MAJOR INSECT PESTS OF COWPEA (*Vigna unguiculata* L. Walp.) AND THEIR MANAGEMENT PRACTICES

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DEPARTMENT OF ENTOMOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207, BANGLADESH

DECEMBER, 2009

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BY

MD. NURUNNABI
REGISTRATION NO.: 08-03197

A Thesis

Submitted to the Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka,

in partial fulfillment of the requirements

for the degree of

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IN

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CERTIFICATE

This is to certify that thesis entitled, **"MAJOR INSECT PESTS OF COWPEA (*Vigna unguiculata* L. Walp.) AND THEIR MANAGEMENT PRACTICES"** submitted to the **Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka,** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. NURUNNABI, Reg. No. 08-03197** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2009

Dhaka, Bangladesh

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Prof. Dr. Mohammed Ali
Research Supervisor

DEDICATED

TO

MY BELOVED PARENTS

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CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF APENDICES

LIST OF FIGURES

ABSTRACT

A field study was carried out in the farm of Sher-e-Bangla Agricultural University, during March to June, 2009 to investigate the major insect pests of cowpea (*Vigna unguiculata*) and to explore the suitable practice(s) for their management. Among the treated plots, the lowest incidences of bean aphid and jassid were observed in T_1 (Neem oil treated plot @ 3 ml/L of water) at different days after sowing whereas the higher incidences was found in T_6 (Furadan 5G @ 5 g/Plot.) For management of thrips and pod borer, T_1 (Neem oil @ 3 ml/L of water) as well as T_2 (NSKE @ 5 ml/L of water) demonstrated the highest performance whereas T_5 (Dursban 20EC @ 2 ml/L of water) showed the lowest performance under the present study. Yield and yield performance against different insect pests were significantly influenced by different treatments. Highest number of healthy pods (480.33)/4m^2 was obtained in T_1 (Neem oil treated plot) where the lowest (263.67)/4m^2 in T_5 (Dursban 20 EC treated plot). The highest percent of pods weight (78.32%) was obtained with T_1 (Neem oil treated plot) treatment while the lowest percent of pods weight (69.21%) was obtained with T_4 (Marshal 20 EC treated plot) considering percent infestation of pods by number and weight

CHAPTER I

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is an important food and fodder legume crop in the semi-arid tropics covering Asia, Africa, Southern Europe, Southern United States and Central and South America. The name “cowpea” (Felon) is probably of American origin from the fact that the plant was an important source of hay for cows in the United States and was first used in print in 1798. When this crop was first grown in the United States, it was called "pease," and later, “corn-field pease”, because of the early custom of planting it between the rows of field corn. It is now called “southernpeas,” “blackeyed peas,” “field peas,” “pinkeyes,” and “crowders” etc. (Atwal, 1986).

Cowpea is a major source of protein, minerals and vitamins in the daily diets and thus it positively impacts on the health of women and children. Cowpea seed is a nutritious component in the human diet, as well as a nutritious livestock feed. Nutrient content of cowpea seed is Protein- 24.8%, Fat- 1.9%, Fiber- 6.3%, Carbohydrate- 63.6%, Thiamine- 0.00074%, Riboflavin- 0.00042% and Niacin- 0.00281%. (Hossain and Awrangzeb,1992).

Being a drought tolerant and warm weather crop, cowpea is well adapted to the drier regions of the tropics where other food legumes do not perform well. It also has the unique ability to fix atmospheric nitrogen through its nodules. Also, it is shade tolerant and therefore, compatible as an intercrop with maize, millet, sorghum, sugarcane and cotton as well as with several plantation crops and thus it forms a valuable component of the traditional cropping systems. The plant's ability to fix atmospheric nitrogen helps maintain soil fertility, while its tolerance to drought extends its adaptation to drier areas considered marginal for most other crops (Singh *et al*., 1995).

In Bangladesh it is a minor pulse crop which is cultivated in small scale mainly in southern part in Chittagong, Vhola, Feni, Laximpur, Noakhali and Patuakhali district of the country (BARI, 1986).

The world production of cowpea is nearly 80.3 million metric tons grown on more than 240 million hectres yielding about 0.48 metric tons per hectare. (Ezueh, 1984). Average yield of cowpea grain is 1594 kg ha^{-1} and Fodder is 1520 kg ha^{-1} (Bakar, 1980).

In our country the demand of pulse is very high but the production is 204000 metric ton, cultivated in 558000 acre land (BBS, 2009). The production of pulse crops is reduced day by day and the demand and price of pulse are increased by leaps and bounds. Due to low production and higher price of pulse the poor people and low income groups are failing to meet up their minimum demand of daily dal requirement. In this context, due to higher price of pulse, cowpea can be used as good source for meeting the demand of people, as it is a drought tolerant and warm weather crop, and is well adapted to the drier regions of the country where other food legumes do not perform well.

But, the crop, cowpea faces the serious infestation of different insects from its seedling to harvesting stage, even in storage. The major insect pests of cowpea are aphid, jassid, flower thrips and pod borer etc (Kumar *et al.*, 1997). Due to the attack of these insect pests, its yield sometimes reduced drastically.

Aphid, jassid, thrips and pod borer are common and serious insect pests against successful cowpea production. They cause serious damage of this crop.

The bean aphid, *A. craccivora* Koch is the most serious pest of bean plants from seedling to pod bearing stage, causing considerable yield losses (Malik *et al.*. 1988). Aphid causes damage directly by sucking cell sap of plant and indirectly by transmitting several vital diseases (Mickinlay *et al.*, 1992). The losses are colossal and irreparable (Butani and Jotwani, 1984). Both the nymphs and adults cause damage by sucking sap from flowers, buds, pods and tender shoots of the plants and reduce the vitality of the bean and leguminous crops (Thakur *et al.*, 1984). In severe cases, plants fail to give flowering and pods resulting 20-40% yield loss (Singh, 1980). These aphids also secrete abundant sticky honeydew, which enhance the growth of shooty mold fungus and reduces photosynthetic efficiency of the plant (El-Fatah, 1991).

Among the different insects pests attacking vegetables crops, cotton jassid, *Amrasca devastans* (Distant) is considering as the destructive one. The nymphs and adults of *A. devastans* can attack host leaves at all stages of development. It infests the lower surface of the leaves. Injury of the leaves is caused by the adults and nymphs feeding on the sap and injected saliva into the tissues, which causes toxemia. Infested leaves curl upwards along the margin. Outer leaf area appears yellowish or burned. The edges of the infested leaves turn pale-green, then yellow and finally brick red or brown in colour. The colour changes are accompanied by severe crinkling and curling of the leaf. The whole leaf gradually dries up and drops. The plant becomes stunted; quality of fruit is also affected (Nair, 1986). Due to sever infestation fruit set hampered seriously. It also transmitted viral disease like mosaic virus. (Ali & Karim, 1991) reported that 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.

In most seasons, damage by thrips to newly emerging pea or field bean crops, occurs to a greater or lesser degree. Attacks are more severe during periods of slow growth. Thrips cause severe injury to infested plants. Leaves become yellow, white or brown, and then crinkle and die. Heavily infested fields sometimes acquire a bronze color. Damaged terminal growth may be discolored, stunted, and deformed. Feeding usually occurs on foliage, but on pepper, a less suitable host, flowers are preferred to foliage. Fruits may also be damaged; scars, deformities, and abortion.

Pod borer is one of the most serious pests for cowpea in our country and all over the world. Dina (1979) and Bakar *et al*. (1980) found that it is a serious insect pest of leguminous vegetables. Butani and Jotwani (1984) found that Lepidoterous larvae as pests causing damage by boring tender or mature pods. Bean pod borer is able to establish itself from vegetative to reproductive stage. At the early stage of plant growth, the bean pod borer, attack the crop making clusters of leaves, tendrils and young shoots of the plant and later at flowering and pod setting stages of plants. The insect bores into these reproductive organs, where the insect feeds internally (Karim, 1993).

There are several pest control methods for controlling bean aphid, jassid, thrips and pod borer, as cultural (Sharma, 1998). Natural and applied biological (Karim, 1995) and chemical control measures (Rahman and Rahman, 1988). Insecticide applications, particularly a single application, may often fail to provide successful control of the pest (Begum, 1993; Rahman, 1989). As a result, multiple applications of control measure are required for controlling these pests.

To over come and minimize the pest's attack on cowpea and to increase the ultimate production of cowpea the research work will be drawn in various ways. Keeping the above situation in mind, the present study was under taken to fulfill the following objectives:

Objectives

1. To identify the major insect pests attacking cowpea and their intensity of infestation.
2. To develop a suitable management technique for controlling the insect pests of cowpea.

3. To evaluate some effective control tactics for the management of the major insect pests of cowpea.

CHAPTER II

REVIEW OF LITERATURE

The aphid, jassid, thrips and pod borer considered as important and most damaging pest of cowpea. Substantial works have been done regarding its geographical distribution, host range, seasonal abundance, population dynamics, its infestation intensity, loses incurred by them, existing IPM practices and others at home and abroad. Although the review could not be made so comprehensive due to limited scope and facility, it is hoped that most of the relevant information available in and around Bangladesh could be collected and reviewed. However, these studies are reviewed below covering the aforesaid areas.

2.1 Aphid

Aphid (*Aphis craccivora* Koch) is a polyphagous insect with marked preference to legumes. Amongst legumes, mungbean along with cowpea and groundnut are most damaged by this pest.

2.1.1 Biology

Adult aphids are black or dark brown, shiny, abdomen with large, dark, practically solid dorsal plate. Winged parthenogenetic females are 1.5 to 2.0 mm long, dark dorsal abdominal plate. Antennae are about two third as long as the body. Nymphs are wingless, dark with fairly rounded body 0.12 mm shape. Nymphs appear on the crop soon after germination from adults having over wintered or spent dry season on near by leguminous plants. In tropics only females, winged or wingless, are found, and parthenogenetic reproduction occurs throughout the year. The aphid is ovoviviparous, with females retaining eggs inside their bodies and giving birth to small nymphs. Males are winged and sexual forms are occasionally found. The optimal development temperature is 24-28.5°C and relative humidity 65%. The optimal day length for nymphal development is 16 hours light and 8 hours of darkness (Abdel Malek *et al.*, 1982)

2.1.2 Nature of damage

Young aphids cluster over tender shoots and occasionally young pods of mungbean and suck plant sap-from these plant parts. Heavy infestation weakens the plant and entire plant can be destroyed. Severe attack at the time of flowering and seed formation affects yield and produce wilt symptoms. In addition, abnormalities due to virus diseases - rosetting, stunting, mosaic, mottle etc can be observed.

The greatest damage results from virus diseases which are transmitted by *A. craccivora*, especially in groundnut. Among the virus vectored by this aphid in various crops are: alfalfa mosaic, bean common mosaic, bean yellow mosaic, cowpea aphid-borne mosaic, cowpea banding mosaic, cowpea mild mottle, bean leaf roll and chickpea stunt virus. In mungbean, it transmits at least three viruses; green mosaic, leaf curl browning and little leaf (Bishara *et al*., 1984).

