BIOEFFICACY OF SOME CHEMICAL AND BOTANICAL INSECTICIDES AGAINST JASSID, *AMRASCA DEVASTANS* ON BRINJAL AND THEIR IMPACT ON NATURAL ENEMIES

BY

MST. FATEMA KHATUN

REGISTRATION NO. 27468/00667

A Thesis

Submitted to the faculty of Agriculture
Department of Entomology
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (M.S.)

IN

ENTOMOLOGY

SEMESTER: JULY – DECEMBER, 2007

Approved by:

(Dr. Md. Abdul Latif)
Associate Professor
Department of Entomology
Supervisor

(Mohammed Sakhawat Hossain)
Assistant Professor
Department of Entomology
Co-supervisor

(Prof. Jahanara Begum)
Chairman
Department of Entomology
Sher-e-Bangla Agricultural University. Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled, Bioefficacy of some chemical and botanical insecticides against jassid, *Amrasca devastans* on brinjal and their impact on natural enemies submitted to the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN ENTOMOLOGY embodies the result of a piece of bona fide research work carried out by MST. FATEMA KHATUN, Registration No. 27468/00667 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 by her.

Dated : December, 2007
Dhaka, Bangladesh

Supervisor
Dr. Md. Abdul Latif
Associate Professor
Department of Entomology

Dedicated to
My
Beloved Parents and late younger brother

ACKNOWLEDGEMENT

Alhamdulillah! All the gratefulness is due to the Almighty Allah, (S.W.T.) the Cherisher and Sustainer of the world. His blessings have enabled the author to complete her thesis leading to Master of Science Degree.

The author expresses her deepest sense of respect and heartiest gratitude to her honorable teacher and supervisor, Dr. Md. Abdul Latif, Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka for his efficient and scholastic guidance, constructive criticism, valuable suggestions and immense help to carry out the research work toward successful completion and preparation of the thesis by necessary correction through reviewing the text.

The author pleased to avail herself of the opportunity to express her profound appreciation and thanks to her honorable Co-supervisor, Mohammed Sakhawat Hossain, Assistant Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his generous guidance, broad view of discussion and stimulating assistance during the period of research work.

Cordial thanks to Prof. Jahanara Begum, Chairman, Department of Entomology, Prof. Dr. Serajul Islam Bhuiyan, Prof. Dr. Mohammed Ali, Associate Professor, Md. Razzab Ali, Md. Mizanur Rahman, Associated Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for their continuous inspiration and valuable suggestions during the research work and preparation the manuscript of the thesis.

The author would like to take the opportunity to express her deepest ineptness for all the facilities placed at her disposal and kind cooperation provided her respected teachers of the Dept. of Entomology. She also acknowledges the help and co-operation of the staff of Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for the valuable teaching, sympathetic co-operation and inspiration throughout the course of this study and research work.

She would like to extend cordial thanks to her friends specially Dilruba Shabnam, Sormin Chowdhury, Mustahid-Ur-Rob for their kind co-operation. Special thanks are also offered to her elder sister Mariam Parvin, for her kind co-operation, valuable advice during study. Diction is not enough to express profound gratitude and deepest appreciation to her father and mother who sacrificed their happiness during the entire period of study.

The Author

BIOEFFICACY OF SOME CHEMICAL AND BOTANICAL INSECTICIDES AGAINST JASSID, *AMRASCA DEVASTANS* ON BRINJAL AND THEIR IMPACT ON NATURAL ENEMIES

BY

MST. FATEMA KHATUN

THESIS ABSTRACT

An experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University Dhaka, during Feb-Aug 2007 to evaluate some chemicals and botanicals against jassid, *Amrasca devastans* on brinjal and their impact on natural enemies. Nine treatments such as Admire 200SL, Ripcord 10EC, Marshal 20EC, Actara 24WG, Neem seed kernel, Neem oil + Trix, Trix, Mahua leaf extract and untreated control plots were used in Randomized Completely Block Design (RCBD) with 3 replications. The population of jassid adult gradually increased with plant age irrespective of treatments. The lowest population of adult (2.36 before fruiting stage and 9.80 during fruiting stage) and nymph (0.73 before fruiting stage and 1.67 during fruiting stage) per 5 leaves/ plant was observed in Marshal 20EC treated plot. The yield contributing characters such as, number of leaves and branches/plant, number of fruits/plant, length, diameter and weight of individual fruit were found the highest in Marshal 20EC @ 2 ml/l treatments. The same treatment gave the highest yield (29.58 t/ha) and increased 44.65% yield over control. The maximum net return (330071 Tk./ha) and the highest benefit cost ratio (2.28) were also observed in Marshal 20EC. Admire 200SL showed the similar performance in all regards against jassid on brinjal. Ripcord 10EC also gave the satisfactory results in reducing jassid infestation and increasing brinjal yield. Among the botanicals tested, Neem oil + Trix and Neem seed kernel showed satisfactory control of jassid on brinjal. Marshal 20EC, Admire 200SL and Ripcord 10EC reduced more than 80% population of spider and lady bird beetle. Botanicals also decreased the population of spider and lady bird beetle over control but their effect was moderate.

CONTENTS

CONTENTS (cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

LIST OF ABBREVIATED TERMS

FULL NAME	ABBREVIATION
Agro-Ecological Zone	AEZ
And others (at elli)	*et al.*
Active ingredient	a.i.
Benefit cost ratio	BCR
Centimeter	cm
Coefficient of variation	CV
Degree Celsius	°C
Duncan's Multiple Range Test	DMRT
Days After Transplanting	DAT
Degrees of freedom	d.f
Emulsifiable concentrate	EC
Etcetera	etc
Food and Agricultural Organization	FAO
Figure	Fig.
Gram	g
Hectare	ha
Hydrogen ion conc.	pH
Hour	hr
Journal	J.
Kilogram	kg
Liter	l
Meter	m
Millimeter	mm
Month	mo
Muriate of Potash	MP
Number	no.
Percent	%
Relative humidity	RH
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Soluble liquid	SL
Square meter	m^2
Triple Super Phosphate	TSP
Weattble granule	WG

Chapter I
Introduction

CHAPTER I

INTRODUCTION

Brinjal, *(Solanum melongena)* also known as egg plant, is one of the most popular and principal vegetable crops grown in Bangladesh and other parts of the world. It is the second most important vegetable crops after potato in relation to its production and consumption. Brinjal is well known for its nutritive value as a source of carbohydrate, proteins, minerals and vitamin (FAO 1995). It is also a good source of dietary fiber and folic acid, and is very low in saturated fat, cholesterol and sodium.

It is a native of India and is extensively grown in all the Southeast Asian countries which is grown on over 510000 ha in India (FAO 2004) and approximately 64234.82 ha in Bangladesh (Anon. 2004). Bangladesh produced 382 thousand tons brinjal which was approximately 17% of the total vegetable production of the country during the year of 2000-2001 (Anon, 2004). Brinjal is one of the three most important vegetable in South Asia (India, Nepal and Srilanka). The region South Asian accounts for almost 50% of the world area under cultivation (Alam *et al.* 2003). Brinjal is grown in Bangladesh throughout the year including the summer season, when the supply of vegetables in the market is scarce. Thus, the farmers find it as a cash crop, which serves as a source of continuous flow of income (FAO 2003).

Sales of egg plant throughout the prolonged harvest season provide farmers with valuable cash income (Alam *et al.* 2003).

Brinjal is a high income generating crop and its price reaches up to Tk.80 per kilogram during the month of Ramadan in Bangladesh. The fruit can be eaten raw or served as a baked, grilled, fried or boiled vegetable and can be used in stews or as a garnish (FAO 2003). In Bangladesh, brinjal made "Beguni" has high demand during the holy Ramadan month. Due to various uses of brinjal, it is liked by rich and poor, urban and rural, upper and lower classes people. The importance of brinjal to the farmers stems from its reasonably consistent and high yields of about 19 tons/ha per growing season. The crop is relatively hard and can withstand adverse conditions better than other crops. It can also be chopped and re-grown as a perennial crop.

Brinjal is extensively grown in kitchen and commercial gardens in both rabi and kharif season in Bangladesh, especially in the hot humid monsoon season when other vegetables are in short supply. Brinjal is practically the only vegetable that is available at an affordable price for rural and urban consumers. It is cultivated largely on small family owned farms, where weekly sales of it brings in a readily cash income. The crop is infested by various arthropods pest species in the field. El-Shafie (2001) recorded 28 species of insect pests under 7 different insect orders from the brinjal ecosystem in Sudan. Latif (2007) observed 20 species of pest under 6 different orders, jassid (*Amrasca devastans*) was the second most common in the field. Alam *et al.* (2003) reported that it was attacked by 53 species of insect pest among them, jassid (*Amrasca devastans*) was the second major pest .

Both nymph and adult of jassid attack host leaves at all stages of development and suck the sap from lower surface of the leaves. They also inject saliva into the tissues, which causes toxemia and injury of the leaves. The infested leaves curl upwards along the margin and ultimately the whole leaf gradually dries up and drops off from the plant. The plant becomes stunted, quality of fruit is also affected (Nair, 1986). It also transmitted viral disease like mosaic virus. The younger plants were found susceptible to jassid attack than the older plants. As the plants grew older, they become less susceptible to jassid infestation Ali (1990). This pest also attacks cotton, okra, potato, pea and other solanaceous crops and also some wild plants, like hollyhock, kangi buti (*Abutlon indicus*) etc. (Atwal 1986). It is also one of the key pests of cotton and causes major damage every year. Bhat *et al.* (1984) reported that jassid caused more than 50% reduction of seed cotton yield in some cotton genotypes.

The management of jassid (*Amrasca devastans*) through various non-chemical method namely, cultural, mechanical, biological and host plant resistant etc. was limited throughout the world. Management practices of jassid in Bangladesh and other countries are still limited to frequent spray of toxic chemical pesticides (Alam 2005, Anon. 2005, Misra and Senapati 2003, Singh and Choudhary 2001, Bhargava *et al.* 2001, Ali and Karim 1994, Yadgirwar *et al.* 1994, Singh *et al.* 1991). The insecticides used mostly belong to organophosphates, Carbamates, and synthetic

Pyrithroides. Bangladeshi farmers usually apply six to eight schedule based insecticide sprays against this pest through out the season. But this kind of insect pest control strategy relying solely on chemical protection had got many limitations and undesirable side effects (Husain 1993, 1984) and this in the long run led to many insecticides related complications (Frisbie 1984) such as direct toxicity to beneficial insect, fishes and other non target organism (Munakata 1997, Goodland *et al.* 1985, Pimentel 1981), human health hazards (Bhaduri *et al.* 1989) resurgence of pests (Husain 1993, Luckmann and Metcalf 1975) out break of secondary pest (Hagen and Franz 1973) and environmental pollution (Fiswick 1988, Kavadia *et al.* 1984).

To overcome the hazards of chemical pesticides, botanicals such as neem seed kernel extracts, neem oil, soap water are now used in many developed and developing countries for combating this pest infestation with the aim of increasing crop yield (Hossain *et al.* 2003, Mote and Bhavikatti 2003, Singh and Kumar 2003, Rao and Rajendran 2002, Gahukar 2000, Lawrence *et al.* 1996). But in Bangladesh, information on the efficacy of Neem and other botanicals, soap water are scanty. Moreover, pesticides companies are introducing new chemicals for the management of jassid in Bangladesh. Many of the insecticides have been reported to fail to control the pest effectively (Alam *et al.* 2003). So, careful and detailed investigations about the effectiveness of new insecticidal chemicals against jassid are essential.

Keeping this perspective in view, the experiment was undertaken against jassid to fulfill the following objectives:

- to evaluate the effectiveness of some selected chemical insecticides and botanicals against the jassid in brinjal,
- to know the effect of those chemicals and botanicals on yield contributing characters and yield of brinjal against jassid infestation and
- to evaluate the impact of those chemicals and botanicals on natural enemies in the brinjal field.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Jassid, *Amrasca devastans* is considered as one of the major insect pest of different vegetable crops, which causes significant damage to crop every year. The incidence of this pest occurs sporadically or in epidemic form throughout Bangladesh and affecting adversely the quality and yield of the crop. In the favourable weather severe infestation may occur and total crop may be damaged. Literatures regarding its population dynamics and management in brinjal are scanty. However, review of the available literatures relevant to the present study is presented below under the following sub-headings.

2.1 Taxonomy

This insect belongs to the order: Homoptera and Family: Cicadellidae Synonym: *Amrasca biguttula biguttula* Ishida, common name: cotton jassid, okra jassid or brinjal jassid etc.

2.2 Origin and distribution

Jassid is a versatile and widely distributed insect. It has been recorded in India, China, Pakistan, Iran, Syria, Greece, Spain, Argentina, Brazil and the USA. It is distributed widely throughout the Eastern, Southern and Central Africa.

2.3 Host Range

Jassid is widely distributed in India and most destructive to American cotton in the north-western region. Besides cotton it also feeds, potato, brinjal and some wild plant like hollyhock, kangi buti, etc. (Atwal, 1986). The insect also invades cotton, lady's finger, tomato and many other malvaceous and solanaceous plants (Alam 1969). Jacob *et al.* (2000) identified *A. devastans* on castor bean, which attained at pest status. A survey report in Madhya Pradesh, India revealed that *A. devastans* infested potatoes in that area (Dharpure 2003). Mamun (2006) reported that jassid prefers tomato, sweet gourd, country bean, brinjal, okra and cotton as host.

2.4 Seasonal abundance

Population of jassid varies in different time of the year. Alam *et al.* (2005) stated that jassid population was higher during the dry period especially mid February to mid April and number of jassid per leaf reached to its maximum (15.41) peak during the month of April. During long dry period especially in the month of February-March jassid became a serious problem for brinjal cultivation (Alam *et al.* 2006).

Mall *et al* (1992) described that seasonal incidence of jassid was more prevalent during vegetative phase of the crop up to the 3rd week of September when the average temperature and humidity were more than 28°C and 80 percent respectively.

