INCIDENCE AND MANAGEMENT PRACTICES OF INSECT PEST COMPLEX OF SWEET GOURD AND THEIR EFFECT ON NATURAL ENEMIES

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CERTIFICATE

This is to certify that thesis entitled **"INCIDENCE AND MANAGEMENT PRACTICES AGAINST INSECT PESTS COMPLEX OF SWEET GOURD AND THEIR IMPACT ON NATURAL ENEMIES "** submitted to the **Faculty of Agriculture,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MOHAMMAD MIZANUR RAHMAN Registration no. 14-06307** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2016

Place: Dhaka, Bangladesh

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ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University central farm during the period from October 2015 to July 2016 to know the incidence and management practices of insect pest complex of sweet gourd and their effect on natural enemies. The variety; suprima (Lalteer) of Sweet gourd was selected for the study. There were seven treatments *viz*, (i) T_1 (spraying Phytoclean @ 1.0 ml/l of water), (ii) T_2 (spraying Sevin 85 SP @ 1.5g/l of water), (iii) T_3 (spraying Suntaf 50 SP @ 1.5 g/l of water), (iv) T_4 (spraying Ripcord 10 EC @ 1.0 ml/l of water), (v) T_5 (spraying Sumialpha 5EC @ 1.0 ml/l of water), (vi) T_6 (Mechanical and Cultural practices) all treatments are applied at 7 days interval and (vii) T_7 (untreated control). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results revealed that in terms of leaf infestation by red pumpkin beetle, epilachna beetle, whitefly and leaf cutting caterpillar; shoot infestation by red pumpkin beetle and leaf cutting caterpillar; and also fruit infestation by fruit fly and whitefly; in each case, best performance was obtained by T_2 by reducing leaf, shoot and fruit infestation and also by producing highest healthy leaves, shoots and fruits. Results also revealed that the highest healthy fruit yield (61.08 tha^{-1}) and lowest % infested fruits yield by weight (8.15%) was achieved by T_2. The highest % reduction of infested fruit by weight over control (72.73%) was also obtained from the plot of this treatment (T_2).

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LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
DAS	=	Days after sowing
$Kgha^{-1}$	=	Kilogram/hectare
LER	=	Land Equivalent Ratio
TSP	=	Triple Super Phosphate
tha^{-1}	=	ton/hectare

CHAPTER I

INTRODUCTION

Sweet gourd (*Cucurbita moschata*) belongs to the family cucurbitaceae is a commercially important vegetable for its year wide cultivation, availability, high carotene content and longer keeping quality. Sweet gourd grows well throughout the entire tropical and sub-tropical regions of the world. It is annual, day-neutral, monoceious, highly cross-pollinated and vine crop (Katyal and Chand, 1985). Sweet gourd is relatively high in energy and carbohydrates and a good source of vitamins, especially high carotene and minerals (Bose and Som, 1986). Sweet gourd can be consumed at mature and immature stages as vegetable, its leaves and tender stem are also used as delicious and nutritious vegetables. Seeds are also very nutritious (contains 40-50% oil and 30% protein) and eaten in many countries of the world (Tindall, 1987). The total area under cultivation of sweet gourd is 4,658 ha with a total production of 27,830 tons (BBS, 2012), which is very low compared to that of other developed countries where the yield is as high as 7.0-12.0 tha^{-1} (Yamaguchi, 1998).

Insect pest infestation is a major problem of crop production in Bangladesh. It reduces yield and marketable quality of the produce and thereby farmers incur huge financial loss (Rashid, 1993). Among them, red pumpkin beetle cucurbit fruit fly, epilachna beetle and white fly etc. are the major pests responsible for considerable damage of cucurbits (Butani and jotwai, 1984). These, insect pests are the most important and cause enormous quantity of yield losses in every season of every year.

Among the entire sweet gourd insect pest, red pumpkin beetle (RPB) is the major pests and cause considerable damage to all cucurbitaceous crops (Butani and Jotwani, 1984; Yawalker, 1985). The damage continues to be caused even in the later stages of the crop, but it is not so much serious as in the case of seedlings (Hassan *et al*., 2012). It may cause up to 70% damage on leaves and 60% damage on flowers of cucurbits (Alam, 1969). Fruit fly, *Bactrocera* sp. is a major pest causing yield loss in cucurbits, (Anon., 2004) and infests all 15 kinds of cucurbit vegetables grown in Bangladesh (Rakshit *et al.*, 2011). Due to its nature of infestation, it is very difficult to control the pest (Akhtaruzzaman *et al.*, 1999). *Epilachna dodecastigma* (Wied) is fairly common in Bangladesh and causes serious damage to Cucurbitaceous and Solanaceous vegetable crops. As a result, growth and development of the plants are greatly impaired and their yield is markedly reduced by Epilachna beetle (Rajagopal and Trivedi, 1989). The whitefly, *Bemisia tabaci* causes damage to the plants by feeding on the leaf with stylets inserted into the leaf tissue. Whitefly reduces crop yield and act as a vector of viral pathogens (Kajita and Alam, 1996).

Management practices of cucurbit pests in Bangladesh and other countries are still limited to frequent spray of toxic chemical pesticides (Alam, 2005; Anon., 2005, Misra and Senapati, 2003). At present synthetic pyrethroids are regularly used for the control of insect pest and their indiscriminate use, leading to major insect pest resurgence is well documented (Reddy and Srinivasan, 2009). The present day emphasizes not only the use of different groups of chemicals that are eco-friendly but also satisfactory control of insect pest population by their novel mode of action. Information on the seasonal incidence of the insect pests in cucurbit ecosystem and their management, particularly in this agro-climatic situation in the recent past is meager. The abuse of pesticides, including the use of excessive rates and non-registered chemicals, as well as disregard for re-entry and harvest-delay intervals, have resulted both loss of effectiveness of pesticides and damage to the environment and human health (Rashid *et al.*, 2004). The indiscriminate use of chemical insecticides also creates adverse effects on natural enemies, pest resistance and secondary pest outbreak, health hazards and environmental pollution (Bhadauria *et al.*, 1999). Injudicious use of insecticides frequently kills the natural enemies and affects arthropod biodiversity. As a result, harmful impact of insecticides on the environment and natural enemies is imposing a serious threat. Therefore, the effective control of insect pest in sweet gourd deserves some new approaches which are eco-friendly, economically and socially viable.

Therefore, under the above circumstances the present study was conducted with the following objectives:

- To study the incidence and determine infestation level of insect pests of sweet gourd during the growing season.
- To find out efficacy of the management practices against insect pests complex attacking sweet gourd.
- To evaluate the effect of management practices on the natural enemies during the study period.

CHAPTER II

REVIEW OF LITERATURE

Sweet gourd, an important member of the cucurbits is a naturally cross-pollinated crop. However, it is frequently observed that the plant produces very few fruits even Though it had enormous number of male and female flowers. In Bangladesh sweet gourd 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 sweet gourd

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 test insect

Phylum – Arthropoda
Class – Insecta
Sub-Class: Pterygota
Order – Coleoptera
Family – Chrysomelidae
Genus – *Aulacophora*
Species – *A. faveicollis*

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 Seasonal abundance of red pumpkin beetle

On various species of cucurbit plants, incubation, larval and pupal periods of red pumpkin beetle *A. foveicollis* were lowest during pre-monsoon (7.00, 11.00 and 7.94 days respectively) followed by monsoon (10.00, 13.00 and 9.26 days respectively) and post-monsoon (15.00, 14.74 and 15.02 days respectively) periods. Adult emergence percentage was the highest in pre-monsoon (80%) followed by monsoon (74.40%) and post-monsoon (62.75%) periods.

Alam (1969) reported that the maximum population of RPB observed during April and May and again in July and August in Bangladesh. The infestation on bottle gourd flowers observed from December and reaches its peak by the first week of January and then it declines. He also reported that reproduction is very limited and mortality is high during winter with five generations in a year. Overlapping of generations of the insect is very common during the period of its incidence. Uddin (1996) reported that its first generation appears in June and early July as well as in late August and September but the second generation received the favorable condition for their development.

According to Butani and Jotwani (1984), red pumpkin beetles are active from March to October, though the peak period of activity is April to June. According to Nair (1986) the RPB adults hibernate in November and reappear by the end of April and the broods overlap thereafter with higher mortality among the hibernating adults. Hazarika (1951) reported that the beetles of A. abdominalis in East Pakistan (now Bangladesh) become abundant in spring.

2.1.1.4 Host range of red pumpkin beetle

Alam *et al*. (1964) reported that bitter gourd, cucumber, snake gourd, sweet gourd, bottle gourd and many others plants are found to be seriously damaged by the red pumpkin beetle. He also indicated that melon, ribbed gourd, sponge gourd, snake gourd, cucumber, teasle gourd and kankri (Cucumis utilissimus) are also attacked by RPB in Bangladesh. Pradhan (1969) has reported that the RPB has a special preference for the leaves of cucurbit plants except those of the bitter gourd on which they have not been reported to feed to any appreciable extent.

Azim (1966) reported that the insect feeds on tomato, maize and lucerne besides cucurbits in Greece. In addition, the pest was recorded to attack forest trees like Dalbergia latifolia, Michela champaca and Tectona grandis in India. He also reported that this insect was found to feed on rice plants in Indo-China. Butani and Jotwani (1984) reported that this beetle is a polyphagous pest and prefers cucurbit vegetables and melons. However, some leguminous crops are found as their main alternate hosts. According to Rahman and Annadurai (1985), the RPB is particularly severe pest of pumpkins, muskmelons and bottle gourds, but it appears to be able to feed on any available cucurbits. They also reported that when cucurbits are absent, it is found feeding on other plant families.

According to Uddin (1996), *Aulacophora* sp. is a serious pest of sweet potato and cucurbits attacking cucumber, melons and gourds. Leaves of snake gourd plants at their flowering and fruiting stage were found to be severely damaged by a group of even more than 20 beetles per leaf at Bangladesh Agricultural Research Institute (BARI) farm, Joydebpur, Gazipur.

