USE OF SOME CHEMICALS AND NON-CHEMICAL METHODS FOR THE MANAGEMENT OF RED PUMKIN BEETLE, *AULACOPHORA FOVEICOLLIS* (LUCAS) ATTACKING WHITE GOURD.

BY

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A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE
IN
ENTOMOLOGY

SEMESTER: JANUARY-JUNE, 2007

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CERTIFICATE

This is to certify that the thesis entitled, **"Use of some chemicals and non-chemical methods for the management of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) attacking white gourd."** Submitted to the Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in ENTOLOGY embodies the result of a piece of bonafide research work carried out by Md. Asaduzzaman, Registration No. 07-2603 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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Dedicated to
My
Beloved Parents

ACKNOWLEDGEMENT

The author's gratefulness to almighty Allah who enabled him to accomplish this thesis paper.

The author expresses his heartiest respect, deepest sense of gratitude, profound appreciation to my supervisor, Dr. Md. Abdul Latif, Associate professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.

His expresses his heartiest respect and profound appreciation to his co-supervisor, Dr. Mohammed Ali, Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.

He also expresses his sincere respect to the Chairman and all the teachers of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.

Heartiest thanks to Basu Dev Rao who has helped him technical support to prepare this thesis paper. He also thanks all of his roommates and friends to help his study.

Mere diction is not enough to express his profound gratitude and deepest appreciation to his mother, brothers, sisters, and friends for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate him to this level.

December 2008 ***The Author***

USE OF SOME CHEMICALS AND NON-CHEMICAL METHODS FOR THE MANAGEMENT OF RED PUMKIN BEETLE, *AULACOPHORA FOVEICOLLIS* (LUCAS) ATTACKING WHITE GOURD.

THESIS ABSTRACT

BY

MD. ASADUZZAMAN

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period of March to August, 2008 to evaluate the effectiveness of some chemicals and non-chemical methods for the management of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) in white gourd. The experiment comprised of 7 treatments with 3 chemical insecticides (cypermethrin 10EC, chlorpyriphos 20EC, cartap 50SP), 3 non-chemical methods (viz. mosquito net barrier at seedling stage, application of ash, hand collection and destruction of adult beetle) and an untreated control. Among the 3 chemicals, cypermethrin 10EC was found as the most effective insecticide in reducing the beetle population (88.20%) as well as in minimizing the percent leaf area damage (17.08%) and increasing fruit length (23.62%), diameter of fruit (50.75%) and yield (43.20 %) of white gourd. Application of ash at 7 days interval showed superior performance against the beetle among the non-chemical methods. Considering all 7 treatments, application of cypermethrin 10EC was the most effective for the management of red pumpkin beetle followed by application of ash, chlorpyriphos, cartap, hand collection and destruction of adult beetle and mosquito net barrier at seedling stage respectively.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Vegetables are the cheaper source of human nutrition especially vitamins and minerals. People of Bangladesh and other least developed countries are suffering from malnutrition due to lack of sufficient supply of vegetables and fruits. In Bangladesh, the annual production of vegetables is only 4161 thousand tons including potato and sweet potato (Anon. 2006). However, most of the important vegetables are produced in winter, which amount 2214 thousand tons. In summer, only 1947 thousand tons of vegetables are produced (Anon. 2006). Most of the vegetables can not be grown in kharif season due to the adverse climatic condition. Only the cucurbitaceous vegetables can be grown easily in kharif season. Therefore, cucurbitaceous vegetables play an important role to supplement the shortage of vegetables during the lag period (Rashid 1993). White gourd (*Benincasa hispida)* is also an important cucurbit vegetables crop in Bangladesh. It provides large amount of ready cash to the farmers. However, the average yield of white gourd is only 20-23 t ha^{-1} in Bangladesh, which is very low as compared to the world average (Mangal and Singh 2004).

Two species of pumpkin beetle, red pumpkin beetle, *Aulacophora foveicollis* and blue pumpkin beetle, *Aulacophora atripenis*, are common insect pests of white gourd in north-western India, the former being more important. It is widely distributed in Asia, Australia, Southern Europe and Africa. It is a serious pest of cucurbitaceous vegetables specially cucumber, white gourd, water melon, muskmelon and sweet gourd (Razak 2001). Both the adult and the grubs of red pumpkin beetle cause considerable damage to cucurbit plants during all stages of plant development (Atwal 1986). The beetles are very destructive to cucurbitaceous vegetables, particularly during March to April when the creepers are very young. It caused 100% damage of muskmelon seedlings after 10 days of germination and none of these plants reached the 5-true leaf stage (Tariq *et al.* 2005).

The adult also feed flowers and in some cases on young fruits, while the grubs attack the root, under ground stem and leaves closely in touch with soil thereby lowering the yield substantially. The adults feed on both surface of leaves. When the adult feed on the middle of the leaf, they produce a characteristic circular ring like injury. The adult while feeding on flowers feed mainly on petals. They also feed anthers, pollens, stigma and ovary rendering the flowers incapable of fruiting. The beetles also injure fruits, producing characteristic circular bands on the fruits, which help in rotting and subsequent attack of disease of the fruits (Atwal 1986). The pest, however, occurs throughout the year and causes severe damage to the crops especially at seedling stage (Reeta and Johri 2003c).

Current pest control strategy of *A. foveicollis* is based largely on synthetic insecticides of different chemical groups in Bangladesh and elsewhere (Tariq et al. 2006, Lakshmi *et al.* 2005). However, sole reliance on insecticides for control of pests may lead to many well known and serious problem viz., resistance to chemicals in pest populations; resurgence of treated populations; outbreak of secondary pests; residues on food and forage products and legal complications, destruction of beneficial predators, parasites and pollinators; hazards to applicators, domestic animals, fish and wildlife and expense of pesticides, involving recurrent costs for equipment, labour and material. However, farmers of Bangladesh and other countries also use some cultural and mechanical methods such as application of ash, hand collection and destruction of adult beetle, mosquito net barrier around seedlings. Several researchers also used these non-chemical methods for the control of *A. foveicollis* but their efficacy was not unsatisfactory (Rajak and Singh 2002, Das et al. 1999). Although the effectiveness of these non-chemical methods is less than chemical control they are environmentally safe.

In Bangladesh, research reports on the chemical insecticides and non-chemical methods against *A. foveicollis* are limited. Therefore, the present research work was conducted to fulfill the following objectives:

- To determine the efficacy of three chemical insecticides for the management of red pumpkin beetle.
- To evaluate the effectiveness of commonly used non-chemical methods for the control of red pumpkin beetle and
- To know the comparative effectiveness of those chemical insecticides and non-chemical methods for the management of red pumpkin beetle.

Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

Much has been said on the different aspects of the red pumpkin beetle, *Aulacophora foveicollis* (Lucas) at home and abroad. A comprehensive search of literatures reveals very little information about control practices of red pumpkin beetles during cultivation of the cucurbit vegetables. In this chapter, relevant information on the research works on red pumpkin beetle management by botanicals and synthetic insecticides have been cited below:

2.1 General review of red pumpkin beetle

The general review of red pumpkin beetle is described by the following heading

2.1.1 Systematic position

Order: Coleoptera
Family name: Chrysomelidae
Genus: Aulacophora
Scientific name: *Aulacophora foveicollis* (Lucas)

2.1.2 Origin and Distribution

The Deputy collector of Berhampore in Bengal under the colonial British India reported *Aulacophora abdominalis* Fabricius as an insect injurious to leaves and fruits of cucumber vines in 1895 (Anon. 1896). Hutson (1927) has reported that the red pumpkin beetle occurred on various cucurbits in Ceylon. Pawlacos (1940) stated *Raphidopalpa foveicollis* (Lucas) as one of the most important pests of melons in Greece. Manson (1942) reported it to occur in Palestine. Azim (1966) has reported that the red pumpkin beetle, *Aulacophora foveicollis* (Lucas), is a serious pest of cucurbitaceous vegetables, specially cucumber and melons, in then Pakistan, India, Assam, Ceylon, Burmah, Iraq, Persia, Palestine, Greece, Turkey, Israil, and the Mediterranean countries. He has mentioned that the genus

Aulacophora is widely distributed throughout all zoogeographic regions of the world except the Neoarctic and the Neotropical regions. From the insect survey report of the Division of Entomology under East Pakistan (now Bangladesh) Agricultural Research Institute, Dhaka, it was revealed that *A. foveicollis* was a serious pest of cucurbitaceous vegetables in every district of East Pakistan (Azim 1966). Alam (1969) has reported that the red pumpkin beetle, *A. foveicollis* (Lucas), was widely distributed throughout Pakistan, India, Afganistan, Ceylon, Burmah, Indo-china, Iraq, Iran, Persia, Palestine, Greece, Turkey, Israil, South Europe, Algeria, Egypt, Cyprus and the Andaman Island. Butani and Jotwani (1984) reported that the red pumpkin beetle is widely distributed all over the South-East Asia as well as the Mediterranean region towards the West and Australia in the East. In India, it is found in almost all the states, though it is more abundant in the Northern states (Butani and Jotwani 1984). According to York (1992), this insect pest was found in the Mediterranean region, Africa and Asia.