Early plantings are more injured by the cidadellid than the late planting. The pest breed practically throughout the year but during the winter month only adult was found on plants such as potato, brinjal, tomato etc. In spring they migrate to okra and started breeding. Particularly the American cotton was very susceptible to this pest (Nair 1986). The cotton jassid was formally considered to be on early season pest attacking plant in Bangladesh (Bohlen 1984).

Ali (1987) reported that jassid had been found to attack plants through out the season. The incidence of jassid on brinjal planted at various dates from 20 July to 20 December was higher an early planted crop than on late planted crops (Borah 1995).

Seasonal abundance of cotton jassid on okra was dependent on meteorological parameters. Jassid population was maximum during middle of April (30.00 Nymph / leaf) to last week of May (37.5 Nymph/leaf). High temperature (30.36°C) evening relative humidity (below 80%) and low rainfall period coupled with bright sunshine hours were favourable for the development of cotton jassid population (Inee *et al.* 2000).

Muthukumar and Kalyanasundaram (2003) observed that jassid had a negative association with minimum temperature and rainfall when investigation on the seasonal incidence of jassid (*Amrasca biguttula biguttula*) population on okra and their correlation with abiotic factors were carried out kharif 1990 in the semi arid region in India. The infestation of jassid started in the fourth week of July and reached peak in the second and fourth weeks of September respectively (Kumawat *et al.* 2000).

Studies on the seasonal incidence of jassid on cotton under rainfed conditions were conducted at Bharuch, and Gujarat in India, during 1979-80 and 1981-82. Results showed that population of *Amrasca devastans* ranged from 0.59 to 2.78 per plant recorded in the 2nd fortnight of November (Patel and Patel 1998).

The spatial distribution of *A. devantans* was studied in upland cotton in India. Environmental heterogeneity at low population in July and innate behaviour at high population were responsible for aggregated dispersion in the species of hemiptera (Singh *et al.* 1990).

Ali and Karim (1991) investigated the influence of cotton plant age on the seasonal abundance of *A. biguttula.* They found that the insect remained below the economic threshold level of 1 insect/leaf for up to 35 days of plant age in kharif cotton and 65 days of plant age in robi 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.

The population of leaf hopper on brinjal was positively correlated with average maximum-minimum temperature, relative humidity and total rainfall (Shukla 1989). Observation on the jassid population was made from the 2nd week of July up to the 3rd week of September. The pest population increased from July to August. The maximum activity of the pest occurred from the 1st week to the middle of August. After this period, the jassid population gradually declined, probably due to the slight increase in atmospheric temperature and RH, maximum crop damage coincidence with the maximum activity of the pest (Poonia, 2005).

Investigations on the seasonal incidence of jassid population on okra with abiotic factors were carried out during kharif 1996 in the semi arid region of Rajasthan, India. The infestation of jassid started in the 4th week of July and reached peaks in the 2nd and 4th weeks of September, respectively (Kumawat *et al.* 2000).

2.5 Infestation status

Jassid, *A. devastans* infestation was manifested by some characteristics symptoms; the primary symptom was characterized by leaf edge curling and the secondary symptom was characterized by leaf edge curling along with reddish colouring of leaves and the late symptoms were characterized by leaf edge and vein colouring and drying of the leaves. From the initial infestations, these symptoms developed in sequence leading to hopper burn and shedding of leaves incase of severe infestation, which ultimately caused the retraction of plant growth and reduction of yield (Afzal and Ghani 1953).

2.6 Biology of the pest

2.6.1 Egg

The adults mated two days after emergence and the eggs were laid two to seven days after copulation (Nair 1986). Eggs were laid on the leaves of food plants and are hatched in about a week (Alam 1969). Eggs were laid singly within leaf veins in the paranchymatous layer between the vascular bundles and the epidermis on the upper leaf surface. An average of 15 eggs (with a maximum of 29) was laid per female. Mature leaves (35-45 days old) were preferred for egg deposition; curved, greenish-yellow, eggs (0.7-0.9 × 0.15-0.2 mm) were laid, the egg period last for 4-11 days (Nair 1986). The females deposited slender white eggs within the stems and larger veins of the leaves and hatching period was 6-9 days (Davidson 1987). A female laid 25-30 eggs of 1-4 eggs per day, which were hatched in 4 to 11 days (Nair 1986).

2.6.2 Nymph

Nymphs were pale green, wedge shaped, 0.5-2.0 mm long, have a characteristics crab like, side ways movement when disturbed. They were confined to the under surface of leaves during the day time but found anywhere on the leaves at night. The nymphal period varied from 7 to 21 days depending on food supplies and temperature they passed through six stages of growth during nymphal period (Atwal 1986). Another study revealed that they became full grown in seven days in autumn and 25 days in winters. Nair (1986) reported the five nymphal instars completed in 19-21 days.

Bohlen (1984) stated five nymphal instars and the nymphs resembled the adult but had no wings. The nymphs were smaller than the adult but wingless. Nymphs were found on the underside of leaves (FAO 2003).

2.6.3 Adult

The adult were small, elongate, wedge shaped, about 2.5 mm long, body pale green semi-transparent wings very active having aside way walk like the nymph, but quick to hop and fly when disturbed. The adult of the summer brood were greenish yellow in color and those of the winter broad radish. Unmated adults lived for 3 month or more, when mated, they lived five weeks in summer and seven weeks in winter. Life cycle was completed in 15-46 days in the different seasons and up to eleven generation was completed in a year (Nair 1986). They were also attracted to light at night (Atwal 1986).

Adults were usually less than 13 mm long with slender, tapered bodies of various colors from bright grey to yellow green with shiny wings and had two distinct black spot at distal found on the foliage in large numbers and moved around by jumping but flew very rapidly when disturbed. The adults were found on the under sides of the leaves. (FAO 2003).

2.6.4 Nature of Damage

Jassid, *Amrasca devastans* infestation was manifested by some characteristic symptoms. The primary symptom was characterized by leaf edge curling and the secondary symptom was characterized by leaf edge curling along with leaf edge and vein colouring and drying of the leaves. From the initial infestation, the symptoms developed in sequence leading to hopper burn and shedding of leaves in severe cases of infestations, which ultimately caused the retraction of plant growth and reduction of yield (Afzal and Ghani 1953).

Nair (1986) reported that the nymphs and adults of *A. devastans* attacked host leaves at all stages of development. The adults and nymphs fed on the sap and injected saliva into the tissues, which caused toxemia and injury of the leaves. The edges of the infested leave turned pale-green, then yellow and finally brick red brown in colour. The colour changes were accompanied by severe crinkling and curling of the leaf. The whole leaf gradually dried up and dropped. The plant became stunted and quality of fruit was also affected.

El-Tom (1987) reported that cotton jassid; *A. devastans* was one of the key pests of cotton and in the major factor limiting cotton yield in Bangladesh. This pest caused more than 50% reduction of seed cotton yield in some cotton genotypes (Bhat *et al.* 1984).

The jassid while sucking the plant sap injected some toxic substances with saliva into the cotton plants. Time required to development characteristic jassid damage symptoms in cotton plants were found positively correlated with age of the plant. The younger plants were found susceptible to jassid attack than the older plants (Nayer *et al.* 1984). As the plants grew older, they became less susceptible to jassid infestation (Ali 1990). Rote *et al.* (1985) reported a significant positive correlation between jassid damage symptoms and jassid population levels on the plant. Yield losses of cotton due to sucking pests (*Amrasca biguttula biguttula*) were evaluated during the rainy seasons of 1985 and 1986 in Karnataka, India. The average yield loss was 46.41% (Panchabhavi *et al.* 1990).

2.7 Management

The management of jassid (*Amrasca devastans*) through various non-chemical method namely, cultural, mechanical, biological and host plant resistant etc. was limited throughout the world. The research work on non-chemical control measure of this pest was also scanty. The farmers of Bangladesh usually apply six to eight schedule based insecticide sprays against this pest through out the season. But this kind of insect pest control strategy relying solely on chemical protection had got many limitations and undesirable side effects (Husain 1993, 1984) and this in the long run led to many insecticides related complications (Frisbie 1984) such as direct toxicity to beneficial insect, fishes and other non target organism (Munakata 1997, Goodland *et al.* 1985, Pimentel 1981), human health hazards (Bhaduri *et al.*, 1989) resurgence of pests (Husain 1993, Luckmann and Metcalf 1975) out break of secondary pest (Hagen and Franz 1973) and environmental pollution (Fishwick 1988, Kavadia *et al.* 1984). To overcome these problems botanical insecticide soap-water and water are now used in many developed and developing countries for combating this pest infestation with the aim of increasing crop yield.

2.7.1 Botanicals for jassid management

Botanical pesticides are the most cost effective and environmentally safe inputs in integrated pest management [IPM] strategies. There were about 3000 plants and trees with insecticidal and repellant properties in the world, and India was home to about 70 percent of this floral wealth (Narayanasamy 2002). He stated the use of more than 450 botanical derivatives used in traditional agricultural system and neem was one of the well-documented trees, and almost all the parts of the tree had been found to have insecticidal value. The neem seed kernel extracts, neem oil, extracts from the leaves and barks had all been used since ancient times to keep scores of insect pests away. A number of commercial neem based insecticides were now available and they had replaced several toxic chemical insecticides. The extracts were of particular value in controlling the sucking and chewing pests. The young caterpillars devouring the tender leaves were well managed by the botanical insecticides. The plant materials should be thoroughly washed before preparing the extract and the right quantity should be used.

With the continued robust growth of the global bio-pesticide market, Azadirachtin is uniquely positioned to become a key insecticide to expand in this market segment. In the USA, actual or impending cancellation of some organophosphate and Carbamate insecticides that had either lost patent protection or were not being re-registered in many markets because of the food quality protection Act of 1996, had opened new opportunities for bio-pesticides and reduced risks of pesticides in general. The broad-spectrum activity of Azadirachtin at low use rates (125-140g a.i. ha^{-1}) coupled with the insect growth regulator activity (in all larval /nymphal instars including the pupal stages) and unique mode of action (ecdysone disruptor) made Azadirachtin an ideal candidate for insecticide resistance, integrated pest control and organic pest control programs.

The pest control potential demonstrated by various extracts and compounds isolated from the kernels and leaves of the neem plant [*Azadirachta indica*, (Meliaceae)] seem to be of tremendous importance for agriculture in developing countries. Laboratory and field trial data had revealed that neem extracts were toxic to over 400 species of insect pests; some of which had developed resistance to conventional pesticides, e.g. sweet potato white fly (*Bemisia tabaci* Genn. Homoptera:

Aleyrodidae), the diamond back moth (*Plutella xylostella* L Lepidoptera: Plutellidae) and cattle ticks (*Amblyomma cajennense* F. Acarina: Ixodidae and *Boophilus microplus* Canestrini Acarina: Ixodidae).

The compounds isolated from the neem plant manifested their effects on the test organisms in many ways, e.g. as antifeedants, growth regulators, repellents, toxicants and chemosterilants. This review strived to assess critically the pest control potential of neem extracts and compounds for their use in the tropics. This assessment was based on the formulation, stability and phytotoxicity information available on the wide range of pests against which neem extracts and compounds had proven to be toxic, toxicity to non target organisms, e.g. parasitoids, pollinators, mammals and fish. (Lawrence *et al.* 1996)

Azadirachtin had been exempted from residue tolerance requirements by the US environmental protection agency for food crop applications. It exhibited good efficacy against key pests with minimal to no impact on non-target organisms. It was also compatible with other biological control agents and had a good fit into classical integrated pest management programs (John and Immaraju, 1997).

Products derived from leaves and kernels of neem (*Azadirachta indica*) are becoming popular in plant protection programs for cotton, mainly because synthetic pesticides have several undesirable effects. Neem products acted both as systemic and as contact poisons and their effects were antifeedant, toxicological, repellent, sterility inducing or insect growth inhibiting. Furthermore, neem products appeared to be environmentally safe and IPM compatible and had the potential to be adopted on a broad scale, together with other measures, to provide a low cost management strategy (Hillocks 1995, Gahukar, 2000). Indigenous plant materials were cheaper and hazard free in comparison to chemical insecticide (Saxena *et al.* 1992). These were also easily available in everywhere in our country. Ofori and Sackey (2003) reported that acetylic, aqueous neem seed extract reduced the *Amrasca biguttula* on okra.

The biological control agents *Bacillus thuringiensis* (Bt; Delfin 85 WG) at 0.04% and *Trichograma chilonis* at 60000/ha and insecticides Azadirachtin (Econeem) at 0.0006%, Lufenuron (Match 5EC) at 0.005%, Avermectin (Vertimec [Abamectin] at 0.0004%, Monocrotophos 36SL (Monocil) at 0.05%, Spark 36EC (Deltamethrin1EC + Triazophos 35EC) at 0.05%, Bulldock star 262.5EC (Beta-cyfluthrin12.5EC + Chlorpyrifos 250 and Nurelle-D-505. 55EC Cypermethrin 5 + Chlorpyrifos 50) at 0.05% were tested in a field trial in Rahuri, Maharashtra, India, during the kharif season of 2000 against pest complex of brinjal. Azadirachtin was moderately effective against the sucking pest including *Bemisia tabaci, Aphis gossypii, Amrasca biguttula biguttula* (Mote and Bhavikatti 2003).

The joint action potential of methanoic extract of neem seed kernel (*Azadirachta indica*) in combination with methanolic extracts of two other botanical, viz., sweet flag (*Acorus calamus*) and *Pongamia glabra* (*P. pinnata*) against *Ammrasca devastans* at 1:1:1, 2:1:1 and 3:1:1 (v/v) ratio were studied. This combination at 0.42% concentration gave superior control of *A. devastans* (Rao and Rajendran, 2002).

