EVALUATION OF SOME CHEMICAL AND NON-CHEMICAL MANAGEMENT PRACTICES AGAINST THE EPILACHNA BEETLE IN BRINJAL

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CERTIFICATE

This is to certify that the thesis entitled *"EVALUATION OF SOME CHEMICAL AND NON-CHEMICAL MANAGEMENT PRACTICES AGAINST THE EPILACHNA BEETLE IN BRINJAL"* 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. Monsur Ali, Registration No. 01046,*** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information as has been availed of during the course of this inquire have been duly acknowledged and the contents & style of the thesis have been approved and recommended for submission.

Dr. Md. Abdul Latif
Supervisor
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Dated:
Dhaka, Bangladesh

Dedicated To

My Beloved Parents

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LIST OF ABBREVIATIONS

Full Word	**Abbreviation**
AEZ	Agro-Ecological Zone
Atm.	Atmospheric
BBS	Bangladesh Bureau of Statistics
DAT	Days After Transplanting
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TDM/ TDW	Total Dry Matter/ Total Dry Weight

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EVALUATION OF SOME CHEMICAL AND NON-CHEMICAL MANAGEMENT PRACTICES AGAINST THE EPILACHNA BEETL IN BRINJAL

BY

MD. MONSUR ALI

THESIS ABSTRACT

An experiment was conducted to evaluate of some chemical and non-chemical management practices against the epilachna beetle attacking brinjal at the experimental farm of Sher-e-Bangla Agricultural University. The study comprised seven treatments such as mechanical control, Cypermethrin 10 EC, Sevin 85 SP, Chlorpyriphos 20 EC, neem seed kernel, mechanical control with application of neem seed kernel and an untreated control. The experiment was carried out in Randomized Completely Block Design (RCBD) with three replications. Sevin 85 SP, Cypermethrin 10 EC and Chlorpyriphos 20 EC reduced more than 90% of the epilachna beetle population in the brinjal field. Mechanical control in combination with neem seed kernel spray also provided more than 80% reduction of the pest. Sevin 85 SP gave the highest fruit yield (20.0 t/ha) of brinjal but Cypermethrin 10 EC and Chlorpyriphos 20 EC produced 19.90 t/ha and 16.20 t/ha yield, respectively. Sevin and Cypermethrin also increased more than 200% yield of brinjal over control. Chlorpyriphos and mechanical control with neem seed kernel application increased more than 150% brinjal yield. Negative linear relationship was observed between percent leaf infestation and yield, and percent plant infestation and yield of brinjal. The highest benefit-cost ratio (12.34) was observed in Sevin 85 SP. Almost equal BCR was calculated in Cypermethrin and Chlorpyriphos (7.38 and 7.34, respectively) treated plots. Mechanical control with application neem seed kernel, and neem seed kernel only gave the BCR of 5.39 and 4.89, respectively. The lowest BCR 2.37 was obtained in mechanical control plots. Sevin 85 SP, Cypermethrin l0 EC and Chlorpyriphos 20EC had strong negative impact on the natural enemy population. Mechanical control with application neem seed kernel, and neem seed kernel had moderate effect on natural enemies.

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Brinjal or eggplant (*Solanum melongena* L.) is one of the most popular and principal vegetable crops in Bangladesh and other parts of the world. It is a native of India and is extensively grown in all the Southeast Asian countries. Bangladesh produced 382 thousand tons of brinjal which was approximately 17% of the total vegetable production of the country during the year of 2000-2001 (Anonymous 2004). Brinjal is the second most important vegetable crop after potato in relation to its production and consumption. It is extensively grown in kitchen garden and commercial field in both Rabi and Kharif seasons covering approximately 64234.82 ha in Bangladesh (Anonymous 2006). When other vegetables are in short supply, especially in hot humid monsoon, brinjal is practically the only vegetable that is available at an affordable price for rural and urban consumers.

Brinjal cultivation helps to improve human nutrition and also income generation. The 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.

Such an important vegetable is attacked by 53 species of insect pests among which the most obnoxious and detrimental one was the brinjal shoot and fruit borer and the second major pest was epilachna beetle (*Epilachna spp.*) (Alam *et al.* 2003, Tewari and Sandana 1990, Chattopadhyay 1987, Nair 1986, Butani and Jotwani, 1984). Latif (2007) observed 20 species of pest under 6 different orders, among them epilachna beetle (*Epilachna* sp.) was a major pest.

The epilachna beetle (*Epilachna* spp.*)* is a serious pest among insect pest community causing considerable damage to a number of Solanaceous and Cucurbitaceous vegetable crops such as brinjal, potato, tomato, cowpea, teasel gourd, beans, cucumber, gourds, etc. The incidence of the pest occurs throughout the year. Its number increases in the dry season. Both larvae and adults are injurious and feed on the epidermal tissues of the leaves by scraping surface resulting the drying and falling of the attacked foliage. The grubs and adults scrap the green matter from leaves and damage up plants. As a result, growth and development of the plants greatly are hampered and their yield is markedly reduced. Rajgopal and Trivedi (1989) reported that Epilachna beetle damaged up to 80 % of plant, while Alam (1969) recorded 10-20 % yield of loss in Brinjal.

The management of Epilachna beetle (*Epilachna spp.*) through various non-chemical method namely, cultural, mechanical, biological and host plant resistance, etc. was limited throughout the world. Management practices of epilachna in Bangladesh and other countries are still limited to frequent spray of toxic chemical pesticides (Alam 2005, Anonymous 2005, Misra and Senapati 2003, Bhargava 2001, Singh *et al.* 2001). The insecticide use mostly belongs to organophosphates, carbamates and synthetic pyrethroids. The farmers of Bangladesh usually apply six to eight schedule based insecticide sprays against this pest throughout the season.

But this kind of insect pest control strategy relying solely on chemical protection had got many limitations and undesirable side effects (Husain 1984) and this in the long run led to many insecticide related complications (Frisbie 1984) such as direct toxicity to beneficial insect, fishes and other non target organism (Munakata 1997, Goodland *et al.* 1985, Pimentel 1981) human health hazards (Bhaduri *et al.* 1989), resurgence of pests (Husain 1993, Luckmann and Metcalf 1975) outbreak of secondary pest and environmental pollution (Fishwick 1988, Kavadia *et al.* 1984).

To overcome the hazards of chemical pesticides, researchers are searching alternatives for the management of this obnoxious pest. Botanicals such as neem seed kernel extracts and neem oil 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). Several researchers also suggested mechanical control techniques for the management of this pest (FAO 2003, Karmakar and Bhattacharya 2000). However, in Bangladesh, information regarding neem products and mechanical control are scanty. Moreover, pesticides companies are introducing new chemicals for management of epilachna 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 some chemicals and non-chemical methods against epilachna beetle are essential. Keeping this perspective in view, the study was undertaken against epilachna beetle to fulfill the following objectives:

- to evaluate some control tactics for the management of the epilachna beetle (*Epilachna* spp.) on brinjal
- to identify the most effective control measure for epilachna beetle (*Epilachna* spp.) on brinjal and
- to know the impact of these control tactics on natural enemies in the brinjal field

Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

Epilachna beetle, *Epilachna* spp. Muls. belongs to the order Coleoptera and family Coccinellidae. A review of literature on the biology, host-range and effectiveness of different chemicals and non-chemical management practices against epilachna beetle is presented below:

2.1 Biology

2.1.1 Life History:

Adult:

Nakano and Katakura (1999) observed that the shape of this beetle usually round with the head deeply sunk into the thorax and their colour shows a wide variation of a brownish yellow to deep yellow background with black spots or patch. *E. vigintioctopunctata* beetle are deep red and usually have 14 black spots on each elytron while the beetles of *E. dodecastigma* are deep copper colour and have 6 black spots on each elytron. The adults are 8-9 mm in length. The adults are white voracious feeders and they feed both on the upper and lower surface of the leaf. The adults are long-lived (more than a month) and being strong fliers, infest wide areas. The life stages are spent on foliage.

Egg:

Hirano (1993) observed that the female lays up to 450 eggs in batches on the underside of the leaves. The eggs are yellow, cigar shaped which are very prominent on the green leaves. Datta (1966) also observed that the incubation period of *Epilachna dodecastigma* was 3-5 days in summer and 6-8 days in winter.

Larva:

The hatched larvae have characteristic shape, the body being broad in front and narrow behind and covered with spiny structure all over. They confined their feeding activities generally to the under surface of the leaves. The larval period varies from 12-18 days with 3 larval instars. The full-grown larvae are 6-8 mm in length. Ahmed and Khatun (1996) found the larval duration of *Epilachna dodecastigma* was 10-15 days.

Pupa:

Datta (1966) observed that the pupation takes place on the leaf surface. At that time the full-grown larva attaches the last segment of its abdomen to the leaf surface by means of its sticky secretion and the pupa is formed within the last larval skin which splits on the dorsal side. The pupal period lasts for 4-8 days. The life cycle is completed in 2-3 weeks during the summer but it extends up to 2 months during the winter.

2.1.2 Nature of damage:

Many grubs and adults can be seen on the ventral surface of the leaves. Both the adult and grub stages feed on the leaf surface and skeletonize the leaves which present a lace like appearance as the green matter in-between the veins is eaten away leaving the skeleton of anastomizing veins. The attacked leaves turn brown, dry up and fall off. In case of severe infestation the crop presents a very unhealthy look. The vigour of the plant and thereby its yield is adversely affected.

