INCIDENCE AND DAMAGE SEVERITY OF CHEWING INSECT PESTS AND FRUIT FLY ON BOTTLE GOURD AND THEIR MANAGEMENTS

NITAI CHANDRA SARKER

DEPARTMENT OF ENTOMOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

DECEMBER, 2017

INCIDENCE AND DAMAGE SEVERITY OF CHEWING INSECT PESTS AND FRUIT FLY ON BOTTLE GOURD AND THEIR MANAGEMENTS

BY

NITAI CHANDRA SARKER

REGISTRATION NO. : 16-07559

A Thesis

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 (MS)

IN

ENTOMOLOGY

SEMESTER: JULY-DECEMBER, 2017

Approved by:

Prof. Dr. Tahmina Akter
Supervisor
Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Assoc. Prof. Dr. Ayesha Akter
Co-supervisor
Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Dr. Mst. Nur Mohal Akhter Banu
Associate Professor
Chairman
Examination Committee

DEPARTMENT OF ENTOMOLOGY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

*This is to certify that the thesis entitled **'Incidence and Damage Severity of Chewing Insect Pests and Fruit Fly on Bottle Gourd and their Managements'** submitted to the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY**, embodies the results of a piece of bona fide research work carried out by **NITAI CHANDRA SARKER**, Registration No. **16-07559** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2017
Dhaka, Bangladesh

Prof. Dr. Tahmina Akter
Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

At first the author expresses his profound gratitude to the 'Omnipotent Creator' who enables the author to complete this work. It is a great pleasure to express his reflective gratitude to his respected parents, who entiled much hardship inspiring for prosecuting his studies, thereby receiving proper education.

The author would likes to express his earnest respect and deepest sense of gratitude to his respected supervisor Dr. Tahmina Akter, Professor, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for her scholastic guidance, support, valuable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing including data analysis.

The author wishes to express his gratitude and best regards to his respected Co-Supervisor Dr. Ayesha Akter, Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for her scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses his sincere gratitude towards the sincerity of the Chairman, Dr. Mst. Nur Mohal Akhter Banu, Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for her cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Entomology, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses his sincere appreciation to brothers, relatives, well wishers and all of the friends for their inspiration, help and encouragement throughout the study period.

The Author

INCIDENCE AND DAMAGE SEVERITY OF CHEWING INSECT PESTS AND FRUIT FLY ON BOTTLE GOURD AND THEIR MANAGEMENTS

ABSTRACT

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from September, 2017 to May, 2018 to assess the incidence and damage severity of chewing insect pests and fruit fly on bottle gourd and their managements. BARI Lau 4 were used as the test crop for this study. The experiments consists of different management practices as treatment and they were T_1: Mechanical and Cultural practices at 7 days interval, T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval, T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval, T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval, T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval, T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval and T_7: Untreated control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Red pumpkin beetle, epilachna beetle, green leaf eating caterpillar, cutworm, grasshopper and fruit fly were observed during the study period. At vegetative and reproductive stage, the lowest leaf infestation (3.49% and 5.38%) was observed from T_4 treatment, whereas the highest infestation (15.56% and 15.02%) in T_7 treatment. In number and weight basis at early, mid and late fruiting stage the lowest fruit infestation (2.67% and 4.40%, 2.22% and 5.97%, 3.13% and 5.13%) was observed from T_4 treatment, whereas the highest infestation (10.65% and 10.53%, 10.15% and 16.24%, 11.92% and 14.54%) in T_7 treatment. The highest healthy fruit yield (69.96 t/ha) was recorded from T_4, whereas the lowest (57.32 t/ha) from T_7 treatment. From the above findings it can be concluded that among the treatments, T_4 (Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval) may be revealed as the best treatments in respect of higher healthy fruit yield by reducing leaf and fruit infestation of bottle gourd.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATE

LIST OF APPENDIX

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Vegetables are cheaper source of vitamins and minerals which are essential for maintaining sound health although production of vegetable in Bangladesh is far below of actual requirements. In 2014-2015, total vegetable (summer and winter season) production area was 645.04 thousand hectares of land with total production of 1.87 million tons (BBS, 2016). The per capita production of vegetable in Bangladesh is very low as compared to that of other countries. The present consumption is only about 30 g, with potato and sweet potato it is 70g/day/person. The per capita consumption of vegetable in Nepal (42 g), Pakistan (69 g), Srilanka (120 g) and India (135 g) which are higher than that of Bangladesh (Yoldas *et al*., 2008). The daily requirement of vegetables for a full grown person is 285 gm (Ramphall and Gill, 1990).

In Bangladesh, the vegetables production is not evenly distributed throughout the year and most of the vegetables are produced in winter (Anon., 2001). Although all vegetables cannot be grown in kharif season due to the climatic condition but all the cucurbits can be grown in kharif season because cucurbits easily grown year the round. As a result, cucurbitaceous vegetables play an important role to supplement of vegetable shortage during the lag period (Rashid, 1993). In Bangladesh cucurbits occupy 66% of the land under vegetable production and contribute 11% of total vegetable production (BBS, 2016). Cucurbits include bottle gourd, sweet gourd, cucumber, squash, bitter gourd, watermelon etc. Bottle gourd are most widely grown and consumed in all over the Bangladesh, preferred mainly for its nutritional value as a source of various compounds, such as vitamins, minerals, antioxidants, as well as its anticancer properties (Umar *et al*., 2013). The edible portion of bottle gourd fruit contains moisture: 96.3%, Energy: 15 kcal, Carbohydrates: 5.87 g, Fat: 0.02 g, Protein: 0.6 g, Vitamin C: 10.100 mg, Zinc: 3.77 mg, Potassium: 3320.0 mg and Magnesium: 162.33 mg (Parle and Kuar, 2011).

Bottle gourd, *Lagenaria siceraria* (Malina) is a popular vegetable in India and some other Asian countries. But its productivity constraints limit the potential yield and several insect pests have been reported to cause considerable damage in different parts of the world. Bottle gourd is primarily a winter vegetable but now a days it is available also in summer. Now bottle gourd is grown round the year. They are grown in homestead for family consumption as well as in larger plots for commercial purpose (Umar *et al*., 2013). In Bangladesh per unit area bottle gourd production is comparatively low with the other countries. However, low yield may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties, delayed sowing after the harvest of transplanted aman rice, fertilizer management, disease and insect infestation and improper or limited irrigation facilities, use of traditional cultural practices like other cole crops etc. A major and common one is the high incidence of insect pests, and management practices.

Cucurbits are infested with various insect right from the primordial stages of the crop to harvest of the products which are considered to be the significant obstacles for its economic production and besides the direct damage, many pests act as vector for viruses (Muthusamy *et al*., 2017). The main pests of cucurbit crops are leaf eating caterpillar, *Diaphania indica*; fruity fly, *Bactrocera cucurbitae* (Coquillet); leaf miner, *Liriomyza trifolii*; white flies, *Bemisia tabaci*; Hadda (Epilachna) beetle, *Epilachna viginctioctopunctata* (Fabricius); aphids, *Aphis gossypii* (Glover) and ash weevil, *Myllocerus subfasciatus* (Haldhar *et al*., 2014). Red pumpkin beetle (*Aulacophora foveicollis*) and were found to be the major pests and it appeared from early to mid crop growth stage (6.2-35.6% damage) and from mid to late crop growth stage (16.3-45.6% damage). The green semilooper (Trichoplusia ni) attacked the crop during prime vegetative growth stage and caused about 7.5-19.2% foliage damage). Study also revealed that some of the meteorological parameters exerted significant influences on the growth and development of the pest populations and hence their resultant damages.

The extent of damage varies from year to year, season to season and locality to locality depending on the seasonal abundance of the pests affected by the influence of prevailing abiotic and biotic factors and impact of control measures adopted (Anon., 2001). Although there are different methods of controlling the pest but the growers in Bangladesh frequently use chemical insecticides in order to protect vegetables from insect attacks (Karim, 1995). A survey on pesticide use in vegetables revealed that only about 15% to 16% of the farmers received information from the pesticide dealers and extension agents (Islam, 1999). In most cases, the farmers did not care to follow those instructions and went on using insecticides at their own choice. As a result, the indiscriminate use of chemical pesticides has given many serious problems including resistance of pest species, toxic residues in harvested products, increasing cost of application, environmental pollution, hazards from handling, destruction of natural enemies of pests and non-target organisms etc. (Sharaby, 1988).

Hence, search for the alternative method of insect pest control utilizing some environment friendly and human health hazard free methods are being pursued now-a-days. The complex of insect pests, the safety issues regarding the level of control required problems with insecticide resistance and the health risks to operators and consumers associated with excessive insecticide use all contribute to the intractability of the problem (Bhowmik and Saha, 2017). In view of the above facts, the main focus of this paper is lying in the following specific objectives:

- To study the incidence of different chewing insect pests and fruit fly on bottle gourd;
- To find out the damage severity of those insect pests on bottle gourd; and
- To establish an effective control measure for the management of chewing insect pests and fruit fly of bottle gourd.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Bottle gourd is one of the important members of the cucurbits fruits and is a naturally cross-pollinated crop. It is frequently observed the plant produces very few fruits even through it had enormous number of male and female flowers. In Bangladesh bottle gourd is attacked by different species of insect pests. The major pests of bottle gourd are red pumpkin beetle, epilachna beetle, Green leaf eating catterpillar, cutwarm, grasshopper white fly, cucurbit fruit fly etc. A very few research works related to incidence and damage severity of different chewing insect pests on bottle gourd and their managements have been carried out in Bangladesh. However, some of the important and informative research findings in this aspects on bottle gourd and other crops of cucurbits so far been done at home and abroad have been reviewed in this chapter under the following headings and sub-headings-

2. 1 Morphological description of major cucurbits insect pests

2.1.1 Red pumpkin beetle

Red pumpkin beetle, *Aulacophora foveicollis* (Lucas) is a common, serious and major destructive insect pest of a wide range of cucurbitaceous vegetables and plays a vital role for the reduction of yield of cucurbitaceous vegetables.

2.1.1.1 Systematic position

Phylum: Arthropoda

Class: Insecta

Sub-Class: Pterygota

Order: Coleoptera

Family: Chrysomelidae

Genus: *Aulacophora/Raphidopalpa*

Species: *A. foveicollis*

2.1.1.2 Origin and distribution

Butani and Jotwani (1984) stated that red pumpkin beetle (RPB), *Aulacophora foveicollis* (Lucas) is widely distributed all over the South-East Asia as well as the Mediterranean region towards the west and Australia in the east. According to York (1992) this insect pest is also found in the Mediterranean region, Africa and Asia. RPB is widely distributed throughout all zoogeographic regions of the world except the Neo-arctic and Neo-tropical region. Alam (1989) reported that the RPB is widely distributed throughout the Pakistan, India, Afghanistan, Ceylon, Burma, Indo-China, Iraq, Iran, Persia, Palestine, Greece, Turkey, Israel, South Europe, Algeria, Egypt, Cyprus and the Andaman Island. In India, it is found in almost all the states, though it is more abundant in the northern states (Butani and Jotwani, 1984).

2.1.1.3 Nature of damage and host preferences

Red Pumpkin Beetle is the most serious pest of the cucurbits and it causes around 35-75% damage at seedling stage for all cucurbits except Bitter. They feed underside the cotyledonous leaves by bitting holes into them. Percent damage rating gradually decreases from 70-15% as the leaf canopy increases. Percent losses are obvious from the percent damage, which may be reached upto 35-75% at seedling stage (Yamaguchi, 1983).

Khan (2013) carried out an experiment to determine the biochemical composition of cucurbit leaves and their influence on RPB and stated that the highest quantity of moisture was recorded in young leaf of bottle gourd (86.49%) and mature leaf of Khira (87.95%). The lowest moisture content was obtained in young leaf of Snake gourd (79.21%) and mature leaf of Ribbed gourd (76.43%). The highest nitrogen content was found in young leaf (6.79%) of sweet gourd and in mature leaf (5.57%) of bottle gourd. The lowest percentage of nitrogen was found in young leaf (3.64%) of bitter gourd and in mature leaf (2.52%) of ribbed gourd. The highest quantity of total sugar was found in young leaf of bottle gourd (4.90%) and mature leaf of sweet gourd

(4.76%). The lowest quantity of total sugar was found in young (2.03%) and mature leaves (2.09%) of bitter gourd. The highest quantity of reducing sugar was estimated from young leaves of musk melon (4.14%) and from mature leaves (4.01%) of sweet gourd. The lowest quantity of reducing sugar was in young (1.85%) and mature (1.83%) leaves of bitter gourd. They also recorded positively relationship between RPB populations per leaf with the percent nitrogen, total and reducing sugar content of leaves of cucurbits.

Khan *et al*. (2012) reported that the highest population of RPB was recorded in the month of May. In March, food availability was the lowest because plants were young. In May, plant growth was maximal covering largest canopy. In June, plants were at their senescent stage causing food scarcity. They also reported that the highest incidence of pumpkin beetles at around 9:00 am and 6:00 pm, while the lowest incidence was at 2:00 pm. The highest population of RPB was recorded in the month of May on sweet gourd, cucumber, ribbed gourd and sponge gourd.

Khan (2012) studied to find out preferred cucurbit host(s) of the pumpkin beetle and to determine the susceptibility of ten different cucurbits to the pest under field conditions. The results revealed that the most preferred host of the red pumpkin beetle (RPB) was muskmelon, which was followed by Khira, cucumber and sweet gourd, and these may be graded as susceptible hosts. Bitter gourd, sponge gourd, ribbed gourd and snake gourd were least or non preferred hosts of RPB and these may be graded as resistant hosts. Other two crops, the bottle gourd and ash gourd were moderately preferred hosts of the insect and these may be graded as moderately susceptible hosts. According to his result, it indicate that the order of preference of RPB for ten tested cucurbit hosts was muskmelon> sweet gourd> cucumber > khira > ash gourd > bottle gourd > sponge gourd. Ribbed gourd > snake gourd > bitter gourd.