2.1.3 Yield loss due to aphid

During cultivation of cowpea the farmers face a serious problem with bean aphid as it is one of the most destructive pests of world wide distribution (Begum *et al*., 1991) and is one of the limiting factors in the cultivation of country bean. (Malik *et al*.,1988). Bean aphid is polyphagous, with marked preference for leguminosae (Blackman and Eastop, 1984). Cowpea was found to be the most preferred crop by *A. craccivora* (Waghmare and Pokharker, 1974).

A. craccivora is the most damaging species causing significant damage throughout the world (Jackai and Daoust, 1986) and resulting 100% yield loss in different varieties of country bean (*L. purpureus*), barbati (*Vigna sesquipendalis*), black gram (*V. mungo*), mung bean (*V. radiata*) and cow-pea (*V. unguiculata*) in different places (Ganguli and Roychaudhury, 1984). In Bangladesh small, shiny black coloured bean aphid is known as *A. medicaginis* but in India this species is called *A. craccivora* (Verdcourt, 1970).

The bean aphid, *A. craccivora* Koch is the most serious pest of bean plants from seedling to pod bearing stage, causing considerable yield losses (Malik *et al*., 1988). Aphid causes damage directly by sucking cell sap of plant and indirectly by transmitting several vital diseases (Mickinlay *et al*., 1992). The losses are colossal and irreparable (Butani and Jotwani, 1984). Both the nymphs and adults cause damage by sucking sap from flowers, buds, pods and tender shoots of the plants and reduce the vitality of the bean and leguminous crops (Thakur *et al*., 1984). In severe cases, plants fail to give flowering and pods resulting 20-40% yield loss

(Singh and Allen, 1980). These aphids also secrete abundant sticky honeydew which enhance the growth of shooty mold fungus and reduces photosynthetic efficiency of the plant (Rizkalla *et al*., 1994).

The aphids are peculiar insects for their biology and adaptation to agro-ecosystem. They are perhaps the most prolific insects, due to their rapid growth and telescoping of generations rather than to the number of young per female (Harries, 1968). There are many exceptions in the different species, but in general the aphids over-winter in the egg stage, and the hatching nymphs become stem mothers which produce living young in succeeding generations during the summer. These may be both wingless or winged agamic viviparous forms. In the fall winged males may appear which mate with the females to complete the cycle. In warmer climates the sexual part of the cycle may be entirely eliminated.

A. craccivora is a soft bodied prolific breeder and produces offsprings, parthenogenetically (Singh and Rai, 1994). Due to its parthenogenetic viviparity, short developmental period, high fecundity and polymorphic nature this insects soon build up a high population and thus causes a considerable damage to bean p1ant (Das, 1985).

Sunil *et al.* (1998) studied the life history of *Aphis craccivora* at 20°C, 50% RH and LD 16:8 h and showed the presence of four instars. Aphid infestation without control may account for more than 1000 million aphids per acre. On the other hand, yield, protein and carotene content of bean may -be reduced to half due to aphid infestation. It injects a toxin through salivary secretion into the plant during feeding, which causes vitality and reduction of growth (Jayappa and Lingappa, 1988).

From the economic standpoint the control of bean aphid is vital for successful bean production. The factors influencing its multiplication and colonization to host crop need to study before adopting control measures. The present study was undertaken with a view to evaluating the effective control measure.

2.1.4 Control Measures

2.1.4.1 Biological control

Most natural enemies of aphids are polyphagous attacking wide range of aphid species in a particular habitat. There fore, important natural enemies attacking particular aphid species on crops tend to be different according to crop species and climate. This is especially true of aphid species such as *A. craccivora*, attacking a range of crop over large geographical areas. In addition, many natural enemies, especially parasitoids are members of species complexes, morphologically very similar but with different host preferences and geographical distribution. Some of the important parasitoids of *A. craccivora* are: *Thioxysindicus*, *Lysiphlebus fabarumand* L, *Tesaceipes*. (Singh and Sinha (1983) found 9.4% parasitism by *T. indicus* shortly after appearance of *A. craccivora* on pigeon pea, in India. The peak rate of 64.6% was observed in later stages of infestation which was sufficient to suppress aphid populations on pigeonpea.

Important predators include coccinellid beetles, e.g. *Cheilomenessex maculate* and *Coccinella septempunctata*, neuropteran larvae, e.g. *Micro mustimidus* and predatory diptera, e.g. *Aphidoletes aphidimyza* and a syrphid, *Ischiodon scutellaris*. Use of chemical insecticides however, suppresses activityof all these beneficial arthropods. To conserve these natural enemies insecticidesthat are least toxic to predators and parasites that too only cases of absolute necessity.

2.1.4.2 Cultural control

Densely planted groundnut fields sown as soon as possible discourage colonization by aphids. Early sowing allows plants to start flowering before aphids appear, while dense sowing provide a barrier to aphids penetrating in from field edges. Sanitary measures are needed during the season and between seasons to prevent spread of viruses vectored by *A. craccivora*. Virus infected plants should be removed and any volunteer plants or weeds that could harbor viruses should be destroyed promptly. Insecticide applications were more effective in minimizing the incidence of *A. craccivora* when chickpeas were intercropped with barley or linseed. However, mungbean. cowpea or groundnut are not suitable crops for intercropping due to the risk of spread of the insect between these favorable host-plants.

2.1.4.3 Chemical control

Most major groups of insecticides, especially organophosphorus and carbamates, have been tested and some of them found effective against wide variety of aphid on economically important crops. Pirimicarb a selective aphicideis widely used to control various species of aphids. Other chemicals include acephate, dimethoate, endosulfan, menazon, and thiometon which have been recommended for aphid control. Other sprays found promising on crops include neem (Dreyer, M. 1987) and petroleum oil (El-Tom, 1987).Cost of some of these sprays could, however, be prohibitive to subsistence farmers growing mungbean.

2.1.4.4 Integrated pest management

Potential exist for the integrated control of *A. craccivora*. Combinations of selective insecticides, predators and parasites, cultural methods and resistant cultivars have potential of controlling the pest on a sustainable basis. In groundnut, monitoring pest populations to time insecticide spray application is combined with the use of cultural methods and resistant cultivars (Misra *et al*., 2003). In Bangladesh the IPM involving using malathion along with natural predation of *Menochilus sexmaculatus* was successful in controlling *A. craccivora* on beans (Ahmad *et al*., 1985).

During 1995-1996, a partial insecticide experiment was carried out on farms in Igalaland, Kogi State, Nigeria, to study the effects on the nature of insect pest attack of treating only a certain proportion (0, 25, 50, 75 or 100%) of the plants in a cowpea stand with a systemic insecticide (carbofuran as Furadan 3G, 3% a.i.). Numbers of both cowpea aphid (*Aphis craccivora*) and bean foliage beetles (*Ootheca mutabilis*) were determined and cowpea leaf damage was assessed. It was found that the greater the proportion of insecticide-treated plants in a plot, the lower the foliage pest infestation and damage on the susceptible (untreated) component. The reductions in leaf damage on untreated plants grown in admixture with insecticide-treated plants were often statistically significant although not as great as that achieved by the insecticide-treated plants themselves. It is concluded that the reduction of insect pests on the susceptible component was caused by a redistribution of pests, exposing them to toxins, after the initial infestation. A final set of experiments attempted to validate these results utilizing an aphid resistant variety of cowpea, but the results were inconclusive.

2.2 Jassid

Jassid, *Amrasca divastans* (Distant) is considered as one of the major pest of different vegetable crops, which causes significant damage to crop. The incidence of this pest occurs sporadically or in epidemic forth every year 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.

2.2.1 Biology

Egg: The adults mate two days after emergence and the eggs are laid two to seven days after copulation. Eggs are laid singly within leaf veins in the paranchymatous layer between the vascular bundles and the epidermis on the upper leaf surface. All average of 15 eggs (with a maximum of 29) s laid per female. Mature leaves (35-45 days old) are preferred for egg deposition. Curved, greenish-yellow eggs (0.70.9 x 0.15-0.2mm) are laid. Egg period lasts for 4-11 days (Nair, 1986).

Nymph: Nymphs are pale green, wedge-shaped, 0.5-2.0 mm long, have a characteristic crab-like, side ways movement when disturbed. They are confined to the under surface of leaves during the day time but can be found anywhere on the leaves at night. The nymphal period can vary from 7 to 21 days depending on food supplies and temperature. They pass through six stages of growth during nymphal period (Atwal, 1986). Another study revealed that they become full-grown in seven days in autumn and 25 days in winter.

Adult: The adults are small, elongate, wedge-shaped, about 2.5 mm long, body pale green with semi-transparent, shimmering wings; very active, having a side way walk like, the nymphs, but quick to hop and fly when disturbed. The adults of the summer brood are greenish yellow in colour and those of the winter brood reddish. Unmated adults live for three months or more, when mated they live for longer than five weeks in summer and seven weeks in winter. Life cycle is completed in 15-46 days in the different seasons and up to eleven generation is completed in a year (Nair, 1986). They are also attracted to light at night (Atwal, 1986).

2.2.2 Nature of Damage

Jassid, *A. devastans* infestation are manifested by some characteristic symptoms. The primary symptom is characterized by leaf edge curling and the secondary symptom is characterized by leaf edge curling along with reddish colouring of leaves and the late symptoms are characterized by leaf edge curling along with leaf edge and vein colouring and drying of the leaves. From the initial infestation, these symptoms develop in sequence leading to `hopper burn' and shedding of leaves in severe causes of infestation, which ultimately causes the retraction of plant growth, reduction of yield (Afzal and Ghani, 1953).

2.2.3 Yield loss due to jassid

Nair (1986) reported that the nymphs and adults of *A. devastans* could attack host leaves at all stages of development. The adults and nymphs feeding on the sap and injected saliva into the tissues, which causes toxemia, cause injury of the leaves.

The edges of the infested leave turn pale-green, then yellow and finally brick red or brown in colour. The colour changes are accompanied by severe crinkling and curling of the leaf. The whole of the leaf gradually dries up and drops. The plant becomes stunted; quality of' fruit is also affected. Gandhi, 1978. reported that if the plants infested by jassid during their early ages, the plant growth may be arrested.

The jassids while sucking the plant sap inject some toxic substance with saliva into the cotton plants (Nayer *et al*., 1976). Time required to development characteristic jassid damage symptoms in cotton plants were found positively correlated with age of the plant. The younger plants were found susceptible to jassid attack than the older plants.

As the plants grew older, they become less susceptible to jassid infestation (Ali, 1991). Gupta, 1980 reported a significant positive correlation between jassid damage symptoms and jassid population levels on the plant. Yield losses of cotton due to sucking pests (*Amrasca biguttula biguttula*) were evaluated during the rainy seasons of 1985 and 1986 in Karnataka, India. The average loss was 46.41 (Panchabhavi *et al*., 1980)

2.2.4 Control measure

2.2.4.1 Botanical control

Botanical pesticides are the most cost effective and environmentally safe inputs in integrated pest management (IPM) strategies. There are about 3000 plants and trees with insecticidal and repellant properties in the world, and India is home to about 70 per cent of this floral wealth (Nazrussalam, 2008). Nazrussalam has chronicled the use of more than 450 botanical derivatives used in traditional agricultural systems and neem is one of the well-documented trees, and almost all the parts of thee tree have been found to have insecticidal value. The ncem seed kernel extracts, ncem oil, extracts from the leaves and barks have all been used since ancient times to keep scores of insect pests away. A number of commercial ncem-based insecticides are now available and they have displaced several toxic chemical insecticides. The extracts are of particular value in controlling the sucking and chewing pests. The young caterpillars devouring the tender leaves ca~ be well managed by the botanical insecticides. The plant material should be thoroughly washed before preparing the extract, and the right quantity should be used.