2.1.3 Identification

The beetle is active, brilliant orange red coloured, about 7 mm long and about 2.6 mm broad. The body has a very shining dorsal, smooth surface and its underside is entirely black and covered with short white soft hair like setae. The grub is small yellowish white with a brownish head and when full grown measured about 12 mm in length. Other allied species are orange coloured species *Aulacophora abdominalis* (Fabricius) and blue coloured species, *Aulacophora frontalis* (Baly) (Atwal 1986).

2.1.4 Hosts

Both the adults and the grubs of red pumpkin beetle feed underground stems and the leaves closely in touching with the soil. The insect damages to cucurbit vegetables especially sweet gourd, bottle gourd, bitter gourd, white gourd, cucumber and melons. The beetles feed on the leaves, flower and in some cases on fruits while the grubs attack the roots, prefer feeding on seedlings. Incase of heavy infestation all leaves of the young plant are eaten up except leaf veins and subsequently the seedlings die (Atwal 1986).

Tariq et al. (2005) reported that the host preference of red pumpkin beetle, *A. foveicollis* (Lucas) was distributed among watermelon (*Citrullus lanatus)*, long melon (*Cucumis melo)*, cucumber (*Cucumis sativus*), red gourd (*Cucurbita moschata*), bottle gourd (*Lagenaria siceraria*) and musk melon (*C. melo*), sponge gourd (*Luffa acutagula*). Long melon and muskmelon showed 100% damage after 10 days of germination and none of these plants reached the 5-true leaf stage.

Reeta and Johri (2003a) stated that *A. foveicollis* (Lucas) adult showed poor feeding response on ridge gourd (*Luffa acutangula*) and sponge gourd (*L. cylindrical*) when leaf disc were offered separately and alternately with the standard plant (bitter gourd: *Momordica charantia*). Adults showed a higher preference index that is 2.53, 2.45, 1.05 and 1.03 on pumpkin (*Cucurbita maxima*), bottle gourd (*Lagenaria siceraria*), cucumber and muskmelon (*C. melo*), respectively. Adults did not show feeding response towards the standard plant.

Vandana *et al.* (2001) studied the host preference of *R. foveicollis* (*A. foveicollis*) using 8 plants: *Benincasa hispida*, *Lagenaria siceraria*, *Momordica charantia*, cucumber, *Cucurbita maxima*, water melon, (*C. vulgaris*), *L. acutangula*, and sweet potato. In multiple choice tests, (*C. maxima)* was the most preferred by the pest. In no choice test, significant leaf damage was observed in water melon, cucumber and *L. siceraria*. No feeding was observed in *M. charantia.*

Rajak (2001) conducted an experiment to determine the host range and food preference of *A. foveicollis*. The host crops evaluated included 11 cucurbitaceous and 12 other crops viz. pumpkin (*C. moschata*), cucumber, bottle gourd (*L. aegyptica*), ash gourd (*Benincasa hispida*), ridge gourd (*L. acutangula*), snake gourd (*Trichosanthes anguina*), pointed gourd (*Trichosanthes dioica)*, bitter gourd (*M. charantia*), aubergine, potato, tomato, pea, cowpea, berseem (*Trifolium alexandrinum*), chickpeas (*Cicer arietinum*), Indian mustard, cauliflower, maize, oat and sweet potato. Out of 23 crops red pumpkin beetle was observed only in 11 crops viz. pumpkin, cucumber, bottle gourd, water melon, ridge gourd, snake gourd, pointed gourd and berseem. The most preferred host was musk melon. The least preferred host was snake gourd, while bitter gourd was not preferred.

Singh et al. (2000) studied the host preferences of red pumpkin beetle, *A. foveicollis* and melon fruit fly, *Dacus cucurbitae* using different cucurbits during the summer of 1997 in India. Observations on the density of red pumpkin beetles per leaf and percentage infestation on the vines, leaves and flowers of cucurbits were made every morning. They stated the host preferences of red pumpkin beetle and bitter gourd ranked (*M. charantia*) as medium in preference, round gourd *(C. lanatus*) and long melon (*Cucumis utilissiums*) as highly preferred and watermelon as the favourite host. However, percentage damage was significantly highest on bitter gourd (31.27%) and watermelon (28.55%).

Sharma et al. (1999) studies on the host preferences of *R. foveicollis (A. foveicollis)* revealed that musk melon was the most preferred host with 43.6 beetles per plot, while bitter gourd (*M. charantia)* was the least preferred with 1.6 beetles per plot. Plant damage was also highest on musk melon (15.32%), while bitter gourd was free of any damage.

Das and Ishaque (1998) counted the infestation of *A. foveicollis* and the food plants were bottle gourd (*L. siceraria*), cucumber (*C. sativus*), watermelon (*Citrullus lanatus*), ridge gourd (*L. acutangula*), pointed gourd (*T. dioica*) and ash gourd (*B. hispida*). Infestation varied from 3-20% during different periods of the year. Other food plants, namely; sweet potato (*Ipomea batatus*) and green grain (*Vigna radiate*), were collateral hosts.

Dhillon (1993) reported that purified cucurbitacin B and E act as feeding stimulants for the red pumpkin beetle, but on testing three pairs of isogenic bitter and non-bitter lines of cucumber (*C. Sativus)* no relationship was found between the bitter gene and the degree of damage caused by this beetle. In summer squash (*Cucurbita pepo*), both resistant and susceptible lines contain cucurbitacin at the susceptible plant growth stage (cotyledon) but there was no correlation between the quantity of totals phenols, free amino acids or reducing sugars in this material at the resistance plant growth stage. Bitter gourd (*M. charantia*), which has cucurbitacin in the cotyledons, was not preferred by the beetle.

Metha and Sandhu (1989) conducted laboratory experiments with 10 cucurbit vegetables as food plants for *A. foveicollis*, bitter gourd (*M. charantia*) was highly resistant to the chrysomelid, and sponge gourd (*L. acutangula*) and bottle gourd (*L. siceraria*) were resistant. Cucumber, musk melon and water melon were moderate and round melon and wink melon were susceptible to cucurbits.

2.1.5 Biology

Reeta and Johri (2003c) observed that incubation, larval and pupal periods of red pumpkin beetle *A. foveicollis* on various species of cucurbit plants were lowest during pre-monsoon (7.00, 11.00 and 7.94 days) followed by monsoon (10.00, 13.00 and 9.26 days) and post monsoon (15.00, 14.74 and 15.02 days) periods. Adult emergence percentage was highest in pre-monsoon (80%) followed by monsoon (74.40%) and post-monsoon (62.75%) periods. The seasonal abundance of beetle on cucurbit plants revealed that the peak infestation and the least infestation were in the month of July and February when relative humidity ranged at 70.55% to 60.60% respectively.

Reeta and Johri (2003b) conducted an experiment and stated that maximum growth index of *A. foveicollis* was obtained on pumpkin (*C. maxima*) followed by cucumber (*C. sativus*), melon (*C. melo*), water melon, bottle gourd (*L. siceraria*). The lowest growth index was obtained on sponge gourd (*L. cylindrica*) and ridge gourd (*L. acutangula*). The development of the pest could not be completed on bitter gourd (*M. charantia*).

In a laboratory study, Das and Isahaque (1998a) reported that the oviposition period of red pumpkin beetle varied from 10 to 15 days. Eggs were laid singly in batches of 34 to 75. Fecundity ranged from 90 to 200 eggs. Eggs incubation period, larval period, pre-pupal and pupal periods were 11.40-12.10, 18.90-20.60, 4.80-5.20 and 12.10-13.90 days, respectively. The longevity of adults varied from 45 to 55 days.

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Dwivedi et al. (1994) observed the effect of different food plants on growth and development of *A. foveicollis*. On *M. charantia*, larvae died within 2 days of hatching. On *L. acutangula* and *L. aegyptiaca*, all the chrysomelids died before pupation. The life cycle was completed successfully on *L. cylindrical*, *C. pepo* and *Cucumis utilissimus* in order of suitability. The beetle had the highest number of viable eggs and the shortest development period at 30^0C and 70% relative humidity (Chaudry and Khan 1990).

In a laboratory study, Roy and Pande (1991) found that the most favorable temperature for development and survival of red pumpkin beetle was 27.5^0C $days^{-1}$ and egg, larval and pupal stages lasted 8.3-15.8, 12.6-18.1 and 10.0-15.2 days respectively. The life cycle from egg to adult emergence varied from 27 to 56 days and there were 6-8 overlapping generations in a year.