2.1.1.5 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 (Yamaguchi, 1983).

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*. (2012) reported that the highest population of RPB was recorded in the month of May. In March, food availability was the lowest because plants were young. In May, plant growth was maximal covering largest canopy. In June, plants were at their senescent stage causing food scarcity. 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 indicates 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. Sweet gourd (pumpkin), Cucurbita maxima Duch was the preferred host. 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.

An experiment was conducted on the host preference of *A. foveicollis* Lucas (Coleoptera, Chrysomelidae) on melon Cucumis melo, snake cucumber *C. flexuosus,* cucumber *C. sativus* and bottle gourd *Lagenaria siceraria*. Descending order of host preference was *C. melo, C. sativus* and *L. siceraria* for both 1975 and 1978 seasons. Yet, the first three crops did not differ significantly in their preference from each other and, thus, can be regarded collectively as the beetle's first choice. A field experiment was conducted by Shivalingaswamy *et al*. (2008) at Research Farm of Indian Institute of Vegetable Research, Variance during 2001-2002 (summer). Twenty seven diverse genotypes including some popular cultivars of bottle gourd were sown in plots (3 m x 2 m) with three replications. After 15 days of germination, the damage level in terms of damaged leaf area was recorded on newly "merging seedlings at 4-6 leaf stages. The average damage leaf area among test cultivars varied from 17.45% in VRBG-50 to 34.32% in NDBG-56. Only four cultivars that recorded less damage were VRBG-50 (17.45%), VRBG-48 (17.79), VRBG-43 (17.83%), and VRBG-17 (18.31 %). On the other extreme, the cultivars manifesting greater susceptibility to the beetle damage were NDBG-56 (34.32%), PSPL (33.77%), DVBG-2 (1) (29.17%) and VRBG-46 (28.55%).

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.

2.1.2 White fly

Whitefly is the most important pest damaging the plants resulted reduced crop yield and act as vectors of viral pathogens (Kajita and Alam, 1996).

2.1.2.1 Systematic position of test insect

Phylum: Arthropoda

Class: Insecta

Sub-Class: Pterygota

Order: Hemiptera

Family: Aleyrodidae

Genus: *Bemisia*

Species: *B. tabaci*

2.1.2.2 Origin and distribution

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 i*s 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 greenhouse 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 Seasonal occurrence and abundance

In a study in Sudan Kranz *et al.* (1977) found a sharp increase in whitefly population in September and October which was directly correlated with higher relative humidity (80-90%) and increasing temperature (36-38ºC). These conditions favour the development of the juvenile stages by shortening the duration of each stage. They indicated that the population decreases due to high mortality rate at eggs and free juvenile stages in March, April and May when the temperature is high (43-45ºC) and RH is low (8-17). On the other hand, Gerling *et al.* (1986) observed that the extreme RH, both high and low, was unfavorable for the survival of immature stages. Thus in Sudan, Horowitz (1986) found significant drop of whitefly population levels at heavy rainy condition.

2.1.2.4 Host range

B. tabaci is highly polyphagous and has been recorded on a very wide range of cultivated and wild plants. Greathead (1986) updated the information reported by Mound and Hasley (1978) and listed 506 species of plants belonging to 74 families. It may be pointed out that 50% of the total number of host plants belonging to only 5 families, namely, Leguminosae, Compositae, Malvaceae, Solanaceae and Euphorbiaceae.

2.1.2.5 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 onset 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. Sastry and Singh (1973) estimated 20-75% loss in tomato yield due to tomato leaf curl virus disease in India.

2.1.3 Epilachna Beetle

The insect is found throughout the country and it causes considerable damage to cucurbitaceous vegetables.

2.1.3.1 Systematic position of test insect

Phylum: Arthropoda

Class: Insecta

Sub-Class: Pterygota

Division: Endopterygota

Order: Coleoptera

Family: Coccinellidae

Genus: *Epilachna*

Species: *E. dodecastigma*

2.1.3.2 Origin and distribution

Adults Epilachna beetle, *E. dodecastigma* (Wied.) are spherical, pale yellowish brown elytra mottled with 12 black spots, male genitalia with median lobe dentulate dorsally, sipho nearly straight at the apex which has an eyelet, female genital plate with rounded notch on the inner margin. Grubs are yellowish with spines all over body. Pupation is on leaves, pupae are hemispherical. Life cycle is completed in 25-50 days (Kapur, 1965).

Epilachna beetle, *E. dodecastigma* (Wied.) is originally described from southern india, the species is very widely distributed in South and East Asia, Japan, Australia, America and the East Indies. Two species of epilachna beetle viz., *E. dodecastigma* (Wied.) and *E. vignitioctopunctata* Fab. are serious pests of vegetables in Bangladesh (Khan *et al.*, 2000).

2.1.3.3 Seasonal abundance of Epilachna beetle

The spotted leaf beetle, *Henosepilachna vigintioctopunctata* (F.) is an important pest of the solanaceous (e.g. brinjal, tobacco, tomato, potato, etc.) and cucurbitaceous (e.g. gourds, melon, cucumber, etc.) plants (Azam *et. al.*, 1974). The pest also attacks wild species *Amaranthus caudatus* L. (Hameed and Adlakha, 1973) and some medicinal plants such as Physalis spp. (Mohansundaram and Uthamaswamy, 1973), Datura spp., Solanum spp. and *Withania somnifera* Dunal (Mathur and Srivastava, 1964). *Henosepilachna vigintioctopunctata* is widely distributed in Southeast Asian countries, Korea and Australia (Kapur, 1950). The pest has been noticed since many decades in different parts of India (Bassi, 1963). The high incidence of the pest has been reported during temperature range of 2431°C and relative humidity 58-75% RH in the field (Ramzan *et. al.*, 1990; Ghosh and Senapati, 2001). The outbreak of *H. vigintioctopunctata* was noticed during 2004-2005 on *W. somnifera* plants in Bangalore, India.

2.1.3.4 Host-range and feeding habit of Epilachna beetle

Shukla and Upadhay (1985) suggested that temperature and relative humidity had the most profound effect on the digestion of food but light had no significant effect on *E. dodecastigma*. The optimum conditions for digestion by *E. dodecastigma* were 25-30°C, 50-60% relative humidity and natural light as compared with continuous darkness.

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

Gajendra *et al.* (1987) reported that larvae of *E. dodecastigma* did not feed on pteridophyta or gymnosperms (in the spematophyta) of the 9 orders of Legume group of dicotyledons. Only species of the Cucurbitaceae were accepted. No species of Herbaceous were accepted as food Monocotyledons were also rejected *E. dodecastigma* could not survive on four species of Solanaceae (including aubergine and *Capsicum annum).* Newly hatched larvae of *E. vigintioctopunctata* survived and developed well on Solanaceae but failed to survive on cucurbits.

Richards and Wood (1990) stated that food preference of *E. vigintioctopunctata* was influenced by odour, taste, vision and age of plant and also by thickness of leaves, proportion of crude fibres, parenchymatous tissues and water content

Murata *et al.* (1994) reared 4th instar larvae of *E. vigintioctopunctata* on a series of synthetic diets, some solid and some in liquid form absorbed into paper Dry leaf powder and solid diet with ethanol extract of the food plant *Solanum carolinese* did not elicit feeding behavior, although the later did attract the larvae Only the liquid diets absorbed onto paper elicited stable feeding behavior, generating feeding marks similar to those observed on *Solanum tuberosum.*

Khan (1997) studied the food consumption of *E. dodecastigma* in different host plants and found that the total food consumption by the larva on water melon was 2375 mm' and on sweet gourd was 780.7mm^2.

Imura and Ninomiya (1998) reported that the leaf area of a Solanaceous weed, *Solatium carolinense*, consumed by larvae and adults of a leaf scraping coccinellid beetle, *E. vigintioctopunctata* was measured by the image processing system (IPS). An average, beetle consumed 1429.5 mm' of leaves to complete its larval development and consumed 2510.9 mm' of leaves during the first 10 days of its adult stage.

Moniruzzaman (1999) studied the food consumption of *E. dodecastigma* on different host plants and found that total food consumption by a single larva during its whole larval life on brinjal, ridged gourd, kakrol, bean and wild brinjal was 185.62±51.36, 451 25±92.28, 247.90±74.53, 349.94±74.63 and

169.50±37.73 mm', respectively and total food consumption by single adult dunng its whole adult life on brinjal, ridged gourd, kakrol, bean and wild brinjal was 587.48±51.80, 533.90±47.69, 663.60±51.80, 415.03±34.95 and 399.50*40.18 mm^2, respectively.

Choudhuri *el al.* (1983) observed the effect of rearing on two different food plants on the bionomics of *E. dodecasiigma*, an important pest of Cucurbitaceous and Solanaceous crops. The effect of availability of the food-plants, bitter gourd was the preferred food plants; populations increased faster and damage was greater on these crops.

Shukla and Upadhay (1983) investigated the effects of range of laboratory temperature (20-40°C) on the attraction of adults of *E. dodecastigma* to plants and flowers of *Luffa cylindrica* in India. The attractiveness of both plants and flowers was greatest at 25°C, and it was concluded that control measures on the field would be particularly effective at this temperature. I hey also investigated that light had little influence on the attraction of the coccinellid, *E. dodecastigma* to its host plants. Under normal light conditions, *Luffa cylindrica* was the most preferred crop, followed by *L. acutangula, Trichscmthes dioica, Cucurbita muschata* and *Lagenaria siceraria.* In the dark and yellow, red or green light, the order of preference was the same but fewer adults were attracted to *L. aegyptica.*

Rahman (2002) studied on the feeding behavior and food preference of *E. dodecastigma* on different host plants and observed that total food consumption by a larva on ridged gourd, kakrol, snake gourd, sweet gourd and bitter gourd was 4466±39.41, 2484.5±39.4I, 3318.5±39.41, 2408 7±39.41 and 2245.1 ±39.41 mm^2, respectively and the total food consumption by an adult on ridged gourd, kakrol, snake gourd, sweet gourd and bitter gourd was 537.44±41.95, 661 18±41.95, 447.84±43.04, 347.13±42.48 and 397.47±46.9 mm^2, respectively.

