MANAGEMENT OF SUCKING INSECT PESTS OF BRINJAL USING PLANT EXTRACTS

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CERTIFICATE

This is to certify that the thesis entitled, **"MANAGEMENT OF SUCKING INSECT PESTS OF BRINJAL USING PLANT EXTRACTS."** 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 bonafide research work carried out by **MD. FOZLUL KARIM**, **Registration No. 09-03746** 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 him.

Date: June, 2011
Place: Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

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THESIS ABSTRACT

An experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University Dhaka, during February to August, 2012 to evaluate some plant extracts against sucking insect pests such as aphid (*Aphis gossypii*), jassid (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), mealybug (*Paracoccus marginatus*) attacking brinjal. Neem seed kernel extract, Mehogoni seed extract, Tamarind fruit extract, Bonkolmi leaf extract, Biskatali leaf extract, Tobacco leaf extract, Mustard seed extract and untreated control plots were set in Randomized Completely Block Design (RCBD) with 3 replications. The population of aphid, jassid, whitefly and mealybug were gradually decreased with plant age in respective of treatments. The lowest number of aphid, jassid, whitefly and mealybug (5.33, 3.33, 4.33 and 2.33 before fruiting stage and 12.67, 10.67, 11.67 and 9.67 during fruiting stage) per 5 leaves/plant were observed in neem seed kernel extract treated plots. The number of leaves and branches/plant, number of fruits/plant, length, diameter and weight of individual fruit were found the highest in neem seed kernel extract @ 20g/l treatment. The same treatment gave the highest yield (29.58t/ha) and increased 41.10% yield over control. The maximum net return (330071 tk/ha) and the highest benefit cost ratio (2.28) was also observed in neem seed kernel extract. Bishkatali leaf extract showed the similar performance in all regards against on aphid, jassid, whitefly and mealybug on brinjal. Bonkolmi leaf extract also gave the satisfactory result in reducing aphid, jassid, whitefly and mealybug infestation and increasing brinjal yield.

CONTENTS

CONTENTS (cont'd)

LIST OF TABLES

LIST OF FIGURE

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 vegetables in South Asia (India, Nepal and Srilanka). This region of South Asian accounts for almost 50% of the world area under brinjal 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 biguttula biguttula*) was the second most common in the field after brinjal shoot and fruit borer. Alam *et al.* (2003) reported that it was attacked by 53 species of insect pest among them, jassid (*Amrasca biguttula biguttula*) was the second major pest .

Srinivasan (2009) reported that, eggplant production is severely constrained by several insect and mite pests. The major pests include eggplant shoot and fruit borer, leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer, blister beetle, red spider mite, and little leaf disease.Both nymph and adult of jassid affect host leaves at all stage 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 (*Abutton 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 senap ati, 2003; singh and choudhary, 2001; Bhargava *et al*., 2001; Ali and Karim, l994; Yadgirwar *et al.,* 1994; singh *et al*., l99I). 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 Metcalt, 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 extract, 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.

Neem is a relatively new product on the market. It is derived from the neem tree that grows in arid tropical regions. Extracts from the neem tree have been reported to control over 200 types of insects, mites, and nematodes. The neem spray solution should not be exposed to sunlight and must be prepared with water having a temperature between 50 and 90°F. The solution is effective for only 8 hours after mixing. Neem is most effective under humid conditions or when the insects and plants are damp. It has a low toxicity to mammals.

There are various insecticides that can be used to control aphids. Nowadays, there are many plant extracts and plant products that are eco-friendly and control aphids as effectively as chemical insecticides. Shreth *et al.*, (2009) suggested use of neem products and lantana products to protect plants against aphids. For small backyard infestations, simply spraying the plants thoroughly with a strong water jet every few days is sufficient protection for roses and other plants.

Nicotine (tobacco) concentrate is very poisonous if inhaled. It is derived from tobacco and is commonly sold as a 40 percent nicotine sulfate concentrate. Nicotine is a fast acting contact killer for soft bodied insects, but does not kill most chewing insects. It is less effective when applied during cool weather. Do not spray within 7 days of harvest.

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

- to evaluate the effectiveness of some selected botanicals against the sucking insect pests in brinjal,
- to know the effect of those botanicals on yield contributing characters and yield of brinjal against sucking insect pests infestation and
- to evaluate the impact of those botanicals on natural enemies in the brinjal field.

Chapter II
Review Of Literature

CHAPTER II

REVIEW OF LITERATURE

Sucking insect pests are very much dangerous for most of the vegetable crops. Aphid, Jassid, whitefly and mealybug are considered as major sucking insect pests of different vegetable crops, which cause significant damage to crop every year. The incidence of those insects occurs sporadically or in epidemic form throughout Bangladesh and affecting adversely the quality and yield of the crop. In the favorable weather severe infestation may occur and total crop may be damaged. Literatures regarding their 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 of insect pests of brinjal

Aphid belongs to the order: Hemiptera and Family: Aphididae Synonym: *Myzus persicae*, common name: cotton aphid, melon aphid or melon and cotton aphid, green peach aphid etc.

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

Whitefly belongs to the order: Hemiptera and Family: Aleyrodidae Synonym: *Bemisia tabaci*, common name: whitefly.

Mealybug belongs to the order: Hemiptera and Family: Pseudococcidae Synonym: *Paracoccus marginatus*, common name: papaya mealybug, citrus mealybug etc.

2.2 Origin and distribution

Aphids are distributed worldwide, but are most common in temperate zones. In contrast to many taxa, aphid species diversity is much lower in the tropics than in the temperate zones. They can migrate great distances, mainly through passive dispersal by riding on winds. For example, the currant lettuce aphid, *Nasonovia* *ribisnigri*, is believed to have spread from New Zealand to Tasmania in this way (Pip Courtney, 2005). Aphids have also been spread by human transportation of infested plant materials.

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.

The whitefly, *Bemisia tabaci* was first discovered in Australia in 1994. Hosts of the SLW include at least 500 crops and ornamental plants worldwide and it is a pest on many of them Silverleaf whitefly has been identified in most major cotton areas in Australia, where it is readily found on a range of ornamental plants (poinsettia, duranta, hibiscus and lantana) in nurseries, and on ornamental plants and weeds in the field. It has also been identified in cotton crops in most areas.

Mealybugs occur in all parts of the world. They are a large number of species in the Palearctic ecozone and fewer in the Neotropic ecozone (Johnson *et al*., 2001). Mealybugs occur worldwide and are widely distributed throughout the United States. In 1967, McKenzie recognized 46 genera of mealybugs in North America. Thirty-seven species within these genera were associated with grassesn (Baxendale, 1994).

2.3 Host Range

Many aphid species are monophagous (that is, they feed on only one plant species). Others, like the green peach aphid *Myzus persicae*, feed on hundreds of plant species across many families. Aphids passively feed on sap of phloem vessels in plants, as do many of their fellow members of Hemiptera such as scale insects and cicadas. As they feed, aphids often transmit plant viruses to the plants, such as to potatoes, cereals, sugarbeets and citrus plants (Henry, 1997). These viruses can sometimes kill the plants.