Alam (1969) stated that the adult male of red pumpkin beetle measured 5.5 mm to 6.75 mm in length with an average of 6.25 mm. The breadth average 2.45 mm. The adult female was slightly larger than the male and was 6.25 to 8.25 mm in length with an average of 6.75 mm. The breadth averages 3.01 mm. Oviposition period extended over a period from 9 to 99 days; fecundity ranged from 27 to 293 eggs. The pre-oviposition and incubation periods were 19-45 and 8-13 days, respectively. The larval period varied from 15 to 18 days. The pupa was on an average of 5.33 mm in length and 2.96 mm in breadth. The pupal period was from 10 to 14 days the total life cycle took 32 to 47 days.

2.1.6 Nature of damage

The red pumpkin beetles feed primarily on leaves and flowers of cucurbits and occasionally on fruits and stems. Adults eat on both the surface of leaves when the adults feed on the middle of the leaf they produce a characteristics circular ring like injury. Sometimes feeding causes irregular injuries resulting in the skeletonization of leaves. The insect also attacks along the leaf margin and proceeds inward. Heavily infested plants dry up and die. The adults while feeding on flowers feed mainly on petals, but they also attack anthers, pollens, stigmas and ovary rendering the flowers incapable of fruiting. The grubs attack the root and under ground stem. They feed on the roots and sometimes actually bore into them. They also feed on the shed leaves on the ground. During early instars, the grubs eat on the ventral side of the leaves, closely in touch with the soil and skeletonize them (Atwal 1986).

2.2 Management practices

Tariq *et al.* (2006) stated that eight insecticidal and non insecticidal treatments including control were tested against red pumpkin beetle, *A. foveicollis* (Lucas) on cucumber at National Agricultural Research Centre, Islamabad. All insecticidal treatments were very effective in avoiding complete plants mortality by red pumpkin beetle. Carbaryl dust + dung ash at 0.1:10 (a.i.) was in reducing insecticidal use and also equally effective as rest of insecticides. However, 3 to 4 leaf stage cucumber plants when transplanted were equally effective in avoiding complete plant mortality. Dung ash application alone did not prove to be an effective method for avoiding red pumpkin beetle attack. Carbofuran and carbaryl dust were more effective in killing the red pumpkin beetle adults, which were found dead near plants.

Lakshmi *et al.* (2005) evaluated some eco-friendly pesticides for the management of red pumpkin beetle, *A. foveicollis* on pumpkin plant in Bapatla, Andhra pradesh, India. The treatments comprised carbaryl at 0.2%, monocrotophos at 0.54%, chlorpyriphos [chlorpyrifos] at 0.54% nimbecidine (*Azadirachta indica*) formulation at 0.2%. *Bacillus thurigiensis* at 0.20%, thiodicarb at 0.075%, Bt at 0.1% + thiodicarb at 0.0375%, nimbecidine + thiodicarb, spinosed at 0.015% and an untreated control. Carbaryl (46.53%) was the most effective in reducing the beetle population as well as in reducing the leaf damage (10.61%) and increasing the yields of pumpkin (13.14 g ha^{-1}). This was followed by monocrotophos (39.93%), chloropyriphos (35.02%) and nimbecidine (28.66%).

Sabri and Tariq (2004) tasted the toxicity of advantage 20EC [carbosulfan], Match 50 EC [difenzoquat], Tracer 240 SC and deltaphos-R 10+350EC on the haemocytes of red pumpkin beetle, *A. fovoicollis*. Five types of haemocytes were identified. i.e. prohamocytes, plasmatocytes, oenocytoids, granulocytes and coagulocytes, in the haemolymph of *A. foveicollis*. The total haemocyte count was 4372 cells m^{-3} on average, in the haemolymph. The major abnormalities observed in the haemocytes after insecticide application were distortion of the shape of blood cells, abnormal staining of the cells, enlargement, denucleation, rupturing of the cells, and rupturing of the wall of the cytoplasm.

Pandey *et al.* (2003) conducted an experiment in Bihar, India to study the comparative effect of synthetic pyrethroid insecticide and chloropyriphos insecticide to control red pumpkin beetle and common house hold borer in bottle gourd. It was observed that both insecticides were effective but synthetic pyrethroid insecticide was more effective than chloropyriphos insecticide; pyrethroid insecticide controlled 76% red pumpkin beetle and common house hold borer where chloropyriphos insecticide controlled 60%. As a result of decreased leaf infestation and adult insect and number of infested fruit was also decreased more effectively with the use of synthetic pyrethroid insecticide than chloropyriphos insecticide. Significantly higher qualitative fruit yield was also obtained by using pyrethroid insecticide.

Rajak and Singh (2002) conducted an experiment in Uttar Pradesh, India on melon cv. NDM-2 to determine the efficacy of insecticides, plant leaf powder and dung ash against the red pumpkin beetle *A. foveicollis*. All the insecticidal treatments were significantly superior over the control except plant leaf powder and cow dung ash, Dung ash + kerosene and dung ash alone proved effective only up to 3 days. Among the plant leaf powders, neem (*Azadirachta indica*) was the most effective followed by bakayen (*Melia azadirach*).

Das *et al.* (1999) studied that the efficacy of some plant products for the control of *A. foveicollis* on pumpkin was studied in Jorhat, India. The leaf extracts of *Polygonum hydropiper*, *Eupatorium odoratum*, *Chromolaena odorata* and *Azadirachta indica* were compared with wood ash and malathion 50 EC (0.1 %). Malathion 50 EC was the most effective treatment followed by *Azadirachta indica*, *P. hydropiper* and wood ash. *C. odorata* was the least effective treatment.

Borah (1998) studied on various insecticidal schedules against *Bactrocera cucurbitae* and *A. foveicollis* on pumpkin in Assam. The most effective treatment in terms of lowest pest incidence and highest yield was carbofuran at 1.5 kg a.i. ha^{-1} applied 15 days after germination.

Borah (1997) conducted a field study to observe the effect of insecticides on pest incidence in cucumber. Deltamethrin, cypeimethrin and fenvalerate gave acceptable levels of control of *A. foveicollis* and *Bactrocera cucurbitae* infesting cucumbers.

Thapa and Neupane (1992) conducted a field study to evaluate the efficacy of various insecticides for the control of *A. foveicollis* on watermelon seedlings. Deltamethrin, cypermethrin and fenvalerate were effective in controlling the chrysomelid for about one week. Soaking the seeds of watermelon in carbofuran was only effective for two days after germination; but its application as a soil treatment was effective against *A. foveicollis* for about 3 weeks.

During conducting a field experiment against *A. foveicollis* on melons, five insecticides were applied at 0.1, 0.5 and 1% 3 times at intervals of 15 days, and the numbers of beetles per plant were counted. Cypergard (a mixture of cypermethrin and dimethoate) was the most effective followed by cropgard (a mixture of cypermethrin with cytrolane [mephosfolan]), Sunmerin (cypermethrin), Mavrik (fluvalinate) and stinger (dimethoate) (Khan and Khattak 1992).

Bajwa and Mavi (1981) carried out a field study to evaluate the effectiveness of several granular insecticides against *Aulacophora foveicollis* (Lucas) on muskmelon. The compounds (aldicarb, carbaryl, carbofuran, phorate and quinalphos) were applied as side-dressings two weeks after sowing at the rate of 0.5 and 1.0 kg ha^{-1}. On the basis of numbers of beetles per treated plant, carbofuran at both rates was found to be most effective against the pest followed by mephosfolan at both rates, carbaryl at 1 kg ha^{-1} and quinalphos at 1 kg ha^{-1}. The remaining treatments were considerably less effective.

Chapter III

Materials and Methods

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during March to August, 2008. The brief description on experimental site, climate and soil, experimental design, crop production, data collection and their analyses is given below under the following headings:

3.1 Location of the study

3.1.1 Geographical Location

The experimental area is situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level (Anon. 2004).

3.1.2 Agro Ecological Region

The experimental field belongs to the Agro Ecological Zone of "The Modhupur Tract", AEZ-28 (Anon. 1988). This is a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon. 1988). The experimental site is shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period is presented in Appendix II.

3.2 Characteristics of soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series (FAO 1988). Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.1-6.3 and had organic matter 1.29%. The experimental area is flat having available irrigation and drainage system and above flood level. The physicochemical properties of the soil are presented in Appendix III.

3.3 Land preparation

The experimental field was well prepared thoroughly followed by 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 cowdung (decomposed). Raised plots of 3m×2m in size were prepared accommodating 2 pits plot^{-1} and pit to pit distance was 2m.

3.4 Manuring and fertilization

The following dose of manures and fertilizers were applied in the pit preparation as per recommendation (Rashid 1999).