Host preference of RPB among ten cucurbitaceous crops (viz., sweet gourd, bottle gourd, ash gourd, bitter gourd, sponge gourd, ribbed gourd, snake gourd, cucumber, khira and muskmelon) was studied by Khan *et al*. (2011). At 1, 6, 12 and 24 hours after release (HAR), RPB population was found highest on sweet gourd. At 48 HAR the highest peak was found on muskmelon. The population of RPB on those two crops was significantly different only at 6 HAR. The populations of RPB on ash gourd, ribbed gourd, cucumber and khira ranged 1.00-3.33, 0.00-2.00, 0.67-1.67 and 0.00-2.00 per two plants, respectively. Three crops (Sweet gourd, musk melon and ash gourd) may be noted as highly preferred hosts of RPB. Bitter gourd was free from infestation and it was noted as non-preferred host. On khira and cucumber average population of RPB was 1.07-1.53 per two plants. On other cucurbits, population of RPB was less than one accordingly the highest percentage of leaf area damage per plant was observed on musk melon leaves followed by sweet gourd and ash gourd. The lowest percentage of leaf area damage was found on snake gourd followed by sponge gourd and bottle gourd. This insect showed different preference for various host species. In the present study sweet gourd and wax gourd were found to be the most preferred host of red pumpkin beetle and bitter gourd was found as non preferred host of RPB. The highest percentage of leaf area damage per plant was observed on sweet gourd leaves followed by wax gourd. The lowest percentage of leaf area damage per plant was on snake gourd leaves followed by sponge gourd and bitter gourd.

Roy and Pande (1990) investigated the preference order of 21 cucurbit vegetables and noted that bitter gourd was highly resistant to the beetle, while the sponge gourd and bottle gourd were moderately resistant; muskmelon and cucumber were susceptible to the pest. They also observed that banana squash, muskmelon and bottle gourd were the preferred hosts of the adults, while cucumber, white gourd/ash gourd, chinese okra, bitter gourd, snake gourd, watermelon and sponge gourd achieved the second order of preference to the beetle, *A. foveicollis*.

2.1.2 Epilachna beetle

Among the major insect pests that attack cucurbitaceous vegetables, the Epilachna beetle, is very important one.

2.1.2.1 Systematic position

Phylum: Euarthropoda

Class: Insecta

Order: Coleoptera

Family: Coccinellidae

Genus: Epilachna

Species: *Epilachna*

Scientific name: *Epilachna spp*.

2.1.2.2 Origin and distribution

Epilachna beetle, is a notorious polyphagous pest extensively found all over countries. It is widely distributed in South and East Asia, Australia, America, and the East Indies (Halder and Srinivasan, 2011).

2.1.2.3 Nature of damage and host preferences

Epilachna beetle is a notorious polyphagous leaf eating pest of solanaceous and cucurbitaceous vegetable crops causing considerable damage to the host (Rahaman *et al*., 2008). The beetle and its larvae feed on the epidermal tissues of leaves, flowers and fruits (Sharma and Saxena, 2012). Larvae feeding on leaves make distinctive short parallel grooves on the underside. These areas of grooves may form holes in the leaves. Adult feeding can also result in ragged holes in leaves. The pest is seen infesting cucurbitaceous vegetables and other economically important crops belonging to solanaceous and cucurbitaceous groups. Lately the pest is also seen attacking leguminous crops especially cowpea (Anam *et al*., 2006; Rahaman *et al*., 2008, Halder and Srinivasan, 2011) causing considerable economic damage. The pest also feeds on brinjal, tomato, tobacco, pumpkin and bitter gourd. The larvae and adults scrape the green matter from leaves and cause damage up to 80% (Rajagopal and Trivedi, 1989).

2.1.3 Green leaf eating caterpillar

The caterpillar, *Spodoptera litura* (Fab.) is one the insect pests of c cucurbitaceous vegetables and it's synonym are Cabbage caterpillar.

2.1.3.1 Systematic position

Phylum: Arthopoda

Class: Insecta

Order: Lepidoptera

Family: Noctuidiae

Genus: *Spodoptera*

Species: *Spodoptera litura*

Scientific name: *Spodoptera litura* (Fab.)

2.1.3.2 Origin and distribution

Hill (1983) reported that *S. litura* (Fab.) is a polyphagous pest of cucurbits vegetables. It is originated from South and Eastern Old World tropics. The caterpillar is found throughout the tropical and subtropical parts of the world. It is widely spread in India (Atwal, 1986). This pest has been reported from India, Pakistan, Ceylon, Burma, Thailand, Malaysia, Cambodia, Laos, Vietnam, Sabah, Indonesia, the Philippines, Taiwan, Queensland, Papua New Guinea, West Iran, Solomon Islands, Gilbert Islands, New Caledonia, Fiji, Samoa, Tonga, Society Islands, Gilbert Islands and Micronesia (Grist *et al.,* 1989).

2.1.3.3 Nature of damage and host preferences

The Green leaf eating caterpillar, *S. litura* (Fab.) attacks the tender leaves, and only the larvae caused the damage in cucurbits vegetables. The female moth of caterpillar laid eggs on the lower surface of the leaves, the tiny caterpillar starts feeding on host plant. In the early stage of caterpillars reached to the newly emerging little leaf and consumed it. The nature and extent of damage differed with age of the green leaf eating caterpillar. Succeeding generations can do greater damage and can come out as a serious phase of infestation for their voracious feeding habit (Tofael, 2004).

2.1.4 Cutworm

Cutworms are moth larvae that hide under litter or soil during the day, coming out in the dark to feed on plants. A larva typically attacks the first part of the plant it encounters, namely the stem, often of a seedling, and consequently cuts it down; hence the name *cutworm*.

2.1.4.1 Systematic position

Phylum: Arthropoda
Class: Insecta
Order: Lepidoptera
Family: Noctuidae
Genus: Agrotis
Species: *A. ipsilon*
Scientific name: *Agrotis ipsilon*

2.1.4.2 Origin and distribution

The origin of cutworm is uncertain, though it is now found in many regions of the world, being absent principally from some tropical regions and cold areas. It is more widespread, and damaging, in the northern hemisphere than the southern hemisphere (Sharma and Saxena, 2012). It annually reinvades temperate areas, overwintering in warmer or subtropical regions. Long distance dispersal of adults has long been suspected in Europe, China, and North America. The basic pattern is to move north in the spring, and south in the autumn.

2.1.4.3 Nature of damage and host preferences

Young caterpillars climb plants and skeletonise the leaves or eat small holes. The older larvae may also climb to browse or cut off leaves, but commonly cut through stems at ground level and feed on the top growth of felled plants. Caterpillars that are almost fully grown often remain underground and chew into plants at or below ground level. They usually feed in the late afternoon or at night. By day they hide under debris or in the soil (Khan *et al*., 2011).

2.1.5 Fruit fly

Fruit fly is the most damaging pest and considered as an important obstacle for economic production of cucurbitaceous vegetables.

2.1.5.1 Systematic position of fruit fly

Phylum: Arthropoda
Class: Insecta
Sub-Class: Pterygota
Division: Endopterygota
Order: Diptera
Sub-order: Cyclorrhapha
Family: Tephritidae
Genus: *Bactrocera*
Species: *Bactrocera cucurbitae*

2.1.5.2 Origin and distribution

Fruit fly is considered to be the native of oriental, probably India and south east Asia and first discovered in the Yaeyama Island of Japan in 1919 (Anon., 1987). However, the fruit fly is widely distributed in India, Bangladesh, Pakistan, Myanmar, Nepal, Malaysia, China, Philippines, Formosa (Taiwan), Japan, Indonesia, East Africa, Australia, and Hawaiian Island. In the Commonwealth of the Northern Mariana Islands, it was detected in 1943 and eradicated by sterile-insect release, but re-established from the neighboring Guam in the year 1981 (Wong *et al.*, 1989). It was detected in Nauru in 1982 and eradicated in 1999 by male annihilation and protein bait spraying, but was re-introduced in 2001 (Hollingsworth and Allwood, 2002). Although it is found in Hawaii, it is absent from the continental United States (Weems and Heppner, 2001). The distribution of a particular species is limited perhaps due to physical, climatic and gross vegetational factors but most likely due to host specificity. Such species may become widely distributed when their host plant are widespread, either naturally or cultivation by man (Kapoor, 1993).

The dipteran family Tephritidae consists of over 4000 species, of which nearly 700 species belong to Dacine fruit flies (Fletcher, 1987). Nearly 250 species are of economic importance, and are distributed widely in temperate, sub-tropical, and tropical regions of the world. Forty-three species have been described under the genus *Bactrocera* including from Asia, Africa, and Australia (Fletcher, 1987; Cavalloro, 1983; Munro, 1984). Two of the world most damaging tephritids, *Bactrocera dorsalis* and *B. cucurbitae,* are widely distributed in Malaysia and other South East Asian countries of the world (Vijaysegaran, 1987). According to Aktheruzzaman (1999) *Bactrocera cucurbitae, Bactrocera tau and Bactrocera ciliates* have been currently identified in Bangladesh of which *Bactrocera ciliates* is a new record. *B. cucurbitae* is dominant in all the locations of Bangladesh followed by *B. tau and B. ciliates*.

2.1.5.3 Nature of damage

Maggots feed inside the fruits, but at times, also feed on flowers, and stems. Generally, the females prefer to lay the eggs in soft tender fruit tissues by piercing them with the ovipositor. The eggs are laid into unopened flowers, and the larvae successfully develop in the taproots, stems, and leaf stalks (Weems and Heppner, 2001). Miyatake *et al.* (1993) reported more than 1% damage by pseudo-punctures by the sterile females in cucumber, sponge gourd and bitter gourd. After egg hatching, the maggots bore into the pulp tissue and make the feeding galleries. The fruit subsequently rots or becomes distorted. The vinegar fly, *Drosophilla melanogaster* has also been observed to lay eggs on the fruits infested by melon fly, and acts as a scavenger (Dhillon *et al.,* 2005). The extent of losses varies between 30 to 100%, depending on the cucurbit species and the season. Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89%. The melon fruit fly has been reported to infest 95% of bitter gourd fruits in Papua (New Guinea), and 90% snake gourd and 60 to 87% pumpkin fruits in Solomon Islands (Hollingsworth *et al.,* 1997). Singh *et al.* (2000) reported 31.27% damage on bitter gourd and 28.55% on watermelon in an earlier experiment at India.

2.1.6 Grasshopper

Grasshoppers are plant-eating insects characterized by long hind legs designed for locomotion by jumping.

2.1.6.1 Systematic position

Phylum: Euarthropoda

Class: Insecta

Order: Orthoptera

Family: Acrididae

Genus: Atractomorpha

Species: Oxya

Scientific name: *Oxya velox*

2.1.6.2 Origin and distribution

Grasshoppers are distributed worldwide and occasionally reach serious pest outbreak status causing major crop loss. Occasionally, large flights of grasshoppers are detected on radar. The more than 20,000 species in this order have a worldwide distribution but are most diverse in the tropics (Kevan 1982; Rentz 1991).

2.1.6.3 Nature of damage and host preferences

The plants are damaged by the grasshopper gnawing on the leaves, and young vegetable plants can be eaten to the ground. Most of the feeding damage is caused by the third, fourth, and fifth instars. Those three stages have a much larger appetite than the adults. Significant damage to plants occurs when these insects become very abundant. Abundance commonly an increase in favored foods, typically weedy grasses. This can result from weather that favors grasses such as mild winters, increased rainfall, suppression of grazing by livestock, or soil tillage. Almost any type of plant including corn, alfalfa, cotton, millet, peanut, rice, ryegrass, sorghum, soybean, sugarcane, vegetables, wheat, flowers and landscape plants are the host of grasshopper (Kristensen, 1995).

2.2 Management practices of cucurbitaceous insect pests

2.2.1 Red pumpkin beetle

Kevan (1982) evaluated fourteen insecticides for the control of *A. foveicollis* and reported that phosphamidon @ 0.03 per cent was the most effective throughout the observation period with 64 per cent reduction in population over control even after 15 days treatment followed by carbaryl @ 0.2 per cent and endosulfan @ 0.05 per cent. Six granular insecticides for the control of *A. foveicollis* and reported that carbofuran @ 0.5 and 1 kg a.i per hectare proved quite effective in controlling the beetles up to 37 days after its application followed by carbaryl @ 1 kg a.i per hectare up to 25 days after its application.

Khan and Mukhopadhyay (1985) conducted a field study at Hissar (Haryana) for the simultaneous control of *A. foveicollis*, mite, *Tetranychus cucurbitae* and powdery mildew and observed that sevisulf 40:50 WP and tank mixture of carbaryl and sulphur gave good control of these pests. The soil application with carbofuran granules @ 0.5 kg a.i per hectare proved to be most effective and seed treatment with carbofuran WP 3 to 4 per cent equally effective against *A. foveicollis* without any adverse effect on seed germination.

Pawar *et al*. (1984) used seven insecticides for the control of *A. foveicollis* and reported that fortnightly sprays of carbaryl @ 0.5 per cent was the most effective (6.75 beetles/wine) as compared to untreated check (23.00 beetles/wine). Application of phoxim and pirimiphos-methyl @ 187.5 g a.i per hectare provided effective control of *A. foveicollis* for 10 days (Mavi and Bajwa, 1984). In a field study conducted at Ludhiana, (Punjab) by Mavi and Bajwa (1985) for the control of this pest, carbaryl @ 0.05 percent and @ 0.075 per cent was found the most potent insecticide up to 10 days after its application followed by permethrin, phoxim and pirimiphos, each @ 0.075 per cent remained effective for 4 days after their application.

A field experiment was conducted by Pareek and Kavadia (1988) in two different agro-climatic regions of Rajasthan, the semi-humid Udaipur and the semi-arid Jobner which revealed that four sprays of 0.2 per cent carbaryl at 3, 5, 9 and 11 weeks after sowing of musk melon proved the most effective against *A. foveicollis*, resulting in increased yield and net profit.

Mehta and Sandhu (1990) used cucurbitacin as kairomones in combination with malathion and carbaryl as poison baits for the monitoring of beetles and observed that maximum number of beetles were trapped in carbaryl poison baits than that of malathion and concluded that these baits could be used to reduce the destructive behavior of this pest.