2.2 Seasonal abundance

The beetles appear on the plants in March to April. The pest remains active from April to October, but the greatest damage is caused during April- May. The adults hibernate under straw, creepers or in cracks and crevices in soil in the winter (Alam 1969).

Ghosh and Senapati (2001) observed the seasonal incidence, population fluctuation and biology of *Henosepilachna vigintioctopunctata* (*Epilachna vigintioctopunctata*) on brinjal cv. Pusa Purple Long in west Bengal, India. The beetles were recorded from April to October, and the highest population (8.14 beetles/plant) was observed in mid-September. Beetle population showed significant positive correlation with average temperature, relative humidity and rainfall. Rajagopal and Trivedi (1989) reported that *Epilachna dodecastigma, Epilachna vigintioctopunctata, Epilachna ocellata* and *Epilachna sparsa* commonly attack Solanaceous plants. The peak period of infestation varied with season, but the peak was generally in July-August. The pest also fed on tobacco, pumpkin and bitter gourd. The larvae and adults scraped the green matter from leaves and damaged upto 80% of plants.

2.3 Host range and food habit

Alauddin and Alam (1962) described that *Epilachna vigintioctopunctata* Fab. is a serious pest of brinjal and other Solanaceous and Cucurbitaceous plants. They also stated that the yield loss ranged from 10-20 percent.

Ali and El-Saeady (1986) tested the feeding activity, growth rate and preference of *Epilachna elaterii* for cucumber, squash, watermelon and snake cucumber. Both larvae and adults consumed the largest amount of food when provided with watermelon leaves and the smallest amount when provided with cucumber leaves. Ayyar (1940) recorded the insect to occur on brinjal and potato. He also noted that the most important of the leaf feeding pest of brinjal was the Epilachna beetle.

Beeson (1941) described the insect as a wide spread species occurring in Japan, India and Australia on wild and cultivated solanaceous and cucurbitaceous plants. Ganga and Nagappan (1983) studied the differences in the feeding activities of adults *Epilachna vigintioctopunctata* Fab. on 4 Solanaceous plants, egg plant, tomato and the wild plants *Datura fastuosa* and *Physalis minima*, and the differences in the nutritive values of the plants. The rate of feeding, assimilation and conservation by the coccinellids were determined for each plant. The assimilation efficiency was very high (>98%) on all 4 plants and the damage potential of the pest was significant on brinjal and that in the wild plants were also suitable food plants, *D. fastuosa* promoted greater consumption and *P. minima* promoted greater net conversion.

Gannon and Bach (1996) studied the effect of trichome density on development of *Epilachna varivestis,* using larvae reared on 3 soybean (*Glycine max*), isolines isogenic excepts for trichome density, glabrous, normal, and dense. Feeding performance, as determined by choice tests, also significantly varied among development stages. First instar larvae caused 6-8 times more feeding damage on the pubescent isolines, while third and forth instars caused 3-13 times more damage on the glabrous isoline than on the normal and dense isolines. Adult did not show a significant feeding preference.

Imura and Ninomiya (1998) reported that the leaf area of a Solanaceous weed, *Solanum carolinense,* consumed by larvae and adults of a leaf scraping Coccinellid beetle, *Epilachna vigintioctopunctata* Fab., was measured by the Image Processing System (IPS). An average beetle consumed 1429.5 mm^2 of leaves to complete its larval development and consumed 2510.9 mm^2 of leaves during the first 10 days of its adult stage.

Iwao and Mizuta (1965) identified the insect Epilachna beetle occurs on potato, egg plant, tomato, cucumber and red-pepper. Jones *et al.* (1981) investigated different chemical stimuli and physical structures significantly influenced food consumption rate of Epilachna beetle.

Khan *et al.* (2000) studied the larval life table of *Epilachna dodecastigma* and their growth on six different host plant species: ribbed gourd *(Luffa acutangula),* tomato, sweet gourd *(Cucurbita moschata)* watermelon, teasle gourd *(Momordica dioica)* and aubergine, under laboratory condition. The total food consumption by the larvae for 10 days was highest on watermelon and lowest on sweet gourd. Kogan (1972) studied that food preference of *Epilachna varivestis* was not influenced by the leaf pubescence of soybean.

Lever (1942) reported Epilachna beetle as a pest of citrus, pineapple and tobacco in Fiji. Prdhan *et al.* (1991) stated that *Epilachna vigintioctopunctata* Fab, is a serious pest of brinjal, potato and other Solanaceous plants. Both grubs and adults cause damage, the grubs confining their attack on the lower surface of the leaves and adults usually feeding on the upper surface of the leaves.

Richards and Filewood (1990) stated that food preference of *Epilachna vigintioctopunctata* was influenced by odour, taste, vision and age of plant and by thickness of leaves, proportion of crude fibres, parenchymatous tissue and water content. Sengupta *et al.* (1961) observed that *Epilachna vigintioctopunctata* Fab. was the most important leaf feeding insect that attacks brinjal, *Solanum melongena* and potato in Orissa, India.

Shukla and Upadhyay (1987) investigated the effect of light on the feeding preference of adults of *Epilachna dodecastigma* for different parts of *Luffa* *cylindrica*. Under natural light conditions, the flower was the most preferred part of the plant, followed by the leaf, stem, bud and fruit. The pattern of preference was similar under various light conditions, Most insects were attracted under natural light and least under green light.

Sinha and Chandra (1988) investigated the dietary value of fruits, leaves and flowers of *Luffa aegptiaca* and *Solanumm melongena* for *Epilachna vigintioctopunctata.* On the 3 plant parts of *Luffa aegptiaca* tested, the fruit and leaf were the most suitable as larval food while the flower was less suitable in terms of the mean lifespan, percentage survival, frequency of moulting in the immature stages and adult emergence. The fruit of *S. melongena* was the most suitable food for larvae with respect to mean lifespan and frequency of moulting, while the leaf and flower were unsuitable. All 3 plant parts of *S. melongena* failed to support pupation of the coccinellid.

Tilavov (1981) found that Epilachna beetle fed most actively in-the morning and evening during the summer and feeding declined rapidly in middle of the day and after midnight. The daily fluctuation in the rate of feeding depended mainly on the temperature of the environment, which determined the level of metabolism. Srivastava and Katiyar (1972) found 35-75% leaves of cowpea were severely damaged by adults and larvae of *Epilachna vigintioctopunctata* (F.) and *Epilacnha dodecastigma* Muls.

Wolfenbarger and Sleesman (1962) reported that among the species of *Phaseolus*, a correlation was found between maturities and mean leaf feeding damage by genus *Epilachna* indicating that resistance is greatest in the species that took longest time to mature.

2.4 Mechanical control of epilachna beetle

Karmarkar and Bhattacharya (2000) observed that some local cultivar of brinjal showed good yield performance (5-11 brinjal/plant) with desirable plant and brinjal qualities. Epilachna beetle, *Henosepilachna vigintioctopunctata* (Fab.) was found to be destructive pests in the terai zone of West Bengal. Mechanical destruction of epilachna beetle reduced the population well below the economic injury level (1.25-11 insects/plot)

2.5 Chemical control of epilachna beetle

Mandal and Kumar (2001) conducted field study to evaluate the efficacy of monocrotophos, quinalshos, cypermethrin and fenvalerate against *Epilachna vigintioctopunctata* Fab. infesting brinjal cv. Pusa purple, spraying 60, 75, 90 and 105 days after transplanting during kharif season. All the insecticides reduced the epilachna beetle populations but cypermethrin showed the highest reduction in the pest population at all stages of plant growth.

Rajendran *et al.* (1998) found the toxicity and growth regulatory effects of neem Azal-T/S (1% azadirachtin) and neem Azal-F (5% azadirachtin) against the pupae and adults of *Henosepilachna vigintioctopunctata* [*Epilachna vigintioctopunctata*]. Neem Azal formulations affected the normal emergence of adults, 1 ml/litre of neem Azal-F resulting in 35% emergence. They concluded that these two neem azal treatments have adverse effects on the fecundity and moderate growth regulatory effects on *Epilachna vigintioctopunctata.*

Mall *et al.* (1998) studied that the use of combination of phosphamidon (0.03% at 600L/ha) and monocrotophos (0.04% at 800L/ha) during the vegetative phase, and endosulfan (0.7%) + fenvalerate (0.005%) (1000L/ha), and methyl parathion (25kg/ha) and cypermethrin (25kg/ha) during the fruiting phases of brinjal for the control of insect was evaluated during 1991 in Uttar Pradesh, India. Monocrotophos showed better control than phosphamidon and both reduced the number of epilachna beetle. Cypermethrin was more effective than parathion methyl against epilachna beetle *(Epilachna vigintioctopunctata* Fab.)

Saeed *et al.* (1998) carried out a field study in Pakistan to test the efficacy of 3 insecticides against *Epilachna* spp.in brinjal. The insecticides were azocard (monocrotophos + cypermethrin), edmitol (fenvalerate+dimethoate) and sumicidin (fenvalerate) and Sevin (carbaryl) was used as a standard. Results were non significant after 96 hours of application but Sevin gave better results than the other insecticides.