The pest control potential demonstrated by various extracts and compounds isolated from the kernels and leaves of the neem plant [*Azadirachta indica*] seem to be of tremendous importance for agriculture in developing countries.

Laboratory and field trial data have revealed that neem extracts are toxic to over 400 species of insect pests some of which have develop resistance to conventional pesticedes, e.g. sweet potato whiteny (*Bemisia tabaci* Gen. Homoptera: Aleyrodidae), the diamond back moth (*Plutella xylostella* L. Lcpidoptcra: Plutcllidae) and cattle ticks (*Amblyomma cajenniense* F. Acarina: Ixodidae and *Boophilus microplus* Canestrini. Acarina: Ixodidae). The compounds isolated from the neem plant manifest their effects on the test organisms in many ways, e.g. as antifeedants, growth regulators, repellents, toxicants and chemosterilants.

Plate 1: Heavy attack of black aphids on cowpea plant

Plate 2: Jassid (nymphs and adult) feeding on lower surface of leaves

.

Plate 3: Jassid adult on leaf

This review strives to assess critically the pest control potential of neem extracts and compounds for their use in the tropics. This assessment is based on the Information available on the wide range of pests against which neem extracts and compounds have proven to be toxic, toxicity to non-target organisms, e.g. parasitoids, pollinators, mammals and fish, formulations, stability and phytotoxicity (Lawrence *et al*., 1996)

Azadirachtin has been exempted from residue tolerance requirements by the US Environmental Protection Agency for food crop applications. Azadirachtin exhibits good efficacy against key pests. Azadirachtin has minimal to no impact on non-target organisms, is compatible with other biological control agents and has a good fit into classical Integrated Pest Management programmes (Islam, 1999).

An experiment was conducted with okra in India to determine the efficacy of neem based pesticide against the cotton jassid, *A. biguttulla*. 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 a untreated control. Endosulfan a 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 ether treatments. However on the basis of cost benefit ratio NSKE (3%) ranked first (Singh, 1983).

2.2.4.2 Chemical control

Ali and Karim (1993) reported monocrotophos methamidophos and bifenthrin gave 91-97.53% mortality on the 2nd days post-treatment, and 73.27-79.17% mortality 30 days post- treatment of Anirasca devastans on cotton, Equivalent figures for dimethoate formulations were 56.50-72.37%, carbofuran had no effect on the 2nd day post treatment and gave only 8.72% mortality. All the insecticides tested were toxic to parasitoids and predators of A. devastans up to 30 days post - treatment.

A flexible 3-tier spraying threshold level (0.75 cicadellids/leaf during pre-flowering, l.0 cicadellid/leaf post flowering and 1.5 cicadellids/leaf during ball maturity stages) was suggests for A. devastans on cotton in Bangladesh (Ali and Karim, 1994).

Yadav *et al*. (1980) tested ten commercial formulations of commonly used insecticides against *A. devsastans* on okra at Haryana, India. Endosulfan at 0.05% carbaryl at 0.15% and oxydemcton-methyl at 0.025% were observed as most effective compounds for controlling jassid. Maximum mortality of the pest was observed I day after treatment. In the seed crop, any of the three compounds can be used safely but in vegetable okra, use of oxydemeton-methyl should be discontinued after the initiation of square formation; after fruit formation, eildosulfan, carbaryl or 0.05% malathion can be used.

Parkash and Verma (1985) determined the effectiveness of granular formulations of dimelhoatc, disulfoton, phorate, aldicards and carbofuran applied by various methods against the cicadellid, *A. devastans* and the aleyrodid, *Bemisia tabci* on brinjal. The methods involved were application to the nursery bed at 2.5 kg a.i./ha seven days before transplanting, soil applications around the seedlings at 1.Okg/lea at the time of transplanting, and all possible combinations of the three. These were Compared with foliar sprays containing 0.2% DDT, 0.03% dimethoate, 0.025`10 endrin (each applied at 20-days intervals). All the insecticidal treatments were equally effective in relation to untreated plots, and all the granular insecticides were equally effective against both pests. Among the various methods used to apply the latter, the least effective were application to the nursery bed, as a seedling root dip or with a combination of these 2; when applied by the other methods, the granular insecticides were as effective as the foliar sprays.

2.3 Thrips

In most seasons, damage by thrips to newly emerging pea or field bean crops, occurs to a greater or lesser degree. Attacks are more severe during periods of slow growth and in particular on stony soils.

2.3.1 Biology

Thrips are tiny, narrow bodied, black insects of the type known as thunder flies. many generations of thrips are wingless and spend most of the year in the soil, feeding on a wide range of non-legume crops including Brassicae, linseed and sugar beet. As peas or beans begin to emerge in the spring thrips feed inside the tightly rolled leaves of the growing point. Because feeding causes damage to the leaf surface, young leaflets appear pale and slightly distorted and if held to the light, small translucent markings are obvious. On beans, leaves may appear shiny and speckled with sooty black markings. The underside of bean leaves develop a rusty discoloration. By carefully unfolding the leaflets of affected seedlings, thrips may be found in varying numbers. In severe attacks the thrips are too numerous to count.

2.3.2 Nature of damage

Damage evident as blotching, expanding leaves at their worst in when cold and dry. Cosmetic damage to pods silvering effect. Only a problem if selling spotted peas. Also giving the leaves a 'leathery' look.

Feeding by thrips causes tiny scars on leaves and fruit, called stippling, and can stunt growth. Damaged leaves may become papery and distorted. Infested terminals may discolour, become rolled, and drop leaves prematurely. Petals may exhibit “color break,” which is pale or dark discolouring of petal tissue that was killed by thrips feeding before buds opened. Avocado, citrus, and greenhouse thrips cause silvery to brownish, scabby scarring on the avocado and citrus fruit surface, but this cosmetic damage does not harm the internal fruit quality. Faeces may remain on leaves or fruit long after thrips have left. Where thrips lay eggs on grapes, dark scars surrounded by lighter “halos” may be found on the fruit. Thrips feeding on raspberries, apples, and nectarines can deform or scar developing fruit; sugar pea pods may be scarred or deformed.

2.3.3 Review on thrips

Tolerance as a mechanism of resistance to the melon thrips, *Thrips palmi Karny* (Thysanoptera; Thripidae), in common beans, *Phaseolus vulgaris* L., was evaluated under field and greenhouse conditions. Seven resistant (Brunca, BH-5, BH-60, BH-130, BH-144, EMP 486, and FEB 115) and five susceptible (PVA 773, EMP 514, BAT 477, APN 18, and RAZ 136) bean genotypes were assessed according to adult and larval populations, visual damage and reproductive adaptation scores, and yield components in field trials. From these genotypes, four resistant (Brunca, BH-130, EMP 486, and FEB 115) and two susceptible (APN 18 and RAZ 136) genotypes were selected for quantification of proportional plant weight and height increase changes due to thrips infestation in greenhouse tests. Under medium to high thrips infestation in the field, most resistant genotypes tended to have higher reproductive adaptation and lower yield losses, though they did not always suffer less damage, as compared to susceptible genotypes. In the greenhouse, resistant genotypes showed less reduction in plant dry weight and height increase than did some susceptible ones under the same infestation pressure. Results from both field trials and greenhouse tests suggest the possible expression of tolerance as a mechanism of resistance to *T. palmi* in the resistant genotype EMP 486, and confirm the existence of antixenosis in FEB 115, whereas tolerance might be combined with other resistance mechanisms in Brunca (Islam, 2006).

Field study was carried out at Bangladesh Agricultural Research Institute (BARI) farm during March to August 2005 to find out the most appropriate management practices against thrips of mungbean. The experiment consisted of seven treatments of various management practices. It was laid out in Randomized Complete Block Design (RCBD) with four replications. The incidence of this pest was first noticed during vegetative and flowering stage. The infestation rate was highest in reproductive stage. Application of Furadan 5G as a seed treatment gave the maximum yield (950.5 kg/ha). On the other hand, minimum yield was found in control treatment. Two times application of Shobicron 425EC also gave the satisfactory result but it was not economically viable. Neem oil with Trix gave the significant result in comparison with other treatments and it may be environmentally friendly (Kyamanywa, 2009).

We used regression analysis to quantify yield variations in cowpea due to major insect pests, i.e., aphids (*Aphis craccivora* Koch), thrips (*Megalurothrips usitatus* Trybom), Maruca pod borer, *Maruca vitrata* Fabricius and a complex of pod-sucking bugs. Variability in pest infestation was created by growing *E. belat* (an erect cowpea cultivar) in two locations over three seasons and under different insecticide spray schedules. Stepwise regression for individual locations and seasons' data indicated that most of the variation in cowpea grain yields was caused by thrips. We estimated that to the total variation in cowpea grain yields, on average, the major pests contribute 51–69% in Pallisa and 24–48% in Kumi. Thrips alone contribute 35–41% and 13–19% at these two sites, respectively (Kyamanywa, 2009).

Antixenosis and antibiosis in the resistance of common beans (*Phaseolus vulgaris* L.) to the melon thrips, *Thrips palmi* Karny, were investigated under laboratory and field conditions. Experiments were conducted for four moderately resistant genotypes ('Brunca', BH-130, EMP 486, and FEB 115) in comparison with one susceptible genotype (APN 18). Multiple-choice tests recorded most thrips on EMP 486 and least on FEB 115. Dual-choice tests conducted in both laboratory and field confirmed the antixenotic effect of FEB 115 and the attractant effect of EMP 486 on thrips. These results demonstrate the significance of antixenosis in the resistance of common beans to *T. palmi*. Life-table studies showed significant differences in egg duration, immature and adult survivorship, female body length and longevity, daily oviposition rate, and total fecundity among the bean genotypes. The intrinsic rate of natural increase (rm) and its associated population parameters varied significantly with the bean genotype on which *T. palmi* cohorts were reared. Based on mean rm values, the five bean genotypes can be divided into two groups, with BH-130 and 'Brunca' being less favorable for the population growth of thrips than EMP 486 and FEB 115; the latter were comparable to the susceptible genotype APN 18. These life-table results indicate the role of antibiosis in enhancing the resistance of common beans to *T. palmi* (Cardona *et al.*, 2009).

