# BIORATIONAL MANAGEMENT OF CUCURBIT FRUIT FLY ON SWEET GOURD BY USING SOME NEW GENERATION INSECTICIDES

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# *CERTIFICATE*

*This is to certify that thesis entitled,* **"BIORATIONAL MANAGEMENT OF CUCURBIT FRUIT FLY ON SWEET GOURD BY USING SOME NEW GENERATION INSECTICIDES"** *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 (MS) in*** **ENTOMOLOGY**, *embodies the result of a piece of bona-fide research work carried out by* **NAZNIN NAHAR**, *Registration No.* **14-06003** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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## ABSTRACT

The experiment was carried out in the central farm of Sher-e-Bangla Agricultural University, Sher- e-Bangla Nagar, Dhaka to find out biorational management of cucurbit fruit fly on sweet gourd by using some new generation insecticides during rabi season from November, 2019 to April, 2020. There were five treatments *viz*, $T_1$=Fytomax 3 EC @ 1 ml/L of water, $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha, $T_3$= Bait trap + Success 2.5 SC @ 650 ml/ha, $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice), $T_5$ = Untreated control. All treatments were applied at 7 days interval.The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Among the treatments, Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha showed the best performance in controllingcucurbit fruit fly. The highest yield (37.44 t/ha), the healthy fruits (34.21 t/ha) and lowest infested fruit (3.23 t/ha) were obtained from the treatments $T_2$ followed by treatments $T_1$. The lowest percent fruit yield (18.37 t/ha) healthy fruit (12.04), and highest infested fruit (6.33 t/ha) were obtained from $T_5$(untreated control). The use of Pheromone trap (Cuelure) + Success 2.5 SC could be effectively utilized in the cucurbit fruit fly management.

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# CHAPTER I

# INTRODUCTION

Sweet gourd (*Cucurbita moschata*) is one of nature's most outstanding fruits, containing all the essential nutrients that are required for maintaining good health. It is rich in various phytoconstituents including flavonoids, alkanoids, oleic acid, palmitic acid and linoleic acid (Yadav *et al*., 2010). It is the most popular and principal vegetables among the 118 genera and 825 species of the family Cucurbitaceae (Rai and Kumar, 2008). Sweet gourd grows well in tropical to temperate regions worldwide. Now-a-days, sweet gourd is extensively cultivated commercially in Bangladesh also grown in homestead as a field crop both in summer and winter seasons though bulk of its production is obtained during winter season. It is available in the market throughout the year. Both the cultivable land and production is increasing frequently throughout the recent years. The total cultivable land for sweet gourd production was 26383 acres in summer season and 43171 acres in winter season with total annual production of 310892MT (BBS, 2020). Although all vegetables cannot be grown in Kharif season due to climatic condition, cucurbitaceous vegetables play an important role to supplement this shortage during the lag period (Rashid, 1993). It is available in the market throughout the year. Among the cucurbits, sweet gourd is the best and has the highest monetary value. Sweet gourd is profoundly cross-pollinated, monoecious and vine crop (Katyal and Chans, 1985).

The agro-ecological conditions of Bangladesh are primarily conducive for growing cucurbit vegetables but there are numerous constraints to increasing cucurbit vegetable production in a sustainable way. Insect pests are the main constraints of cucurbit production due to their persistent attack which leads to significant losses in yield. Their attack not only reduces the yield but also affect on fruit quality and make them unfit for consumption and nonprofitable for commercial farming. Insect pests out breaks which is intensify by poor management practices. Sweet gourd is infested by a wide range of cucurbitaceous and noncucurbitaceous

insect pests such as, cucurbit fruit fly (*Bactrocera cucurbitae*), red pumpkin beetle (*Raphidopalpa foveicollis*), epilachna beetle (*Epilachna spp.*), thrips (*Thrips spp*.), cutworm (*Agrotis ipsilon*), aphid (*Aphis gossypii*) and whitefly (*Bemisia tabaci*). Among them cucurbit fruit fly *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae), is a devastating pest of different cucurbit vegetables in many parts of the world which may cause more than 60% yield loss (Kapoor, 1993). Cucurbit fruit fly which causes damage to all cucurbits and its infestation level ranges from 20 to 100% depending on the cucurbitaceous species, climatic region, and cultivation season (Sapkota *et al*., 2010). The severity of insect pest infestation varies from year to year, season to season and location to location. The yield losses due to fruit fly infestation may vary in different vegetables and its minimum in ridge gourd 21% and maximum in sweet gourd 71% (Amin *et al*., 2011).

Adult female infestation was more prevalent in young, green, tender and skinned fruit. The female flies cause direct damage to fruit by puncturing the skin to lay eggs. During egg laying, bacteria from the intestinal flora are introduced into the fruit. After egg hatching, maggots feed on the flesh fruits. They facilitate entry for microorganism and increase the fruit decay, making fruits unsuitable for human consumptions and unfit for marketable.

Management of this insect is extremely difficult because of its internal feeding behavior. Presently, the vegetable growers in Bangladesh are completely reliant on the use of chemical pesticides of different groups like organophosphate, carbamate, pyrethroids, nicotinoids to control this pest. However, the indiscriminate use of synthetic insecticides has many drawbacks such as development of resistance by the target insects, high pesticide residues, pest resurgence, secondary pest outbreaks, ecological imbalance and health hazards of the pesticide applicator (Tahir *et. al*., 2011). Use of biopesticide products have many potentialities such as non-toxic to non-target species, moderate residual effect, long lasting activity, eco-friendly and are safer for farmers. Several microbial derivative biopesticides are available in the local market of

Bangladesh. Therefore, the study was conducted to develop an environment friendly and biorational based management against cucurbit fruit fly of sweet gourd.

The present study has been conducted to accomplish the following objectives-

- To know the infestation level of cucurbit fruit fly on sweet gourd during the growing season.
- To identify the effectiveness of biorational insecticides against cucurbit fruit fly.
- To reduce the use of chemical pesticide in sweet gourd production.

# CHAPTER II

# REVIEW OF LITERATURE

The cucurbit fruit fly, *Bactrocera cucurbitae* (Coquillett) is one of the most devastating insect pest of different cucurbit vegetables in many parts of the world. For controlling cucurbit fruit fly, it is necessary to have a concept of the origin and distribution, host range, seasonal abundance, life cycle and nature of damage of this pest. Management of this pest is very difficult because of its internal feeding behavior. Farmers mainly use chemical insecticides to control cucurbit fruit fly. So, information related to biorational management of cucurbit fruit fly is very scanty. Some of the important and informative works and research findings related to the biorational management of cucurbit fruit fly so far been done at home and abroad have been reviewed in this chapter under the followings sub-headings.

## 2.1 Taxonomic Tree of Cucurbit Fruit Fly

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

**Synonyms**

*Bactrocera cucurbitae* (Coquillett) is also known as:

i. *Chaetodacus cucurbitae*
ii. *Dacus cucurbitae*
iii. *Strumeta cucurbitae*
iv. *Zeugodacus cucurbitae*

## 2.2 Origin and Distribution of Cucurbit Fruit Fly

The fruit fly is distributed worldwide but India is considered to be its native habitat. *Bactrocera cucurbitae* was first discovered in Hawaii in the year 1890 (Meyer *et al*., 2007). In 1984, *Bactrocera cucurbitae* was detected for the first in Solomon Islands and now widespread in all the provinces except Makira, Rennell, Bellona and Temotu (Eta, 1985). The distribution of this species was mapped by Drew in 1982.Although it is found in Hawaii, it is absent from the continental United States (Weems and Heppner, 2001).

According to Meyer *et al*. (2007) *Bactrocera cucurbitae* is found in several countries in East and West Africa including Benin, Gambia, Ivory, Nigeria, Senegal, Kenya, Sudan, Uganda, and Tanzania. However, this pest is widely distributed in India, Pakistan, Myanmar, Nepal, Malaysia, China, Philippines, Taiwan, Japan, Indonesia, East Africa, Australia, and Hawaiian Island (Atwal, 1993).

Akhtaruzzaman *et al*. (2000) reviewed that *Bactrocera cucurbitae, Bactrocera tau* and *Bactrocera ciliates* have been currently identified in Bangladesh of which *Bactrocera ciliates* is a new record. *Bactrocera cucurbitae* is dominant in all the locations of Bangladesh followed by *Bactrocera tau* and *Bactrocera ciliates.*

## 2.3 Host Preferences

Fruit flies are considered the most destructive insect pests of fruit and vegetables in the world (Ekesi *et al*., 2009). Fruit fly is a polyphagous insect pests that infests over 125 plants including members of cucurbitaceae family (Weems, 1964). Based on the extensive surveys carried out in Asia and Hawaii, plants belonging to cucurbitaceae family are most favored (Allwood *et al*., 1999). Alam (1962) recorded ten cucurbit vegetables as hosts of fruit fly in Bangladesh. Doharey (1983) found that it infests over 70 host plants among which bitter gourd (*Momordica charantia*), muskmelon (*Cucumis melo*), snap

melon (*Cucumis melo* var. *momordica*) and snake gourd (*Trichosanthes asguina* and *T. cucumeria*) are the most preferred hosts. Tropical almond, African wild mango, vitello and seanut are important wild hosts with high rate infestations (Goergen *et al*., 2011). Kabir *et al*. (1991) found that 16 species of plants act as the host of fruit flies among which sweet gourd was the most preferred host of both *B. cucurbitae* and *B. tau*.

