DEVELOPMENT OF INTEGRATED PEST MANAGEMENT PACKAGE(S) AGAINST INSECT PEST COMPLEX OF SOME WINTER CUCURBIT VEGETABLES

RIFAT NAZNIN MUNNI

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

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BY

RIFAT NAZNIN MUNNI

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APPROVED BY:

Prof. Dr. Tahmina Akter
Supervisor
Department of Entomology
SAU, Dhaka

Prof. Dr. Mohammed Ali
Co-Supervisor
Department of Entomology
SAU, Dhaka

Dr. Mst. Nur mohal Akhter Banu
Chairman
Department of Entomology
and
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 **'DEVELOPMENT OF INTEGRATED PEST MANAGEMENT PACKAGE(S) AGAINST INSECT PEST COMPLEX OF SOME WINTER CUCURBIT VEGETABLES'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Entomology**, embodies the result of a piece of *bonafide* research work carried out by **Rifat Naznin Munni**, Registration number: **10-04023** 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 duly been acknowledged.

Dated: June, 2016
Dhaka, Bangladesh

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

Dedicated

To

My Beloved Parents

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The Author

Development of integrated pest management package(s) against insect pest complex of some winter cucurbit vegetables

ABSTRACT

The research work was conducted on integrated pest management package(s) against insect pest complex of some winter cucurbits vegetables during rabi season (October-May) of 2015-2016. The experiment was embraced of six treatments including untreated control treatment and laid out Randomized Complete Block Design (RCBD) with three replications. At the vegetative and reproductive stage of bottle gourd, in term of leaf infestation due to red pumpkin beetle, aphid, white fly and leaf eating caterpillar, T_5 (Cultural + Mechanical control method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment showed the best performance of all of the treatments and reduction over control were (64.12, 73.91, 74.19, 68.56 and 56.49, 75.20, 75.61, 74.26 % respectively) whereas the lowest performance showed the untreated control treatment T_6. Similar trend of result was found incase of sweet gourd and cucumber on the leaf infestation by red pumpkin beetle, aphid, white fly and leaf eating caterpillar at the growing stages of plant. At the reproductive stage of bottle gourd, sweet gourd and cucumber, the highest number of fruit fly were recorded (14.67, 13.67 and15.67) from T_6 (Untreated control), but the lowest number of fruit fly were recorded (2.67, 1.33 and 1.33 respectively) from T_2 (Mechanical control method + pheromone trap) at 7 days interval and reduced percent fruit infestation (100, 100 and 100 respectively) over control were estimated. The highest weight of single fruit bottle gourd, sweet gourd and cucumber (1255.00, 1050.00 and 201.00 gm) were recorded in the T_5 treated plot, on the other hand the lowest weight of single fruit (1051.67, 898.00 and 109.33 gm) was recorded in the untreated control plot $T_{6.}$ From the research findings it may be concluded that among the treatments, T_5 (Cultural + Mechanical control method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment was considered as the best treatment followed by T_4 (Mechanical control method +Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) and T_3 (Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval) in respect of higher healthy fruit yield by reducing leaf and fruit infestation.

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LIST OF ABBRIVIATIONS

LSD	=	Least Significant Difference
RCBD	=	Randomized Complete Block Design
BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
MP	=	Muriate of Potash
m	=	Meter
P^{H}	=	Hydrogen ion conc.
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

CHAPTER I

INTRODUCTION

Vegetables are a cheaper source of vitamins and minerals which are essential for maintaining sound health. Bangladesh has a serious deficiency in vegetables. The daily requirement of vegetables for a grownup person is 285 gm (Ramphall and Gill, 1990). But in Bangladesh the percept consumption of vegetables is only 50 gm per day, which is the lowest among the countries of south and south East Asia (Rekhi, 1997). As a result, chronic malnutrition is commonly seen in Bangladesh. The annual production of vegetables is only 610 thousand tons including potato and sweet potato (Anon 2001). In Bangladesh, the vegetables production is not evenly distributed throughout the year. Most of the important vegetables are produced in winter, which amount 367 thousand tons. In summer only 243 thousand tons vegetables are produced (Anon 2001). Although all vegetables cannot be grown in kharif season due to the climatic condition, cucurbits can be grown easily in kharif season. Because cucurbits are mainly warm weather crops but it is also sown in winter. The sowing time of cucurbits in winter is September-October. As a result, cucurbitaceous vegetables play an important role to supplement this shortage during the lag period (Rashid 1993). Cucurbits include sweet gourd, bottle gourd, cucumber, squash, bitter gourd, watermelon etc. Cucurbits occupy 66% of the land under vegetable production in Bangladesh and contribute 11% of total vegetable production in our country. Bangladesh produced 103 thousand tons of sweet gourd in the winter season and 77 thousand tons in the summer season of 2006-2007(Anon. 2007). Cucurbits are infested by a number of insect pests, which are considered to be the significant obstacles for its economic production. Among them, cucurbit fruit fly, white fly and red pumpkin beetle are the major pests responsible for considerable damage of cucurbits (Butani and jotwai 1984). Inspite of being a prospective crop, high incidences of insect pests have, limited the crop into its low yield and poor quality. Farmers in our country face various problems including the availability of quality seeds, fertilizer and manures, irrigation facilities, modern information in the fields of technical and instrumental inputs, pests and diseases in cultivation of the crop. (Rashid, 1993), among these, insect pets are the most important and cause enormous quantity of yield losses in every season and every year. Although no regular statistical records are kept, as per conservative estimate the yield loss in cucurbit vegetables is due to high insect pest. Different methods of controlling the pest are available, growers in Bangladesh, however, frequently use chemical insecticides in order to protect vegetables from damages due to insect attacks (Rahman, 2006; Karim, 1995). A survey on pesticide use in vegetables conducted in 1998 revealed that only about 15% to 16% of the farmers received information from the pesticide dealers and extension agents respectively (Islam, 1999). In most cases, the farmers either forgot the instructions or did not care to follow those instructions and went on using insecticides at their own choice or experience. As a result, the indiscrimination use of chemical pesticides has given rise to many well known serious problems including resistance of pest species, toxic residues in stored products, increasing cost of application, environmental pollution, hazards from handling, destruction of natural enemies of pests and non-target organisms etc. Hence, search for the alternative method of insect pest control utilizing some non-toxic, environment friendly and human health hazard free methods are being pursued now-a-days. Pest management in tropical and sub-tropical cucurbit vegetable crops has been particularly problematical for many years. The complex of insect pests, the quality 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. Implementation of Integrated Pest Management (IPM) systems in vegetable crops is also difficult as it usually involves more complex decision-making processes when compared with calendar treatment with insecticides.

At present situation in Bangladesh, there is a great need of information about appropriate management of pest in cucurbit vegetables. Evidence suggests that a series of experiments were conducted, which will help to formulate appropriate future plan for developing suitable management approach for controlling insect pests of cucurbit vegetables. However, the use of quality insecticide and its proper management overall on the effective control (IPM) of insect pest is a burning issue in respect of agro socio economic and environmental aspect.

OBJECTIVES:

1) To develop an integrated management approach for combating vegetables pests during the growing season in Bangladesh.
2) To find out efficacy of the management practices against insect pests complex of cucurbits vegetables.
3) To find out the best approach to manage cucurbits vegetable crops at tolerable level.

CHAPTER II

REVIEW OF LITERATURE

Bottle gourd, Sweet gourd and Cucumber are an important member of the cucurbits and naturally cross-pollinated crop. However, it is frequently observed that the plant produces very few fruits even through it has enormous number of male and female flowers. In Bangladesh cucurbits vegetable is attacked by different species of insect pests. The major pests of sweet gourd are red pumpkin beetle, white fly, epilachna beetle, cucurbit fruit fly etc.

2. 1 Morphological description of major insect pest of cucurbits vegetables

2.1.1 Red pumpkin beetle

The 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 on their yield reduction.

2.1.1.1 Systematic position of red pumpkin beetle

Phylum – Arthropoda

Class – Insecta

Sub-Class: Pterygota

Order – Coleoptera

Family – Chrysomelidae

Genus – *Aulacophora/ Raphidopalpa*

Species – *A. foveicollis*

2.1.1.2 Origin and distribution of red pumpkin beetle

Hutson (1972) reported that the red pumpkin beetle (RPB) occurs on various cucurbits in Ceylon. Pawlacos (1940) stated *Raphidopalpa foveicollis* (Lucas) as one of the most important pests of melon in Greece. Manson (1942) reported it to occur in Palestine. Azim (1966) indicated that the red pumpkin beetle, *Aulacophora foveicollis* (Lucas), is widely distributed throughout all zoogeographic regions of the world except the Neo-arctic and Neo-tropical region. Alam (1969) reviewed that the red pumpkin beetle, *Aulacophora foveicollis* (Lucas), 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. Butani and Jotwani (1984) reported that the RPB is widely distributed all over the South-East Asia as well as the Mediterranean region towards the west and Australia in the east. In India, it is found in almost all the states, though it is more abundant in the northern states (Butani and Jotwani, 1984). According to York (1992), this insect pest is found in the Mediterranean region, Africa and Asia.

2.1.1.3 Nature of damage and host preferences of red pumpkin beetle

Cucurbits are attacked by a number of insect pests, including striped cucurbit beetle, 12 spotted cucumber beetles and Red Pumpkin Beetle. The Red Pumpkin Beetle, *Aulacophora foveicophora* Lucas is the most serious pest of the cucurbits. It causes 35-75% damage to all cucurbits except Bitter Gourd at seedling stage and the crop needs to be resown. 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 reach upto 35-75% at seedling stage.

Khan (2013) studied to determine the biochemical composition of cucurbit leaves and their influence on red pumpkin beetle. Result revealed 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. Relationship of RPB population per leaf with the percent nitrogen, total and reducing sugar content of mature leaves of cucurbits was found positively correlated.

Khan *et al*. (2011) 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. From the present study, it was also found that the highest incidence of pumpkin beetles was observed at around 9:00 am and 6:00 pm, while the lowest incidence was at 2:00 pm. The highest population of red pumpkin beetle on sweet gourd, cucummber, ribbed gourd and sponge gourd was recorded in the month of May.

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 Red Pumpkin Beetle, *A. foveicollis* was studied by Khan *et al*. (2011) among ten cucurbitaceous crops (viz., sweet gourd, bottle gourd, ash gourd, bitter gourd, sponge gourd, ribbed gourd, snake gourd, cucumber, khira and muskmelon). 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*.

Mehta and Sandhu (1989) studied 10 cucurbitaceous vegetables and noted that bitter gourd was highly resistant to the RPB, while sponge gourd and bottle gourd were resistant. The cucumber, muskmelon and water melon were moderately resistant to the pest.

2.1.4 Management of red pumpkin beetle

Dabi *et al*. (1980) 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.

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 *et al.*, 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 by Babu *et al*. (2002) 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).

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. Mahmood *et al*., (2006) studied the comparartive 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. In Sri Lanka, neem based formulations were also effectively used for the control of this pest in organic crop production.

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 per hectare at 15, 25, 35 and 45 days after sowing (1.26 adults/plant) (Anonymous, 2007).

2.1.2 Whitefly

The whitefly (*Bemisia tabaci)* feeds on a wide range of vegetables and is an important pest of many crops including soybean and many types of ornamental plants. The whitefly also attack cucumber, bottle gourd, okra, pumpkin, lablab bean and eggplant

2.1. 2.1 Systemic position of whitefly

Phylum- Arthopoda

Class- Insecta

Order- Hemiptera

Family- Aleyrodidae

Genus- *Bemisia*

Species- *B. tabaci*

2.1.2.2 Origin and Distribution of Whitefly

Bemisia tabaci was first described as a pest of tobacco in Greece in 1889. Outbreaks in cotton occurred in the late 1920s and early 1930s in India and subsequently in Sudan and Iran from the 1950s and 1961 in EL Salvador (Hirano *et al.*, 1993). *B. tabaci* is widespread in the tropics and subtropics and seems to be on the move, having been recorded in many areas outside the previously known range of distribution. The whitefly has been reported as a green house pest in several temperate countries in Europe, e. g., Denmark, Finland, France, Norway, Sweden and Switzerland. Besides in green houses, the species has been reported on outdoor plants in France and Canada (Basu, 1995).

2.1.2.3 Nature of Damage:

According to Butani and Jotwani (1984) the white, tiny, scale like insects may be seen darting about near the plants or crowding in between the veins on ventral of leaves, sucking the sap from the infested parts. The pest is active during the dry season and its activity decreases with the on set of rains. As a result of their feeding the affected parts become yellowish, the leaves wrinkle and curl downwards and are ultimately shed. Besides the feeding damage, these insects also excrete honeydew which favors the development of sooty mould. In case of severe infestation, this black coating is so heavy that it interferes with the photosynthetic activity of the plant resulting in its poor and abnormal growth. The whitefly also acts as a vector, transmitting the leaf curl virus disease, causing severe loss.

2.2.4 Management of Whitefly:

To manage whiteflies, it is necessary to know which plants are affected by whiteflies and to understand the nature of its damage to crops, the biology of the whiteflies and their natural enemies, and how to monitor whitefly populations (sites, population dynamics, action thresholds). Also, it is critical to know the limitations of various control tactics, which include cultural controls (such as altered planting practices and physical barriers), host plant resistance, chemical controls, and natural controls.