Araujo and Almeida (2004) stated that *E. vigintioctopunctata* is a pest of many plants of agricultural importance in Asia. In 1990, the species was found in Brazil, near Curitiba, State of Parana, in Cucurbitaceous plants. In February 2002, specimens were collected in *Solanum americanum* in Itajai, State of Santa Catarina

Hndo *et al.* (2004) reported that the phytophagous lady beetle *E. vigintioctomaculata* feeds mainly on potato (*Solanum tuberosum)* leaves. The methanol extracts of potato leaves showed feeding stimulative effects on the adult of the beetle. The feeding stimulants were isolated and identified as methyl linolenate from a lipid-soluble fraction, and glucose and fructose from an aqueous fraction. Although methyl linolenate alone was inactive, it acted synergistically with sugars. Methyl linolenate maximized the feeding activity of sugars at the concentration contained in the potato leaves. It is suggested that methyl linolenate plays an important role in the host selection of *E. vigintioctomaculata.*

Huq (2005) studied on the leaf consumption of *E. dodecastigma* on two different hosts and found that the total food consumption per larva dunng its whole period was 99 8 mm^2 on brinjal and 240.3 mm^2 on wild brinjal. The total food consumption per adult on brinjal was 1105.07 mm: and on wild brinjal was 1478.43 mm'

Hossain (2006) found that the larval food consumption of *E. dodecastigma* on kakrol, bitter gourd, sponge gourd and yard long bean was 2540±535.41, 2356±141.42, 1635.56±314 42 and 1082.25±95.78 mm^2, respectively The food consumption of adult on kakrol, bitter gourd, sponge gourd and yard long bean was 26490±188.56, 12820±942.81, 15300±49.22 and 12719i 1616.0 mm^2, respectively.

Hossain *et al.* (2008) studied food consumption of *E. dodecastigma* on bitter gourd and found that the larva and adult consumed 3650 mm^2 and 18832 mm^2 leaves, respectively in terms of area.

2.1.3.5 Nature of damage

Both grubs and adults are highly injurious to the cucurbitaceous plants. The nature of damage by the larvae is somewhat distinct from that of the adults. The grubs feed on the epidermal layer of leaves and the adults feed irregularly upon the upper surface of leavers and its grubs also feed on the lower surface of leaves by scraping, causing net like appearance of the host plants leaves that turn brown in color, entirely dry up due to extensive infestation by the growing population and finally defoliate (Pradhan *et al.*,1990*)* Consequently, vegetative growth and development of the plants are greatly harmed and their economic yield is noticeably declined (Aslam, 1969; Rajagopal and Trivedi, 1989).

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 test insect

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 of fruit fly

Fruit fly is considered to be the native of oriental region, probably India and South East Asia and it was first discovered in the Yaeyama island in 1919 (Anon., 1987). The pest is widely distributed in India, Bangladesh, Mayanmar, Nepal, Malaysia, China, Philippines, Taiwan, Japan, Indonesia, East Africa, Australia and Hawaiian Islands (Alam, 1969; Atwal, 1993) and Mediterranean region (Andrewartha and Birch, 1960).

Gapud (1993) has citied references of 5 species of fruit fly in Bangladesh e.g., melon fruit fly, *Bactrocera brevistylus*(Alam *et al*., 1964; Alam 1965), fruit fly Dacus (*Zeugodacus*) caudatus (Alam *et al*., 1964; Alam. 1965), melon fly D. (*Strumela*) *cucurbitae* (Alam *et al*., 1964; Alam, 1965; Kranz *et al*.; 1977), mango fruit fly, *D.* (*Bactrocera*) *dorsalis* (Alam *et al*., 1964; Alam, 1962-63; Alam 1965; Kranz *et al.*, 1977) and zonate fruit fly, *D.* (*Chactodacus*) *zonatus* (Alam, 1968).

2.1.4.3 Seasonal occurrence and abundance

Kapoor (1993) pointed out that the fruit fly species *B. cucurbitae and B. zonata*are active throughout the year except for a short period from December to mid february due to excessive cold when the adults do not breed and it hides under leaves of guava, citrus, mango and other trees. *B. cucurbitae* is abundant only where the mean annual temperature is 70-77^{0}F and it becomes active between 55-97^{0}F (Syed, 1971).

The peak population of fruit fly in India is attained during rainy months of July and August (Nair, 1986). The fly population is generally low during dry weather and increase rapidly with adequate rainfall (Butani and Jotwani, 1984). Amin (1995) also observed the heighest population incidence at the ripening stage of cucumber. In another study of Bangladesh, Nasiruddin (1991) showed that the incidence of fruit flies in cucurbit was highest in February and lowest in September.

2.1.4.4 Host range

Many fruit fly species cause serious damage it fruits, vegetables, oilseed and ornamental plants. Melon fly is one of the most notorious fruit fly pests found in Hawaii. Pandey *et al*., (2008) reported that more than 100 plant species have been recorded as hosts of melon fly worldwide, it commonly infests the cucurbitaceous (melons, squash and gourds) and solanaceous (tomatoes and pappers) crops.

Melon fruit fly damages over 81 plant species. Based on the extensive surveys carried out in Asia and Hawaii, plants belonging to the family cucurbitaceae are preferred most (Ellwood *et al*., 1999). Doharey (1983) reported that it infests over 70 host plants, amongst which, fruit of bitter gourd (*Momordica charantia*), muskmelon (*Cucumismelo*), snap melon (*Cucumismelo var. momordica*) and snake gourd (*Trichosanthes anguina and T. cucumeria*) are the most preferred hosts.

According to Narayanan and Batra (1960) different species of fruit fly attack a wide variety of fruits and vegetables such as mango, guava, plum, peach, pear, fig, apple, quince, persimmon, banana, pomegranate, jujube, sweet lime, orange, chilies, jack fruit, carambola, papaya, avocado, bread fruit, coffees, berries, passion, fruit, star apple, Spanish pepper, cucurbits, cherries, blackberry, cape gooseberry, grapes, mulberry etc.

In Bangladesh, Alam (1962) recorded ten cucurbit vegetables as the host of fruit fly. Kabir *et al*. (1991) found that 16 species of plants act as the host of fruit flies among which sweet gourd was the most preferred host of both B. *cucurbitae* and *B. tau.*

2.1.4.5 Nature of damage

The external damage caused by fruit fly varies from host to host although the pattern of the damage inside the pulp is more or less similar (Janjua, 1948; Narayanan and Batra, 1960)

The adult female lays eggs just below the epidermis or sometimes a little deeper in the pulp, and/or sometimes on young leaves or stems of the host plants. The insertion of the ovipositor causes wound on the fruits or vegetables in the fruit of punctures, which appear like dark spots on the fruits. In freshly punctured specimens, the fluid that exudes collects in the form of a droplet which later dries up and appears like brown resinous deposit (Shah *et al*., 1948; Narayanan and Batra, 1960; York, 1992). After hatching, th larvae feed into pulpy tissue and make tunnels in fruits causing direct damage. They also indirectly damaged the fruits by contaminating with frass and accelerate rotting of fruits by pathogenic infection. Infested fruits if not rotten, become deformed and hardly which make it unfit for consumption. The infested flowers often become juicier and drop from the stack at slight jerk (Kabir *et al*., 1991).

Depending on the environmental conditions and susceptibility of the crop species, the extent of losses varies between 30 to 100% (Gupta and Verma, 1992; Dhillon *et al*., 2005; Shooker *et al*., 2006)

Accordind to the reports of Bangladesh Agricultural Research Institute, fruit infestations were 22.48, 41.88 and 67.01 percent for snake gourd, bitter gourd, and musk melon, respectively (Anon., 1988). Kabir *et al*. (1991) reported that yeiled losses due to fruit infestation varies in different fruits and vegetables and it is minimum in cucumber (19.19%) and maximum in sweet gourd (69.96%). In cucumber, Amin (1995) observed 42.08 per cent fruit infestation while, Uddin (1996) reported 45.14 percent infestation.

The field experiments on assessment of losses caused by cucurbit fruit fly in different cucurbits been reported 28.7 – 59.2, 24.7 – 40.0, 27.3 – 49.3, 19.4 – 22.1, and 0 – 26.2% yield losses in pumpkin, bitter gourd, bottle gourd, cucumber and sponge gourd, respectively, in Nepal (Pradhan, 1976).

2.2 Management practices

2.2.1 Management of red pumpkin beetle

Singh and Mishra (1977) evaluated eight insecticides against *A. foveicollis* at Pantnagar, Uttrakhand and observed carbaryl @ 0.1 per cent to be the most effective (mean mortality 289.00) followed by monocrotophos @ 0.06 per cent (mean mortality 220.33). Singh *et al*. (1977) reported that the soil treatment with carbofuran @ 0.5 kg a.i. per hectare was effective in controlling the pest and protected the seedlings at its most vulnerable stage effectively.

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. Bajwa and Mavi (1981) tested 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.

Anand and Chauhan (1983) conducted a field study at Hissar (Haryana) for the simultaneous control of A. foveicollis, mite, Tetranychus cucurbitae (Rahman & Sapra) and powdery mildew and observed that sevisulf 40:50 WP and tank mixture of carbaryl and sulphur gave good control of these pests. According to Sinha and Chakrabarti (1983), the soil application with carbofuran granules @ 0.5 kg a.i per hectare proved to be most effective and seed treatment with carbofuran WP 3 to 4 per cent equally effective against *A. foveicollis* without any adverse effect on seed germination.

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

A field experiment was conducted by Pareek and Kavadia (1988) in two different agro-climatic regions of Rajasthan, the semi-humid Udaipur and the semi-arid Jobner which revealed that four sprays of 0.2 per cent carbaryl at 3, 5, 9 and 11 weeks after sowing of musk melon proved the most effective against *A. foveicollis,* resulting in increased yield and net profit. Mehta and Sandhu (1990) used cucurbitacin as kairomones in combination with malathion and carbaryl as poison baits for the monitoring of beetles and observed that maximum number of beetles were trapped in carbaryl poison baits than that of malathion and concluded that these baits could be used to reduce the destructive behavior of this pest.