An experiment was conducted with okra in India to determine the efficacy of neem based pesticide against the cotton jassid, *A. biguttula*. The treatments comprised Endosulfan at 0.07%, A Chook at 3% Neemarin at 0.7%, neem seed kernel extract (NSKE) at 1%, NSKE at 3% with an untreated control. Endosulfan followed by A Chook and NSKE (3%) were most effective in controlling the okra jassid. A Chook treated plots gave the highest yield of 50.06 q/ha and significantly superior to other treatments. However on the basis of cost benefit ratio NSKE (3%) ranked first (Singh and Kumar 2003).

Schneider and Madel (1992) reported that the treatments of neem seed kernel extract (NSKE) did not show a significant reduction in parasitization rate of fecundity of larval parasitoid, *Diadegma semiclausum*. The aqueous NSKE had no adverse effects on *D. semiclausum* following direct contact. Patel and Patel (1998) reported that application of Quinalphos and Triazophos resulted in a resurgence of *A. biguttula* on okra and abergine (Brinjal), while Endosulfan at 0.07% and Repelin (based on *Azadirachta indica*) 1% were highly effective. Nandagopal and Soni (1992) observed that in India neem oil was least persistant insecticides and caused >50% mortality of jassid only up to 24 hours after application.

Different concentrations of soap solution were applied against jassid of cotton. Soap powder (25gm/liter of water) predominantly reduced the pest population during the period and harvested the best yield than other treatments. Economic return is reasonably satisfied (Hossain *et al.* 2003).

2.7.2 Chemicals for jassid management

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

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

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

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

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

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

Ali and Karim (1994) evaluated six new chemical insecticides for their biological efficacy against *Amrasca devastans.* Azodrin 40WSC (Monocrotophos) @ 2ml/1 water, Tamaron 40SL (Methamidophos) @ 2ml/1 water and Talstar 2.5EC (Bifenthrin) @ 0.25 ml/1 water were very effective against the pest, causing 91 to 97.53% mortality on the second day post-treatment and were effective up to the 30th day post-treatment causing 73.27 to 79.17% mortality. The Dimethoate formulation (Polygor 40EC and Sunagr 40EC) @ 2 ml/1 water was relatively less effective causing 56.5 to 72.37% mortality on the second day post-treatment and 65.79 to 70.54% mortality on the 30th day post-treatment. Furadan 5G (Carbofuran) @ 2 kg a.i./ha was not effective on the second day post-treatment causing only up to 8.72% mortality but was effective during the subsequent post treatment counts showing up to 68.68% mortality on the 30th day post-treatment. All insecticides were toxic to non target arthropod parasitoid and predators of cotton pests even on the 30th day post treatment.

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

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

Yadgirwar *et al*. (1994) tested synthetic pyrithroid (Cypermethrin and Deltamethrin) and organophosphate insecticides (Dimethoate and Phosphamidon) alone and in combination to control *Amrasca biguttula biguttula (A. devastans)* on cotton in Mararashtra, India. Among all 9 treatments, the combination of Deltamethrin 0.0025% + Dimethoate 0.03% was the most effective.

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

(2001) evaluated some insecticides against cotton jassid on okra and noticed that Endosulfan was effective in controlling jassid.

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

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

Shakharappa and Patil (2001) studied on the efficacy of Silafloufen 20EC, a new insecticide of Slanecophanes group, for the control of leafhopper in transitional cotton cv. DCH-32 belt. Silafloufen 20EC was tested at 2 concentrations, i.e. 50 and 100 g a.i./ha and compared with other insecticides, Methyl Demeton 25EC, Phosphamidon 85WSC, Neem gold and untreated control. The crop was sprayed 4 times during September-October. The pretreatment population of leafhopper ranged from 2.67 to 2.86 in the experimental plots. The lowest population of 2.20 leafhoppers/leaf was recorded in the treatment Silafluofen 20EC at 100 g a.i./ha which was on per with Methyl Demeton 25EC with 2.24 leafhoppers per leaf. Both treatments were significantly superior to the rest of the treatments. The next best treatments were Phosphamidon and Silafluoen at 50 g a.i./ha.

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

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

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

Alam (2005) found that jassid infestation varied in different growth stages of okra plants and hampered okra production severely. The chemical Milfan 20EC was the most effective against okra jassid. Besides this, Chloroced 20EC and Sumithion 50EC also showed better result. Anon. (2005) reported that Admire, Kranda, Corofen and Neembicidine had significant effect in controlling jassid.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment on the population dynamics and management of jassid (*Amrasca devastans*) in Brinjal, Homoptera, Cicadellidae was carried out at the experiment field of the Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during February to August 2007. The materials and methods adopted in this study are discussed in the following sub heading:

3.1 Location

The experimental site was located at the experimental farm of Sher-e-Bangla Agriculture University, Dhaka-1207, during the period from February to August, 2007. The experimental field was located at 90°335′E longitude and 23°774′N latitude at a height of meter above the sea level. The land was medium high and well drained.

3.2 Climate

The experimental site was situated in the sub-tropical climatic zone characterized by heavy rainfall during the month from February to August. Monthly maximum and minimum temperature, relative humidity and total rainfall recorded during the period of study at the SAU experimental farm have been presented in Appendix I. The data recorded and calculated as monthly average temperature, relative humidity and rainfall for the crop growing period of experiment were noted from the

Bangladesh Meterological Department (climate division), Agargaon, Dhaka-1207 and has been presented.

3.3 Soil

The soil of the study was silty clay in texture. The area represents the agroecological zone of "Madhupur Tract" (AEZ No. 28). Organic matter content was very low (0.82%) and soil pH varied from 5.47-5.63.

3.4 Design and layout

The study was conducted considering nine treatments including a control for controlling jassid at seedling to harvesting stages. The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications in the field of the Entomology Department. The whole field was divided into three blocks of equal size and each block was sub divided into nine plots. The unit plot size was 3m x 2m accommodating eight pits plots. The distance between row to row was 100cm and that of the plant to plant was 75cm.

3.5 Land preparation

The soil of the experimental field was well prepared thoroughly followed by ploughing, and cross ploughing, leveling, and laddering to have a good tilth. All weeds and debris of previous crops were removed and the land was finally prepared with the addition of basal dose of cow manure (decomposed). Raised plots of 3 x 2 m size were prepared accommodating required numbers of pit plot.

3.6 Manuring and fertilization

The following doses of manure and fertilizers were applied as per recommendation of Rashid (1999) for brinjal.

Manure/Fertilizers	Dose/hectare
Cow-dung	10 tons
Urea	360 kg
Triple Super Phosphate(TSP)	150 kg
Muriate of Potash (MP)	250 kg

The full dose of cowdung and TSP were applied as basal dose during land preparation. One third of the MP and urea were applied in the pits one week before transplanting and rest of the MP and urea were applied as the top dressing after the plant transplanting 21, 35 and 50 days interval.

3.7 Raising of seedling and transplanting

Brinjal seed (Variety: Shingnath) were collected from East West seed Bangladesh Ltd. Dhaka. A small seed bed measuring 5m × 1m was prepared and seeds were sown in the nursery bed at SAU entomology field on 26 February, 2007. Standard seedling raising practice was followed (Rashid 1999). The plots were lightly irrigated regularly for ensuring proper development of the seedlings. The seed bed was mulched for ensuring seed germination, proper growth and development of the seedlings. Forty days old (3/5 leaf stage) healthy seedlings were transplanted on 1st April 2007 in the experimental field. A total of 216 seedlings were transplanted in 27 plots @ 8 seedlings per plot.

3.8 Intercultural operations

3.8.1 Gap filling: At the time of each transplanting few seedlings were transplanted in the border of the experimental plots for gap filling. Very few numbers of seedling were damaged after transplanting and such seedling were replaced by healthy seedlings from the same planted earlier on the border of the experiment plot. The seedlings were transplanted with a mass of soil roots to minimize the transplanting shock.

3.8.2 Irrigation: After transplanting light irrigation was given to each plot. Supplementary irrigation was applied at an interval of 2-3 days. Stagnant water was effectively drained out at the time of over irrigation. The urea was top dressed in three splits as mentioned earlier.

3.8.3 Weeding: Weeding was done as and when necessary to break the soil crust and to keep the plots free from weeds. First weeding was done after 20 days of planting and the rest were carried out at an interval of 15 days to keep the plot free from weeds.

3.8.4 Earthing up: Earthing up was done in each plot to provide more soil at the base of each plant. It was done 40 and 60 days after transplanting.

3.9 Treatment for control measures

The comparative effectiveness of the selected nine treatments was evaluated on the basis of reduction in jassid infestation of egg plant. The individual control measure under each treatment as well as standard practice an untreated control are described and discussed below:

3.9.1 Details of the treatments for jassid

T_1 = Admire 200SL @ 1.2 ml/liter of water

T_2 = Marshal 20EC @ 2 ml/liter of water

T_3 = Ripcord 10EC @ 1 ml/liter of water

T_4 = Actara 25WG @ 0.3 g/liter of water

T_5 = Neem seed kernel @ 5.0 g/liter of water

T_6 = Neem oil + Trix @ (3.0 ml + 1.0 ml)/liter of water

T_7 = Trix @ 5 ml/liter of water

T_8 = Mahua leaf @ 5 g/liter of water

T_9 = Control

3.10 Application of insecticides

The insecticides were applied with the help of knapsack sprayer. The first application of insecticide was initiated after 4^{th} week of transplantation and subsequent applications in each treatment were made at seven days intervals. Precautions were taken to avoid drift to the adjacent plots.

3.11 Data collection

Data were collected some pre-selected parameters, such as population dynamics of jassid, yield contributing characters of brinjal like number of leaves and braches per plant, number of fruits/plant, fruit length and diameter, weight of individual fruits and fruit yield of brinjal. The population dynamics of the jassid was studied on treated and untreated plots of brinjal throughout the cropping season starting from 30 days after transplantation. Adults and nymphs of jassid were counted from a random sample of five plants taken from each plot. Five leaves were chosen randomly on each plant, two from the bottom (older leaves), one from the middle and two from the top (younger leaves). The lower surface of the leaf was thoroughly examined for the presence of insects. Counts were made before 08.00 hr (Bangladesh local time) to avoid the excessive mobility of the adult insects after this time, but nevertheless, the migration of the fast moving and mobile adults from one plot to the other could not be totally avoided. The data were pooled over the cropping season and the population density was expressed as number of individuals per five leaves of the plant.

Observation of the symptoms developed on the leaves and number of branches/plant was recorded at an interval of 7 days starting from 3rd week after transplanting and was continued up to 8th week. Five plants were randomly selected from each plot and tagged. The selected plants were observed regularly at weekly intervals in the morning. Healthy and infested leaves and number of branches per/plant were counted for estimating the infestation intensity. The data were converted to mean healthy and infested leaves and number of braches per plant.

Fruits were harvested at 7 days intervals and the number of fruits was recorded for each plot. Twenty fruits were selected randomly from each plot; length, diameter and weight of the selected fruit were recorded at each harvest. The data were pooled over the cropping season; length, diameter and weight of individual fruit were estimated. The total weight of fruit was recorded every harvest, right from the beginning of the first harvest and continued until the end of the growing season.

The cumulative yield of fruits per plot from 12 harvests was calculated and it was then expressed as t/ha. The population of spiders and lady bird beetles were counted by randomly selected five branches from 5 plants of each plot at weekly interval.

Assessment of treatment effects

The performance profile of each treatment was judged by the reduction of the insect population densities in the treated plots and it was further confirmed by the comparison of yield contributing characters such as number of leaves and branches per plant, number of fruits/plant, fruit length and diameter, weight of individual fruits and yield obtained in each case at the end of the cropping cycle.

Percent infestation of leaves

The infested leaves were calculated by the following procedure:

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

Percent reduction of population

Percent reduction of population the effect of treatments on Jassid was determined by counting the numbers of pests per plant application of treatments. The percent reduction of jassid was calculated using the following formula:

$$\text{\% Reduction of population} = \frac{\text{No. in treated plot - No. in control plot}}{\text{No. in control plot}} \text{ X } 100$$

Yield per hectare: The total yield of brinjal per hectare for each treatment was calculated in tons from cumulative production in a plot. Effect of different treatments on the increase and decrease of brinjal yield over control was calculated in case of jassid.

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

3.12 Benefit-Cost analysis:

For benefit cost analysis, records of the costs incurred for labour, insecticide, application of insecticide in each treatment and that of control without insecticide were maintained. The untreated control (T_9) did not require any pest management cost. The price of the harvested marketable healthy fruit of each treatment and that of control were calculated at market rate. The result of Benefit-Cost analysis was expressed in terms of Benefit-Cost Ratio (BCR).

3.13 Statistical analysis

Data were analyzed by using MSTAT software for analysis of variance after square root transformation. ANOVA was made by F variance test and the pair comparisons were performed by Duncan Multiple Range Test (DMRT) (Gomez and Gomez 1984).

A. Adult jassid

B. Jassid infested leaf

Plate. Jassid and jassid infested leaf of brinjal

Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to evaluate some chemical and botanical insecticides against jassid on brinjal in terms of population dynamics of jassid, yield contributing characters and yield of brinjal. The results have been presented and discussed, and the possible interpretations have been given under the following headings:

4.1 Population dynamics of jassid under different treatments

The population of jassid on brinjal under different treatments was studied in relation to age of the plant. The population of jassid nymph was gradually increased with the age of the plant and reached its peak in the 7th week after transplantation and then sharply declined with the age of the plant (Figure 1). The highest population of nymph was observed in control plots in comparison to the lowest in Marshal 20EC treated plots. The population of jassid nymph was also lower in other treated plots than control plot. Similarly, the adult jassid population the highest in control plots as compared the lowest in Marshal 20EC treated plots, and that was also lower in other treated plots than control plot. However, the population trend of adult jassid was different from the nymph with the plant age. Although the population of adult jassid increased with the plant age but it did not declined in 7th week after transplantation like nymph population (Figure 2). These results agree to Mall *et al* 1992), who reported that jassid was more prevalent during vegetative phase of the crop.