The use of insecticides and oils to affect virus transmission by whiteflies has yielded more or less satisfactory results in a limited number of cases. Cultural control measures to reduce the disease incidence included sanitation, mixed cropping, use of reflective surfaces by way of mulches, physical barriers and cultivation of resistant varieties. No strategy for control of whitefly borne Gemini viruses has proved effective in practice (Brown and Bird, 1992).

Many reports, from cultural to transgenics have been published on the management of Tomato in the world. Few works are reviewed under the following subheading.

i) Sanitation: To manage the leaf curl disease tomato fields should be kept weed free and TYLCV infected plants should be clean out immediately. Tomato fields should be cleaned up immediately after harvest. TYLCV resistant cultivars should be used if available (Schuster and Polston, 1999).

ii) Use of Reflective Surfaces:

B. tabaci is strongly attracted to yellow plastic or straw mulches and killed by reflected heat. Mulching of tomatoes and cucumber fields with saw dust, straw or yellow polythene sheets markedly reduced the incidence of TYLCV and cucumber vein virus and populations of the whitefly vector (Cohen and Melamed-Madjar, 1978). In West Bengal, India, the incidence of yellow mosaic disease of okra was 24.3% in plots with yellow polythene mulch against 58.6% in control (Khan and Mukhopadhyay 1985).

Chemical Control of Whiteflies

Chemical control of whiteflies is both expensive and increasingly difficult. If the rate of whitefly re-infestation is great enough, the cost of effective insecticide treatments may be prohibitive. Besides the cost of treatment, other factors involved in chemical control decisions are the need for thorough coverage, the risk of secondary pest outbreaks, the risk of whiteflies developing insecticide resistance, and the regulatory restrictions on the use of insecticides. These factors have to be weighed against the expected returns for a given crop at a given planting date. Many systemic and contact insecticides have been tested for control of whiteflies, but few give effective control. Currently registered systemic insecticides, such as oxamyl, have been only partially effective. Certain contact insecticide combinations, especially pyrethroids such as fenpropathrin or bifenthrin plus organo-phosphates such as acephate or metamidophos, have provided excellent control in greenhouse and field studies as long as there was thorough coverage of the foliage. However, by exposing pest populations to two types of chemicals at once, combinations may accelerate selection for resistance to both materials. Therefore, tank mixes should be resorted to only when single applications are not effective. Other products with contact activity, such as oils, soaps and K-salts of fatty acids, can be very effective with thorough coverage, but in field tests they are often less effective because of poor coverage. Good coverage of the foliage with contact insecticides is essential for best results. Most whiteflies are located on the undersides of leaves where they are protected from overtop applications, and the immature stages (except for the crawler) are immobile and do not increase their exposure to insecticides by moving around the plant. Use drop nozzles where appropriate, adequate pressure, and calibrate and maintain equipment carefully. Specific insecticides should be selected according to the stage(s) of whitefly to be controlled. The effectiveness of the few currently registered insecticides could be lost if they are excessively and repeatedly applied. There are techniques for monitoring resistance to determine which insecticides are still active against whiteflies. Generally, if an insecticide treatment is properly made with sufficient coverage and yet is ineffective, then that whitefly population should be tested for resistance to the product. There is a possibility that treating a resistant whitefly population with certain insecticides could actually accelerate population growth. This could be because more eggs are laid when the insect is under biochemical stress, or because beneficial arthropods are eliminated. To minimize this potential problem, insecticide applications should be used judiciously and combined with non-chemical control tactics. Furthermore, distinct classes of chemical compounds should be rotated at least every other spray. Distinct classes of insecticide include the pyrethroids (Ambush, Asana, Danitol, Karate, etc.), organo-phosphates (Orthene, Monitor, Lorsban), carbamates (Vydate), chlorinated hydrocarbons (Thiodan), insect growth regulators (Applaud, fenoxicarb), oils, and soaps and detergents. Resistance to soaps and oils is unlikely to ever develop, so these materials should be used as much as possible.

The effectiveness of 19 insecticides and insecticides combinations against the Aleyrodid, *Bemisia tabaci* were evaluated in Venezuela by Marcano and Gonzalz (1993) and they observed that the most effective insecticedes against eggs and nymphs of the pest were: Imidacloprid (91.67 and 78.61 litres/ha); Mineral oil +Imidacloprid (88.85 and 71.33litres/ha); Cyfluthrin + Methamidophos (87.85 and 69.08 litres/ha); Buprofezin (86.1 and 53.19 litres/ha); Lambda-cyhalothrin (86.1 and 47.47 liters/ha); Profnofos + Cypermethrin (85.93 and 70.18 litres/ha).

Imidacloprid (a systemic chloronicotinyl insecticide) gained major importance for control of *Bemisia tabaci* in both field and protected crops, in view of extensive resistance to Organophosphorous, Pyrethroid and Cyclodiene insecticides (Cahil *et al.,* 1995).

Azam *et al.* (1997) conducted an experiment during 1993-95 with some insecticides (Carbofuran, Endosulfan, Dimethoate, Buprofezin and Triazophos) for the control of *B. tabaci* and yellow leaf curl bigeminivirus (TYLCV) and found that Endosulfan had the most affect to control *Bemisia tabaci.*

The plots treated with seed bed netting and two spray of Imidacloprid 200SL had the lowest number of Whitefly and it was statistically similar with the treatment seed bed netting with the spraying Nimbicidine and seed treatment only (Anon., 2005).

2.1.3 Leaf eating caterpillar

The caterpillar, *Spodoptera litura* (Fab.) and it synonym are Cabbage caterpillar or Prodenia caterpillar.

2.1.3.1 Systematic position of leaf eating caterpillar

Phylum: Arthopoda

Class: Insecta

Order: Lepidoptera

Family: Noctuidiae

Genus: *Spodoptera*

Species: *S. litura*

Scientific name: *Spodoptera litura* (Fab.)

2.1.3.2 Origin and distribution of leaf eating caterpillar

The caterpillar is found throughout the tropical and subtropical parts of the world. It is widly spread in India (Atwal, 1986). This pest has been reported from India, Pakiatan, Ceylon, Burma, Thailand, Malaysia, Cambodia, Laos, Vietnam, Sabah, Indonesia, the Philippines, Taiwan, Queensland, New South Wales, Papua New Guinea, West Iran, Solomon Islands, Gilbert Islands, New Caledonia, Fiji, Samoa, Tonga, Society Islands, Gilbert Islands and Micronesia (Grist *et al.,* 1989).

Hill (1983) reported that *S. litura* (Fab.) is a polyphagous pest ofcucurbits vegetables. It is originated from South and Eastern Old World tropics, including Pakistan, India, Bangladesh, Srilanka, S.E. Asia, Chin, Korea, Japan, The Philippines, Indonesia, Australia, Pacific islands, Hawaii and Fiji..

2.1.3.3 Nature of damage of leaf eating caterpillar

The caterpillar, *Spodoptera litura* (Fab.) attacks the tender leaves, and only the larvae caused the damage. 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. As a result, many newly emerging leaf of cucurbits vegetables could not form and at that time it was not economical to replace it with another new seedling. The nature and extent of damage differed with age of the caterpillars. The young caterpillar along with mature caterpillar also caused greater damage. In field, later stage of cucurbits was not found to be infested. Succeeding generations can do greater damage and can come out as a serious phase of infestation for their voracious feeding habit.

2.1.3.4 Management practices of 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 anti feedant 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.

2.1.4 Fruit fly

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

2.1.4.1 Systematic position of fruit fly

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

2.1.4.2 Origin and distribution

Fruit fly is considered to be the native of oriental, probably India and south east Asia and it was 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 (Alam, 1969). It was discovered in Solomon Islands in 1984, and is now widespread in all the provinces, except Makira, Rennell-Bellona and Temotu (Eta, 1985). In the Commonwealth of the Northern Mariana Islands, it was detected in 1943 and eradicated by sterile-insect release in 1963 (Steiner *et al.*, 1965), but re-established from the neighboring Guam in 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). In July 2010, fruit flies were discovered in traps in Sacramento and Placer counties. 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 (Christenson and Foote, 1960). The first report on melon fruit flies was published by Bezzi (1913), who listed 39 species from India. Forty-three species have been described under the genus *Bactrocera* including *cucurbitae*, *dorsalis, zonatus, diversus*, *tau, oleae*, *opiliae*, *kraussi, ferrugineus, caudatus, ciliatus, umbrosus, frauenfeldi, occipitalis, tryoni, neohumeralis, opiliae, jarvisi, expandens, tenuifascia, tsuneonsis, latifrons, cucumis, halfordiae, cucuminatus*, *vertebrates*, *frontalis*, *vivittatus*, *amphoratus*, *binotatus*, *umbeluzinus*, *brevis*, *serratus*, *butianus*, *hageni*, *scutellaris*, *aglaia*, *visendus*, *musae*, *newmani*, *savastanoi, diversus*, *and minax*, from Asia, Africa, and Australia (Fletcher, 1987; Cavalloro, 1983; Drew and Hooper, 1983; Munro, 1984).Among these, *Bactrocera cucurbitae* (Coquillett) is a major threat to cucurbits (Shah *et al.*, 1948). Senior-White (1924) listed 87 species of Tephritidae in India. Amongst these, the genus, *Bactrocera (Dacus*) causes heavy damage to fruits and vegetables in Asia (Nagappan *et al.*, 1971). The melon fruit fly is distributed all over the world, but India is considered as its native home. Two of the world most damaging tephritids, *Bactrocera dorsalis* and *B. cucurbitae,* are widely distributed in Malaysia and other South East Asian countries (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*.

2.1.4.3 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. A watery fluid oozes from the puncture, which becomes slightly concave with seepage of fluid, and transforms into a brown resinous deposit. Sometimes pseudo-punctures (punctures without eggs) have also been observed on the fruit skin. This reduces the market value of the produce. In Hawaii, pumpkin and squash are heavily damaged even before fruit set. 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. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition. 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.* (2007) reported 31.27% damage on bitter gourd and 28.55% on watermelon in India.

2.1.4.4 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).

Field sanitation is an essential pre requisite to reduce the insect population or defer the possibilities of the appearances of epiphytotics or epizootics. 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. 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 (Fang, 1989).

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. 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 0.0596 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 during 1997. 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 (ail at 100h a.i.ha^{-1}) 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 during 1968-1990.

Protein hydrolysate insecticide formulations are now used against various dacine fruit fly species (Kapoor, 1993). New a day, different poison baits are used against various *Batrocra species* which are 20g Malathion 50% or 50ml 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 50g 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 80SP 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) achived very good resuly 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. *B. dorsalis* was cradicated from the island of Rota by male annihilation using Methy1 eugenol as attractant (Steiner *et al.*, 1965).

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.* Neemberiatives have been demonstrated as repelients, antifeedants, growth inhibitors and cgemosterilant (Steets, 1976; Leuschner, 1972; Butterworth and Morgan, 1968). 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

The experiment was conducted to study development of an integrated pest management package(s) against insect pest complex of some winter cucurbits vegetables during rabi season (October-May) of 2015-2016 following the standard cultivation methods and others related activities.

Experimental site

The experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in 23^{0}74'N latitude and 90^{0}35'E longitude (Anon., 1989)

Weather condition

The climate of experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979)

Soil characteristics

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) corresponding AEZ No.28. The soil of the experimental area is shallow red brown terrace soil.

Planting material

Seeds of bottle gourd, sweet gourd, and cucumber were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur**.**

Land preparation

The land was opened with the tractor drawn disc plough. Then the soil was ploughed and cross ploughed. Ploughed soil was then brought into desirable fine tilth by the operations of ploughing, harrowing and laddering. The stubble and weeds were removed. Experimental land was divided into unit plots following the design of experiment.

During land preparation 15t/ha decomposed cowdung were mixed with soil. In each plot 2 pits were prepared for seedling transplanting.

Manures and fertilizers application

Recommended doses of fertilizer comprising urea, TSP, MP at the rate of 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 MP 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 MP were applied at flower initiation and third top dressing means one-third urea +one-third MP was applied at fruit initiation.

Seeds sowing, raising of seedling and transplanting in the field

For rapid germination the seeds of bottle gourd, Sweet gourd, cucumber varieties were soaked for 12 hours in water. Two seeds of variety were then sown per polythen bags containing a mixture of equal proportion of well-decomposed cowdung and loamy soil. seedlings were placed to partly sunny place for hardening. Finally, 15 days old seedlings were transplanted to the experimental plots as two seedlings per pit on last week of October, 2015. At the time of transplanting the polybags were cut and removed carefully in order to keep the soil intact with the root of the seedlings. The seedlings were watered until they got established.

Plate 01. Raising of seedling in polythen bag in the nursery bed

Plate 02. Experimental field during the study period

Details of the Treatments

Therefore, treatment combinations of this experiment wereas follows:

T_1: (IPM Package 1): Applying Cultural and Mechanical control method at 7 days interval

Cultural control method: Cultural pest control is the management of pests (insects, diseases, weeds) by manipulation of the environment or implementation of preventive practices including using plants that are resistant to insect pests, raising the mowing height of turf to shade out weeds, aerating turf to reduce compaction and plant stress, clean cultivation to keep the plot free from weeds and debris to discourage pupation.

