield of okra

Application of imidacloprid increased fruit yield of okra. The data (Table 5) revealed that the highest yield of fruits was obtained in T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) 13.84 t/ha followed by 13.56 t/ha and 13.09 t/ha in T_4 and T_5 respectively. The intermediate amount of yield was obtained from the T_3 (15.45 t/ha) and T_1 (12.30 t/ha) having no significant different between them. The lowest yield of fruits was obtained from the control plot (11.21 t/ha), which was significantly lower than all other treated plots.

Table 4. Total number of fruits of okra per plot in treated and untreated plots

Treatments	No. of fruit $plot^{-1}$	Percent increase over control
T_1	519.0e	3.39
T_2	652.0a	29.88
T_3	537.3d	7.03
T_4	641.3b	27.75
T_5	623.8c	24.26
T_6	502.0f	-
LSD $_{0.05}$	8.835	-
CV (%)	1.01	-

In a column, values with different letter(s) are significantly different at 5% level by DMRT.

T_1 = Seed treatment by Gauchu 70WS
T_2 = Seed treatment by Gauchu 70WS + foliar spray with Admire 200SL
T_3 = Band application of Gauchu 70WS
T_4 = Seed treatment by Gauchu 70WS + band application of Gauchu 70WS
T_5 = Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line + foliar spray with Admire 200SL
T_6 = Control

The overall results indicated that seed treatment by Gauchu 70WS + foliar spray with Admire 200SL (T_2) gave better yield over control plot.

From this study it was evident that all treated plots had significantly higher yield than that of control plot. The result supports the findings of Praveen *et al*. (2007) who reported that seed treatment with imidacloprid gave the highest seed yield of 642 kg/ha against jassid attack. Gandhi *et al*. (2006) showed that the systemic chemical insecticide imidacloprid performed better producing 11.280 and 11.580 t/ha of marketable fruit yield of okra. Swaroop *et al*. (2005) also found that imidacloprid formulation, Confidor 350SC was the most effective treatment in reducing the jassid incidence and produced the maximum fruit yield of 8.74 t/ha. Misra and Senapati (2003) also reported that imidacloprid gave significant control of the jassid (83.3-100.00%) during both the test seasons and increased the marketable fruit yield (32.40-35.44%) of okra compared to untreated control.

4. 7 Benefit cost ratio analysis

Economic analysis for the management of okra jassid by the selected treatments is presented in Table 6. The highest benefit cost ratio (23.2) was obtained in the T_1 (Seed treatment by Gauchu 70WS @ 5 g/kg seed) treated plot. The second highest benefit cost ratio (3.67) was found in T_2 (Seed treatment by Gauchu 70WS @ 5g/kg seed + Foliar spray with Admire 200SL @ 0.5 ml/l of water) treated plot followed by 2.80 in T_4 (Seed treatment by Gauchu 70WS @ 5 g/kg seed + Band application of Gauchu 70WS @ 2 g/l of water) treated plot.

Table 5. Fruit yield of okra under different treatments

Treatments	**Weight of fruit plot^{-1} (kg)**	**Yield (t ha^{-1})**	**Percent increase of yield over control**
T_1	8.863d	12.30d	9.76
T_2	9.988a	13.84a	23.69
T_3	8.962d	12.45d	10.98
T_4	9.762b	13.56b	20.89
T_5	9.425c	13.09c	14.45
T_6	8.075e	11.21e	-
LSD $_{0.05}$	0.2184		-
CV (%)	1.58		-

Values with different letter(s) in column are significantly different at 5% level

T_1 = Seed treatment by Gauchu 70WS
T_2 = Seed treatment by Gauchu 70WS + foliar spray with Admire 200SL
T_3 = Band application of Gauchu 70WS
T_4 = Seed treatment by Gauchu 70WS + band application of Gauchu 70WS
T_5 = Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line + foliar spray with Admire 200SL
T_6 = Control

The lowest benefit cost ratio (0.72) was found in T_5 (Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line @ 2 g/l of water + Foliar spray with Admire 200SL @ 0.5 ml/l of water) treated plot. Similarly the adjusted net return was also the highest in T_2 treated plot i.e. Tk. 41,300/ha followed by T_4 treated plot which are Tk. 34,600/ha. Other treatment also gave the positive net return and benefit cost ratio. The result in terms of benefit cost ratio for the management of okra jassid thus found in the present study is similar to Nazrussalam *et al*. (2008), who found the highest benefit cost ratio by application of as calendar spray for the management of okra jassid. Thus, the result found in this study validates his reports.