The application of carbofuran @ 1.5 kg a.i per hectare at sowing, vining and flowering stages was found to be the most effective treatment in controlling *A. foveicollis* with 84.3 per cent reduction over control after 80 days of sowing (Thomas and Jacob, 1994). Chaudhary (1995) found monocrotophos @ 200 g a.i. followed by carbaryl @ 500 g a.i (spray and dust) effective during first year and cypermethrin 25 g a.i. followed by deltamethrin 10g a.i and carbaryl @ 500g a.i. (spray) per hectare during second year. Under field conditions, cypermethrin 0.1 per cent + molasses solution 1 per cent was found most effective in reducing the beetle population (8.8 beetles/5 plants) followed by cypermethrin 0.01 per cent (9.2 beetles/5 plants) and deltamethrin 0.0028 per cent (10.2 beetles/5 plants) as compared to control (18.0 beetles/5 plants) (Borah, 1997).

Borah (1998) observed that application of carbofuran @ 1.5 kg a.i. at 15 days after germination to be the most effective followed by deltamethrin @ 12.5 g a.i. and decis 12.5 g a.i. per hectare at flower bud initiation stage followed by another spray at 15 days later. Khan and Jehangir (2000) studied the efficacy of different concentrations of sevin dust and found high concentration (2.0 %) to be the most effective followed by medium (1.0 %) and low (0.5 %).

Khan and Wasim (2001) assessed different plant extracts and found neem extract in benzene most effective in repelling *A. foveicollis* followed by bakaion extract in benzene. Comparative efficacy of seven insecticides viz., neem, triazophos, chlorpyriphos, monocrotophos, abamectin, SIL-942 and Beta-cyfluthrin evaluated under field conditions against *A. foveicollis* revealed that beta-cyfluthrin @ 18.75 g a.i. per hectare (6.86% damaged leaves/plant) to be the most effective followed by beta-cyfluthrin @ 12.5 g a.i. (14.9% damaged leaves/plant), monocrotophos @ 700 g a.i. (14.12% damaged leaves/plant), neem 3ml per liter of water (15.33% damaged leaves/plant) and SIL-942 @ 100 g a.i. (17.28% damaged leaves/plant).

Mehmood *et al*. (2006) studied the comparative effect of different control methods against red pumpkin beetle and observed insecticidal treatments viz., carbofuran and carbaryl dust more effective in killing the beetles, near the plants. Among various insecticides and biopesticides for the control of *A. foveicollis* and found deltamethrin followed by carbofuran and carbaryl most effective among the tested insecticides. Whereas, among biopesticides only neem powder proved to be effective against this pest. In Sri Lanka, neem based formulations were also effectively used for the control of this pest in organic crop production (Khan and Jehangir, 2000).

Rahaman and Prodhan (2007) studied the effect of net barrier and synthetic pesticides on *A. foveicollis* and reported zero infestation in case of net barrier and lowest infestation by the use of carbofuran. Soil treatment with carbofuran @ 500 g a.i per hectare at the time of sowing proved effective (0.93 adult/plant) followed by seed treatment with thiamethoxam @ 3 g per kg of seed + rice husk ash @ 30 kg/ha hectare at 15, 25, 35 and 45 days after sowing (1.26 adults/plant) (Anon., 2008). Bio-efficacy of neem based and synthetic insecticides against red pumpkin beetle under laboratory conditions and found maximum mortality in neem based commercial formulation gronim and neem-azal-F (29.98%) and carbaryl (63.36%).

2.2.2 Green leaf eating caterpillar

The repellent, antifeedant and ovicidal properties of the extracts of *Acorus calamus, Croton oblingifolis, Strychnos nux-vomica, Santalum album, Simarouba glauca* [*Quassia simarouba*] and *Vitox negundo* against *S. litura* infesting vegetables in Bangalore, Karnataka, India were determined under laboratory conditions by Murthy *et al.* (2006). All the extracts exhibited repellent, antifeedant and ovicidal properties, with *Acorus calamus* and *V. negundo* exhibiting the highest biological properties, regardless of the concentration.

Ghatak *et al.* (2005) conducted an experiment in West Bengal, India to investigate the biological efficacy of indigenous plant products in controlling *S. littoralis.* Petroleum ether extracts from seeds of *Pachyrhizus erosus* (PE) and *Annona squamosa* (AS) at 1, 2 and 3% concentration; Neem plus 1500 ppm at 0.5, and 2% concentration; and Monocil 36 SL [monocrotophos] at 0.03, 0.05, and 0.07% concentration were sprayed on third instar larvae *S. littoralis*, and effects were assessed at 12, 24, 48, 72 and 96 hour after treatment. Larval mortality under PE, AS and neem was 40.00-83.33, 46.66-70.00 and 40.00-60.00, respectively after 96 hour of treatment. Larval mortality due to monocil was 76.66-86.66 even at 48 hour after treatment. Based on LC50 values, monocil was the most toxic pesticide, while seed extract of AS was the least toxic.

Sharma *et al.* (1999) conducted and experiment for the effect of host plants like castor (*Ricimus communis*), cabbage, cauliflower, tomatoes and wild cabbage and also the effect of neem oil on food utilization indices of *S. litura.* They stated that, cauliflower was the most preferred host. Neem oil markedly decreased feeding by *S. litura* larva on these plants. Neem oil (*S. indica*) at 8 and 16% exhibited complete repellent and antifeedant effect against larvae of *S. litura* on *Vigna mungo* leaves. At 0.5-4% repellency and antifeedant activity increased with increasing concentration. Neem oil at 0.5 and 1.0% lost its antifeedant property after 5 days (Malathi *et al.*, 1999).

Kumar *et al.* (1997) investigated the effect of exudates from reddish terminal leaves of neem, *Azadirachta indica* on *S. litura*. A significant increase in the larval mortality, antifeedancy and ovipositional repellency was found after treatment with acetone extracts of neem leaf exudates to fifth instar larvae. Reduced consumption, growth and nutritional efficiency were evident. Extended larval and pupal durations and reduced longevity and fecundity were observed by neem leaf extract treatment.

The repellency, antifeedant activity and development period increased with increase in concentration of biosol, neemark, repelin and neem oil. Moreover, adult emergence, growth, survival, larval and pupal weight, number of eggs laid and hatchability of eggs decreased with increase in concentration and neem oil had the greatest effects on *S. litura*, followed by neemark, biosol and repelin (Rao *et al.,* 1993).

Kaul (1987) determined dose response relationship of *Calamun* oil using food acceptance, feeding ratio, weight gain and larval development as parameters in choice tests against *S. litura.* At concentrations of 0.5% and 1.0% *Calamus* oil was effective in both tests inducing a significant reduction in feeding and inhibition of growth in early 3rd instar larvae. Neem oil had such effect only at 2%, particularly in no choice tests.

2.2.3 Management practices of fruit fly

Cultural control

Cultural methods of the pest control aim at reducing, insect population encouraging a healthy growth of plants or circumventing the attack by changing various agronomic practices (Chattopadhyay, 1991). The cultural practices used for controlling fruit flies were described by the following headings.

In the pupal stage of fruit fly, it pupates in soil and also over winter in the soil. In the winter period, the soil in the field as turned over or given a light ploughing; the pupae underneath are exposed to direct sunlight and killed. They also become a prey to the predators and parasitoids. A huge number of pupae are died due to mechanical injury during ploughing (Kapoor, 1993; Nasiruddin and Karim, 1992; Chattopadhyay, 1991 and Agarwal *et al.,* 1987). The female fruit fly lays eggs and the larvae hatch inside the fruit, it becomes essential to look for the available measures to reduce their damage on fruit. One of the safety measures is the field sanitation (Nasiruddin and Karim, 1992).

According to Kapoor (1993), in this method of field sanitation, the infested fruits on the plant or fallen on the ground should be collected and buried deep in to the soil or cooked and fed to animals. Field sanitation is an essential pre requisite to reduce the insect population or defer the possibilities of the appearances of epiphytotics or epizootics. Systematic picking and destruction of infested fruits in proper manner to keep down the population is resorted to reduce the damages caused by fruit flies infesting cucurbit, guava, mango, peach etc. and many borers of plants (Chattopadhyay, 1991).

Mechanical control

Mechanical destruction of non-cultivated alternate wild host plants reduced the fruit fly population, which survive at times of the year when their cultivated hosts are absent (Kapoor, 1993). Collection and destruction of infested fruits with the larvae inside helped population reduction of fruit flies (Nasiruddin and Karim, 1992).

Sometimes each and every fruit is covered by a paper or cloth bag to block the contact of flies with the fruit thereby protecting from oviposition by the fruit fly and it is quite useful when the flies are within the reach and the number of fruits to be covered and less and it is a tedious task for big commercial orchards Kapoor (1993). Baggging of the fruits against *Bactrocera cucurbitae* greatly promoted fruit quality and the yields and net income increased by 45 and 58% respectively in bitter gourd and 40 and 45% in sponge gourd.

Amin (1995) obtained significantly lowest fruit fly infestation (4.61%) in bagged cucumber compared to other chemical and botanical control measures. Covering of fruits by polythene bag is an effective method to control fruit fly in teasel gourd and the lowest fruit fly incidence in teasel gourd occurred in bagging. Fruits (4.2%) while the highest (39.35) was recorded in the fruits of control plot (Anon., 1988).

Systematic picking and destruction of infested fruits in proper manner to keep down the population is resorted to reduce the damages caused by fruit flies infesting cucurbits, guava, mango, peach etc. and many borers of plants (Chattopadhyay, 1991).

Kapoor (1993) reviewed that fine wire netting may sometimes be used to cover small garden. Though it is a costly method, but it can effectively reduce the fruit fly infestation and protect the fruit from injury and deform, and also protects fruit crops against vertebrate pest.

Chemical control

The method of insecticide application is still popular among the farmers because of its quick and visible results but insecticide spraying alone has not yet become a potential method in controlling fruit flies. A wide range of organophosphoras, carbamate and synthetic pyrethroid of various formulations have been used from time to time against fruit fly (Kapoor, 1993). Spraying of conventional insecticide is preferred in destroying adults before sexual maturity and oviposition (Willoamson, 1989).

Kapoor (1993) reported that 0.05%. Fenitrothion, 0.05% Malathion, 0.03% Dimethoate and 0.05% Fenthion have been used successfully in minimizing the damage to fruit and vegetables against fruit fly but the use of DDT or BHC is being discouraged now. Sprays with 0.03% Dimethoate and 0.035% Phosnhamidon and Endosulfan are effectively used for the control of melon fly (Agarwal *et al.,* 1987). In field trials in Pakistan in 1985-86, the application of

Cypermethrin 10EC and Malathion 57 EC at 10 days intervals (4 sprays in total) significantly reduced the infestation of *Bactrocera cucurbitae*on Melon (4.8-7.9) compared with untreated control. Malathion was the most effective insecticide (Khan *et al.,* 1992*).*

Hameed *et al.* (1980) observed that Fenthion, Malathion, Trichlorophos and Fenthion with waiting period of five, seven and nine days respectively was very effective in controlling *Bactrocera cucurbitae*on cucumber in Himachal Pradesh, Various insecticide schedules were tested against *Bactrocera cucurbitae* 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} (Borah, 1998).

Nasiruddin and Karim (1992) reviewed that comparatively less fruit fly infestation (8.56%) was recorded in snake gourd sprayed with Dipterex 80SP compared to those in untreated plot (22.485%).

Pawer *et al.* (1984) reported that 0.05% Monocrotophos was very effective in controlling *Bactrocera cucurbitae* in muskmelon. Rabindranath and Pillai (1986) reported that Synthetic pyrethroids. Permethrin, Fenvelerate, Cypermethrin were very useful in controlling *Bactrocer cucurbitae,* in bittere gourd in South India, Kapoor (1993) listed about 22 references showing various insecticidal spray schedules for controlling for fruit flies on different plant hosts tried.

Protein hydrolysate insecticide formulations are now used against various dacine fruit fly species. Different poison baits are used against various *Batrocra species* which are 20 g Malathion 50% or 50 ml of Diazinon plus 200 g of molasses in 2 liters of water kept in flat containers or applying the bait spray containing Malathion 0.05% plus 1% sugar/molasses or 0.025% of protein water) or spraying plants with 500 g molasses plus 50 g Malathion in 50 liters of water or 0.025% Fenitrothion plus 0.5% molasses. This is repeated at weekly intervals where the fruit fly infestation is serious (Kapoor, 1993)

Nasiruddin and Karim (1992) reported that bait spray (1.0 g Dipterex 80 SP and 100 g of molasses per liter of water) on snake gourd against fruit fly (*Bactrocera cucurbitae)* showed 8.50% infestation compared to 22.48% in control.

Agarwal *et al.* (1987) achieved very good result for fruit fly (*B. cucurbitae)* management by spraying the plants with 500 g molasses and 50 liters of water at 7 days intervals. According to Steiner *et al.* (1988) poisoned bait containing Malathion and protein hydrolysate gave better results in fruit fly management program in Hawaii.

A field study was conducted to evaluate the efficacy of some bait sprays against fruit fly (*B. cucurbitae)* in comparison with a standard insecticide and bait traps. The treatment comprised 25 g molasses + 2.5 ml Malathion, (Limithion 50EC) and 2.5 litres water at a ratio of 1:0.1:100 satisfactorily reduced infestation and minimized the reduction in edible yield (Akhtaruzzaman *et al.,* 2000).

The fruit flies have long been recognized to be susceptible to attractants. A successful suppression programme has been reported from Pakistan where mass trapping with Methy1 eugenol, from 1977 to 1979, reduced the infestation of *B. zonata* below economic injury levels (Nasiruddin and Karim, 1992).

The attractant may be effective to kill the captured flies in the traps as reported several authors, one percent Methy1 eugenol plus 0.5 percent Malathion (Bagle and Prasad, 1983) have been used for the trapping the oriental fruit fly, *B. dorsalis and B. Zonata.*

Singh and Srivastava (1985) found that alcohol extract ofneem oil Azadirachtaindica (%) reduced oviposition of *B. cucurbitae* on bitter gourd completely and its 20% concentration was highly effective to inhibit oviposition of *B. zonata* on guava. Stark *et al*. (1990) studied the effect of Azadiractin on metamorphosis, longevity and reproduction of *Ceratilis Capitala* (Wiedemann), *B. cucurbitae and B. dorsalis.*

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to assess the incidence and damage severity of different chewing insect pest on bottle gourd and their managements. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area and also the materials that were used for conducting the experiment i.e. treatment and design of the experiment, growing of crops, data collection and data analysis procedure has been presented under the following headings-

3.1 Description of the experimental site

3.1.1 Experimental period

The field experiment was conducted from September, 2017 to April, 2018.