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

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

Khan and Wasim (2001) assessed different plant extracts and found neem extract in benzene most effective in repelling *A. foveicollis* followed by bakaion extract in benzene. Comparative efficacy of seven insecticides viz., neem, triazophos, chlorpyriphos, monocrotophos, abamectin, SIL-942 and Beta-cyfluthrin evaluated under field conditions against A. foveicollis 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).

Rajak and Singh (2002) evaluated 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. Mehmood *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 (Rajpakse and Ratnasekera, 2007).

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, 2007-2008). Bioefficacy of neem based and synthetic insecticides against red pumpkin beetle was studied by Rathod *et al*. (2009) under laboratory conditions and found maximum mortality in neem based commercial formulation gronim and neem-azal-F (29.98%) and carbaryl (63.36%).

2.2.2 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, and action thresholds).

2.2.2.1 Cultural control

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).

Csizinsky *et al*. (1995) conducted field experiment on the effect of six different plastic mulches like blue, orange, red, aluminum, yellow, white/black on fruit yields and insect vectors of tomato. Aluminum and orange mulches reduced the whitefly numbers, delayed virus infection and increased the yield. Virus symptom development was not delayed and yield did not increase in yellow mulch in spite of lower number of whiteflies. They concluded that under high insect stress, the insect repellent, soil-microclimate-modifying and biologically beneficial effects of the mulch be considered when a mulch color is selected for tomato production.

Molla (2000) worked on different mulching materials (blue, aluminum, yellow, black, transparent polyethylene, rice straw, dried natural grass) and weed control on tomato yellow leaf curl virus (TYLCV). Mulching reduced the disease incidence by 50% as compared to control. Aluminum colored mulch had the lowest disease incidence but higher yield was obtained from yellow colored mulch.

Xienqui (2000) evaluated the effect of inter planting tomato with vegetable soybean, corn, sweet potato, cucumber, okra on whitefly population and incidence of TYLCV in the field. All the crop combination partially reduced TYLCV infection. Among the intercrops cucumber and vegetable soybean were much preferred by whiteflies as compared to others.

The impact of whitefly transmitted Gemini viruses on tomato yield depends on plant age at the time of infection and is highest during the first eight weeks after germination. This is the critical period. In order to delay the Tomato yellow mottle Gemini virus (ToYMoV) in tomato, some living ground covers were evaluated by Hilje (2000) in Costa Rica.

2.2.2.2 Chemical Control

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 71.33 litres/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).

Mason *et al*. (2000) studied the effect of 'Thiamethoxam' a new neonicotinoid insecticide in preventing transmission of Tomato yellow leaf curl virus (TYLCV) by the whitefly, *Bemisia tabaci*. Results have demonstrated that foliar and drench applications of thiamethoxam could prevent TYLCV transmission by *B. tabaci.* Thiamethoxam proved to be very effective in preventing virus acquisition because up to 8 weeks after foliar application, no whitefly survived the 24h feeding period and later on, there was a high mortality of acquiring adults. They suggested that integration of resistant variety and one or two foliar applications of thiamethoxam could be effective to reduce TYLCV damage in tomato crop.

Savary (2000) reported that Imidacloprid and Cypermethrin/ imidacloprid in rotation were effective in reducing the TYLCV disease incidence by 50%. It was suggested that these two insecticides could be used in an IPM package.

2.2.3 Epilachna beetle

Epilachna vigintioctopunctata is an important pest that causes considerable economic losses to many crops including sweet gourd. So, it is necessary to control for successful crop production.

2.2.3.1 Management of Epilachna beetle

Matsumoto and Saitoh (2002) studied the activity of four insecticides (fenitrothion, phenthoate, malathion, and cypermethrin) against Mexican bean beetle, Epilachna varivesties in leguminous vegetable fields in Yamanashi and Nagano prefectures, Japan in 1997. The most toxic material against adults was cypermethrin (0.24 ppm), followed by fenitrothion (43.1 ppm) and phenthoate (163.6 ppm). Malathion showed lower activity than other pesticides.

Mandal and Kumar (2001) evaluated the efficiency of monocrotophos, quinalphos, cypermethrin and fenvalerate against *Epilachna vigintioctopunctata* infesting aubergine cv. Pusa Purple, sprayed 60, 75, 90 and 105 days after transplanting of aubergine, in Ranchi, Bihar, India during the kharif season of 1995. Treatment with all the insecticides reduced the *E. vigintioctopuntata* populations, with cypermethrin recording the highest reduction in the pest population at all stages of plant growth.

Saeed *et al*. (1998) carried out a field study in Pakistan to test the efficacy ol three insecticides against Epilachna spp. in aubergins. The insecticides were azocard (monocrotophos + cypermethrin), edmitol (fenvalerate + dimethoate) and sumicidin (fenvalerate). Sevin SP (carbary 1) was used as a standard. Results were non significant after 96 hours, but Sevin SP gave better results than the other insecticides.

Mall *et al*. (1996) found that monocrotophos (0.04%) was better than phosphamidon (0.5%) and both were very promising in reducing the intensity of jassid, aphid and epilachna beetle during vegetative phase of brinjal. In fruiting phase insecticidal emulsion were found to be significantly superior over dust. Between emulsions, endosulfan proved significantly superior over fenvalerate against jassid and was very identical among themselves for controlling aphid and epilachna beetle.

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

Surjeet *et al*. (1996) tested malathion and endosulfan against hadda beetle, *E. vigintioctopunctata* and malathion was found more toxic than endosulfan. Larval mortality obtained with 50 and 100 ppm of malathion was 82.0 and 96.2% at 48 hours.

Mohasin and De (1994) conducted a field trials with five insecticides namely, carbaryl 50 WP, endosulfan 35EC, quinalphos 25EC, fenitrothen 1000EC and monocrotophos 40EC against epilachna beetle on potato. The experimental results showed that endousulfan 35EC followed by carbaryl 50 WP and quinalphos 25EC gave reasonably good control of epilachna beetles within 10 days of treatments.

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

Thomas and Jacob (1994) conducted laboratory and field studies in Kerala, India, during 1991, and found that carbofuran granules applied to bitter gourds at 1.5 kg a.i.ha^{-1} at sowing, vining and flowering gave an effective level of control of *E. vigintioctopunctata*.

Krishnaia and Bhaskaran (1993) tested malathion, fanvalerate with dicofol and a fungicide separately and in various combination against pests of brinjal in Tamil Nadu. India, in 1986-87. Mixing malathion with the fungicide and dicofol was found most effective in controlling the larvae of *E. vigintioctopunctata* on brinjal.

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

Mohan and Jagan (1991) observed the efficiency of profenofos, bromophos, ethion. prothiofos. permethirin and butylphenyl methylcarbamate (fenobucarb) against *E. vigintioctopunctata* on brinjal. The insecticides were sprayed 3 times at fortnightly intervals during the fruiting stage and estimations of mortality were based on larval counts. Fenobucarb, ethion, profenofos (all at 0.5 kg a.i.ha^{-1}) and permethrin (0.1 kg a.i.ha^{-1}) were most effective in controlling the larvae of *E. vigintioctopunciaia* at 10 days after first spray.

Mensah (1988) carried out a field trials in Swaziland in 1982-84 on the effect of insecticides against *Ootheca* spp. and *E. dodecastigma* on 3 cowpea cultivars. Insecticides tested were dichlorovos, cypermethrin and monocrotophos. Cypermethrin reduced the number of *Ootheca* spp. and *E. dodecastigma* by 58% and 39% respectively and monocrotophos reduced the number by 28% and 14%.

Bhatnagar and Yadava (1987) conducted an experiment where insecticidal sprays of 0.025% quinalphos, 0.05% fenitrothion, 0.05% dichlorvos, 0.05% malathion and 0.2% carbaryl, and dusts of 10% carbaryl, 5% malathion, 5% mtrichlorfon, 2% fenitrothion, 0.65% lindane and 2% methyl parathion were tested for the control of *E. dodecastigma* on watermelons in Rajasthan, India, in 1983. The carbaryl spray gave the best control, followed by 0.05% malathion and 0.05% dichlorvos. The 10% carbaryl dust also gave good control.

Shanker *et al*. (1987) conducted an experiment where adult males of *E. dodecastigma* were fed on leaves of *Luffa cylindrica* that had been soaked for 15 min in water containing 0.05% carbaryl and fenthion. Carbaryl was found more effective to control *E. dodecastigma*.

2.2.4 Fruit fly

Fruit fly is the most damaging factor of cucurbits almost all over the world. Although there are various methods are available to combat this cost, there is not a single such method which has so far been successfully reduced the damage of fruit fly.

2.2.4.1 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 werte 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 redice 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 (Reddy and Joshi, 1992). According to Kapoor (1993), in this method of field sanitation, the infested fruits on the plant or fallen on the ground should be collected and buried deep in to the soil or cooked and fed to animals. 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).

2.2.4.2 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, 1901). 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.

2.2.4.3 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 pyrethrodis of various formulations have been used from time to time against fruit fly (Kapoor, 1993; Nayar *et al.,* 1989; Grazdyev *et al.,* 1983 and Canamas and Mendoza, 1972). 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 (Qureshi *et al.,* 1981). *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.*

2.3 Role of lady bird beetle for controlling insect pest

The ladybird beetle belongs to the family Coccinellidae of order Coleoptera. The members of the family are exclusively predator on aphids, mealybugs, scale-insects, whiteflies, thrips, leafhoppers, mites and other small soft bodied insect pests (Omkar and Pervez, 2000). It is known to prey on about 39 Arthropod species (Gautam, 1989). The family Coccinellidae comprises 5,200 described species worldwide (Hawkeswood, 1987). Pushpendra (2010) have reported 31 species of Lady beetles.