Table 6. Economic analysis of different application methods of imidacloprid in managing okra jassid

Treatments	Cost of pest management	Yield (t ha^{-1})	Gross return (Tk.)	Net return (Tk.)	Adjusted net return (Tk.)	Benefit cost ratio (BCR)
T_1	900	12.30	2,46,000	2,45,100	20,900	23.22
T_2	11,300	13.84	2,76,800	2,65,500	41,300	3.67
T_3	11,500	12.45	2,49,000	2,37,500	13,300	1.16
T_4	12,400	13.56	2,71,200	2,58,800	34,600	2.80
T_5	21,900	13.09	2,61,800	2,39,900	15,700	0.72
T_6	00	11.21	2,24,200	2,24,200		

Cost of insecticides: Admire 200SL @ Tk. 100/250 ml. bottle, & Gauchu 70WS @ Tk. 200/250g.
Labour cost: Two labourers/spray/ha @ Tk.150/day. Spray volume required 500 l/ha.
Average market price of okra: Tk. 20/kg. Value of marketable fruits has been considered in calculating the BCR

T_1 = Seed treatment by Gauchu 70WS.
T_2 = Seed treatment by Gauchu 70WS + foliar spray with Admire 200SL.
T_3 = Band application of Gauchu 70WS.
T_4 = Seed treatment by Gauchu 70WS + band application of Gauchu 70WS.
T_5 = Pre-plant injection by Gauchu 70WS at a depth of 4.0 cm below the seed line + foliar spray with Admire 200SL.
T_6 = Control.

CHAPTER V

SUMMARY AND CONCLUSION

A study was conducted to evaluate the effect of different application methods of imidacloprid on the abundance and management of jassid in okra plant in the experimental farm of Entomology, Sher-e-Bangla Agricultural University, during May to June, 2009.

The pest was noticed first in early April just seven days after germination and attacked seriously. After 15 days of germination different symptoms like leaf curling and leaf burning occurred and plant growth was affected severely. Very little attack was found in the T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) treated plot. The highest mean number of jassid (99.00/plant) was found on 22 May, 2009 at untreated plot. Number of jassid per plot was highest on last week of May to first week of June. Plant height, number of fruit per plot and yield per plot were seriously reduced by jassid infestation.

Experimental results showed that the jassid population was significantly different with the application of different control measures. The lowest number of jassid (6.00/plant) was observed at T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) treated plot during 15 May, 2009. Plant height, number of fruit per plot and yield per plot were also significantly different with the application of different control measures. The highest plant height (244.8 cm), highest number of fruit (652) and highest yield (13.84 t/ha) were observed at T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) treated plot.

The result of T_4 and T_5 was statistically similar with the T_2 treated plot. The study also revealed that the highest benefit cost-ratio (BCR) was obtained in T_1 (23.22) and the highest adjusted net return (Tk. 41,300) was obtained in T_2 which treated as the best treatment in this study.

It can be concluded from the present research findings that jassid infestation varied with various ages of okra plant and hampered the growth okra plant severely. The T_2 (seed treatment by Gauchu 70WS + foliar spray with Admire 200SL) treated plot was the most effective against okra jassid. T_5 and T_4 treated plot followed by T_3 and T_1 treated plot was also effective to some extant against jassid over control. It should be advised to use seed treatment by Gauchu 70WS + foliar spray with Admire 200SL for controlling jassid when the populations of jassid are very high. T_5 and T_4 could be applied when the jassid population is low in the field. In the present study it was observed that the populations of the pest were higher at first week after germination from last week of May to first week of June, which caused death of young plant and greatly reduced the yield of fruit. From the above results it can be concluded that seed treatment by Gauchu 70WS + foliar spray with Admire 200SL at weekly interval could provide better control of okra jassid.

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March to June, 2009

Months	Temperature (ºC)			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
March, 2009	31.35	21.55	26.40	74.65	34
April, 2009	32.98	23.22	28.35	89.10	66
May, 2009	33.80	24.50	34.33	79.55	155
June, 2009	33.20	26.15	30.00	69.05	183

Source: Dhaka Meteorological Center

Appendix II. Population trend of jassid at untreated plot in relation to plant age

Weeks after germination	Average number of jassid $plant^{-1}$
3rd	68.75
4th	45.75
5th	30.00
6th	33.75
7th	58.50
8th	99.00
9th	91.75
10th	98.75

Appendix III. Population trend of jassid at untreated plot during cropping season

Months	Dates	Average number of jassid plant^{-1}
April	17.04.09	68.75
	24.04.09	45.75
May	01.05.09	30.00
	08.05.09	33.75
	15.05.09	58.50
	22.05.09	99.00
	29.05.09	91.75
June	10.06.09	98.75

Appendix IV. Percent (%) reduction of jassid population over control

Treatments	Average jassid population plant^{-1}	Percent reduction of jassid over control
T_1	22.60 b	65.64 d
T_2	14.66 e	77.71 a
T_3	20.60 bc	68.68 cd
T_4	18.72 cd	71.55 bc
T_5	16.47 de	74.96 ab
T_6	65.78 a	

Appendix V. Population trend of jassid at the best treated plot in relation to plant age

Weeks after germination	Average number of jassid plant^{-1}
3rd	40.75
4th	28.50
5th	13.50
6th	8.50
7th	6.00
8th	7.00
9th	7.50
10th	8.00

Appendix VI. Population trend of jassid at the best treated plot during cropping season

Months	Dates	Average number of jassid plant^{-1}
April	17.04.09	40.75
	24.04.09	28.50
May	01.05.09	13.50
	08.05.09	8.50
	15.05.09	6.00
	22.05.09	7.00
	29.05.09	7.50
June	10.06.09	8.00

Appendix VII. Name of the company of chemical insecticides used in the experiment

Chemical insecticides	Company name
Admire 200SL	Bayer Crop Science Limited
Gauchu 70WS	Bayer Crop Science Limited

Source: Plant Protection Wing, DAE.