3.1.2 Experimental location

The present research work was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.3 Climatic condition

The climatic condition of experimental site is subtropical and characterized by three distinct seasons, the Rabi from November to February and the Kharif-I, pre-monsoon period or hot season from March to April and the Kharif-II monsoon period from May to October. During the experimental period the maximum temperature (33.7^{0}C), highest relative humidity (82%) and highest rainfall (234 mm) was recorded in the month of September, 2017, whereas the minimum temperature (22.6^{0}C), minimum relative humidity (67%) and no rainfall was recorded for the month of December, 2017. The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix II.

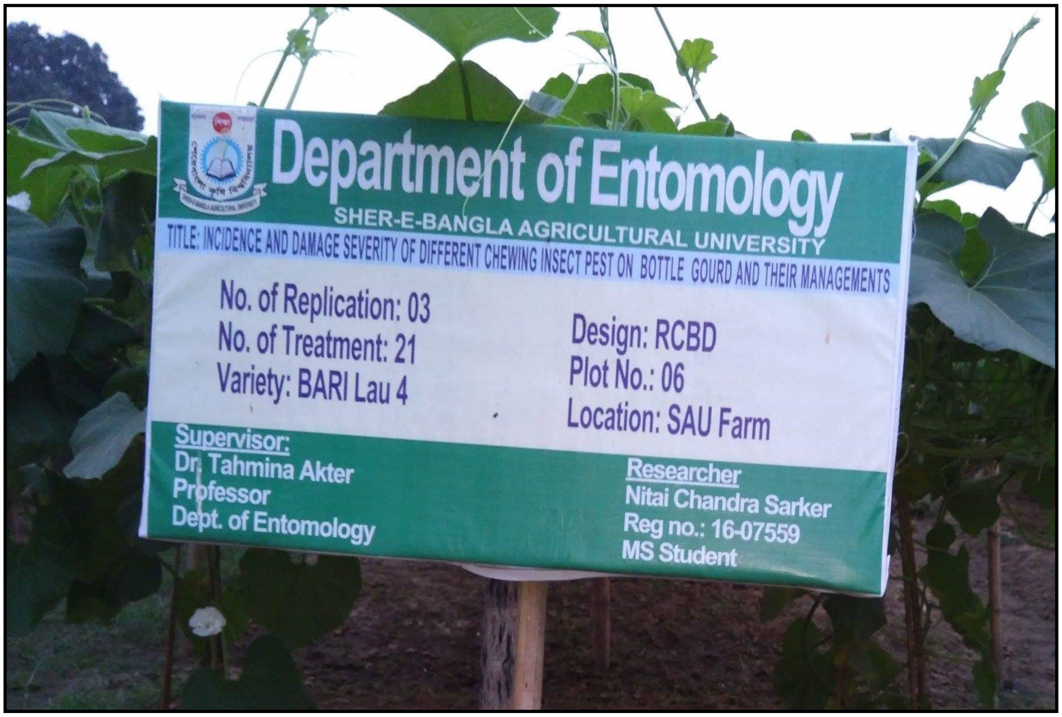


Plate 1. Photograph showing experimental plot

3.1.4 Soil characteristics

The general soil type of the experimental field was Shallow Red Brown Terrace soil and belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28). A composite sample of the experimental field was made by collecting soil from several spots of the field at a depth of 0-15 cm before starting the experiment. The collected soil was air-dried, grind and and analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of sandy loam with pH and organic matter 5.9 and 1.15%, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay. Details morphological, physical and chemical properties presented in Appendix III.

3.2 Experimental details

3.2.1 Planting material

The seeds of BARI Lau 4 were used as the test crop under the study.

3.2.2 Treatment of the experiment

The experiment comprised seven treatments including an untreated control as stated below-

T_1: Mechanical and Cultural practices at the 7 days interval

T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval

T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval

T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval

T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval

T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval

T_7: Untreated control

3.2.3 Application of different treatments

Sevin, Folithion, Rogor, Dizol and Proclaim were sprayed in assigned plots and dosages as per treatments by using knapsack sprayer. The spraying was always done in the afternoon to avoid bright sunlight to protect/save the foraging beneficial insects. The spray materials were applied uniformly to obtain complete coverage of whole plants of the assigned plots in 7 days interval. Caution was taken to avoid any drift of the spray mixture to the adjacent plots at the time of the spray application. At each spray application the spray mixture was freshly prepared. Mechanical, cultural practices and field sanitation was done as per treatments.

3.2.4 Experimental design and layout

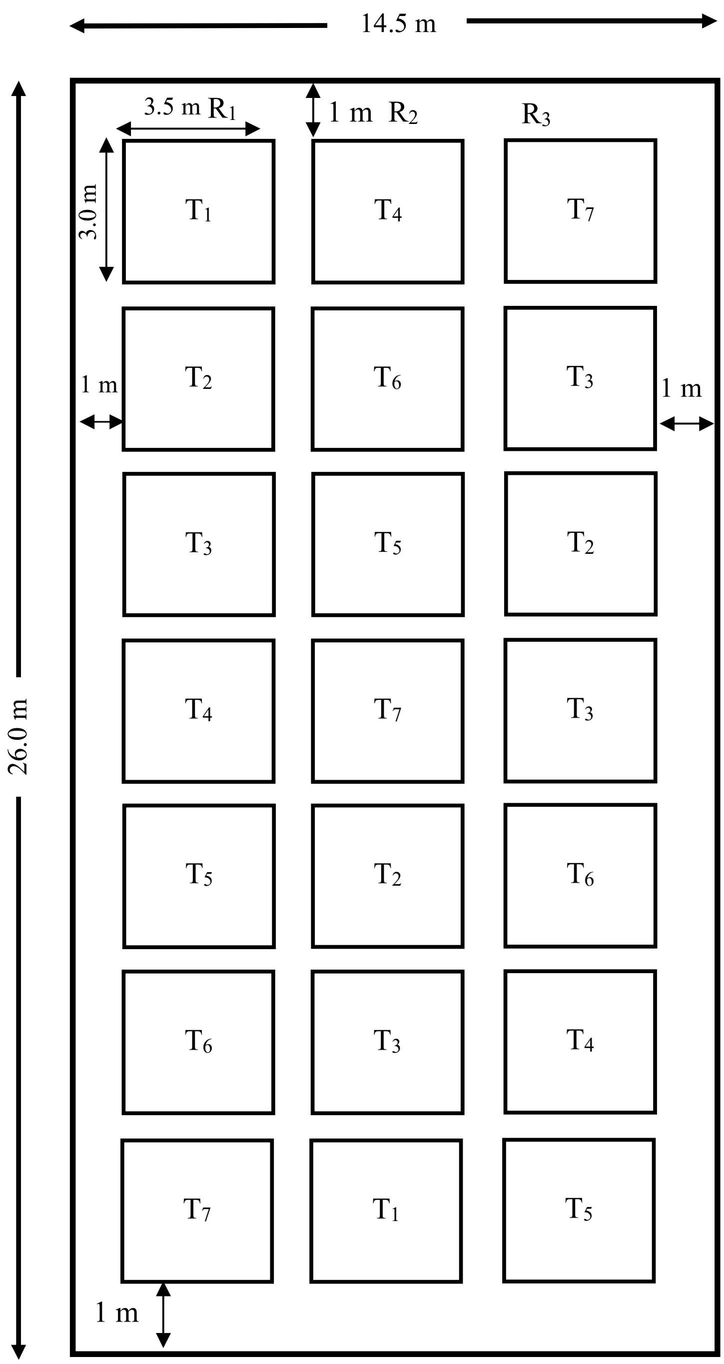
The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications, where the experimental area was divided into three equal blocks representing the replications to minimize the soil heterogenous effects. Each block was divided into 7 equal unit plots demarked with raised bunds for allocating different treatments. Thus the total numbers of plots were 21. The unit plot size was 3.5 m × 2.5 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

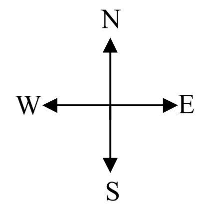
3.3 Growing of crops

3.3.1 Seed collection and sprouting

The seeds of BARI Lau 4 were collected from Bangladesh Agricultural Research Institute (BARI). For rapid and uniform germination the seeds of BARI Lau 4 were soaked for 12 hours in water before sowing in the polyethylene bags.

Plate 2. Photograph showing red pumpkin beetle with infested leaf





T_1: Mechanical and Cultural practices at the 7 days interval

T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval

T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval

T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval

T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval

T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval

T_7: Untreated control

Figure 1. Layout of the experimental plot

3.3.2 Raising of seedlings

Seeds were sown at 7th September, 2017 in the in polyethylene bags (12 cm × 18 cm) containing a mixture of soil with equal proportion of well decomposed cowdung and irrigated regularly to bring moist condition for proper seed germination. After germination the seedlings were sprayed with water by a hand sprayer for easy uprooting and it was done once a day for one week.

3.3.3 Land preparation

The main plot which was selected for conducting the experiment was opened in the 2nd week of September, 2017 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed accordingly. The experimental main plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated 3.3.4 were mixed with the soil of each unit plot. Then pit were made at the middle of each plot from transplanting of bottle gourd seedlings.

3.3.4 Fertilizers and manure application

Recommended doses of fertilizer for bottle gourd comprising urea, TSP, MoP @ 250, 150, 125 t/ha respectively were applied. Half of cowdung and TSP were applied at the time of land preparation .The rest amount of cowdung, TSP and one third of MoP in pits at the time of transplanting. First top dressing means one-third urea was applied at 15 DAT. Second top dressing means one-third urea +one-third MoP were applied at flower initiation and third top dressing means one-third urea +one-third MP was applied at fruit initiation.

3.3.5 Transplanting of seedling

Two seedlings were placed in a shady place and were transplanted on 21th September, 2017 in the pits of each plot of the experimental field after 14 days of seeds sowing. At the time of transplanting, polyethylene bag was cut and removed carefully in order to keep the soil intact with the root of the seedling.

After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. The following intercultural operations were done.

3.3.6.1 Irrigation and drainage

Irrigation was provided to maintain moist condition in the early stages for establishment of the seedlings and then irrigated when ever necessary throughout the entire growing period. No water stress was encountered in reproductive phase. Proper drainage facilities were made surrounding the experimental plots for drainage of excess water.

Plate 3. Photograph showing green leaf eating caterpillar with infested leaf

Plate 4. Photograph showing cucurbit fruit fly and infested bottle gourd with fruit fly

Plate 5. Photograph showing infested bottle gourd with maggot of fruit fly

3.3.6.2 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 30 DAT and 60 DAT by mechanical means.

3.4 Harvesting of bottle gourds

Harvesting of bottle gourd was done when the fruits attained marketable size**.** The optimum marketable sized bottle gourd were collected by hand picking of each plot and yield was converted into t/ha.

Plate 6. Photograph showing harvested healthy bottle gourd

3.5 Monitoring and data collection

The bottle gourd plants under different treatment were closely examined at regular intervals. The following data were collected during the course of the experiment.

- Number of identified different insect pests
- Number of healthy and infested leaves
- Number of healthy and infested fruits
- Weight of healthy and infested fruits
- Length of single fruit
- Girth of single fruit
- Total number of fruits/plot
- Single fruit weight
- Healthy fruit yield
- Infested fruit yield

3.6 Apparatus and instruments used

Weighing balance was used for taking weight of healthy and infested bottle gourds. Polythene bag, mosquito net and iron cases were used for adult moth identification.

3.7 Determination of fruit infestation in number

All the bottle were counted from each plot and examined. The collected data were divided into early, mid and late fruiting stage. The healthy and damaged bottle gourd were counted and the percent infestation was calculated using the following formula:

$$\text{\% Fruit Infestation (\%)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

3.8 Determination of fruit infestation in weight

All the bottle were counted from each plot and examined. The collected data were divided into early, mid and late fruiting stage. The healthy and damaged fruits were weighted and the percent damage was calculated using the following formula:

$$\text{Fruit infestation (\%)} = \frac{\text{Weight of infested fruits}}{\text{Total weight of fruits}} \times 100$$

3.9 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments. The mean values of all the characters were calculated and analysis of variance was performed by using MSTAT-C software. The significance of the difference among the treatments means was estimated by the by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to assess the incidence and damage severity of different chewing insect pest on bottle gourd and their managements. Data on identified different chewing pest/plot, number of leaves/plot at vegetative and reproductive stage, healthy fruits, infested fruits and percentage of fruit in number and weight basis/plot, yield contributing characters and yield of bottle gourd were recorded. The results have been presented and discussed, and possible explanations have been given under the following headings and sub-headings:

4.1 Common insect pests of bottle gourd during the study period

At vegetative and reproductive stage, red pumpkin beetle, epilachna beetle, green leaf eating caterpillar, cutworm, fruit fly and grasshopper were observed and statistically significant was recorded in terms of their number per plots due to different management practices (Table 1 and Table 2) during the study period in the experimental field.

4.1.1 At vegetative stage

At vegetative stage, no red pumpkin beetle per plot were observed from T_4 (Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval) and T_6 treatment (Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at the 7 days interval) which was followed (1.00) by T_2 treatment (Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval), whereas the highest number of red pumpkin beetle (8.00) was recorded from T_7 treatment (Untreated control) which was followed (3.83, 3.67 and 3.33, respectively) by T_1 (Mechanical and Cultural practices at 7 days interval), T_3 (Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval) and T_5 (Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval) treatment, respectively and they were statistically similar (Table 1). In case of epilachna beetle, no epilachna beetle were found from T_4 and T_6 treatment at vegetative stage which was followed (1.00) by T_2 treatment, while the highest number of epilachna beetle (6.33) was observed from T_7 treatment which was followed (2.33 and 2.00, respectively) by T_1, T_3 and T_5 treatment, respectively and they were statistically similar (Table 1). Muthusamy *et al.* (2017) reported that Cucurbits are infested with various insect right from the primordial stages of the crop to harvest of the products.