Surjeet *et al.* (1998) were evaluated some insecticides under laboratory conditions against malathion and endosulfan against resistant and susceptible strains of *Epilachna vigintioctopunctata* Fab. The resistant strain exhibiting 7.79 fold resistance to malathion showed cross resistance to cypermethrin (1.20 fold), fenvalerate (1.20-fold), monocrotophos (1.90-fold), carbaryl (1.30-fold) and endosulfan (2.24 fold). Cross resistance was observed for cypermethrin (1.10-fold), fenvalerate (1.07-fold), monocrotophos (1.20-fold), malathion (2.60 fold) and carbaryl (1,17-fold). They concluded that the resistant strains did not show any significant cross resistance to the tested insecticides.

Gupta and Dogra (1996) stated that difluobenzuron (DF) and penfluron (PF) at 1.125-20 ppm in acetone (25 dip treatment) were equally effective in dose dependent manners against eggs of *Henosepilachna vigintioctopunctata* Fab., but freshly laid eggs were more sensitive than 1day-old eggs.

In a laboratory study, Haque *et al.* (1996) found that when first and third instar larvae and adults of *Epilachna dodecastigma* (Wied.) were exposed to 0.25, 0.5, 1.0 and 2.0 % neem oil applied on brinjal leaf discs, the feeding activity of first and third instar larvae and adults decreased with increasing oil concentration.

Surjeet *et al* (1996) carried out an experiment on the toxicity of malathion and endosulfan aganist third instar larvae and adults of *Epilachna vigintioctopunctata* Fab. The results showed that different populations did not differ significantly in their susceptibility to malathion and endosulfan. The average LC_{50}s of malathion and endosulfan to larvae were 0.032 and 0.018%, and 0.022 and 0.013% to adults, respectively.

Ahmed and Khatun (1996) found neem oil as a potential feeding deterrent and growth inhibitor of Epilachna beetle, *Epilachna dodecastigma.* He stated that mortality increased and adult emergence decreased with increasing concentration. The larval duration prolonged and adult longevity become shorten.

Mohasin and De (1994) conducted a field trails to control the epilachna beetle of potato. Seven insecticides namely, carbaryl 50 WP, endosulfan 35EC, quinalphos 25EC, fenitrothion 100EC and monocrotophos 40EC were tested for two years. The experimental results showed that endosulfan 35EC followed by carbaryl 50 WP and quinalphos 25EC gave reasonably good control of Epilachna beetles within 10 days after treatments.

Reddy (1994) carried out a field experiment in 1992 at Rajendranagar, Andhra Pradesh India, 8 insecticides were sprayed on bitter gourd against *Epilachna vigintioctopunctata* Fab. at fortnightly intervals between 30 and 105 days after sowing, Fenvalerate was found most effective insecticide against *Epilachna vigintioctopunctata* Fab.

Singh *el al.* (1994) found that the body protein concentrations were declined in matathion and BHC exposed insects. They also stated that the body protein types showed a declined trend in insects exposed to insecticides.

Thomas and Jacob (1994) conducted laboratory and field studies in Kerala, India, during 1991. Carbofuran granules applied to bitter gourds (*Momordica charantia*) at 1.5 kg a.i./ha at sowing, vining, and flowering gave an effective level of control of *Henosepilachna vigintioctopunctata* Fab.

Singh and Kavidia (1993) carried out field trials in Rajasthan, India, to determine the effectiveness of various insecticides against pests of brinjal during the fruiting stage. Epilachna beetles were most effectively controlled by application of aldicarb, malathion and fenitrothion.

Krishnaia and Bhaskaran (1993) tested an insecticide (0.1% malathion), an acaricide (0.25% dicofol) and a fungicide separately and in various combinations against pests of brinjal in Tamil Nadu, India, in 1986-87. Mixing malathion with the other compounds did not adversely affect its effectiveness against *Epilachna vigintioctopunctata* on brinjal.

Mohon and Jagan (1991) observed that the efficiency of profenofos, bromophos, ethion, prothiofos, permethrin and butylphenyl methyl carbamate (fenobucarb) against *Epilachna vigintioctopunctata* on brinjal. The insecticides were sprayed 3 times at fortnightly intervals during the fruiting stage and estimations of mortality were based on larval counts. Fenobucarb, ethion, profenofos (all at 0.5 kg a.i./ha) and permethrin (0.1 Kg a.i./ha) were most effective in controlling the larvae of *Epilachna vigintioctopunctata* Fab. at 10 days after first spray .

Srinivas *et al*. (1991) carried out an experiment and stated the combination treatments of 0.0325% triflumuron with 0.025% fenobucarb or 0.075% carbaryl were found to be most effective against *Epilachna vigintioctopunctata* Fab.

Islam (1985) found that neem seed kernel extracts was effective against Eplichna beetle, *Eplichna 12-punctata.* He reported that early instar was affected much than later ones and larval mortality was significantly increased with higher concentrations.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment on management of epilachna beetle (*Epilachna spp.*) (Coleoptera: Coccinellidae) attacking Brinjal, was carried out at the experimental field of the Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during February to August 2007. The materials and methods adopted in the study are discussed in the following sub-headings:

3.1. Location

The experimental field is located at 90°35´E longitude and 23°74´N latitude at a height of 8.2 meter above the sea level (BCA, 2006). The land was medium high and well drained.

3.2. Climate

The experimental site is situated in the sub-tropical climatic zone characterized by heavy rainfall during the month from February to August. The data on monthly maximum and minimum 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 have been presented in Appendix I.

3.3. Soil

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

3.4. Design and layout of the experiment

The study comprised seven treatments including a control for the management of epilachna beetle at seedling to harvesting stages. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole field was divided into three blocks of equal size and each block was sub- divided into seven plots. The unit plot size was 3m x 2m accommodating eight pits per plot. The distance between rows was 100cm and that of the plant to plant was 75cm.

3.5. Land preparation

The soil of the experimental field was well prepared thoroughly followed by ploughing, and cross-ploughing, leveling, and laddering to have a good tilth. All weed and debris of previous crops were removed and the land was finally prepared with the addition of basal dose of cow-dung (decomposed). Raised plots of 3 x 2 m size were prepared accommodating 8 numbers of pits/ plot.

3.6. Manuring and fertilization

The following dose of manures and fertilizers were applied in crop growing season as per recommendation (Rashid 1999).

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

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

3.7. Raising of seedlings and transplanting

Brinjal seed (variety: Uttara) were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur. A small seed bed measuring 5m × 1m was prepared and seeds were sown in the nursery bed at SAU Entomology field on 27 February 2007. Standard seedling raising practice was followed (Rashid, 1999). The plots were lightly irrigated regularly for ensuring proper development of the seedlings. The seed bed was mulched for ensuring seed germination, proper growth and development of the seedlings. Forty days old (3/5 leaf stage) healthy seedlings were transplanted on 5th April 2007 in the experimental field. A total 168 seedlings were transplanted in 21 plots @ of 8 seedlings per plot.

3.8. Intercultural operation

Gap filling:

At the time of each transplanting few seedlings were transplanted in the border of the experimental plots for gap filling. Very few numbers of seedlings were damaged after transplanting and such seedlings were replaced by healthy seedlings collected from the border of the experimental plot. The seedlings were transplanted with a mass of soil roots to minimize the transplanting shock.

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 and rainfall. The urea was top dressed in three splits as mentioned earlier.

Weeding:

Weeding was done 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.

Earthing up:

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

3.9. Treatments for control measures

The comparative effectiveness of the following seven treatments was evaluated on the basis of reduction in epilachna beetle infestation on brinjal. The individual control measure under each treatment as well as standard practice and an untreated control are described and discussed below:

Details of the treatments

T_1 = Mechanical control at 7 days interval

(Hand picking and destruction of egg mass, grubs and adults)

T_2 = Cypermethrin 10EC 1.5 ml/l of water at 7 days interval

T_3 =Sevin 85SP 3.4g/l of water at 7 days interval

T_4 = Chlorpyriphos 20EC 3ml/l of water at 7 days interval

T_5 = Neem Seed Kernel 5g/l of water at 7 days interval

(5g of powdered neem seed kernel was taken in 1L of water and settle for 12 hours. Then the mixture was filtered and sprayed in the field.)

T_6 = Mechanical control+ Neem Seed Kernel 5g/l of water at 7 days interval

T_7 = Control plot

3.10. Application of insecticides

The insecticides were applied with the help of a knapsack sprayer. The first application of insecticide was applied after fourth week of transplantation and subsequent application in each treatment were made at seven days intervals. Precautions were taken to avoid drift to the adjacent plots.

3.11. Data collection

The effect of different treatments in controlling epilachna beetle infestation was determined on the basis of the following parameters.

3.11.1. Counting brinjal leaves and epilachna beetle population

Epilachna beetle infested brinjal leaves (after 20 days of transplanting) were recorded at seven days interval, which started at the first appearance of the pest continued up to 10th week of transplantation. To determine the population of adult, larvae and egg masses per plant, five plants were randomly selected from each plot and tagged. Ten leaves of each plant were selected randomly and observed visually at early morning. The number of adult, larvae and egg masses of epilachna was counted. The number of healthy and infested leaves per plant was counted for estimating their abundance. They were calculated for mean infested and healthy leaves per plants. The number of both nymph and adult Epilachna beetle were counted from the selected five plants after one month of transplanting and continued days after transplanting.

Assessment of treatment effects

3.11.2. Percent infestation of leaves

The infested leaves were calculated by the following procedures:

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

3.11.3. Percent reduction of population

The effect of treatments on percent reduction of population on epilachna beetle was determined by counting the numbers of pests per plant for each treatment. The percent reduction of Epilachna beetle per plant was calculated using the following formula:

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

3.11.4. Yield per hectare

The total yield (tons) of brinjal per hectare for each treatment was calculated 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 Epilachna beetle.