Mechanical control method: Mechanical insect pest control is the management and control of insect pests using mechanical means such as removal of infested leaves, shoots, fruits and plants, to collect eggs larvae, pupa, adult insect etc and destroyed at 7 days interval

T_2: (IPM Package 2): Applying Mechanical control method at 7 days interval + using pheromone trap

Mechanical control method: Mechanical insect pest control is the management and control of insect pests using physical means such as removal of infested leaves, shoots, fruits and plants, to collect eggs larvae, pupa, adult insect etc and destroyed at 7 days interval

Pheromone trap: A pheromone trap is a type of insect trap that uses pheromones ‘cuelure’ which mimics the scent of female flies, attracts the male flies and traps them then resulting mating disruption. Cuelure and pheromone water traps was collected from Ispahani agro biotech limited, Gazipur. Half-fill the trap with soapy water and put pheromone cuelure from the lid using string or wire. Attach the trap to a bamboo or wooden stake or hang on branch of a tree

T_3: (IPM Package 3): Applying Cultural control method and spraying Suntaf 50 SP @ 1.5 gm per liter of water at 7 days interval

Cultural control method: Same as T_1 (IPM Package1) and including dilute Suntaf 50 SP @ 1.5 gm in 1 liter of water and spraying this mixture at 7 days interval.

T_4: (IPM Package 4): Applying Mechanical control method and spraying Sumialpha 5EC @ 1.0 ml per liter of water at 7 days interval

Mechanical control method: Same as T_2 (IPM Package 2) and including dilute Sumialpha 5EC @ 1.0 ml in 1 liter of water and spraying this mixture at 7 days interval.

T_5: (IPM Package 5): Combination of Chemical (Sevin 85 SP @ 1.5 gm in 1 liter of water), Cultural and field sanitation at 7 days interval

T_6: Untreated control

Field layout and design: The experiment was laid out with six treatments including one untreated control and using RCBD (Randomized Complete Block Design) with three replications. At first main experimental plot area was divided into three blocks. Again each block was divided into three sub-blocks for replications of applied treatments. Each block contained individual crop such as block-I for bottle gourd, block-II for sweet gourd and block-III for Cucumber vegetable growing. Each block contains unit 18 plots. There were total 54 unit plots in the experimental main plot. The unit plot size will be 3m × 3m having 1m distance between the blocks and 1m distance between the plots. Each plot contains 2 pits.

Intercultural operations

After transplanting the plants were initially irrigated by watering cane. Irrigation at an interval of 2-3 days, replacement of dead or damaged seedlings by healthy one. After 7 days of transplanting, propping of each plant by bamboo sticks was provided on about 1 m high from ground level for additional support to allow normal creeping. MP and urea were top dressed in 3 splits. Weeding and mulching in the plots were done, whenever necessary.

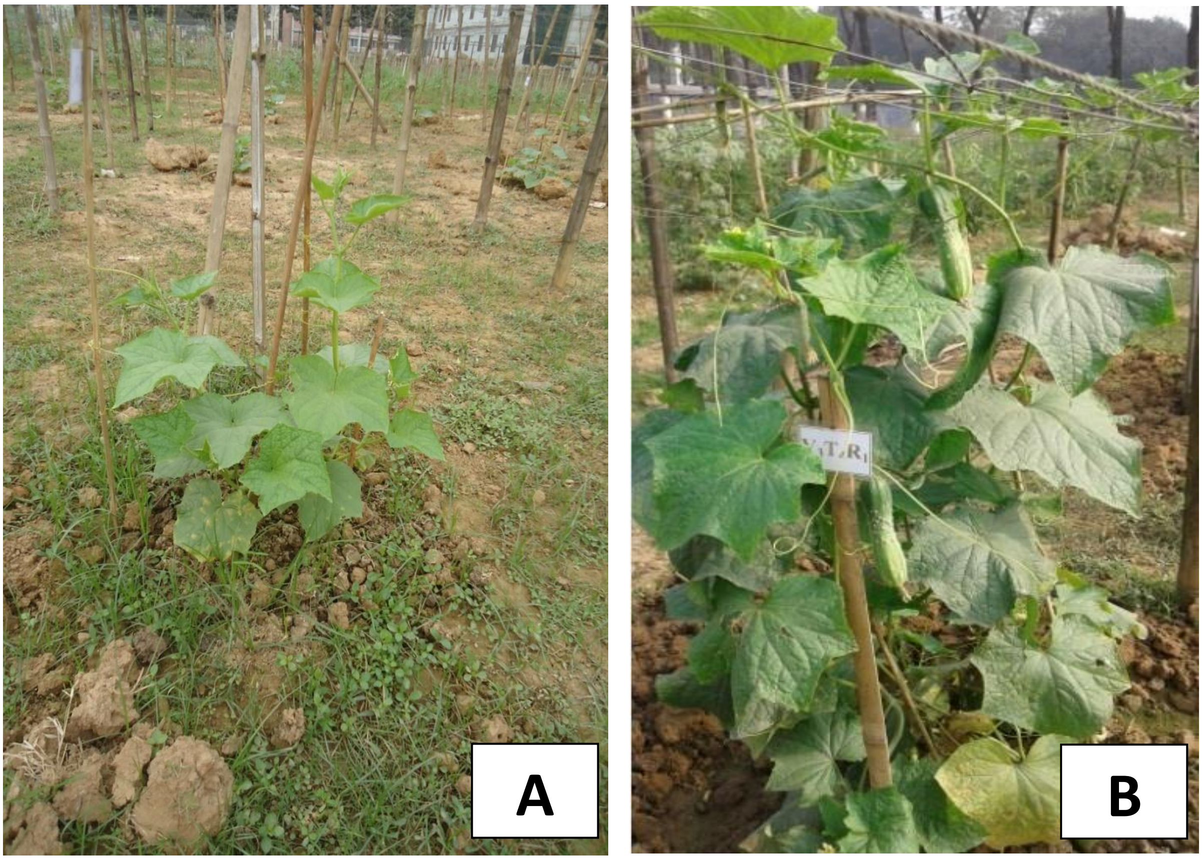

Plate 03. Seedling stage (A) and fruiting stage (B) of cucumber plant in the experimental field

Insecticides application

All the insecticides were collected from the local market of Dhaka District. In the Knapsack sprayer insecticide was shaken well always. Spray machine was calibrated and required quantity was found for three plots. Spraying was done in the afternoon to avoid bright sunlight and drift caused by strong wind and effect on pollinating bees.

Data collection: Data will be collected in the following parameters:

- Number of insects per plant or plot
- Number of beneficial insects per plot
- Number of infested or healthy leaves per plot
- Number of infested or healthy shoots per plot
- Number of infested or healthy flower per plot
- Number of infested fruits per plot
- Number of healthy fruits per plot
- Weight of healthy fruits and infested fruits
- Yellow mosaic virus infested leaves and fruits per plot
- Yield per plot
- Total yield in the experimental plot.

Plate 04. Infested cucumber seedling in the pit by red pumpkin beetle and leaf eating caterpillar

Plate 05. Infested bottle gourd leaf by red pumpkin beetle

Actual damage of fruit

Randomly selection of infested fruits from each treatment of each plot at each harvest. Harvest was recorded (in early, mid and late fruiting stage). Then determination of edible & inedible portion by slicing of these fruits.

$$\text{Extent of inedible damage (losses \%)} = \frac{\text{Weight of inedible portion of infested fruits}}{\text{Total weight of the harvested fruits}} \times 100$$

Fruit bearing capabilities in different treatments

$$\text{\% Fruit bearing ability at any fruiting stage} = \frac{\text{Number of fruits bearing ability at any fruiting stage}}{\text{Total number of fruits in that treatment}} \times 100$$

Intensity of attack

At first infested leaves, shoots, flower and fruits from each plot in each treatment after each harvest were done and this was done in all the 3 stages separately.

Plate 6. Healthy Bottle gourd plant with healthy fruits

Plate 07. Healthy Sweet gourd plant with healthy fruits

Plate 08. Infested fruit of cucumber with maggot of fruit fly

Plate 09. Green leaf eating caterpillar on bottle gourd leaf

Plate 10. Adult white fly on cucumber leaf

Yield per plot

At first weight of healthy and infested fruits at each harvest for each treatment were taken. Then cumulative weights of healthy infested fruits for each treatment were taken and finally total weight of fruits healthy+ infested) were taken.

Yield per hectare

Cumulative yield of healthy and infested fruits of each treatment was converted into ton/yield. Then effect of different treatments on the increase or decrease of fruits yield over control was also calculated.

Plate 11. Pheromone trap in the experimental field

DATA ANALYSIS

ANOVA of different parameters like percent leaves, shoots, flower and fruits infestation; healthy leaves, shoots, flower and fruits, and total yield; extent of damage; fruit bearing capabilities and intensity of attack were performed. Range test was done by using DMRT. Data were transformed (SQRT, Arcsine, etc.) whenever necessary. Data were analyzed by MSTAT-C software. Relationship between different parameters and yield will be shown by regression analysis.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2015 to march, 2016 to development integrated pest management package(s) against insect pest complex of some winter cucurbit vegetables such as sweet gourd, bottle gourd, cucumber. The results on different parameters have been interpreted, discussed and presented under the following sub-headings:

4.1 Common insect pest of cucurbits vegetables found in the field

Under the present study, the insect pests of cucurbits vegetables found in the experiment field are presented in Table 1.

Table 1. List of insect pest of cucurbits vegetables with stages of insect, site of infestation and nature of damage

Sl. No.	Common name of insect	Scientific name	Stage of insect	Site of infestation	Nature of damage
1.	Red pumpkin beetle	*Aulacophora foveicollis*	Larva, adult	Leaf, shoot	Both Adults and larva feed on young leaves. Damage also occurs to flowers and tender shoot
2.	Leaf eating caterpillar	*Spodoptera litura*	Larva	Leaf, flower, shoot	Larvae damage plants by chewing on leaves, flowers, shoots, and immature fruits**.**
3.	White fly	*Bemisia tabaci*	Adult	leaf	Both Adults and nymph feed by sucking sap from the foliage.
4.	Aphid	*Myzus persicae*	Adult	Leaf, shoot	Both Adults and nymph feed by sucking sap from the tender leaves and shoots.
5.	Fruit fly	*Bactrocera cucurbitae*	Larva, adult	Fruit	The adult female lays eggs by puncturing the epidermis and larvae feed internal tissues.

4.2 Damage severity of leaves at different growing stages of bottle gourd by red pumpkin beetle

From table 2, it was observed that, in the vegetative stage the highest number of red pumpkin beetle per plant (6.67) was found from T_6 (Untreated control) which was statistically different from among all other treatments. On the other hand the lowest number of red pumpkin beetle per plant (2.00) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 (2.33) treatment (Appendix I).

At the vegetative stage, the highest number of healthy leaves per plant (73.33) was found from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically similar to T_2 (70.33), T_3 (71.33) and T_4 (72.67) treatments respectively, whereas the lowest number of healthy leaves per plant were observed (61.33) in T_6 (Untreated control), which was closely followed by T_1 (68.33) treatment. On the other hand, the highest number of infested leaves per plant (15.33) was found from T_6 (Untreated control) which was statistically different from all other treatments and the lowest number of infested leaves per plant (5.67) was found from T_5 treatment which was closely followed by T_4 (Mechanical method +Spraying Sumialpha 5EC @ 1.0 ml/L of water at 7 days interval) (Table 1.1).

In case of leaf infestation, the highest percent of leaf infestation (20.01) was observed from T_6 (Untreated control) treatment, which was statistically different from among all other treatments and the lowest percent of leaf infestation (7.18) was observed from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically similar with T_4 (8.41). Leaf infestation reduction over control was estimated and the highest value was recorded from the treatment T_5 (64.12) following T_4 (57.97), T_3 (49.38) and T_2 (47.88) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (25.49) treatment.

Similar trends of result in case of number of red pumpkin beetle per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of bottle gourd (Table 2). Percentage of leaf infestation of bottle gourd in each treatment was presented in figure 1 and 2.

Table 2. Damage severity of leaves of bottle gourd at vegetative and reproductive stage by red pumpkin beetle in different treatments

Treatments	Vegetative stage					Reproductive stage				
	Insects/ plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control
T_1	4.67 b	68.33ab	12.00 b	14.91b	25.49	10.50 b	87.67 ab	15.67 b	15.16 b	28.99
T_2	4.33 b	70.33 a	8.17 c	10.43 c	47.88	10.33 b	90.33 ab	12.67 c	12.37bc	42.06
T_3	2.67 c	71.33 a	8.00 cd	10.13 c	49.38	7.67 c	94.00 a	12.00 cd	11.34 c	46.89
T_4	2.33 cd	72.6a	6.67 de	8.41 d	57.97	6.33 cd	90.33 ab	10.33 d	10.26 c	51.94
T_5	2.00 d	73.33 a	5.67 e	7.18 d	64.12	5.33 d	97.67 a	10.00 d	9.29 c	56.49
T_6	6.67 a	61.33 b	15.33 a	20.01 a	--	14.67 a	80.33 b	21.67 a	21.35 a	--
$LSD_{(0.05)}$	0.614	7.204	1.357	1.539	--	1.346	10.06	2.220	3.030	--
Level of significance	0.01	0.05	0.01	0.01	--	0.01	0.05	0.01	0.01	--
CV(%)	8.93	5.69	8.01	7.14	--	8.09	6.14	8.89	12.52	--

In a column, data represent the mean values 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

[**T_1:** Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interval
T_2: Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap
T_3: Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval
T_4: Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval
T_5: Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval
T_6: Untreated control]

4.3 Damage severity of leaves at the different growing stages of bottle gourd by aphid

From table 3, it was revealed that, in the vegetative stage the highest number of aphid per plant (32.33) was found from T_6 (Untreated control) which was statistically different from among all other treatments and the lowest number of aphid per plant (7.67) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically similar to T_4 (8.33) and T_3 (9.67) treatments respectively. On the other hand, the highest number of infested leaves per plant (33.33) was observed from T_6 (Untreated control) which was statistically different from all other treatments and the lowest number of infested leaves per plant (7.67) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically similar with treatment of T_4 (8.33) treatment and closely followed by T_3 (10.67) treatment.

in case of leaf infestation, the highest percent of leaf infestation (29.35) was observed from T_6 (Untreated control) which was statistically different from among all other treatments and the lowest percent of leaf infestation (7.28) treatment which was closely followed by T_4 (8.44) treatment. Leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (75.20) following T_4 (71.24), T_3 (65.25) and T_2 (58.81) and the lowest reduction of leaf infestation over control from T_1 (33.32) treatment (Appendix II).