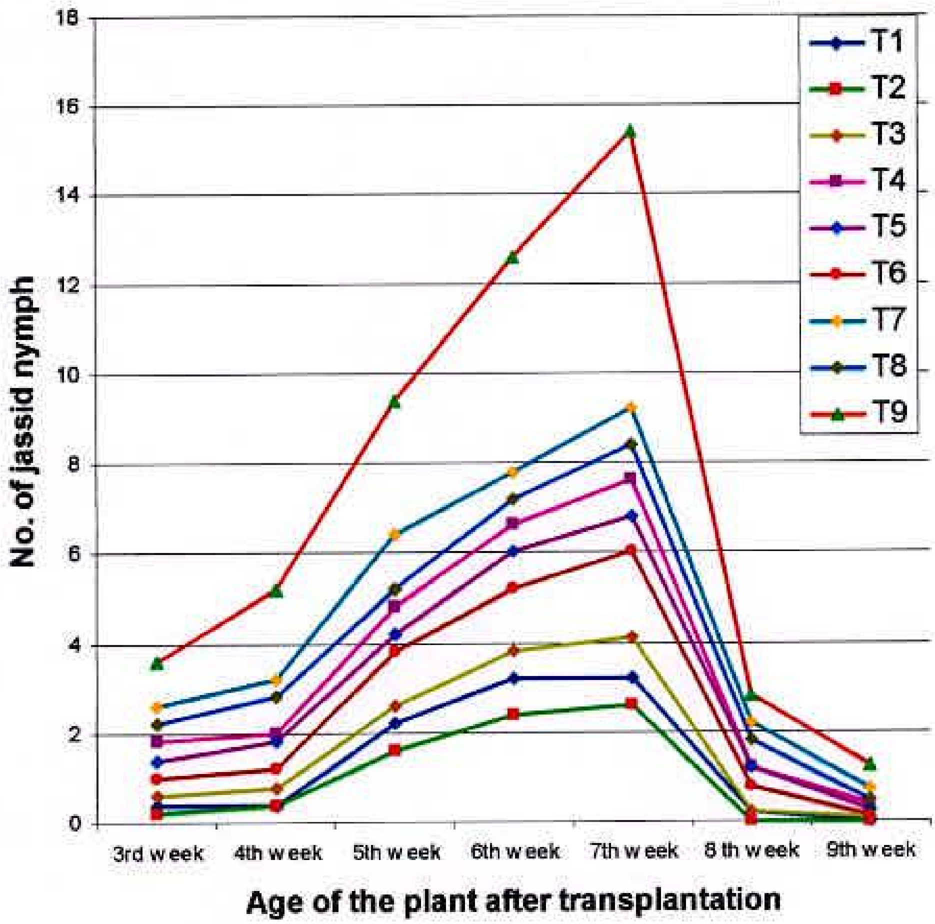

Figure 1. Population of jassid nymph in relation to age of the brinjal plant under different treatments.

T_1 = Admire 200SL @ 1.2 ml/liter of water
T_2 = Marshal 20EC @ 2 ml/liter of water
T_3 = Ripcord 10EC @ 1 ml/liter of water
T_4 = Actara 25WG @ 0.3 g/liter of water
T_5 = Neem seed kernel @ 5.0 g/liter of water
T_6 = Neem oil + Trix @ (3.0+1.0) ml/liter of water
T_7 = Trix @ 5 ml/liter of water
T_8 = Mahua leaf @ 5 g/liter of water
T_9 = Untreated control

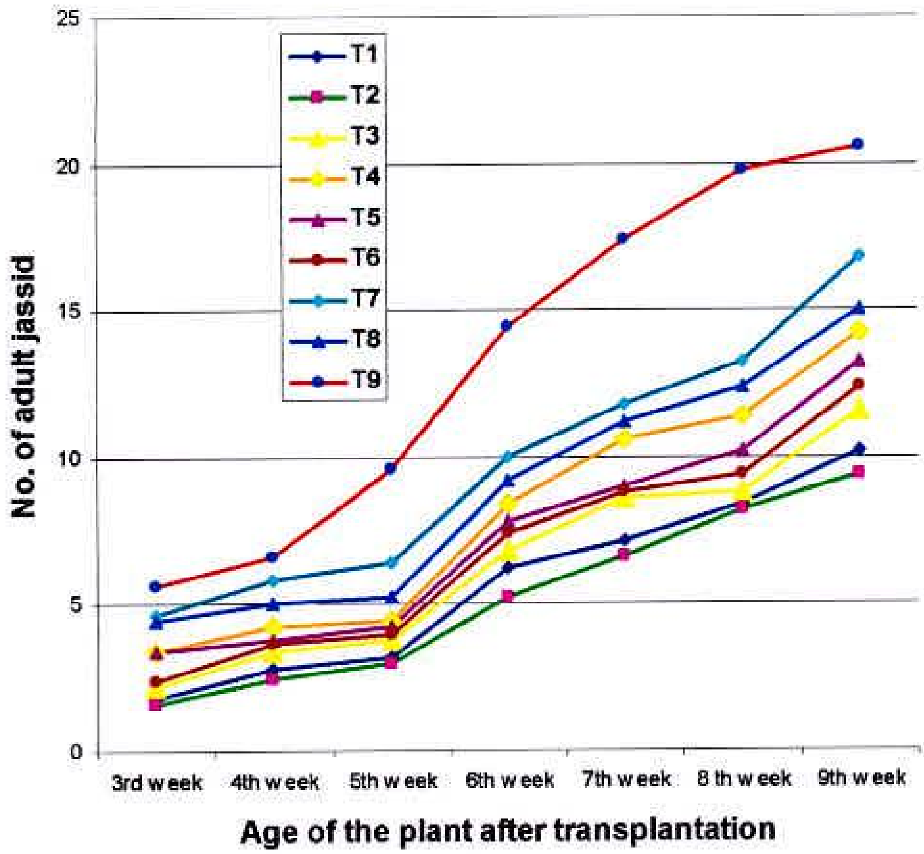

Figure 2. Population of adult jassid in relation to age of the brinjal plant under different treatments.

T_1 = Admire 200SL @ 1.2 ml/liter of water
T_2 = Marshal 20EC @ 2 ml/liter of water
T_3 = Ripcord 10EC @ 1 ml/liter of water
T_4 = Actara 25WG @ 0.3 g/liter of water
T_5 = Neem seed kernel @ 5.0 g/liter of water
T_6 = Neem oil + Trix @ (3.0+1.0) ml/liter of water
T_7 = Trix @ 5 ml/liter of water
T_8 = Mahua leaf @ 5 g/liter of water
T_9 = Untreated control

The findings of the study may contradict to findings of other researchers, However, it is logical because population of jassid varies with environmental temperature, relative humidity and rainfall. Shukla (1989) reported that the population of leaf hopper was positively correlated with temperature, relative humidity and total rainfall.

4.2 Effect of different treatments on jassid population

The effect of different treatments on adult and nymph of jassid was evaluated before fruiting and fruiting stage of brinjal. Before fruiting stage, the lowest number of adult/plant (2.36) was observed in Marshal 20EC treated plots, which was significantly lower than rest of the treatments. In contrast, significantly higher number of adult/plant (7.27) was obtained in control plots followed by (5.60) in Trix treated plot. Neem seed kernel treated plots had 3.80 adult /plant, which was significantly lower than control but statistically similar with that of the Actara 24WG treated plots (Table 1). The highest percent reduction (67.54%) of population over control was obtained by application of Marshal 20EC followed by 64.24% in Admire 200SL treated plots. Among the different treatments, Trix had the lowest effectiveness in reducing the adult /plant (22.97%). Neem seed kernel provided 47.73% reduction of adult /plant followed by Actara 24WG (44.98%) and no significant difference was found between them. Neem oil in combination with Trix and Mahua leaf extract also reduced the adult jassid population but their effectiveness was low.

Table 1. Number of adult jassid/5 leaves/plant under different treatments at two different stages of brinjal

Treatments	Dose	Before fruiting stage		Fruiting stage	
		Number of adult	Percent reduction over control	Number of adult	Percent reduction over control
Admire 200SL	1.2 ml/l	2.60 g	64.24	10.64 f	55.80
Marshal 20EC	2.0 ml/l	2.36 h	67.54	9.80 g	59.29
Ripcord 10EC	1.0 ml/l	3.13 f	56.95	11.93 f	50.44
Actara 25WG	0.3 g/l	4.00 d	44.98	14.87 d	38.22
Neem seed kernel	5.0 g/l	3.80 d	47.73	13.40 e	44.33
Neem oil + Trix	(3.0+1.0) ml/l	3.36 e	53.78	12.67 e	47.36
Trix	5.0 ml/l	5.60 b	22.97	17.27 b	28.25
Mahua leaf	5.0 g/l	4.87 c	33.01	15.93 c	33.82
Untreated control		7.27 a	--	24.07 a	--
LSD		**0.41**		**1.13**	
CV (%)		**6.78**		**7.05**	

Data are the mean value of 3 replications derived from 7 recordings before fruiting stage and 13 recordings at fruiting stage. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

During the fruiting stage, the lowest (9.80) number of adult per plant in plots treated with Marshal 20EC, which was significantly lower than all the treatments. Admire 200SL and Ripcord 10EC treated plots had 10.64 and 11.93 adult jassid per plant respectively having no significant difference between them (Table 1). On the other hand, significantly higher number of adult jassid/plant (24.07) was observed in untreated control. No significant difference was observed between adult jassid/plant treated with neem seed kernel and Neem oil in combination with Trix (13.40 and 12.67, respectively). The highest reduction of population over control (59.29%) recorded in Marshal 20EC treated plots followed by Admire 200SL and Ripcord 10EC treated plots(55.80%, 50.54%) at fruiting stage as against the lowest reduction (28.25%) of jassid population over control was recorded in Trix treated plots. Neem oil in combination with trix provided (47.36%) reduction of number of jassid population over control followed by (44.33%) in Neem seed kernel treated plots.

Similarly, the lowest population of nymph/plant (0.73) was observed in the treated plots with Marshal 20EC followed by Admire 200SL (1.00) and Ripcord 10EC (1.33) treated plots before fruiting stage and no significant difference was observed among them.

On the other hand, the highest population of nymph/plant (6.07) was obtained in control plots, which was significantly higher than all other treatments (Table 2). No significant difference was observed among populations of nymph in Actara 24WG, Neem seed kernel and Neem oil + Trix treated plots. In terms of reduction of population over control, Marshal 20EC showed the best effectiveness by reducing (87.97%) nymph population followed by Admire 200SL(83.53%) and Ripcord 10EC (78.09%) treated plots.

Table 2. Number of jassid nymph/5 leaves/plant under different treatments at two different stages of brinjal

Treatments	Dose	Before fruiting stage		Fruiting stage	
		Number of nymph	Percent reduction over control	Number of nymph	Percent reduction over control
Admire 200SL	1.2 ml/l	1.00 e	83.53	2.20 d	79.42
Marshal 20EC	2.0 ml/l	0.73 e	87.97	1.67 d	84.38
Ripcord 10EC	1.0 ml/l	1.33 e	78.09	2.73 d	74.46
Actara 25WG	0.3 g/l	2.87 d	52.72	5.27 b	50.70
Neem seed kernel	5.0 g/l	2.47 d	59.31	4.76 c	55.47
Neem oil + Trix	(3.0+1.0) ml/l	2.00 d	67.05	4.04 c	62.21
Trix	5.0 ml/l	4.07 b	32.95	6.64 b	37.89
Mahua leaf	5.0 g/l	3.40 c	43.99	5.96 b	44.25
Untreated control		6.07 a	--	10.69 a	--
LSD		**6.09**		**1.35**	
CV (%)		**5.96**		**8.33**	

Data are the mean value of 3 replications derived from 7 recordings before fruiting stage and 13 recordings at fruiting stage. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

Neem oil + Trix provided (67.05%) reduction of nymph/plant followed by Neem seed kernel (59.31%) and Actara 24WG (52.72%). The results (Table 2) also reveal that the lowest number of nymph/plant (1.67) was observed in Marshal 20EC treated plots followed by in Admire 200SL and Ripcord 10EC treated plots (2.20 and 2.73, respectively) during fruiting stage having no significant difference among them. Control plots had the highest number of nymph/plant (10.69), which was significantly higher than all other treatments. No significant difference was observed among populations of nymph in Actara 24WG, Neem seed kernel and Neem oil + Trix treated plots. The highest reduction of nymph/plant (84.38%) was achieved by application of Marshal 20EC followed by Admire 200SL and Ripcord 10EC (79.42% and 74.46%, respectively). Neem oil + Trix provided (62.21%) reduction of nymph population over control followed by Actara 200SL (50.70%) and Neem seed kernel (55.47%). Mahua leaf extract reduced (44.25%) nymph population over control which was higher than Trix (37.89%).

The above results indicate that Marshal 20EC was the most effective insecticide against the nymph and adult jassid in brinjal; Admire 200SL and Ripcord 10EC also showed the similar effectiveness but none of the insecticides was able to exceed the standard level of 80% reduction in case of adult in both stages of the crop. However, Marshal 20EC were able to exceed the standard level (80%) of nymph population reduction over control in both stages of crop while Admire 200SL and Ripcord 10EC were able to exceed the standard level of reduction (80%) of nymph/

plant before fruiting stage. Neem seed kernel, Actara 24WG and Neem oil + Trix were moderately effective against jassid in brinjal and Trix showed the least effectiveness in reducing jassid population. Mahua leaf extract had considerable effect on reduction of jassid population in brinjal but its effectiveness was low.

The results, efficacy of Admire 200SL against jassid agree to the study of Misra and Senapati (2003) who reported that Imidacloprid gave the significant control of jassid.