In field trials conducted at the Experiment Station and in a farmer's field at Mbita near the shores of Lake Victoria, Kenya, applications of 2% or 3% neem seed extract (NSE) @ 200 l/ha with a knapsack sprayer at 38, 47 and 51 days after emergence (DE) of the cowpea crop or 5%, 10% or 20% NSE sprayed @ 10 l/ha with an ultra-low-volume applicator at 31, 39 and 49 DE often significantly reduced the number of larvae of the flower thrips, *Megalurothrips usitatus* (Trybom), in cowpea flowers recorded 2 days after each treatment. Also fewer adults occurred in flowers at 51 DE in plots sprayed with 5%, 10% or 20% NSE. Cowpea grain yield was significantly higher in plots sprayed with 20% NSE than in untreated control plots and was comparable to the grain yield obtained in plots sprayed thrice with cypermethrin. Because of the low cost of NSE treatment, the net gain was often more when the crop was sprayed with NSE than with cypermethin. Also, grain quality was superior in neem-treated plots than in untreated or cypermethrin-treated plots (Kidiavai, 2009).

Thrips (Thysanoptera) and their predators were investigated from 2005–2007 on a wide range of vegetables grown mostly in the winter period in Çukurova region of Turkey. A total of 2989 adult thrips and 406 thrips larvae were extracted from the vegetables. The adults belonged to 14 thrips species of which *Melanthrips* spp. were the most dominant species. The dominance of the commonly found pests *Thrips tabaci* and *Frankliniella occidentalis* differed greatly. *F. occidentalis* was the predominant thrips infesting broad bean, lettuce and parsley, while *T. tabaci* was more abundant on leek, onion and pea. The most thrips were collected from flowers or heads of vegetables in early spring. Numbers of predatory insects dwelling on the sampled vegetables were lower in comparison to total numbers of thrips obtained in the years 2006 and 2007. Of the predators, the hemipteran generalists *Orius laevigatus* and *O. niger* were the most prevalent and high numbers of them were recorded often on flowers of broad bean in winter. Further investigations should be planned to understand clearly the predatory habit of *Melanthrips* (Atakan, 2008).

Cowpea is an important legume in sub-Saharan Africa where its protein rich grains are consumed. Insect pests constitute a major constraint to cowpea production. Flower bud thrips (FTh) is the first major pest of cowpea at the reproductive stage and if not controlled with insecticides is capable of reducing grain yield significantly. Information on the inheritance of resistance to FTh is required to facilitate breeding of resistant cultivars. The genetics of resistance was studied in crosses of four cowpea lines. Maternal effect was implicated while frequency distributions of the F2 and backcross generations suggest quantitative inheritance. Additive, dominance and epistatic gene effects made large contributions and since improved inbred lines are the desired product, selection should not be too severe in the early generations to allow for desirable gene recombination. This study suggested that some of the genes involved in the control of resistance to FTh are different in TVu1509 and Sanzi. Broad sense heritability ranged from 56% to

73%. Choice of maternal parent in a cross will be critical to the success of resistance breeding (Omo-Ikerodah, 2010).

The bean flower thrips (*Megalurothrips usitatus*) is one of the most serious pests of common bean (*Phaseolus vulgaris*) in Uganda. Although information is lacking on the pest density at which economic loss occurs (i.e., economic injury level), prophylactic application of insecticides is recommended in Uganda. This study assessed bean-yield losses caused by *M. usitatus* in both mono-and intercropping situations to determine the relationship between thrips population density and bean yield (Kyamanywa, 2009).

2.4 Pod borer

The Pod borer, *Maruca testulalies* is considered as an important and most damaging pest of cowpea.

The larval feeding causes round holes in the corolla of the flowers, distorted pods associated with the inflicted holes, webbed flowers and young pods, and presence of frass. Damaged flowers become a mass of brownish-fuzz a day after infestation (Pawar *et al*., 1996).

The pod borer has been considered as serious pest of grain legumes in the tropics and sub-tropics, because of its extensive host range, destructiveness and more wide distribution (Taylor, 1978; Raheja, 1974). With continuous changes in global environment, its floral and faunal compositions, the insect may spread further in places beyond its known distribution.

2.4.1 Biology and life history strategies

Adults are small, dark gray in color with white brown patterns of the wing. The color patterns can be more conspicuous on the fore wings, with a silvery white brown spot at the apical margin, than on the hind wings. The females have brownish abdomen with bifid hairy ovipositors. After emergence from the pupae, adult males and females mate, which may sometimes take place until the early morning, some males would mate more than once, although females usually mate once (Jackai *et al*., 1990). But some males may not be successful in finding females.

Usually a female moth oviposits up to 400 eggs during her lifetime (Okeyo-owuor and Ochieng, 1981). The eggs are normally deposited on the under surface of plants parts (Vishakntaiah and Babu, 1980.).

The eggs are white in color, which become translucent later. The eggs are oval, dorsoventrally flattened and have faint reticulate sculpturing on the delicate chorion (Okeyon-Owuor and ochieng, 1981). The mean incubation period is 3 days under at around 25-28°C and over 80% relative humidity (Vishakantiah and Babu, 1980, Rai, 1983).

After hatching the first instar larvae move on the surface of leaves, flower buds and flower for few minutes before starting feeding. A larva has to pass through 5 (five) instars before moulting into a pupa. The larvae are creamy white in color with dark brown head and prothoracic shield. At the early stage the body of larvae bears light spots becomes turn into dark sports at the fifth instar which are distinctly visible. A larva at the fifth instar feeds voraciously on flower buds, flowers and pods (Rai, 1994) The total larval period is 10-14 days. Differences in weather conditions, particularly the humidity in different regions might also have caused variations in duration of this larval period.

The fifth instar larva stops feedings and the body shrunk before entering into the pupal stage. To pupate, the larva spins silken threads around it in a net fashion and moult into a pupa within the silken cocoon covered under dried leaves on soil. The pupa is reddish brown in colour. The lower development threshold temperature for pupae is 15.6 - 17.8°C and the upper threshold in 28°C to 34°C (Sharma, 1998).

The pupal period is average 9 days. The female moths have been found to live 11 or 12 days, whereas the males live 9 or 10 days at around 28°C (Singh, 1983).

2.4.2 Nature of damage of pod borer

Maruca testulalis G. is a very important pest causing serious damages to the beans in Bangladesh. Toylor (1978) reported pod borer (*Maruca testulalies* G.). As a pest of tropical grain legumes. *Maruca* causes damage in pegion pea both by boring into the flower and pod as well as by webbing flowers, pods and leaves to form clusters (Rahman, 1988).

Babu (1989) found hyacinth bean was the most favorable food plant for *M. testulalis* G. Including Bangladesh, *Maruca testulalis* (Geyer) is a tropical insect attacking several species of food legumes in Asia, Africa, Central America, and

South America. In Asia, it is an important pest of pigeon pea common beams, soybean, red gram and cowpeas (Singh and Jackal, 1988). It damages buds, flowers and pods which severely affect grain yield (Singh and Taylor, 1978).

At flowering stage, the larvae entered into the flower buds and flowers. The attacked buds and flowers subsequently withered. In a seriously infested field, large numbers of infested flower buds and flowers were often encountered. With the onset of pod formation, the insect larvae started attacking the pods. The infested flower buds, flower and pods were found webbed together (Karim, 1993). by scrapping. The larvae of later instars, in most cases, entered into the pods, bored the seed and fed on the seeds by making circular holes; but the holes were often plugged with excreta. Occasionally they consumed the entire seed. They also burrow into flower buds and hollow them out. Some times leaves are spun together and caterpillars feed within the web (Das and Islam, 1985).

The first and second instar larvae fed mostly on the inner walls of the young pods by scrapping.

A developing larva after entering into a pod usually did not leave it until its food larvae/pod in only a few cases (Das and Islam, 1985). Pyralid pod borer, *Maruca testulalis*, is an important pest which attack pods and extruded frass is usually a rather obvious indicator of such damage (Emden, 1980).

Plate 4: Pod borer larva feeding on cowpea pod

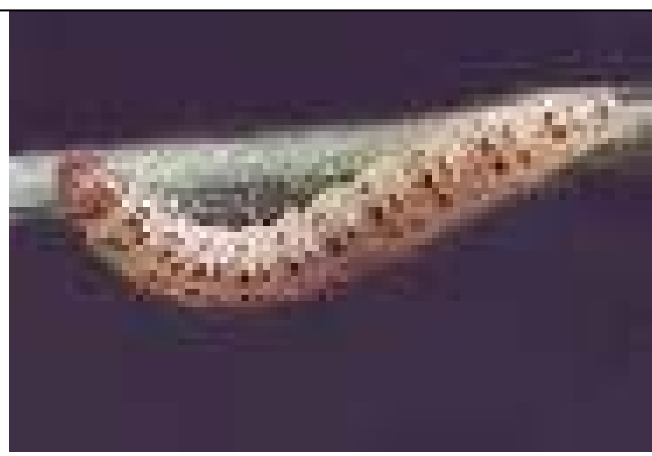

Plate 5: Adult larva on bean pod

2.4.3 Yield loss due to pod borer

Pod borer is every important pest of the bean. In recent study, *Maruca testulalis* G was found to cause maximum damage in pigeon pea in Bangladesh (Rahman, 1989). As an important pest of leguminous vegetables, substantial works have been done on *Maruca testulalis* .G. The susceptibility of bean genotype to pod borer, *Maruca testulalis* G., was studied at the Regional Agricultural Research Station, Jamalpur. Out of 32 genotypes, the highest percentage of infestation was found in Bata (Mirsharai) (16.81+ 1.21%), and the lowest percentage of infestation in sword bean (0.74 + 0.05%) (Kabir *et al*.,1983). The pod borers were found to cause 38% yield loss through flower and pod damage and have been reported as the most important pests of pigeon pea in Bangladesh (Rahman *et al*., 1981). Pod borer is considered as a major pest of legumes in Africa, Asia, South and Central America and Australia causing yield loss ranging between 20% and 60%. When dimethoate applied the highest (78%) flower damage by *M. testulalis* G and grain yield of 684 kg /ha was achieved. But when applied methomy flower damage was 6.2 and grain yield was 1240 kg /ha as against 80.1% flower damage and 102 kg /ha grain yield in control (Singh and Allen, 1980).

Maruca testulalis G. in one of the important insect pests of French beam. Studies at the Sokoine Univeristy of agriculture (Morogoro, Tanzania) have indicated that uncontrolled populations of pod bores, particularly *M. testulalis*, decreased the seed yield by 20-50% in some local cultivars. In Kenya, studies have revealed that

Maruca testulalis G. is the most important pest of cowpea, reducing yields by up to 80% (Karel, 2004).

2.4.4 Management of pod borer

2.4.4.1 Use of Neem oil

Neem (*Azadirachta indica*) seed oil, a botanical pesticide have also been used to control different insect pests of important agricultural crops in different countries of the world. More than 2000 species of plants have been reported to posses insecticidal properties (Grainge and Ahmed, 1985). The neem tree (*Azadirachta indica* A. Juss) is one of them.

The development and use of botanical pesticides become an integral part of the integrated pest management (IPM) strategies. Stoll (1992) summarized the potential benefits of botanical pesticides which diminish the risk of resistance development, natural enemy elimination, and secondary out break of pest and ensure overall safety to the environment.