% Increase or decrease of yield over control

$$= \frac{\text{Yield of treated plot- Yield of control plot}}{\text{Yield of the control plot}} \times 100$$

3.11.5. Counting of natural enemies

The populations of spider and lady bird beetle were counted by randomly selected five branches from five plants of each plot at weekly interval.

3.12. Benefit-Cost analysis

For benefit cost analysis, records of the costs incurred for labour, insecticide, application of insecticide in each treatment and that of control (without insecticide) were maintained. The untreated control (T_7) did not require any pest management cost. The price of the harvested marketable healthy fruit of each treatment and that of control were calculated at market rate. The result of Benefit-Cost analysis was expressed in terms of Benefit-Cost Ratio (BCR).

3.13. Statistical analysis

Data were analyzed by using MSTAT-C software for analysis of variance after necessary transformation. The analysis of variance (ANOVA) of different parameters was performed and the means were separated by using Duncan's Multiple Range Test (DMRT).

Relationship between number of infested leaves and yield; and relationship between percent plant infestation and yield of brinjal were shown by regression analysis.

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to evaluate some management practices against epilachna beetle (*Epilachna* spp.) on brinjal. The results have been presented and discussed, and the interpretations have been made under the following headings:

4.1. Effect of different treatments on epilachna beetle population

The adult population of epilachna beetle per plant of brinjal was counted under different treatments during the period from February to August 2007. The results (Table 1) reveal that the lowest number of adult/plant (0.13) was found in T_3 (Seven 85SP) treated plots followed by 0.16 in T_2 (Cypermethrin) and T_4 (Chlorpyriphos) sprayed plots. In contrast, significantly higher number of adult/plant (1.95) was obtained in (untreated control) T_7 followed by 1.03 in T_1 (mechanical control). No significant difference was observed in T_3, T_2, T_4, T_5, and T_6 treated plots in terms of adult epilachna beetle/plant. Neem seed kernel (T_5) had 0.90 adult/plant, which was significantly lower than untreated control (T_7) but statistically similar with that of the T_6 (Mechanical control +Neem seed kernel) treated plots. The results further revealed that T_3 (Sevin 85SP) reduced the highest percent (93.33%) of adult population of epilachna beetle over control treated plot followed by 91.48% in T_2 (Cypermethrin) and T_4 (Chlorpyriphos). Mechanical control (T_1) only reduced (47.17%) adult/plant population over control but mechanical

Table 1. Number of adult epilachna beetle/plant of brinjal as affected by different treatments

Treatments	No of adults/ plant	Percent reduction of adult/plant
T_1	1.03 b	47.17
T_2	0.16 b	91.48
T_3	0.13 b	93.33
T_4	0.16 b	91.48
T_5	0.90 b	53.84
T_6	0.32 b	83.58
T_7	1.95 a	
LSD	1.34	
CV (%)	10.93	

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

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

control in combination with neem seed kernel (T_6) provided more than 80% reduction of adult population over control.

The data (Table 2) indicate that the lowest number of larvae/plant (0.04) was found in T_3 (Seven 85SP) followed by 0.16/plant in T_2 (Cypermethrin) and T_4 (Chlorpyriphos) treated plots. No significant difference was observed in T_3 (Seven 85SP), T_2 (Cypermethrin), T_4 (Chlorpyriphos), T_5 (Neem seed kernel) and T_6 (Mechanical control +Neem seed kernel) in terms of larval population per plant. In contrast, significantly higher number of larvae/plant (6.06) was obtained in T_7 (Untreated control) followed by 3.13 larvae/plant in T_1 (Mechanical control). Neem seed kernel (T_5) had only 0.80 larvae/plant, which was significantly lower than control but statistically similar with that of the T_6 (Mechanical control +Neem seed kernel) treatments. The table 2 also indicates that T_3 (Seven 85SP), T_2 (Cypermethrin), T_4 (Chlorpyriphos), and T_6 (Mechanical control +Neem seed kernel) reduced more than 90% of larval population over control. Neem seed kernel (T_5) alone gave 86.79% reduction of larval population/plant while mechanical control reduced only 48.34% larvae of epilachna beetle per plant over control.

Similarly, the lowest number of egg mass/plant (0.11) was found in T_3 (Seven 85SP) followed by 0.12 and 0.13 per plant in T_2 (Cypermethrin) and T_4 (Chlorpyriphos), respectively (Table 3). No significant difference was observed in T_3, T_2, T_4, T_5 and T_6 in number of egg mass of epilachna beetle per plant (Table 3). In contrast, significantly higher number of egg mass/plant (4.05) was obtained in untreated control (T_7), which was significantly higher than all treatments.

Table 2. Number of epilachna beetle larvae/plant of brinjal in different treatments

Treatments	Number of larvae/plant	Percent reduction of larva/plant over control
T_1	3.13 b	48.34
T_2	0.16 c	97.35
T_3	0.04 c	99.33
T_4	0.16 c	97.35
T_5	0.80 c	86.79
T_6	0.53 c	91.25
T_7	6.06 a	
LSD	1.35	
CV (%)	11.23	

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

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem Seed Kernel 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel 5g/l of water

T_7 = Untreated Control

The same table (Table 3) further reveals that Seven 85SP (T_3) reduced the highest percent of egg mass/plant (97.28%) over control followed by 97.03% and 96.79% in T_2 (Cypermethrin) and T_4 (Chlorpyriphos), respectively. Among the different treatments, T_1 (Mechanical control) had the lowest effectiveness in reducing (47.40%) egg mass/plant over control. However, T_5 (Neem seed kernel) and T_6 (Mechanical control +Neem seed kernel were provided more than 90% reduction of epilachna beetle egg mass/plant over control.

The above results indicate all the chemical and non-chemical treatments significantly reduced the adults, larvae and egg masses of epilachna beetle in brinjal. Sevin 85SP, Cypermethrin 10EC and Chlorpyriphos 20EC showed the highest effectiveness by reducing more than 90% population of the three different stages of epilachna beetle. On the other hand, mechanical control alone showed the lowest effectiveness while Neem seed kernel treatments alone showed moderate efficacy against the different stages of this pest. However, Mechanical control in combination with neem seed kernel application reduced more than 80% population of the epilachna beetle in the field.

The findings of the present study agree with the findings of the other researchers (Mandal and Kumar 2001, Mall *et al.* 1998, Saeed *et al.* 1998, Mohasin and De 1994, Islam 1985). Mandal and Kumar (2001) stated that cypermethrin reduced the highest amount of population of epilachna beetle at all stages of plant growth. Saeed *et al.* (1998) and Mohasin and De (1994) reported that Sevin gave better results against the epilachna beetle infesting

Table 3. Number of epilachna beetle egg mass/plant of brinjal as infected by different treatments

Treatments	No of egg masses/plant	Percent reduction of egg mass/plant over control
T_1	2.13 b	47.40
T_2	0.12 c	97.03
T_3	0.11 c	97.28
T_4	0.13 c	96.79
T_5	0.35 c	91.35
T_6	0.25 c	93.82
T_7	4.05 a	
LSD	1.45	
CV (%)	9.56	

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

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

brinjal in the field. Moreover, Mall *et al*. (1998) also stated that Cypermethrin was more effective than methyl parathion against epilachna bettle *(Epilochna vigintioctopunctata* Fab.) in brinjal. However, the results also partially contradicted with that of the Karmakar and Bhattacharya (2000), who reported that mechanical destruction of epilachna beetle reduced the population at well below the economic injury level. The difference in results may be due to genotypes and ecological conditions. The moderate efficacy of neem oil also agrees with the results obtained by Ahmed and Khatun (1996) who reported that neem oil was moderately effective against epilachna beetle but the efficacy was increased its with concentration.

4.2. Effect of different treatments on leaf infestation caused by epilachna beetle

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 (28.50) was recorded in T_3 (Sevin 85SP) followed by 27.21 and 27.01 per plant in T_2 (Cypermethrin) and T_4 (Chlorpyriphos) treated plots respectively having no significant difference among them (Table 4). The lowest number of infested leaves was observed in these treatments. The number of healthy leaves was also statistically similar in T_6 (26.56) and T_5 (25.54) treated plot but significantly higher than that of control. The lowest number of healthy leaves/plant (23.34) was observe in T_7 (Untreated control), which was significantly lower than all other treatments. The data (Table 4) also revealed that the percent leaf infestation was significantly lower (0.52%) in T_3 (Sevin 85SP), which was statistically similar to that of T_2 (0.72%) and T_4 (0.77). In contrast, the highest percent leaf infestation (21.28%) was observed in T_7 (Untreated control), which was significantly higher than all other treatments. Mechanical control (T_1) and Neem seed kernel (T_5) treatments had 14.19% and 10.42%, respectively leaf infestation having no significant difference between them. The data (Table 4) further expressed that T_3 (Sevin 85SP), T_2 (Cypermethrin) and T_4 (Chlorpyriphos) provided more than 90% reduction of leaf infestation over control against the epilachna beetle in brinjal. Moreover, Mechanical control in combination with Neem seed kernel (T_6) reduced 86.84% leaf infestation over contol. Neem seed kernel (T_5) alone reduced 52.93% leaf infestation over control against the

Table 4. Effect of different treatments on leaf infestation per plant caused by epilachna beetle in brinjal

Treatments	No. of healthy leaves/plant	No. of infested leaves/plant	Percent leaf infestation	Percent reduction of leaf infestation
T_1	24.30 d	4.02 b	14.19 b	36.29
T_2	27.21 a	0.20 c	0.72 d	96.83
T_3	28.50 a	0.15 c	0.52 d	97.62
T_4	27.01 ab	0.21 c	0.77 d	96.67
T_5	25.54 cd	2.97 b	10.42 b	52.93
T_6	26.56 bc	0.83 c	3.03 c	86.84
T_7	23.34 e	6.31 a	21.28 a	
LSD	1.67	1.45	4.5	
CV(%)	6.23	7.56	14.3	

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

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

pest infestation. Hand collection and destruction of epilachna beetle (T_5) was protected only 36.29% leaf infestation over control.