Sarwar and Saqib (2010) conducted an experiment with seven-spotted ladybird beetle *Coccinella septempunctata* L., a natural enemy of aphids, had been reared on natural and alternative artificial foods. Both larvae and adults of *C. septempunctata* fed on aphid and artificial diet, the predator normally completed its development from egg to adulthood in 20.6 days on aphid prey, in contrast to 29.0 days, when fed on artificial diet. These results indicated that artificial diet containing important ingredients for adults and larvae of *C. septempunctata* can serve as substitute food for the coccinellids, and reproduction nevertheless can occur in the absence of preferred insect prey.

Soni *et al*. (2004) conducted a laboratory experiment to determine the feeding potential of *C. septempunctata*, *Menochilus sexmaculatus*, *Cheilomenes sexmaculata*, and *Brumoides suturalis* on some insect and they reported that the adult of *C. septempunctata* consumed more larvae.

Vandenberg (2000) reported that among the natural enemies' coccinellids are the best known beneficial predatory insects. Coccinellids are commonly known as ladybird, lady beetles or lady bugs. Lady bird belongs to the family Coccinellidae and order Coleoptera. About 6000 species of ladybird beetles found all over the world.

Rafi *et al*. (2005) reported that ladybird beetles generally considered as useful insects as many species feed on soft bodied insects like aphids, jassids, psyllids, whiteflies, scale insects, mealy bugs, insect eggs, small larvae and phytophagus mites which are injurious to agricultural crops and forest plantations.

The success of capturing prey of ladybird beetle depends on abiotic and biotic factor such as plant structure, species of aphid attacked, the predator, in its particular age, level of hunger and genetic characteristics, intra and inter specific competition. (Ferran, 1993).

Agarwala *et al*. (1988) reported that the predacious coccinellid beetles, commonly known as lady bird beetles are considered to be of great economic importance in the agro-ecosystem. They have been successfully employed in the bio-control to many injurious insects.

Kalra (1988) reported that, in the field mustard aphid population is naturally controlled to a large extent by its predator, *Coccinella septempunctata* and plays a vital role in lowering the population of mustard aphid in the field.

Singh *et al*. (2003) studied relative abundance of the effective natural enemies of mustard aphid *L. erysimi*, in farmers' fields; the *C. septempunctata* was the highest

(41.97%) occurring species. All the natural enemies showed increasing trend till harvest of the crop, whereas, the coccinellids occupied a major share with maximum relative abundance of *C. septempunctata*.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to study the incidence and management practices of insect pest complex of sweet gourd and their effect on natural enemies during the period from 17 November 2015 to May 2016. The details materials and methods are presented below:

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in 23074/N latitude and 90035/E longitude (Anon; 1989).

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) corresponding AEZ No. 28 and is shallow red brown terrace soil. The land of the selected plot is medium high under the Tejgaon series (FAO, 1988). The characteristics of the soil of the plot were analyzed in the Soil Testing Laboratory, SRDI, Dhaka and has been presented in Appendix I.

3.3 Climate

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). Meteorological data related to the temperature, relative humidity and rainfall during the study period was collected from Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and has been presented in Appendix II.

3.4 Planting material

The variety Suprima (Lalteer) of Sweet gourd was selected for the study during Rabi season 2015-2016. The seed of this variety was collected from local market.

3.5 Land preparation

The selected plot of the experiment was opened with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done two times with a country plough followed by laddering to make the land suitable for growth of sweet gourd seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was ensured. The soil was treated with insecticides (Cinocarb 3G @ 4 $kgha^{-1}$) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.6 Fertilizer application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot shown in Table 1. The total amount of cowdung, Urea, TSP and MP was applied as basal dose at the time of land preparation. Urea was applied at four installment at 1^{st}, 2^{nd}, 3^{rd} and 4^{th} harvest, respectively (BARI, 2015).

Table 1. Dose of application of fertilizers & manure in sweet gourd field

Fertilizers and Manures	Dose ha^{-1}
Cowdung	20 – 25 ton
Urea	200 kg
TSP	200 kg
MP	175 kg

3.7 Treatments of the experiment

T_1 = Spraying Phytoclean (detergent type substance) @ 1.0 ml l^{-1} of water at the 7 days interval
T_2 = Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval
T_3 = Spraying Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval
T_4 = Spraying Ripcord 10 EC @ 1.0 ml l^{-1} of water at the 7 days interval
T_5 = Spraying Sumialpha 5EC @ 1.0 ml l^{-1} of water at the 7 days interval
T_6 = Mechanical and Cultural practices comprising with clean cultivation,removal of infested flowers and fruits at the 7 days interval
T_7 = Untreated control

3.8 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications in the central farm of SAU. The field with good tilth was divided into 3 blocks. Each block was sub-divided into 7 sub plots, each of which was of 3 m × 2.5 m maintaining plot to plot distance 1.0 m and row to row distance 0.5m (Fig. 1).

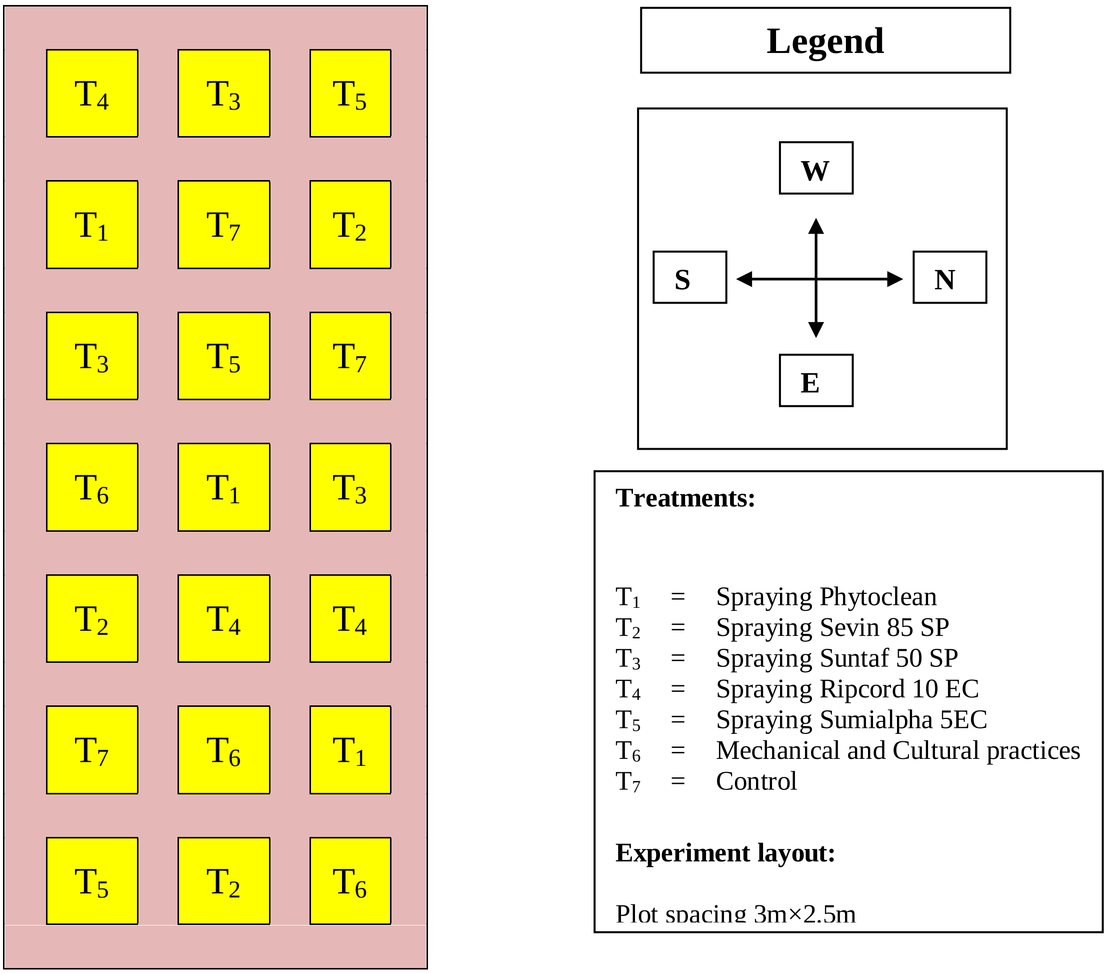

Figure 1. Layout of the experimental plot

3.9 Growing of crops

3.9.1 Seeds sowing and transplanting: The seeds of sweet gourd were sown in the polyethene bags (12cm x 18cm) containing a mixture of equal proportion of well decomposed cowdung and loam soil. After 20 days of sowing, Seedlings (Plate 1) were transplanted in pit having a depth of 2-3 cm maintaining distance from 2.0 m and 2.0 m from row to row and plant to plant, respectively.

Plate no. 1: Seedling of sweet gourd in polythene bag

3.9.2 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling by healthy seedlings, weeding, earthing up, irrigation, pest and disease control etc. were accomplished for better growth and development of the sweet gourd seedlings (Plate 2).

Plate 2. Experimental plot in central farm of SAU, Dhaka

3.9.3 Gap filling

The seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after germination and such seedling were replaced by new seedlings Replacement was done with healthy seedling having a boll of earth which was also planted on the same date by the side of the unit plot. The seedlings were given water for 7 days starting from germination for their proper establishment.

3.9.4 Weeding

The hand weeding was done 20, 40 and 60 days after sowing to keep the plots free from weeds.

3.9.5 Earthing up

Earthing up was done at 20 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

3.9.6 Irrigation

Light watering was given by a watering cane at every morning and afternoon and it was continued for a week for rapid and well establishment of the germinated seedlings.

3.10 Harvesting

Fruits were harvested based on the attaining maturity and ripening of fruits. Harvesting was done manually.