However, these findings partially contradict to the findings of Kaur (2002) who observed higher efficacy of Cypermethrin against population of cotton jassid. The difference in results may be due to different crop and ecological conditions. The higher efficacy of Marshal 20EC against jassid population on brinjal could not compare with that of the others due to lack of available information. The moderate effect of Neem seed kernel against jassid population in the present investigation confirms the findings reported by Mote and Bhavikatti (2003) and Ofori and Sackey (2003), who observed that aqueous Neem seed extract was moderately effective against jassid. These results also contradict with those of Singh and Kumar (2003) who reported the highest efficacy of Neem seed kernel in controlling okra jassid. Consequently, the difference of the results is logical because effectiveness of any insecticides may vary with crop canopy, spraying methods and ecological variations. Moreover, the effectiveness of Trix obtained in the present study agrees with the results of Hossain *et al*. (2003) who reported that soap powder application reduced the jassid population of cotton.

4.3 Effect of different treatments on yield contributing characters and yield of brinjal against jassid infestation

Effect on number of leaves/plant and leaf infestation: The results on the effect of different treatments on leaf infestation caused by the jassid have been studied. A remarkable variation was observed in number of healthy and infested leaves/plant and percent leaf infestation in different treatments. The highest number of healthy leaves/plant (36.71) was recorded in Marshal 20EC followed by Admire 200SL (36.29), Ripcord 10EC (35.98), Neem seed kernel (34.90) and Neem oil + Trix (35.42), respectively having no significant difference among them (Table 3).

On the other hand, the lowest number of healthy leaves/plant (30.36) was recorded in untreated control, which was significantly lower than all other treatments. No significant difference was observed among the healthy leaves/plant for Actara 24WG, Neem seed kernel, Mahua leaf extract and Trix treated plots. The lowest leaf infestation (9.51%) was found in the plots treated with Marshal 20EC followed by Admire 200SL (10.12%) with no significant difference between them. In contrast, (21.50%) leaf infestation was obtained in control plot, which was significantly higher than all the treatments. In terms of percent reduction of leaf infestation over control, all treatments reduced considerable amount of the leaf infestation. The highest reduction of leaf infestation (55.77%) was recorded in Marshal 20EC treated plots followed by (52.93%) in Admire 200SL and (50.98%) in Ripcord 10EC treated plots. Neem oil + Trix, Neem seed kernel and Actara 24WG, respectively reduced (46.79%), (43.21%) and (39.44%) leaf infestation over control. Trix reduced only (26.28%) leaf infestation which was significantly lower than other insecticides.

Table 3. Effect of different treatment on leaves per plant in number for population dynamics and management of jassid in brinjal

Treatments	Dose	Number of leaves/plant		Percent leaf infestation	Percent reduction of leaf infestation
		Healthy	Infested		
Admire 200SL	1.2 ml/l	36.29 ab	3.92 fg	10.12 gh	52.93
Marshal 20EC	2.0 ml/l	36.71 a	3.75 g	9.51 h	55.77
Ripcord 10EC	1.0 ml/l	35.98 ab	4.03 f	10.54 fg	50.98
Actara 25WG	0.3 g/l	34.46 bcd	4.61 d	13.02 d	39.44
Neem seed kernel	5.0 g/l	34.90 abcd	4.44 de	12.21 de	43.21
Neem oil + Trix	(3.0+1.0) ml/l	35.42 abc	4.26 e	11.44 ef	46.79
Trix	5.0 ml/l	33.28 d	5.41 b	15.85 b	26.28
Mahua leaf	5.0 g/l	34.07 cd	5.02 c	14.62 c	32.00
Untreated control		30.36 e	6.82 a	21.50 a	--
LSD		**1.67**	**0.22**	**0.93**	
CV(%)		**2.79**	**2.69**	**4.07**	

Data are the mean value of 3 replications derived from 10 recordings. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

4.4 Effect on number of branches/plant: The number of branches/plant at different days after transplanting was significantly influenced by the application of different treatments. The results revealed that the highest number of branches/plant (10.20) was recorded from Marshal 20EC treated plots followed by Admire 200SL (9.80) treated plots with no significant difference between them (Figure 3). Statistically similar number branches/plant was observed in Admire 200SL and Ripcord 10EC treated plots (9.80 and 9.60, respectively). The lowest number of branches/plant (6.40) was observed in control plots, which was significantly lower than all treatments. Among the different chemicals and botanicals Trix had the lowest number of branches/plant (7.60), having no significant difference with that of the Mahua leaf treatment (7.80).

4.5 Effect on number of fruits/plant: The result revealed that the highest number of fruits/plant (29.71) was obtained in Marshal 20EC treated plots followed by (28.05) in Admire 200SL treated plots during summer season (Feb- Aug 2007) with no significant difference between them. Next to them, Ripcord 10EC treated plots had (26.94) fruit/plant, which was statistically similar with Admire 200SL but significantly higher than other treatments. In contrast, the lowest number of fruit/plant (15.68) was recorded from control plots, which was significantly lower than all insecticides treated plots (Table 4). In terms of increase of fruit over control Marshal 20EC and Admire 200SL gave the highest result of (89.48%) and (78.89%) respectively, Ripcord 10EC increased (71.81%) fruits/plant, while Neem oil + Trix and Neem seed kernel treatments respectively increased (55.10%) and (51.40%) fruits/ plant. Other treatments also increased significant number of fruits/plant but their effectiveness was not satisfactory.

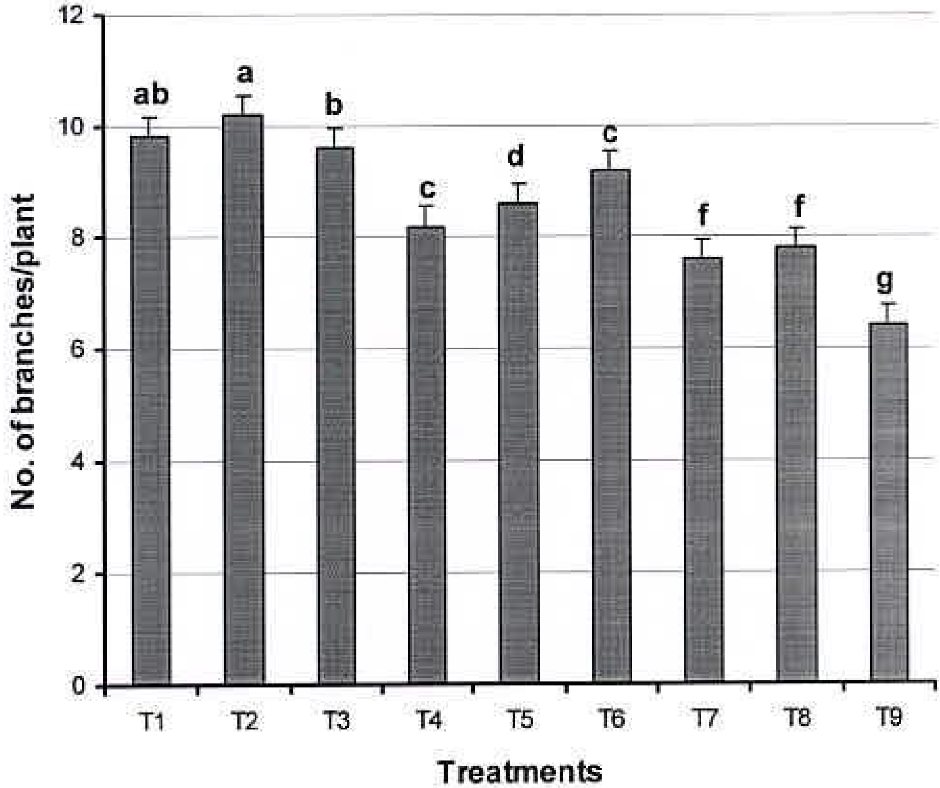

Figure 3. Average number of branches per plant in different treatments. Columns annotated with the same letter are statistically identical ($P > 0.05$, Duncan multiple range test). The T-shaped beams represent the LSD values.

T_1 = Admire 200SL @ 1.2 ml/liter of water
T_2 = Marshal 20EC @ 2 ml/liter of water
T_3 = Ripcord 10EC @ 1 ml/liter of water
T_4 = Actara 25WG @ 0.3 g/liter of water
T_5 = Neem seed kernel @ 5.0 g/liter of water
T_6 = Neem oil + Trix @ (3.0+1.0) ml/liter of water
T_7 = Trix @ 5 ml/liter of water
T_8 = Mahua leaf @ 5 g/liter of water
T_9 = Untreated control

Table 4. Effect of different treatments on number fruits per plant of brinjal against jassid infestation

Treatments	Dose	Total number of fruits per plant	Percent increase of fruit/plant over control
Admire 200SL	1.2 ml/l	28.05 ab	78.89
Marshal 20EC	2.0 ml/l	29.71 a	89.48
Ripcord 10EC	1.0 ml/l	26.94 b	71.81
Actara 25WG	0.3 g/l	22.16 d	41.33
Neem seed kernel	5.0 g/l	23.74 c	51.40
Neem oil + Trix	(3.0+1.0) ml/l	24.32 c	55.10
Trix	5.0 ml/l	20.14 e	28.44
Mahua leaf	5.0 g/l	22.58 d	44.01
Untreated control		15.68 f	--
LSD		**1.41**	
CV (%)		**8.97**	

Data are the mean value of 3 replications derived from 12 recordings. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

4.6 Effect on fruit length: The effect of different chemical and botanical insecticides on brinjal fruit length against jassid infestation has been presented in (Table 5). The result reveals that the highest fruit length (12.90 cm) was observed in Marshal 20EC treated plots followed by (12.76 cm) and (12.62 cm) in Admire 200SL and Ripcord 10EC, respectively with no significant difference among them. Next to them, Neem oil + Trix treated plots had (12.39 cm) fruit length of brinjal followed by (12.08 cm) in Neem seed kernel having no significant difference between them. The lowest fruit length of brinjal (10.72 cm) was recorded from control plots, which was significantly lower than all other treated plots. In terms of increase of fruit length over control, Marshal 20EC showed the best performance by increasing (20.34%) fruit length followed by Admire 200SL and Ripcord 10EC (19.03% and 17.72% respectively). On the other hand, Trix and Mahua leaf showed the least effectiveness in increasing length of fruit.

4.7 Effect on fruit diameter: Application of different chemical and botanical insecticides had a considerable effect on average fruit diameter of brinjal. The result reveals that the highest diameter of brinjal fruit (3.01 cm) was recorded from Marshal 20EC treated plots, which was significantly higher than other treatments. Next to it, Admire 200SL and Ripcord 10EC showed the better performance (2.88 cm 2.83 cm, respectively) regarding this parameter (Table 6). The lowest diameter of brinjal fruit (2.14 cm) was recorded from control plots, which was significantly lower than all other treatments. In terms of increasing fruit diameter, Marshal 20EC showed the best performance (40.65%) followed by Admire 200SL and Ripcord 20EC, which increased (34.58%) and (32.24%) respectively. On the other hand, Trix showed the lowest performance by increasing only (10.28%) fruit diameter. Neem oil + Trix and Neem seed kernel provided (28.50%) and (24.30%) increase of fruit diameter over control.

Table 5. Average length/fruit of brinjal in different treatments against jassid infestation

Treatments	Dose	Average length of brinjal (cm)	Percent increase of fruit length over control
Admire 200SL	1.2 ml/l	12.76 ab	19.03
Marshal 20EC	2.0 ml/l	12.90 a	20.34
Ripcord 10EC	1.0 ml/l	12.62 ab	17.72
Actara 25WG	0.3 g/l	11.94 d	11.38
Neem seed kernel	5.0 g/l	12.08 cd	12.69
Neem oil + Trix	(3.0+1.0) ml/l	12.39 bc	15.58
Trix	5.0 ml/l	11.46 e	6.90
Mahua leaf	5.0 g/l	11.70 de	9.14
Untreated control		10.72 f	--
LSD		**0.39**	
CV(%)		**5.85**	

Data are the mean value of 3 replications derived from 12 recordings. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

Table 6. Average diameter/fruit of brinjal in different treatments against jassid infestation

Treatments	Dose	Average diameter/fruit (cm)	Percent increase of fruit diameter over control
Admire 200SL	1.2 ml/l	2.88 b	34.58
Marshal 20EC	2.0 ml/l	3.01 a	40.65
Ripcord 10EC	1.0 ml/l	2.83 bc	32.24
Actara 25WG	0.3 g/l	2.55 e	19.16
Neem seed kernel	5.0 g/l	2.66 d	24.30
Neem oil + Trix	(3.0+1.0) ml/l	2.75 cd	28.50
Trix	5.0 ml/l	2.36 f	10.28
Mahua leaf	5.0 g/l	2.48 e	15.89
Untreated control		2.14 g	--
LSD		**0.11**	
CV(%)		**6.47**	

Data are the mean value of 3 replications derived from 12 recordings. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

4.8 Effect on individual fruit weight: The highest weight of brinjal fruit (80.96 g) was recorded from Marshal 20EC treated plots, followed by (78.13 g) and (74.85 g) in Admire 200SL and Ripcord 10EC, respectively but weight of individual fruit in Marshal 20EC was significantly higher than all other treatments (Figure 4). No significant difference was observed in individual fruit weight of Ripcord 10EC and Neem oil + Trix (74.85 g and 73.03 g, respectively). Neem seed kernel and Actara 24WG also gave the statistically similar fruit weight against jassid attack (70.19g and 68.68g, respectively). The lowest weight of individual fruit (59.02g) was observed in control, which was significantly lower than all other treatments.