4.3. Effect of different treatments on plant infestation caused by epilachna beetle

The results (Table 5) revealed that the number of infested plant/plot (0.49) was lowest in T_3 (Sevin 85SP), which was statistically similar with that of the T_2 (0.50) and T_4 (0.57), T_6 (0.95) and T_5 (1.17) treated plots, respectively. In contrast, the highest number of infested plant/plot (2.36) was obtained in T_7 (Untreated control) followed by (2.01) in T_1 (Mechanical control) treated plot having no significant difference between them. The Table 5 further revealed that T_3 (Sevin 85SP) was superior in reducing plant infestation and provided 79.23% protection of plant infestation against epilachna beetle over control. T_2 (Cypermethrin) and T_4 (Chlorpyriphos) reduced 78.81% and 75.84% plant infestation of brinjal over control. Nevertheless, T_1 (Mechanical control) had the lowest effectiveness in reducing the plant infestation (14.83%). T_6 (Mechanical +Neem seed kernel) and T_5 (Neem seed kernel) reduced 50.42% plant infestation over control.

Table 5. Effect of different treatments on plant infestation of brinjal caused by epilachna beetle

Treatments	Number of infested plants/plot	Percent reduction of plant infestation over control
T_1	2.01 ab	14.83
T_2	0.50 c	78.81
T_3	0.49 c	79.23
T_4	0.57 c	75.84
T_5	1.17 abc	50.42
T_6	0.95 bc	59.74
T_7	2.36 a	--
LSD	1.28	
CV (%)	6.98	

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

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

4.4. Effect of different treatments on yield of brinjal

Observations on the fruit yield of brinjal under different treatments indicated that the maximum fruit yield of brinjal (20.0 t/ha) was obtained in T_3 (Sevin 85SP) against the epilachna beetle infestation followed by 19.90 t/ha in T_2 (Cypermethrin) having no significant difference between them (Figure 1). In contrast, significantly lower fruit yield (6.22 t/ha) was obtained in T_7 (Untreated control). T_4 (Chlorpyriphos) and T_6 (Mechanical +Neem seed kernel) treatments gave 16.20 t/ha and 15.89 t/ha fruit yield. Moreover, T_5 (Neem seed kernel) produced 13.32 t/ha fruit yield of brinjal against this insect infestation.

Similarly, Figure 2 illustrated that all the treatments increased the fruit yield of brinjal over control but their effectiveness were varied. T_3 (Sevin 85SP) increased the highest percent of yield (221.54%) over control followed by 219.93% and 160.40% in T_2 (Cypermethrin) and T_4 (Chlorpyriphos), respectively. Mechanical control in combination with Neem seed kernel (T_6) increased 155.46% fruit yield of brinjal against the epilachna beetle infestation. However, Neem seed kernel (T_5) and mechanical control (T_1) separately increased 114.14% and 53.21%, respectively fruit yield of brinjal.

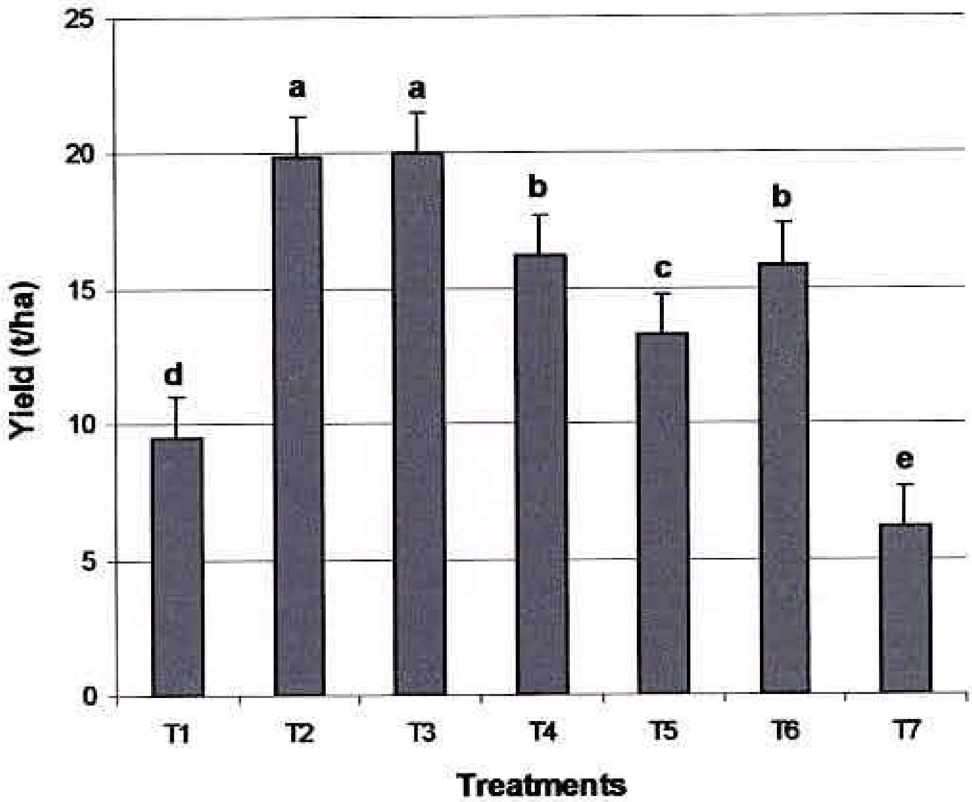

Figure 1. Average fruit yield of brinjal in different treatments against epilachna beetle infestation. T-shaped beams indicate the LSD values. Bars having similar letter(s) are statistically identical at 5% level of significance.

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

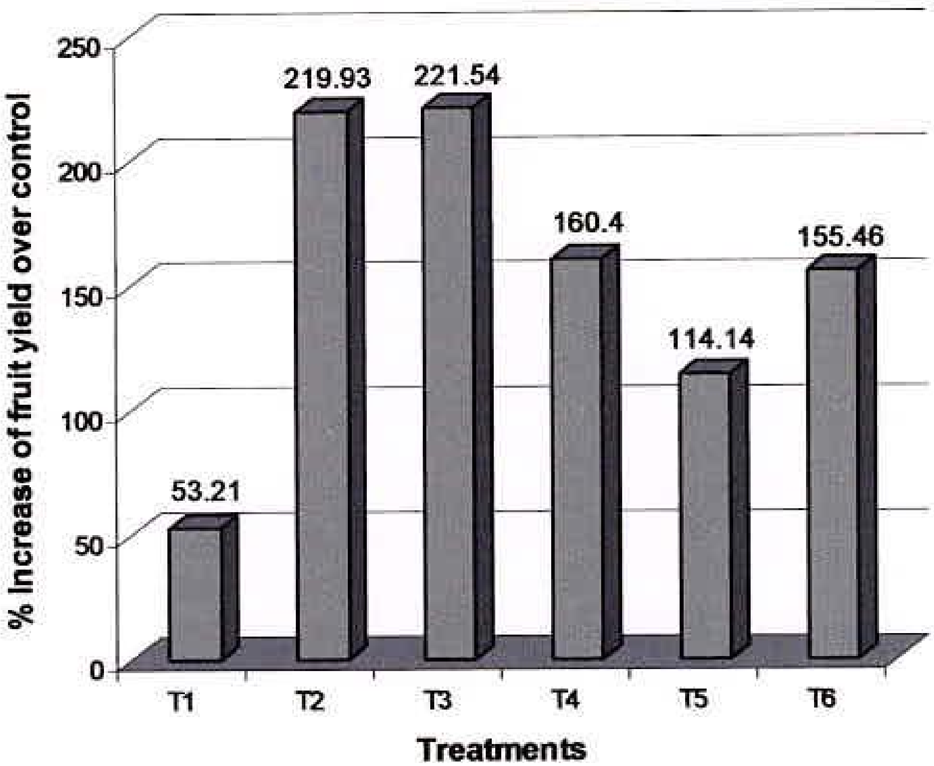

Figure 2. Percent increase of fruit yield of brinjal in different treatments against epilachna beetle infestation.

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

4.5. Relationship between number of infested leaves and yield

The data on no. of infested leaves/plant were corelated against yield of brinjal and a negative linear relationship was obtained between them. It was evident from the Figure 3 that the equation $y= -0.3808x+18.501$ gave a good fit to the data and the co-efficient of determination ($R^2 =0.7752$) showed that the fitted regression line had a significant regression co-efficient. It is also evident from the regression line and equation that the yield increased with the decreased of number of infested leaves/plant in different management practices against epilachna beetle.