Similar trends of result in case of number of aphid per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of bottle gourd (Table 3). Percentage of leaf infestation of bottle gourd in each treatment (figure 3 and 4) was decreases due to management practices and highest damage severity of leaves of bottle gourd was exposed at vegetative stage by aphid.

Table 3. Damage severity of leaves of bottle gourd at vegetative and reproductive stage by aphid in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	23.33b	21.33 b	19.57 b	33.32	20.67b	13.33 b	16.34 b	23.61
T_2	12.67 c	12.33 c	12.09 c	58.81	18.33 c	8.33 c	10.61 c	50.40
T_3	8.33 d	10.67cd	10.20 cd	65.25	9.67 d	6.00 d	7.82 d	63.44
T_4	5.67 e	8.33 d	8.44 de	71.24	8.33 d	5.67 de	7.24 d	66.15
T_5	5.33 e	7.67 d	7.28 e	75.20	7.67 d	4.33 e	5.58 d	73.91
T_6	29.67 a	33.33 a	29.35 a	--	32.33 a	16.67 a	21.39 a	--
$LSD_{(0.05)}$	1.857	2.927	2.203	--	2.127	1.387	2.288	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	7.20	10.31	8.36	--	7.23	8.41	10.94	--

In a column, data represent the mean values 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

[**T_1:**Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interval
T_2: Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap
T_3: Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval
T_4: Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval
T_5: Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval
T_6: Untreated control]

4.4 Damage severity of leaves at the different growing stages of bottle gourd by whitefly

At the vegetative stage the highest number of whitefly per plant (30.33) was found from T_6 (Untreated control) which was statistically different from among all other treatments (Appendix III). Whereas the lowest number of whitefly per plant (6.33) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically different from among all other treatments. On the other hand, the highest number of infested leaves per plant (15.33) was observed from T_6 (Untreated control) treatment which was statistically different from all other treatments and the lowest number of infested leaves per plant (4.00) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically different from among all other treatments.

In case of leaf infestation, the highest percent of leaf infestation (16.11) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (3.93) was observed from T_5 treatment which was closely followed by T_4 (5.58). However, Leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (75.61) treatment following T_4 (65.36), T_3 (62.82) and T_2 (52.95 treatments respectively) and the lowest reduction of leaf infestation over control from T_1 (34.51) treatment (Table 4).

Similar trends of result in case of number of white fly per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of bottle gourd (Table 4). Percentage of leaf infestation of bottle gourd in each treatment was decreases due to management practices and highest damage severity of leaves of bottle gourd was exposed at vegetative stage by white fly (figure 5 and 6).

Table 4. Damage severity of leaves of bottle gourd at vegetative and reproductive stage by whitefly in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	21.33a	10.33 b	10.55 b	34.51	20.33b	5.67 b	7.67 b	35.92
T_2	19.33a	7.33 c	7.58 c	52.95	12.67 c	4.00 c	5.37 c	55.14
T_3	12.33c	6.00 d	5.99 c	62.82	10.33 c	3.33 cd	4.45 cd	62.82
T_4	6.67 d	5.33 d	5.58 cd	65.36	10.67 c	2.67 d	3.54 d	70.43
T_5	5.33 d	4.00 e	3.93 d	75.61	6.33 d	2.33 d	3.09 d	74.19
T_6	16.67b	15.33 a	16.11 a	--	30.33 a	8.33 a	11.97 a	--
$LSD_{(0.05)}$	2.335	1.085	1.922	--	3.510	1.072	1.366	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	9.43	7.40	12.74	--	12.77	13.43	12.48	--

In a column, data represent the mean values 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

[**T_1:**Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interval
T_2: Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap
T_3: Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval
T_4: Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval
T_5: Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval
T_6: Untreated control]

4.5 Damage severity of leaves at the different growing stages of bottle gourd by leaf cutting caterpillar

From table 5, it was observed that, in the vegetative stage the highest number of leaf cutting caterpillar per plant (15.33) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of leaf cutting caterpillar per plant (1.33) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically different from among all other treatments.

At the vegetative stage (Appendix IV), the highest number of infested leaves per plant (5.67) was observed from T_6 (Untreated control) treatment which was statistically similar to T_1 (Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage population) + Mechanical control method(removal of infested shoots and fruits) at 7 days interval) treatment whereas the lowest number of infested leaves per plant (2.00) was found from T_5 (Cultural + Mechanical control method + Spraying sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 (2.33) treatment. In case of leaf infestation, the highest percent of leaf infestation (8.46) was observed from T_6 (Untreated control) treatment which was statistically similar with T_1(Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage population) + Mechanical method(removal of infested shoots and fruits) at 7 days interval) treatment and the lowest percent of leaf infestation (2.66) was observed from T_5 (Cultural + Mechanicalcontrol method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 (3.12) treatment. However, Leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (68.56) treatment following T_4 (63.12), T_3 (52.01) and T_2

Table 5. Damage severity of leaves of bottle gourd at reproductive stage by leaf cutting caterpillar in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	8.67 b	5.67 a	7.67 a	9.34	8.33 b	12.33 b	12.34 b	34.78
T_2	9.33 b	4.67 b	6.25 b	26.12	4.33 c	8.67 c	8.81 c	53.44
T_3	4.67 c	3.00 c	4.06 c	52.01	3.67 cd	8.33 c	8.14 cd	56.98
T_4	4.00 c	2.33 cd	3.12 cd	63.12	3.00 de	6.33 d	6.54 de	65.43
T_5	1.33 d	2.00 d	2.66 d	68.56	2.33 e	5.00 e	4.87 e	74.26
T_6	15.33 a	5.67 a	8.46 a	--	21.67 a	18.67 a	18.92 a	--
$LSD_{(0.05)}$	1.123	0.808	1.332	--	1.072	1.283	1.827	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	8.54	11.42	13.63	--	8.16	7.13	10.11	--

In a column, data represent the mean values 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

[**T_1:**Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interval
T_2: Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap
T_3: Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval
T_4: Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval
T_5: Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval
T_6: Untreated control]

(26.12) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (9.34) treatment. Similar trends of result incase of number of leaf cutting caterpillar per plant, leaf infestation and leaf infestation reduction over control were also found from at the reproductive stage of bottle gourd (Table 5). Percentage of leaf infestation of bottle gourd in each treatment was decreases due to management practices and highest damage severity of leaves of bottle gourd was exposed at vegetative stage by leaf cutting caterpillar (figure 7 and 8).

4.6 Damage severity of fruits of bottle gourd by fruit fly, *Bactrocera cucurbitae* at the reproductive stage during the study period

At the reproductive stage, the highest number of fruit fly per two sweeping (14.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments (Appendix V), whereas the lowest number of fruit fly per two sweeping (2.67) was found from T_2 (Mechanical method (removal of infested shoots and fruits) at 7 days interval + pheromone trap) treatment (even though large number of fruit flies were captured in pheromone trap a two sweeping) which was closely followed by T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment. In case of number of fruits, the highest number of healthy fruits per plant (16.00) was observed from T_2 (Mechanical method (removal of infested shoots and fruits) at 7 days interval + pheromone trap) treatment which was statistically different from all other treatments whereas the lowest number of healthy fruits per plant (2.00) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments. On the other hand, the highest number of infested fruits per plant (6.00) was observed from T_6 (Untreated control) which was statistically different from among all other treatments, The lowest number as well as no infested fruits per plant (0.00) was observed from T_2 (Mechanical method (removal of infested shoots and fruits) at 7 days interval + pheromone trap) treatment which was statistically different from among all other treatments. In case of fruit infestation, the highest percentage of fruit infestation (74.93) was observed from T_6 treatment whereas the lowest percentage of fruit infestation (0.00) as well as no infestation was observed from T_2 treatment (Table 6). However, fruit infestation reduction over control was estimated and the highest value was found from the treatment T_2 (100) treatment following T_5 (87.86), T_4 (85.17) and T_3 (80.88) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (55.52) treatment. The single fruit weight of T_1, T_2,

T_3, T_4, T_5 and T_6 treatments were (1051.67g), (1103.33g), (1106.67g), (1206.67g), (1255.00g) and (1051.67g). Kabir *et al*., (1991) said that yield loss due to cucurbit insect pest infestation varies from 19.19 to 69.96 percent in different cucurbit fruits and vegetables.

Table 6. Damage severity of fruits of bottle gourd by fruit fly in different treatments

Treatments	No. of insects/ two sweeping	Healthy fruits/ plant (No.)	Infested fruits/plant (No.)	Fruit infestation (%)	Fruit infestation reduction over control (%)	Single fruit weight (g)
T_1	10.33 b	6.00 d	3.00 b	33.33 b	55.52	1051.67 c
T_2	2.67 d	16.00 a	0.00 d	0.00 e	100.00	1103.33 bc
T_3	4.33 c	6.00 d	1.00 c	14.33 c	80.88	1106.67 bc
T_4	4.00 c	8.00 c	1.00 c	11.11 cd	85.17	1206.67 ab
T_5	3.33 cd	10.00 b	1.00 c	9.10 d	87.86	1255.00 a
T_6	14.67 a	2.00 e	6.00 a	74.93 a	--	1051.67 c
$LSD_{(0.05)}$	1.072	1.064	0.575	4.649	--	128.10
Level of significance	0.01	0.01	0.01	0.01	--	0.05
CV(%)	8.99	7.31	5.81	10.74	--	6.23

In a column, data represent the mean values 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

[**T_1:**Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interval
T_2: Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap
T_3: Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval
T_4: Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval
T_5: Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval
T_6: Untreated control]

4.7 Damage severity of leaves at the different growing stages of sweet gourd by red pumpkin beetle

From table 7, it was revealed that, in the vegetative stage of sweet gourd, the highest number of red pumpkin beetle per plant (18.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments whereas the lowest number of red pumpkin beetle per plant (6.00) was found from T5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar to T_4 treatment (6.33) and T_3 treatment (7.67). The highest number of healthy leaves per plant (78.00) was found from T_5 treatment which was statistically similar with T_4 (76.33) treatment and the lowest number of healthy leaves per plant (63.33) closely followed by T_1 (66.00) treatment. The highest number of infested leaves per plant (15.33) was observed from T_6 (Untreated control) treatment which was statistically different from all other treatments whereas the lowest number of infested leaves per plant (4.67) which was closely followed by T_4 (5.33) treatment.

In case of leaf infestation, the highest percent of leaf infestation (19.50) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (5.65) was observed from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar with T_4 (6.54). However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (71.03) treatment following T_4 (66.46), T_3 (57.38) and T_2 (52.10) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (34.51) treatment.

Table 7. Damage severity of leaves of sweet gourd at vegetative and reproductive stage by red pumpkin beetle in different treatments

Treatments	Vegetative stage					Reproductive stage				
	Insects/ plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	14.67 b	66.00 bc	9.67 b	12.77b	34.51	11.33b	82.33ab	14.67 b	15.15b	36.77
T_2	14.33 b	71.33abc	7.33 c	9.34 c	52.10	8.33 c	87.67ab	9.33 c	9.62 c	59.85
T_3	7.67 c	73.67 ab	6.67 cd	8.31 c	57.38	6.67 d	91.33 a	8.00 cd	8.06 d	66.36
T_4	6.33 c	76.33 a	5.33 de	6.54 d	66.46	6.00 d	93.67 a	7.33 d	7.30de	69.53
T_5	6.00 c	78.00 a	4.67 e	5.65 d	71.03	5.33 d	94.00 a	6.67 d	6.63 e	72.33
T_6	18.67 a	63.33 c	15.33 a	19.50a	--	13.67a	77.33 b	24.33 a	23.96a	--
$LSD_{(0.05)}$	1.809	8.892	1.370	1.683	--	1.314	11.43	1.747	1.293	--
Level of significance	0.01	0.05	0.01	0.01	--	0.01	0.05	0.01	0.01	--
CV(%)	8.82	6.84	9.22	8.94	--	8.45	7.16	8.19	6.03	--

In a column, data represent the mean values 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

[**T_1:** Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interval
T_2: Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap
T_3: Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval
T_4: Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval
T_5: Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval
T_6: Untreated control]

Similar trends of result incase of number of red pumpkin beetle per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of sweet gourd (Table 7). Percentage of leaf infestation of sweet gourd in each treatment was presented in figure 1and 2.

4.8 Damage severity of leaves at the different growing stages of sweet gourd by aphid

From these table it was exposed that, in the vegetative stage of sweet gourd, the highest number of aphid per plant (16.33) was found from T_6 (Untreated control) which was statistically different from among all other treatments and the lowest number of aphid per plant (5.33) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically similar to T_4 treatment (6.00) and T_3 treatment (6.67).