4.9 Effect on yield of brinjal: The effect of different insecticides on jassid had influenced on yield of brinjal. The data (Table 7) indicates that the maximum yield of brinjal (29.58 t/ha) was obtained in Marshal 20EC followed by (28.85 t/ha) in Admire 200SL treated plots during summer season having no significant difference between them. In contrast, it was only (20.45 t/ha) in control plots, which was significantly lower than all other treatments. Ripcord 10EC and Neem oil + Trix sprayed plots produced (27.74 t/ha) and (26.78 t/ha), respectively which were significantly higher than that of other treatments. Neem seed kernel and Actara 24WG gave (25.70 t/ha) and (24.90 t/ha), respectively with no significant difference between them. In terms of increase of yield over control, all chemical and botanical insecticides increase yield over control but their effectiveness were varied. Marshal 20EC increased the highest percent of yield (44.65%) over control followed by Admire 200SL (41.08%) and Ripcord 10EC (35.65%) respectively.

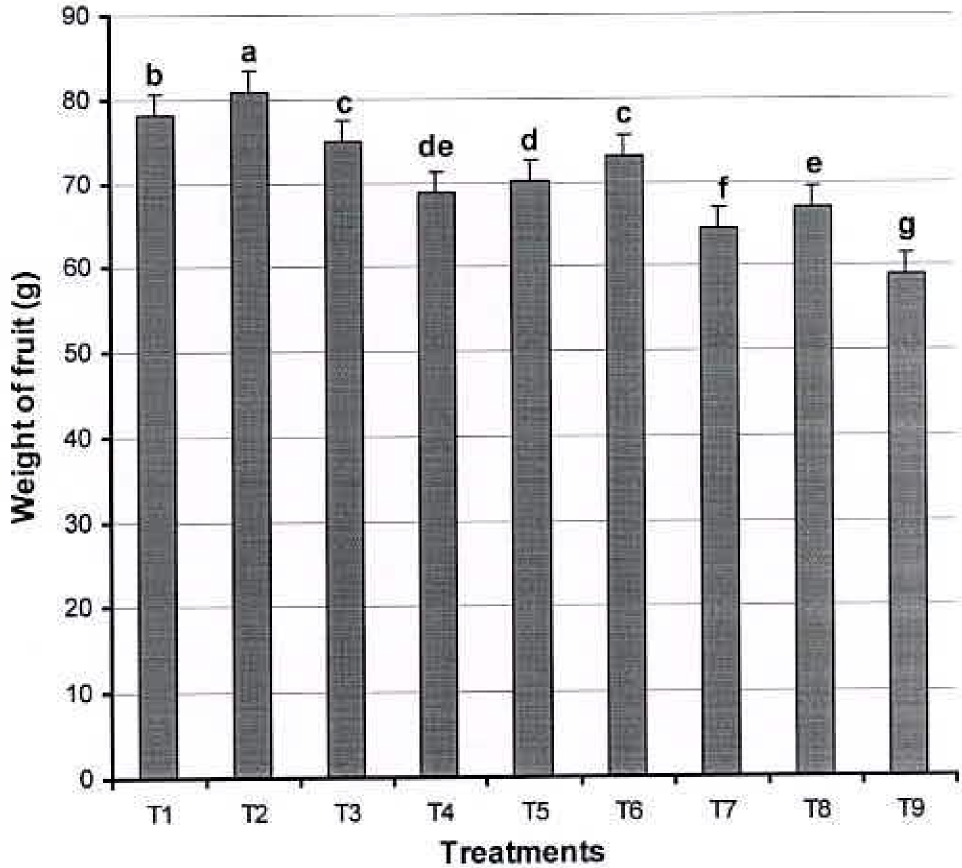

Figure 4. Average weight of individual fruit in different treatments against jassid infestation. Values having different letters are significantly different ($P < 0.05$, Duncan Multiple Range Test). The T-shaped beams represent the LSD values.

T_1 = Admire 200SL @ 1.2 ml/liter of water
T_2 = Marshal 20EC @ 2 ml/liter of water
T_3 = Ripcord 10EC @ 1 ml/liter of water
T_4 = Actara 25WG @ 0.3 g/liter of water
T_5 = Neem seed kernel @ 5.0 g/liter of water
T_6 = Neem oil + Trix @ (3.0+1.0) ml/liter of water
T_7 = Trix @ 5 ml/liter of water
T_8 = Mahua leaf @ 5 g/liter of water
T_9 = Control

Table 7. Average fruit yield of brinjal in different treatments against jassid infestation

Treatments	Dose	Yield (t/ha)	Percent increase of yield over control
Admire 200SL	1.2 ml/l	28.85 ab	41.08
Marshal 20EC	2.0 ml/l	29.58 a	44.65
Ripcord 10EC	1.0 ml/l	27.74 bc	35.65
Actara 25WG	0.3 g/l	24.90 ef	21.76
Neem seed kernel	5.0 g/l	25.70 de	25.67
Neem oil + Trix	(3.0+1.0) ml/l	26.78 cd	30.95
Trix	5.0 ml/l	22.87 g	11.83
Mahua leaf	5.0 g/l	24.01 fg	17.41
Untreated control		20.45 h	--
LSD		**1.39**	
CV(%)		**3.12**	

Data are the mean value of 3 replications; each replication is derived from 12 recordings. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

Neem oil + Trix and Neem seed kernel increased (30.95%) and (25.67%) yield over control. (Table 7). also reveals that other treatments increased yield but their effectiveness were not satisfactory.

The results obtained in the present investigation suggest that the application of different chemical and botanical insecticides reduce the jassid infestation on brinjal as well as increase the yield contributing characters such as number of leaves/plant and branches/plant, total number of fruits/plant, fruit length and diameter, individual fruit weight and overall, yield of brinjal. But the efficacy of those chemicals and botanicals insecticides varied greatly depending on the biological activities of the pesticides. Among the different insecticides, Marshal 20EC and Admire 200SL performed the best effectiveness in all the parameters ensuring higher fruit yield of brinjal. Next to them Ripcord 10EC and Neem oil + Trix provided the satisfactory protection of jassid attack. Neem seed kernel and Actara 24WG showed moderate effect against jassid and increased the yield contributing characters and fruit yield of brinjal. Other insecticides also ensured higher fruit yield of brinjal but their effect was not satisfactory.

The higher efficacy of Marshal 20EC against jassid infestation on brinjal could not be compared with that of the others due to lack of information. The efficacy of Admire 200SL against jassid was similar to the study of some researchers (Misra and Senapati 2003, Anon. 2005) who observed that Admire 200SL gave the significant control of jassid and increased the fruit yield of okra. However, these findings partially coincide with those Kaur (2002), who reported higher efficacy of

Cypermethrin against population of cotton jassid. The difference in results may be due to different crop and ecological conditions. Moreover, the efficacy of the Actara 24WG found in this study contradicts with that of Misra and Senapati (2003). They observed excellent control of jassid and significant increase of okra fruit yield by application Actara 24WG (Thiomethoxam). The moderate effect of Neem seed kernel against jassid population in the present investigation confirms the findings reported by other researchers (Anon. 2005, Mote and Bhavikatti 2003, Ofori and Sackey 2003), who published that aqueous Neem seed extract was moderately effective against jassid. These results contradict with those of Singh and Kumar (2003) who reported the highest efficacy of Neem seed kernel in controlling okra jassid. However, the difference of the results is logical because effectiveness of any insecticides may vary with crop canopy, spraying methods and ecological variations. Nevertheless, the effectiveness of Trix obtained in the present study agrees with the results of Hossain *et al.* (2003) who observed that soap powder application reduced the jassid population of cotton.

4.10 Benefit Cost Analysis

Economic analysis for the management of jassid by some chemical and botanical insecticides on brinjal is presented in (Table 8). The results reveal that the highest benefit cost ratio (2.28) was obtained in the plot treated with Marshal 20EC followed by Admire 200SL (2.10) and Ripcord 10EC (2.04) treated plots, respectively. BCR of (1.88) and (1.85) was obtained in Mahua leaf and Neem oil + Trix treated plots, respectively. Neem seed kernel gave the BCR of (1.70), which was higher than Actara 24WG treated plots (1.57). On the other hand, the lowest BCR (1.19) was recorded for Trix treated plot. Similarly, the net return was also found the highest (Tk. 330071/-/ha) in Marshal 20EC treated plot followed by Admire 200SL and Ripcord 10EC treated plots (313715/- and 304092/- Tk./ha) respectively. The present findings agree with the results reported by Ali and Karim (1994) in Bangladesh and Pawer and Lawande (1993), who observed that application of insecticides resulted higher crop yield and higher benefit cost ratio of okra.

Table 8. Economic analysis of different chemicals and botanicals for management of jassid in brinjal

Treatments	Cost of pest management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net return (Tk.)	Adjusted net return (Tk)	Benefit Cost Ratio (BCR)
T_1	32485	28.85	346200	313715	68315	2.10
T_2	24889	29.58	354960	330071	56765	2.28
T_3	28788	27.74	332880	304092	58692	2.04
T_4	20800	24.90	298800	278000	32600	1.57
T_5	23333	25.70	308400	285067	39667	1.70
T_6	26667	26.78	321360	294693	49293	1.85
T_7	13252	22.87	274440	261188	15788	1.19
T_8	14814	24.01	288120	273306	27906	1.88
T_9	0	20.45	245400	245400	--	--

Cost of insecticides : Admire: Tk.110/15 ml, Marshal: Tk. 42/50 ml, Ripcord: 120/100 ml, Actara: 35/5 g, Neem Seed Kernel: Tk.150/kg, Neem oil: Tk. 150/l, Trix: Tk. 60/500 ml

Cost of spray : Two labourers/spray/ha @ Tk 120.00/day. Spray volume required: 500 l/ha

Cost of mahua leaf : Two labourers/spray/ha

Market price of brinjal : Tk 12.00/ kg.

T_1 = Admire 200SL @ 1.2 ml/liter of water
T_2 = Marshal 20EC @ 2 ml/liter of water
T_3 = Ripcord 10EC @ 1 ml/liter of water
T_4 = Actara 25WG @ 0.3 g/liter of water
T_5 = Neem seed kernel @ 5.0 g/liter of water
T_6 = Neem oil + Trix @ (3.0+1.0) ml/liter of water
T_7 = Trix @ 5 ml/liter of water
T_8 = Mahua leaf @ 5 g/liter of water
T_9 = Control

4.11 Effect of different treatments on natural enemies in the brinjal field

The effect of different chemicals and botanicals on the population of spider and lady bird beetle in brinjal field have been studied and presented in Table 9 and 10. The data (Table 9) reveal that Marshal 20EC treated plots had the lowest number of spider (0.08/5leaves/plant), which was significantly different from all other treatments. In contrast the highest number of spider (1.49/5leaves/plant) was observed in control plots, which was significantly higher than all other treatments. The other treatments had significantly lower number of spiders than control. In terms of reduction of spider population, all chemical and botanical insecticides reduced the spider population in the brinjal field. Marshal 20EC reduced (94.63%) spider population in brinjal field followed by Admire 200SL, Ripcord 10EC and Neem oil + Trix, which reduced (87.92%), (76.51%) and (71.14%) spider population respectively. Neem seed kernel and Actara 24WG had moderate effect while Mahua leaf and Neem oil + Trix less effect in reducing spider population in brinjal field.

Table 9. Effect of different treatments on population of spider for managing jassid in brinjal field

Treatments	Dose	Average number spider/plant	Percent decrease over control
Admire 200SL	1.2 ml/l	0.18 f	87.92
Marshal 20EC	2.0 ml/l	0.08 g	94.63
Ripcord 10EC	1.0 ml/l	0.35 e	76.51
Actara 25WG	0.3 g/l	0.65 c	56.38
Neem seed kernel	5.0 g/l	0.54 d	63.76
Neem oil + Trix	(3.0+1.0) ml/l	0.43 e	71.14
Trix	5.0 ml/l	0.85 b	42.95
Mahua leaf	5.0 g/l	0.78 b	47.65
Untreated control		1.49 a	--
LSD		**0.08**	
CV(%)		**7.78**	

Data are the mean value of 3 replications; each is derived from 20 recordings. In a column, mean having similar letter(s) are statistically identical at 5% level of significance.

Table 10. Effect of different treatments on population of lady bird beetle for management of jassid in the brinjal field

Treatments	Dose	Average number lady bird beetle/plant	Percent decrease over control
Admire 200SL	1.2 ml/l	0.21 g	91.89
Marshal 20EC	2.0 ml/l	0.14 g	94.59
Ripcord 10EC	1.0 ml/l	0.31 f	88.03
Actara 25WG	0.3 g/l	0.58 d	77.61
Neem seed kernel	5.0 g/l	0.50 e	80.69
Neem oil + Trix	(3.0+1.0) ml/l	0.42 e	83.78
Trix	5.0 ml/l	0.79 b	69.50
Mahua leaf	5.0 g/l	0.70 c	72.97
Untreated control		2.59 a	--
LSD		**0.08**	
CV(%)		**6.57**	

Data are the mean value of 3 replications; each is derived from 20 recordings. In a column, means having similar letter(s) are statistically identical at 5% level of significance.

Similarly, the results (Table 10) reveal that the lowest number of lady bird beetle (0.14/5leaves/plant) was observed in Marshal 20EC followed by Admire 200SL (0.21/5leaves/plant) having no significant difference between them. In contrast, the highest number of lady bird beetle (2.59/5 leaves/plant) was observed in control, which was significantly higher than all other treatments. The other chemicals and treatments had significantly lower number of lady bird beetle than control. In terms of reduction of lady bird beetle population all chemicals and botanicals reduced the population of lady bird beetle in brinjal field. Marshal 20EC, Admire 200SL, Ripcord 10EC, Neem oil + Trix and Neem seed kernel reduced more than 80% lady bird beetle population over control in brinjal field but Marshal 20EC and Admire 200SL had the strong negative impact on lady bird beetle. Other treatments had moderate effect on these two predators in the brinjal field.