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, 1936). 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.

According to Bambawale, 1964 Mealybug are polyphagous and multiply on different hosts. The silverleaf whitefly has been found on as many as 500 different hosts. Some preferred hosts are canna lilies, bearded iris, crepe myrtle, lantana, petunia, rose and bottle brush.Initially the pest breeds on weeds and later migrates to cotton crop. Parthenium is a favourite host for the pest. It also feeds on Itsit, datura, milkweed, *Chenopodium* sp. It multiplies well on okra, tomato and brinjal.

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 28ºC and 80 percent respectively.

Early plantings are more injured by the cicadellidae 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. Particulady 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 eafly 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 (30.36ºC) 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 biguttula biguttula* ranged from 0.59 to 2.78 per plant recorded in the second fortnight of November (Patel and Patel, 1998).

The spatial distribution of *A. biguttula biguttula* 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 rabi cotton. Most of the cicadellids were found in 35 to 75 days old cotton plants in kharif and 65 to 130 days old cotton plants in the rabi season.

Cotton grown in the kharif season was more vulnerable to insect attack than cotton grown in the rabi season. 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 second week of July up to the third week of September. The insect population increased from July to August. The maximum activity of the insect occurred from the 1^{st} 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).

Aphid (Homoptera: Aphididae) seasonal flight activity and abundance in wheat, *Triticum aestivum* L., and the signifcance of aphid species as vectors of barley yellow dwarf virus were studied over a nine-year period in the South Carolina coastal plain. Four aphid species colonized wheat in a consistent seasonal pattern. Greenbug, *Schizaphis graminum* (Rondani), and rice root aphid, *Rhopalosiphum rufiabdominalis* (Sasaki), colonized seedling wheat immediately after crop emergence, with apterous colonies usually peaking in December or January and then declining for the remainder of the season. These two aphid species are unlikely to cause economic loss on wheat in South Carolina, thus crop managers should not have to sample for the subterranean *R. rufiabdominalis* colonies (Chapin *et al.*, 2001).

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 of 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).

Rashid *et. al.* (2003) made an experiment on seasonal abundance of spiraling whitefly, *Aleurodicus dispersus* on guava and its control were conducted. The seasonal distribution of spiraling whitefly indicated that winter months December, January and February were major peak period of infestation. Adult whitefly started to infest the guava plants in September and increased to maximum in January. Whitefly infestation decreased to zero from April and continued to August. The change in the level of infestation was due to difference in environmental temperature and rainfall. Field trials were conducted to test the efficacy of some common insecticides against the whitefly. Although all the chemicals reduced the population of different stages of whitefly, the overall effect was found to be better with systemic insecticides. Dimethoate was found most effective in controlling spiraling whitefly of guava followed by spray treatment with, phosphamidon, cypermethrin, malathinon. Diclorvos was comparatively less effective insecticide. Study on biological control of whitefly showed that a coccinelid predator *Axinocymnus puttarudriahi* Kapur and Manshi (Coleoptera: Coccinellidae) was effective in controling the whitefly without associated ant.

The average mealybug (*Phenacoccus solenopsis* Tinsley) population was maximum (2.69, 2.40 and 1.73 adults/plant) on *Parthenium hysterophorus* at wasteland, in or near field and weeds present near stacks at Muktsar. At Ferozepur, the mean mealy bug population was 1.10 adults/plant on cotton. On the weeds, near or in the field, the maximum population (5.94 adult/plant) was recorded on *P. hysterophorus* followed by *Digeria arvensis* (3.74 adults/plant). The population was 2.69, 2.66 and 2.86 adults/plant on *Sida acuta*, *Abutilon theophrasti* and *Achryanthus aspera*, respectively. On wasteland weeds, similar trend was observed, i.e. maximum population was on *P. hysterophorus* (7.31 adults/plant), while minimum (3.00 adults/plant) on *S. acuta*, during 2008. Similar trend was followed in 2009 in Muktsar and Ferozepur but the population was lower than the previous year. Among the weeds, *P. hysterophorus* was the most preferred host for multiplication. During carry-over studies all the stages and ovisac was maximum, followed by detached leaves in Muktsar and in Ferozepur again on *P. hysterophorus*. In Ludhiana, the maximum population was observed on *Hibiscus* sp. followed by ratoon cotton crop (Kumar, 2011).

2.6 Biology of the pest

2.6.1. Jassid

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 prefened for egg deposition; curved, greenish-yellow, eggs (0.7-0.9 x 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).

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 2l 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 19-21days.

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).

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, 1936). 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).

2.6.2. Aphid

According to George (1993) some aphid species have unusual and complex reproductive adaptations, while others have fairly simple reproduction. Adaptations include having both sexual and asexual reproduction, creation of eggs or live nymphs and switches between woody and herbaceous types of host plant at different times of the year (about 10% of aphid species produce generations that alternate between woody and herbaceous plants).

Only females are present in the population (although, a few species of aphids have been found to have both male and female sexes). The overwintering eggs that hatch in the spring result in females, called *fundatrices*. Reproduction is typically parthenogenetic and viviparous. Eggs are parthenogenetically produced without meioisis (Hales *et al.*, 2002 and Blackman, 1979) and the offspring are clonal to their mother. The embryos develop within the mothers ovarioles, which then give live birth to first instar female nymphs (viviparous). The offspring resemble their parent in every way except size, and are called *virginoparae*.

This process iterates throughout the summer, producing multiple generations that typically live 20 to 40 days. Thus one female hatched in spring may produce thousands of descendants. For example, some species of cabbage aphids (like *Brevicoryne brassicae*) can produce up to 41 generations of females.

Hales *et al.* (2002) reported that, in autumn, aphids undergo sexual, oviparous reproduction. A change in photoperiod and temperature, or perhaps a lower food quantity or quality, causes females to parthenogenetically produce sexual females and males. The males are genetically identical to their mothers except that they have one less sex chromosome. These sexual aphids may lack wings or even mouthparts (George, 1993).

Sexual females and males mate, and females lay eggs that develop outside the mother. The eggs endure the winter and emerge as winged or wingless females the following spring. This is, for example, the life cycle of the rose aphid (*Macrosiphum rosae*, or less commonly *Aphis rosae*), which may be considered typical of the family. However in warm environments, such as in the tropics or in a greenhouse, aphids may go on reproducing asexually for many years (Henry, 1997).

Some species produce winged females in the summer, sometimes in response to low food quality or quantity. The winged females migrate to start new colonies on a new plant, often of quite a different kind. For example, the apple aphid (*Aphis pomi*), after producing many generations of wingless females on its typical food-plant, gives rise to winged forms which fly away and settle on grass or corn-stalks.

Ettay and Moshe (2001) said that, some aphids have telescoping generations. That is, the parthenogenetic, viviparous female has a daughter within her, who is already parthenogenetically producing her own daughter. Thus a female's diet can affect the body size and birth rate of more than two generations (daughters and granddaughters).