Fertilizer	Dose
Cowdung	10 t ha^{-1}
Urea	200 kg ha^{-1}
TSP	200 kg ha^{-1}
MP	150 kg ha^{-1}
ZnO	8 kg ha^{-1}
Zypsum	80 kg ha^{-1}
Ash	5 kg ha^{-1}

3.5 Planting material

The seed of white gourd variety BARI chal kumra-1 was collected from Horticultural Research Centre (HRC) of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.6 Experimental Design

The experiment was laid out in Randomized Completely Block Design (RCBD) with 3 replications. The size of each plot was 3m×2m. The total number of plots was 21 and pit to pit distance was 2m.

3.7.1 Details of the treatments

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.

T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.

T_3= Application of cartap 50SP (Suntap 50SP) @ 1·0 g L^{-1} at 7 days intervals.

T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.

T_5= Hand collection and destruction of adult beetle.

T_6= Application of ash at 7 days intervals.

T_7= Untreated control.

3.8 Sowing of seed

Ten seeds were sown in the pit at 19th March, 2008. Before sowing germination test were done, the germination percentages were ranges from 90-95% approximately.

3.9 Intercultural operation

3.9.1 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 subsequent weeding were done at an interval of 15 days to keep the plot free from weeds.

3.9.2 Thinning

Excess seedlings of white gourd plant were removed from the pit after 15 days of seed germination. Only two times thinning were performed.

3.9.3 Irrigation

After seed sowing light irrigation was given to each pit $plot^{-1}$. Supplementary irrigation was applied at interval of 2-3 days. Stagnant water was effectively drained out at the time of over irrigation and rainfall.

3.10.1 Insecticide application

The insecticides were applied with the help of a knapsack sprayer. The first application of insecticides was applied after 1^{st} week of the seedling emergence and subsequent application in each treatment were made at seven days intervals. Precautions were taken to avoid drift to the adjacent plots.

3.10.2 Mosquito net barrier

It is the equipment used for controlling red pumpkin beetle. This technique was used starting from emergence and continued up to 40 days under the present study.

3.10.3 Hand collection and destruction of adult beetle

It is an effective indigenous technique used for controlling red pumpkin beetle. This technique was done at all stages during the experiment under the present study.

3.10.4 Application of ash

This technique was introduced a long time ago in our country and it is continued till today. Application of ash was done at 7 days interval during the experimental period under the present study.

3.11 Data collection

Data were collected on the following parameters.

3.11.1 Vine length

Vine length of each plant was measured at 5, 10 and 12 weeks after emergence and then the mean vine length was calculated.

3.11.2 Number of leaf plant^{-1}

The total number of leaves plant^{-1} was counted at two days after emergence. It was continued up to five weeks after emergence and then averaged.

3.11.3 Number of infested leaf plant^{-1}

The total number of infested leaves plant^{-1} by *A. foveicollis* was counted at two days after emergence. It was continued up to five weeks after emergence and then averaged.

3.11.4 Number of adult beetle plant^{-1}

Number of adult beetle plant^{-1} was counted after emergence of seedlings.

3.11.5 Number of primary or secondary branches plant^{-1}

The total number of primary or secondary branches plant^{-1} was counted from 5th week after emergence and continued up to after emergence of the number of primary or secondary branches at the end of the cropping season. The data were pooled over and average to obtain mean value.

3.11.6 Number of fruit plant^{-1}

Harvesting was done when the fruits were matured. The total number of fruits plant^{-1}was counted separately and it was continued up to last harvest.

3.11.7 Fruit weight

After each harvest, the weight of the fruit was recorded separately. After final harvest and then yield was calculated t ha^{-1}.

3.11.8 Fruit length and diameter

The length and diameter of the fruits were measured after each harvest and continued until the end of the cropping season. The data were pooled over and then averaged to obtain the mean value of length and diameter of the fruits.

3.11.9 Assessment of treatment effects

The performance of each treatment was judge by the reduction of the insect population densities in the treated plot and it was further continued by the comparison of yield contributing characters such as number of fruits plant^{-1}, weight of individual fruit, fruit diameter and length and yield obtained in each case at the end of the cropping cycle.

3.11.10 Percent infestation of leaves

The infested leaves were calculated by the following formula:

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

3.11.11 Percent reduction of population

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

% reduction of pests

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

3.11.12 Yield per hectare

The total yield of white gourd t ha^{-1} for each treatment was calculated from cumulative production in a plot. Effect of different treatments on the increase and decrease of white gourd yield over control was calculated incase of red pumpkin beetle

% increase or decrease of yield over control

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

3.12 Statistical analysis

The data collected on different parameters were statistically analyzed using the MSTAT-C computer package program. Mean values were ranked by Duncan's Multiple Range Test, DMRT at 5% level of significance and it was used to compare the mean differences among the treatments (Gomez and Gomez 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The results of the experiments on the use of some chemicals and non chemical methods for the management of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) attacking white gourd are presented under different subheadings. The results have been interpreted, elaborated and discussed in the light of result and as well on that of the relevant available research report.

4.1 Effect of different treatments on leaf infestation

The leaf infestation was occurred against different treatments by the following headings

4.1.1 Number of leaves plant^{-1}at seedling stage

The number of leaves plant^{-1} at seedling stage was significantly varied in different treatments against *A. foveicollis* attack. The Table 1 expressed that the highest number of leaves (22.45 plant^{-1}) was found in the treatment T_1, which was statistically identical with T_2 (21.45 plant^{-1}) and T_3 (21.22 plant^{-1}) but significantly different from other treatments. On the other hand the lowest number of leaves (16.17 plant^{-1}) was observed in untreated control (T_7), which was significantly lower than other treatments. Although the number of leaves plant^{-1} was varied in T_2 (21.45 plant^{-1}) and T_3 (21.22 plant^{-1}) however, no significant differences were observed among these treatments regarding this parameter.

4.1.2 Number of infested leaves plant^{-1} at seedling stage

The result (Table 1) demonstrated that the lowest number of infested leaves (1.40 plant^{-1}) was found in the treatment T_1, which was significantly different from other treatments. On the other hand the highest number of infested leaves (4.68 plant^{-1}) was observed in untreated control (T_7), which was significantly different from other treatments. No significant difference was found in T_2 (2.00 plant^{-1}) and T_6 (2.02 plant^{-1}), considering the number of infested leaves plant^{-1}.

4.1.3 Percent leaf infestation

The percent leaf infestation at seedling stage was significantly varied in different treatments against *A. foveicollis* attack. The data (Table 1) also expressed that the lowest percent of leaf infestation (6.25%) was observed in the T_1, which was significantly different from other treatments. On the other hand the highest percent of leaf infestation (28.97%) was observed in untreated control (T_7), which was significantly higher than other treatments.

4.1.4 Percent leaf area damage

The results (Table 1) illustrated that the lowest percent of leaf area damage (17.08%) was in the treatment T_1, which was significantly different from other treatments but in the treatment, T_5 (25.24%), T_2 (22.38%), T_6 (26.82%) and T_3 (26.65%) showed lower percent leaf area damage compared with (T_1). On the other hand the highest percent leaf area damage (65.38%) was observed in untreated control (T_7), which was significantly different from other treatments but the treatment, T_4 (38.68%) showed higher percent leaf area damage compared with (T_7).

4.1.5 Percent increase of leaf area over control

Application of different treatments significantly increased the leaf area plant^{-1}. However, the best result was found in T_1 (Figure 1), which increased (73.87%) leaf area plant^{-1} over control against *A. foveicollis* attack. On the other hand the lowest result (40.85%) was found in (T_4), which was significantly lower than other treatment.

4.1.6 Percent reduction of leaf area damage over control

Figure 1 also illustrated that cypermethrin (T_1) decreased maximum (70.04%) of leaf area damage over control against *A. foveicollis* infestation. On the other hand the lowest result (28.74%) was found in (T_4), which was significantly lower than other treatment.

Table 1. Number of total and infested leaves plant^{-1} at seedling stage in different treatments against red pumpkin beetle.