The seed and leaves of the neem tree contain terpenoids with potent anti-insect activity. One of the most active terpenoids in neem seeds is “azadirachtain” which acts as an antifeedant and growth disrupter against a wide range of insect pest at microgram levels. The active terpenoids in neem leaves include nimbin, deactylnimbin and thionemone (Simmonds *et al*., 1992).

Experiment with botanical pesticides has also been conducted in Bangladesh on a limited scale. Islam (2004) reported that extract of leaf, seed and oil of neem, showed potential as antifeedants or feeding and oviposition deterrents for the control of brown plant hopper, green leaf hopper, rice hispa and lesser rice weevil. He also conducted experiments to ascertain the optimal doses of the extract against rice hispa, and pulse beetle. Addition of sesame or linseed oil to extract of neem resulted in higher mortality of the grubs and in greater deterrence in feeding and oviposition compared to those obtained with neem extract alone (Islam, 2006).

Field trail with neem products have shown, not only a decrease in damage by pest but also an increase in crop yield compared to those obtained with recommended synthetic insecticides. A methanol suspension of 2-4% of the neem leaves have been used against the caterpillar of diamondback moth, *Plutella xylostella* and it was as effective as either synthetic insecticide Mevinphous (0.05%) or Deltamethrin in (0.02%) in Togo. In Thailand, a field trail showed that fiperanyl butoxide increased the efficacy of neem and the combination was as active as Cypermethrin (0.025%) against *Plutella xylostella* and *Spodoptera litura*, which revealed that neem oil with synthetic insecticides may have some synergetic effect in controlling insect pests (Dreyer, 1987).

The leaf extract of neem tested against the leaf caterpillar of brinjal, *Selepa docilis* Bult. at 5% concentration had a high antifeedant activity with a feeding ratio of 28.29 followed by 3% having only medium antifeedant properties with 23.89 as the feeding ratio (Jacobson and Sheila, 1994).

Entomologists of many countries including India, Philippines, Pakistan and Bangladesh have conducted various studies of neem against different insect pests. Most of the cases the investigators have been used a particular concentration of the neem extract. Neem seed kernel extracts (3-5%) were effective against *Nilaparbata lugens*, *Nephotettix* sp., *Marasmia patnalis, Oxya nitidula* and Asian). They use different emulsifier to mixe neem oil with the water. Neem oil normally gall midge. Neem leaf extract, however, is less effective than neem seed kernel extract. But the same extract of 5-10% was highly effective, inclusive of *Scirpophaga incertulus* and thrips (Jacopson, 1994). Damage by leaf folders was reduced by 3% neem oil. Neem seed kernel extracts reduced egg deposition on rice seedling by *Nephotettix* spp. and *Nilaparbata lugens* (John, 1997).

Neem seed kernel extract was an effective antifeedent to pigeon pea pod borer. He also found that there has been no adverse effect, even though neem was systemic. According to him neem oil can be used @ 1-3% without any problem. But 5% neem oil will cause phytotoxicity in many plants. The effect of neem oil is systemic, though not persistent (John, 1997). It should be noted that application of neem oil beyond 5% will cause serious phytotoxicity in rice. At 3%, the initial phytotoxicity effect is minimum and the plant can recovered completely. Thus, neem oil should be applied at concentrations not beyond 3% (John, 1997).

Most of the cases, the user of neem oil use it at different doses ranged from 0.5-50% (Krishnaiah and Kalode, 1991stays separately on the upper surface of the water. Detergent in water helps neem oil to emulsify in the water. In a field observation of neem oil they used soap as emulsifier with water. Although, they have never mentioned the dose of the emulsifier in their trail.

Another study with neem oil in rice field, Saxena and Palanginan (1988) added 1.66% Teepol (liquid detergent) to the extract solutions as an emulsifier. In a study of Bangladesh Rice Research Institute (BRRI), Gazipur, Alam (1991) added 1 ml

(0.1%) of teepol detergent per liter of water and spray at 7 days interval against stem borer of rice.

2.4.4.2 Control with chemical insecticides

A number of reports revealed that a hundred of insecticides are used against pod borer. Most of the cases the farmers do not reduce their spray interval. A report showed that the vegetable growers of Jessore Region of Bangladesh spayed insecticides almost every day or every alternate day in their bean field (Anon., 1994). Some of the farmers spray insecticides in their vegetable field even 84 times in one season. Majority of the farmers were found to sell their produce harvested residues with bean that causes health hazards to the consumers.

Search of review reveals that bear pod bean control is dominated by chemical approaches. In India, a number of insecticides have been found to use for the control of pod borer in pulses including pigeon pea (Rahman, 1989). Several commonly used insecticides such as Endosulfan, Carbaryl, Methomyl, Monocrotophos have been found effective against *Maruca testulalis* G. on cowpea (Singh, 1977; Lalasangi, 1988). Cypermethrin was sprayed at 0.2 kg a.i./ha to control different densities of pyralid *M. testulalis* larvae when infestation in flowers reached 10, 20, 30, 40 and 50% in 1985 and 10; 20 and 30% in 1986 (Ogunwolu, 1990).

Four sprays of 0.08% cypermethrin (at flowering, 50 and 100% flowering and 100% pod setting) afforded complete protection against *Maruca testulalis* on pigeon pea in Bangladesh in winter season of 1987-88. But Dimethoate was not as effective as Cypermethrin (Rahman and Rahman, 1988). A schedule of insecticide sprays using Decis (Deltamethrin) and Systoate (Dimethoate) on 35, 45, 55 and 65 days after planting was investigated in Benin in 1985 to determine the most effective treatment against the pyralid *M. testulalis* on cow pea (Atachi and Djihou, 1994).

Broadley obtained control of *M. testulalis* with methomyl when applied at 337-450g (a.i.)/ha. Because of hidden nature of larval and pupal stages of the pest, it is difficult to control *Maruca* pod borer by chemical or other conventional means. Application of Deltamethrin, Cypermethrin or Fenvalerate @ 0.008% or dimethoate, fenitrothrin, malathion, quinalphos or monocrotophos @ 0.008% or endosulfan 0.10% one at flowering and then at pod setting stage would be highly effective. However, at lower infestation, insecticide application would not be economically advisable (Rahman, 1989). Application of Deltamethrin, Cypermethrin or Fenvalerate or Cyfluthrin at the rate of 1.0 ml / 1 of water may be helpful for the control of the pod borer (Karim, 1995).

Dandale *et al*., (1981) reported the superiority of cypermethrin, fenvalerate and endosalfan in reducing pod borer infestation in red gram. Spraying of synthetic pyrethroid insecticides at the rate of 1 ml per liter of water has been recommended for the control of the pest (Karim, 1993).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, during March to June, 2009 to evaluate the major insect pests of cowpea and their management. Required adopted materials and methodology are described below under the following sub-heading.

3.1 Location

The study was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is 23°74'N latitude and 90°35' E longitude and an elevation of 8.2 m from sea level.

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Khamarbari, Dhaka and it has presented in Appendix II.

3.3 Weather condition of the experimental site

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. Details of the metrological data related to the temperature, relative humidity and rainfalls during the period of the experiment (March to June 2009) was collected from the Bangladesh Meteorological Department, Dhaka and presented in the Appendix I.

3.4 Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The target land was divided into 21 equal plots (2 m x 2 m) with plot to plot distance 1 m and block to block distance 1 m. Standard dosages of cowdung and fertilizers were applied as recommended by Rashid (1993) for cowpea cultivation @ 45 kg Urea, 100 kg TSP and 60 kg MP per hectare.

3.5 Collection of seed and seedling raising

The seeds of BARI cowpea 2 were collected from Bangabandhu Shekh Mujubur Rahman Agricultural University, Gazipur for rapid and uniform germination the seeds of cowpea were soaked for 12 hours in water. Seeds were then directly sown in the middle of March, 2009 in soil. After germination the seedlings were sprayed with water by a sprayer.

3.6 Cultural practices

After sowing, a light irrigation was given. Subsequent irrigations were applied in all the plots and whenever requited. Thinning, weeding in the plots was done at regular interval upto the flowering stage.

3.7 Treatments

The experiment was laid out with seven treatments including one untreated control and replicated three time using Randomized Complete Block Design (RCBD).

The treatments of the experiment are as follows:

T_1 = Neem oil @ 3 ml/L of water

T_2 = Neem Seed Kernel Extract @ 5 ml/L of water

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

T_4 = Marshal 20EC @ 2 ml/L of water

T_5 = Dursban 20EC @ 2 ml/L of water

T_6 = Furadan 5G @ 5 g/plot

T_7 = Control (Untreated)

3.8 Collection of treatment materials

The neem oil and NSKE was collected from Chawkbazar. Dhaka and the trix liquid detergent were collected from the local market of Agargaon bazaar. Ripcord 10EC, Marshal 20EC, Dursban 20EC, Furadan 5G were collected from local market.

3.9 Procedure of spray application

Neem oil with trix (@ 3 ml/L of water) , NSKE, Ripcord 10EC, Marshal 20EC, Dursban 20EC were sprayed in assigned plots and dosages by using Knapsack sprayer where Furadan 5G was applied with dry sand manually then the plots were irrigated. The spraying was always done in the afternoon to avoid bright sunlight. The spray materials were applied uniformly to obtain complete coverage of whole plants of the assigned plots. Caution was taken to avoid any drift of the spray mixture to the adjacent plots at the time of the spray application. At each spray application the spray mixture was freshly prepared.

3.10 Data collection and calculation

The effectiveness of each treatment in reducing selected insect under the present study infestation was evaluated on the basis of some pre-selected parameters. The following parameters were considered during data collection.

Ten plants per plot were tagged randomly from inner rows leaving 15cm from the corner. These plants were used for taking data on bean aphid, jassid, thrips and pod borer. Bean aphid, jassid, thrips and pod borer were counted from five fully unfolded top leaves of the plant. Data on number of insects were recorded at an interval of 10 days commencing from first incidence and continued up to the harvest of the crop.

3.11 Number and weight of healthy and infested fruits

Data were collected on the basis of the number and weight of healthy and infested pods in each treatment.

3.12 Pod infestation

3.12.1 Percent pod infestation by number

After harvesting the healthy pods and the infested pods were separated by visual observation. The number of healthy pods and infested pods were counted and the

percent pods infestation for each treatment was calculated by using the following formula:

$$\%\text{Pod infestation (by number)} = \frac{\text{Number of infested pods}}{\text{Total number of pods observed}} \times 100$$

3.12.2 Percent pod infestation by weight

After harvest at each fruiting stage, the total pods were sorted into healthy and infested once for each treatment. On the basis of weight of healthy pods and infested pods the percent pods infestation was calculated.

$$\%\text{Pod infestation (by weight)} = \frac{\text{Weight of infested pods}}{\text{Total weight of pods observed}} \times 100$$

3.13 Pod yield

Pod yield was measured by adding the total harvest attaining from all harvest in individual plot and converted into per hectare yield.

3.13.1 Increase or decrease of yield over control

Increase or decrease over control was calculated using the following formula:

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

$$\text{Percent decrease of yield over control} = \frac{\text{Yield in untreated control plot - Yield in treated plot}}{\text{Yield in untreated control}} \times 100$$

3.14 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performing by the `F' (variance ratio) test. The significance of the difference among the treatments combination means were estimated by the Randomized Complete Block Design (RCBD) test at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained from present study for different crop characters, yields and other analyses have been presented and discussed in this chapter.