Table 1. Number of identified different chewing pest/plot in bottle gourd at vegetative stage

Treatments	Red pumpkin beetle	Epilachna beetle	Green leaf eating cater pillar	Cutworm	Grasshopper
T_1	3.83 b	2.33 b	1.67 b	2.00 b	3.67 b
T_2	1.00 c	1.00c	0.00 c	0.00 c	1.33d
T_3	3.67 b	2.00 b	1.33 b	1.67 b	3.00bc
T_4	0.00 d	0.00 d	0.00 c	0.00 c	0.00 e
T_5	3.33 b	2.00 b	1.00 b	1.33 b	2.67c
T_6	0.00 d	0.00d	0.00 c	0.00 c	1.00 d
T_7	8.00 a	6.33 a	4.67 a	4.67 a	6.67 a
$LSD_{(0.05)}$	0.809	0.596	0.733	0.948	0.658
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	6.89	6.89	9.11	10.33	5.06

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

It revealed that at vegetative stage no green leaf eating caterpillar were observed from T_2, T_4 and T_6 treatment, whereas the highest number of green leaf eating caterpillar (4.67) was found from T_7 treatment which was followed (1.67, 1.33 and 1.00, respectively) by T_1, T_3 and T_5 treatment, respectively and they were statistically similar (Table 1). At vegetative stage no cutworm were observed from T_2, T_4 and T_6 treatment, while the highest number of cutworm (4.67) was found from T_7 treatment which was followed (2.00, 1.67 and 1.33, respectively) by T_1, T_3 and T_5, respectively and they were statistically similar (Table 1). In case of grasshopper at vegetative stage, no grasshopper were found from T_4 which was followed (1.00 and 1.33, respectively) by T_6 and T_2 treatment and they were statistically similar, whereas the highest number of grasshopper (6.67) was observed from T_7 which was followed (3.67 and 3.00, respectively) by T_1 and T_3 treatment, respectively and they were statistically similar (Table 1).

4.1.2 At reproductive stage

At reproductive stage, no red pumpkin beetle per plot were found from T_4 and T_6 treatment which was followed (2.00) by T_2 treatment, while the highest number of red pumpkin beetle (7.33) was observed from T_7 treatment (Table 1). For epilachna beetle, no epilachna beetle were recorded from T_4 and T_6 treatment at reproductive stage which was followed (1.00) by T_5 treatment, while the highest number of epilachna beetle (6.00) was observed from T_7 treatment which was followed (2.33) by T_1 and T_3 treatment, respectively and they were statistically similar (Table 1). Data revealed that at reproductive stage no green leaf eating caterpillar were observed from T_4 and T_6 treatment, whereas the highest number of green leaf eating caterpillar (7.33) was found from T_7 treatment (Table 1). At reproductive stage no fruit fly were observed from T_4 and T_6 treatment, while the highest number of fruit fly (7.33) was found from T_7 treatment which was followed (3.67) by T_1 treatment (Table 1). In case of grasshopper at reproductive stage, no grasshopper were found from T_4 and T_6 treatment which was followed (1.33) by T_5, while the highest number of grasshopper (4.33) was found from T_7 treatment which was followed (2.33) by T_1 treatment (Table 2).

Table 2. Number of identified different chewing pest/plot in bottle gourd at reproductive stage

Treatments	Red pumpkin beetle	Epilachna beetle	Green leaf cater pillar	Fruit fly	Grasshopper
T_1	3.00 b	2.33 b	3.67 b	3.67 b	2.33 b
T_2	2.00 d	1.67 c	2.67 d	1.67 d	1.67 d
T_3	2.33 c	2.33 b	3.33 c	2.33 c	2.00 c
T_4	0.00 e	0.00 e	0.00 f	0.00 e	0.00 f
T_5	2.33 c	1.00 d	2.00 e	1.67 d	1.33 e
T_6	0.00 e	0.00 e	0.00 f	0.00 e	0.00 f
T_7	7.33 a	6.00 a	7.33 a	7.33 a	4.33 a
$LSD_{(0.05)}$	0.481	0.529	0.265	0.291	0.308
Level of significance	0.01	0.01	0.01	0.01	0.05
CV(%)	9.33	5.65	4.81	4.67	8.94

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.2 Leaf infestation by different insect pests

Number of healthy leaves, infested leaves and per cent infestation of leaf by different insect pests showed statistically significant differences at vegetative and reproductive stage for different management practices (Table 3 and Table 4).

4.2.1 At vegetative stage

At vegetative stage, the highest number of healthy leaves/plot (29.47) was recorded from T_4 which was statistically similar (28.53 and 26.60, respectively) with T_6 and T_2 treatment, respectively, while the lowest number (21.00) was found from T_7 treatment which was statistically similar (22.53 and 23.67, respectively) with T_1 and T_3 treatment (Table 3). The lowest number of infested leaves/plot (1.07) was recorded from T_4 treatment which was statistically similar (1.33) with T_6 treatment, whereas the highest number (3.87) was observed from T_7which was followed (2.00, 1.67 and 1.60, respectively) by T_1, T_3 and T_5, respectively. The lowest leaf infestation (3.49%) was observed from T_4 treatment which was statistically similar (4.46%) with T_6 treatment and followed (5.47% and 5.91%, respectively) by T_2 and T_5 treatment, respectively, whereas the highest infestation (15.56%) was recorded in T_7 treatment which was followed (8.16%) by T_1 treatment. In consideration of infestation reduction over control the highest value (77.57%) was recorded from T_4 treatment and the lowest value (47.56%) was found from T_1 treatment. Haldhar *et al*., (2014) reported that Red pumpkin beetle and epilachna beetle were found to be the major pests of bottle gourd and it appeared from early to mid crop growth stage (6.2-35.6% damage) and from mid to late crop growth stage (16.3-45.6% damage). They also reported that green semilooper attacked the crop during prime vegetative growth stage and caused about 7.5-19.2% foliage damage).

Table 3. Effect of different management practices on the basis of number of healthy, infested leaves and leaf infestation of bottle gourd at vegetative stage

Treatments	Number of leaves/plot		% infestation	Infestation reduction over control (%)
	Healthy leaves (No.)	Infested leaves (No.)		
T_1	22.53 d	2.00 b	8.16 b	47.56
T_2	26.60 ab	1.53 c	5.47 cd	64.85
T_3	23.67 cd	1.67 bc	6.61 c	57.52
T_4	29.47 a	1.07 d	3.49 e	77.57
T_5	25.47 bc	1.60 bc	5.91 cd	62.02
T_6	28.53 a	1.33 cd	4.46 de	71.34
T_7	21.00 d	3.87 a	15.56 a	--
$LSD_{(0.05)}$	2.746	0.394	1.493	--
Level of significance	0.01	0.01	0.01	--
CV(%)	6.78	3.94	5.33	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.2.2 At reproductive stage

At reproductive stage, the highest number of healthy leaves/plot (83.43) was recorded from T_4 which was statistically similar with other treatment except T_7 and T_1 treatment, while the lowest number (65.47) was found from T_7 treatment which was statistically similar (71.63) with T_1 treatment (Table 4). The lowest number of infested leaves/plot (4.73) was recorded from T_4 treatment which was statistically similar (4.97) with T_6 treatment, whereas the highest number (11.50) was observed from T_7 which was followed (7.53 and 6.97, respectively) by T_1 and T_3 and T_5, respectively. The lowest leaf infestation (5.38%) was observed from T_4 treatment which was statistically similar (5.84%) with T_6 treatment and followed (7.19% and 7.58%, respectively) by T_2 and T_3 treatment, respectively, whereas the highest infestation (15.02%) was recorded in T_7 treatment which was followed (9.15%) by T_1 treatment. In consideration of infestation reduction over control the highest value (64.18%) was recorded from T_4 treatment and the lowest value (36.68%) was found from T_1 treatment.

4.3 Fruit infestation by different insect pests

Number of healthy fruits, infested fruits and per cent infestation of fruit by different insect pests at early, mid and late fruiting stage in number and weight basis showed statistically significant variation due to different management practices (Table 5 to Table 10).

4.3.1 At early fruiting stage in number basis

At early fruiting stage, the highest number of healthy fruits/plot (9.73) was recorded from T_4 which was followed (9.20) by T_6 treatment, whereas the lowest number (6.67) was found from T_7 treatment which was followed (6.67) byT_1 treatment (Table 5). The lowest number of infested fruits/plot (0.27) was recorded from T_4 treatment which was statistically similar (0.33 and 0.40, respectively) with T_2, T_6 and T_5 treatment, respectively whereas the highest number (0.80) was observed from T_7 which was statistically similar (0.60) with T_1. The lowest fruit infestation (2.67%) in number basis was observed from T_4

Table 4. Effect of different management practices on the basis of number of healthy, infested leaves and leaf infestation of bottle gourd at reproductive stage

Treatments	Number of leaves/plot		% infestation	Infestation reduction over control (%)
	Healthy leaves (No.)	Infested leaves (No.)		
T_1	71.63 bc	7.53 b	9.51 b	36.68
T_2	75.33 abc	5.83 de	7.19 cd	52.13
T_3	75.20 abc	6.17 cd	7.58 cd	49.53
T_4	83.43 a	4.73 f	5.38 e	64.18
T_5	78.77 ab	6.97 bc	8.14 bc	45.81
T_6	80.30 ab	4.97 ef	5.84 de	61.12
T_7	65.47 c	11.50 a	15.02 a	--
$LSD_{(0.05)}$	9.379	0.960	1.701	--
Level of significance	0.01	0.01	0.01	0.01
CV(%)	6.96	7.92	11.40	

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 5. Effect of different management practices on the basis of healthy, infested fruits and fruit infestation in number basis of bottle gourd at early fruiting stage

Treatments	Number of fruits/plot		% infestation	Infestation reduction over control (%)
	Healthy fruit (No.)	Infested fruit (No.)		
T_1	7.47 f	0.60 ab	7.45 b	30.05
T_2	8.87 cd	0.33 cd	3.61 d	66.10
T_3	8.13 e	0.53 bc	6.14 bc	42.35
T_4	9.73 a	0.27 d	2.67 d	74.93
T_5	8.67 d	0.40 bcd	4.42 cd	58.50
T_6	9.20 bc	0.33 cd	3.50 d	67.14
T_7	6.67 g	0.80 a	10.65 a	--
$LSD_{(0.05)}$	0.468	0.205	2.209	--
Level of significance	0.01	0.01	0.01	--
CV(%)	4.22	12.17	15.02	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

treatment which was statistically similar (3.50%, 3.61% and 4.42%, respectively) with T_6, T_2 and T_5 treatment, respectively, whereas the highest infestation (10.65%) was recorded in T_7 treatment which was followed (7.45%) by T_1 treatment. In consideration of infestation reduction over control the highest value (74.93%) was recorded from T_4 treatment and the lowest value (30.05%) was found from T_1 treatment.

4.3.2 At mid fruiting stage in number basis

At mid fruiting stage, the highest number of healthy fruits/plot (11.67) was recorded from T_4 which was followed (11.07) by T_6 treatment, whereas the lowest number (7.67) was found from T_7 treatment which was followed (8.33) by T_1 treatment (Table 6). The lowest number of infested fruits/plot (0.27) was recorded from T_4 treatment which was statistically similar (0.40) with T_6 treatment, while the highest number (0.87) was observed from T_7 which was statistically similar (0.80 and 0.73) with T_1 and T_3. In number basis, the lowest fruit infestation (2.22%) was observed from T_4 treatment which was statistically similar (3.49%) with T_6 treatment, whereas the highest infestation (10.15%) was recorded in T_7 treatment which was statistically similar (8.77%) by T_1 treatment. In consideration of infestation reduction over control the highest value (78.13%) was recorded from T_4 treatment and the lowest value (13.60%) was found from T_1 treatment.

4.3.3 At late fruiting stage in number basis

At late fruiting stage, the highest number of healthy fruits/plot (10.27) was recorded from T_4 which was statistically similar (10.07) with T_6 treatment, whereas the lowest number (7.40) was found from T_7 treatment which was followed (8.20) by T_1 treatment (Table 7). The lowest number of infested fruits/plot (0.33) was recorded from T_4 treatment which was statistically similar (0.40) with T_6 treatment, while the highest number (1.00) from T_7 which was statistically similar (0.87) with T_1. The lowest fruit infestation in number basis (3.13%) was observed from T_4 treatment which was statistically similar (3.82%)

Table 6. Effect of different management practices on the basis of healthy, infested fruits and fruit infestation in number basis of bottle gourd at mid fruiting stage

Treatments	Number of fruits/plot		% infestation	Infestation reduction over control (%)
	Healthy fruit (No.)	Infested fruit (No.)		
T_1	8.33 g	0.80 a	8.77 ab	13.60
T_2	10.73 c	0.47 cde	4.16 ef	59.01
T_3	9.27 f	0.73 ab	7.31 bc	27.98
T_4	11.67 a	0.27 f	2.22 g	78.13
T_5	10.27 d	0.53 cd	4.93 de	51.43
T_6	11.07 b	0.40 def	3.49 efg	65.62
T_7	7.67 h	0.87 a	10.15 a	--
$LSD_{(0.05)}$	0.319	0.164	1.516	--
Level of significance	0.01	0.01	0.01	--
CV(%)	4.85	17.49	15.87	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

with T_6 treatment, whereas the highest infestation (11.92%) was recorded in T_7 treatment which was followed (9.57%) by T_1 treatment. In consideration of infestation reduction over control the highest value (73.74%) was recorded from T_4 treatment and the lowest value (19.71%) was found from T_1 treatment.