Pandey et al. (2008) reported that more than 100 plant species have been recorded as hosts of melon fly spread throughout the world. It infests the cucurbitaceous and solanaceous (tomatoes and peppers) crops.

In Tanzania, Mwatawala et al., (2010) revealed that *Bactrocera cucurbitae* utilizing 19 hosts to be polyphagous of which 11 belongs to cucurbitaceae family. Pointed gourd were damaged by *Bactrocera cucurbitae* and limiting the crop production (Jha *et al*., 2007).

In Bangladesh, fruits of melon, sweet gourd, snake gourd, cucumber, ivy gourd, luffa, bitter gourd etc. are infested by fruit fly (Saha *et al*., 2007).

## 2.4 Seasonal Abundance

The population of *Bactrocera cucurbitae* was observed throughout the year (Agrawal *et al*., 1987). The peak activity of *Bactrocera cucurbitae* was reported from third week of September to last week of October (Banerji *et al*., 2005). Seasonal variations in weather factors play a vital role in the growth, development reproduction and distribution of insects and influences their population dynamics and infestation rates (Namini *et al*., 2017). Among the weather parameters, minimum temperature had a significant negative impact of fruit fly populations while maximum temperature, relative humidity, rainfall and sunshine were not significantly associated with the fruit fly populations (Ganie *et al*., 2013). Khan et al. (2003) reported that rainfall showed to have the greatest effect on fruit fly dynamics. Fruit flies showed fluctuations in their

abundance on sweet gourd and caused higher infestation in summer than winter (Amin *et al*., 2019).

Sujit (2005) revealed that the population of fruit fly fluctuates throughout the year and the abundance of fruit fly population varies from month to month, season to season, even year to year depending upon various environmental factors. Fruit fly abundance increases when the temperature falls below 32℃ and relative humidity ranges from 60% to 70% (Sapkota *et al*., 2010).

Raghuvanshi *et al*. (2012) reported that a significant correlation of *Bactrocera cucurbitae* population with maximum and minimum temperature. Maximum temperature had a negative correlation whereas evening relative humidity had positive correlation with fruit fly infestation (Shinde *et al*., 2018).

Ghule *et al*. (2015) reported that rainfall positively influenced the population of fruit fly infesting ridge gourd.

## 2.5 Nature of Damage

Fruit fly is a serious pest causes destructive damage to cucurbits which leads to considerable reduction of yield, quality and marketable value. In Hawaii, pumpkin and squash are heavily damaged even before fruit set. The eggs are laid into unopened flowers and the larvae successfully developed in the taproots, stems and leaf stalks (Weems and Heppner, 2001). Female fruit fly deposits eggs beneath the skin of the fruit and the maggot developed inside the fruit feed on the inner pulp and they cause up to 71.5% of fruit infestation on sweet gourd in Bangladesh (Amin *et al*., 2011).

Larval feeding in host tissues is the most damaging and the damage usually consists of tissues breakdown and internal rotting (Plate 4). The feeding damage of fruit fly larvae destroy the pulp and allowing the entry of bacteria, fungi and causes premature fruit drop and reduce the quality of production (Sarwar, 2015).

According to Singh (1984), the maggots bore and feed inside the fruit causing discolored patches, distortion and open cracks. Affected fruits prematurely ripe and drop from the plants. These cracks on fruits helps to cause pathogenic infection resulting in fruit decomposition. Kapoor (1993) reported that some flies make gall on different parts of the plant. The damage of crops caused by melon flies result from oviposition in fruit and soft tissues of hosts, feeding by the larvae and decomposition of plant due to invading secondary micro-organisms (Ronald, 2003).

The fruit flies damage fruits and vegetables by laying eggs under the skin. The eggs hatch into the larvae feeding in the decaying flesh of the fruits and vegetables quickly, become rotten and inedible or drop to the ground prematurely which causes considerable losses in production (Hollingsworth *et al*., 1997).

## 2.6 Yield Loss Caused by Cucurbit Fruit Fly

Fruit flies *Bactrocera cucurbitae* (Coquillett) attack the fruits of crop and the extent of losses caused by them varied from 30.0% to 100.0% depending on cucurbit species and season (Gazmer *et al*., 2017). During the crop season, melon fruit fly causes 20%-70% damage to the crop but in epidemic forms, it destroys the whole crop (Rahman, 1994). The damage caused by fruit fly is the most serious in melon after the first shower in monsoon when it often reaches up to 100%. Others cucurbit might also be infested and the infested might be gone up to 50% (Atwal, 1993).

These flies can infest various cucurbit crop species in different seasons and the infestation rates rising from 30% to 100% and they can heavily reduce both yield and quality of fruits (Nath and Bhusan, 2006).

Sapkota *et al*. (2010) has been reported that cucurbit fruit fly preferred young and immature fruits and resulted in a loss of 9.7% female flowers, more than one-fourth (26%) fruits were dropped or damaged just after set and 14.04%

fruits were damaged during harvesting. Depending on the environmental conditions and susceptibility of the crop species, the extent losses varies between 30%-100% (Dhillon *et al*., 2005).

## 2.7 Life Cycle

The management of fruit fly is challenging because their life stages occur at different sites and remain protected eg. Eggs, larvae in the host, pupae in soil and adults are active flier. The life cycle from egg to adult requires 14-27 days. Mukherjee *et al*. (2007) studied the life history of *Bactrocera cucurbitae* on sweet gourd and reported pre-oviposition, oviposition, incubation, larval and pupal periods. Adult male and female longevity 11.25, 9.75, 0.81, 12.25, 7.75, 18.25 and 23.50 days respectively.

Rahman *et al*. (2005) reported that the cucurbit fruit fly eggs laid singly or in cluster, they were creamy, white, slightly curved, elongated and tapering towards the ends. Freshly laid eggs were on an average 0.78 mm in length and 0.16 mm in width. The first instar larvae were apodous white translucent a bit flattened dorsoventrally and length 1.48 mm and width 0.26 mm. The average length of second instar larva was 5.2 mm and width 0.84 mm. The length of third instar larva was 8.8 mm and width 1.52 mm. The average length and width of pupa was 4.22 mm and 1.76 mm respectively. The adult male was 13.78 mm long and width was 7.06 mm whereas adult female was 15.62 mm long and 8.86 mm in width. The mean incubation period, larval period were 21.3 days and 27.67 days respectively. The life cycle from egg to adult requires 14-27 days.

Sohrab *et al*. (2018) reported that the range of pre-oviposition, oviposition, incubation period, larval period, pupal period and adult (male and female) longevity 10-15, 12-28, 1-15, 4-6, 9-10, 12-15 days respectively.

Mir *et al*. (2014) studied on biology of melon fruit fly *Bactrocera cucurbitae* and revealed that the freshly laid eggs were glistening white, slightly curved,

tapering on one end round on another end. The length of egg, larvae, pupa and adult male and female varied from 0.98 to 1.28,1.17 to10.66,5.46 to 5.9, 8.05 to8.74 and 9.50 to 10.12 mm respectively. The breadth of egg, larvae, pupa and adult male and female varied from 0.21-0.34 mm, 0.22-2.72 mm, 2.32-2.68mm, 10.0-12.69 mm and 14.88-16.90 mm respectively. Pre-oviposition and oviposition period ranged from 10 to 15 days and from 12 to 28 days respectively. Longevity of adults was extended 30-32 days for males and 30-60 days for females.

Patel and Patel (2018) reared *Bactrocera cucurbitae* in different cucurbitaceous vegetables *viz*, bitter gourd, bottle gourd, water melon. The significant differences were observed in the life cycle of the pest. Egg, larval period and pupal period varied from 1-3 days, 7-10 days, and 5-11 days. The entire life cycle from egg to adult requires 28-42 days for female and 22-37 days for male.

## 2.8 Management of Cucurbit Fruit Fly

Cucurbit fruit fly is the main pest that causes significant economic damage to cucurbits. It is critical to control the pest outbreak. Typically, farmers use chemical insecticides to control this pest, but they fail because larvae grow within the fruit and feed on internal content resulting in insect resistance. Fruit fly management is to reduce the yield loss and enhance fruit quality by eliminating adult fruit fly and maggot in fruits and vegetables. These are several management methods practiced in the world based on economic resources and its availability in the market.

### 2.8.1 Field Sanitation

Field sanitation is an essential prerequisite to reduce the insect population or differ the possibilities of the appearance of *epipphytotics* or *epizotics* (Reddy and Joshi, 1992). According to Kapoor (1993), the infested fruits on the plat or

fallen on the ground should be collected and buried deep into the soil or cooked and fed to animals.

### 2.8.2 Management with Pheromone Trap

Pheromones are volatile chemical compounds secreted by insects or other animals to communicate with other individuals of the same species. Pheromone is naturally occurring substance, they are environmentally safe, target specific and effective at incredibly low concentrations. Sex pheromones have been utilized in the insect pest control program through population monitoring survey, mass trapping, mating disruption and killing the target pest into the trap (Bottrell, 1997). Sex pheromone trapping techniques have become widespread alternative methodologies for managing pests especially Lepidopteran and Dipteran (fruit fly) insects (Islam and Ando, 2012).