At the vegetative stage the highest number of infested leaves per plant (18.33) was observed from T_6 (Untreated control) which was statistically different from all other treatments whereas the lowest number of infested leaves per plant (5.67) was found from T_5 treatment which was statistically different from among all other treatments. In case of leaf infestation, the highest percent of leaf infestation (22.46) was observed from T_6 (Untreated control) which was statistically different from among all other treatments and the lowest percent of leaf infestation (6.78) was observed from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 treatment (8.76) treatment. However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (69.81) following T_4 (61.00), T_3 (54.63) and T_2 (43.50) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (23.51) treatment (Table 8).

Table 8. Damage severity of leaves of sweet gourd at vegetative and reproductive stage by aphid in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	14.67b	13.67b	17.18 b	23.51	16.3b	14.67b	15.20 b	43.33
T_2	10.33c	10.33 c	12.69 c	43.50	11.67c	11.33 c	11.46 c	57.27
T_3	6.67 d	8.33 d	10.19 d	54.63	8.00 d	9.33 cd	9.29 d	65.36
T_4	6.00 d	7.33 d	8.76 de	61.00	7.33 d	8.67 d	8.49 d	68.34
T_5	5.33 d	5.67 e	6.78 e	69.81	6.67 d	7.33 d	7.24 d	73.01
T_6	16.33a	18.33 a	22.46 a	--	21.33a	28.33 a	26.82 a	--
$LSD_{(0.05)}$	1.473	1.616	2.076	--	1.510	2.195	1.975	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	8.19	8.37	8.77	--	6.98	9.09	8.30	--

In a column, data represent the mean values 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

[**T_1:** Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interval

T_2: Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap

T_3: Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval

T_4: Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval

T_5: Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval

T_6: Untreated control]

Similar trends of result incase of number of aphid per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of sweet gourd (Table 8). Percentage of leaf infestation of sweet gourd in each treatment (figure 3 and 4) was decreases due to management practices and highest damage severity of leaves of sweet gourd was exposed at vegetative stage by aphid and Leaf infestation reduction over control also decreases at the reproductive stage of sweet gourd (Table 8).

4.9 Damage severity of leaves at the different growing stages of sweet gourd by whitefly

The highest number of whitefly per plant (16.67) was found from T_6 (Untreated control) treatment which was statistically similar with T_1 (15.67) treatment and the lowest number of whitefly per plant (6.00) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 (6.67) treatment were recorded at the vegetative stage (Table 9).

In case of infested leaves, the highest number of infested leaves per plant (5.67) was observed from T_6 (Untreated control) treatment which was statistically different from all other treatments whereas the lowest number of infested leaves per plant (2.00) was found from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 (2.33) treatment.

In case of leaf infestation, the highest percent of leaf infestation (8.23) was observed from T_6 treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (2.50) was observed from T_5 treatment which was closely followed by T_4 (2.97) treatment. However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (69.62) which was followed by T_4 (63.91), T_3 (57.59) and T_2 (45.44) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (30.50) treatment (Appendix no. 8).

Similar trends of result incase of number of white fly per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of sweet gourd (Table 9). Percentage of leaf infestation of sweet gourd (figure 5 and 6) in each treatment was decreases due to management practices and premier damage severity of leaves of sweet gourd was exposed at vegetative stage by white fly.

Table 9. Damage severity of leaves of sweet gourd at vegetative and reproductive stage by whitefly in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	15.67a	4.00 b	5.72 b	30.50	18.67b	5.33 b	6.12 b	32.45
T_2	12.33b	3.33 c	4.49 c	45.44	15.33c	4.67 b	5.04 bc	44.37
T_3	7.33 c	2.67 d	3.49 d	57.59	10.67d	4.33 b	4.52 c	50.11
T_4	6.67cd	2.33 de	2.97 de	63.91	8.33 e	3.00 c	3.11 d	65.67
T_5	6.00 d	2.00 e	2.50 e	69.62	8.00 e	2.33 c	2.42 d	73.29
T_6	16.67a	5.67 a	8.23 a	--	20.33a	7.67 a	9.06 a	--
$LSD_{(0.05)}$	1.032	0.598	0.938	--	1.473	0.964	1.243	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	5.27	9.87	11.30	--	5.97	11.63	13.54	--

In a column, data represent the mean values 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

[**T_1**: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l **T_2:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; **T_3:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; **T_4:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; **T_5:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; **T_6:** Untreated control]

4.10. Damage severity of leaves of sweet gourd at vegetative stage by leaf cutting caterpillar

At the vegetative stage from the table 10, it was revealed that, the highest number of leaf cutting caterpillar per plant (8.33) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of leaf cutting caterpillar per plant (3.00) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically different from among all other treatments (Appendix 9).

At the vegetative stage the highest number of infested leaves per plant (5.33) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments whereas the lowest number of infested leaves per plant (2.33) was found from T_5 treatment which was statistically similar with T_4 (2.67) treatment. In case of leaf infestation, the highest percent of leaf infestation (7.79) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (2.93) was observed from T_5 treatment which was statistically similar with T_4 (3.38) treatment. However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (62.39) which was followed by T_4 (56.61), T_3 (49.68) and T_2 (36.59) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (20.80) treatment (Table 10).

A similar trend of result was exposed from Table (10), incase of number of leaf cutting caterpillar per plant, leaf infestation and leaf infestation reduction over control were also found from at the reproductive stage of sweet gourd. Percentage of leaf infestation of sweet gourd in each treatment (figure 7 and 8) was decreases due to management practices and peak damage severity of leaves of sweet gourd was exposed at reproductive stage by leaf cutting caterpillar.

Table 10. Damage severity of leaves of sweet gourd at reproductive stage by leaf cutting caterpillar in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	6.67 b	4.33 b	6.17 b	20.80	6.33 b	8.33 b	9.24 b	24.14
T_2	6.00 b	3.67 bc	4.94 bc	36.59	4.67 c	5.33 c	5.75 c	52.79
T_3	4.67 c	3.00 cd	3.92 cd	49.68	3.33 d	4.67 c	4.87 c	60.02
T_4	4.33 c	2.67 d	3.38 d	56.61	2.67de	4.33 c	4.43 cd	63.63
T_5	3.00 d	2.33 d	2.93 d	62.39	2.00 e	3.00 d	3.10 d	74.55
T_6	8.33 a	5.33 a	7.79 a	--	14.67a	10.67 a	12.18 a	--
$LSD_{(0.05)}$	1.050	0.774	1.454	--	1.216	1.032	1.666	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	10.50	11.95	6.46	--	11.92	9.37	13.89	--

In a column, data represent the mean values 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

[**T_1**: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l **T_2:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; **T_3:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; **T_4:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; **T_5:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; **T_6:** Untreated control]

4.11 Damage severity of fruits of sweet gourd at the reproductive stage by fruit fly, *B. cucurbitae* during the study period

From the table (11) it was found that, in the reproductive stage the highest number of fruit fly per two sweeping (13.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of fruit fly per two sweeping (1.33) was found from T_2 (Mechanical method (removal of infested shoots and fruits) at 7 days interval + pheromone trap) treatment (although large number of fruit fly were captured in pheromone trap then two sweeping) which was statistically different from among all other treatments. On the other hand the highest number of healthy fruits per plant (15.00) was observed from T_2 (Mechanical method (removal of infested shoots and fruits) at 7 days interval + pheromone trap) which was statistically different from all other treatments whereas the lowest number of healthy fruits per plant (5.00) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments. In case of fruit infestation, the highest number of infested fruits per plant (4.00) was observed from T_6 treatment which was statistically different from among all other treatments whereas the lowest number of infested fruits per plant (0.00) was observed from T_2 treatment which was statistically different from among all other treatments. The highest percentage of fruit infestation (44.33) was observed from T_6 (Untreated control) treatment and the lowest percentage of fruit infestation (0.00) was observed from T_2 treatment. However, fruit infestation reduction over control was estimated and the highest value was found from the treatment T_2 (100) which was followed by T_5 (82.59), T_4 (81.19) and T_3 (62.62) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (25.11) treatment. The single fruit weight of T_1, T_2, T_3, T_4, T_5 and T_6 treatments were (953.00g), (1004.00g), (1022.00g), (1025.00g), (1050.00g) and (898.00g) (Table 11).

Nasiruddin and Alam (2007) studied fruit flies lay their eggs through long ovipositor within young and tender fruits. After hatching larvae feed on internal soft tissue and finally fruits are rotten. A recent survey report revealed that controlling this insect farmer sprayed 2-3 insecticides in a mixture at 2-3 days interval in Bangladesh.

Table 11. Damage severity of fruits of sweet gourd by fruit fly, *Bactrocera cucurbitae* during the study period

Treatments	No. of insects/2 sweeping	Healthy fruits/ plant (No.)	Infested fruits/plant (No.)	Fruit infestation (%)	Fruit infestation reduction over control (%)	Single fruit weight (g)
T_1	12.00 b	6.00 d	3.00 b	33.20 b	25.11	953.00 bc
T_2	1.33 e	15.00 a	0.00 e	0.00 e	100.00	1004.00 ab
T_3	4.67 c	10.00 c	2.00 c	16.57 c	62.62	1022.00 ab
T_4	4.00 cd	11.00 bc	1.00 d	8.34 d	81.19	1025.00 ab
T_5	3.33 d	12.00 b	1.00 d	7.72 d	82.59	1050.00 a
T_6	13.67 a	5.00 d	4.00 a	44.33 a	--	898.00 c
$LSD_{(0.05)}$	1.064	1.114	0.686	4.710	--	73.15
Level of significance	0.01	0.01	0.01	0.01	--	0.01
CV(%)	8.99	6.23	10.53	14.10	--	4.06

In a column, data represent the mean values 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

[**T_1**: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l **T_2:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; **T_3:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; **T_4:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; **T_5:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; **T_6:** Untreated control]

4.12 Damage severity of leaves at vegetative stage and reproductive stage of cucumber by red pumpkin beetle

From table 12, the highest number of red pumpkin beetle per plant (15.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of red pumpkin beetle per plant (5.00) was found from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically different from among all other treatments were recorded at the vegetative stage.

At the vegetative stage, the highest number of healthy leaves per plant (65.33) was found from T_5 treatment which was statistically similar to T_1 (58.67), T_2 (60.33), T_3 (62.67), T_4 (63.33) treatments respectively and the lowest number of healthy leaves per plant (51.33) was found from T_6 (Untreated control) treatment. The highest number of infested leaves per plant (6.67) was observed from T_6 treatment which was statistically different from all other treatments whereas the lowest number of infested leaves per plant (2.00) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar with T_4 (Mechanical method +Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment. In case of leaf infestation, the highest number of leaf infestation (11.48) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (2.97) was observed from T_5 treatment which was statistically similar with T_4 (3.56). However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (74.13) following T_4 (68.99), T_3 (56.01) and T_2 (49.91) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (35.63) treatment.

Table 12. Damage severity of leaves of cucumber at vegetative and reproductive stage by red pumpkin beetle in different treatments

Treatments	Vegetative stage					Reproductive stage				
	Insects/ plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestatio n (%)	Leaf infestation reduction over control (%)
T_1	13.33 b	58.67 a	4.67 b	7.39 b	35.63	4.00 b	73.33bc	8.67 b	10.57b	42.37
T_2	8.67 c	60.33 a	3.67 c	5.75 c	49.91	3.67bc	78.33abc	6.33 c	7.55 c	58.83
T_3	8.00 c	62.67 a	3.33 c	5.05 c	56.01	3.00 cd	80.67ab	5.33cd	6.19 d	66.25
T_4	6.67 d	63.33 a	2.33 d	3.56 d	68.99	2.67 de	81.33ab	4.67de	5.43de	70.39
T_5	5.00 e	65.33 a	2.00 d	2.97 d	74.13	2.00 e	84.67 a	4.00 e	4.52 e	75.35
T_6	15.67 a	51.33 b	6.67 a	11.48a	--	5.67 a	68.33 c	15.33a	18.34a	--
$LSD_{(0.05)}$	1.229	6.148	0.635	1.019	--	0.814	10.13	1.032	1.324	--
Level of significance	0.01	0.01	0.01	0.01	--	0.01	0.05	0.01	0.01	--
CV(%)	7.06	5.61	9.25	9.29	--	12.78	7.16	7.68	8.30	--

In a column, data represent the mean values 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

[$\mathbf{T_1}$: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l $\mathbf{T_2}$**:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; $\mathbf{T_3}$**:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; $\mathbf{T_4}$**:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; $\mathbf{T_5}$**:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; $\mathbf{T_6}$**:** Untreated control]

Similar trends of result incase of number of red pumpkin beetle per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of cucumber (Table 12). Percentage of leaf infestation of cucumber in each treatment was presented in figure 1and 2.

4.13 Damage severity of leaves of cucumber at vegetative stage by aphid

From table 13, it was revealed that, at the vegetative stage the highest number of aphid per plant (19.00) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of aphid per plant (7.33) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar to T_4 treatment (7.67) and T_3 treatment (8.33) respectively.

In case of leaves infestation, the highest number of infested leaves per plant (9.33) was observed from T_6 (Untreated control) treatment which was statistically different from all other treatments whereas the lowest number of infested leaves per plant (2.67) was found from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar to T_4 (3.33) treatment. In case of leaf infestation, the highest number of leaf infestation (15.39) was observed from T_6 which was statistically different from among all other treatments and the lowest percent of leaf infestation (3.94) was observed from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar to T_4 (5.01). However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (74.40) following T_4 (67.45), T_3 (54.78) and T_2 (50.10) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (36.58) treatment (Appendix XII).