Table 7. Effect of different management practices on the basis of healthy, infested fruits and fruit infestation in number basis of bottle gourd at late fruiting stage

Treatments	Number of fruits/plot		% infestation	Infestation reduction over control (%)
	Healthy fruit (No.)	Infested fruit (No.)		
T_1	8.20 f	0.87 ab	9.57 b	19.71
T_2	9.67 c	0.53 de	5.23 d	56.12
T_3	8.60 e	0.80 b	8.51 bc	28.61
T_4	10.27 a	0.33 f	3.13 e	73.74
T_5	9.20 d	0.60 cd	6.12 d	48.66
T_6	10.07 ab	0.40 ef	3.82 e	67.95
T_7	7.40 g	1.00 a	11.92 a	--
$LSD_{(0.05)}$	0.367	0.134	1.326	--
Level of significance	0.01	0.01	0.01	--
CV(%)	5.34	12.23	11.51	--

T_1: Mechanical and Cultural practices at the 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5g/L of water at the 7 days interval; T_3: Spraying Folithion50 EC @ 1.12 ml/L of water at the 7 days interval; T_4: Mechanical control + Spraying Rigor 40 L @ 1.0 ml/L of water at the 7 days interval ;T_5: Spraying Dizol 60EC @ 1.0 ml/L of water at the 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0g/L of water at the 7 days interval; and T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.3.4 At early fruiting stage in weight basis

At early fruiting stage, the highest weight of healthy fruits/plot (24.60 kg) was recorded from T_4 which was statistically similar (23.47 kg) with T_6 treatment, whereas the lowest weight (17.60 kg) was found from T_7 treatment which was followed (19.40 kg) by T_1 treatment (Table 8). The lowest weight of infested fruits/plot (1.13 kg) was recorded from T_4 treatment which was followed (1.40

kg and 1.47 kg, respectively) with T_5 and T_6 treatment, respectively whereas the highest weight (2.12 kg) was observed from T_7 which was statistically similar (2.00 kg) with T_1 treatment. In weight basis, the lowest fruit infestation (4.40%) was observed from T_4 treatment which was followed (5.88% and 6.02%, respectively) by T_6 and T_5 treatment, respectively, while the highest infestation (10.53%) was recorded in T_7 treatment which was followed (9.36% and 8.51%, respectively) by T_1 and T_3 treatment, respectively. In consideration of infestation reduction over control in weight basis, the highest value (58.21%) was recorded from T_4 treatment and the lowest value (11.11%) was found from T_1 treatment.

4.3.5 At mid fruiting stage in weight basis

At mid fruiting stage, the highest weight of healthy fruits/plot (34.60 kg) was recorded from T_4 which was statistically similar (32.20 kg and 31.87 kg) with T_6 and T_5 treatment, whereas the lowest weight (25.80 kg) was found from T_7 treatment which was statistically similar (28.40 kg) with T_1 treatment (Table 9). The lowest weight of infested fruits/plot (2.20 kg) was recorded from T_4 treatment which was followed (2.60 kg) T_6 treatment, while the highest weight (5.00 kg) was observed from T_7 which was followed (4.40 kg) by T_1 treatment. In weight basis, the lowest fruit infestation (5.97%) was observed from T_4 treatment which was followed (7.48%) by T_6 treatment, whereas the highest infestation (16.24%) was recorded in T_7 treatment which was followed (12.88%) by T_1 treatment. In consideration of infestation reduction over control in weight basis, the highest value (63.24%) was recorded from T_4 treatment and the lowest value (20.69%) was found from T_1 treatment.

Table 8. Effect of different management practices on the healthy, infested fruits and fruit infestation by fruit fly in weight basis of bottle gourd at early fruiting stage

Treatments	Weight of fruits/plot		% infestation	Infestation reduction over control (%)
	Healthy fruit (kg)	Infested fruit (kg)		
T_1	19.40 e	2.00 ab	9.36 b	11.11
T_2	21.53 cd	1.73 bc	7.45 c	44.16
T_3	20.07 de	1.87 bc	8.51 bc	19.18
T_4	24.60 a	1.13 e	4.40 e	58.21
T_5	21.87 bc	1.40 d	6.02 d	42.83
T_6	23.47 ab	1.47 d	5.88 d	44.16
T_7	17.60 f	2.12 a	10.53 a	--
$LSD_{(0.05)}$	1.69	0.18	1.10	--
Level of significance	0.05	0.05	0.05	--
CV(%)	4.86	5.32	6.93	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 9. Effect of different management practices on the healthy, infested fruits and fruit infestation by fruit fly in weight basis of bottle gourd at mid fruiting stage

Treatments	Weight of fruits/plot		% infestation	Infestation reduction over control (%)
	Healthy fruit (kg)	Infested fruit (kg)		
T_1	28.40 cd	4.20 b	12.88 c	20.69
T_2	30.20 bc	3.80 c	11.18 d	53.94
T_3	30.07 bc	3.40 d	10.16 e	37.44
T_4	34.60 a	2.20 g	5.97 h	63.24
T_5	31.87 ab	3.00 e	8.61 f	46.98
T_6	32.20 ab	2.60 f	7.48 g	53.94
T_7	25.80 de	5.00 a	16.24 a	--
$LSD_{(0.05)}$	3.04	0.40	0.64	--
Level of significance	0.05	0.05	0.01	--
CV(%)	6.14	5.55	4.90	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.3.6 At late fruiting stage in weight basis

At late fruiting stage, the highest weight of healthy fruits/plot (33.20 kg) was recorded from T_4 which was followed (30.80 kg and 30.60 kg) with T_2 and T_6 treatment and they were statistically similar, whereas the lowest weight (21.20 kg) was found from T_7 treatment which was followed (26.20 kg, 27.80 kg and 28.20 kg, respectively) by T_1, T_3 and T_5, treatment (Table 10). The lowest weight of infested fruits/plot (1.80 kg) was recorded from T_4 treatment which was statistically similar (2.12 kg) T_6 treatment, while the highest weight (3.60 kg) was observed from T_7 which was statistically similar (3.40 kg) with T_1 treatment. In weight basis, the lowest fruit infestation (5.13%) was observed from T_4 treatment which was followed (6.52%) by T_6 treatment, whereas the highest infestation (14.54%) was recorded in T_7 treatment which was followed (11.50%) by T_1 treatment. In consideration of infestation reduction over control in weight basis, the highest value (64.72%) was recorded from T_4 treatment and the lowest value (20.91%) was found from T_1 treatment.

4.4 Yield attributes and yields of bottle gourd

Statistically significant variation was recorded in terms of different yield attributes and yield of bottle gourd due to different management practices under the present trial (Table 11 to Table 13).

4.4.1 Length of single fruit

The highest length of single fruit (55.91 cm) was recorded from T_4 treatment which was statistically similar with other treatment except T_7 and T_1 treatment, while the lowest length of fruit (45.39 cm) was recorded from T_7 which was statistically similar (48.68 cm) with T_1 treatment (Table 11). In consideration of length of single fruit in percent increase over control, the highest value (23.18%) was recorded from T_4 treatment and the lowest value (7.25%) from T_1 treatment.

Table 10. Effect of different management practices on the healthy, infested fruits and fruit infestation by fruit fly in weight basis of bottle gourd at late fruiting stage

Treatments	Weight of fruits/plot		% infestation	Infestation reduction over control (%)
	Healthy fruit (kg)	Infested fruit (kg)		
T_1	26.20 c	3.40 ab	11.50 b	20.91
T_2	30.80 b	2.53 d	7.64 e	47.46
T_3	27.80 c	3.20 bc	10.32 cd	29.02
T_4	33.20 a	1.80 e	5.13 f	64.72
T_5	28.20 c	2.87 cd	9.24 d	36.45
T_6	30.60 b	2.12 e	6.52 e	55.16
T_7	21.20 d	3.60 a	14.54 a	--
$LSD_{(0.05)}$	2.21	0.33	1.22	--
Level of significance	0.05	0.01	0.05	--
CV(%)	4.82	5.80	6.19	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 11. Effect of different management practices on length and girth of single fruit of bottle gourd

Treatments	Length of single fruit (cm)	Percent increase over control	Girth of single fruit (cm)	Percent increase over control
T_1	48.68 bc	7.25	21.11 c	0.67
T_2	54.21 ab	19.43	22.97 abc	9.54
T_3	51.08 abc	12.54	21.86 bc	4.24
T_4	55.91a	23.18	25.00a	19.22
T_5	53.52 ab	17.91	22.28 abc	6.25
T_6	55.27 ab	21.77	24.55 ab	17.07
T_7	45.39 c	--	20.97 c	--
$LSD_{(0.05)}$	6.134	--	2.696	--
Level of significance	0.01	--	0.05	--
CV(%)	6.73	--	7.72	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.4.2 Girth of single fruit

The highest girth of single fruit (25.00 cm) was recorded from T_4 treatment which was statistically similar with other treatment except T_7, T_1 and T_3 treatment, while the lowest girth of fruit (20.97 cm) was recorded from T_7 which was statistically similar (21.11 cm and 21.86 cm, respectively) with T_1 and T_3 treatment, respectively (Table 11). In consideration of girth of single fruit in percent increase over control, the highest value (19.22%) was recorded from T_4 treatment and the lowest value (0.67%) was found from T_1 treatment.

4.4.3 Number of fruits/plot

The highest number of fruits/plot (32.54) was recorded from T_4 treatment which was followed (31.47) by T_6 treatment, while the lowest number (24.41) was recorded from T_7 which was followed (26.27) by T_1 treatment (Table 12). In consideration of number of fruits/plot in percent increase over control, the highest value (33.31%) was recorded from T_4 treatment and the lowest value (7.62%) was found from T_1 treatment.

4.4.4 Single fruit weight

The highest single fruit weight (2.95 kg) was recorded from T_4 treatment which was statistically similar (2.85 kg) with T_6 treatment and followed (2.65 kg) by T_2 treatment, while the lowest weight (1.90 kg) was recorded from T_7 which was statistically similar (1.95 kg) with T_1 treatment (Table 12). In consideration of single fruit weight in percent increase over control, the highest value (55.26%) was recorded from T_4 treatment and the lowest value (2.63%) from T_1 treatment.

4.4.5 Healthy fruit yield

The highest healthy fruit yield (69.96 t/ha) was recorded from T_4 treatment which was statistically similar with other treatment except T_7 and T_1 treatment, whereas the lowest healthy fruit yield (57.32 t/ha) was recorded from T_7 which was statistically similar (60.74 t/ha) with T_1 treatment (Table 13). In consideration of healthy fruit yield in percent increase over control, the highest value (25.36%) was recorded from T_4 treatment and the lowest value (5.97%) from T_1 treatment.

Table 12. Effect of different management practices on total number and single fruit weight of bottle gourd

Treatments	Total number of fruits/plant	Percent increase over control	Single fruit weight (kg)	Percent increase over control
T_1	26.27 f	7.62	1.95 de	2.63
T_2	30.60 c	25.36	2.65 b	39.47
T_3	28.06 e	14.95	2.20 cd	15.79
T_4	32.54 a	33.31	2.95 a	55.26
T_5	29.67 d	21.55	2.35 c	23.68
T_6	31.47 b	28.92	2.85 ab	50.00
T_7	24.41 g	--	1.90 e	--
$LSD_{(0.05)}$	0.739	--	0.246	--
Level of significance	0.01	--	0.01	--
CV(%)	6.89	--	7.37	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 13. Effect of different management practices on total healthy and infested fruits in total cropping season

Treatments	Healthy fruit yield (t/ha)	Percent increase over control	Infested fruit yield (t/ha)	Percent decrease over control
T_1	60.74 bc	5.97	24.64 ab	4.16
T_2	64.35 abc	12.26	22.50 cd	12.49
T_3	63.91 abc	11.50	23.69 bc	7.86
T_4	69.96 a	25.36	19.45 e	24.35
T_5	65.14 ab	13.64	22.44 cd	12.72
T_6	66.89 ab	16.70	21.38 d	16.84
T_7	57.32 c	--	25.71 a	--
$LSD_{(0.05)}$	6.868	--	1.705	--
Level of significance	0.05	--	0.01	--
CV(%)	6.54	--	5.14	--

T_1: Mechanical and Cultural practices at 7 days interval; T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval; T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval; T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval; T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval; T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval; T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 2 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.4.6 Infested fruit yield

The highest infested fruit yield (25.71 t/ha) was recorded from T_7 treatment which was statistically similar (24.64 t/ha) with T_1 treatment, whereas the lowest infested fruit yield (19.45 t/ha) was recorded from T_4 which was followed (21.38 t/ha, 22.44 t/ha and 22.50 t/ha) with T_6, T_5 and T_2 treatment (Table 13). In consideration of infested fruit yield in percent decrease over control, the highest value (24.35%) was recorded from T_4 treatment and the lowest value (4.16%) was found from T_1 treatment.

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from September, 2017 to May, 2018 to assess the incidence and damage severity of different chewing insect pest and fruit fly on bottle gourd and their managements. The seeds of BARI Lau 4 were used as the test crop for this study. The experiments consists different management practices as treatment and they were T_1: Mechanical and Cultural practices at 7 days interval, T_2: Field sanitation + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval, T_3: Spraying Folithion 50 EC @ 1.12 ml/L of water at 7 days interval, T_4: Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval, T_5: Spraying Dizol 60 EC @ 1.0 ml/L of water at 7 days interval, T_6: Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval and T_7: Untreated control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on of identified different chewing pest/plot, number of healthy fruits, infested leaves/plot at vegetative and reproductive stage, healthy fruits, infested fruits and percentage of fruit in number and weight basis/plot, yield contributing characters and yield of bottle gourd were recorded and statistically significant variation was recorded for different management practices.

At vegetative and reproductive stage, red pumpkin beetle, epilachna beetle, green leaf eating caterpillar, cutworm, fruit fly and grasshopper were observed on different treatments. At vegetative stage, no red pumpkin beetle per plot were observed from T_4, whereas the highest number of red pumpkin beetle (8.00) was recorded from T_7 treatment. In case of epilachna beetle, no epilachna beetle were found from T_4 and T_6 treatment at vegetative stage, while the highest number of epilachna beetle (6.33) was observed from T_7 treatment. No green leaf eating caterpillar were observed from T_2, T_4 and T_6 treatment, whereas the highest number of green leaf eating caterpillar (4.67) was found from T_7 treatment. At vegetative stage no cutworm were observed from T_2, T_4 and T_6 treatment, while the highest number of cutworm (4.67) was found from T_7 treatment. In case of grasshopper at vegetative stage, no grasshopper were found from T_4 treatment, whereas the highest number of grasshopper (6.67) from T_7 treatment.