Thomas *et al.* (2005) evaluated two Parapheromones *viz* Cuelure and methyl eugenol to attract *Bactrocera cucurbitae* in bitter gourd field and found that melon fruit fly were attracted to only cuelure traps.

The use of pheromone lure was considered most practical management measures followed by use if botanical (Adhikari *et al*., 2020). Sarker *et al* .(2017) reviewed that the highest no. of files was recorded in sex pheromone trap at mid fruiting stage of bitter gourd.

Methyl eugenol and cue-lure traps have been reported to attract *Bactrocera cucurbitae* males from mid-July to mid-November (Zaman, 1995).

According to Vargas *et al.* (2000) methyl eugenol and cuelure were highly attractive kairomone lures to oriental fruit fly *Bactrocera dorsalis* and melon fly *Bactrocera cucurbitae* respectively. Vargas *et al*. (2009) evaluated various traps with methyl eugenol and cuelure for capturing fruit flies and observed that *Bactrocera dorsalis* was captured in methyl eugenol traps and *Bactrocera cucurbitae* in cuelure traps.

Rakshit *et al*. (2011) assessed the economic benefits of managing fruit fly infesting sweet ground using pheromones. A pheromone called cuelure

imported by the BARC used for suppressing fruit fly infesting sweet ground. Analysis of the potential benefits of farmers adopting cuelure technology projects benefits over 15 years range from 187m Tk to 428m Tk depending on assumptions.

Singh *et al*. (2007) tasted sex attractant methyl eugenol cuelure and food attractant protein hydrolysate for attraction to fruit files and reported the five fly species *viz Bactrocera zonata, Bactrocera affinis, Bactrocera dorsalis, Bactrocera correcta* and *Bactrocera diversa* (Coquillett) were attracted to mythyl eugenol traps two species viz *Bactrocera cucurbitae* and *Bactrocera nigrotibialss* (perkins) to cuelure traps.

Chakraborty *et al*. (2019) studied the performance of different management strategies against fruit fly *Bactrocera cucurbitae* (Coquillett) infesting bitter gourd and revealed that frequently lowest number of maggots, fruit infestation and highest fruit yield as compared to other treatments was recorded in the treatment with the pheromone traps @25/ha + gur based poison bait trap (5 ml Malathion 50E C + 200 g gur + 2 L water).

Hossain *et al*. (2019) showed that the highest fruit yields was obtained from treatments sex pheromone trap + poison bait + sanitation (16 spot) and lowest fruit yield was obtained from farmers' practice.

### 2.8.3 Management with Chemical Insecticide

Farmers of Bangladesh are entirely depend on different kinds of broad spectrum chemical insecticides like carbamate, organophosphorus, nicotinoids, pyrethroids etc. groups to control cucurbit fruit fly. The bio-efficacy of the insecticides revealed that significantly lowest number of ovipositional punctures, maggot, fruit infections, highest marketable fruit yield and more cost benefit ratio was recorded in the treatment with Spinosad 45 SC (15 ml/L) during kharif and summer season (Srinivas *et al*., 2018).

Gazit and Akvia (2017) revealed that three sprays of Spinosad 45 SC @ 200 mL/ha alone at interval 12 days was most effective against fruit fly infesting

cucumber. Kakani *et al*. (2010) reported that Spinosad had used science 2004 to control olive fruit fly *Bactrocera oleae* in California and Hawaii. Bhowmik *et al* .(2014) found that the most effective treatment in reducing the fruit infestation by melon fruit fly was spinosad against all other treatments in pre-kharif season.

Nasiruddin and Karim (1992) reviewed that comparative less fruit fly infestation 8.56% was recorded in snake gourd spray with Dipterex 80SP compared to those in untreated plot (22.48%).

Oke and Sinon (2013) reported that, ecofriendly insecticides like malathion with molasses and cypermethrin, applied one after another as per schedule resulted in minimum fruit damage dichlorvos, phosphamidon and endosulfun are moderately effective against the melon fruit fly (Agarwal *et al*., 1987).

# CHAPTER III
# MATERIALS AND METHODS

The present study was conducted to evaluate "Biorational Management of Cucurbit Fruit Fly on Sweet Gourd by Using Some New Generation Insecticides" during the period from November 2019 to March 2020. A concise description of the experimental site, soil and climate, experimental design, planting materials, land preparation, manure and fertilizer application, treatments, cultural practices, data collection and analysis of different parameter were used for conducting the experiment are presented under the following subheadings:

## 3.1 Experimental Site

The experiment was carried out at the Sher-e-Bangla Agricultural University research field Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh which is situated at 23.74°N latitude and 90.35°E longitude and an elevation of 8.2m above sea level (Plate 1).

## 3.2 Soil and Climate

The soil type of the experimental area was shallow Red Brown Terrace and belongs to the Madhupur Tract Agro-ecological zone (AEZ No. 28) (Appendix I) with pH 5.8-6.5, CEC-25-28. The analytical data of the soil sample collected from the experimental area were determined by Soil Resources Development Institute, Farmgate, Dhaka (Appendix II). The climate of experimental area was subtropical. Meteorological data during experimental area was collected from Bangladesh Meteorological Department (Climate and Weather Division), Agargaon, Dhaka (Appendix III).

## 3.3 Experimental Design

The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The area was divided into three blocks. Each block was divided into five plots for treatments. The size of unit plot was 3m

long and 2.8m broad. The distance maintained between block to block and row to row 1m and 0.5m respectively.

### 3.4 Planting Materials

*BARI Mistikumra-2* seeds were used as a test crop under this report.

### 3.5 Seed Source

The seeds of *BARI Mistikumra-2* were collected from Vegetable division, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

### 3.6 Land Preparation

The experimental plot was cross-ploughed several times by power tiller and labeled prior to seed sowing. Weeds and stubbles were removed from the field during land preparation. The experimental plot was divided into unit plot according to experimental design. Two pits of 30cm x 30cm x 30cm size were dug in each plot with a rectangular arrangement. Basal doses of Cowdung, Urea, TSP, MoP, Gypsum were mixed with the soil of experimental plot.

### 3.7 Seed Sowing

Seeds were sown at depth of 2cm and covered with a fine layer of soil followed by light watering using water can on 08 November 2019. Before sowing, the seeds were treated with Vitavex 200@ 2g / kg of seed.

### 3.8 Manures and Fertilizers

Manures and fertilizers and its methods of application:

| Manures and Fertilizers | Quantity | Application Method |
|---|---|---|
| Cowdung | 20 ton / ha | Basal dose |
| Urea | 175 kg/ ha | 25, 45, 60,75 DAS |
| TSP | 175 kg/ ha | Basal dose |
| MoP | 150 kg/ ha | 25 DAS |
| Gypsum | 100 kg/ ha | Basal dose |

(*Krishi Prajukti Hatboi, 2019)*

### 3.9 Treatments

$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ha

$T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha

$T_3$ = Fytomax 3 EC @ 1 ml/L of water

$T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice)

$T_5$= Untreated control

### 3.10 Cultural Practices

Necessary cultural practices were done during cropping season for better growth and development of sweet gourd plants and to obtain desirable output of the experiment.

#### 3.10.1 Gap Filling

After germination, dead, injured and week seedlings were replaced by new healthy seedlings having a ball of earth.

#### 3.10.2 Weeding

Weeding were carried out manually at 15, 30 and 45 DAS to keep the field free from weeds.

### 3.10.3 Earthing Up

Earthing up was done at 30 and 50 DAS.

### 3.10.4 Irrigation

Light irrigation was provided immediately after seed sowing. Then it was provided at 2 to 3 days interval after seed germination for proper growth and development of seedlings.

### 3.10.5 Disease control

Thiovit 80WG @ 2.25 kg/ha was sprayed to control Powdery mildew disease in the crop field.

### 3.10.6 Harvesting

Harvesting was started from 8 March 2020 when the fruit reached at marketable size. The fruits were collected by hand picking method (Plate 5&6).

## 3.11 Preparation of Pheromone Trap and Bait Trap

### 3.11.1 Pheromone Trap

The pheromone trap was made from rectangular plastic container with triangular cutting. A small piece of cotton ball was soaked with 5 to 6 drop of cuelure. Then it was hanged inside the container within wire. Water containing detergent should be maintained in the container. After 7 days cotton ball was replaced by new ones. Pheromone trap dispenser should be maintained throughout the cropping season (Plate 2).

### 3.11.2 Bait Trap

Bait trap with MSG: The poison bait trap was prepared with a 100g mashed sweet gourd, Sevin 50WP @ 2g mixed with 100ml of water and it was developed by Bangladesh Agricultural Research Institute (BARI). Freshly prepared bait in a small earthen pot were placed at 50 cm above the ground level with the help of bamboo supports. Used bait materials were replaced by freshly prepared baits at 3 to 4 days interval to attract more cucurbit fruit fly. It was placed in the center of the selected plots (Plate 3).