4.1 Incidence of aphid

Incidence of aphid (*Aphis craccivora*) in a bean field is a common incidence. During this experiment, the incidence of aphid was significant (Table 1). Various chemicals and botanicals were used to suppress the incidence of aphid and to test the effectiveness of chemicals and botanicals. It was observed that the highest incidence of aphid was occurred in the untreated control treatment T_7. But compare with other treatments where chemicals and botanicals were used, T_4 (Marshal 20EC @ 2 ml/L of water) and T_5 (Dursban 20EC @ 2 ml/L of water) represented less affectivity to control bean aphid in the cowpea crop field at all stages of the crop. On the other hand treatment T_1 (Neem oil @ 3 ml/L of water) represented the highest effectiveness to management aphid in the crop field of cowpea. With the application of neem oil the lowest percent incidence of aphid in cowpea field; 5.00, 7.33, 7.67, 4.34, 4.67 and 4.33 respectively were observed at 10, 20, 30, 40, 50 DAS respectively. Significantly similar results were obtained in T_2 (NSKE @ 5 ml/L of water), T_3 (Ripcord 10EC @ 1 ml/L of water) and T_6 (Furadan 5G @ 5 g/polt) at 30, 50 DAS. The results obtained from all other treatments showed intermediate percent incidence of aphid compared to highest and lowest incidence.

The most serious pest of bean plants is aphid from seedling to pod bearing stage, causing considerable yield losses (Malik *et al*.. 1988). Both the nymphs and adults cause damage by sucking sap from flowers, buds, pods and tender shoots of the plants and reduce the vitality of the bean and leguminous crops (Thakur *et al*., 1984; Shrivastava and Singh, 1986). So, aphid control is very much essential for successful crop production. Under the present study neem oil was the effective application to control bean aphid.

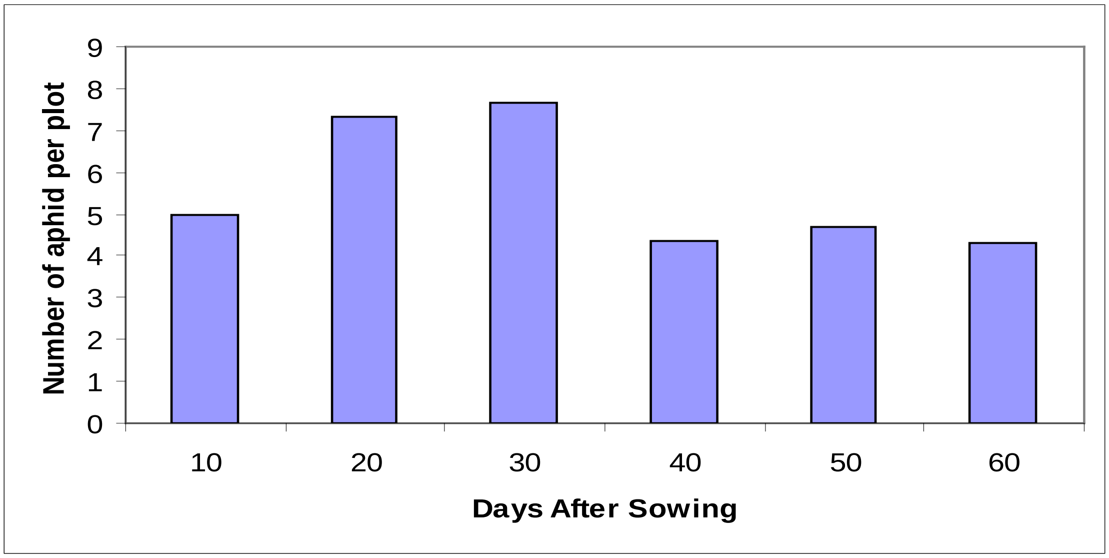

Figure-1: Population trend of aphid at best treated plot at different DAS.

Table 1. Incidence of aphid in different treatments at different days after sowing (DAS) in the experimental field of cowpea

Treatments	Average number of aphid plot^{-1}						Mean
	10 DAS	**20 DAS**	**30DAS**	**40 DAS**	**50 DAS**	**60 DAS**	
Neem oil	5.00 c	7.33 d	7.67 c	4.34 d	4.67 c	4.33 c	5.55
NSKE	6.67 bc	8.33 b-d	7.67 c	5.67 cd	5.67 bc	5.33 bc	6.57
Ripcord 10EC	7.00 bc	7.67 cd	7.67 c	6.00 b-d	5.33 bc	5.67 bc	6.55
Marshal 20EC	8.33 b	10.00 b	9.00 bc	7.00 bc	6.33 bc	6.67 ab	7.89
Dursban 20EC	8.00 b	9.67 b	10.67 b	7.67 b	6.67 b	6.67 ab	8.23
Furadan 5G	7.67 b	9.33 bc	8.33 c	5.67 cd	5.33 bc	5.00 bc	6.89
Control	12.3 a	14.33 a	14.67 a	10.67 a	8.67 a	8.00 a	11.44
$LSD_{0.05}$	**2.29**	**1.78**	**1.78**	**1.77**	**1.76**	**1.67**	
CV(%)	**5.53**	**6.87**	**5.83**	**4.71**	**7.34**	**6.48**	

NSKE = Neem Seed Kernel Extract

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

4.2 Incidence of jassid

The incidence of jassid in cowpea field was a familiar occurrence. During the experiment, the incidence of jassid was significant (Table 2). Various chemicals and botanicals were used to control the incidence of jassid and to test the effectiveness of insecticides. It was observed that the highest occurrence was found in the untreated control treatment T_7. But incase of other treatments where insecticides were used, T_6 (Furadan 5G @ 5 g/plot) represented the lowest effectivity to control jassid in the cowpea field at all stages of the crop. On the other hand, T_2 (NSKE @ 5 ml/L of water) represented the highest effectiveness to manage jassed in the crop field of cowpea. With the application of the insecticides the lowest percent incidence of jassid; 9.00, 10.00, 13.00, 16.33, 21.33 and 27.67 respectively were observed at 10, 20, 30, 40, 50 DAS respectively which were statistically similar with T_1 (Neem oil). The results obtained from all other treatments showed intermediate percent incidence of jassid compared to highest and lowest incidence.

Nair (1986) reported that the nymphs and adults of *A. devastans* could attack host leaves at all stages of development. As the plants grew older, they become less susceptible to jassid infestation (All, 1990). As per treatments under the present study neem oil was the most effective control measure and that was supported by Singh and Kumar (2003).

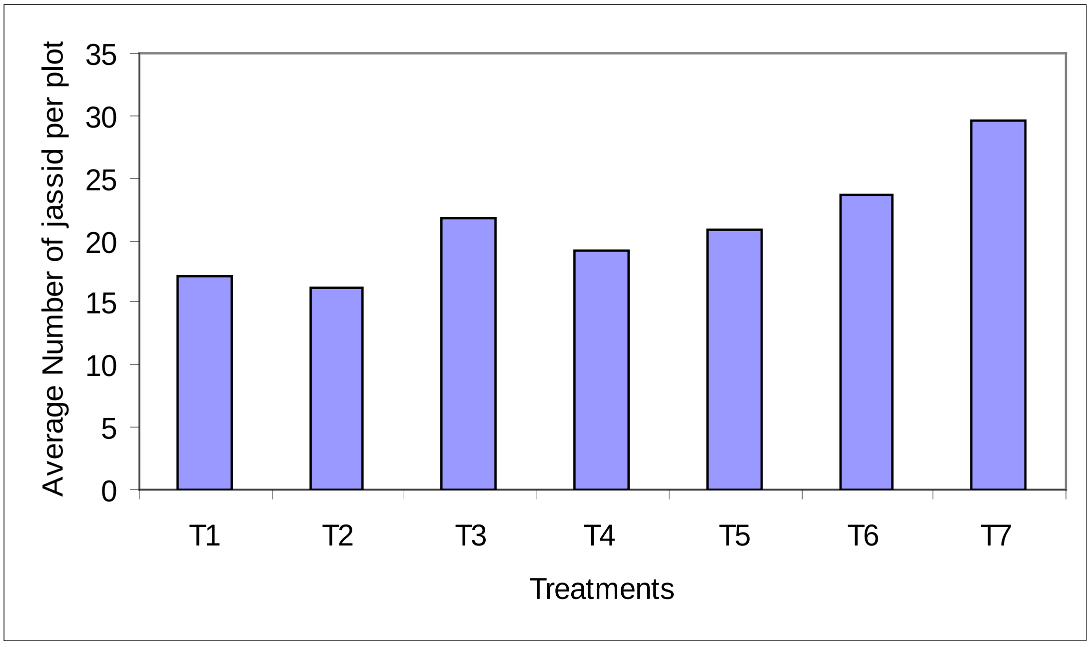

Figure-2: Incidence of jassid in different treatments

T_1 = Neem oil @ 3 ml/L of water	**T_3 = Ripcord 10EC @ 1 ml/L of water**	**T_5 = Dursban 20EC @ 2 ml/L of water**
T_2 = Neem Seed Kernel Extract @ 5 ml/L of water	**T_4 = Marshal 20EC @ 2 ml/L of water**	**T_6 = Furadan 5G @ 5 g/plot**
T_7 = Control (Untreated)		

Table 2. Incidence of jassid in different treatments at different days after sowing (DAS) in the experimental field of cowpea

Treatments	**Average number of jassid plot^{-1}**						**Mean**
	10 DAS	**20 DAS**	**30 DAS**	**40 DAS**	**50 DAS**	**60 DAS**	
Neem oil	8.33 d	12.33 d	14.33 de	17.00 cd	22.33 d	28.33 d	17.11
NSKE	9.00 d	10.00 e	13.00 e	16.33 d	21.33 d	27.67 d	16.23
Ripcord 10EC	14.33 b	16.67 c	17.67 bc	20.33 bc	26.33 bc	35.00 c	21.72
Marshal 20EC	10.00 cd	14.67 c	15.67 cd	19.00 b-d	23.00 cd	32.67 c	19.17
Dursban 20EC	12.67 bc	15.33 c	17.00 bc	19.33 b-d	26.00 bc	34.00 c	20.79
Furadan 5 G	14.67 b	19.33 b	18.67 b	21.67 b	28.33 b	39.33 b	23.67
Control	18.67 a	23.67 a	23.67 a	29.00 a	34.67 a	47.67 a	29.56
$LSD_{0.05}$	**2.83**	**2.05**	**2.12**	**3.55**	**3.23**	**3.85**	
CV(%)	**6.70**	**6.93**	**9.08**	**9.81**	**6.99**	**8.97**	

NSKE = Neem Seed Kernel Extract

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

4.3 Incidence of thrips

Thrips is also harmful for bean crops production. During this experiment, the percent incidence of thrips was significant (Table 3). It was observed that the highest number of thrips occurrence was found in the untreated control treatment T_7. But incase of other treatments where insecticides were used, T_3 (Ripcord 10EC @ 1 ml/L of water), T_5 (Dursban 20EC @ 2 ml/L of water) and T_6 (Furadan 5G @ 5 g/plot) represented less effectivity to control thrips in the cowpea field at all stages of the crop. Among the treatments where the insecticides were used, the highest percent incidence of thrips was observed in T_5 (Dursban 20EC @ 2 ml/L of water) at all stages of crop production. On the other hand, treatment T_1 (Neem oil @ 3 ml/L of water) represented the highest effectiveness to manage pod borer in the cowpea field. With the application of this chemical the lowest percent incidence of thrips; 6.83, 8.33, 10.67, 14.33, 19.00 and 25.33 respectively were observed at 10, 20, 30, 40, 50 DAS respectively which was statistically similar with T_2 (NSKE). The results obtained from all other treatments showed intermediate effectiveness to control thrips compared to affectivity of other treatments.