At reproductive stage, no red pumpkin beetle per plot were found from T_4 and T_6 treatment, while the highest number of red pumpkin beetle (7.33) was observed from T_7 treatment. For epilachna beetle, no epilachna beetle were recorded from T_4 and T_6 treatment at reproductive stage, while the highest number of epilachna beetle (6.00) was observed from T_7 treatment. No green leaf eating caterpillar were observed from T_4 and T_6 treatment, whereas the highest number of green leaf eating caterpillar (7.33) was found from T_7 treatment. At reproductive stage no fruit fly were observed from T_4 and T_6 treatment, while the highest number of fruit fly (7.33) was found from T_7 treatment. In case of grasshopper at reproductive stage, no grasshopper were found from T_4 and T_6 treatment, while the highest number of grasshopper (4.33) was found from T_7 treatment.

At vegetative stage, the lowest leaf infestation (3.49%) was observed from T_4 treatment, whereas the highest leaf infestation (15.56%) was recorded in T_7 treatment. In consideration of infestation reduction over control the highest value (77.57%) was recorded from T_4 treatment and the lowest value (47.56%) was found from T_1 treatment. At reproductive stage, the lowest leaf infestation (5.38%) was observed from T_4 treatment, whereas the highest infestation (15.02%) was recorded in T_7 treatment which was followed (9.15%) by T_1 treatment. In consideration of infestation reduction over control the highest value (64.18%) was recorded from T_4 treatment and the lowest value (36.68%) was found from T_1 treatment.

At early fruiting stage, the lowest fruit infestation (2.67%) in number basis was observed from T_4 treatment, whereas the highest infestation (10.65%) was recorded in T_7 treatment. In consideration of infestation reduction over control the highest value (74.93%) was recorded from T_4 treatment and the lowest value (30.05%) was found from T_1 treatment. At mid fruiting stage, the in number basis, the lowest fruit infestation (2.22%) was observed from T_4 treatment, whereas the highest infestation (10.15%) was recorded in T_7 treatment. In consideration of infestation reduction over control the highest value (78.13%) was recorded from T_4 treatment and the lowest value (13.60%) from T_1 treatment. At late fruiting stage, the lowest fruit infestation in number basis (3.13%) was observed from T_4 treatment, whereas the highest infestation (11.92%) was recorded in T_7 treatment. In consideration of infestation reduction over control the highest value (73.74%) was recorded from T_4 treatment and the lowest value (19.71%) from T_1 treatment.

At early fruiting stage, in weight basis, the lowest fruit infestation (4.40%) was observed from T_4 treatment, while the highest infestation (10.53%) was recorded in T_7 treatment. In consideration of infestation reduction over control in weight basis, the highest value (58.21%) was recorded from T_4 treatment and the lowest value (11.11%) was found from T_1 treatment. At mid fruiting stage, in weight basis, the lowest fruit infestation (5.97%) was observed from T_4 treatment, whereas the highest infestation (16.24%) was recorded in T_7 treatment. In consideration of infestation reduction over control in weight basis, the highest value (63.24%) was recorded from T_4 treatment and the lowest value (20.69%) was found from T_1 treatment. At late fruiting stage, in weight basis, the lowest fruit infestation (5.13%) was observed from T_4 treatment, whereas the highest infestation (14.54%) was recorded in T_7 treatment. In consideration of infestation reduction over control in weight basis, the highest value (64.72%) was recorded from T_4 treatment and the lowest value (20.91%) was found from T_1 treatment.

Statistically significant variation was recorded in terms of different yield attributes and yield of bottle sq gourd due to different management practices. The highest length of single fruit (55.91 cm) was recorded from T_4 treatment, while the lowest length of fruit (45.39 cm) was recorded from T_7 treatment. In consideration of length of single fruit in percent increase over control, the highest value (23.18%) was recorded from T_4 treatment and the lowest value (7.25%) was found from T_1 treatment. The highest girth of single fruit (25.00 cm) was recorded from T_4 treatment, while the lowest girth of fruit (20.97 cm) was recorded from T_7 treatment. In consideration of girth of single fruit in percent increase over control, the highest value (19.22%) was recorded from T_4 and the lowest value (0.67%) was found from T_1 treatment. The highest number of fruits/plot (32.54) was recorded from T_4, while the lowest number (24.41) was recorded from T_7 treatment. In consideration of number of fruits/plot in percent increase over control, the highest value (33.31%) was recorded from T_4 treatment and the lowest value (7.62%) was found from T_1 treatment.

The highest single fruit weight (2.95 kg) was recorded from T_4 treatment, while the lowest weight (1.90 kg) was recorded from T_7 treatment. In consideration of single fruit weight in percent increase over control, the highest value (55.26%) was recorded from T_4 treatment and the lowest value (2.63%) was found from T_1 treatment. The highest healthy fruit yield (69.96 t/ha) was recorded from T_4 treatment, whereas the lowest healthy fruit yield (57.32 t/ha) was recorded from T_7 treatment. In consideration of healthy fruit yield in percent increase over control, the highest value (25.36%) was recorded from T_4 and the lowest value (5.97%) was found from T_1 treatment. The highest infested fruit yield (25.71 t/ha) was recorded from T_7 treatment, whereas the lowest infested fruit yield (19.45 t/ha) was recorded from T_4 treatment. In consideration of infested fruit yield in percent decrease over control, the highest value (24.35%) was recorded from T_4 treatment and the lowest value (4.16%) was found from T_1 treatment.

CONCLUSION

From the above findings it can be concluded that among the treatments, T_4 (Mechanical control + Spraying Rogor 40 L @ 1.0 ml/L of water at 7 days interval) was considered as the best followed by T_6 treatment (Field sanitation + Spraying Proclaim 5 SG @ 1.0 g/L of water at 7 days interval) in respect of higher healthy fruit yield by reducing leaf and fruit infestation of bottle gourd.

RECOMMENDATIONS

Considering the findings of the present experiment, further studies in the following areas may be suggested:

1. This experiment may be conducted in different agro-ecological zones of Bangladesh for regional trial before final recommendation.

2. Other chemical with non-chemical components may be used for further study.

3. Integrated pest management practices may be introduced for effective control of insect pest complex of bottle gourd.

References

REFERENCES

Agarwal, M.I., Sharma, D.D. and Rahman, O. (1987). Melon fruit fly and its control. *Indian Hort.* **32**(2): 10-11.

Akhtaruzzaman, M., Alam, M.Z. and Sardar, M.A. (2000). Efficacy of different bait sprays for suppressing fruit fly on cucumber. Bulletin of the Institute of Tropical Agriculture, Kyushu University. **23**: 15-26.

Akhtaruzzaman, M. (1999). Identification and distribution of fruit cucurbits in Bangladesh. *Bangladesh J. Entomol*. **9**: 93-101.

Alam, M.Z. (1989). Pest of cucurbits vegetables. **In**: Insects-Pests of Vegetables and Their Control. Agricultural Information Service, Department of Agriculture, Dhaka, pp. 87- 110.

Amin, M.R. (1995). Effect of some indigenous materials and pesticides in controlling fruit fly *Bactrocera cncurbitae* Coquillet on cucumber. *M. S. Thesis*. Department of Entomology, Institute of Postgraduate Studies in Agriculture, Gazipur, Bangladesh. p. 56.

Anonymous. (1987). Comparative efficacy of bagging and trapping in controlling fruit fly, *Bactrocera cucurbitae* Coq. Attacking kakrol research report on fruit fly in cucurbits (1987-1988). Paper presented at the International Review Workshop held on August 28-30, 1988. Division of Entomology, BARI, Gazipur, Bangladesh. p. 17.

Anonymous. (1988). Melon Fly Eradication Project in Okinawa Prefecture. Akatsuki Pruning Ltd., Japan. p. 28.

Anonymous. (2001). Research and development of vegetables crops. Paper presented in the workshop on research and development of vegetable crops held on march 9-10, 2001 at IPSA, Gazipur, Bangladesh. pp. 1-7.

Atwal, A.S. (1986). Agricultural Pests of India and South-East Asia. Plant Protection Department. Punjab Agricultural University, Ludhiana, India. pp. 251.

Bagle, B.G. and Prasad, V.G. (1983). Effect of weather parameters on population dynamics of oriental fruit fly, *Dacus dorsalis* Hendel. *J. Entomol. Res*. **7:** 95-98.

BBS. (2016). Statistical Year Book of Bangladesh 2002. Bangladesh Bureau of Statistics (BBS). Planning Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka. P. 144

Bhowmik, S. and Saha, S. (2017). Study on the pest complex of bottle gourd in the gangetic plains of West Bengal. *J. Entom. Zool. Studies*. **5**(2): 725-727.

Borah, R.K. (1998). Evaluation of an insecticide schedule for the control of red pumpkin beetle and fruit fly of red pumpkin in the hills zone of Assam. *Indian J. Entomol*. **50**(4): 417-419.

Butani, D. and Jotwani, M. (1984). Insects in vegetables. Periodical Expert book Agency, Vivek- Vihar, Delhi (India). p. 29.

Cavalloro, R. (1983). Fruit Flies of Economic Importance. **In:** Cavalloro R. editor. CEC/IOBC Symposia, Athens, Greece 1982. Rotterdam: Balkema, Germany. p. 642

Chattopadhyay, S.B. (1991). Principles and Procedures of Plant Protection. 3rd Edition Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India. p. 584.

Chaudhary, R.N., (1995). Management of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) using polyethylene cages on cucumber. Pest Management in Horticultural Ecosystems, **1**(1): 55-57.

Dhillon, M.K., Naresh, J.S. and Sharma, N.K. (2005). Influence of physico-chemical traits of bitter gourd, *Momordica charantia* L. on larval density and resistance to melon fruit fly, *Bactrocera cucurbitae (Coquillett*). *J. Appl. Entomol*. **129**: 393-399.

Fletcher, B.S. (1987). The biology of Dacine fruit flies. *Annu. Rev. Entomol*. **32**: 115-144.

Ghatak, S.S., Reza, M.W. and Bhattacharjhya, M. (2005). Bio-efficacy of indigenous plant products on tobacco caterpillar, *Spodoptera littoralis* (F.) (Noctuidae: Lepidoptera). Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur 741 252. *India Env. Ecol*. **23**(4): 751-753.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2^{nd} edn.). *Intl. Rice Res. Inst., A Willey Int. Sci*., pp. 28-192.

Grist, D.H. and Lever, R.J.A.W. (1989). Pests of Rice. Published by Longmans, Green and Company Limited, London, Great Britain. pp. 139-140.

Haldhar, S.M., Choudhary, B.R., Bhargava, R. and Sharma, S.K. (2014) Development of an organic integrated pest management (IPM) module against insect-pests of muskmelon in arid region of Rajasthan, India. *J. Expt. Biol. Agric. Sci*., **2**(1): 19-24.

Hameed, S.F., Suri, S.M. and Kashyap, N.P. (1980). Toxicity and persistence of residues of some organophosphorus insecticides applied for the control of *Bactrocera cucurbitae* Coq. On fruits of cucumber. *Indian J. Agri. Sci.* **50**(1): 73-77.

Hill, D.S. (1983). Agricultural Insect Pests of the Tropics and their Control. 2^{nd} edn. Cambridge University Press, London. p. 746.

Hollingsworth, R. and Allwood, A.J. (2002). Melon fly. **In**: SPC Pest Advisory Leaflets. pp. 1-2.

Hollingsworth, R., Vagalo, M. and Tsatsia, F. (1997). Biology of melon fly, with special reference to the Solomon Islands. In: Allwood A.J. and Drew R.A.I. editors. Management of fruit flies in the Pacific. *Proc. Australian Ind. Agric. Res*. **76**: 140-144.

Islam, M.A. (1999). Integrated pest (Insects) management of vegetables. Consultancy, report, 18 November 1998 to17 May 1999. AVRDC-USAID Bangladesh project, Horticulture Research center, BARI, Gazipur-1701.

Kapoor, V.C. (1993). Indian Fruit Flies. Oxford and IBH Publishing Co. Ltd. New Delhi, India. p. 228.

Karim, M.A. (1995). Management of insect pests of vegetables. **In**: M.L. Chandha, K.U. Ahmed, S. Shanmugasundaram and A. Quasem 1995. (eds.) vegetable crops agribusiness. Proceeding of a workshop held at BARC, Dhaka, Bangladesh 2-4 May 1995.AVRDC, BARC, and BARI.

Kaul, B. (1987). *Calamun* oil using food acceptance, feeding ratio, weight gain and larval development as parameters in choice tests against *S. litura. Indian J. Entom.* **52**(2): 151-154.

Kevan, D.K.E. (1982). Orthoptera. In: Synopsis and Classification of Living Organisms (edited by S. P. Parker). New York: McGraw Hill.

Khan, L., Inayatullah, C. and Manzoor, U.H. (2012). Control of melon fly, *Dacus cucurbitae* (Diptera: Tephritidae) on melon in Pakistan. *Trop. Pest Manage*. **38**: 261-264.

Khan, M.A. and Mukhopadhyay, S. (1985). Studies on the effect of some alternative control methods on the incidence of yellow vein mosaic virus disease of Okra (*Abelmoschus esculentus*). *Indian J. Virol.* **12**(2): 69-72.

Khan, M.A., Inayatullah, C. and Mukhopadhyay, S. (1992). Studies on the alternative control methods on the incidence of yellow vein mosaic virus disease of Okra (*Abelmoschus esculentus*). *Indian J. Virol.* **12**(2): 69-72.

Khan, M.M.H. (2013). Biochemical composition of cucurbit leaves and their influence on red pumpkin beetle. *Intl. J. Res. Appl., Natural & Social Sci*. (IJRANSS). **1**(2): 131-138.

Khan, M.M.H., (2012). Host preference of pumpkin beetle to cucurbits under field conditions. *J. Asiatic Soc. Bangladesh*, **38**(1): 75-82.

Khan, M.M.H., Alam, M.Z. and Rahman, M.M. (2011). Host preference of red pumpkin beetle in choice test under net case condition. *Bangladesh J. Zool*. **39**(2): 231-234.