### 3.12 Data Collection

Data were recorded just before the application of treatments in the field for the evaluation of different management practices. Data were recorded at 7 days interval. The entire reproductive period of sweet gourd was split into three stages early, mid and late stages. First flower initiation to 14 days was treated as early stage, 14 to 28 days was called mid fruiting stages and after 28 days was called late fruiting stage. The following parameters were considered during data collection :

- Number of healthy and infested female flower
- Number of healthy and infested fruits per plot
- Weight of healthy and infested fruits
- Weight of single healthy fruit
- Weight of single infested fruit

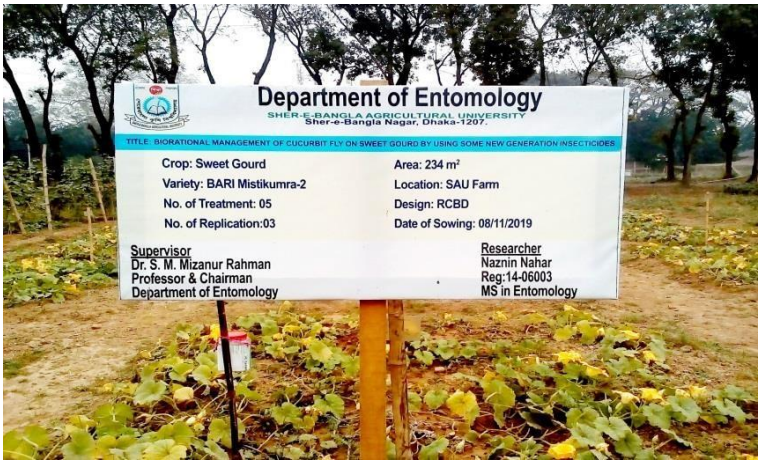



**Plate 1: Experimental site**

**Plate 2: Pheromone trap**

**Plate 3: Bait trap**

**Plate 4: Infested sweet gourd**

**Plate 5: Healthy sweet gourd in the experimental field after harvesting**

**Plate 6: Infested sweet gourd in the experimental field after harvesting**

### 3.13 Instruments

Weighing balance was used for taking weight of healthy and infested sweet gourd.

### 3.14 Data Analysis

After harvesting the healthy fruits and the infested fruits were separated by visual observation.

#### 3.14.1 Percent Fruit Infestation by Number

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

$$\% \text{ Fruit infestation by number} = \frac{No.of\ infested\ fruit}{Total\ no.of\ fruits\ (healthy+infested\ )} \times 100$$

#### 3.14.2 Percent Fruit Infestation by Weight

The percent infested fruit by weight for each treatment was calculated by using following formula:

$$\% \text{ Fruit infestation by weight} = \frac{Weight\ of\ infested\ fruit}{Weight\ of\ healthy\ fruit+weight\ of\ infested\ fruit} \text{x } 100$$

#### 3.14.3 Fruit Yield

After harvesting, the weight of healthy fruits and infested fruits were separately recorded and the total yield under each treatment was finally converted to determine the yield ton/ha. The percent increase and decrease of yield over control was computed by using the following formula:

% Increase of yield over control

$$= \frac{Field\ of\ treated\ plot - Field\ of\ control\ plot}{Field\ of\ control\ plot} \times 100$$

% Decrease of yield over control

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

### 3.14.4 Statistical Analysis

Data were analyzed by SPSS software for proper interpretation. Data recorded on different parameters were subjected to Analysis of Variance (ANOVA) and means were computed according to Least Significance Difference (LSD) at 5 % level of significance.

# CHAPTER IV

# RESULTS AND DISCUSSION

The comparative research on the biorational management of cucurbit fruit fly on sweet gourd by using some new generation insecticides was conducted in 2019 November to 2020 April, during Rabi season at the experimental field of the Sher- e-Bangla Agricultural University , Dhaka. The results obtained from the study have been presented and discussed under the following sub headings:

## 4.1 Effect of different treatments at early fruiting stage

### 4.1.1 Infestation on the basis of number of fruits

At early fruiting stage, the percent fruit infestation by number among different treatments varied significantly (Table 1). The percent fruit infestation by number under the treatments $T_2$ comprising of Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha resulted significantly the lowest level of infestation (20.67%) as compared to untreated control plot (73.52%) (Table 1). The highest level of fruit infestation was obtained from the untreated control plot $T_5$ (73.52%) which was significantly higher than all other treatments. Among the controlled plot, $T_4$ treatment comprised showed the highest % fruit infestation by number (52.51%).

Considering of healthy fruit production per plot, the highest number of healthy fruits/ plot (14.22) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments which was significantly different from all other treatments. The treatments $T_3$ (Fytomax 3 % EC @ 1 ml/L of water) showed higher number of fruits/plot but significantly different from treatment $T_2$. However, the lowest number of healthy fruits/ plot (3.00) were recorded from the untreated control plot $T_5$. Among the treated plots, treatments $T_4$ comprised of Ripcord 10 EC @ 1 ml/L of water (Farmers' practice) showed the lowest healthy fruits/ plot (6.33) by number.

In terms of total fruits/ plot at early stage, the highest fruit yield (17.45) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments where the lowest fruit yield (11.33) was obtained from the untreated control plot $T_5$.

**Table 1: Effect of different treatments against cucurbit fruit fly on sweet gourd on the basis of infestation by number at early fruiting stage**

| Treatments | Number of healthy fruits /plot | Number of infested fruits /plot | Total fruit/plot | Percent infestation by number |
|---|---|---|---|---|
| $T_1$ | 9.22c | 4.67b | 13.89bc | 33.62c |
| $T_2$ | 14.22a | 3.22c | 17.45a | 20.67d |
| $T_3$ | 12.33b | 3.33bc | 15.66b | 21.26d |
| $T_4$ | 6.33d | 7.00a | 13.33c | 52.51b |
| $T_5$ | 3.00e | 8. 33a | 11.33d | 73.52a |
| $LSD_{0.05}$ | 1.227 | 1.537 | 1.358 | 2.870 |
| CV | 7.95 | 13.35 | 8.14 | 11.01 |

(In a column, numeric data represents the mean value of 3 replications. Means followed by the similar letter(s) did not differ significantly and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.)

[$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ ha; $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha; $T_3$= Fytomax 3 EC @ 1 ml/L of water; $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice); $T_5$= Untreated control]

### 4.1.2 Infestation on the basis of weight of fruits

Significant variation was observed in healthy fruit weight, infested fruit weight ,total fruit weight per plot and percent infestation of fruit weight at early fruiting stage (Table 2). The weight of infested fruits/ plot varied significantly in untreated control plot $T_5$. The lowest weight of infested fruits/plot (2.45kg) under the treatments $T_2$ comprising of Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha which was statistically identical with treatments $T_1$ (2.55kg) comprised of Bait trap + Success 2.5 SC @ 650 ml/ ha. The highest amount of infested fruits /plot was recorded from the untreated control plot $T_1$ (4.17kg) which was significantly different than all other treatments.

Considering of healthy fruit production per plot, the highest amount of healthy fruits/ plot (9.13kg) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments which was significantly different from all other treatments. The treatments $T_3$ (Fytomax 3 % EC @ 1 ml/L of water) showed good performance compared to treatments $T_2$. However, the lowest amount of healthy fruits/ plot (2.10kg) were recorded from the untreated control plot $T_5$ . Among the treated plots, treatment $T_4$ comprised of of Ripcord 10 EC @ 1 ml/L of water (Farmers' practice) showed the lowest healthy fruits/ plot (4.83kg) by weight.

In terms of total fruit weight/ plot at early stage, the highest fruit yield (11.58kg) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments where the lowest fruit yield (6.27kg) was obtained from the untreated control plot $T_5$ .

**Table 2: Effect of different treatments against cucurbit fruit fly on sweet gourd on the basis of infestation by weight at early fruiting stage**

| Treatments | Number of healthy fruits /plot | Number of infested fruits /plot | Total fruit/plot | Percent infestation by weight |
|---|---|---|---|---|
| $T_1$ | 6.67c | 2.55c | 9.22b | 27.65d |
| $T_2$ | 9.13a | 2.45c | 11.58a | 21.15e |
| $T_3$ | 7.86b | 3.13b | 10.99a | 28.48c |
| $T_4$ | 4.83d | 3.43ab | 8.26c | 41.52b |
| $T_5$ | 2.10e | 4.17a | 6.27d | 66.50a |
| $LSD_{0.05}$ | 0.7025 | 0.8159 | 0.692 | 2.628 |
| CV | 8.25 | 9.13 | 7.12 | 11.13 |

(In a column, numeric data represents the mean value of 3 replications. Means followed by the similar letter(s) did not differ significantly and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.)

[$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ ha; $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha; $T_3$= Fytomax 3EC @ 1 ml/L of water; $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice); $T_5$= Untreated control]

### 4.2 Effect of different treatments at mid fruiting stage

#### 4.2.1 Infestation on the basis of number of fruits

At mid fruiting stage, the percent fruit infestation by number among different treatments varied significantly (Table 3). The percent fruit infestation by number under the treatments $T_2$ comprising of Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha resulted significantly the lowest level of infestation (21.42%) as compared to untreated control plot $T_5$ (84.84 %) (Table 3).The highest level of fruit infestation was obtained from the untreated control plot $T_5$ (84.84%) which was significantly higher than all other treatments. Among the controlled plot, $T_4$ treatment comprised showed the highest % fruit infestation by number (60.53%).