2.6.3. Mealybug

Jahn *et al.*(2003) said, mealybugs are sexually dimorphic, meaning that the sexes have distinct morphological differences. Females are nymphal, exhibit reduced morphology, and are wingless, though unlike many female scale insects, they often retain legs and can move. The females do not change completely and are likely to be neotenic (exhibiting nymphal characteristics). Males are winged and do change completely during their lives. Since mealybugs (as well as all other Hemiptera) are hemimetabolous insects, they do not undergo complete metamorphosis in the true sense of the word, i.e. there are no clear larval, pupal and adult stages, and the wings do not develop internally. However, male mealybugs do exhibit a radical change during their life cycle, changing from wingless, ovoid nymphs to "wasp-like" flying adults.

Mealybug females feed on plant sap, normally in roots or other crevices. They attach themselves to the plant and secrete a powdery wax layer (therefore the name mealybug) used for protection while they suck the plant juices. The males on the other hand, are short-lived as they do not feed at all as adults and only live to fertilize the females. Male citrus mealy bugs fly to the females and resemble fluffy gnats.Some species of mealybug lay their eggs in the same waxy layer used for protection in quantities of 50-100; other species are born directly from the female.

The most serious pests are mealybugs that feed on citrus; other species damage sugarcane, grapes, pineapple (Jahn *et al.,* 2003), coffee trees, cassava, ferns, cacti, gardenias, papaya, Mulberry, sunflower and orchids.

Mealybugs only tend to be serious pests in the presence of ants because the ants protect them from predators and parasites. Mealybugs also infest some species of carnivorous plant such as *Sarracenia* (pitcher plants), in such cases it is difficult to eradicate them without repeated applications of insecticide such as diazinon. Small infestations may not inflict significant damage. In larger amounts though, they can induce leaf drop.

Fossil specimens of *Acropyga* genus ants have been recovered from the Burdigalian stage Dominican amber deposits and several individuals are preserved carrying the extinct mealybug genus *Electromyrmococcus*. These fossils represent the oldest recorded record of the symbiosis between mealybugs and *Acropyga* species ants (Johnson *et al.,* 2001).

2.7 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. biguttula biguttula* attacked host leaves at all stages of development. The adults and nymphs feed 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. biguttula biguttula* 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 corelated 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 at.* (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 season of 1985 and 1986 in Karnataka, India. The average yield loss was 46.41% (Panchabhavi *et al*., 1990).

2.8 Management

The management of (*Amrasca biguttula biguttula*) 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 insect pest was also scanty. The farmers of Bangladesh usually apply six to eight schedule based insecticide sprays against this insect pests through out the season. But this kind of insect pests control strategy relying solely on chemical protection had got many limitations and undesirable side effects (Hussain 1993, 1984) and this in the long run led to many insecticides related complications (Frisbie, 1984) such as direct toxicity to beneficial insects, fishes and other non target organism (Munakata, 1997; Goodland *et al*., 1985, Pimentel, 1981), human health hazards (Bhaduri *et a1.*, 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 at.,* 1984). To overcome these problems botanical insecticide soaprvater and water are now used in many developed and developing countries for combating this pest infestation with the aim of increasing crop yield.

Johnson *et al.* (2001) assigned that, mealybugs can be controlled using the biocontrol agent, e.g. *Verticillium lecanii*.

In sustainable agriculture, prevention strategies are one of the most important tactics that growers can employ to avert aphid infestation. These include cultural techniques such as use of physical barriers, removal of crop in space and time, mulching, crop rotation, border crops and cover crops. Both synthetic and living mulches have been shown to reduce population of alate aphids reaching/landing on plants and hence reducing the incidence of aphid-transmitted viruses. Crops receiving high levels of nitrogen are more susceptible (attractive) to aphids; therefore, slow release fertilizers may be an alternative to avoid high aphid infestations. Aphids receive visual cues to land on crops when there is a clearly defined contrast in color between tilled bare soil and the lush foliage of crops. Living mulches reduce the contrast between the bare ground and the plant foliage so aphids do not detect their host. These mulches provide additional feeding sites for viruliferous aphids (aphids carrying virus) around the crop and hence reduce the incidence and spread of aphid-borne non-persistently transmitted viruses (Toba *et al.*, 1977).

2.8.1 Plant extracts for sucking insect pests 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 extract, 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 insect 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.

Pink mealybug infests the mulberry plants and cause Tukra diseases that leads to qualitative loss of leaves. Hence a study was carried out to evaluate the efficacy of various indigenous native plant extracts for their repellency property against pink mealybug, *Maconellicoccus hirsutus* (Green) at the Tamil Nadu Agricultural University, Coimbatore. The native botanicals such as Andrographis leaf extract, Leucas leaf extract, Neem seed kernel extract, vitex leaf extract, fish oil rosin soap, ocimum leaf extract and lawsonia leaf extract at different dose levels viz., 1, 2, 4, 8 and 10 percent respectively. After 48 hours (Hour of release) the highest repellency was recorded in case of Andrographis leaf extract (99.0%) followed by Leucas leaf extract and NSKE (99.0%). Vitex leaf extract and FORS showed on par results among various treatments. The ocimum leaf extract (90.1%) also recorded a moderate repellent effect and the least repellency was recorded in case of Lawsonia leaf extract (81.3%). Similar trend was recorded during 24 hour of release also. As the dose increases the repellent effect also increased irrespective of the native botanical extracts against mealybugs (V. Sathyaseelan and V. Bhaskaran, 2010*)*.

There are various insecticides that can be used to control aphids. Nowadays, there are many plant extracts and plant products that are eco-friendly and control aphids as effectively as chemical insecticides. Shreth *et al.,* suggested use of neem products and lantana products to protect plants against aphids (Chongtham et al., 2009). For small backyard infestations, simply spraying the plants thoroughly with a strong water jet every few days is sufficient protection for roses and other plants.

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 whitefly (*Bemisia tabaci* Genn. Homoftera: Aleyrodidae), the diamond back moth (*Plutella xylostella* L Lepidoptera: Plutellidae) and cattle ticks (*Amblyomma cajennense* F. Acarina: Ixodidae and *Tsoaphilus microplus* Canestrini Acarina: Ixodidae).

The compounds isolated from the neem plant manifested their effects on the test onganisms 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 l995, 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 (Detramethrin lEC + 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, ;ring 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 dfuect contact. Patel and Patel (1998) reported that application of Quinalphos and Triazophos resulted in a resurgence of *A. biguttuta* on okra and abergine (Brinjal), while Endosulfan at 0.07% and Repelin (based on *Azadirachta indica*) l% 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).

Chapter III
Materials & Methods

CHAPTER III

MATERIALS AND METHODS

The experiment on the population dynamics and management of sucking insect pests 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 2012. The materials and methods adopted in this study are discussed in the following sub headings:

3.1. Location

The experimental site was located at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period form Feb to Aug, 2012. The experimental field was located at 90^{0}335' east longitude and 23^{0} 774' North latitude at a height of 4 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 of 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 the Appendix I. The recorded and calculated as monthly average temperature, relative humidity and rainfall for the crop growing period of experiment were noted from the Bangladesh meteorological 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 to 5.63.