The result thus obtained in the study indicate that Marshal 20EC, Admire 200SL, Ripcord 10EC and Neem oil + Trix had strong negative effect, Actara 24WG and Neem seed kernel had moderate impact on predaceous insect in brinjal field. The findings of the current study suggest that Trix and Mahua leaf extract have no deleterious effect on spider under field condition when applied at seven days intervals. The negative impact of most of the insecticides against lady bird beetle and spider thus obtained in the present study agrees with the findings reported by many researchers. FAO (2003) reported that application of insecticides reduced the population of beneficial insect especially spiders and lady bird beetle from the brinjal plant. Maleque *et al*. (1999) and Rahman (2006) reported that the lady bird beetles and spiders were seriously affected in the field where Cypermethrin was applied at weekly intervals. Less toxicity of Admire 200SL against different species of lady bird beetle and spider was also reported by other researchers (Kannan *et al.* 2004, Katole and Patil 2000), which contradicts the findings of the present study. The difference in results may be due to different crops and ecological conditions.

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The current study was carried out at the experimental farm of Sher-e-Bangla Agricultural University Dhaka, Bangladesh, during the period from Feb-Aug 2007 to evaluate the effectiveness of some chemical and botanical insecticides in managing the jassid of brinjal crop and their impact on natural enemies. To meet the objectives, nine treatments consisting Admire 200SL, Marshal 20EC, Ripcord 10EC, Actara 24WG, Neem seed kernel, Neem oil + Trix, Trix, Mahua leaf extract and untreated control were tested.

The population of jassid adult was gradually increased in all the treatments with progressing of the plant age. Although, the population of jassid nymph was increased with the plant age up to 7th week after transplantation however, it was declined later on. The population of jassid nymph was always higher in control than all other treatments. The lowest number of adult (2.36/plant before fruiting stage and 9.80/plant during fruiting stage) and nymph (0.73/plant before fruiting stage and 1.67/plant during fruiting stage) was observed in Marshal 20EC treated plots, which also reduced the maximum population of the pest

All the treatments significantly reduced the jassid infestation and increased the number of leaves and branches per plant. Application of Marshal 20EC gave the highest number of leaves (36.71) and branches (10.20) per plant. Admire 200SL also showed the similar performance regarding these parameters.

Jassid infestation on brinjal reduces the number of fruits/plant, fruit length and diameter as well as individual fruit weight. Marshal 20EC produced the maximum number of fruits/plant (29.71) and increased (89.48%) fruits/plant over control. Neem oil + Trix and Neem seed kernel extract application also increased more than 50% fruits/plant. Application of all the treatments increased considerable amount of fruit length, diameter and weight of individual fruits. Among the chemicals, Marshal 20EC and Admire 200SL gave the maximum results for these parameters. On the other hand, Neem oil + Trix and Neem seed kernel extract significantly increased the yield contributing characters of brinjal.

Yield of brinjal significantly varied in different treatments and the best results were obtained by application of Marshal 20EC and Admire 200SL (29.58 t/ha, 28.85 t/ha), which increased more than 40% yield of brinjal. Neem oil + Trix and Neem seed kernel treatments also gave the higher yield over control and increased considerable amount of fruit yield.

The highest benefit cost ratio (2.28) was obtained by the application of Marshal 20EC @ 2 ml/l of water at weekly intervals. Almost similar BCR (2.10) was obtained by application of Admire 200SL @ 1.2 ml/l of water applied at same interval. Neem oil + Trix, and Neem seed kernel application gave the BCR of (1.85

and 1.70), respectively. Trix provided the lowest protection, minimum yield and the lowest BCR (1.09).

All the chemicals and botanicals significantly reduced the natural enemy population in brinjal agroecosystem. Marshal 20EC, Admire 200SL and Ripcord 10EC had the strong negative impact on spider and lady bird beetles while Neem oil+ Trix and Neem seed kernel had moderate effect on these two predators.

Based on the above results it can be concluded that Marshal 20EC @ 2 ml/l of water and Admire 200SL @ 1.2 ml/l of water may have good impact for the management of jassid, *Amrasca devastans* in brinjal but it is necessary to fix up the appropriate dose of these two insecticides and also requires further investigation in large scale farmer's field.

References

REFERENCES

Afzal, M. and Ghani, M. A. (1953). Cotton jassid in Panjab. The Pakistan Association for the Advancement of Science, University institute chemistry. Lahore. 101pp.

Afzal, M., Latif, Z. and whalia, M. A. (1996). The comperative efficacy of different doses of Tamaraon 600SL (Methamidophos) against *Amrasca devastans*. *Pakistan Entomologist.* **18** (1-2): 38-40.

Alam, M. Z. (1969). Insect pest of vegetable and their control in East Pakistan publish by the Agriculture Information Services, Department of Agriculture, 3, R. K. Mission Road, Dhaka-3. East Pakistan.

Alam, S. N., Rashid, M. A., Rouf, F. M. A., Jhala, R. C., Patel, J. R., Satpaphy, S. Shivlingaswamy, T. M., Rai, S., Wahundeniya, I., Cork, A., Ammaranan, C. and Talekar, N. S. (2003). Development of an integrated pest management strategy for egg plant fruit and shoot borer in south asia. Technical Bulletin 28, AVRDC- The world vegetable center, Shanhua, Taiwan, 66p.

Alam, M. S. (2005). Efficacy of Some synthetic and botanical insecticides in controlling okra jassid *(Amrasca devastams*). M. S Thesis. Department of Entomology, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Alam, S. N., Sarker, D and Rahman, A. K. M. Z. (2005). Annual Report. Division of Entomology, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp. 82.

Alam, S. N., Hossion, M. I., Rouf, F. M. A., Jhala, R. C., Patel, M.G., Nath, L. K., Sengupta, A., Baral, K., Shylesha, A. N., Satpathy, S., Shivalingaswamy, T. M., Cork, A. and Talekar,N. S. (2006). Control of egg plant and shoot and fruit borer in South Asia. Technical Bulletin 36, AVRDC- The World Vegetable Center, Shanua, Taiwan. 88p.

Ali, M. I. (1987). Report on the entomological experiments on cotton. Division of entomology, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp. 34.

Ali, M. I. (1990). The development of systems due to attack of the cotton jassid, *Amrasca biguttula* (Homoptera: Jassidae) on cotton. *Bangladesh J. Zool.* **18** (2): 211-214.

Ali. M. I. and Karim, M. A. (1991). Plant-age-specific seasonal abundance of cotton jassid on cotton plants. *Bangladesh J. Agril. Res.* **16**(1): 11-16.

Ali, M. I. and Karim, M. A. (1993). Biological efficacy of some chemical insecticides against the cotton jassid, *Amrasca devastans* (Dist.) *Bangladesh J. zool.* **21** (1): 161-167.

Ali, M. I. and Karim, M. A. (1994). Spraying threshold level of cotton jassid, *Amrasca devastans* (Dist.) on cotton in Bangladesh. *Bangladesh J. Zool.* **21** (1) : 47-54.

Anonymous. (1993). Research and development of vegetable crops. Paper presented in the workshop on Research and Development of vegetable crops held on march 9-10, 1993 at IPSA, Gazipur. pp. 1-7.

Anonymous. (2004). Statistical pocket book of Bangladesh. Bangladesh Bureau of Statistics. Government of the Peoples Republic of Bangladesh, Dhaka, Bangladesh. 155p.

Anonymous. (2005). Development of a management Approach against jassid Infestation on lady`s finger (*Abelmoschus esculentus*). Annual Research Report, Entomology Division, Bangladesh Agriculture Research Institute Gazipur, Bangladesh. pp. 5-6.

Arif, M. I., Attique, M. R. and Ahmad, Z. (1998). Comparison of different methods of sampling of cotton jassid, *Amrasca devastans* (Distant) (Homoptera: Cicadellidae). *Pakistan J. Zool.* **30**(2) : 151-154.

Atwal, A. S. (1986). Agricultural pests of India and South-East Asia. Kalyani Publishers. New Delhi. pp. 279-280.

Bellis, G. A., Donaldson, M., Carver, D. L., Hancock and Fletcher, M. J. (2004). Record of insect pests on Christmas Island and (Keeling) Islands, Indian Ocean. *Australian Entomologist.* **31** (3): 93-102.

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**: 169-173.

Bhaduri, N., Ram, S. and Patil, B. D. (1989). Evaluation of some plant extracts as protectants against the pulse beetle, *Callosobruchus maculates* (Fab.) infestaing cowpea seeds. *J. Entomol. Res.* **9**(2): 183-187.

Bhargava, K. K., Sharma, H. C. and Kaul, C. L. (2001). Bioefficacy of insecticides against okra jassid and fruit borer. *Pest Management and Economic Zoology*. **9**(2): 193-195.

Bohlen, E. (1984). Cotton pests in Bangladesh. A field guide for identification and control. Bangladesh Cotton development board, Dhaka Bangladesh. pp. 1-6.

Borah, R. K. (1994). Evaluation of an insecticide Schedule against jassid, *Amrasca biguttulla biguttulla* ishida on okra. *Indian J. Entomol.* **56**(2): 196-198.

Borah, R. K. (1995). Incidence of jassid leaf roller in relation to the time of brinjal planting in the hill zone of Assam. Ann. of Agril. Res. **16**(2): 220-221.

Davidson, R. H. (1987). Insect pest of farm garden and orchard. Eighth edition. Canada. 278p.

Dahiya, A. S, Sharma, S. S., Verma, A. N. and Ombir (1990). Comparative efficacy of different insecticides against jassid *Amrasca biguttula biguttula* Ishida on okra. *J. Insect Sci.* **3**(1): 83-87.

Dharpure, S. R. (2003). Changing scenario of insect pests of potato in Satpura plateau of Madhya Pradesh. *J. Indian Potato Association*. 29(3/4): 135-138.

El-Tom, H. A. (1987). Integrated pest management for cotton in Bangladesh. FAO/UNDP cotton improvement programme. Cotton Research Station, Rangpur, Bangladesh. p.43.

El-Shafie, H. A. F. (2001). The use of neem products for sustainable management of homopterous key pests on potato and eggplant in the Sudan. PhD. Thesis. Institute of Phytopathology and Applied Zoology Experimental Station Justus Liebig University of Giessen, Germany. 165p.

FAO (Food and Agriculture Organization). (1995). Celebrates its 50th anniversary agriculture magazine for the middle East and Arab world Sep. -Oct. Issue No. 7.

FAO (Food and Agriculture Organization). (2003). Inter country programme for integrated pest management in vegetables in South and South-East Asia. Eggplant intregrated pest management: An ecological guide. 177p.

FAO (Food and Agriculture Organization of the United Nations). (2004). FAO Production Yearbook. FAO, Rome. 259p.

Fiswick, R. B. (1988). Pesticide residues in gain arising from post harvest treatments. *Aspects Appl. Biol.* **17**(2): 37-46.

Frisbie, R. E. (1984). Guidelines for integrated control of cotton pests. FAO plant production and protection paper 48. FAO, Rome, Italy. pp. 187.

Gahukar, R. T. (2000). Use of neem products pesticides in cotton pest management. *International J. Pest Management*. **46**(1): 149-160.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. Second Edition. A Wiley Interscience Publications Jhon Wiley and Sons, New York, Chichester, Torento, Singapore. Pp 680.

Goodland, R., Watson, C. and Ladac, G. (1985). Biocides bring poisoning and pollution to third world. The Bangladesh observer, 16th and 17th January. 1985.

Hagen, K. S. and Franz, J. M. (1973). A history of biological control. Pp. 443-467. In: Smith, R. F., Mittler, T. E. and Smith, C. N. (eds). History of Entomology. Ann. Rev. Inc. Palocetto, California. 872p.

Hillocks, R. J. (1995). Integrated management of insect pests, diseases and weeds of cotton in Africa. Springer Science+Business Media B.V., Formaly Kluwer Academic Publishers B. V. **1**(1): 31-47.

Hossain, S. M. A., Rahman, H. and Rahman, F. (2003). Effect of soap water against sucking pests of cotton. Annual. Research. Report. Cotton Development Board. Khamarbari, Farmgate, Dhaka.

Husain, M. (1984). Controlling rice borers under Bangladesh conditions. *Pestology*. **8**(8): 28-30.

Husain, M. (1993). Anistakar Kit-patango Daman (control of harmful insects). Bangla Academy, Dhaka. pp. 220.

Inee, G., Dut, B. C. and Gogoi, I. (2000). Seasonal abundance of cotton jassid, *Amrasca biguttula biguttula* on okra. *J. Agril. Sci. Soc.*, North East India. **13**(1): 22-26.

Jamil, F.F., Qureshi, M. J. Haq, A., Bashir, N. and Naqvi, S. H. M. (1998). Efficacy of the controlled release of 14 C carbofuran formulation for pest control in cotton. Pesticides. food and environmental implications. In: proceedings of a symposium held in Nsurherberg, 24-27 November, (1987). Vienna, Austria, International Atomic Energy Agency. pp. 169-175.

Jacob, P. S., Ramasubbara, V. and Punnaiah, K. C. (2000). Leafhopper fauna associated with oil seeds crops in andhra Pradesh, India. *Pest management and Economic Zool.* **8**(1): 11-27.

John, A. and Immaraju. (1997). The commercial use of *Azadirachtin* and its integration into viable pest control programmes. *Pesticide Sci.* **54** (3): 285-289.

Kavadia, V. S., Pareek, B. L. and Sharma. (1984). Residues of malathion and carbaryl in stored sorghum. *Bull. Grain. Tech.* **22**(3): 247-250.

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

Kaur, S. (2002). Management of cotton jassid, *Amrasca biguttula biguttula* and spotted bollworm, *Earias* Spp. in okra. *Vegetable science.* **29**(2): 172-175.

Kannan, M., Uthamasamy, S. and Mohan, S. (2004). Impact of insecticides on sucking pests and natural enemy complex of tansgenic cotton. *Current Science.* **86**(5): 726-729.

Kumar, M. and Singh, A. K. (2001). Bioefficacy of insecticides against the cotton jassid, *Amrasca biguttula biguttula* on okra. *Pest management and Economic Zoology.* **9**(1): 55-58.