Considering of healthy fruit production per plot, the highest number of healthy fruits/ plot (14.67) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments which was significantly different from all other treatments. The treatments $T_3$ (Fytomax 3 % EC @ 1 ml/L of water) showed higher number of fruits/plot but significantly different from treatment $T_2$. However, the lowest number of healthy fruits/ plot (1.67) were recorded from the untreated control plot $T_5$. Among the treated plots, treatment $T_4$ comprised of Ripcord 10 EC @ 1 ml/L of water (Farmers' practice) showed the lowest healthy fruits/ plot (5.00) by number.

In terms of total fruits/ plot at mid fruiting stage, the highest fruit yield (18.67) was recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha ) treatments where the lowest fruit yield (11.00) was obtained from the untreated control plot $T_5$ .

**Table 3: Effect of different treatments against cucurbit fruit fly on sweet gourd on the basis of infestation by number at mid fruiting stage**

| Treatments | Number of healthy fruits /plot | Number of infested fruits /plot | Total fruit/plot | Percent infestation by number |
|---|---|---|---|---|
| $T_1$ | 9.33c | 4.33c | 13.67c | 31.67c |
| $T_2$ | 14.67a | 4.00c | 18.67a | 21.42e |
| $T_3$ | 11.35b | 4.12c | 15.49b | 26.59d |
| $T_4$ | 5.00d | 7.67b | 12.67cd | 60.53b |
| $T_5$ | 1.67e | 9.33a | 11.00d | 84.84a |
| $LSD_{0.05}$ | 1.029 | 0.529 | 1.251 | 3.142 |
| CV | 7.09 | 9.60 | 9.81 | 5.36 |

(In a column, numeric data represents the mean value of 3 replications. Means followed by the similar letter(s) did not differ significantly and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.)

[$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ ha; $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha; $T_3$= Fytomax 3 EC @ 1 ml/L of water; $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice); $T_5$= Untreated control]

### 4.2.2 Infestation on the basis of weight of fruits

Significant variation was observed in healthy fruit weight, infested fruit weight total fruit weight per plot and percent infestation of fruit weight at mid fruiting stage (Table 4). The weight of infested fruits/plot aried significantly in untreated control plot T5. The lowest amount of infested fruits /plot (3.47kg) was found under the treatments T2 comprising of Pheromone trap ( Cuelure) + Success 2.5 SC @ 650 ml/ha which was statistically similar with treatments T1 (3.23 kg ) comprised of Bait trap + Success 2.5 SC @ 650 ml/ha. The highest amount of infested fruits /plot was obtained from the untreated control plot T5 (7.35 kg ) which was significantly different than all other treatments.

Considering of healthy fruit production per plot, the highest amount of healthy fruits/ plot (12.35kg) was recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments which was significantly different from all other treatments. The treatments $T_3$ (Fytomax 3 EC @ 1 ml/L of water) showed good performance compared to treatments $T_2$. However, the lowest amount of healthy fruits/ plot (1.47kg) were recorded from the untreatedcontrol plot $T_5$. Among the treated plots, treatment $T_4$ comprised of Ripcord 10EC @ 1 ml/L of water (Farmers' practice) showed the lowest healthy fruits/ plot (4.52kg) .

In terms of total fruit weight/ plot at mid fruiting stage, the highest fruit yield (15.82kg) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments where the lowest fruit yield (9.82kg) was obtained from the untreated control plot $T_5$.

**Table 4: Effect of different treatments against cucurbit fruit fly on sweet gourd on the basis of infestation by weight at mid fruiting stage**

| Treatments | Number of healthy fruits /plot | Number of infested fruits /plot | Total fruit/plot | Percent infestation by weight |
|---|---|---|---|---|
| $T_1$ | 8.18c | 3.23b | 11.41c | 28.30c |
| $T_2$ | 12.35a | 4.00b | 18.67a | 21.93d |
| $T_3$ | 10.58b | 4.12b | 15.49b | 27.53c |
| $T_4$ | 4.52d | 3.95b | 8.47e | 46.66b |
| $T_5$ | 1.47e | 7.35a | 9.82d | 74.84a |
| $LSD_{0.05}$ | 0.9530 | 0.9256 | 1.156 | 2.956 |
| CV | 7.60 | 9.86 | 5.70 | 7.06 |

(In a column, numeric data represents the mean value of 3 replications. Means followed by the similar letter(s) did not differ significantly and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.)

[$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ ha; $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha; $T_3$= Fytomax 3 EC @ 1 ml/L of water; $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice); $T_5$= Untreated control]

### 4.3 Effect of different treatments at late fruiting stage

#### 4.3.1 Infestation on the basis of number of fruits

At late fruiting stage, the percent fruit infestation by number among different treatments varied significantly (Table 5). The percent fruit infestation by number under the treatments $T_2$ comprising of Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha resulted in significantly the lowest level of infestation (26.47%) as compared to untreated control plot (76.19%). The highest level of fruit infestation was obtained from the untreated control plot $T_5$ (76.19%) which was significantly higher than all other treatments. Among the controlled plot, $T_4$ treatment showed the highest % fruitinfestation by number (46.70%) which is statistically similar to treatments $T_1$ (46.40).

Considering of healthy fruit production per plot, the highest number of healthy fruits/ plot (8.33) was recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments which was significantly different from all other treatments. The treatments $T_3$ (Fytomax 3 EC @ 1 ml/L of water) showed higher number of fruits/plot but significantly different from treatments $T_2$. However, the lowest number of healthy fruits/ plot (1.25) was recorded from the untreated control plot $T_5$. Among the treated plots, treatment $T_4$ comprised of Ripcord 10 EC @ 1 ml/L of water ( Farmers' practice ) showed the lowest healthy fruits/ plot (3.80) .

In terms of total fruits/ plot at late fruiting stage, the highest fruit yield ( 11.33) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments where the lowest fruit yield (5.25) was obtained from the untreated control plot $T_5$ .

**Table 5: Effect of different treatments against cucurbit fruit fly on sweet gourd on the basis of infestation by number at late fruiting stage**

| Treatments | Number of healthy fruits /plot | Number of infested fruits /plot | Total fruit/plot | Percent infestation by number |
|---|---|---|---|---|
| $T_1$ | 5.00c | 4.33a | 9.33b | 46.40b |
| $T_2$ | 9.22a | 3.00c | 11.33a | 26.47d |
| $T_3$ | 6.67b | 3.33b | 10.00b | 33.33c |
| $T_4$ | 3.80d | 3.33b | 7.13c | 46.70b |
| $T_5$ | 1.25e | 4.00a | 5.25d | 76.19a |
| $LSD_{0.05}$ | 0.918 | 0.4721 | 1.275 | 2.924 |
| CV | 11.27 | 9.82 | 7.77 | 13..21 |

(In a column, numeric data represents the mean value of 3 replications. Means followed by the similar letter(s) did not differ significantly and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.)

[$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ ha; $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha; $T_3$= Fytomax 3 EC @ 1 ml/L of water; $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice); $T_5$= Untreated control]

### 4.3.2 Infestation on the basis of weight of fruits

Significant variation was observed in healthy fruit weight, infested fruit weight ,total fruit weight per plot and percent infestation of fruit weight at mid fruiting stage (Table 6). The weight of infested fruits/ plot varied significantly in untreated control plot $T_5$. The lowest amount of infested fruits/plot (2.27kg) was found under the treatments $T_2$ comprising of Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha. The highest amount of infested fruits /plot was obtained from the untreated control plot $T_5$ (5.40kg) which was significantly different than all other treatments.

Considering of healthy fruit production per plot, the highest amount of healthy fruits/ plot (12.95kg) were recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments which was significantly different from all other treatments. The treatments $T_3$ (Fytomax 3 EC @ 1 ml/L of water) showed good performance compared to treatment $T_2$. However, the lowest amount of healthy fruits/ plot (1.29kg) were recorded from the untreatedcontrol plot $T_5$. Among the treated plots, treatments $T_4$ comprised of of Ripcord10 EC @ 1 ml/L of water (Farmers' practice) showed the lowest healthy fruits/ plot (4.25kg) .

In terms of total fruit weight/ plot at mid fruiting stage , the highest fruit yield ( 15.20kg) was recorded from $T_2$ (Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) treatments where the lowest fruit yield (6.75kg) was obtained from the untreated control plot $T_5$.

**Table 6: Effect of different treatments against cucurbit fruit fly on sweet gourd on the basis of infestation by number at late fruiting stage.**

| Treatments | Number of healthy fruits /plot | Number of infested fruits /plot | Total fruit/plot | Percent infestation by weight |
|---|---|---|---|---|
| $T_1$ | 6.60c | 5.30a | 11.90b | 45.40c |
| $T_2$ | 12.95a | 2.27c | 15.20a | 19.52e |
| $T_3$ | 8.00b | 4.60b | 12.60b | 39.80d |
| $T_4$ | 4.25d | 5.07a | 9.32c | 54.39b |
| $T_5$ | 1.35e | 5.40a | 6.75d | 79.26a |
| $LSD_{0.05}$ | 1.29 | 0.7223 | 1.523 | 3.235 |
| CV | 10.23 | 8.43 | 9.64 | 8.78 |

(In a column, numeric data represents the mean value of 3 replications. Means followed by the similar letter(s) did not differ significantly and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.)