Table 13. Damage severity of leaves of cucumber at vegetative and reproductive stage by aphid in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	14.67 b	6.33 b	9.76 b	36.58	13.67 b	11.67 b	13.74 b	51.05
T_2	10.67 c	5.00 c	7.68 c	50.10	9.33 c	9.67 c	11.09 c	60.49
T_3	8.33 d	4.67 c	6.96 c	54.78	7.67 d	8.33 d	9.36 d	66.65
T_4	7.67 d	3.33 d	5.01 d	67.45	7.33 d	7.67 d	8.61 d	69.33
T_5	7.33 d	2.67 d	3.94 d	74.40	6.67 d	6.33 e	6.97 e	75.17
T_6	19.00 a	9.33 a	15.39 a	--	16.67 a	26.67 a	28.07 a	--
$LSD_{(0.05)}$	1.314	1.032	1.825	--	1.396	1.314	1.459	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	6.41	10.87	12.35	--	7.51	6.16	6.18	--

In a column, data represent the mean values 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

[**T_1**: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l **T_2:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; **T_3:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; **T_4:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; **T_5:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; **T_6:** Untreated control]

4.13.2 Damage severity of leaves of cucumber at reproductive stage by aphid

At the reproductive stage the highest number of aphid per plant (16.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of aphid per plant (6.67) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar with T_4 (7.33) treatment and T_3 (7.67) treatment. On the other hand, In the reproductive stage the highest number of infested leaves per plant (26.67) was observed from T_6 (Untreated control) treatment which was statistically different from all other treatments whereas the lowest number of infested leaves per plant (6.33) was found from T_5. In case of leaf infestation, the highest number of leaf infestation (28.07) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (6.97).However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (75.17) which was followed by T_4 (69.33), T_3 (66.65) and T_2 (60.49) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (51.05) treatment.

4.14 Damage severity of leaves of cucumber at the different growing stages of cucumber by whitefly during study period

It was observed from the table 14 that, the highest number of whitefly per plant (20.33) was found from T_6 (Untreated control) treatment which was statistically similar with T_2 (15.33) treatment and the lowest number of whitefly per plant (8.33) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 treatment (10.00) at the vegetative stage. on the other hand, the highest number of infested leaves per plant (4.67) was observed from T_6 (Untreated control) treatment which was closely followed by T_1 (4.00) treatment whereas the lowest number of infested leaves per plant (2.00) was found from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) which was statistically similar with T_4 (2.33) treatment and closely followed by T_3 (2.67) treatment. In case of leaf infestation, the highest number of leaf infestation (8.32) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (2.97) was observed from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar with T_4 (3.58) treatment. However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (64.30) which was followed by T_4 (56.97), T_3 (50.60) and T_2 (36.90) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (23.20) treatment (Table 14) at vegetative stage of cucumber.

Similar trends of result in case of number of white fly per plant, leaf infestation and Leaf infestation reduction over control were also found from at the reproductive stage of cucumber (Table 14). Percentage of leaf infestation of cucumber (figure 5 and 6) in each treatment was decreases due to management practices and premier damage severity of leaves of cucumber was exposed at vegetative stage by white fly.

Table 14. Damage severity of leaves of cucumber at vegetative and reproductive stage by whitefly in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	18.67 a	4.00 ab	6.39 b	23.20	15.00 b	4.67 ab	5.99 b	21.70
T_2	15.33 b	3.33 bc	5.25 bc	36.90	12.33 c	3.67 bc	4.56 c	40.39
T_3	10.67 c	2.67 cd	4.11 cd	50.60	8.67 d	3.33 cd	3.97 cd	48.10
T_4	10.00 cd	2.33 d	3.58 d	56.97	8.00 d	2.67 cd	3.16 d	58.69
T_5	8.33 d	2.00 d	2.97 d	64.30	6.00 e	2.33 d	2.66 d	65.23
T_6	20.33 a	4.67 a	8.32 a	--	16.67 a	5.67 a	7.65 a	--
$LSD_{(0.05)}$	2.092	0.830	1.430	--	1.387	1.085	1.321	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	8.28	14.41	15.41	--	6.86	8.02	15.56	--

In a column, data represent the mean values 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

[**T_1**: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l **T_2:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; **T_3:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; **T_4:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; **T_5:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; **T_6:** Untreated control]

4.15 Damage severity of leaves at growing stages of cucumber by leaf cutting caterpillar

It was exposed from the table 15 that, in the vegetative stage the highest number of whitefly per plant (6.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of whitefly per plant (3.00) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 treatment (3.67).

At the vegetative stage the highest number of infested leaves per plant (5.33) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments whereas the lowest number of infested leaves per plant (2.33) was found from T_5 treatment which was closely followed by T_4 (2.67). In case of leaf infestation, the highest number of leaf infestation (9.40) was observed from T_6 treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (3.45) was observed from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was statistically similar with T_4 (4.04) treatment. However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5 (63.30) following T_4 (57.02), T_3 (51.28) and T_2 (44.26) and the lowest reduction of leaf infestation over control from T_1 (37.23) treatment (Table 15).

Table 15. Damage severity of leaves of cucumber at reproductive stage by leaf cutting caterpillar in different treatments

Treatments	Vegetative stage				Reproductive stage			
	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Leaf infestation reduction over control (%)
T_1	5.33 b	3.67 b	5.90 b	37.23	3.67 b	5.33 b	6.80 b	32.67
T_2	4.67 bc	3.33 bc	5.24 bc	44.26	3.00 c	4.67 bc	5.68 bc	43.76
T_3	4.00 cd	3.00bcd	4.58 cd	51.28	2.67cd	4.00 cd	4.72 cd	53.27
T_4	3.67 de	2.67 cd	4.04 d	57.02	2.33de	3.67 de	4.30 cd	57.43
T_5	3.00 e	2.33 d	3.45 d	63.30	2.00 e	3.00 e	3.43 d	66.04
T_6	6.67 a	5.33 a	9.40 a	--	5.67 a	7.67 a	10.10 a	--
$LSD_{(0.5)}$	0.719	0.737	1.108	--	0.592	0.921	1.407	--
Level of significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	8.66	11.95	11.21	--	10.08	10.71	13.24	--

In a column data represent the mean values 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

[**T_1**: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l **T_2:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; **T_3:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; **T_4:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; **T_5:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; **T_6:** Untreated control]

4.15.2 Damage severity of leaves of cucumber at reproductive stage by leaf cutting caterpillar

At the reproductive stage, the highest number of whitefly per plant (5.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments whereas the lowest number of whitefly per plant (2.00) was found from T_5 (Cultural method + Mechanical method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 (2.33) treatment. In the reproductive stage the highest number of infested leaves per plant (7.67) was observed from T_6 treatment which was statistically different from among all other treatments and the lowest number of infested leaves per plant (3.00) was observed from T_5 treatment which was closely followed by T_4 (3.67) and T_3 (4.00) treatment. In case of leaf infestation, the highest number of leaf infestation (10.10) was observed from T_6 treatment which was statistically different from among all other treatments and the lowest percent of leaf infestation (3.43) was observed from T_5 (Cultural method + Mechanical method +Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment which was closely followed by T_4 (4.30) and T_3 (4.72%) treatments respectively. However, leaf infestation reduction over control was estimated and the highest value was found from the treatment T_5(66.04) following T_4 (57.43), T_3 (53.27) and T_2 (43.76) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (32.67) treatment (Table 15).

4.16.1 Damage severity of fruits of cucumber at reproductive stage by fruit fly

From these table it was observed that, in the reproductive stage the highest number of fruit fly per two sweeping (15.67) was found from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of fruit fly per two sweeping (1.33) was found from T_2 (Mechanical method (removal of infested shoots and fruits) at 7 days interval + pheromone trap) treatment which was statistically different from among all other treatments.

On the other hand the highest number of healthy fruits per plant (20.00) was observed from T_5 which was statistically similar with T_4 (19.00) treatment whereas the lowest number of healthy fruits per plant (8.00) was found from T_6 (Untreated control) which was statistically different from among all other treatments. In case of fruit infestation, the highest number of fruit infestation per plant (8.00) was observed from T_6 (Untreated control) treatment which was statistically different from among all other treatments and the lowest number of infested fruits per plant (0.00) was observed from T_2 treatment which was statistically different from among all other treatments. The highest percentage of fruit infestation (49.97) was observed from T_6 (Untreated control) treatment and the lowest percentage of fruit infestation (0.00) was observed from T_2 treatment. However, fruit infestation reduction over control was estimated and the highest value was found from the treatment T_2 (100) which was followed by T_5 (81.79), T_4 (72.56) and T_3 (66.58) treatments respectively and the lowest reduction of leaf infestation over control from T_1 (29.22) treatment. The single fruit weight of T_1, $T_{2,}$ $T_{3,}$ $T_{4,}$ T_5 and T_6 treatments were (121.33g), (151.00g), (170.67g), (192.67g), (201.00g) and (109.33g) (Table 16).

Table 16. Damage severity of fruits of cucumber by fruit fly in different treatments

Treatments	No. of insects/2 sweeping	Healthy fruits/ plant (No.)	Infested fruits/plant (No.)	Fruit infestation (%)	Fruit infestation reduction over control (%)	Single fruit weight (g)
T_1	12.00 b	11.00 c	6.00 b	35.37 b	29.22	121.33 d
T_2	1.33 e	16.00 b	0.00 e	0.00 e	100.00	151.00 c
T_3	4.67 c	15.00 b	3.00 c	16.70 c	66.58	170.67 b
T_4	4.00 c	19.00 a	3.00 c	13.71 c	72.56	192.67 a
T_5	3.00 d	20.00 a	2.00 d	9.10 d	81.79	201.00 a
T_6	15.67 a	8.00 d	8.00 a	49.97 a	--	109.33 d
$LSD_{(0.05)}$	0.791	2.508	0.575	3.714	--	12.41
Level of significance	0.01	0.01	0.01	0.01	--	0.01
CV(%)	6.41	9.29	8.62	9.81	--	4.33

In a column data represent the mean values 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

[**T_1**: Cultural (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical control method (removal of infested shoots and fruits) at 7 days interva;l **T_2:** Mechanical control method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap; **T_3:** Cultural control method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval; **T_4:** Mechanical control method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval; **T_5:** Cultural + Mechanical control method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval ; **T_6:** Untreated control]

Effect of different pest management practices on leaf infestation at vegetative stage by red pumpkin beetle of bottle gourd, sweet gourd and cucumber during the study period

The comparative effect of different pest management practices (Treatments) on leaf infestation by red pumpkin beetle at vegetative stage has been demonstrated in Figure 1. The graph illustrated that the highest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (20.01, 19.50 and 11.48 respectively) was observed in T_6 (untreated control) treatment at vegetative stage whereas the lowest % of leaf infestation in bottle gourd, sweet gourd and cucumber (7.18, 5.65and 2.97 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment at vegetative stage.

Effect of different pest management practices on leaf infestation at reproductive stage by red pumpkin beetle of bottle gourd, sweet gourd and cucumber during the study period

The comparative effect of different pest management practices (Treatments) on leaf infestation by red pumpkin beetle at reproductive stage has been demonstrated in Figure 2. The graph illustrated that the highest percent of leaf infestation in bottle gourd (21.35) was observed in T_6 (untreated control) treatment at reproductive stage. Similar results were observed in T_6 (untreated control) treatment in sweet gourd (23.96) and cucumber (18.34) at reproductive stage whereas the lowest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (9.29, 6.63 and 4.52 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment at reproductive stage.

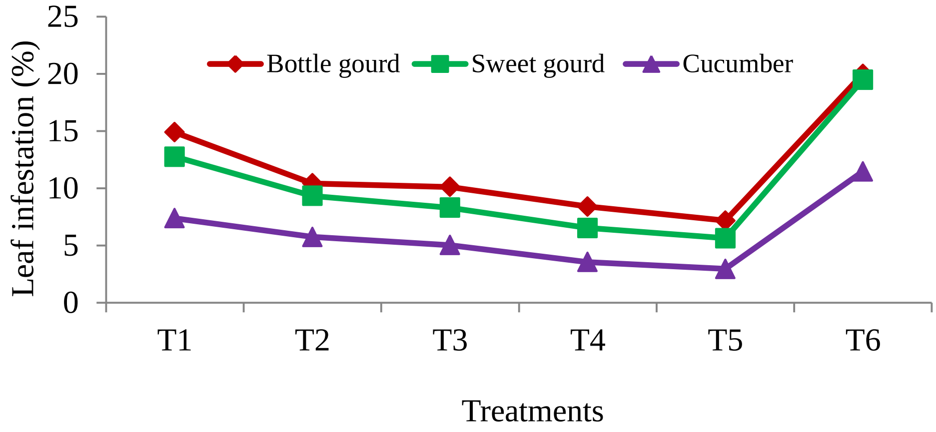

Figure 1. Effect of different pest management practices on leaf infestation at vegetative stage by red pumpkin beetle of bottle gourd, sweet gourd and cucumber

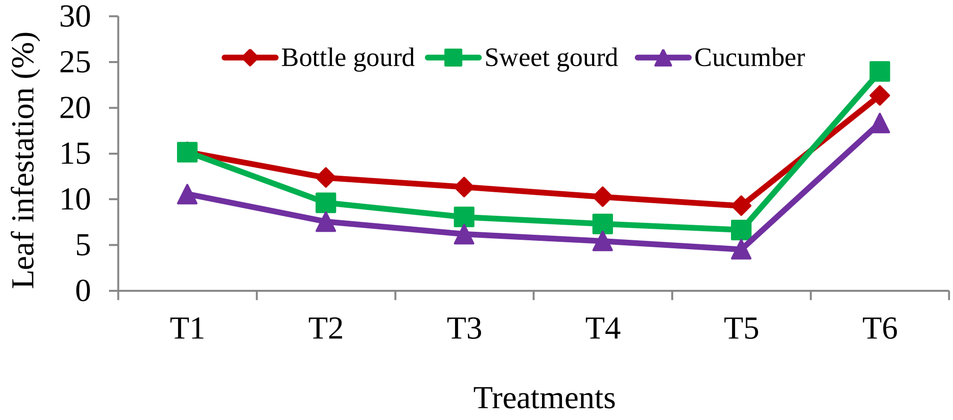

Figure 2. Effect of different pest management practices on leaf infestation at reproductive stage by red pumpkin beetle of bottle gourd, sweet gourd and cucumber

T_1: Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical method (removal of infested shoots and fruits) at 7 days interval

T_2: Mechanical method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap

T_3: Cultural method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval

T_4: Mechanical method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval

T_5: Cultural method + Mechanical method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval

T_6: Untreated control

Effect of different pest management practices on leaf infestation at vegetative stage by aphid of bottle gourd, sweet gourd and cucumber during the study period

The comparative effect of different pest management practices (Treatments) on leaf infestation by aphid at vegetative stage has been demonstrated in Figure 3. The graph illustrated that the highest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (21.39, 22.46, and 15.39 respectively) was observed in T6 (untreated control) treatment at vegetative stage whereas the lowest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (5.58, 6.78 and 3.94 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment at vegetative stage.