3.4. Design and layout

The study was conducted considering eight treatments including a control for controlling sucking pest at seedling to harvesting stage. 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 three blocks of equal size and each block was sub divided into nine plots. The unit plot size was 3m × 2m accommodating eight pits per plot. The distance between row to row was 100cm and that of the plants to plants was 70cm.

3.5. Land preparation

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

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

The full dose cow-dung and TSP were applied as basal dose during final 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 at 21, 35 and 50 days after transplanting.

3.7. Raising of seedling and transplanting

Brinjal seed (Vatiety: Shinghnath) 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 Feb, 2007. Standard seedling raising practice was followed (Rashid, 1999).The plots were lightly irrigated regularly for ensuring seed proper development of the seedlings. The seedbed was mulched for ensuring proper seed germination, proper growth and development of the seedlings. Forty days old (3/5 leaf stage) healthy seedlings were transplanted on 1st April 2012 in the experimental field. A total of 216 seedlings were transplanted in 24 plots at the rate of 8seedlings per plot.

3.8. Intercultural operations

3.8.1. Gap filling

At the time of transplanting few seedlings were transplanted in the border of the experimental plots for gap filling. Very few numbers of seedlings 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 eight treatments was evaluated on the basis of reduction in sucking insects pest 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 sucking insects

T_1 : Neem (*Azadirachta indica*) seed kernel extract (20g /L): The fruit was collected and pelled out its outer part and dried in oven & grinded. Then 20g of grinding powder was mixed in 1 litre water and extract was made.

T_2 : Mehogoni (*Swietenia macrophylla*) seed extract (20g/L): The seed was collected and dried in oven and grinded .Then 20g of grinding powder was mixed in 1liter water and extract was made.

T_3 : Tamarind (*Tamarindus indica*) fruit extract (20g/L): The ripe fruit was collected and pelled out its outer part. Then 20g was kept in 1 litre water for 12 hours. Then it was mashed by hand and filtered and extract was made.

T_4 : Bonkolmi (*Ipomoea carnea*) leaf extract (10g/L): Fresh leaf was collected and Pressed. Then 10g leaf was kept in 1 litre water for one night. Then it was filtered and extract was made.

T_5 : Bishkatali (*Polygonum hydropiper*) leaf extract (10g/L): Fresh leaf was collected and pressed. Then 10g leaf was kept in 1 litre water for one night.Then it was filtered and extract was made.

T_6 : Tobacco (*Nicotiana tabacum*) leaf extract (10g/L): Dry leaf was collected and Pressed. Then 10g dry leaf dust was kept in 1 litre water for one night.Then it was filtered and extract was made.

T_7 : Mustard (*Brassica nigra*) seed extract (20g/L): The seed was collected and dried in oven & grinded. Then 20g of grinding powder was mixed in 1 litre water and extract was made.

T_8 : Untreated control

3.10 Application of insecticides

The plant extracts were applied with the help of knapsack sprayer. The first application was initiated after 4th 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 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 number of aphid, jassid, whitefly and mealybug was counted from treated and untreated plots of brinjal throughout the cropping season starting from 30 days after transplantation. Adults and nymphs of sucking insects were counted from a 30 random sample of five plants taken from each plot. Five leaves were chosen randomly from 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 sucking pest was determined by counting the numbers of pests per plant application of treatments.

The percent reduction of sucking pest was calculated using the following formula:

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

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 sucking pest.

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

3.12 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).

Chapter IV
Results & Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to evaluate some plant extracts against major sucking insect pests of brinjal in terms of population dynamics of them, 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 Effect of different treatments on sucking insect pests population

The effect of different treatments on of sucking pests was evaluated before fruiting and fruiting stage of brinjal.

4.1.1 Effect on aphid population

Before fruiting stage, the lowest number of aphid (5.33/plant) was observed in neem seed kernel extract treated plots, which was significantly lower than rest of the treatments. In contrast, significantly higher number of aphid (11.33/plant) was recorded in control plots followed by (9.33/plant) in mustard extract treated plot (Table 1). Bishkatali leaf extract treated plots had 6.00 aphid/plant, which was significantly lower than control (Table 1). The highest percent reduction (52.93%) of population over control was obtained by application of neem seed kernel extract followed by 47.04% in bishkatali extract treated plots. Among the different treatments, mustard had the lowest effectiveness in reducing the population (17.63%).

During the fruiting stage, the lowest number of aphid per plant (12.67) in plots treated with neem seed kernel extract, which was significantly lower than all the treatments (Table 1). On the other hand, significantly higher number of aphid/plant (20.80) was observed in untreated control. No significant difference was observed between aphid/plant treated with mehogoni seed extract and tamarind fruit extract (17.67 and 18/plant, respectively). The highest

Table 1 Incidence of aphid under different treatments at two different stages of brinjal

Treatments	Before fruiting stage		Fruiting stage	
	Aphid incidence (No./5 leaves/plant)	**Percent reduction over control**	**Aphid incidence (No./5 leaves/plant)**	**Percent reduction over control**
T_1	5.33f	52.93	12.67f	50.64
T_2	8.33c	26.45	17.67c	31.16
T_3	8.00c	29.39	18.00c	29.88
T_4	7.33e	35.28	14.67e	42.85
T_5	6.00f	47.04	13.33e	48.07
T_6	7.66d	32.33	16.33d	36.38
T_7	9.33b	17.63	20.33b	20.80
T_8	11.33a		25.67a	
LSD	**1.18**		**1.155**	
CV%	**8.55**		**3.80**	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract

T_2 = Mehogoni seed extract

T_3 = Tamarind fruit extract

T_4 = Bonkolmi leaf extract

T_5 = Bishkatali leaf extract

T_6 = Tobacco leaf extract

T_7 = Mustard seed extract

T_8 = Untreated control

reduction of population over control (50.64%) recorded in neem seed kernel extract treated plots followed by bishkatali leaf extract treated plots (48.07%) at fruiting stage as against the lowest reduction (22.56%) of aphid population over control was recorded in mustard seed extract treated plots.

4.1.2 Effect on jassid population

Before fruiting stage, the lowest number of jassid/plant (3.33) was observed in neem seed kernel extract treated plots, which was significantly lower than rest of the treatments. In contrast, significantly higher number of jassid/plant (9.33) was obtained in control plots followed by (7.333) in mustard seed extract treated plot (Table 2). Bishkatali leaf extract treated plots had 4.00 /plant, which was significantly lower than control (Table 2). The highest percent reduction (64.28%) of population over control was obtained by application of neem seed kernel extract followed by 57.13% in bishkatali leaf extract treated plots. Among the different treatments, mustard seed extract had the lowest effectiveness in reducing the jassid/plant (21.40%).