Treatments	Number of leaves plant^{-1} at seedling stage	Number of infested leaves plant^{-1} at seedling stage	Percent leaf infestation at seedling stage	Percent leaf area damage
T_1	22.45 a	1.40 e	6.25 e	17.08 f
T_2	21.45 ab	2.00 d	9.34 d	22.38 e
T_3	21.22 ab	2.64 c	12.46 c	26.65 c
T_4	19.00 c	3.34 b	17.56 b	38.68 b
T_5	20.47 bc	3.34 b	16.30 b	25.24 d
T_6	20.85 b	2.02 d	9.67 d	26.82 c
T_7	16.17 d	4.68 a	28.97 a	65.38 a
CD (0.05)	1.06	0.59	1.90	0.97
CV (%)	7.39	9.03	7.64	6.73

In a column, means having similar letter (s) are statistically identical at 5% level of significance by DMRT.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1.0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

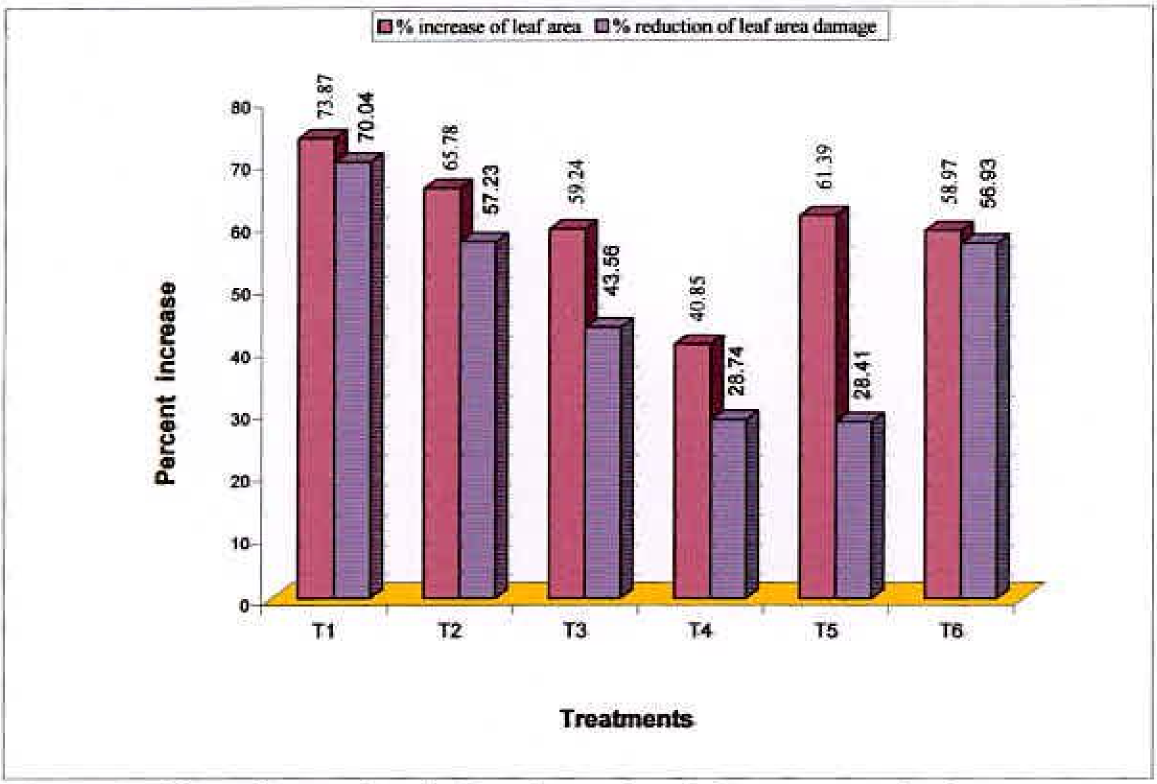

Figure 1.Effect of some chemicals and non chemicals on percent leaf area for the management of red pumpkin beetle ($LSD_{0.05}$= 0.511 and 1.078 respectively).

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1.0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

The above result clearly indicated that cypermethrin showed the least effectiveness against *A. foveicollis* infestation on white gourd leaves. Spraying of cartap and application of ash at 7 days interval were equally effective in avoiding leaf infestation. These results agree with the findings of Pandey et al. (2003), who reported that synthetic pyrethroid was more effective than chloropyriphos against *A. foveicollis.*

4.2 Effect of different treatments on *A. foveicollis* population

The results showed that the lowest number of adult insect (0.57 plant^{-1}) was found in the treatment T_1 (Table 2), which was significantly different from other treatments. On the other hand the highest number of adult insect (4.83 plant^{-1}) was observed in untreated control, (T_7) which was statistically identical with T_4 (3.34 plant^{-1}) but significantly different from other treatments. Although the number of adult insect plant^{-1} was varied in T_2 (0.93 plant^{-1}) and T_3 (0.79 plant^{-1}), no significant difference was observed among these treatments regarding this parameter.

Similarly cypermethrin (T_1) showed the best efficacy against *A. foveicollis* by reducing 88.20% population over control. Chloropyriphos (T_2) and cartap (T_3) also reduced more than 80% population over control. None of the non-chemical methods were effective as chemicals in reducing population of *A. foveicollis* in white gourd. However, application of ash (T_6) and hand collection and destruction of adult beetles (T_5) reduced more than 60% population of *A. foveicollis* in white gourd.

The results of the present study agree with the findings of Rajak and Singh (2002), who reported that insecticidal treatments were superior to non-chemical control and dung ash was effective up to 3 days of application.

Table 2. Number of adult *A. foveicollis* plant^{-1} and percent decrease of population under different treatments.

Treatments	Number of adult insect plant^{-1}	Percent reduction of insect population over control
T_1	0.57 c	88.20 a
T_2	0.93 c	80.69 c
T_3	0.79 c	83.59 b
T_4	3.34 a	30.83 f
T_5	1.64 b	66.13 d
T_6	1.83 b	62.07 e
T_7	4.83 a	--
CD (0.05)	1.38	1.55
CV (%)	10.83	8.24

In a column, means having similar letter (s) are statistically identical at 5% level of probability by DMRT.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1.0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

4.3 Growth characters of plant

4.3.1 Length of vine

The vine length of plant was significantly varied in different treatments against *A. foveicollis* attack. The Table 3 illustrated that the highest vine length (412.10 cm) was found in the treatment T_1, which was significantly different from other treatments. Among the non-chemical methods, higher vine length (301.90 cm) was found in T_6, which was significantly lower than chemical control. On the other hand the lowest vine length of plant (212.20 cm) was observed in untreated control, (T_7) which was significantly different from other treatments.

The data (Table 3) also revealed that application of cypermethrin (T_1) showed the best efficacy against *A. foveicollis* attack and increased 94.16% length of the vine compared to control. Application of ash (T_6) was more effective than other non-chemical methods, which increased 42.27% length of the vine.

4.3.2 Number of flowers plant^{-1}

The Table 4 demonstrated that the highest number of flowers (19.92 plant^{-1}) was obtained in the treatment T_1, which was significantly different from other treatments but in the treatment. On the other hand the lowest number of flowers (5.33 plant^{-1}) was observed in untreated control (T_7), which was significantly different from other treatments. No significant difference was observed in T_4 (7.25 plant^{-1}), T_6 (7.25 plant^{-1}) and T_3 (7.38 plant^{-1}). Regarding this parameter, similarly, cypermethrin increased the highest percent of flowers (273.50%) plant^{-1}, which was significantly different from other treatments. Among the non-chemical methods, hand collection and destruction of adult beetle (T_5) gave the best efficacy by increasing 54.70% flowers plant^{-1} compared to control. Other treatments also increased the number of flowers plant^{-1} compared to control.

Table 3. Length of the vine of white gourd and percent increase of length of vine under different treatments.

Treatments	Vine length (cm)	Percent increase of vine length over control
T_1	412.10 a	94.16 a
T_2	343.60 b	61.92 b
T_3	311.20 c	45.94 c
T_4	224.40 f	5.75 f
T_5	254.00 e	19.65 e
T_6	301.90 d	42.27 d
T_7	212.20 g	--
CD (0.05)	1.05	1.55
CV (%)	6.20	5.89

In a column, means having similar letter (s) are statistically identical at 5% level of significance by DMRT.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1.0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

Table 4. Number of flowers plant^{-1}and percent increase flowers plant^{-1} over control under different treatments.

Treatments	Number of flowers plant^{-1}	Percent increase of flower over control
T_1	19.92 a	273.50 a
T_2	13.33 b	250.00 b
T_3	7.38 d	38.33 d
T_4	7.25 d	35.95 d
T_5	8.25 c	54.70 c
T_6	7.25 d	35.95 d
T_7	5.33 e	--
CD (0.05)	0.56	13.29
CV (%)	3.21	6.82

In a column, means having similar letter (s) are statistically identical at 5% level of significance by DMRT.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1·0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

4.4 Effect of yield contributing characters and yield of white gourd against *A. foveicollis* infestation.

4.4.1 Number of fruits plant^{-1}

The highest number of fruits (3.09 plant^{-1}) was found in the treatment T_1 (Table 5), which was significantly different from other treatments. On the other hand the lowest number of fruits (1.21 plant^{-1}) was observed in untreated control (T_7) which was statistically identical with T_4 (1.75 plant^{-1}) but significantly different from other treatments. Although the number of fruits was varied in T_3 (2.42 plant^{-1}), T_6 (2.38 plant^{-1}), T_2 (2.34 plant^{-1}) and T_5 (2.17 plant^{-1}), no significant difference was observed among these treatments regarding this parameter. Application of different treatments significantly increased the number of plant^{-1}. However, the best result was found in T_1 (Figure 2), which increased (155.10%) fruits plant^{-1} over untreated control against *A. foveicollis* attack. On the other hand the lowest result (44.88%) was found in (T_4), which was significantly lower than other treatment.