Effect of different pest management practices on leaf infestation at reproductive stage by aphid of bottle gourd, sweet gourd and cucumber during the study period

The comparative effect of different pest management practices (Treatments) on leaf infestation by aphid at reproductive stage has been demonstrated in Figure 4. The graph illustrated that the highest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (29.35, 26.82 and 28.07 respectively) was observed in T_6 (untreated control) treatment at reproductive stage whereas the lowest percent of leaf infestation (7.28, 7.24 and 6.97 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment at reproductive stage in bottle gourd, sweet gourd and cucumber.

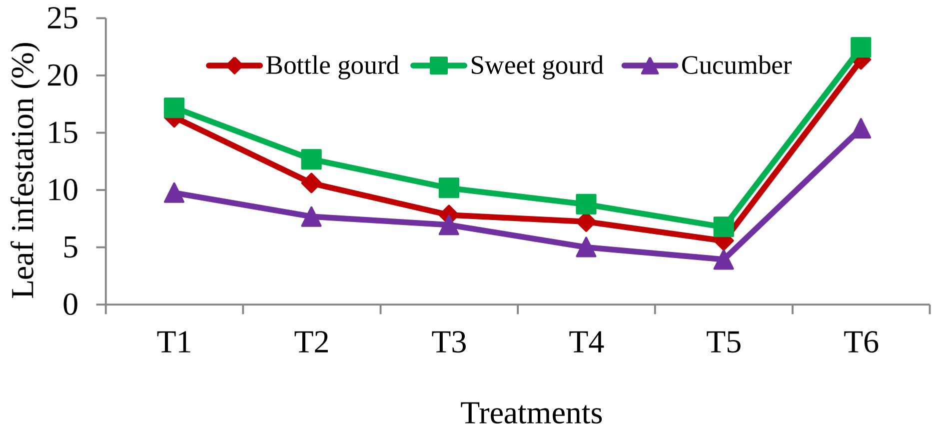

Figure 3. Effect of different pest management practices on leaf infestation at vegetative stage by aphid of bottle gourd, sweet gourd and cucumber

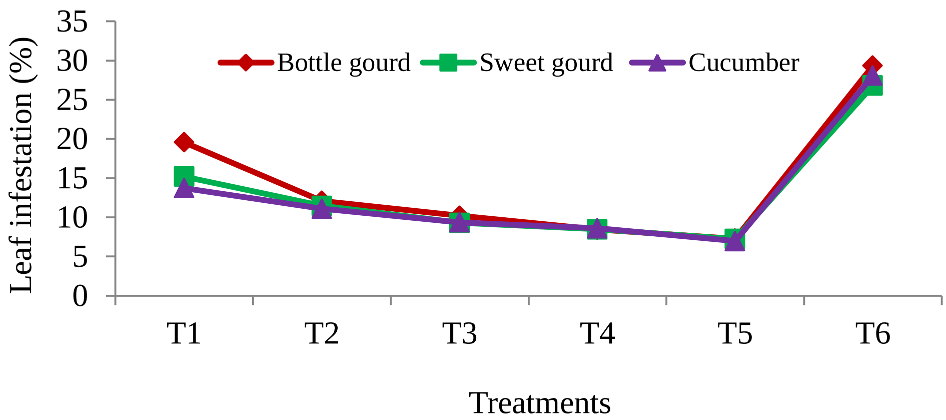

Figure 4. Effect of different pest management practices on leaf infestation at reproductive stage by aphid of bottle gourd, sweet gourd and cucumber

T_1: Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical method (removal of infested shoots and fruits) at 7 days interval

T_2: Mechanical method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap

T_3: Cultural method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval

T_4: Mechanical method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval

T_5: Cultural method + Mechanical method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval

T_6: Untreated control

Effect of different pest management practices on leaf infestation at vegetative stage by whitefly of bottle gourd, sweet gourd and cucumber:

The comparative effect of different pest management practices (Treatments) on leaf infestation by whitefly at vegetative stage has been demonstrated in Figure 5. The graph illustrated that the highest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (11.97, 8.23 and 8.32 respectively) was observed in T6 (untreated control) treatment at vegetative stage whereas the lowest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (3.09, 2.50 and 2.97 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment at vegetative stage.

Effect of different pest management practices on leaf infestation at reproductive stage by whitefly of bottle gourd, sweet gourd and cucumber

The comparative effect of different pest management practices (Treatments) on leaf infestation by whitefly at reproductive stage has been demonstrated in Figure 6. The graph illustrated that the highest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (16.11, 9.06, 7.65) was observed in T_6 (untreated control) treatment at reproductive stage whereas the lowest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (3.93, 2.42 and 2.66 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment at reproductive stage..

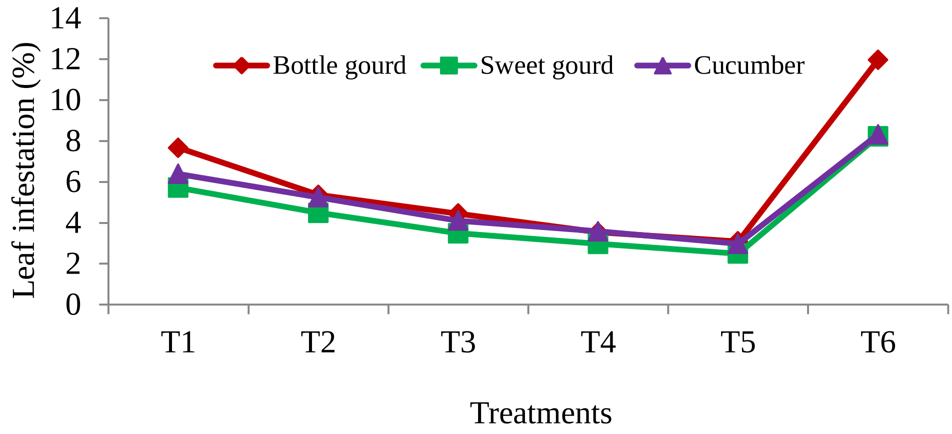

Figure 5. Effect of different pest management practices on leaf infestation at vegetative stage by whitefly of bottle gourd, sweet gourd and cucumber

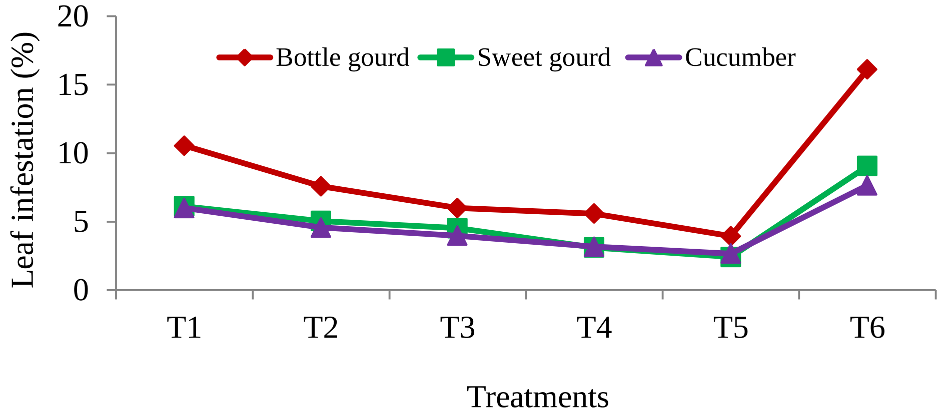

Figure 6. Effect of different pest management practices on leaf infestation at reproductive stage by whitefly of bottle gourd, sweet gourd and cucumber

T_1: Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical method (removal of infested shoots and fruits) at 7 days interval

T_2: Mechanical method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap

T_3: Cultural method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval

T_4: Mechanical method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval

T_5: Cultural method + Mechanical method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval

T_6: Untreated control

Effect of different pest management practices on leaf infestation at vegetative stage by leaf cutting caterpillar of bottle gourd, sweet gourd and cucumber

The comparative effect of different pest management practices (Treatments) on leaf infestation by leaf cutting caterpillar at vegetative stage has been demonstrated in Figure 7. The graph illustrated that the highest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (8.46, 7.79 and 9.40 respectively) was observed in T_6 (untreated control) treatment at vegetative stage whereas the lowest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (2.66, 2.93 and 3.45 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) treatment at vegetative stage.

Effect of different pest management practices on leaf infestation at reproductive stage by leaf cutting caterpillar of bottle gourd, sweet gourd and cucumber

The comparative effect of different pest management practices (Treatments) on leaf infestation by leaf cutting caterpillar at reproductive stage has been demonstrated in Figure 8. The graph illustrated that the highest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (18.92, 12.18 and 10.10 respectively) was observed in T_6 (untreated control) treatment at reproductive stage whereas the lowest percent of leaf infestation in bottle gourd, sweet gourd and cucumber (4.87, 3.10 and 3.43 respectively) was observed in T_5 (cultural method+ mechanical method+ spraying sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) at reproductive stage..

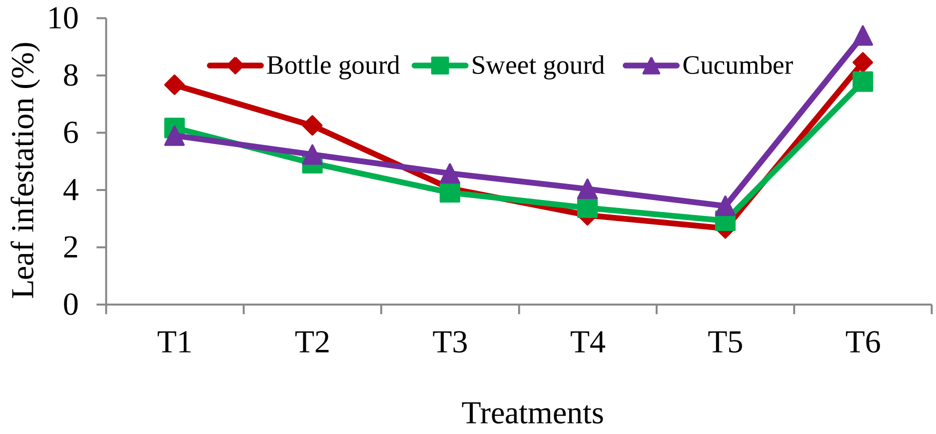

Figure 7. Effect of different pest management practices on leaf infestation at vegetative stage by leaf cutting caterpillar of bottle gourd, sweet gourd and cucumber

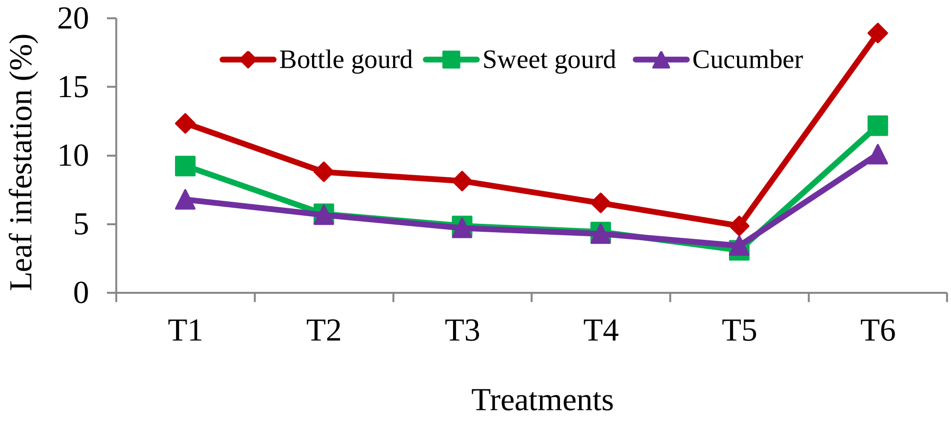

Figure 8. Effect of different pest management practices on leaf infestation at reproductive stage by leaf cutting caterpillar of bottle gourd, sweet gourd and cucumber

T_1: Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation) + Mechanical method (removal of infested shoots and fruits) at 7 days interval

T_2: Mechanical method (removal of infested shoots and fruits) at 7 days interval + Pheromone trap

T_3: Cultural method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval

T_4: Mechanical method + Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval

T_5: Cultural method + Mechanical method + Spraying Sevin 85 SP @ 1.5 g/L of water at 7 days interval

T_6: Untreated control

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted is the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2015 to May, 2016 to evaluate the performance of different management practices in controlling major insect pests of cucurbit vegetables. The experiment laid out Randomized Complete Block Design (RCBD) with three replications. Data were collected in respect of number of insects per plant or plot, number, number of infested or healthy leaves per plot, number of infested or healthy shoots per plot, number of infested or healthy flower per plot, number of infested fruits per plot, number of healthy fruits per plot, weight of healthy fruits and infested fruits and yield per plot. The data obtained for different characters were statistically analyzed to find out the significance level of the treatment.