4.6. Relationship between percent plant infestation and yield

Correlation study was done to establish a relationship between percent plant infestation and yield of brinjal. From the study it was revealed that significant correlations existed between the characters (Figure 4). The regression equation $y = -6.367x+21.76$ gave a good fit to the data and the value of co-efficient of determination ($R^2 =0.8777$). From this it can be concluded that percent plant infestation in number decrease the yield.

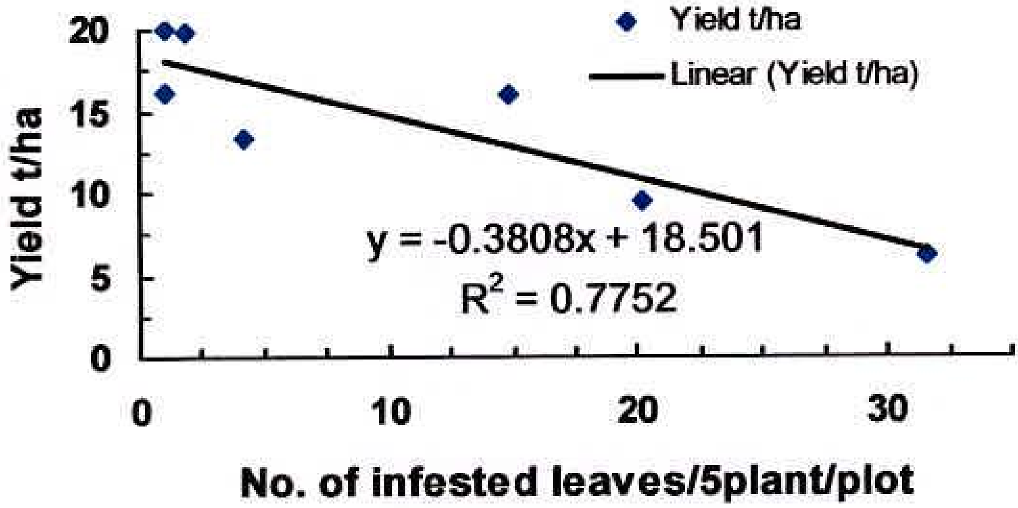

Figure 3. Relationship between number of infested leaves per plant and yield of brinjal

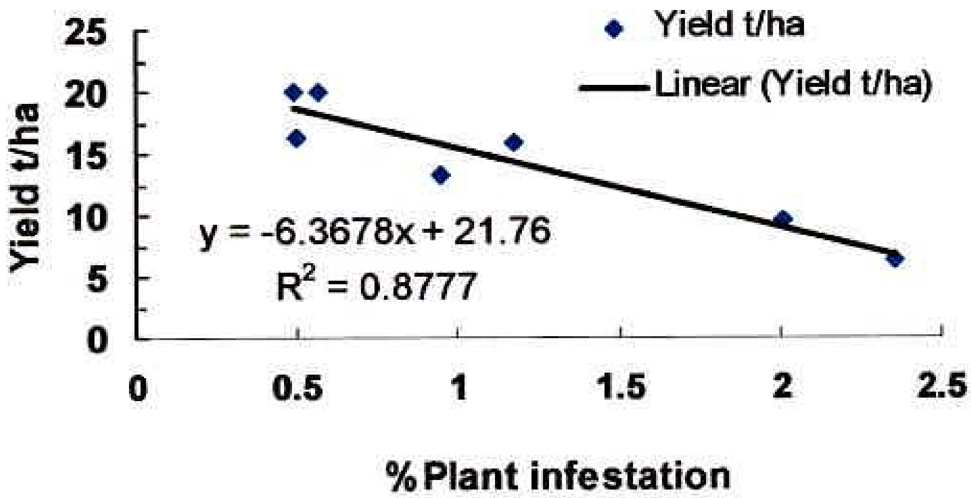

Figure 4. Relationship between percent plant infestation and yield of brinjal

4.7. Benefit Cost Analysis

Economic analysis for the management of epilachna beetle by some chemicals and non-chemical methods on brinjal has been presented in Table 6. The results revealed that highest benefit cost ratio (12.34) was obtained in T_3 (Sevin 85SP). T_4 (Chlorpyriphos) and T_2 (Cypermethrin) gave the BCR of 7.38 and 7.34, respectively the management epilachna beetle in brinjal. Moreover, BCR of 5.39 and 4.89 was obtained in T_6 (Mechanical control +Neem seed kernel) and T_5 (Neem seed kernel), respectively. On the other hand, the lowest BCR (2.37) was calculated for T_1 (Mechanical control). The Table 6 further indicates that the net return was also found highest (Tk. 347208/ha) in Sevin 85SP treated plot followed by Tk. 321812/- and Tk. 294111/- per hectare in T_2 (Cypermethrin) and T_4 (Chlorpyriphos), respectively.

Table 6. Economic analysis of different chemicals and non-chemical methods for management of epilachna beetle in brinjal

Treatments	Cost of pest management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net return (Tk.)	Adjusted net return (Tk)	Benefit Cost Ratio (BCR)
T_1	6000	9.53	130600	124600	14200	2.37
T_2	28788	19.90	350600	321812	211412	7.34
T_3	19192	20.0	366400	347208	236808	12.34
T_4	24889	16.20	319000	294111	183711	7.38
T_5	23333	13.32	246400	223067	112667	4.82
T_6	29333	15.89	297800	268467	158067	5.39
T_7	0	6.22	110400	110400	--	--

Cost of insecticides: Sevin 85SP: Tk.80/100g, Chlorpyriphos 20EC: Tk. 81/100 ml, Cypermethrin 10EC: 120/100 ml, Neem seed kernel: Tk.150/kg.
Cost of mechanical control: Two laboures/ha/week
Cost of spray : Two labourers/spray/ha @ Tk 120.00/day.
Spray volume required: 500 l/ha
Market price of brinjal: Tk 20.00/

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

The findings of the present study indicate that Sevin, Cypermethrin and Chlorpyriphos significantly reduced the plant and leaf infestation caused by epilachna beetle, increased yield of brinjal and gave the higher benefit-cost ratio (BCR). Neem seed kernel along with mechanical control also showed the better performance inrespect of the above parameters. Neem seed kernel alone gave moderate efficacy in terms of decreasing leaf and plant infestation and increasing brinjal yield. The results of the current study agree the findings of the other researchers. Mandal and Kumar (2001) observed that Cypermethrin decreased leaf infestation of brinjal against epilachna beetle and increased fruit yield. Moreover, the superiority of cypermethrin against epilachna beetle also confirmed by Mall *et al.* (1998), who stated that Cypermethrin reduced the leaf infestation of brinjal and gave the higher brinjal yield.

The best performance of Sevin against epilachna beetle was in accordance with the results of Saeed *et al.* (1998) and Mohasin and De (1994), who reported that Sevin gave better results against the epilachna beetle and produced higher brinjal yield. However, the results also partially contradict with that of the Karmakar and Bhattacharya (2000), who reported that mechanical destruction of epilachna beetle reduced infestation at well below the economic injury level and increased yield of brinjal. The difference in results may be due to application methods of chemicals, genotypes of brinjal and environmental conditions. The moderate efficacy of neem oil also agrees with the results obtained by Ahmed and Khatun (1996) who reported that neem oil was moderately effective against epilachna beetle but the efficacy was increased with its concentration.

4.8. Effect of different treatments on natural enemies in the brinjal field

The effect of different chemicals and botanicals on the population of spider and lady bird beetle in brinjal field have been studied and presented in Table 7 and 8. The data (Table 7) revealed that T_3 (Sevin 85SP) treated plots had the lowest number of spider (0.66/plant), which was significantly different from all other treatments. In contrast, the highest number of spider (2.50/plant) was observed in T_7 (Untreated control), which was significantly higher than all other treatments. The other treatments had significantly lower number of spiders than control. In terms of reduction of spider population, all the treatments reduced the spider population in the brinjal field. T_3 (Sevin 85SP) reduced 73.6% spider population in brinjal field followed by 69.6% and 62.8% in T_2 (Cypermethrin) and T_4 (Chlorpyriphos), respectively. T_5 (Neem seed kernel) and T_6 (Mechanical +Neem seed kernel) had moderate effect in reducing spider population in brinjal field. Similarly, the results (Table 8) revealed that the lowest number of lady bird beetle (0.70/plant) was observed in T_3 (Sevin 85SP) followed by (1.06/plant) in both T_2 (Cypermethrin) and T_4 (Chlorpyriphos) treated plots. In contrast, the highest number of lady bird beetle (1.93/plant) was observed in T_7 (Untreated control), which was significantly higher than all other treatments. The other treatments had significantly lower number of lady bird beetle/plant than control. In terms of reduction of lady bird beetle population all the treatments reduced the

Table 7. Effect of different treatments on population of spider in brinjal field during management of epilachna beetle

Treatments	Number of spider/plant	Percent reduction of spider over control
T_1	1.60 b	36.0
T_2	0.76 f	69.6
T_3	0.66 g	73.6
T_4	0.93 e	62.8
T_5	1.40 c	44.0
T_6	1.13 d	54.8
T_7	2.50 a	
LSD	0.09	
CV (%)	7.89	

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

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

population of lady bird beetle in brinjal field. T_3 (Sevin 85SP) reduced 63.73% lady bird beetle population in brinjal field followed 45.07% and 45.07% in Cypermethrin and Chlorpyriphos treated plots, respectively. T_5 (Neem seed kernel) and T_6 (Mechanical +Neem seed kernel) had moderate effect in reducing lady bird beetle population in brinjal field.