Thrips is also a devastating insect which cause considerable damage to crops and to control of this insect various kinds of treatments were taken under the present study. According to Saxena (1998) neem oil is an important factor that control thrips effectively.

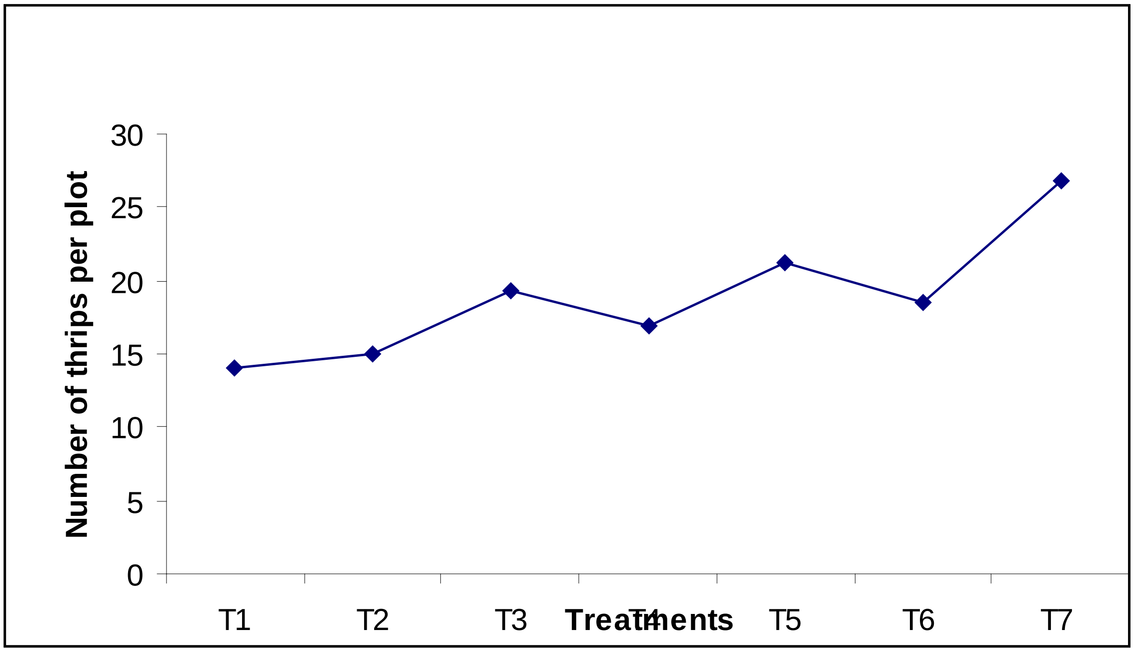

Figure-3: Incidence of thrips in different treatments

T_1 = Neem oil @ 3 ml/L of water	**T_3 = Ripcord 10EC @ 1 ml/L of water**	**T_5 = Dursban 20EC @ 2 ml/L of water**
T_2 = Neem Seed Kernel Extract @ 5 ml/L of water	**T_4 = Marshal 20EC @ 2 ml/L of water**	**T_6 = Furadan 5G @ 5 g/plot**
T_7 = Control (Untreated)		

Table 3. Incidence of thrips in different treatments at different days after sowing DAS) in the experiment field of cowpea

Treatments	Average number of thrips plot^{-1}						Mean
	10 DAS	**20 DAS**	**30 DAS**	**40 DAS**	**50 DAS**	**60 DAS**	
Neem oil	6.83 d	8.33 e	10.67 d	14.33 c	19.00 d	25.33 d	14.09
NSKE	6.33 d	10.00 de	12.17 cd	15.00 c	20.00 d	26.33 d	14.97
Ripcord 10EC	12.00 b	14.00 bc	15.33 b	18.00 b	24.17 b	32.67 c	19.36
Marshal 20EC	8.17 cd	12.00 cd	13.33 b-d	17.00 bc	20.67 cd	30.33 c	16.92
Dursban 20EC	11.33 bc	17.00 b	16.33 b	19.33 b	26.33 b	36.67 b	21.16
Furadan 5 G	10.33 bc	13.33 cd	15.00 bc	17.17 bc	24.00 bc	31.67 c	18.58
Control	16.33 a	21.00 a	20.00 a	27.33 a	32.00 a	44.33 a	26.83
$LSD_{0.05}$	**3.27**	**3.26**	**2.80**	**2.69**	**3.34**	**3.11**	
CV(%)	**8.09**	**8.46**	**10.73**	**9.32**	**7.91**	**11.13**	

NSKE = Neem Seed Kernel Extract

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

4.4 Incidence of pod borer

Pod borer is very harmful for bean crops and it decreases crop yield, crop quality and market value. It is also a common pest against successful cowpea production. During this experiment, the percent incidence of pod borer was significant (Table 4 and Appendix VI). Various treatments were taken to manage the incidence of pod borer and to test the effectiveness of insecticides that were used in the experiment. It was observed that the highest number of pod borer occurrence was with the untreated control treatment T_7. But incase of other treatments where insecticides were used, T_4 (Marshal 20EC @ 2 ml/L of water), T_5 (Dursban 20EC @ 2 ml/L of water) and T_6 (Furadan 5G @ 5 g/plot) represented less effectivity to control pod borer in the cowpea field at all stages of the crop. Among the treatments where the insecticides were used, the highest percent incidence of pod borer was observed in T_5 (Dursban 20EC @ 2 ml/L of water) which was significantly similar to T_6 (Furadan 5G) at all stages of crop production. On the other hand, treatment of T_1 (Neem oil) represented the highest effectiveness to manage pod borer in the crop field of cowpea. With the application of neem oil the lowest percent incidence of pod borer 2.67, 4.33, 6.33 and 7.33 were observed at 60, 70, 80 and 90 DAS respectively and that was significantly similar to T_2 (NSKE) and T_3 (Ripcord 10EC).

The pod borer has been considered as serious pest of grain legumes in the tropics and sub-tropics because of its extensive host range, destructiveness and wide distribution. Taylor, (1967); Raheja, (1974); Simmonds *et al*., (1992); and Islam, (2006) reported that neem oil is an important substance to control pod borer.

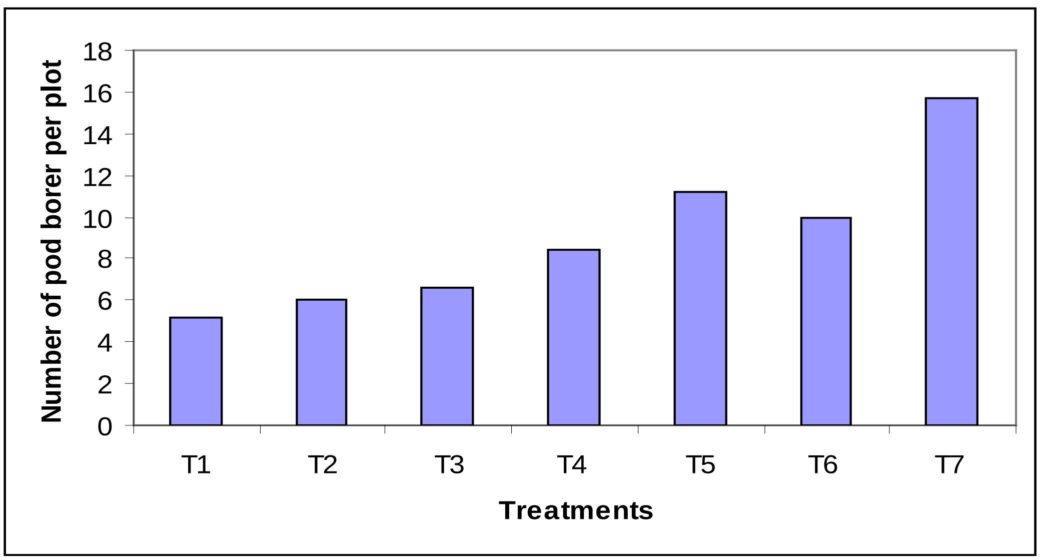

Figure-4: Incidence of pod borer in different treatments

T_1 = Neem oil @ 3 ml/L of water	**T_3 = Ripcord 10EC @ 1 ml/L of water**	**T_5 = Dursban 20EC @ 2 ml/L of water**
T_2 = Neem Seed Kernel Extract @ 5 ml/L of water	**T_4 = Marshal 20EC @ 2 ml/L of water**	**T_6 = Furadan 5G @ 5 g/plot**
T_7 = Control (Untreated)		

Table 4. Incidence of pod borer in different treatments at different days after sowing (DAS) in the experiment field of cowpea

Treatments	Average number of pod bore plot^{-1}				Mean
	60 DAS	70 DAS	80 DAS	90 DAS	
Neem oil	2.67 d	4.33 d	6.33 d	7.33 d	5.17
NSKE	3.67 cd	4.67 d	7.33 cd	8.33 cd	6.00
Ripcord 10EC	4.00 cd	5.33 d	7.67 cd	9.33 cd	6.58
Marshal 20EC	6.00 bc	7.33 cd	9.67 bc	10.67 b-d	8.42
Dursban 20EC	8.33 b	10.67 b	12.67 b	13.33 b	11.25
Furadan 5G	8.67 b	8.33 bc	11.00 b	11.67 bc	9.92
Control	12.67 a	14.67 a	17.33 a	18.00 a	15.67
$LSD_{0.05}$	**2.65**	**2.86**	**3.03**	**3.55**	
CV(%)	**9.73**	**8.38**	**6.57**	**7.78**	

NSKE = Neem Seed Kernel Extract

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

4.5 Performance of management practices

4.5.1 Yield performance in respect of number of pods

Number of healthy pods/plot, number of infested pods/plot, percent number of healthy pods/plot, % increase of healthy pods by number over control were significantly affected by different treatments for the control of insect pests of cowpea (Table 5).