During the fruiting stage, the lowest (10.67) number of jassid per plant in plots treated with neem seed kernel extract, which was significantly lower than all the treatments (Table 2). On the other hand, significantly higher number of jassid/plant (23.67) was observed in untreated control. No significant difference was observed between jassid/plant treated with mehogoni seed extract and tobacco leaf extract (15.67and 14.33 respectively). During the fruiting stage, the lowest (10.67) number of jassid per plant in neem seed kernel extract treated plots and bishkatali leaf extract (14.33) treated plots respectively. The highest reduction of population over control (54.92%) recorded in neem seed kernel extract treated plots followed by bishkatali leaf extract treated plots (53.13%) at fruiting stage as against the lowest reduction (22.56%) of jassid population over control was recorded in mustard seed extract treated plots.

4.1.3 Effect on whitefly population

Before fruiting stage, the lowest number of whitefly per plant (4.33) was observed in neem seed kernel extract treated plots, which was significantly lower than rest of the treatments. In contrast, significantly higher number of whitefly/plant (10.33) was obtained in control plots followed by (8.33) in mustard seed extract treated plot (Table 3). Bishkatali leaf extract treated plots had 5.00 whitefly/plant, which was significantly lower than control (Table 3). The highest percent reduction,(58.05%) of population over control was obtained by application of neem seed karnel extract followed by 51.60% in bishkatali leaf extract treated plots. Among the different treatments, mustard seed extract had the lowest effectiveness in reducing the whitefly /plant (19.33%).

During the fruiting stage, the lowest (11.67) number of whitefly per plant in plots treated with neem seed kernel extract, which was significantly lower than all the treatments (Table 3). On the other hand, significantly higher number of whitefly/plant (24.33) was observed in untreated control. No significant difference was observed between whitefly/plant treated with mehogoni seed extract and tamarind fruit extract (16.67 and 17, respectively). The highest reduction of population over control (52.03%) recorded in neem seed kernel extract treated plots followed by bishkatali leaf extract treated plots (49.32%) at fruiting stage as against the lowest reduction (20.5%) of whitefly population over control was recorded in mustard seed extract treated plots.

Table 2. Incidence of jassid under different treatments at two different stages of brinjal

Treatments	Before fruiting		Fruiting stage	
	Jassid incidence (No./5 leaves/plant)	Percent reduction over control	Jassid incidence (No./5 leaves/plant)	Percent reduction over control
T_1	3.33d	64.28	10.67f	54.92
T_2	6.33bc	32.12	15.67c	33.80
T_3	6.00c	35.69	16.00c	32.40
T_4	5.33c	42.84	12.67e	46.47
T_5	4.00d	57.13	11.33f	52.13
T_6	5.66c	39.26	14.33d	39.46
T_7	7.333b	21.40	18.33b	22.56
T_8	9.333a		23.67a	
LSD	**1.185**		**1.155**	
CV (%)	**11.44**		**4.30**	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract

T_2 = Mehogoni seed extract

T_3 = Tamarind fruit extract

T_4 = Bonkolmi leaf extract

T_5 = Bishkatali leaf extract

T_6 = Tobacco leaf extract

T_7 = Mustard seed extract

T_8 = Untreated control

Table 3. Incidence of whitefly under different treatments at two different stages of brinjal

Treatments	Before fruiting		Fruiting stage	
	Whitefly incidence (No./5 leaves/plant)	Percent reduction over control	Whitefly incidence (No./5 leaves/plant)	Percent reduction over control
T_1	4.33d	58.05	11.67f	52.03
T_2	7.33bc	29.01	16.67c	31.48
T_3	7.00c	32.24	17.00c	30.13
T_4	6.33c	38.69	13.67e	43.81
T_5	5.00d	51.60	12.33f	49.32
T_6	6.66c	35.46	15.33d	36.99
T_7	8.33b	19.33	19.33b	20.5
T_8	10.33a	-	24.33a	-
LSD	**1.185**		**1.155**	
CV (%)	**9.79**		**4.05**	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract

T_2 = Mehogoni seed extract

T_3 = Tamarind fruit extract

T_4 = Bonkolmi leaf extract

T_5 = Bishkatali leaf extract

T_6 = Tobacco leaf extract

T_7 = Mustard seed extract

T_8 = Untreated control

4.1.4 Effect on mealybug population

In case of mealybug, before fruiting stage, the lowest number of mealybug/plant (2.33) was observed in neem seed kernel extract treated plots, which was significantly lower than rest of the treatments. In contrast, significantly higher number of mealybug/plant (8.33) was obtained in control plots followed by (6.33) in mustard seed extract treated plot (Table 2). Bishkatali leaf extract treated plots had 3.00 malybug/plant, which was significantly lower than control (Table 4). The highest percent reduction (72.00%) of population over control was obtained by application of neem seed kernel extract followed by 64.00% in bishkatali leaf extract treated plots. Among the different treatments, mustard seed extract had the lowest effectiveness in reducing the mealybug/plant (24.00%).

During the fruiting stage, the lowest (9.67) number of mealybug per plant in plots treated with neem seed kernel extract, which was significantly lower than all the treatments (Table 4). On the other hand, significantly higher number of mealybug/plant (22.67) was observed in untreated control. No significant difference was observed between mealybug/plant treated with mehogoni seed extract and tamarind fruit extract (14.67 and 15.00, respectively). The highest reduction of population over control (57.36%) recorded in neem seed kernel extract treated plots followed by bishkatali leaf extract treated plots (54.43%) at fruiting stage as against the lowest reduction (23.58%) of mealybug population over control was recorded in mustard seed extract treated plots.

Table 4. Incidence of mealybug under different treatments at two different stages of brinjal

Treatments	Before fruiting		Fruiting stage	
	Mealybug incidence (No./5 leaves/plant)	**Percent reduction over control**	**Mealybug incidence (No./ 5 leaves/plant)**	**Percent reduction over control**
T_1	2.33d	72.00	9.66f	57.36
T_2	5.33bc	36.00	14.67c	35.29
T_3	5.00c	40.00	15.00c	33.83
T_4	4.33c	48.00	11.67e	48.52
T_5	3.00d	64.00	10.3f	54.43
T_6	4.66c	43.99	13.33d	41.20
T_7	6.33b	24.00	17.33b	23.58
T_8	8.33a	-	22.67a	-
LSD	**1.185**		**1.155**	
CV (%)	**13.77**		**4.60**	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated control

The moderate effect of neem seed kernel extract 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 kernel extract was moderately effective against jassid. These results also agreed with those of Singh and Kumar (2003) who reported the highest efficacy of neem seed kernel extract 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.

Narayanasamy (2002) also agreed with these results, and he reported that, plant extracts were of particular value in controlling the sucking and chewing pests. 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.

Sathyaseelan and Bhaskaran (2010) recorded that, neem seed kernel extract had a moderate repellent effect against mealy bugs. This also supports the current results.