Khan, S.M. and Jehangir, M. (2000). Efficacy of different concentrations on seven dust against (*Aulacophora foveicollis* Lucas) causes damage To musk melon (*Cucumis melo L.*) crop. *Pakistan J. Biol. Sci*. **3**(1): 183-185.

Khan, S.M. and Wasim, M. (2001). Assessment of different plantextracts for their repellency against red pumpkin beetle (*Aulacophora foveicollis* Lucas.) on musk melon (*Cucumis melo* L.) crop. *J. Biol. Sci*. **1**(4):198-200.

Kristensen, N.P. (1995). Forty-years' insects phylogenetic systematics. Zool. Beitr. N.F. **36**: 83-124.

Kumar, S.N., Jeyabalan, D. and Murugan, K. (1997). Antifeeding and growth inhibiting effect of neem leaf exudates on *Spodoptera litura. Indian J. Entom.* **59**(2): 151-154.

Malathi, S., Sriramulu, M. and Babu, T.R. (1999). Evaluation of certain eco-friendly insecticides against lepidopterous pests of cabbage. Department of Entomology, College of Agriculture, Rajendranagar, Hyderabad-500030 (A.P), India. *Indian. J. Entomol.,* **61**(2): 127-133.

Mavi, G.S. and Bajwa, D.S. (1984). Comparative efficacy of some emulsifiable concentrates applied with "Fogair" for the control of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) on musk-melon. J. Entomol. Res. **8**(2): 167-170.

Mehmood, T. Khokhar, K.M. Hussain, S.I. and Laghari, M.H. (2006). Host preference of redpumpkin beetle, *Aulacophora* (Raphidopalpa) *foveicolis* (Lucas) among cucurbit crops. *SarhadJ. Agric*. **21**(3):473-475.

Mehta, P.K. and Sandhu, G.S. (1990). Monitoring of red pumpkin beetle (*Aulacophora foveicollis*) by cucurbitacins as kairomones through poison baits. *Indian J. Agric. Sci*. **60**(3): 225-226.

Miyatake, T., Irabu, T. and Higa, R. (1993). Oviposition punctures in cucurbit fruits and their economic damage caused by the sterile female melon fly, *Bactrocera cucurbitae* Coquillett. *Proc. Assoc. Plant Prot. Kyushu*. **39**: 102-105.

Munro, K.H. (1984). A taxonomic treatise on the Decidae (Tephritoidea: Diptera) of Africa. Entomological Memories of the Department of Agriculture, Republic of South Africa. *J. Entomol. Soc. South Africa*. **61**: 1-313.

Murthy, M.S., Jagadeesh, P.S. and Sannaveerappanavar, V.T. (2006). Evaluation of plant extracts for their repellent, antifeedant and ovicidal action against *Spodoptera litura* (Fab.) (Noctuidae : Lepidoptera). Department of Entomology, University of Agricultural Sciences, GKVK, Bangalore 560065. *India. Env. Ecol*. **24**(2): 293-297.

Muthusamy, S.K., Sivalingam, P.N., Sridhar, J., Singh, D. and Haldhar, S.M. (2017). Biotic stress inducible promoters in crop plants-a review. *J. Agric. Ecol*. **4**: 14-24.

Nasiruddin, M. and Karim, M.A. (1992). Evaluation of potential control measures for fruit fly, *Bactrocera (Dacus) cucurbitae* in snake gourd. *Bangladesh J. Entomol*. **2(**2**)**: 31-34.

Pareek, B.L. and Kavadia, V.S.C. (1988). Relative preference of fruit fly, *Dacus cucurbitae* Coquillett on different cucurbits. *Indian J*. **56**(1): 72-75.

Parle, M. and Kuar, S. (2011). Is Bottle Gourd A Natural Gourd? *Intl. Res. J. Pharmacy*. **2**(6): 13-17.

Pawar, D.B., Jony, M.B. and Sonone, H.N. (1984). Chemical control of red pumpkin beetle and fruit fly of musk melon by modern insecticides. *South Indian Hort*. **32**(5): 317-318.

Rajagopal D. and Trivedi, T. P. (1989). Status, bioecology and management of Epilachna beetle, *Epilachna vigintioctopunctata* (Fab.) (Coleoptera: Coccinellidae) on potato in India: *A review, Tropical Pest Management*, **35**(4): 410-413.

Ramphall and Gill, H. S. (1990). Demand and supply of vegetables and pulses in South Asia. **In**: Vegetable Research and Development in South Asia. S. shanmugasundaram (ed). Proe. Workshop held at Islamabad, Pakistan on 24-29 September, 1990. AVRDC Publication No: 90.331, AVRDC, Tainan, Taiwan.

Rao, G. R., Raghavaiah, G. and Nagalingam, B. (1993). Effect of botanicals on certain behavioral responses and on the growth inhibition of *Spodoptera litura* F. *Bot. Pesticides in Integ. Pest Manag.* **13**: 175-182.

Rashid, M. (1993). Vegetables Science (Sabji Bighan) (in Bengali), Bangla Academy, Dhaka. pp. 33-254.

Roy, D.C. and Pande, Y.D. (1990). Host preference and feeding rate of red pumpkin beetle (*Aulacophora foveicollis*) in Tripura. *Indian J. Agric. Sci*. **62** (2): 408-410

Sharaby, A. (1988). Evaluation of some Myrtaceae plant leaves as protectants of rice against the infestation of *Sitophilus oryzae* L. and *Sitophplis granaries* (Coleoptera). *Polskie-Pismo-Entomologiczne.* **59:** (2) 372.

Sharma, B.L., Kulkarni G.G., Ashok, K. and Kumar, A. (1999). Effect of host plants and neem oil on food utilization indices of *Spodoptera litura* (Fab.). *J. Agril Biol. Res*. **4**(1): 37-40.

Singh, R.R. and Srivastava, B.G. (1985). Alcohol extract of neem (*Azadiracta indica*. Juss.) seed oil as oviposition deterrent for *Dacus cucurbitae* Coq. *Indian J. Entomol.* **45**(4): 497-498.

Singh, S.B., Singh, H.M. and Singh, A.K. (2000). Seasonal occurrence of fruit flies in Eastern Utter Pradesh. *J. Appl. Zool. Res*. **18(**2**)**: 124-127.

Stark, J.D., Vargas, R.I. and Thalman, R.K. (1990). Azadirachtin: effect on metamorphosis, longevity and reproduction of three tephritid fly species (Diptera: Tcphritidae). *J. Econ. Entomol*. **83**(4): 2168-2174.

Thomas, C. and Jacob S. (1994). Bio-efficiency of carbofuran against the epilachna beetle, *epilachna punctata* Fab. Infesting bitter gourd (*Momordicacha rantia* L.) under field and laboratory conditions. *Indian Entomol*. **53**: 435-441.

Tofael, A. (2004). Damage severity of *Spodoptera litura* (Fab.) on bottle gourd. *J. Asiatic Soc. Bangladesh Sci.* **16** 71-74.

Umar, S., Anjana, A.N.A. and Khan, N.A. (2013). Nitrate management approaches in leafy vegetables. Nitrate in leafy vegetables: toxicity and safety measures. IK International Publishing House Pvt. Ltd, New Delhi, pp. 166-181.

Vijaysegaran, S. (1987). Combating fruit fly problem in Malaysia. The current situation and strategies to overcome the existing problems. Plant Quarantine and Phytosanitary Barriers to Trade in the ASEAN, Selangor, Malaysia. *ASEAN Plant Quarantine Center and Training Institute OE Review of Applied Entomology*. 9-12 December, 1986. pp. 209-216.

Weems, H.V. Jr., Heppner, J.B. (2001). Melon fly, *Bactrocera cucurbitae* Coquillett (Insecta: Diptera: Tephritidae). Florida Department of Agriculture and Consumer Services, Division of Plant Industry, and T.R. Fasulo, University of Florida. University of Florida Publication EENY-199.

Williamson, D.D. (1989). Oogenesis and Spermatogenesis. In: Fruit flies. Robinson and Hoppers. p. 141.

Yamaguchi, T.P. (1983). Percent losses are obvious from the percent damage by Red Pumpkin Beetle. *Insect Sci. Appl.* **6**(1): 75-78.

York, A. (1992). Pest of cucurbit crops. Marrow, pumpkin, squash, melon and Cucumber. In: Vegetable Crops Pests. R.G. Mc. Kinlay (Eds.). Mc. Millan Press. London. pp. 139-161.

Anam, M., Ahmad, M. and Haque, M.A. (2006). Efficacy of neem oil on the biology and food consumption of epilachna beetle, Epilachna dodecastigma (Weid). *J. Agric Rural Dev*., **4**: 132-136.

Halder, J. and Srinivasan, S. (2011). Varietal screening and role of morphological factors on distribution and abundance of spotted pod borer, *Maruca vitrata (Greyer) on cowpea. Ann. Plant Prot. Sci.,* **19**(1): 71-74.

Rahaman, M.A. and Prodhan, A.U. (2007). Effect of net barrier and synthetic pesticides on *A. foveicollis* and reported zero infestation in case of net barrier and lowest infestation by the use of carbofuran. *J. Agric Rural Dev*. **5**: 45-51.

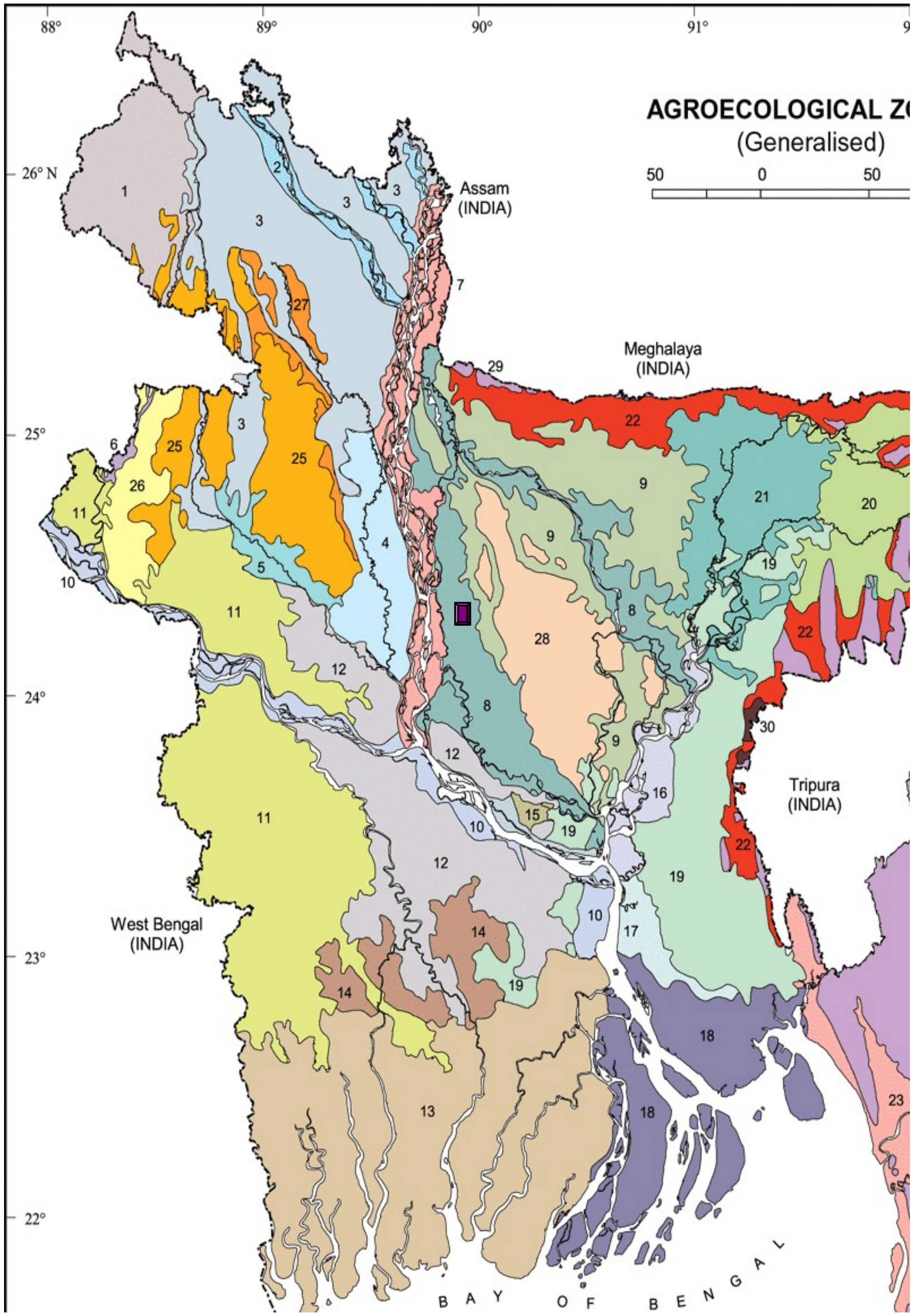
Rahaman, M.A., Prodhan, A.U. Nasir, Y.P. (2008). Economically important crops belonging to solanaceous and cucurbitaceous groups. *J. Econ. Entomol*. **112**(4): 123-129.

Sharm, T.P. and Saxena, A.S. (2012). Epilachna beetle of solanaceous and cucurbitaceous vegetable crops. *Annl. Plant Prot. Sci.* **21**(1): 71-74.

Appendices

APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from September 2017 to April 2018

Month	Air temperature (ºc)		Relative humidity (%)	Total Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
September, 2017	33.7	22.6	82	234	6.8
October, 2017	26.6	19.5	79	34	6.5
October, 2017	25.1	16.2	77	12	6.7
December, 2017	22.6	13.4	67	00	6.6
January, 2018	24.9	12.2	70	07	5.8
February, 2018	27.7	16.9	69	30	6.7
March, 2018	31.4	19.6	72	18	8.4
April, 2018	34.4	23.1	79	128	8.3

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1212

Appendix III. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture farm field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Sandy loam
pH	5.9
Catayan exchange capacity	2.64 meq 100 g/soil
Organic matter (%)	1.15
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45