3.11 Data collection

The data were recorded just before the application of the treatments in the field for the evaluation of efficiency of different management practices on infestation level of insect pest complex of sweet gourd, and other plant and fruit related yield contributing characters as well as impact of these management practices on the population of predatory ladybird beetle, and other arthropods through direct visual counts from the sweet gourd field. Data were collected on the following parameters to assess yield attributes and yields as influenced by different treatments,

1) Number of insects per plant or plot
2) Number of beneficial insects per plot
3) Number of infested or healthy leaves per plot
4) Number of infested or healthy shoots per plot
5) Number of infested or healthy flowers per plot
6) Number of infested fruits per plot
7) Number of healthy fruits per plot
8) Weight of healthy and infested fruits
9) Yellow mosaic virus infested leaves and fruits per plot
10) Yield per plot and
11) Total yield.

3.14.2. Data collection for impact of management practices on natural enemies

The impact of different management practices were also evaluated on the population of predatory ladybird beetle, field spider and other arthropods by collecting data on different parameters such as number of adult and larvae of ladybird beetles, and predatory field ant from three randomly selected plants for each plot by direct visual observation. Subsequently, the tiny ladybird beetle larvae, field spider and other arthropods were identified and counted with the help of magnifying lens and simple microscope as needed.

3.12. Calculation of the recorded data

The data recorded on different parameters were calculated using the following formula:

$$\%\text{ plant leaf/shoot/fruit infestation} = \frac{\text{Number of infested plant leaf/shoot/fruit}}{\text{Total number of plant leaf/shoot/fruit}} \times 100$$

$$\%\text{ increase over control} = \frac{\text{Mean value of (treated plot–untreated plot)}}{\text{Mean value of untreated plot}} \times 100$$

$$\%\text{ decrease over control} = \frac{\text{Mean value of (treated plot–untreated plot)}}{\text{Mean value of untreated plot}} \times 100$$

3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance difference for different out effect of recorded data of sweet gourd. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984)

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2015 to July, 2016 to evaluate the Incidence and management practices of insect pest complex of sweet gourd and their effect on natural enemies by using some promising insecticides as well as their impact on the incidence of natural enemies viz. predatory ladybird beetle, field spider etc. in the sweet gourd field. The results on different parameters have been interpreted, discussed and presented under the following sub-headings:

4.1 Common insect pest of sweet gourd found in the field

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

Table 1. List of insect pest of sweet gourd 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	Adults and larva feed on young leaves. Damage also occurs to flowers and small fruit.
2.	Epilachna beetle	*Epilachna dodecastigma*	Larva, adult	Leaf, shoot	Both grubs and adults are highly injurious to the cucurbitaceous plants, feed in the young leaves.
3.	White fly	*Bemisia tabaci*	Adult	leaf	Feed by sucking the sap from the foliage.
4.	Aphid	*Myzus persicae*	Adult	Leaf, shoot	Suck cell sap from the tender leaves and shoots.
5.	Fruit fly	*Bactrocera cucurbitae*	Larva, adult	Fruit	The adult female lays eggs in fruit by puncturing the epidermis and larvae feed on internal tissues.

4.2 Incidence of insect pest

The incidence of insect pests of sweet gourd by number in each treated plot applied at 7 days (Table 2).

4.2.1 Number of red pumpkin beetle plot^{-1}

Incidence of red pumpkin beetle plot^{-1} was significance among the treatments (Table 2). Results showed that the lowest number of red pumpkin beetle plot^{-1} (6.00) was found in T_2 (Sevin 85 SP @ 1.5gll^{-1}of water at 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5gl^{-1} of water at 7 days interval) (9.00), T_1 (Phytoclean @1.0ml l^{-1} of water at the 7 days interval) (11.00) and T_4 (Ripcord 10EC @1.0ml l^{-1} of water at the 7 days interval) (12.00) where the highest number of red pumpkin beetle plot^{-1} (18.00) was found in T_7 (Untreated contol) followed by T_5 (Sumialpha 5 EC @1.0ml l^{-1} of water at the 7 days interval) (14.00) and T_6 (mechanical and cultural practice) (14.00). From the present finding it was observed that T_2 was more effective in controlling red pumpkin beetle compared to other treatments.

4.2.2 Number of Epilachna beetle plot^{-1}

Incidence of number of epilachna beetle plot^{-1} was significant among the treatments (Table 2). Results showed that the lowest number of epilachna beetle plot^{-1} (5.00) was found in T_2 which was followed by T_3 (7.00) T_1 (8.00) and T_4 (8.00) where the highest number of epilachna beetle plot^{-1} (14.00) was found in untreated control plot followed by T_6 (11.00) and T_5 (10.00). from the present findings it was revealed that T_2 was more effective controlling epilachna beetle compared to other treatments.

4.2.3 Number of whitefly plot^{-1}

Incidence of number of whitefly plot^{-1} was statistically among the treatment (Table 2). Results showed that the lowest number of whitefly plot^{-1} (4.00) was found in Sevin 85 SP@ 1.5gl^{-1}of water treated plot applied at 7 days interval (T_2) followed by Suntaf 50 SP @ 1.5gl^{-1}of water sprayed plot applied at 7 days interval (T_3) and Phytoclean @1.0ml l^{-1} of water applied plot at 7 days interval (T_1) where the highest number of whitefly plot^{-1} (12.00) was found in untreated control plot (T_7). From the present study it was found that Sevin 85 SP@ 1.5gl^{-1}of water at 7 days interval (T_2) was more efficient for controlling whitefly compared to the treatments.

4.2.4 Number of aphid plot^{-1}

Incidence of number of aphid plot^{-1} was significant among the entire treatment (Table 2). Results showed that the lowest number of aphid plot^{-1} (20.00) was found in T_2 (Sevin 85 SP@ 1.5gl^{-1}of water at 7 days interval) followed by T_1 (Phytoclean @1.0ml l^{-1} of water at the 7 days interval) (30.00) where the highest number of aphid plot^{-1} (55.00) was found in T_7 (Untreated control) followed by T_6 (Mechanical and cultural practices). From the present findings it was observed that T_2 (Sevin 85 SP@ 1.5gl^{-1}of water at 7 days interval) was more efficient for controlling aphid compared to other treatments.

4.2.5 Number of fruit fly plot^{-1}

Incidence of number of fruit fly plot^{-1} was significant among the treatments (Table 2). Results showed that the lowest number of fruit fly plot^{-1} (4.00) was found in T_2 (Sevin 85 SP@ 1.5gl^{-1}of water at 7 days interval) treated plot followed by T_1 (Phytoclean @1.0ml l^{-1} of water at the 7 days interval) and T_3 (Suntaf 50 SP @ 1.5gl^{-1}of water at 7 days interval) treated ones where the highest number of fruit fly plot^{-1} (13.00) was found in untreated control plot followed by T_6 (mechanical and cultural practice) plot. From this result it was found that T_2 (Sevin 85 SP@

$1.5gl^{-1}$of water at 7 days interval) was more effective in controlling fruit fly compared to other tested treatments.

Table 2. Incidence of insect pests of sweet gourd in treated plots applied at 7 days interval including untreated control

Treatments	Insect pests				
	Number of red pumpkin beetle $plot^{-1}$	Number of epilachna beetle $plot^{-1}$	Number of whitefly $plot^{-1}$	Number of aphid $plot^{-1}$	Number of fruit fly $plot^{-1}$
T_1	11.00 c	8.00 c	6.00 c	30.00 e	6.00 d
T_2	6.00 e	5.00 e	4.00 d	20.00 f	4.00 e
T_3	9.00 d	7.00 d	6.00 e	40.00 d	6.00 d
T_4	12.00 c	8.00 c	7.00 b	40.00 d	7.00 c
T_5	14.00 b	10.00 b	7.00 b	50.00 c	7.00 c
T_6	14.00 b	11.00 b	7.00 b	55.00 b	8.00 b
T_7	18.00 a	14.00 a	12.00 a	70.00 a	13.00 a
$LSD_{0.05}$	1.01	1.11	0.78	1.21	0.83
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	5.32	6.31	5.22	7.23	5.33

In column means containing same letters indicate significantly similar result by DMRT at 5% level of significance.

[T_1 = Phytoclean @1.0ml l^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP@ $1.5gl^{-1}$of water at 7 days interval, T_3 = Suntaf 50 SP @ $1.5gl^{-1}$of water at 7 days interval, T_4 = Ripcord 10EC @1.0ml l^{-1} of water at the 7 days interval, T_5 = Sumialpha 5 EC@1.0ml l^{-1} of water at the 7 days interval, T_6 = Mechanical and cultural practices at 7 days interval and T_7 = Untreated control]

4.3 Effectiveness of treatments on leaf infestation by red pumpkin beetle

The comparative effectiveness of various treatments on leaf infestation by the red pumpkin beetle at early, mid and late stage have been evaluated in terms of leaf infestation by number, number of healthy leaves, percent leaf infestation and percent reduction over control (Table 3).

4.3.1 Early stage

Among the six tested treatments applied in the plots, significant effect was found on controlling leaf infestation (Table 3). Results revealed that the percent leaf infestation was the lowest (9.68%) in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (12.26%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (21.87%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (27.27%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (27.27%) and T_6 (mechanical and cultural practices at the 7 days interval**)** **(**36.36%**).** The highest percent leaf infestation (39.39%) was recorded in untreated control plot.

In terms of healthy leaves plot^{-1} at early stage, significant variation was found among the treatments (Table 3). The highest number of healthy leavesplot^{-1} (9.33) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval**)** followed by T_3 (7.00**),** T_1 (8.33**),** T_4 (8.00), T_5 (8.00) and T_6 (7.00**).** The lowest number of healthy leavesplot^{-1} (6.67) was recorded in untreated control plot.

In terms of percent leaf infestation reduction over control at early stage, all treatments reduced considerable amount of leaf damage as shown in the Table 3. The highest percent reduction of leaf infestation over control (76.92%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval**)** treated plots followed by T_3 (61.46%**),** T_1 (46.16%**),** T_4 (30.76%), T_5 (30.76%) and T_6 (7.69%**)** treated plots at early stage.

4.3.2 Mid stage

Among the six tested treatments, significant variation was found in controlling leaf infestation (Table 3). Results revealed that the lowest percent leaf infestation (15.15%) was in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (20.01%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (30.91%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (35.00%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (35.83%) and T_6 (Mechanical and Cultural practices at the 7 days interval**)** (38.10%**).** The highest percent leaf infestation at mid stage (44.44%) was recorded in T_7 (Untreated control) plot.