The results thus obtained in the study indicate that Sevin, Cypermethrin, and Chlorpyriphos had strong negative effect, T_6 (Mechanical control +Neem seed kernel) and T_5 (Neem seed kernel) had moderate impact on natural enemies in the brinjal field. The negative impact of most of the insecticides against lady bird beetle and spider thus obtained in the present study agrees with the findings by many researchers. FAO (2003) reported that application of insecticides reduced the population of beneficial insect especially spiders and lady bird beetle from the brinjal plant. Maleque *et al.* (1999) and Rahman (2006) reported that the lady bird beetles and spiders were seriously affected in the field where cypermethrin was applied at weekly intervals. The difference in results may be due to different crops and ecological conditions.

Application of different management practices reduced the infestation of epilachna beetle in brinjal, increased brinjal yield and decreased of two important predators in the brinjal field but their efficacy was greatly varied. Sevin 85SP showed the superior performance against the epilachna beetle in the field. Cypermethrin 10EC and Chlorpyriphos 20EC gave the almost similar results against this obnoxious pest. Mechanical control in combination with application of neem seed kernel at 7 days interval showed satisfactory performance and had moderate effect on natural enemies in the brinjal field.

Table 8. Effect of different treatments on population of lady bird beetle in the brinjal field during management of epilachna beetle

Treatments	No of ladybird beetle	Percent reduction of lady bird beetle
T_1	1.76 b	8.80
T_2	1.06 e	45.07
T_3	0.70 f	63.73
T_4	1.06 e	45.07
T_5	1.66 c	13.98
T_6	1.46 d	24.35
T_7	1.93 a	
LSD	0.09	
CV(%)	8.89	

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

T_1 = Mechanical control

T_2 = Cypermethrin 10EC @ 1.5 ml/l of water

T_3 = Sevin 85SP @ 3.4g/l of water.

T_4 = Chlorpyriphos 20EC @ 3ml /l of water

T_5 = Neem seed kernel @ 5 g/l of water

T_6 = Mechanical control+ Neem seed kernel @ 5 g/l of water

T_7 = Untreated Control

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was conducted at the Sher-e-Bangla Agricultural University farm during the period from February to August 2007 to evaluate some chemicals and non-chemical management approaches against the epilachna beetle attacking brinjal.

Sevin 85 SP, Cypermethrin 10EC and Chlorpyriphos 20EC treatments showed the best performance against the pest in the field. These insecticides reduced more than 90% adults, larvae and egg masses of the epilachna beetle. Mechanical control in combination with Neem seed kernel spray also reduced more than 80% population of the beetle. Mechanical control alone showed the lowest performance against the epilachna beetle.

Application of different tactics decreased the percent leaf and plant infestation of brinjal by epilachna beetle. Sevin 85SP, Cypermethrin 10EC and Chlorpyriphos 20EC treatments gave the best results by reducing more than 90% of the leaf infestation over control. These insecticides also reduced about 80% of the plant infestation. Mechanical control along with neem seed kernel application provided 86.84% and 59.74% reduction of leaf and plant infestation, respectively. Neem seed kernel application reduced 52.93% leaf and 50.42% plant infestation of brinjal.

The yield of brinjal was significantly increased by application of different control tactics. Sevin 85SP treated plots produced the highest fruit yield

(20.0t/ha) while Cypermethrin 10EC and Chlorpyriphos 20EC treatments gave 19.90 t/ha and 16.20 t/ha yield, respectively. Mechanical control along with neem seed kernel treated plots produced 15.89 tones of brinjal per hectare. Control plot gave only 6.22 t/ha brinjal yield. Sevin and Cypermethrin increased more than 200% fruit yield of brinjal over control. On the other hand, Chlorpyriphos and mechanical control with neem seed kernel application increased more than 150% brinjal yield. Neem seed kernel alone increased 114.14% and mechanical control increased 53.21% yield of brinjal.

Negative linear relationship was observed between percent leaf infestation and yield, and percent plant infestation and yield of brinjal. The highest benefit cost ratio (12.34) was observed in Sevin. Almost similar benefit cost ratio was observed in Cypermethrin and Chlorpyriphos (7.38 and 7.34, respectively). Mechanical control with application of neem seed kernel, and neem seed kernel only gave the BCR of 5.39 and 4.89, respectively. The lowest BCR 2.37 was obtained in mechanical control.

All the management practices significantly reduced the spider and lady bird population in the brinjal field. However, the neem seed kernel and mechanical control showed less impact on these two predators. Sevin, Cypermethrin and Chlorpyriphos had strong negative impact on the natural enemy population.

From the environmental safety point of view mechanical destruction of the pest and application of neem seed kernel may be recommended for the management of epilachna beetle but needs further trial in large-scale cultivation of brinjal in farmer's field.

References

CHAPTER VI

REFERENCES

Ahmed, K.N. and Khatun, M. 1996. The biology of epilachna beetle, *Epilachna septima* Dieke (Coleoptera: Coccinellidae) infesting bitter gourd in Bangladesh. *Bangladesh J. Sci. Indus. Res.* **31**(i): 147-152.

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

Alam, M.Z. 1969. Insect pest of vegetables and their control in East Pakistan. *The Agricultural Information Services*, Department of Agriculture, 3, R.K. Mission Road, Dacca-3, East Pakistan. p.149.

Alam, S. N., Rashid, M. A., Rouf, F. M. A., Jhala, R. C., Patel, J. R., Satpaphy, S. T. M., Shivlingas, Wamy, S., Rai, I., Wahundeniya, A., Cork, C., Ammaranan, and N.S. Talekar. (2003). Development of an integrated pest management strategy for egg plant fruit and shoot borer in South Asia. Technical Bulletin 28, AVRDC- The World Vegetable Center, Shanhua, Taiwan. p.66.

Alauddin, K.N. and Alam, M. Z. (1962). The biology of epilachna beetle, *Epilachna vigintioctopunctata* in Pakistan. *Pakistan J. Sci.* **12** (iv): 192-200.

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

Ali, M.A. and El-Saeady, A. A. (1986). Phenology and population dynamics of the melon lady bird beetle, *Epilachna chrysomelina* (F) in Egypt (Coleoptera: Coccinellidae). *Agril. Res. Rev.* **61** (i): 179-191.

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

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

Anonymous. (2006). Statistical year book of Bangladesh. Bangladesh Bureau of Statistics. Government of the Peoples Republic of Bangladesh, Dhaka, Bangladesh.

Beeson, C. F. C. (1941). The Ecology and control of the forest insects of India and neighboring countries. p.220.

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

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

Butani, D.K. and M.G. Jotwani. 1984. Insects in Vegetables. Periodical Expert Book Agency. D- 42, Vivek Vihar, Delhi-110032, India. 356 p.

Chattopadhyay, P. 1987. Entomology, Pest Control and Crop Protection (*in Bangla*). West Bengal State Book Board, Arjo Mansion (9th floor), 6A, Raja Subodh Mollick Square, Calcutta-700013, India. 304 p.

Datta, K. R. (1966). Studies on the life history of *Epilachna dodecastigma* Muls. in relation to the host plant preference. M. Sc. (Ag.) Thesis, East-Pakistan Agril. Univ., Mymensingh. p.31.

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

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

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

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

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

Ganga, G. and Nagappan, M. (1983). Feeding and food utilitarian by the beetle, *Henosepilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) on different host plants. *Indian J. Entom. Biol.* **21**(i): 34-36.

Gannon, A.J. and Bach, C. E. (1996). Effects of soybean trichome density on Mexican bean beetle (Coleoptera: Coccinellidae) development feeding performance. *Environ. Entom*. **25**(v): 1077-1082.\

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

Gupta, P.R, and Dogra, G.S. (1996). Sensitivity of stages of development of *Henosepilachna vigintioctopunctata* Fab. to topical application of diflubenzuron and penfluron. *Rev. Agril. Entom*. **84**(vii): 151.

Hirano, K. (1993). Population dynamics of phytophagous lady beetle. *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae), living in spatiotemporally heterogenous habitats, seasonal changes in adult movement and spatial distribution of the population. *Appl. Entom. and Zool*. **28** (ii): 131-140.

Husain, M. (1993). *Anistakar Kit-Patango Daman* (Control of Harmful Insects). Bangla Academy, Dhaka. pp. 220.

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

Imura, O. and Ninomiya, S. (1998). Quantitative measurement of leaf area consumption by *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) using image processing. *Appl. Entom. and Zool.* **33** (iv): 491-495.

Iwao, S. and Mizuta, K. (1965). Studies on a natural population of the large 28-spotted lady bird beetle. *Rev. App. Entom.* **53** (ix): 425-480.

Jones, C. G., Hoggard, M. P. and Blum, M. S. (1981). Pattern and process in insect feeding behaviour: a quantitative analysis of the Mexican bean beetle, *Epilachna varivestis. Entomol. Expt. Appl.* **30**(iii): 254-264.

Karmakar, K and Bhattacharya, B. (2000). Performance of a local brinjal variety (*Solanum melongena* L.) and its pest management under terai agro-ecological conditions. **18** (ii): 344-346.

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

Khan, M. H., Islam, B. N., Rahman, A. K. M. M. and Rahman, M. L. (2000). Life table and the rate of food consumption of epilachna beetle, *Epilachna dodecastigma* (Wied.) on different host plant species in laboratory condition. *Bangladesh J. Entomol.* **10** (i-ii): 63-70.