It was observed that the highest number of healthy pods (480.33) was obtained by the treatment T_1 (Neem oil @ 3 ml/L of water) which was statistically similar with T_2 (NSKE @ 5 ml/L of water) and the lowest number of infested pods (148.67) was obtained by same treatment (T_1). On the other hand the lowest number of healthy pods (263.67) was obtained by the T_5 (Dursban 20EC @ 2 ml/L of water) where the highest number of infested pods (250.67) was obtained with the untreated control treatment (T_7). But among the treatments where the insecticides were used to control the incidence of insect pests of cowpea, the lowest number of healthy pods (263.67) was obtained in T_5 (Dursban 20EC @ 2 ml/L of water) and highest number of infested pods (234.67) were observed in T_4 (Marshal 20 EC @ 2 ml/L of water).

In case of percent number of healthy pods, it was observed that the highest percent number of healthy pods (76.36%) was obtained by the treatment T_1 (Neem oil @ 3 ml/L of water) and the lowest percent number. On the other hand the lowest percent number of healthy pods (54.01%) was obtained by the untreated control treatment (T_7). But among the treatments where the insecticides were used to manage the insect pests of cowpea, the lowest percent number of healthy pods (65.59%) was observed in the treatment of T_4 (Marshal 20EC @ 2ml/L of water) which was statistically similar to T_5 (Dursban 20EC) and T_6 (Furadan 5G).

It was evident that the highest percent increase of healthy pods over control 41.38% by number was obtained with T_1 (Neem oil). On the other hand the lowest increase of healthy pods over control 21.44% by number were achieved by the treatment T_4 (Marshal 20EC).

The results obtained from all other treatments incase of healthy and infested pods by number and weight showed intermediate value compared to highest and lowest results of these parameters.

Treatments	**Healthy pods plot^{-1}**	**Infested pods by borer plot^{-1}**	**% healthy pods**	**% increase of healthy pods over control**

Neem oil	480.33 a	148.67 f	76.36 a	41.38
NSKE	471.67 a	174.00 d	73.05 b	35.27
Ripcord 10EC	449.67 b	218.30 c	67.31 c	24.62
Marshal 20EC	447.33 b	234.67 b	65.59 d	21.44
Dursban 20EC	263.67 e	225.00 g	67.83 c	25.58
Furadan 5G	349.00 c	161.67 e	68.34 c	26.46
Control	294.33 d	250.67 a	54.01 e	--
$LSD_{0.05}$	**12.43**	**10.75**	**1.15**	**2.14**
CV(%)	**8.05**	**7.64**	**6.26**	**8.86**

Table 5. Effect of different treatments in the field of cowpea in respect of yield performance (by number of pods)

NSKE = Neem Seed Kernel Extract

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

4.5.2 Yield performance in respect of weight of pods

Weight of healthy pods/plot, weight of infested pods/plot, percent weight of healthy pods/plot, % increase of healthy pods by weight over control were significantly affected by different treatments for the control of insect pests of cowpea production (Table 6).

Incase of weight of healthy and infested pods it was observed that the highest weight of healthy pods (966.67 g) was obtained in T_1 (Neem oil @ 3 ml/L of water) which was statistically similar to T_2 (NSKE @ 5 ml/L of water), T_3 (Ripcord 10EC @ 1 ml/L of water) and T_4 (Marshal 20EC @ 2 ml/L of water) and the lowest weight of healthy pods (563.33) were obtained by the treatment T_5 (Dursban 20EC @ 2 ml/L of water).

Incase of percent weight of healthy and infested pods were also varied remarkably during the experiment. It was observed that the highest percent weight of healthy pods (78.32%) was obtained by the treatment T_1 (Neem oil @ 3 ml/L of water). On the other hand the lowest percent weight of healthy pods (60.41%) was obtained by the untreated control treatment (T_7). But among the treatments where the insecticides were used to control the incidence of insect pests of cowpea, the lowest percent weight of healthy pods (69.21%) was observed in the T_4 (Marshal 20EC @ 2 ml/L of water) which was statistically similar with T_3 (Ripcord 10EC), T_5 (Dursban 20EC) and T_6 (Furadan 5G).

It was evident that the highest percent increase of healthy pods over control 29.64% by weight was obtained with T_1 (Neem oil). On the other hand the lowest increase of healthy pods over control 14.57% by weight was achieved by the treatment T_4 (Marshal 20EC).

The results obtained from all other treatments incase of healthy and infested pods by number and weight showed intermediate value compared to highest and lowest results of these parameters.

Table 6. Effect of different treatments in the field of cowpea in respect of yield performance (by weight of pods)

Treatments	Weight of healthy pods $plot^{-1}$	Weight of infested pods $plot^{-1}$	%weight of healthy pods	% increase of healthy pods over control
Neem oil	966.67 a	267.60 f	78.32 a	29.64
NSKE	958.33 a	309.70 d	75.58 b	25.11
Ripcord 10EC	962.00 a	406.10 c	70.32 c	16.40
Marshal 20EC	956.67 a	425.67 a	69.21 d	14.57
Dursban 20EC	563.33 d	413.41 g	71.02 c	17.56
Furadan 5G	746.67 b	295.67 e	71.63 c	18.57
Control	633.33 c	415.00 b	60.41 e	--
$LSD_{0.05}$	**11.31**	**7.78**	**1.21**	**1.11**
CV(%)	**8.24**	**9.06**	**7.33**	**7.22**

NSKE = Neem Seed Kernel Extract

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

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental site of Sher-e-Bangla Agricultural University (SAU) during the period from March to June, 2009 for study the major insect pests of cowpea and their management. Six treatments were used in the study along with a untreated control treatment. The experiment was conducted in randomized complete block design (RCBD) with three replications.

The results showed that the incidence of different insect i.e. bean aphid, jassid, thrips and pod borer in cowpea under the present study were significantly affected by to different treatments with Neem oil, Neem seed kernel extract (NSKE), Ripcord 10EC, Marshal 20EC, Dursban 20EC and Furadan 5G. The treatments were applied viz. Neem oil @ 3 ml/L of water, NSKE @ 5 ml/L of water, Ripcord 10EC @ 1 ml/L of water, Marshal 20EC @ 2 ml/L of water, Dursban 20EC @ 2 ml/L of water and Furadan 5G @ 5 g/plot.

The lowest incidence of bean aphid was observed in Neem oil treated plot at different days after sowing where the highest incidence was in untreated control treatment. But without control the highest incidence were observed in Furadan 5G treated plot. The data represents that Neem oil had the highest performance for controlling aphids where as Furadan 5G had the lowest.

Incase of jassid the higher performance against the insect was with Neem oil and NSKE treated plot where the highest incidence of jassid was with untreated control treatment. But without control the highest incidence was observed in the plot which was treated with Furadan 5G. The data represents that neem oil and NSKE had the highest performance for controlling jassid where Furadan 5G had the lowest.

Effectiveness of different management practices, Neem oil and NSKE treated plot demonstrated the highest performance against thrips where the lowest performance was observed against thrips with untreated control treatment. But among the treated plots the highest incidence were observed in the plot which was treated with Dursban 20 EC. The data represents that Neem oil had the highest performance for controlling thrips where Dursban 20 EC had the lowest under the present study.

Yield and yield performance against different insect pests were significantly influenced by different treatments. The highest performance was achieved with Neem oil incase of number of healthy pods and weight of healthy pods. Highest number of healthy pods (480.33)/4m^2 was obtained from Neem oil treated plot where the lowest (263.67)/4m^2 from Dursban 20 EC treated plot. Incase of weight of healthy pods, Neem oil treated plot showed the same result. Considering the infested pods Neem oil had also the higher performance. NSKE and Ripcord 10 EC had also the higher performance for higher healthy pods production but lower performance on infested pods. Data represents that under the present study Neem had the best performance for healthy pods production where the Dursban 20 EC had the lowest.

The highest percent of healthy pods by number (76.36%) and weight (78.32%) was obtained with Neem oil treatment considering percent infested pods by number and weight and the lowest percent of healthy pods by number (65.59%) and weight (69.21%) was obtained with Marshal 20EC treatment considering percent infested pods by number and weight.

It was evident that the highest percent increase of healthy pods over control 41.38% and 29.64% by number and weight respectively was obtained with T_1 (Neem oil). On the other hand the lowest increase of healthy pods over control 21.44% and 14.57% by number and weight respectively were achieved by the treatment T_4 (Marshal 20EC).

Thus the results obtained exhibited that all the treatments gave considerable results in respect of incidence of different insect pests and yield. Considering the performance of all insecticides under the present study to control insect pests, neem oil is a better approach for cowpea production in respect of higher yield lower insect infestation in plants.

CHAPTER V

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APPENDICES

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

Month	RH (%)	Max. Temp. (ºC)	Min. Temp. (ºC)	Rain fall (mm)
February	50.31	29.50	18.49	0
March	44.95	33.80	20.28	0
April	60.28	34.00	22.89	200
May	65.05	35.00	25.00	190
June	66.44	31.50	24.25	186

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

Appendix II. Physiochemical properties of the initial soil

Characteristics	Value	Critical value
Partical size analysis.		
% Sand	26	…..
% Silt	45	…..
% Clay	29	…...
Textural class	silty-clay	…...
pH	5.6	acidic
Organic carbon (%)	0.45	…...
Organic matter (%)	0.78	…...
Total N (%)	0.03	0.12
Available P (ppm)	20.00	27.12
Exchangeable K (me/100 g soil)	0.10	0.12
Available S (ppm)	45	…...

Appendix III. Incidence of aphid in the experimental field at different days after sowing (DAS)

Source of variations	Degrees of freedom	Mean square					
		10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	3.00	2.33	3.76	2.71	3.19	0.76
Factor A	6	15.32**	16.54**	19.83*	12.49**	5.19*	4.60*
Error	12	0.88	1.00	1.00	0.89	1.02	0.89

Appendix IV. Incidence of jassid in the experimental field at different days after sowing (DAS)

Source of variations	Degrees of freedom	Mean square					
		10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	3.47	7.00	21.14	5.33	3.85	2.47
Factor A	6	40.98*	61.00*	36.21*	53.38*	62.44*	141.94*
Error	12	2.53	1.33	1.42	4.00	3.30	4.69

Appendix V. Incidence of pod borer in the experimental field at different days after sowing (DAS)

Source of variations	Degrees of freedom	Mean square			
		60 DAS	70 DAS	80 DAS	90 DAS
Replication	2	5.28	1.76	0.57	0.04
Factor A	6	37.63**	41.85*	43.71*	38.96*
Error	12	2.23	2.59	2.90	3.99

Appendix VI. Incidence of thrips in the experimental field at different days after sowing (DAS)

Source of variations	Degrees of freedom	Mean square					
		10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	3.61	3.47	10.01	4.29	3.08	2.90
Factor A	6	36.29**	54.88*	27.90**	56.17*	60.55*	126.09*
Error	12	3.39	3.36	2.48	4.29	3.52	13.07

Appendix VII. Yield performance of cowpea in different treatments

Source of variations	Degrees of freedom	Mean square					
		%Number of healthy pods	Number of infested pods by borer	Weight of healthy pods (g)	Weight of infested pods (g)	%Number of healthy pods	%Weight of healthy pods (g)
Replication	2	508.16	772.42	24249.57	2893.63	508.16	429.22
Factor A	6	341.41*	6714.63*	92636.71*	18748.98*	341.41*	266.64*
Error	12	26.86	36.54	40.40	19.15	26.86	10.15