In terms of healthy leaves plot^{-1} by number at mid fruiting stage, significant variation was found among the treatments (Table 3). The highest number of healthy leaves plot^{-1} (28.00) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval**)** treated plot followed by T_3 (26.67**),** T_1 (25.33**),** T_4 (26.00), T_5 (25.67) and T_6 (26.00**)** treated plots**.** The lowest number of healthy leaves plot^{-1} (21.67) at mid stage was recorded in untreated control plot.

In terms of percent leaf infestation reduction over control at mid stage, all treatments reduced considerable amount of leaf damage as shown in the Table 3. The highest percent reduction of leaf infestation over control (71.15%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (61.51%), T_1 (34.62%), T_4 (19.22%), T_5 (17.31%) and T_6 (7.67%) treated plots at mid fruiting stage.

4.3.3 Late stage

Among the treatments applied in the plots, significant influence was found in controlling leaf infestation at late stage (Table 3). Results revealed that the lowest percent leaf infestation (12.69%) was in the plots treated with T_2 (Sevin 85 SP @

1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (16.28%), T_1 (25.17%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (28.48%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (29.41%) and T_6 (mechanical and cultural practices at the 7 days interval) (31.61%). The highest percent leaf infestation at late stage (38.03%) was recorded in T_7 (Untreated control) plot.

In terms of healthy leaves plot^{-1} by number at late stage, significant variation was found among the treatments (Table 3). The highest number of healthy leaves plot^{-1} (36.67) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (36.00), T_1 (35.67), T_4 (34.33), T_5 (32.00) and T_6 (31.00). The lowest number of healthy leaves plot^{-1} (29.33) at late stage was recorded in untreated control plot (T_7).

In terms of percent leaf infestation reduction over control at late stage, all treatments reduced considerable leaf damage over control as shown in the Table 3. The highest percent reduction of leaf infestation over control (70.39%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (61.11%), T_1 33.33%), T_4 (24.06%), T_5 (25.94%) and T_6 (20.39%) treated plots at late stage.

Table 3. Effectiveness of different tested treatment on leaf infestation of sweet gourd by red pumpkin beetle at different stages of crop growth.

Treatments	Leaf infestation by red pumpkin beetle											
	Early stage				Mid stage				Late stage			
	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)
T_1	2.33 bc	8.33 b	21.87 d	46.16	11.33 d	25.33 b	30.91 d	34.62	12.00 d	35.67 b	25.17 d	33.33
T_2	1.00 d	9.33 a	9.68 f	76.92	5.00 e	28.00 a	15.15 f	71.15	5.33 f	36.67 a	12.69 f	70.39
T_3	1.67 c	7.00 c	19.26 e	61.46	6.67 e	26.67 b	20.01 e	61.51	7.00 f	36.00 b	16.28 e	61.11
T_4	3.00 b	8.00 b	27.27 c	30.76	14.00 c	26.00 b	35.00 c	19.22	13.67 c	34.33 c	28.48 c	24.06
T_5	3.00 b	8.00 b	27.27 c	30.76	14.33 c	25.67 b	35.83 c	17.31	13.33 c	32.00 d	29.41 b	25.94
T_6	4.00 a	7.00 c	36.36 b	7.69	16.00 b	26.00 b	38.10 b	7.67	14.33 b	31.00 e	31.61 b	20.39
T_7	4.33 a	6.67 c	39.39 a	--	17.33 a	21.67 c	44.44 a	--	18.00 a	29.33 f	38.03 a	--
$LSD_{0.05}$	0.79	0.39	1.13	2.21	1.20	1.22	1.38	1.11	0.41	0.54	1.11	1.21
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	6.44	5.39	9.77	6.28	10.14	9.32	10.41	5.88	8.33	9.27	8.73	7.44

In column, means containing same letters indicate significantly similar result by DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

From the above findings it was revealed that T_2 comprising Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval performed as the best treatment in reducing leaf infestation during the management of red pumpkin beetle followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval**)** and T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval**)**. The trend of results in terms of reducing the leaf infestation is $T_2>T_3>T_1>T_4>T_5>T_6$ at all stages (early, mid and late stage). More or less similar results were also reported by several researchers viz., Rahaman and Prodhan (2007), Rajak and Singh (2002) and Khan and Jehangir (2000). Khan and Jehangir (2000) found high concentration (2.0%) to be the most effective followed by medium (1.0%) and low (0.5%) for controlling red pumpkin beetle.

4.4 Effectiveness of treatments on shoot infestation by red pumpkin beetle

The comparative effectiveness of various treatments on shoot infestation by the red pumpkin beetle (Plate 3) at early, mid and late stage have been evaluated in terms of shoot infestation by number, number of healthy shoots, percent shoot infestation and percent infestation reduction over control (Table 4).

Plate 03: Red pumpkin beetle on tender shoot of sweet gourd

4.4.1 Early stage

Among the six tested treatments applied, significant variation was found in controlling shoot infestation (Table 4). Results revealed that there was no shoot infestation found in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) and T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) at early stage followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (14.16%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (14.16%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (30.03%) and T_6 (mechanical and cultural practices at the 7 days interval) (30.03%). The highest percent shoot infestation at early stage (37.05%) was recorded in untreated control plot (T_7).

In terms of healthy shoots plot^{-1} by number at early stage, significant variation was found among the treatments (Table 4). The highest number of healthy shoots plot^{-1} (3.33) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (2.33), T_1 2.00), T_4 (2.33), T_5 (2.00) and T_6 (2.33). The lowest number of healthy shoots plot^{-1} (1.67) was recorded in T_7 (Untreated control) plot.

In terms of percent shoot infestation reduction over control at early stage, all treatments reduced considerable amount of shoot damage over control (Table 4). The highest percent reduction of shoot infestation over control (100%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots and T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) followed by T_1 (67.00%) and T_5 (67.00%). No shoot infestation reduction over control at early stage was found in T_4 and T_6 treated plots.

4.4.2 Mid stage

Among the six tested treatments applied, significant variation was found in controlling shoot infestation at mid stage (Table 4). Results revealed that the lowest percent shoot infestation (13.64 %) was recorded in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (23.50 %), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (27.29%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (29.13%), T_6 (mechanical and cultural practices at the 7 days interval) (35.69 %) and T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (36.38%). The highest percent shoot infestation at mid stage (45.88%) was recorded in untreated control plot (T_7).

In terms of healthy shoots plot^{-1} by number at mid stage, significant variation was found among the treatments (Table 4). The highest number of healthy shoots plot^{-1} (6.33) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_6 (6.00), T_5 (5.67), T_1 (5.33), T_4 (4.67) and T_3 (4.33). The lowest number of healthy shoots plot^{-1} (4.33) at mid stage was recorded in T_7 (Untreated control) plot.

In terms of percent shoot infestation reduction over control at mid stage, all treatments reduced considerable amount of shoot infestation over control (Table 4). The highest percent reduction of shoot infestation over control (72.75%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (63.76%), T_1 (45.50%), T_5 (36.51%), T_4 (27.25%) and T_6 (9.26%) treated plots at mid stage.

4.4.3 Late stage

Among the treatments, significant variation was found in controlling shoot infestation (Table 4). Results revealed that the lowest percent shoot infestation (11.41%) was in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (20.00 %), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (27.75%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (31.70%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (32.36%) and T_6 (mechanical and cultural practices at the 7 days interval) (33.31%). The highest percent shoot infestation at late stage (37.84%) was recorded in T_7 (Untreated control).

In terms of healthy shoots plot^{-1} by number at late stage, significant variation was found among the treatments (Table 4). The highest number of healthy shoots plot^{-1} (10.33) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_5 (9.33), T_1 (8.67), T_6 (8.67), T_3 (8.00) and T_4 (7.67). The lowest number of healthy shoots plot^{-1} (7.67) at late stage was recorded in untreated control plot (T_7).

In terms of percent shoot infestation reduction over control at late stage, all treatments reduced considerable amount of shoot infestation over control (Table 4). The highest percent reduction of shoot infestation over control (71.52%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (57.17%), T_1 (28.69%), T_4 (21.41%), T_5 (7.28%) and T_6 (7.28 %) treated plots at late stage.

Table 4. Effectiveness treatments on shoot infestation of sweet gourd by red pumpkin beetle at early, mid and late stage of crop growth

Treatments	Shoot infestation by red pumpkin beetle											
	Early stage				Mid stage				Late stage			
	Number of infested shoots $plot^{-1}$	Number of healthy shoots $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)	Number of infested shoots $plot^{-1}$	Number of healthy shoots $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)	Number of infested shoots $plot^{-1}$	Number of healthy shoots $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)
T_1	0.33 b	2.00 bc	14.16 c	67.00	2.00 c	5.33 b	27.29 c	45.50	3.33 c	8.67 c	27.75 c	28.69
T_2	0.00 c	3.33 a	0.00 d	100.00	1.00 e	6.33 a	13.64 e	72.75	1.33 e	10.33 a	11.41 e	71.52
T_3	0.00 c	2.33 b	0.00 d	100.00	1.33 de	4.33 c	23.50 d	63.76	2.00 d	8.00 d	20.00 d	57.17
T_4	1.00 a	2.33 b	30.03 b	00.00	2.67 b	4.67 c	36.38 b	27.25	3.67 c	7.67 d	32.36 b	21.41
T_5	0.33 b	2.00 bc	14.16 c	67.00	2.33 bc	5.67 ab	29.13 c	36.51	4.33 b	9.33 b	31.70 b	7.28
T_6	1.00 a	2.33 b	30.03 b	00.00	3.33 a	6.00 ab	35.69 b	9.26	4.33 ab	8.67 c	33.31 b	7.28
T_7	1.00 a	1.67 c	37.45 a	--	3.67 a	4.33 c	45.88 a	--	4.67 a	7.67 d	37.84 a	--
$LSD_{0.05}$	0.20	0.59	3.24	2.33	0.50	0.66	3.11	3.11	0.32	0.60	2.23	1.54
Level of significance	0.01	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	4.22	4.79	7.33	8.31	6.91	5.83	10.73	5.11	5.11	6.22	11.39	7.31

In column, means containing same letters indicate significantly similar result by DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

From the above findings it was revealed that T_2 treatment comprising Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval performed the best in reducing shoot infestation by red pumpkin beetle followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) and T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval). The trend of results in terms of reducing the shoot infestation is $T_2>T_3>T_1>T_5>T_4>T_6$ at early and mid stage, and $T_2>T_3>T_1>T_4>T_5>T_6$ at late stage. More or less similar results were also reported by several researchers as Dabi *et al*. (1980), Bajwa and Mavi (1981), Rajak and Singh (2002) and Khan and Jehangir (2000).