[$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ ha; $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha; $T_3$= Fytomax 3 EC @ 1 ml/L of water; $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice); $T_5$= Untreated control]

### 4.4 Effect on fruit yield

The effect of different treatments on yield of sweet gourd was determined in terms of healthy, infested and total fruit yield. The findings has been sown in Table 7.

Significant variations were observed among the treatments on yield of sweet gourd. The highest healthy fruit yield (34.21 t/ha) was recorded in treatments $T_2$ (.Pheromone trap (Cuelure) + Success 2.5 SC@ 650 ml/ha) which was statistically different with other treatments followed by $T_3$ (29.66 t/ha) (Fytomax 3 EC @ 1 ml/L of water) and $T_1$ (26.89t/ha) ( Bait trap + Success 2.5 SC @ 650 ml/ ha). The lowest healthy fruit yield was recorded in treatments $T_5$ (12.04 t/ha) which was statistically different from all other treatments. The lowest infested fruit yield (3.23 t/ha) was recorded in treatments $T_2$ (.Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha) and the highest infested fruit yield (6.33 t/ha) obtained from the treatments $T_5$ (Untreated control) which was significantly different from all other treatments.

**Table 7: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of yield/ha**

| Treatments | Healthy fruit yield (t/ha) | Percent increase over control | Infested fruit yield (t/ha) | Percent decrease over control | Total fruit yield (t/ha) | Percent increase over control |
|---|---|---|---|---|---|---|
| $T_1$ | 26.89c | 123.33 | 4.56c | 27.96 | 31.46c | 64.20 |
| $T_2$ | 34.21a | 184.136 | 3.23d | 22.25 | 37.44a | 100.63 |
| $T_3$ | 29.66b | 146.34 | 5.00c | 21.01 | 34.66b | 81.00 |
| $T_4$ | 17.60d | 46.18 | 5.60b | 11.53 | 23.2d | 18.33 |
| $T_5$ | 12.04e | ……. | 6.33a | ….. | 18.37e | ….. |
| $LSD_{0.05}$ | 1.25 | | 0.50 | | 1.20 | |
| CV | 8.27 | | 7.63 | | 9.15 | |

(In a column, numeric data represents the mean value of 3 replications. Means followed by the similar letter(s) did not differ significantly and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.)

[$T_1$= Bait trap + Success 2.5 SC @ 650 ml/ ha; $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha; $T_3$= Fytomax 3 EC @ 1 ml/L of water; $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice); $T_5$= Untreated control]

# CHAPTER V

# SUMMARY AND CONCLUSION

## 5.1 Summary

Biorational management of cucurbit fruit fly on sweet gourd by using some new generation insecticides was examined at the research field of the Sher- e-Bangla Agricultural University, Sher- e-Bangla Nagar, Dhaka, during the period from November, 2019 to April, 2020. Here, $T_1$= Setting up of poison bait trap, 100gm mashed sweet gourd mixed with water and @2g Sevin 50 WP replaced by freshly prepared bait at 3 to 4 days interval + spraying of Success 2.5 SC @ 650 ml/ha at 7 days interval, $T_2$= setting up of pheromone trap (Cuelure) replaced with new ones at 7 days interval + spraying of Success 2.5 SC @ 650 ml/ha at 7 days interval, $T_3$= Spraying of Fytomax 3 % EC @ 1 ml/L of water at 7 days interval, $T_4$= Ripcord 10 EC @ 1 ml/L of water (Farmers' practice ), $T_5$= Untreated control . Data on fruit infestation by number and weight, yield were recorded of different management practices applied against cucurbit fruit fly on sweet gourd.

Among various treatments, the lowest fruit infestation (20%) by number was recorded in treatments $T_2$ in the field at early fruiting stage of sweet gourd. As a result, the order of efficacy of management practices against cucurbit fruit fly was $T_2 > T_3 > T_1 > T_4 > T_5$.

Among various treatments, the lowest fruit infestation (21.15%) by weight was recorded in treatments $T_2$ in the field at early fruiting stage of sweet gourd. As a result, the order of efficacy of management practices against cucurbit fruit fly was $T_2 > T_3 > T_1 > T_4 > T_5$.

Among different treatments, the lowest fruit infestation (21.42%) by number was recorded in treatments $T_2$ in the field at mid fruiting stage of sweet gourd. As a result, the order of efficacy of management practices against cucurbit fruit fly was $T_2 > T_3 > T_1 > T_4 > T_5$.

Among various treatments, the lowest fruit infestation (21.93%) by weight was recorded in treatments $T_2$ in the field at mid fruiting stage of sweet gourd. As a result, the order of efficacy of management practices against cucurbit fruit fly was $T_2 > T_3 > T_1 > T_4 > T_5$.

Among various treatments, the lowest fruit infestation (26.47%) by number was recorded in treatments $T_2$ in the field at late fruiting stage of sweet gourd. As a result, the order of efficacy of management practices against cucurbit fruit fly was $T_2 > T_3 > T_1 > T_4 > T_5$.

Among various treatments, the lowest fruit infestation (19.52%) by number was recorded in treatments $T_2$ in the field at late fruiting stage of sweet gourd. As a result, the order of efficacy of management practices against cucurbit fruit fly was $T_2 > T_3 > T_1 > T_4 > T_5$.

Among various treatments, the highest fruit yield (37.54 t/ha) was recorded in treatments $T_2$ from the sweet gourd field and the lowest fruit yield (18.37 t/ha) obtained from treatments $T_5$. As a result, the order of efficacy of management practices against cucurbit fruit fly was $T_2 > T_3 > T_1 > T_4 > T_5$.

## 5.2 Conclusion

According to the findings of this study, it may be concluded that biorational management of cucurbit fruit fly on sweet gourd by using some new generation insecticides was significantly different among the treatments. The overall study revealed that the highest performance was obtained from treatments, $T_2$= Pheromone trap (Cuelure) + Success 2.5 SC @ 650 ml/ha. Highest healthy fruit yield (37.44 t/ha), lowest infested fruit yield (3.23 t/ha), highest percent increase over control (100.63) was obtained from the treatments $T_2$.

## 5.3 Recommendations

**Considering the findings of the study the following recommendations can be drawn:**

- Pheromone trap with cuelure and application of the insecticide Spinosad (Success 2.5 SC) will be effective management options.
- It demands further study to know the accuracy of biorational management practices for different locations in Bangladesh.

# REFERENCES


Adhikari, D., Joshi, S.L., Thapa, R.B., Pandit, V. and Sharma, D.R. (2020). Fruit fly management in Nepal: A case from plant clinic. *J. of Biol. Control*. **34**(1): 8-14.

Agarwal, M.L., Sharma, D.D. and Rahman, O. (1987). Melon fruit fly and its control. *Indian J. Hortic*. **32**: 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.

Alam, M.Z. (1962).A list of insect and mites of East Pakistan. *East Pakistan Agri. Inst. Tejgaon Dacca.* p.104.

Allwood, A.J., Chinajariyawong, A., Drew, R.A.I., Hamacek, E.L., Hancock, D.L., Hengsawad, C., Jinapin, J.C., Jirasurat, M., Kong, K.C., Kritsaneepaiboon, S., Leong, C.T.S. and Vijaysegran, S. (1999). Host plant records for fruit flies (Diptera: Tephritidae) in South-East Asia. Raff. *Bull. Zool. Suppl*. **7**: 1-99.

Amin, M.R., Sarkar, T. and Chun, I.J. (2011). Comparison of hosts plants infestation level and life history of fruit fly (*Bactrocera cucurbitae* Coq.) on cucurbitaceous crops. *Hort. Environ. Biotch*. **52**: p.541.

Amin, M.R., Nancy, N.P., Miah, M.R.U., Miah, M.G., Kwan, O. and Suh, S.J. (2019). Fluctuation in fruit fly abundance and infestations in sweet gourd fields in relation to varied meteorological factors. *Ent. Res.* **49**: 223-228.

Atwal, A.S. (1993). Agricultural Pests of India and South East Asia. Kalyani Publ., New Delhi, Ludhiana. p.189.

Banjeri, R., Shaymal,K., Sahoo,K., Das, S.K. and Jha, S. (2005). Studies of incidence of melon fly *Bactrocera cucurbitae* (Coq.) in relation to weather parameters on bitter gourd in new alluvial zone of West Bengal . *J. Ent. Res.* **29**: 179-183.

BBS (2020). Year Book of Agricultural Statistics. Bangladesh Bureau of Statistics. Planning Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka, Bangladesh, 287-341.

Bhowmik, P., Mandal, D. and Chatterjee, M.L. (2014). Chemical management of melon fruit fly *Bactrocera cucurbitae* Coq. (Diptera: Tephritidae) on bitter gourd. *Pestic. Res. J*. **26**(1): 68-73.