4.2 The results on effect of different plant extracts on yield contributing characters and yield of brinjal

4.2.1 Effect on number of leaves/plant and leaf infestation

The results on the effect of different treatments on leaf infestation caused by the aphid 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 (35.33) was recorded in neem seed kernel extract followed by bishkatali leaf extract (34.67), bonkalmi leaf extract (34.33), tobacco leaf extract (34.00) and tamarind fruit extract (32.67), respectively having no significant difference among them (Table 5).

On the other hand, the lowest number of healthy leaves/plant (29.33) was recorded in control, which was significantly lower than all other treatments. The lowest leaf infestation (11.67%) was found in the plots treated with neem seed kernel extract followed by bishkatali leaf extract (13.33%). In contrast, (22.80%) 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 (48.82%) was recorded in neem seed kernel extract treated plots. Mustard seed extract reduced only (19.21%) leaf infestation which was significantly lower than other plant extracts.

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 (36.33) was recorded in neem seed kernel extract followed by bishkatali leaf extract (35.67), bonkolmi leaf extract (35.33), tobacco leaf extract (35.00) and tamarind fruit extract (33.67), respectively having no significant difference among them (Table 6).

On the other hand, the lowest number of healthy leaves/plant (30.33) was recorded in control, which was significantly lower than all other treatments. The lowest leaf infestation (9.167%) was found in the plots treated with neem seed kernel extract followed by bishkatali leaf extract (10.83%). In contrast, (20.20%) 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 (54.62%) was recorded in neem seed kernel extract treated plots. Mustard seed extract reduced only (21.78%) leaf infestation which was significantly lower than other plant extracts.

Table 5. Effects of different treatment on leaves per plant in number for population dynamics and management of aphid in brinjal

Treatments	Number of leaves/plant		Percent infestation	Percent reduction of leaf infestation
	Healthy leaves	Infested leaves		
T_1	35.33a	4.66e	11.67f	48.82
T_2	32.33c	6.66bc	17.09bc	25.04
T_3	32.67c	6.33bcd	16.24bcd	28.77
T_4	34.33ab	5.66cde	14.17def	37.85
T_5	34.67ab	5.33de	13.33ef	41.54
T_6	34.00b	6.00bcd	15.00cde	34.21
T_7	31.00d	7.00b	18.42b	19.21
T_8	29.33e	8.66a	22.80a	-
LSD	0.9829	0.9829	2.487	
CV (%)	1.70	8.93	8.83	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan’s Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated control

Table 6. Effects of different treatment on leaves per plant in number for population dynamics and management of jassid in brinjal

Treatments	Number of leaves/plant		Percent infestation	Percent reduction of leaf infestation
	Healthy leaves	Infested leaves		
T_1	36.33a	3.667e	9.16f	54.62
T_2	33.33c	5.667bc	14.53bc	28.07
T_3	33.67c	5.33bcd	13.67bcd	32.33
T_4	35.33ab	4.67cde	11.67def	42.23
T_5	35.67ab	4.33de	10.83ef	46.39
T_6	35.00b	5.00bcd	12.50cde	38.12
T_7	32.00d	6.00b	15.80b	21.78
T_8	30.33e	7.67a	20.20a	
LSD	0.982	0.982	2.501	
CV (%)	1.65	10.61	10.54	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated control

The results on the effect of different treatments on leaf infestation caused by the whitefly 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 (35.33) was recorded in neem seed kernel extract followed by bishkatali leaf extract (34.67), bonkolmi leaf extract (34.33), tobacco leaf extract (34.00) and tamarind fruit extract (32.67), respectively having no significant difference among them (Table 7).

On the other hand, the lowest number of healthy leaves/plant (29.33) was recorded in control, which was significantly lower than all other treatments. The lowest leaf infestation (11.67%) was found in the plots treated with neem seed kernel extract followed by bishkatali leaf extract (13.33%). In contrast, (22.80%) 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 (48.82%) was recorded in neem seed kernel extract treated plots. Mustard seed extract reduced only (19.21%) leaf infestation which was significantly lower than other plant extract.

The results on the effect of different treatments on leaf infestation caused by the mealybug 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 (38.33) was recorded in neem seed kernel extract followed by bishkatali leaf extract (37.67), bonkalmi leaf extract (37.33), tobacco leaf extract (37.00) and tamarind fruit extract (35.67), respectively having no significant difference among them (Table 8).

On the other hand, the lowest number of healthy leaves/plant (32.33) was recorded in control, which was significantly lower than all other treatments. The lowest leaf infestation (4.167%) was found in the plots treated with neem seed kernel extract followed by bishkatali leaf extract (5.83%). In contrast, (14.91%)

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 (72.05%) was recorded in neem seed kernel extract treated plots. Mustard seed extract reduced only (29.38%) leaf infestation which was significantly lower than other plant extracts.

Table 7. Effects of different treatment on leaves per plant in number for population dynamics and management of whitefly in brinjal

Treatments	Number of leaves/plant		Percent infestation	Percent reduction over control
	Healthy leaves	Infested leaves		
T_1	35.33a	4.66e	11.67f	48.82
T_2	32.33c	6.66bc	17.09bc	25.04
T_3	32.67c	6.33bcd	16.24bcd	28.77
T_4	34.33ab	5.66de	14.17def	37.85
T_5	34.67ab	5.33de	13.33ef	41.54
T_6	34.00b	6.00bcd	15.00cde	34.21
T_7	31.00d	7.00b	18.42b	19.21
T_8	29.33e	8.66a	22.80a	
LSD	**0.9829**	**0.9829**	**2.487**	
CV (%)	**1.70**	**8.93**	**8.83**	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated control

Table 8. Effects of different treatment on leaves per plant in number for population dynamics and management of mealybug in brinjal

Treatments	Number of leaves/plants		Percent infestation	Percent reduction over control
	Healthy leaves	Infested leaves		
T_1	38.33a	1.66e	4.16f	72.05
T_2	35.33c	3.66bc	9.40bc	36.93
T_3	35.67c	3.33bcd	8.54bcd	42.68
T_4	37.33ab	2.67cde	6.66def	55.29
T_5	37.67ab	2.33de	5.83ef	60.88
T_6	37.00b	3.00bcd	7.50cde	49.70
T_7	34.00e	4.00b	10.53b	29.38
T_8	32.33e	5.67a	14.91a	
LSD	**0.9829**	**0.9829**	**2.487**	
CV (%)	**1.56**	**17.06**	**16.82**	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated control

4.2.2 Effect on number of branches/plant

The umber 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 (10.67) was recorded from neem seed kernel extract treated plots followed by bishkatali leaf extract (9.33) treated plots with no significant difference between them (Figure 5). The lowest number of branches/plant (6.33) was observed in control plots, which was significantly lower than all treatments. Among the different botanicals extracts mustard seed extract had the lowest number of branches/plant (6.67).