4.4.2 Length of fruit

The highest length of fruits plant^{-1} (19.27 cm) was found in T_1 (Table 5) which was statistically identical with T_2 (18.36 cm), T_6 (18.07 cm) and T_3 (18.09 cm) but significantly different from other treatments. On the other hand the lowest length of fruits plant^{-1} (15.59 cm) was observed in untreated control, (T_7) which was significantly different from others. Although the length of fruits plant^{-1} was varied in T_2 (18.36 cm), T_6 (18.07 cm) and T_3 (18.09 cm), however, no significant difference was observed among these treatments regarding this parameter. Application of different treatments significantly increased the length of fruits plant^{-1}. However, the best result was found in T_1 (Figure 3), which increased (23.62%) length of fruits plant^{-1} over untreated control against *A. foveicollis* attack. On the other hand the lowest result (12.64%) was found in (T_4), which was significantly lower than other treatment.

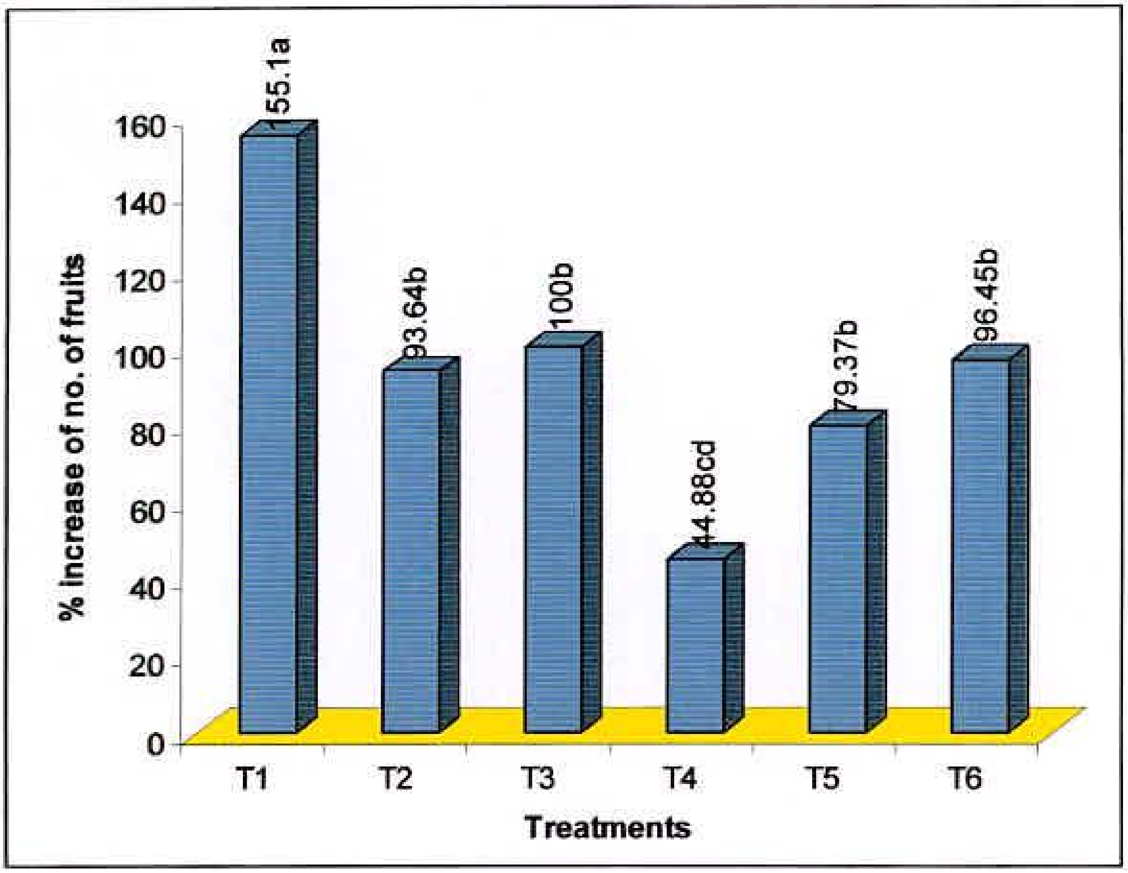

Figure 2. Effect of some chemicals and non chemicals on percent increase of fruits plant^{-1} for the management of red pumpkin beetle.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1.0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

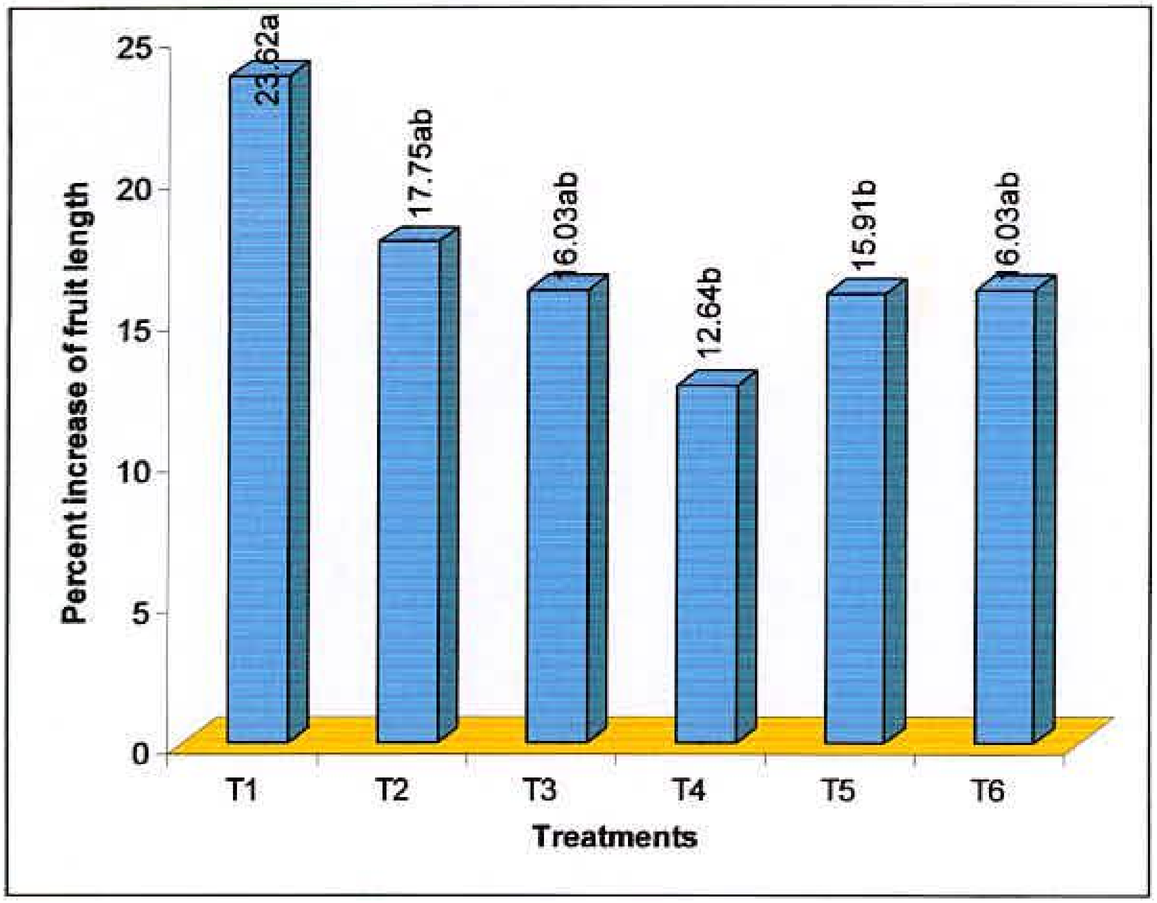

Figure 3. Effect of some chemicals and non chemicals on percent increase of fruits length for the management of red pumpkin beetle.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1.0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

4.4.3 Diameter of fruit

The highest diameter of fruits plant^{-1} (39.68 cm) was in the treatment T_1 (Table 5) which was significantly different from other treatments. On the other hand the lowest diameter of fruits plant^{-1} (26.32 cm) was observed in untreated control, (T_7) which was significantly different from other treatments. Although the diameter of fruits plant^{-1} was varied in T_5 (35.69 cm), T_2 (36.67 cm) and T_6 (35.85 cm), however, no significant difference was observed among these treatments regarding this parameter. Application of different treatments significantly increased the diameter of fruit plant^{-1}. However, the best result was found in T_1 (Figure 4), which increased (50.75%) diameter of fruits plant^{-1} over untreated control against *Aulacophora foveicollis* attack. On the other hand the lowest result (7.69%) was found in (T_4), which was significantly lower than other treatment.

4.4.4 Weight of fruit

The highest weight of fruits (1.82 kg) was recorded in the treatment $T_{1,}$ which was significantly different from other treatments (Table 6). On the other hand the lowest weight of fruits (1.28 kg) was observed in untreated control (T_7) which was statistically identical with T_4 (1.29 kg) but significantly different from other treatment. Although the number of fruits was varied in T_2 (1.56 kg), T_6 (1.61 kg), T_3 (1.50 kg) and T_5 (1.37 kg), no significant difference was observed among these treatments regarding this parameter.