At the vegetative stage in bottle gourd, the highest number of red pumpkin beetle per plant (6.67) was found from T_6 (Untreated control) whereas the lowest number of red pumpkin beetle per plant (2.00) was found from T_5 (Cultural + Mechanical control method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment. At the reproductive stage it was observed that, the highest number of red pumpkin beetle per plant (14.67) was found from T_6 (Untreated control) treatment and the lowest number of red pumpkin beetle per plant (5.33) was found from T_5 treatment .In the vegetative and reproductive stage leaf infestation reduction over control were estimated and the highest value were recorded from the treatment T_5 (64.12 and 56.49 respectively).

Similar trend of results were found from sweet gourd and cucumber incase of number insects were at the vegetative stage (6.00 and 5.00 respectively) and reproductive stage (5.33 and 2.00 respectively) in $T_{5.}$ In case of leaf infestation reduction over control at the vegetative stage in sweet gourd and cucumber (71.03 and 74.13 respectively) and reproductive stage (72.33 and 75.35 respectively) was observed from $T_{5.}$

At the vegetative stage in bottle gourd, the highest number of aphid per plant (29.67) was found from T_6 (Untreated control) whereas the lowest number of aphid per plant (5.33) was found from T_5 (Cultural + Mechanical control method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment. At the reproductive stage it was observed that, the highest number of aphid per plant (32.33) was found from T_6 (Untreated control) treatment and the lowest number of aphid per plant (7.67) was found from T_5 treatment. In the vegetative and reproductive stage leaf infestation reduction over control were estimated and the highest value were recorded from the treatment T_5 (73.91 and 75.20 respectively).

Similar trend of results were found from sweet gourd and cucumber incase of number insects were at the vegetative stage (5.33and 7.33 respectively) and reproductive stage (6.67 and 6.67 respectively) in $T_{5.}$ In case of leaf infestation reduction over control at the vegetative stage in sweet gourd and cucumber (69.81 and 74.40) and reproductive stage (73.01 and 75.17 respectively) was observed from $T_{5.}$

At the vegetative stage in bottle gourd, the highest number of whitefly per plant (16.67) was found from T_6 (Untreated control) whereas the lowest number of whitefly per plant (5.33) was found from T_5 (Cultural + Mechanical control method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment. At the reproductive stage it was observed that, the highest number of whitefly per plant (30.33) was found from T_6 (Untreated control) treatment and the lowest number of whitefly per plant (6.33) was found from T_5 treatment. In the vegetative and reproductive stage leaf infestation reduction over control were estimated and the highest value were recorded from the treatment T_5 (74.19 and 75.61 respectively).

Similar trend of results were found from sweet gourd and cucumber incase of number insects were at the vegetative stage (6.00 and 8.33 respectively) and reproductive stage (8.00 and 6.00 respectively) in $T_{5.}$ In case of leaf infestation reduction over control at the vegetative stage in sweet gourd and cucumber (69.62 and 64.30) and reproductive stage (73.29 and 65.23 respectively) was observed from $T_{5.}$

At the vegetative stage in bottle gourd, the highest number of leaf eating caterpillar per plant (15.33) was found from T_6 (Untreated control) whereas the lowest number of leaf eating caterpillar per plant (1.33) was found from T_5 (Cultural + Mechanical control method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment. At the reproductive stage it was observed that, the highest number of leaf eating caterpillar per plant (21.67) was found from T_6 (Untreated control) treatment and the lowest number of whitefly per plant (2.33) was found from T_5 treatment .In the vegetative and reproductive stage leaf infestation reduction over control were estimated and the highest value were recorded from the treatment T_5 (68.56 and 74.26 respectively).

Similar trend of results were found from sweet gourd and cucumber incase of number insects were at the vegetative stage (3.00 and 3.00 respectively) and reproductive stage (2.00 and 2.00 respectively) in $T_{5.}$ In case of leaf infestation reduction over control at the vegetative stage in sweet gourd and cucumber (62.39 and 63.30 respectively) and reproductive stage (74.55 and 66.04 respectively) was observed from $T_{5.}$

At the reproductive stage in bottle gourd, the highest number of fruit fly per two sweeping (14.67) was found from T_6 (Untreated control) whereas the lowest number of fruit fly per two sweeping (2.67) was found from T_2 [Mechanical control method (removal of infested shoots and fruits) at 7 days interval + pheromone trap]. In the reproductive stage fruit infestation reduction over control was estimated and the highest value was recorded from the treatment T_2.

Similar trend of results were found from sweet gourd and cucumber incase of number insects were at the reproductive stage (1.33and 1.33 respectively) in $T_{2.}$ In case of fruit infestation reduction over control at the reproductive stage (100 and 100 respectively) was observed from $T_{2.}$

From the above findings it can be concluded that among the treatments, T_5 (Cultural + Mechanical control method + Spraying Sevin 85 SP @1.5 g/L of water at 7 days interval) treatment was considered the best followed by T_4 (Mechanical control method +Spraying Sumialpha 5 EC @ 1.0 ml/L of water at 7 days interval) and T_3 (Cultural contol method + Spraying Suntaf 50SP @ 1.5 g/L of water at 7 days interval) in respect of higher healthy fruit and yield by reducing leaf and fruit infestation.

RECOMMENDATIONS

Considering the present results further studies in the following areas may be suggested:

- Integrated pest management practices may be introduced for effective control of insect pest complex of bottle gourd, sweet gourd and cucumber.
- This kind of study needs to be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
- Using chemical with other non-chemical components may be used for further study.

CHAPTER VI

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Appendix I. Analysis of variance of the data on damage severity of leaves of bottle gourd at vegetative and reproductive stage by red pumpkin beetle due to different pest management practices

Source of variation	Degrees of freedom	Mean square							
		Vegetative stage				Reproductive stage			
		Insects/ plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.097	2.347	0.056	0.058	0.181	26.389	0.389	1.625
Treatment	5	9.556**	58.089*	40.081**	68.728**	35.014**	104.322*	57.789**	58.998**
Error	10	0.114	15.681	0.556	0.716	0.547	30.556	1.489	2.773

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix II. Analysis of variance of the data on damage severity of leaves of bottle gourd at vegetative and reproductive stage by aphid due to different pest management practices

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.042	0.014	0.068	1.167	1.056	1.212
Treatment	5	306.500**	71.922**	113.320**	277.300**	298.856**	215.600**
Error	10	1.042	0.581	1.581	1.367	2.589	1.466

** Significant at 0.01 level of probability;

Appendix III. **Analysis of variance of the data on damage severity of leaves of bottle gourd at vegetative and reproductive stage by whitefly due to different pest management practices**

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	1.014	0.181	0.254	2.389	0.056	0.173
Treatment	5	132.056**	15.389**	33.436**	230.756**	52.056**	59.039**
Error	10	1.647	0.347	0.564	3.722	0.356	1.116

** Significant at 0.01 level of probability;

Appendix IV. **Analysis of variance of the data on damage severity of leaves of bottle gourd at vegetative and reproductive stage by leaf cutting caterpillar due to different pest management practices**

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.014	0.097	0.247	0.181	0.431	0.025
Treatment	5	74.356**	8.222**	17.859**	163.556**	74.089**	76.921**
Error	10	0.381	0.197	0.536	0.347	0.497	1.009

** Significant at 0.01 level of probability;

Appendix V. Analysis of variance of the data on damage severity of fruits of bottle gourd by fruit fly and single fruit weight due to different pest management practices

Source of variation	Degrees of freedom	Mean square				
		No. of insects/ two sweeping	Healthy fruits/ plant (No.)	Infested fruits/plant (No.)	Fruit infestation (%)	Single fruit weight (g)
Replication	2	0.181	0.042	0.0001	1.899	162.500
Treatment	5	70.222**	67.200**	14.400**	2243.200**	21015.833*
Error	10	0.347	0.342	0.100	6.531	4955.833

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on damage severity of leaves of sweet gourd at vegetative and reproductive stage by red pumpkin beetle due to different pest management practices

Source of variation	Degrees of freedom	Mean square							
		Vegetative stage				Reproductive stage			
		Insects/ plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.722	2.889	0.167	0.042	0.056	0.389	0.056	0.277
Treatment	5	84.456**	100.356*	46.100**	78.800**	32.622**	134.856*	139.256**	134.903**
Error	10	0.989	23.889	0.567	0.856	0.522	39.456	0.922	0.505

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on damage severity of leaves of sweet gourd at vegetative and reproductive stage by aphid due to different pest management practices

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.389	0.056	0.012	0.222	0.722	0.432
Treatment	5	66.489**	65.656**	102.940**	103.289**	182.722**	159.240**
Error	10	0.656	0.789	1.302	0.689	1.456	1.179

** Significant at 0.01 level of probability;

Appendix VIII. Analysis of variance of the data on damage severity of leaves of sweet gourd at vegetative and reproductive stage by whitefly due to different pest management practices

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.056	0.042	0.173	0.389	0.014	0.064
Treatment	5	67.556**	5.467**	13.651**	85.022**	10.622**	16.910**
Error	10	0.322	0.108	0.266	0.656	0.281	0.467

** Significant at 0.01 level of probability;

Appendix IX. Analysis of variance of the data on damage severity of leaves of sweet gourd at vegetative and reproductive stage by leaf cutting caterpillar due to different pest management practices

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.167	0.014	0.0001	0.181	0.056	0.004
Treatment	5	10.767**	3.822**	10.272**	66.189**	24.722**	35.306**
Error	10	0.333	0.181	0.639	0.447	0.322	0.839

** Significant at 0.01 level of probability;

Appendix X. Analysis of variance of the data on damage severity of fruits of sweet gourd by fruit fly and single fruit weight due to different pest management practices

Source of variation	Degrees of freedom	Mean square				
		No. of insects/ two sweeping	Healthy fruits/ plant (No.)	Infested fruits/plant (No.)	Fruit infestation (%)	Single fruit weight (g)
Replication	2	0.375	0.375	0.042	2.482	1066.667
Treatment	5	76.767**	42.500**	6.500**	868.987**	9312.500**
Error	10	0.342	0.375	0.142	6.702	1616.667

** Significant at 0.01 level of probability;

Appendix XI. Analysis of variance of the data on damage severity of leaves of cucumber at vegetative and reproductive stage by red pumpkin beetle due to different pest management practices

Source of variation	Degrees of freedom	Mean square							
		Vegetative stage				Reproductive stage			
		Insects/ plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/plant (No.)	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.056	2.889	0.056	0.216	0.0001	21.056	0.056	0.153
Treatment	5	50.356**	73.922**	8.756**	28.842**	4.900**	106.622*	53.389**	79.225**
Error	10	0.456	11.422	0.122	0.314	0.200	30.989	0.322	0.530

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix XII. Analysis of variance of the data on damage severity of leaves of cucumber at vegetative and reproductive stage by aphid due to different pest management practices

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.056	0.056	0.276	0.056	0.389	0.880
Treatment	5	65.256**	17.156**	50.598**	49.022**	170.722**	180.023**
Error	10	0.522	0.322	1.006	0.589	0.522	0.643

** Significant at 0.01 level of probability;

Appendix XIII. Analysis of variance of the data on damage severity of leaves of cucumber at vegetative and reproductive stage by whitefly due to different pest management practices

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	1.056	0.042	0.071	0.347	0.222	0.625
Treatment	5	73.689**	3.167**	11.928**	53.556**	4.722**	10.448**
Error	10	1.322	0.208	0.618	0.581	0.356	0.527

** Significant at 0.01 level of probability;

Appendix XIV. Analysis of variance of the data on damage severity of leaves of cucumber at vegetative and reproductive stage by leaf cutting caterpillar due to different pest management practices

Source of variation	Degrees of freedom	Mean square					
		Vegetative stage			Reproductive stage		
		Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)	Insects/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.056	0.097	0.108	0.056	0.056	0.265
Treatment	5	5.156**	3.389**	13.544**	5.289**	8.189**	17.132**
Error	10	0.156	0.164	0.371	0.106	0.256	0.598

** Significant at 0.01 level of probability;

Appendix XV. Analysis of variance of the data on damage severity of fruits of cucumber by fruit fly and single fruit weight due to different pest management practices

Source of variation	Degrees of freedom	Mean square				
		No. of insects/ two sweeping	Healthy fruits/ plant (No.)	Infested fruits/plant (No.)	Fruit infestation (%)	Single fruit weight (g)
Replication	2	0.056	1.500	0.0001	0.075	9.500
Treatment	5	97.422**	64.100**	24.800**	1019.745**	4183.467**
Error	10	0.189	1.900	0.100	4.168	46.567

** Significant at 0.01 level of probability;