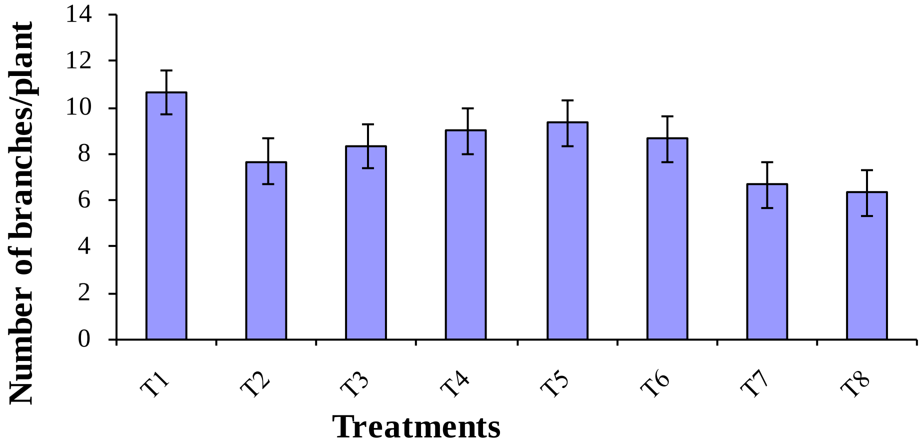

Figure. 5. Average number of branch per plant in different treatments. The T-shaped beams represent the LSD values.

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated control

4.2.3 Effect on number of fruits/plant

The result revealed that the highest number of fruits/plant (27.33) was obtained in neem treated plots followed by (25.33) in bishkatali treated plots with significant difference between them. Next to them, bonkolmi treated plots had (23.33) fruit/plant, which was statistically similar with tobacco but significantly higher than other treatments. In contrast, the lowest number of frui/plant (15.67) was recorded from control plots, which was significantly lower than all insecticides treated plots(Table 9).

4.2.4 Effect on fruit length

The effect of different botanical extracts on brinjal fruit length against sucking pest infestation has been presented in (Table 9). The result reveals that the highest fruit length (12.83cm) was observed in neem treated plots followed by (12.67 cm) and (12.20 cm) in bishkatali and bonkolmi, respectively with no significant difference among them. Next to them, tobacco treated plots had (12.00 cm) fruit length of brinjal followed by (11.80 cm) in tetul having no significant difference between them. The lowest fruit lenglh of brinjal (10.70 cm) was recorded from control plots, which was significantly lower than all other treated plots.

4.2.5 Effect on fruit diameter

Application of different botanical extracts had a considerable effect on average fruit diameter of brinjal. The result reveals that the highest diameter of brinjal fruit (3.10 cm) was recorded from neem treated plots, which was significantly higher than other treatments. Next to it, bishkatali and bonkolmi showed the better performance (2.867 cm 2.833 cm, respectively) regarding this parameter (Table 9). The lowest diameter of brinjal fruit (2.133 cm) was recorded from control plots, which was significantly lower than all other treatments.

Table 9. Effect of different treatments on number of fruit/plant, average length of fruit and average fruit diameter of fruit of brinjal against sucking insect pests infestation

Treatments	Number of fruit/plant	Average length of fruit (cm)	Average diameter of fruit (cm)
T_1	27.33a	12.83a	3.10a
T_2	19.67e	11.50cd	2.53d
T_3	21.67d	11.80bcd	2.66c
T_4	23.33c	12.20ab	2.83b
T_5	25.33b	12.67a	2.86b
T_6	22.33cd	12.00bc	2.76bc
T_7	20.33e	11.20de	2.33e
T_8	15.67f	10.70e	2.13f
LSD	**1.072**	**0.6167**	**0.1238**
CV (%)	**2.79**	**2.97**	**2.73**

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated contro

4..2.6 Effect on individual fruit weight

The highest weight of brinjal fruit (82.00 g) was recorded from neem treated plots, followed by (77.67 g and 75.33 g) in bishkatali and bonkolmi, respectively but weight of individual fruit in neem was significantly higher than all other treatments (Figure 6). No significant difference was observed in individual fruit weight of tobacco and tetul (72.33g and 70.00 g, respectively). The lowest weight of individual fruit (57.00 g) was observed in control, which was significantly lower than all other treatments.

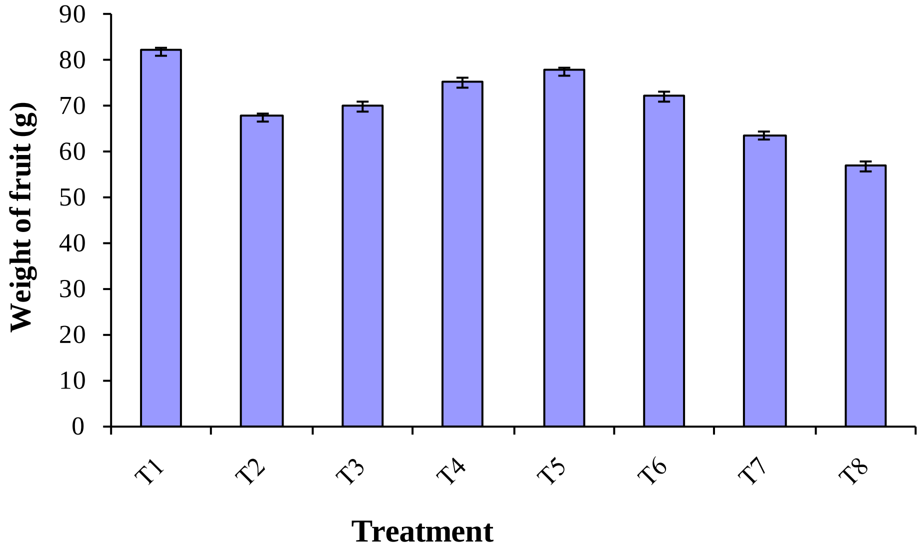

Figure. 2. Average weight of fruit per plant in different treatments. The T-shaped beams represent the LSD values.

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated contro

4.2.7 Effect on yield of brinjal

The effect of different plant extracts had influenced on yield of brinjal. The data (Table 10) indicates that the maximum yield of brinjal (28.90 t/ha) was obtained in neem seed kernel extract followed by (28.67 t/ha) in bishkatali leaf extract treated plots during summer season having no significant difference between them. In contrast, it was only (20.40 t/ha) in control plots, which was significantly lower than all other treatments. Bonkolmi leaf extract and tobacco leaf extract sprayed plots produced (27.70 t/ha) and (26.70 t/ha), respectively which were significantly higher than that of other treatments. The results obtained in the present investigation suggest that the application of different plant extracts reduce the sucking insect pests 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 plant extracts varied greatly depending on the biological activities of the insecticides. Among the different insecticides neem seed kernel extract and bishkatali leaf extract performed the best effectiveness in all the parameters ensuring higher fruit yietd of brinjal. Next to them bonkolmi leaf extract and tobacco leaf extract provided the satisfactory protection of sucking insect pests attack. The higher efficacy of neem seed kernel extract against sucking insect pests infestation on brinjal could not be compared with that of the others due to lack of information.

The highest effect of neem seed kernel extract 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 reported that aqueous neem seed kernel extract was moderately effective against jassid. These results also supports with those of Singh and Kumar (2003) who reported the highest efficacy of neem seed kernel extract 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.