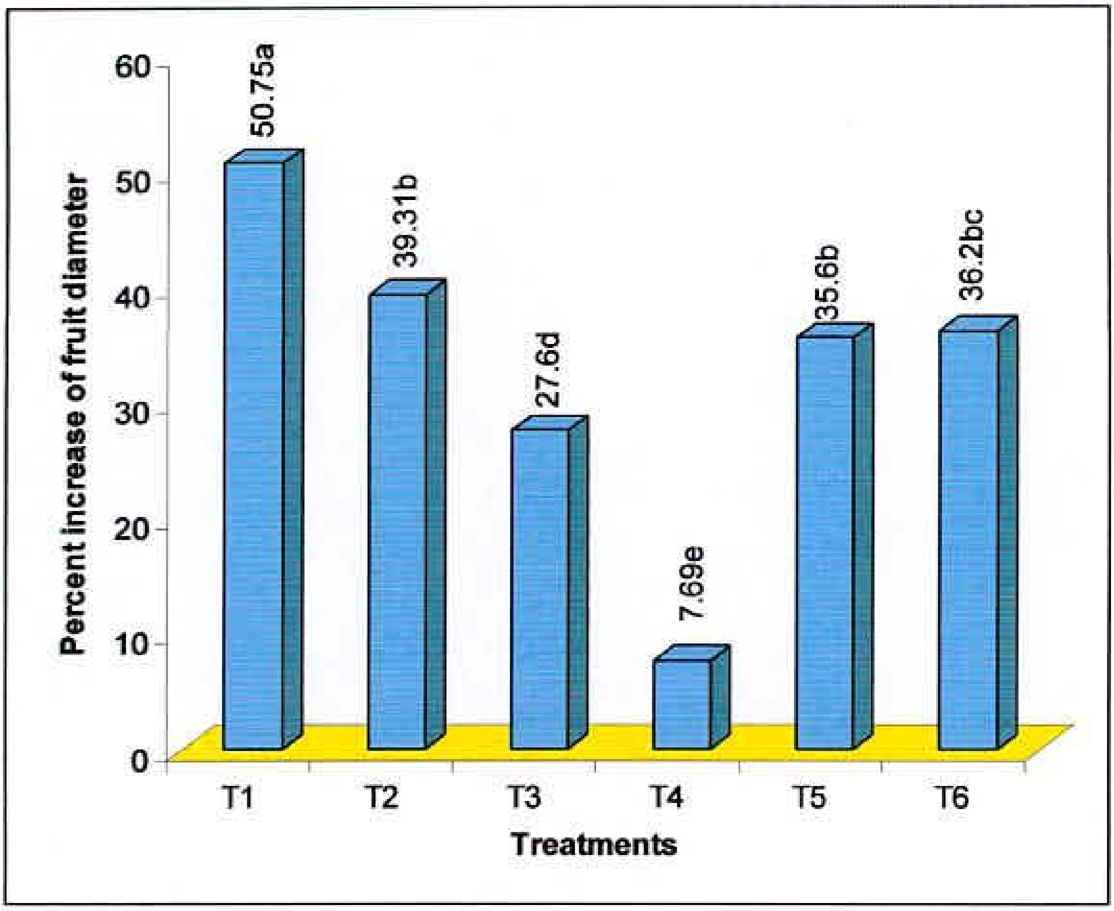

Figure 4. Effect of some chemicals and non chemicals on percent increase of fruits diameter for the management of red pumpkin beetle.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1·0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

Table 5. Number of fruit plant^{-1}, fruit length and fruit diameter in different treatments against red pumpkin beetle attacking white gourd.

Treatments	Number of fruits plant^{-1}	Length of fruit (cm)	Diameter of fruit (cm)
T_1	3.09 a	19.27 a	39.68 a
T_2	2.34 b	18.36 ab	36.67 b
T_3	2.42 b	18.09 ab	33.59 d
T_4	1.75 cd	17.56 b	28.35 e
T_5	2.17 b	17.66 b	35.69 b
T_6	2.38 b	18.07 ab	35.85 bc
T_7	1.21 d	15.59 c	26.32 f
CD (0.05)	0.51	0.53	0.92
CV (%)	7.97	7.22	8.21

In a column, means having similar letter (s) are statistically identical at 5% level of significance by DMRT.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.
T_3= Application of cartap 50SP (Suntap 50SP) @ 1·0 g L^{-1} at 7 days intervals.
T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.
T_5= Hand collection and destruction of adult beetle.
T_6= Application of ash at 7 days intervals.
T_7= Untreated control.

4.4.5 Yield (t ha^{-1})

The data (Table 6) expressed that the highest yield (30.41 t ha^{-1}) was in the treatment T_1 which was significantly different from other treatment. On the other hand the lowest yield (21.23 t ha^{-1}) was observed in untreated control, (T_7) which was not significantly different from T_4 (21.48 t ha^{-1}) but statistically identical from other treatments. Although the yield was varied in T_2 (25.96 t ha^{-1}), T_6 (26.78 t ha^{-1}) and T_3 (25.02 t ha^{-1}), no significant difference was observed among these treatments regarding this parameter. Application of different treatments significantly increased the yield. However, the best result was found in T_1 (Table 6), which increased (43.20%) yield over control against *A. foveicollis* attack. On the other hand the lowest result (1.18%) was found in (T_4), which was significantly lower than other treatments.The result of the present study have clearly demonstrated that application of different chemicals and non-chemical methods have significant effect on yield contributing characters and yield of white gourd. Among the different chemicals cypermethrin showed the best efficacy against *A. foveicollis* attack. It increased the highest number of fruits plant^{-1}, length of individual fruit, weight of fruits, fruit diameter and yield of white gourd. Chloropyriphos and cartap also have significant effect in reducing *A. foveicollis* infestation and yield of white gourd. The order of efficacy of different chemicals were cypermethrin> chloropyriphos> cartap. All the non-chemicals methods also significantly increased the number of fruits plant^{-1}, length of individual fruit, weight of fruits, fruit diameter and yield of cucurbits but their efficacy was lower than chemical insecticides. However, hand collection and destruction of adult beetle and application of ash showed the best performance.

These results agree with the findings of Pandey et al. (2003), who reported that synthetic pyrethroid was more effective than chloropyriphos and gave higher yield. The findings also supported the reports of Tariq et al. (2006), who noted that chemical control was more effective than application of ash.

Table 6. Fruit weight, fruit yield of white gourd and percent increase of fruit yield over control under different treatments against red pumpkin beetle infestation

Treatments	Weight of fruit (kg)	Yield (t ha^{-1})	Percent increase of yield over control
T_1	1.82 a	30.41 a	43.20 a
T_2	1.56 c	25.96 c	22.29 c
T_3	1.50 d	25.02 d	17.82 d
T_4	1.29 f	21.48 f	1.18 f
T_5	1.37 e	22.75 e	7.14 e
T_6	1.61 b	26.78 b	26.14 b
T_7	1.28 f	21.23 f	--
CD (0.05)	0.15	21.48	0.61
CV (%)	8.38	6.16	7.17

In a column, means having similar letter (s) are statistically identical at 5% level of significance by DMRT.

T_1= Application of cypermethrin (Ripcord 10EC) @ 1.50 ml L^{-1} at 7 days intervals.

T_2= Application of chloropyriphos (Dursban 20EC) @ 1.50 ml L^{-1} at 7 days intervals.

T_3= Application of cartap 50SP (Suntap 50SP) @ 1·0 g L^{-1} at 7 days intervals.

T_4= Mosquito net barrier at seedling stage starting from emergence and continued up to 40 days.

T_5= Hand collection and destruction of adult beetle.

T_6= Application of ash at 7 days intervals.

T_7= Untreated control.

Chapter V
Summary and Conclusion

CHAPTER IV
SUMMARY AND CONCLUSION

Red pumpkin beetle, *Aulacophora foveicollis,* Lucas is an important insect pest of cucurbitaceous vegetables. Both chemical insecticides and non-chemical methods are used to control the pest. The present investigation was undertaken to evaluate the effectiveness of three chemical insecticides viz. cypermethrin 10EC chlorpyriphos 20EC, and cartap 50SP, and three no-chemical methods such as mosquito net barrier at seedling stage (40 days), hand collection and destruction of adult beetle and application of ash for the management of the pest.

The lowest percent of leaf infestation (6.25%) and the lowest population of red pumpkin beetle (0.57 plant^{-1}) were found in cypermethrin treated plots. All the chemical insecticides reduced more than 80% population of adult beetle. Application of ash and hand collection of adult beetle reduced more than 60% population of adult beetles.