Bottrell, D.G. (1979). Council on Environmetal Quality : Integrated Pest Management . US Govt. Printing Office, Washington DC. p.120.

Chakraborty, A., Nath, D., Shil, S., Dey, D., Das, R., Chandra, S.B., Islam, N. and Choudhury, S. (2019). Assessment of certain strategies to manage fruit fly *Bactrocera cucurbitae* (Coquillett) in bitter gourd of Tripura. *Int. J. Curr. Microbiol. App. Sci*. **8**(7): 2386-2392.

Dhillon, M.K., Singh, R., Naresh, J. and Sharma, H.S. (2005a). The melon fruit fly *Bactrocera cucurbitae*: A review of its biology and management. *J. Insect Sci*. **5**: 40.

Doharey, K.L. (1983). Bionomics of fruit flies (*Dacus spp*.) on some fruits. *J Indian. Entomol.* **45**: 406-413.

Drew, R.A.I. (1982). I. Taxonomy, **In**: R.A.I. Drew, G.H.S. Hooper, M.A. Bateman, (Eds.). Economics of Fruit Fly of the South Pacific Region. 2nd ed. Brisbane, Australia: Queensland Department of Primary Industries .pp.1-97.

Eta, C.R. (1985). Eradication of the melon fly from Solomon Islands (special report). Solomon Islands Agricultural Quarantine Service, Annual report. Ministry of Agriculture and Land Honiara.

Ekeshi, S., Billah, M.K., Nderitu, P.W., Lux, S. and Rwomushara, I. (2009). Evidence for competitive displacement of *Ceratitis cosyra* by the invasive fruit fly *Bactrocera invades* (Diptera: Tephritidae) on mango and mechanisms contributing to the displacement. *Bulletin of Entomol. Res.* **96**: 379-386.

Ganea, S.A., Khan, Z.H., Ahangar, R.A., Bhat, H.A. and Hussain, B. (2013). Population dynamics, distribution, species diversity of fruit fly on cucurbits in Kashmir valley, India. *J. Insect Sci.* **13**: 15.

Gazit, Y. and Akiva, R. (2017). Toxicity of Malathion and Spinosad to *Bactrocera zonata* and *Ceratitis capitata* (Diptera: Tephritidae*). Florida Entomol*. **100**: 385-38.

Gazmer, R., Laskar, N. and Mandal, S. (2017). Physico- chemical characters of pumpkin (*Cucurbitae moschata* Duch) ex-pair genotype against the melon fly (*Bactrocera cucurbitae*) reveals resistance traits in the terrain region of west Bengal. *India Intl. J. Curr. Microbiol. Appl. Sci*. **6**: 2023-2031.

Ghule, T.M., Devi, L.L., Uikey, B.L. and Jha, S. (2015). Incidence studies on some important insect pests of ridge gourd (*Luffa acutangula). Environ. Ecol*. **33**: 351-355.

Goergen, G., Vassieries, J.F., Gnanvossou, D. and Tindo, M. (2011). *Bactrocera invadens* (Diptera: Tephritidae) a new invasive fruit fly pest for the Afrotropical region : Host range and distribution in west and central Africa. *Environ*. *Entomol*. **40**(4): 844-854.

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

Hossain, M., Mia, M.I., Talukdar, M.A.A.H., Laily, U.K., Haque, M.M. and Khandakar, J. (2019). Control fruit fly for profitable sweet gourd production. *Progressive Agriculture*. **30**(2): 173-178.

Islam, M.A. and Ando, T. (2012). Insects pheromone identification perspective to Bangladesh. *Bangladesh Res. Publ. J*. **6**(4): 449-461.

Jha, S., Khan, M.R. and Sahoo, S. (2007). Infestation of fruit fly *Bactrocera cucurbitae* (Coq.) (Diptera: Tephritidae) on bottle gourd. *Pest Management and Economic Zoology*. **2:** 123-125.

Kabir, S.M., Rahman, H.R. and Mollah, M.A.S. (1991). Host plant of Dacinae fruit flies of Bangladesh. *Bangladesh J. Entomol.* **1**: 60-75.

Kakani, E.G., Zygounidis, N.E., Tsoumani, K.T., Seraphids, N., Zalom, F.G. and Mathiopoulos, K.D. (2010). Spinosad resistance development in wild olive fruit fly *Bactrocera oleae* (Diptera: Tephritidae) populations in California. *Pest Manage*. *Sci*. **66**: 447-453.

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

Katyal, S.L. and Chanda, M.L. (1985). Vegetable Growing in India. Oxford and IBH Publishing Co. Ltd. New Delhi, India. pp.92-93.

Khan, M.A., Ashfaq, M. and Khaliq, A. (2003). Role of abiotic factors in population and infestation fluctuation of fruit flies in guava orchards of Sheikhupura District. *Pakistan Entomol*. **25**: 89-93.

Meyer, M.D., Mohamed,S. and White, I.M. (2007). Invasive fruit fly pests in Africa, Tervuren, Belgium, Royal Museum for Central Africa.

Mir, S.H., Dar, S.A., Mir, G.M. and Ahmad, S.B. (2014). Biology of *Bactrocera cucurbitae* on cucumber. *Florida Entomol*. **97**(2): 753-758.

Mukherjee, S., Tithi, D.A. , Bachchu, A.A., Ara, R. and Amin, M.R. (2007). Life history and management of cucurbit fruit fly *Bactrocera cucurbitae* on sweet gourd. *J. Sci. Technol*. ( *Dinajpur*). **5**: 17-27.

Mwatawala, M., Macrere, A.P., Makundi, R. and De Meyer, M. (2010). Incidence and host range of the melon fruit fly *Bactrocera cucurbitae* (*coquillett*) (Diptera: Tephritidae) in Central Tanzania. *Intl. J. Pest Manage*. **56**(3): 265-273.

Namini, S., Amin, M.R. Miah, M.F., Rahman, F. and Suh, S.J. (2017). Role of weather parameters on seasonal abundance of insects in a mango based agroforestry in Bangladesh with particular reference to mango hopper. *Bangladesh J. Agril. Res*. **42**: 197-205.

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**: 31-34.

Nath, P. and Bhushan, S. (2006). Screening of cucurbit crops against fruit fly. *Ann*. Plant *Sci*. **14**: 472-473.

Oke, A.A. and Sinon, S.G. (2013). Effectiveness of three insecticides to control *Bactrocera cucurbitae* (Diptera: Tephritidae) on the cucumber crop at Praslin, Seychelles. *Florida Entomol*. **96**(1): 120-123.

Pandey, R., Hiraki, C., Fujitani, L. and Hernandez, A. (2008). Insect pests of vegetables. *Indian J. Agric. Sci*. **75**(1): 25-29.

Patel, N.M. and Patel, A.K. (2018). Comparative biology of melon fruit fly, *Bactrocera cucurbitae* in different cucurbitaceous crops. *J. Entomol. Zool. Stud. **6**(6): 694-698.*

Raghuvanshi, A.K., Satpathy, S. and Mishra, D.S. (2012). Role of abiotic factors on seasonal abundance and infestation of fruit fly *Bactrocera cucurbitae* (Coq.) on bitter gourd. *J. Plant Prot. Res*. **52**: 264-267.

Rahman, M.A., Jahan, M., Islam, K.S. and Alam, S.N. (2015). Study on the biology of cucurbit fruit fly *Bactrocera cucurbitae*. *J. Sylhet Agril. Univ*. **2**(2): 203-208.

Rai, M.P.S. and Kumar, S. (2008). Cucurbit research in India: A retrospect cucurbitaceae. **In**: Cucurbitaceae Pitrat. M. (ed.). Proceedings of the IX Eucarpia Meeting on Genetics and Breeding of Cucurbitaceae, INRA, Avigron, France.

Rakshit, A., Karim, R.A.N.M., Hristovska, T. and George, W.N. (2011). Impact assessment of pheromone traps to manage fruit fly on sweet gourd cultivation. *Bangladesh J. of Agril. Res*. **36**(2): 197-203.

Rashid, M.M. (1993). Kumra Paribarer Shabji. **In**: Shabji Biggan (in Bangla). 1st ed. Bangla Academy, Dhaka, Bangladesh.

Reddy, D.B. and Joshi, N.C. (1992). Plant Protection in India. Second edition. Allied Publishers Limited, New Delhi.

Rehman, H. (1994). Effect of different levels of WPK on the performance of three varieties of cucumber *Cucumis sativus* L. Under the agroclimatic conditions of D.I. Khan. MSc. (Hons.). Agric thesis, Faculty of Agriculture, Gomal University, D. I. Khan. pp:40-48.

Ronald, M.N. (2003). A non pesticide method for the control of melon fly. Special Publication of Taichang District Agriculture Improvement Station. **16**: 193-205.

Saha, A.K., Khan, M., Nahar, G. and Yeasmin, F. (2007). Impact of natural hosts and artificial adults diets on some quality parameters of the melon fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae*). Pakistan J. Biol. Sci.* **10**(1): 178-181.