Table 10. Average fruit yield of brinjal in different treatments against sucking insect pests infestation

Treatments	Average Yield of fruit	Percent increase over control
T_1	28.90 a	54.62
T_2	24.87 e	28.03
T_3	25.77 d	32.33
T_4	27.70 b	42.23
T_5	28.67 a	46.37
T_6	26.70 c	38.12
T_7	22.87 f	21.78
T_8	20.40 g	
LSD	**0.3458**	
CV (%)	**0.76**	

Data are the mean of three (3) replications derived from seven recording before fruiting stage and seven recording at fruiting stage. In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Neem seed kernel extract
T_2 = Mehogoni seed extract
T_3 = Tamarind fruit extract
T_4 = Bonkolmi leaf extract
T_5 = Bishkatali leaf extract
T_6 = Tobacco leaf extract
T_7 = Mustard seed extract
T_8 = Untreated control

Chapter V
Summary
&
Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment on the population dynamics and management of sucking insect pests 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 2012. The present experiment was conducted to evaluate some plant extracts against major sucking insect pests of brinjal in terms of population dynamics of them, yield contributing characters and yield of brinjal.

The population of aphid, jassid, whitefly and mealybug were gradually decreased with the age of the plant. The highest population of all the sucking insect pests was observed in control plots in comparison to the lowest in neem treated plots.

Before fruiting stage, the lowest number of aphid/plant (5.33) was observed in neem seed kernel extract treated plots higher number of aphid/plant (11.33) was obtained in control plots. During the fruiting stage, the lowest (12.67) number of aphid per plant in plots treated with neem seed kernel extract. On the other hand, significantly higher number of aphid/plant (20.80) was observed in untreated control.

Before fruiting stage, the lowest number of jassid/plant (3.33) was observed in neem seed kernel extract treated plots and significantly higher number of jassid/plant (9.33) was obtained in control plots. During the fruiting stage, the lowest (10.67) number of jassid per plant in plots treated with neem seed kernel extract and higher number of jassid/plant (23.67) was observed in untreated control.

Before fruiting stage, the lowest number of whitefly/plant (4.33) was observed in neem seed kernel extract treated plots and significantly higher number of whitefly/plant (10.33) was obtained in control plots. During the fruiting stage, the lowest (11.67) number of whitefly per plant in plots treated with neem seed kernel extract and significantly higher number of whitefly/plant (24.33) was observed in untreated control.

In case of mealybug, before fruiting stage, the lowest number of mealybug/plant (2.33) was observed in neem seed kernel extract treated plots and significantly higher number of whitefly/plant (8.33) was obtained in control plots. During the fruiting stage, the lowest (9.667) number of mealy per plant in plots treated with neem seed kernel extract and significantly higher number of mealybug/plant (22.67) was observed in untreated control.

The results on the effect of different treatments on leaf infestation caused by the aphid 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 (35.33) was recorded in neem treated plots. On the other hand, the lowest number of healthy leaves/plant (29.33) was recorded in control, which was significantly lower than all other treatments. In case of jassid the highest number of healthy leaves/plant (36.33) was recorded in neem seed kernel extracts treated plots. On the other hand, the lowest number of healthy leaves/plant (30.33) was recorded in control, which was significantly lower than all other treatments. In case of whitefly the highest number of healthy leaves/plant (35.33) was recorded in neem seed kernel treated plots and the lowest number of healthy leaves/plant (29.33) was recorded in control. In case of mealybug the highest number of healthy leaves/plant (38.33) was recorded in neem seed kernel extract treated plots and the lowest number of healthy leaves/plant (32.33) was recorded in control.

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 (10.67) was recorded from neem seed kernel extract treated plots. The lowest number of branches/plant (6.33) was observed in control plots, which was significantly lower than all treatments. The result revealed that the highest number of fruits/plant (27.33) was obtained in neem treated plot. The effect of different botanical extracts on brinjal fruit length against sucking insect pests infestations has been done. The result reveals that the highest fruit length (12.83cm) was observed in neem seed kernel extract treated plots. The lowest fruit lenglh of brinjal (10.70 cm) was recorded from control plots, which was significantly lower than all other treated plots.

Application of different plant extracts had a considerable effect on average fruit diameter of brinjal. The result showed that the highest diameter of brinjal fruit (3.10 cm) was recorded from neem seed kernel extract treated plots and lowest diameter of brinjal fruit (2.133 cm) was recorded from control plots.

The highest weight of brinjal fruit (82.00g) was recorded from neem seed kernel extract treated plots, followed by (77.67g and 75.33g) bishkatali and bonkolmi, respectively but weight of individual fruit in neem was significantly higher than all other treatments. The lowest weight of individual fruit (57.00g) was observed in control, which was significantly lower than all other treatments. The effect of different plant extracts had influenced on yield of brinjal. The data indicates that the maximum yield of brinjal (28.90 t/ha) was obtained in neem seed kernel extract followed by (28.67 t/ha) bishkatali leaf extract treated plots, where lowest (20.40 t/ha) was found in control plots.

From the above results it was observed that neem seed kernel extract was the most effective against sucking insect pests and mustard seed extract showed the least effectiveness against sucking insect pests attacing brinjal.The order of efficacy of the total plant extract is neem seed kernel extract, bishkatali leaf extract, bonkolmi leaf extract, tobacco leaf extract, tamarind fruit extract, mehogoni seed extract and mustard seed extract.

Based on the above result it can be concluded that, neem seed kernel extract and bishkatali leaf extract may have good impact for the management of sucking insect pests of brinjal. But it is necessary to fix up the appropriate dose of these two insecticides and also further investigation in large scale farmer’s field.

CHAPTER VI

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CHAPTETR VI
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Appendices

APPENDICES

Appendix I. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from November 2010 to March 2011

Month	RH (%)	Max. Temp. (ºC)	Min. Temp. (ºC)	Rain fall (mm)
November	50.26	24.80	16.40	0
December	48.36	24.52	14.18	0
January	55.53	25.00	13.46	0
February	50.31	29.50	18.49	0
March	44.95	33.80	20.28	25
April	61.40	33.74	23.81	185

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

Appendix II. Characteristics of experimental soil was analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B.

Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix iii.Average number of branch per plant in different treatments. The T-shaped beams represent the LSD values.

Treatments	**Branch /plant**
Neem	10.67a
Mehogoni	7.667c
Tetul	8.333bc
Bonkolmi	9.000b
Biskatali	9.333b
Tobacco	8.667bc
Mustard	6.667d
Water	6.333d
LSD	**0.9750**
CV (%)	**6.68**

Appendix IV Average weight of fruit per plant in different treatments. The T-shaped beams represent the LSD values.

Treatments	**Av. wt of frt**
Neem	82.00a
Mehogoni	67.67f
Tetul	70.00e
Bonkolmi	75.33c
Biskatali	77.67b
Tobacco	72.33d
Mustard	63.67g
Water	57.00h
LSD	**0.9656**
CV (%)	**0.78**