Kogan, M. (1972). Feeding and nutrition of insect associated with soybeans, soybean resistance and host preferences of the Mexican bean beetle, *Epilachna varivestis. Ann. Entomol. Soc. America.* **65**(iii): 675-683.

Krishnaia, P.V. and Bhaskaran, P. (1993). Efficacy of malathion and its combinations with dicofol and zineb in controlling major insect pests of brinjal. *Rev. Agril. Entom.* **78**(i): 200.

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

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

Lever, R. J. A. W. (1942). New host record of pests. Rev. Appl. Entomol. Series A. **29**(viii): 390.

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

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

Mall, N.P., Pandey, R.S., Singh, S. V. and Singh, S.K. (1998). Evaluation of insecticidal emulsion and dust formulations for sucking and leaf feeding pests of brinjal. *J. Entomol.* **58** (iii): 264-269.

Mandal, S. K. and Kumar, B. (2001). Evaluation of certain new insecticides against epilachna beetle (*Epilachna vigintioctopunctata* Fab.) on brinjal. *Env. And Ecol.* **19** (ii): 483-484.

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

Mohan, N.J. and Jagan, M.N. (1991). Control of epilachna beetle, *Epilachna vigintioctopunctata* Fab. and fruit borer on brinjal. *Pesticides.* **19**(vii): 32-33.

Mohasin, M.D. and De, B.K. (1994). Effect of insecticides in controlling *Henosepilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) on potato in the plains of West Bengal. Entom. Abs. **25**(ii): 111.

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

Munakata, K. (1997). Insect feeding deterrents in plants. In: Chemical control of insect behaviour (eds.) Shorey, H.H. and J.J. Jr. Mekelvy. Jhon Wiley and Sons, New york .pp. 522.

Nair, M.R.G.K. 1986. Insects and Mites of Crops in India. Revised Edition. Indian Council of Agricultural Research, New Delhi. 408 p.

Nakano, S. and Katakura, H. (1999). Morphology and biology of a phytophagous lady bird beetle, *Epilachna vigintioctopunctata*

(Coleoptera: Coccinellidae) newly recorded on Ishigaki Island. *App. Entom. & Zool*. **30** (i): 189-194.

Pimentel, D. (1981). An Overview of Integrated Pest Management (Mimeograph). Dept. of Entomology, Section of Ecology and Systematic, Cornell Univ., Ithaca, New York. pp. 52.

Pradhan, S., Jotwani, M.G. and Prakash, S. (1991). Comparative toxicity of insecticides to the grubs and adults of *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae). *Indian J. Entom*. **24** (iv): 223.

Rahman, M. M. 2006. Vegetable IPM in Bangladesh, In: E. B. Radcliffe and W. D. Hutchinson [eds.] Radcliffe's IPM World Textbook. URL: http://www.ipm world.umn.edu/chapters/rahman.htm., University of Minnesota, St. Paul, MN.

Rajagopal, D. and Trivedi, T. P. (1989). Status, bioecology and management of epilachna beetle, *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) on potato in India. *Tropical Pest Manage*. **35**(iv): 410-413.

Rajendran, B., Reddy, P.P., Kumar, N.K.K. and Verghese, A. (1998). Effect of neem andendosulfan on the oviposition and hatchability of *Henospilachna vigintioctopunctata* Fab. Advances in IPM for horticultural crops. Proceeding of the First National Symposium on Pest Management in Horticultural Crops: Environmental Implications and Thrusts, Bangalore,India,15-17October 1997.pp.106-107.

Rajendran, B., Reddy, P.P., Kumar, N.K.K. and Verghese, A. (1998). Effect of neem and insecticide on population and parasitisation of egg plant spotted beetle, *Henosepilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae). Advances in IPM for horticultural crops. Proc. of the 1st National Symposium on Pest Management in Horticultural Crops: Environmental Implications and Thrusts, Bangalore, India. 15-17 October 1997. pp. 102-105.

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

Rashid, M. M. 1993. Begun Paribarer Shabji. In: Shabji Biggan (in Bangla). First Edn. Bangla Academy, Dhaka, Bangladesh.

Reddy, A.V. (1994). Evaluation of certain new insecticides against the foliar insect pests of bitter gourd *(Momordica charantia). Rev. April. Entom.* **84** (vi): 265.

Richards, A.M. and Filewood, L.W. (1990). Feeding behaviour and food preference of the pest species comprising the *Epilachna vigintioctopunctata* Fab. Complex (Coleoptera: Coccinellidae). *J. Appl. Entomol.* **110**(v): 501-515.

Saeed, M.Q., Shahid, M. and Gul, H. (1998). Efficacy of different insecticides against *Epilachna* spp. and their most preferred host plants. *Rev. Agril. Entomol.* **86**(i): p.101.

Senapati, B., Swain, H. B., Patnaik, H. P. and Behera, P. K. (1990). larvicidal action of diflubenzuron against the coccinellid beetle, *Henosepilachna sparsa* (Hbst.) *Orissa Agril. Res.* **3**(ii): 93-98.

Sengupta, C.L., Perter, C. and Shirai, Y.(1961). Distribution pattern of immature stages of epilachna beetle, *Epilachna vigintioctopunctata* Fab. on brinjal. *Hort. Res.* **12**(iv): 295-300.

Shukla, G. S. and Upadhyay, V. B. (1987). Food preference of *Epilachna vigintioctopunctata* Wied (Coleoptera: Coccinellidae) on different parts of *Luffa cylindrica* under different lights. *Indian J. Ecol.* 14(i): 111-115.

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

Singh, A.K., Sharma, S. and Enteshamulldin, S. (1994). Effect of Malathion and BHC on body protein and amino acids of *Epilachna vigintioctopunctata* Fab. (Coloptera: Coccinellidae) adults. *Entom. Abs.* **25**(ix): 48.

Singh, S. V. and Kavidia, V. S. (1993). Insecticidal control schedule for the pests attacking brinjal during fruiting stages. *Rev. Agril. Entomol.* **78**(vii): 376-377.

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

Sinha, A. K. and Chandra, D. (1988). Effect of fruits, leaves and flowers of *Luffa aegyptiaca* Mill. (Cucurbitaceae) and *Solanum melongena* L. (Solanaceae) on larval food utilization in *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae). *J. Adv. Zool.* **9**(ii): 123-127.

Srinivas, S., Subbiah, K. R. and Rao, V.R.S. (1991). Effect of chitin inhibitors alone and in combination with carbamate insecticides against the spotted leaf beetle, Epilachna vigintioctopunctata Fab. *Indian J. Entom.* **48**(ii): 200-203.

Srivastava. A. S. and Katiyar, S. S. L. (1972). *Epilachna vigintioctopunctata* F. and *E. dodecastigma* Muls. (Coleoptera: Coccinellidac) as pest on cowpea. *Zeits fur Angewandte Entomol.* **71**(ii): 169-172.

Surjeet, K., Jitender, K., Kumar, S. and Kumar, J. (1996). Baseline data for malathion and endosulfan against hadda beetle *Epilachna vigintioctopunctata* Fab. in H. P. *Himachal, J. Agril. Res.* **22** (i-ii): 51-57.

Surjeet, K., Jitender, K., Kumar, S. and Kumar, J. (1998). Laboratory evaluation of some insecticides against strains of hadda beetle *Epilachna vigintioctopunctata* Fab. resistant to malathion and endosulfan. Pest Manage. *Econ. Zool.* **6** (ii): 133-137.

Tewari, G.C. and Sandana, H.R. 1990. An unusual heavy parasitization of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. by a new braconid parasite. Division of Entomology/Nematology, I.I.H.R., Bangalore, India. *Indian Journal of Entomology*. 1990, 52: 2, 338-341.

Thomas, C. and Jacob, S. (1994). Bio-efficacy of carbofuran against the epilachna beetle, *Henosepilachna vigintioctopunctata* Fab. infesting bitter gourd *(Momordica charantia* L.*)* under field and laboratory conditions. *Indian J. Entomol.* **53**(iii): 435-441.

Tilavov, T. T. (1981). The daily and seasonal feeding rhythm of the adult of the cucumber beetle, *Epilachna chrysomelina* Fab. *Uzbekskei Biologiceskii Zhurnal*. **8**(v): 49-51.

Wolfenbarger, D. and Sleesman, J. P. (1962). Resistance to the Mexican bean beetle in several bean genera and species. *Rev. Appl. Entomol.* Series A. **50** (iii): 675.

Appendices

APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from September 2006 to March 2007

Month	Air temperature (^0C)		R.H. (%)	Total rainfall (mm)
	Maximum	Minimum		
February 07	20.25	18.55	71	22
March 07	22.25	19.30	75	38
Aaril 07	110.20	89.85	80	163
May 07	150.20	110.85	82	185
June 07	320.25	303.55	87	628
July 07	422.25	325.30	90	753
August 07	322.25	219.30	78	538

Source : Dhaka Metrological Center

Appendix II. Results of mechanical and chemical analysis of soil of the experimental plot

Mechanical analysis

Constituents	Percent
Sand	33.45
Silt	60.25
Clay	6.20
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.12
Organic carbon (%)	1.32
Total nitrogen (%)	0.08
Available P (ppm)	20
Exchangeable K (%)	0.2

Source: Soil Resource Development Institute (SRDI)