Sapkota, R., Dahal, K.C. and Thapa, B.C. (2010). Damage assessment and management of cucurbit fruit fly in spring summer squash. *J. Entomol. Nematol.* **2**(1): 7-12.

Sarkar, R., Das, S., Kamal, M.M., Islam, K.S. and Jahan, M. (2017). Efficacy of management approaches against cucurbit fruit fly (*Bactrocera cucurbitae* Coq.) of bitter gourd. *Bangladesh J. Agril. Res*. **42**(4): 757-766.

Sarwar,M. (2015). Mechanical control prospectus to aid in management of fruit fly and correlated tephritid pests. *Int. J. Animal. Biol.* **1**(5): 190-195.

Shinde, P.B., Naik, K.V., Shinde, B.D., Jalgaonkar, V.N. and Golvankar, G.M. (2018). Seasonal abundance of red pumpkin beetle and flea beetle infesting cucumber. *Trends Bio. Sci*. **11**: 3760-3762.

Singh, M.P. (1984). Studies on the field resistance of different jujube cultivers to the fruit fly *Carpomyia vesuviana* . *Madras Agric, J*. **71**: 413-415.

Sohrab., Prasad, C.S. and Hasan, W. (2018). Study on the biology and life cycle of cucurbit fruit fly *Bactrocera cucrbitae (*Coquillett*). J. Pharmacogn. Phytochem*. 223-226.

Srinivas, M.P., Suchitra, K.M.H., Hanuman thraya, L., Thippeshappa, G.N. and Yalleshkumar, H.S. (2018). Bio-efficacy of insecticides against fruit fly *Bactrocera cucurbitae* (Coquillett) in cucumber. *J. Entomol. Zool. Stud*. **6**(6): 449-452.

Sujit, K.B. (2005). Studies on The Bionomics and Management Approaches of Cucurbit Fruit Fly, *Bactrocera cucurbitae* on Bitter Gourd. M.S. Thesis. Department of Entomology. B.A.U. Mymensingh. p.70.

Tahir, A., Ahmad, S. and Tahir, D. (2011). Determination of pesticide residues in fruits of Nawabshah district, Sindh, Pakistan. *Pakistan J. Bot*. **43**: 1133-1139.

Thomas, J., Faleiro, R., Vidya, C.V., Satarkar, V.R., Stonehouse, J.M., Verghese, A. and Mumford, J.D. (2005). Melon fly attraction and control by baits in Central Kerala. *Pest Manage. Hort. Ecosyst.* **11**(2): 110-112.

Vargas, R.I., Burns, R.E., Mau, R.F.L., Stark, J.D., Cook, P. and Pinero, J.C. (2009). Captures in methyl eugenol and cuelure detection traps with and without insecticides and with a farma tech solid lure and insecticide dispenser. *J. Eco. Ent*. **102**(2): 552-557.

Vargas, R.I., Stark, J.D., Kido, M.H., Ketter, H.M. and Whiteland, L.C. (2000). Methyl eugenol and culure traps for suppression of male oriental fruit flies (Diptera: Tephritidae) in Hawaii: Effects of lure mixtures and weathering. *J. Eco. Ent*. **93**(1): 81-87.

Tindall, H.D. (1987). Vegetables in the Tropics. Macmillan Education, London. p.166.

Weems, H.V. (1964). Melon fly (*Dacus cucurbitae* Coquillett) (Diptera: Tephritidae). Entomology Circular Division, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, **29**: 1-2.

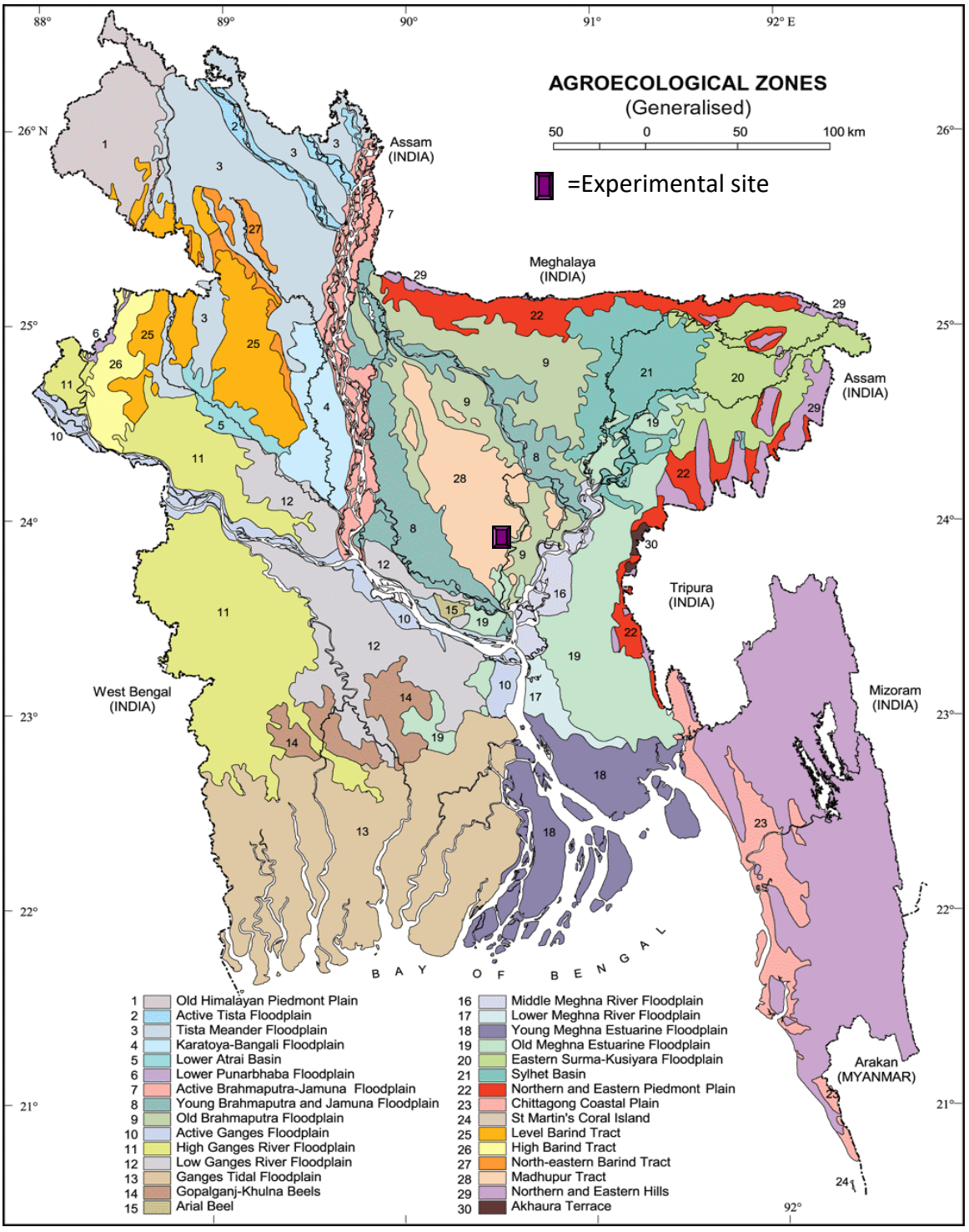
Weems, H.V. and Heppner, J.B. (2001). T Melon fly (*Dacus cucurbitae* Coquillett) (Diptera: Tephritidae). Florida Department of Agriculture and Consumer Services, Divison of Plant Industry, and T.R. Fasulo, University of Florida. University of Florida Publication. EENY. p.199.

Yadav, M., Jain, S. and Tomar , R. (2010). Medicinal and biological potential of pumpkin : an updated review. Nutrition Resource Review. **23**: 184-190.

Zaman, M. (1995). Assessment of the male population of the fruit flies through Kairomone baited traps and the association of the abundance level with the environmental factors. *Sarhad J. of Agri*. **11**: 657-670.

# APPENDICES

## Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



**Appendix II. The physical and chemical characteristics of soil of the experimentalsite as observed prior to experimentation (0-15 cm depth)**

| Constituents | Percent |
|---|---|
| Sand | 26 |
| Silt | 45 |
| Clay | 29 |
| Textural class | Silty clay |

**Chemical composition:**

| Soil characters | Value |
|---|---|
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.54 |
| Total nitrogen (%) | 0.027 |
| Phosphorus | 6.3 µg/g soil |
| Sulphur | 8.42 µg/g soil |
| Magnesium | 1.17 meq/100 g soil |
| Boron | 0.88 µg/g soil |
| Copper | 1.64 µg/g soil |
| Zinc | 1.54 µg/g soil |
| Potassium | 0.10 meg/100g soil |

**Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka**

**Appendix III. Monthly average air temperature, rainfall and relative humidity ofthe experimental site during the period from November 2019 to March 2020**

| Months | Air temperature (°C) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| November, 2019 | 22.78 | 11.50 | 75 | 00 |
| December, 2019 | 23.50 | 13.40 | 69 | 00 |
| January, 2020 | 26.10 | 14.70 | 66 | 33 |
| February, 2020 | 33.40 | 20.60 | 58 | 12 |
| March, 2020 | 34.5 | 22.82 | 63 | 173.4 |

**Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka, Bangladesh.**