Application of cypermethrin and other chemical insecticides and non-chemical methods significantly increased the vine length, number of flowers plant^{-1}, number of fruits plant^{-1}, fruit length, diameter, and individual fruit weight of white gourd. Cypermethrin gave the best results followed by chlorpyriphos and cartap. Among the non-chemical methods application of ash was almost equally effective as cartap in increasing vine length (301.90cm and 311.20 cm respectively) of white gourd.

The number of flowers plant^{-1} was almost similar in cartap and other non-chemical treated plots. Although cypermethrin increased 155.10% fruits plant^{-1} compared to control, cartap and ash also showed a similar efficacy by increasing 100%, 96.45% fruits plant^{-1}, respectively.

The highest length and diameter of fruit (19.27 cm and 39.68 cm, respectively) was found in cypermethrin treated plots followed by chlorpyriphos, cartap and ash application.

The highest weight of individual fruit (1.82 kg) and yield (30.41 t ha^{-1}) was obtained by application of cypermethrin, which also increased 43.20 % yield of white gourd over control. Application of ash at 7 days interval showed better performance than chlorpyriphos and cartap, regarding the fruit yield of white gourd.

From the above findings it can be concluded that application of cypermethrin 10EC at 7 days interval was the most effective control method of red pumpkin beetle attacking white gourd. Considering health hazards and environmental safety point of view application of ash and hand collection and destruction of adult beetle may be used but it needs further trial in large scale.

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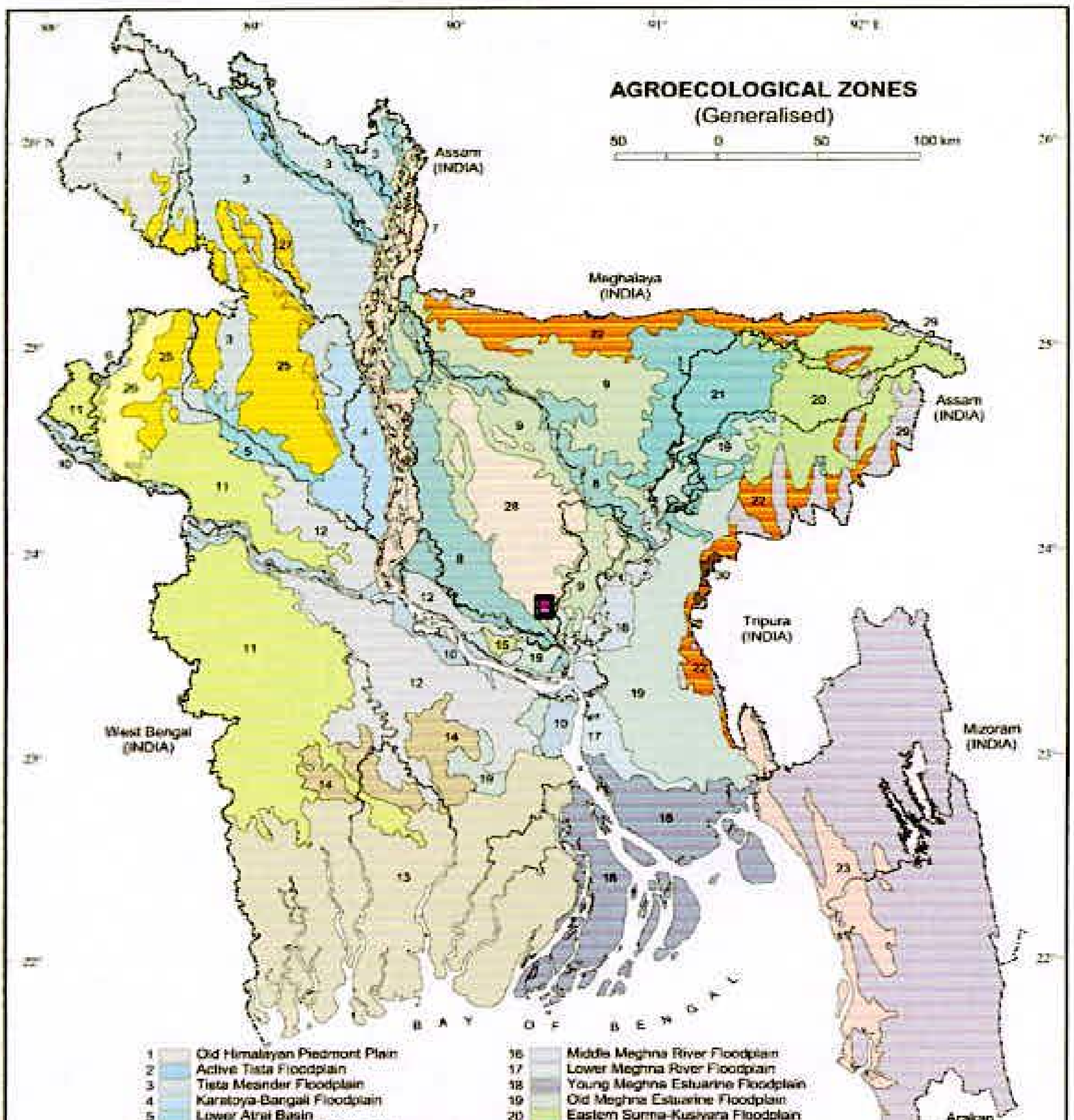
Appendices

APPENDICES

Appendix I. Map showing the experimental site under the study



Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from December 2008 to May 2008 [Source: Bangladesh Metrological Department, Agargaon, Dhaka]

Month	**Year**	**Monthly average air temperature (^{0}C)**			**Average relative humidity (%)**	**Total rainfall (mm)**	**Total sunshine (hours)**
		Maximum	**Minimum**	**Mean**			
March	2008	31.59	22.15	26.867	59.13	258	1821.00
April	2008	34.37	26.06	30.218	61.51	180	2546.00
May	2008	34.78	24.57	29.675	64.23	616	2359.00
June	2008	35.40	28.50	31.95	68.14	446	1246.00
July	2008	34.00	29.30	31.65	63.28	476	949.00
August	2008	36.00	29.50	32.75	69.11	318	1307.00

Appendix III. Physical characteristics and chemical composition of soil of the experimental plot.

Soil Characteristics	**Analytical results**
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Appendix IV. Effect on leaves by the use of some chemicals and non chemicals for the management of red pumpkin beetle

Source of variance	**Mean square**						
	Degrees of freedom	**Number of leaves plant^{-1} at seedling stage**	**Number of infested leaves plant^{-1} at seedling stage**	**% leaf infestation at seedling stage**	**Percent (%) leaf area damage**	**% increase of leaf area over control**	**% reduction of leaf area damage over control**
Replication	2	0.151	0.243	0.415	0.202	0.583	0.066
Treatment	6	32.93**	3.671**	172.003**	787.42**	357.765**	854.008**
Error	12	3.234	0.111	4.144	8.300	0.079	2.351

Appendix V. Effect of insects for using of some chemicals and non chemicals for the management of red pumpkin beetle

Source of variance	Mean square		
	Degrees of freedom	**Number of adult insect plant^{-1}**	**% reduction of insect population over control**
Replication	2	0.015	0.882
Treatment	6	7.315**	1338.40**
Error	12	0.046	0.724

Appendix VI. Effect of vine length for using of some chemicals and non chemicals for the management of red pumpkin beetle

Source of variance	Mean square		
	Degrees of freedom	**Vine length (cm)**	**% increase of vine length over control**
Replication	2	1.367	1.461
Treatment	6	1494.89*	2936.57*
Error	12	0.347	8.721

Appendix VII. Effect on number of flowers plant^{-1} using of some chemicals and non chemicals for the management of red pumpkin beetle

Source of variance	Mean square		
	Degrees of freedom	**Number of flowers plant^{-1}**	**% increase of flower over control**
Replication	2	0.014	5146.393
Treatment	6	78.03*	3921.24*
Error	12	2.099	50.371

Appendix VIII. Effect on fruits using of some chemicals and non chemicals for the management of red pumpkin beetle.

Source of variance	Mean square						
	Degrees of freedom	Number of fruits $plant^{-1}$	% increase of fruits over control	Length of fruit (cm)	% increase length of fruit over control	Diameter of fruit (cm)	% increase diameter of fruit over control
Replication	2	0.001	0.133	0.295	0.568	0.172	0.006
Treatment	6	1.033**	3841.041*	3.799**	46.906**	68.154*	625.004**
Error	12	0.031	6.593	0.087	0.133	0.270	0.115

Appendix IX. Effect on fruit yield using of some chemicals and non chemicals for the management of red pumpkin beetle.

Source of variance	Mean square			
	Degrees of freedom	Weight of fruit $plant^{-1}$ (g)	Yield (t/ha)	% increase of yield over control
Replication	2	26.986	21.849	0.014
Treatment	6	1163.76*	32331.118*	662.721
Error	12	91.888	145.232	0.111