Kumar, N. K. K., Morrthy, P. N. K and Reddy, S. G. E. (2001). Imidacloprid and thiamethoxam for the control of okra leaf hopper, (*Amrasca biguttula biguttula*). *Pest management in Horticulture Ecosystems.* **7** (2): 117 -123.

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

Lawrence, A. D., Williams and Mansingh, A. (1996). The insecticidal and acaricidal actions of compounds from *Azadirachta indica* (A. Juss.) and their use in tropical pest management. *Integrated Pest Management Rev.*(Historical Archive). **1**(3): 133-145.

Latif, M. A. (2007). Effectiveness of some insecticides in managing brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee and their impact on arthropod biodiversity and soil microbial respiration. PhD. Thesis. Bangabandhu Sheikh Mujubur Rahman Agricultural University, Gazipur. 236pp.

Luckmann, W. H. and Metcalf, R. L. (1975). The pest management concept. In: Metcalf, R. L. and W. H. Luckmann (eds). Introduction to Insect Pest Management. John wiley and Sons, New York. pp.3-35.

Mall, N. P., Pandy, R. S., Singh, S. V. and Singh, S. K. (1992). Seasonal incidence of insect pest and estimation of the losses caused by soot and fruit borer on brinjal. *Indian. J. Ent.* **53**(3): 241-246.

Mahal, M. S., Brar, L. S. and Singh, R. (1994). Effect of variable Feeding exposures to jassid, *Amrasca biguttula bigutula* (Ishida) on seed yield of okra *J. Insect Sci.* **7**(2): 125-128.

Maleque, M. A., Islam, M. N., Kundu, R. and Islam, M. S. (1999). Impact of chemical insecticides on the natural enemies of brinjal shoot and fruit borer. *Bangladesh J. Entomol.* **9**(1-2): 53-60.

Mamun, M. R. (2006). Host preference and integrated management of jassid (*Amrasca devastans*) (DISTANT). Homoptera cicadellidae. MS thesis. Sher-e-bangla Agricultural University. Dhaka. 27p.

Misra, H. P. and Senapati, B. (2003). Evaluation of new insecticides against okra jassid (*Amrasca biguttula biguttula*). *Indian J. Agric. Sci.* **73** (10): 576-578. .

Mohan, M. and Sekhon, B.S. (2000). The impact of different insecticides used for bollworm control on the population of jassid in cotton. *Pesticide Research Journal* **12**(1): 99-102.

Mote, U. N. and Bhavikatti, S. (2003). Efficacy of chemical and non-chemical insecticides against major pests of brinjal in kharif season. *J. Appl. Zool. Res.* **14**(1) : 54-56.

Munakata, K. (1997). Insect feeding deterents in plants. P. 93-102. In: "Chemical control of insect behaviour" (eds. Shorey, H.H. and J. J. Jr. Mekelvy). Jhon Wiley and Sons, New York. pp. 522.

Muthukumar, M. and Kalyanasundaram. (2003). Influence of abiotic factors on the incidence of major pests in brinjal (*Solanum melongena* L.). *South Indian Horticulture*. **51**(1/6): 214-218.

Nagen, K.S. and Franz, J. M. (1973). A history of biological control. pp. 443-467 In: Smith, R. F., Mittler, T. E. and Smith, C. N. (eds). History of entomology. Ann. Rev. Inc. Palocetto, Califormia. pp. 872.

Nair, M.R.G.K. (1986). Insects and Mites of Crop in India. Printed in India at Allied Publishers (Pvt.) Ltd. New Delhi, pp. 106.

Nandagopal, V. and Soni, V. C. (1992). Residual effect of some insecticides and neem-oil against jassid on groundnut. *J. Maharashtra Agril. Univ.* **17**(3): 420-422.

Nayer, K.K., Ananthakrisnan, T. N. and David, B.V. (1984). General and applied Entomology. Tata Macgraw Hill Publishing Company Ltd. New Delhi. pp.589.

Narayanasamy, P. (2002). Botanical pesticides for effective plant protection. The Hindu' National daily Newspaper, India. May 02.

Ofori, O. D. and Sackey, J. (2003). Field evaluation of non-synthetic insecticides for the management of insects pests of okra, *Abelmoschus esculentus* (L.) Moench in Ghana. Sinet. Ethiopian *J. Sci.* **26**(2): 145-150.

Panchabhavi, K. S., Kulkarni, K. A., Veeresh, G. K., Hiremath, P. C. and Hegde, R.K. (1990). Comparative efficiency of techniques for assessing loss due to inset pests in upland cotton. *Indian J. Agril. Sci.* **60**(4): 252-254.

Pawer, D. B. and Lawande, K.E. (1993). Threshold level of Jassid and effect of sprays on fruit borer in okra *J. Moharashtra Agri. Univ.* **21**(3): 375-377.

Patel, Z. P. and Patel, J. R. (1998). Resurgence of jassid, *Amrasca biguttula biguttula* in brinjal and development strategy to overcome the resurgence in brinjal. *Indian J. Entomol*. **60**(2): 152-164.

Pimentel, D. (1981). An overview of integrated pest management (Mimeograph). Dept. of Entomology, Section of Ecology and Systematic, Cornell University, Ithaca, New York. 52p.

Poonia, F. S. (2005). Population dynamics of *Empoasca kerri Pruthi*, a jassid pest on cowpea crop in arid region of Rajasthan. Arid legumes for sustainable agriculture and trade **1**: 179-180.

Ramphall and Gill, H. S. (1990). Demand and supply of vegetables and pulses in South Asia. In: Vegetable Research and development in South Asia S. Shanmugasundaram (ed). Porc. workship held at islamabad, Pakistan on 24-29 September 1990. AVRDC Publication no. 90. 331, AVRDC, Taiwan

Radadia, G. G. and Patel. C. B. (1993). Evaluation of different Insecticides Against Aphid (*Aphis gossypii Glov.*) and Jassid (*Amrasca biguttula biguttula Ishida*) on Okra (*Abelmoschus esculentus* (L) *Moench*). *GAU Res. J.* **18** (2): 120-121.

Rashid, M. M. (1999). Begun Paribarer Shabji, In: Shabji Biggan (in Bangla). First edn. Bangla Academy, Dhaka, Bangladesh.

Rao, N. S. and Rajendran, R. (2002). Joint action potential of neem with other plant extracts against the leafhopper, *Amrasca devastans* (distant) on okra. *Pest Management and Economic Zoology*. **10**(2): 131-136.

Rahman, M. M. (2006). Vegetable IPM in Bangladesh, In: E. B. Radcliffe and W. D. Hutchinson [eds.] Radcliffes IPM World Textbook. University of Minnesota, St. Paul, MN.

Rote, N. B., Patel, B. K., Mehta, N. P., Shah, A. H. and Raza, K. R. (1985). Threshold level of *Amrasca biguttula* causing economic injury to cotton. *Indian. J. Agril.* **35**(7): 491-492.

Ripper, W. E. and Geroge, L. (1965). Cotton pests of Sudan: Their habit and control Blackwell Scientific Publications. Oxford. 345p.

Sangha, K. S., Joginder, S., Mahal, M. S., Dhaliwal, Z. S. and Singh, J. (1997). A plan for Sampling cotton jassid, Population on or American Cotton. *J. of Ins. Sci* **10**(2): 128-131.

Sabur, S. A. and Mollah, A. R. (2000). Marketing and economic use of pesticide: Impact on crop production. ARMP contact research report, Dhaka, Bangladesh. 114p.

Schneider, A. and Madel, G. (1992). Fecundity and vitality of adult parasitoids following exposure to neem (*Azadirachta indica*) treated surfaces. Mitteilungen der Deutschen Gesellschaft fur Allgemeine und Angewandate Entomologie. **8**(1/3): 273-278.

Shukla, R. P. (1989). Population fluctuation of *Leucinodes orbonalis* and *Amrasca biguttula biguttula* in brinjal (*Solanum melongena*) in relation to abiotic factors Meghalaya. *Indian J. Agric. Sci.* **59**(4): 260-264.

Shakharappa, S. and Patil, R. K. (2001). Evaluation of Silafluofen 20 EC for the control of leaf hopper on cotton. *Karnataka J. of A*gril. *Sci.* **14** (3): 809-810.

Singh, J., Dhaliwal, Z. S., Sandhu, S. S. and Sidhu, A. S. (1990). Temporal changes in the dispersion of populations of three homopterous insect pests in upland cotton. Insect Sci. and its application. **11**(1): 73-77.

Singh, W., Kotwal, O. R., Singh, R. W. and Singh, R. (1991). Evaluation of some contact insecticides for the control of jassid (*Amrasca biguttula biguttula Ishida*) on okra. *Indian J. Plant Prot.* **19**(2): 182-184.

Singh, S. P. and Choudhary, S. K. (2001). Chemical control of jassid (*Amrasca biguttula biguttula Ishida*) on Okra *J. of Research Binsa Agricultural University*. **13**(2): 215-216.

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

Sexena, R. C., Dixit, O. P. and Harshan, V. (1992). Insecticidal action of Lantana camara against *Callosobruchus chinensis* (Coleoptera: Bruchidae). *J. Stored Prod. Res.* **28**(4): 279-281.

Yadgirwar, P.V., Radke, S.G. and Parlawar, N.D. (1994). Efficacy of combinations of synthetic pyrethroids and organophosphatic compounds against cotton jassids. *Journal of Soils and Crops.* 4(2):158-159.

Appendices

Appendix I. Effect of different treatments on number of branches against jassid infestation

Month	Air temperature (^0C)			RH (%)	Total rainfall (mm)	Sunshine hour
	Maximum	Minimum	Mean			
January	24.6	12.5	18.7	66	0	171.01
February	27.1	16.8	21.95	64	0	158.68
March	31.5	16.9	25.55	47	160	255.01
April	33.74	23.87	28.81	69.41	185	234.6
May	34.7	25.9	30.3	70	185	241.8
June	32.4	25.5	28.95	81	628	96.0
July	31.4	25.7	28.55	84	753	127.1
August	32.4	26.4	29.4	80	505	108.5

Appendix II. Effect of different treatments on number of branches against jassid infestation

Treatment	Number branches/plant	Increase or decrease (%)
T_1	9.80 ab	53.13
T_2	10.20 a	59.38
T_3	9.60 b	50.00
T_4	8.20 e	28.13
T_5	8.60 d	34.38
T_6	9.20 c	43.75
T_7	7.60 f	18.75
T_8	7.80 f	21.88
T_9	6.40 g	--
$LSD_{(0.05)}$	**0.354**	--
CV(%)	**8.91**	--

Appendix III. Effect of different treatments on weight of brinjal against jassid infestation

Treatment	Weight in gm per fruit	
	Average	% reduction
T_1	78.13 b	32.38
T_2	80.96 a	37.17
T_3	74.85 c	26.82
T_4	68.68 de	16.37
T_5	70.19 d	18.93
T_6	73.03 c	23.74
T_7	64.34 f	9.01
T_8	67.04 e	13.59
T_9	59.02 g	--
$LSD_{(0.05)}$	**2.487**	--
CV(%)	**7.03**	--

Appendix IV. Effect of different treatments on adult jassid in brinjal

Treatments	Number of adult/5leaves at harvesting time						
	1st	2nd	3rd	4th	5th	6th	7th
T_1	1.80 d	2.80 fg	3.20 f	6.20 fg	7.13 e	8.40 f	10.20 ef
T_2	1.60 d	2.47 g	3.00 f	5.20 g	6.60 e	8.20 f	9.40 f
T_3	2.20 d	3.40 ef	3.80 e	6.80 ef	8.60 d	8.80 f	11.60 def
T_4	3.40 c	4.20 d	4.40 d	8.40 cd	10.60 c	11.40 cd	14.20 cd
T_5	3.40 c	3.80 de	4.20 de	7.80 de	9.00 d	10.20 de	13.20 cd
T_6	2.40 d	3.67 de	4.00 de	7.40 de	8.80 d	9.40 ef	12.40 cde
T_7	4.60 b	5.80 b	6.40 b	10.00 b	11.80 b	13.20 b	16.80 b
T_8	4.40 b	5.00 c	5.20 c	9.20 bc	11.20 bc	12.40 bc	15.00 bc
T_9	5.60 a	6.60 a	9.60 a	14.40 a	17.40 a	19.80 a	20.60 a
$LSD_{(0.05)}$	0.799	0.641	0.402	1.009	1.049	1.224	2.405
CV(%)	14.14	8.83	4.79	6.96	5.98	6.25	10.14

Appendix V. Effect of different treatments on nymph jassid in brinjal

Treatment	Number of Nymph per 5 leaves at harvesting time						
	1st	2nd	3rd	4th	5th	6th	7th
T_1	0.40 gh	0.40 g	2.20 fg	3.20 fg	3.20 fg	0.20 f	0.00 e
T_2	0.20 h	0.40 g	1.60 g	2.40 g	2.60 g	0.00 f	0.00 e
T_3	0.60 g	0.80 f	2.60 f	3.80 f	4.13 f	0.20 f	0.07 de
T_4	1.80 d	2.00 d	4.80 cd	6.60 cd	7.60 cd	1.20 d	0.40 c
T_5	1.40 e	1.80 d	4.20 de	6.00 de	6.80 de	1.20 d	0.27 cd
T_6	1.00 f	1.20 e	3.80 e	5.20 e	6.00 e	0.80 e	0.13 de
T_7	2.60 b	3.20 b	6.40 b	7.80 b	9.20 b	2.20 b	0.73 b
T_8	2.20 c	2.80 c	5.20 c	7.20 bc	8.40 bc	1.80 c	0.47 c
T_9	3.60 a	5.20 a	9.40 a	12.60 a	15.40 a	2.80 a	1.27 a
$LSD_{(0.05)}$	0.319	0.040	0.736	0.624	1.118	0.319	0.205
CV(%)	12.10	10.11	9.53	5.92	9.18	16.06	32.24