4.5 Effectiveness of treatments on leaf infestation by epilachna beetle

The relative effectiveness of various treatments on leaf infestation by epilachna beetle (Plate 4) at early, mid and late stage have been evaluated in terms of leaf infestation by number, number of healthy leaves, percent leaf infestation and percent leaf infestation reduction over control (Table 5).

Plate 04: Epilachna beetle on the leaf of sweet gourd

4.5.1 Early stage

Among the treatments varied effect was found in controlling leaf infestation (Table 5). Results revealed that the percent leaf infestation was the lowest (7.73%) in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (15.36%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (18.14%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (26.91%) and T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (23.86%). The highest percent leaf infestation (39.98%) was recorded in untreated control plot which was same as T_6 (mechanical and cultural practices at the 7 days interval) (39.98 %).

In terms of healthy leaves plot^{-1} by number at early stage, significant variation was found among the treatments (Table 5). The highest number of healthy leaves plot^{-1} (8.00) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (7.33), T_1 (6.00), T_4 (6.33) and T_5 (5.33). The lowest number of healthy leaves plot^{-1} (5.00) was recorded in T_7 (Untreated control) plot which was same as T_6 (5.00).

In terms of percent leaf infestation reduction over control at early stage, all treatments reduced considerable amount of leaf damage over control except T_6 (Mechanical and Cultural practices at the 7 days interval) (Table 5). The highest percent reduction of leaf infestation over control (79.88%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (60.06%), T_1 (60.06%), T_4 (30.03%) and T_5 (49.85%). There was no reduction of leaf infestation over control at early stage was in T_6 (0.00%) treated plots.

4.5.2 Mid stage

Among the six tested treatments, significant difference was found in controlling leaf infestation (Table 5). Results revealed that the lowest percent leaf infestation (6.38%) was recorded in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (11.93%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (16.34%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (18.37%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (18.37 %) and T_6 (mechanical and cultural practices at the 7 days interval) (22.46%). The highest percent leaf infestation was at mid stage (23.92%) in T_7 (Untreated control) plot.

In terms of healthy leaves $plot^{-1}$ by number at mid stage, significant variation was found among the treatments (Table 5). The highest number of healthy leaves $plot^{-1}$ (14.67) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_1 (13.67), T_3 (12.33), T_4 (13.33), T_5 (13.33) and T_6 (12.67). The lowest number of healthy leaves $plot^{-1}$ (11.67) at mid stage was recorded in untreated control plot (T_7).

In terms of percent leaf infestation reduction over control at mid stage, all treatments reduced considerably the leaf damage over control (Table 5). The highest percent reduction of leaf infestation over control (72.75%) was calculated in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (54.50%), T_1 (27.25%), T_4 (18.26%), T_5 (18.26%) and no % reduction over control was found in T_6 (0.00%) treated plots at mid stage of crop growth.

4.5.3 Late stage

Among the treatments, significant variation was found in controlling leaf infestation (Table 5). Results revealed that the lowest percent leaf infestation (2.42%) was recorded in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (4.47%), T_1 (5.92%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (8.76%), T_6 (mechanical and cultural practices at the 7 days interval) (9.41%) and T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval)

(10.00%). The highest percent leaf infestation at late stage (11.11%) was recorded by T_7 (Untreated control).

In terms of healthy leaves plot^{-1} by number at late stage, significant variation was found among the treatments (Table 5). The highest number of healthy leaves plot^{-1} (40.33) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_1 (37.00), T_5 (36.00), T_3 (35.67), T_6 (35.33) and T_4 (34.67). The lowest number of healthy leaves plot^{-1} (32.00) at late stage of crop growth was recorded in untreated control plot (T_7).

In terms of percent leaf infestation reduction over control at late stage, all treatments reduced considerable amount of leaf damage over control except T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (Table 5). The highest percent reduction of leaf infestation over control (75.00%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (58.25%), T_1 (41.75%), T_4 (16.75%) and T_6 (8.25%) treated plots at late stage of crop growth.

Table 5. Effectiveness of treatments on leaf infestation of sweet gourd by epilachna beetle at early, mid and late stage of crop growth

Treatments	Leaf infestation by epilachna beetle											
	Early stage				Mid stage				Late stage			
	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Percent reduction over control (%)
T_1	1.33 c	6.00 c	18.14 d	60.06	2.67 c	13.67 b	16.34 d	27.25	2.33 d	37.00 b	5.92 e	41.75
T_2	0.67 d	8.00 a	7.73 f	79.88	1.00 e	14.67 a	6.38 f	72.75	1.00 f	40.33 a	2.42 g	75.00
T_3	1.33 c	7.33 b	15.36 e	60.06	1.67 d	12.33 c	11.93 e	54.50	1.67 e	35.67 cd	4.47 f	58.25
T_4	2.33 b	6.33 c	26.91 b	30.03	3.00 b	13.33 b	18.37 c	18.26	3.33 c	34.67 e	8.76 d	16.75
T_5	1.67 c	5.33 d	23.86 c	49.85	3.00 b	13.33 b	18.37 c	18.26	4.00 a	36.00 c	10.00 b	4.68
T_6	3.33 a	5.00 d	39.98 a	0.00	3.67 a	12.67 c	22.46 b	0.00	3.67 b	35.33 d	9.41 c	8.25
T_7	3.33 a	5.00 d	39.98 a	--	3.67 a	11.67 d	23.92 a	--	4.00 a	32.00 f	11.11 a	--
$LSD_{0.05}$	0.52	0.47	1.38	1.28	0.36	0.49	0.72	2.33	0.47	0.63	0.42	2.55
Level of significance	0.01	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	4.88	6.38	9.27	6.24	6.21	11.13	10.85	7.33	5.63	9.11	7.26	5.82

In column, means containing same letters indicate significantly similar result by DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

From the above findings it was revealed that treatment T_2 comprising Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval performed the best in reducing leaf infestation of epilachna beetle followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) and T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval). As a result, the trend of results in terms of reducing the leaf infestation is T_2>T_3>T_1>T_5>T_4>T_6 at early and mid stage, and T_2>T_3>T_1>T_4>T_6>T_5 at late stage. More or less similar results were also reported by several researchers as Mohasin and De (1994), Reddy (1994), Saeed *et al*. (1998) and Matsumoto and Saitoh (2002).

4.6 Effectiveness of treatments on leaf infestation by whitefly

The comparative effectiveness of various treatments on leaf infestation by the whitefly (Plate 5) at early, mid and late stage of crop growth have been evaluated in terms of leaf infestation by number, number of healthy leaves, percent leaf infestation and percent infestation reduction over control (Table 6).

Plate 05: White fly infested leaf of sweet gourd

4.6.1 Early stage

Among the six tested treatments, significant variation was found in controlling leaf infestation (Table 6). Results revealed that the lowest leaf infestation by whitefly (9.68%) was found in the plots treated with T_2 comprising Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (15.36%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (27.75%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (30.27%), T_5 (Sumialpha 5EC @ 1.0 $^{mll-1}$ of water at the 7 days interval) (32.36 %) and T_6 (mechanical and cultural practices at the 7 days interval) (34.40%). The highest percent leaf infestation at early stage (36.36%) was recorded in untreated control plot (T_7).

In terms of healthy leaves plot^{-1} by number at early stage, significant differences was found among the treatments (Table 6). The highest number of healthy leaves plot^{-1} (9.33) was found in T_2 (Sevin 85 SP @ 1.5^{gl-1} of water at the 7 days interval) followed by T_1 (8.67), T_4 (7.67), T_5 (7.67) and T_3 (7.33). The lowest number of healthy leaves plot^{-1} (7.00) was recorded in T_7 (Untreated control) but it was not significantly different from that of T_6 (7.00).

In terms of percent leaf infestation reduction over control at early stage, all treatments reduced leaf damage over control substantially (Table 6). The highest percent reduction of leaf infestation over control (75.00%) was recorded in T_2 (Sevin 85 SP @ 1.5^{gl-1} of water at the 7 days interval) treated plots followed by T_3 (66.75%), T_1 (16.75%) T_4 (16.75%), T_5 (8.25%) and T_6 (8.25%).

4.6.2 Mid stage

Among the six treatments significant variation was found in controlling leaf infestation (Table 6). Results revealed that the lowest percent leaf infestation (10.92%) was recorded in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (16.98%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (18.46%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (22.24%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (26.57%), T_6 (mechanical and cultural practices at the 7 days interval) (29.51%). The highest percent leaf infestation at mid stage (37.71%) was recorded in T_7 (Untreated control) plot.

In terms of healthy leaves plot^{-1} by number at mid stage, significant variation was found among the treatments (Table 6). The highest number of healthy leaves plot^{-1} (19.00) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_1 (17.67), T_4 (16.33), T_5 (15.67), T_3 (14.67) and T_6 (14.33). The lowest number of healthy leaves/plot (12.67) at mid stage was recorded in untreated control plot (T_7).

In terms of percent leaf infestation reduction over control at mid stage, all treatments reduced the leaf damage over control considerably (Table 6). The highest percent reduction of leaf infestation over control (69.62%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (60.89%), T_1 (47.85%), T_4 (39.11%), T_5 (26.08%) and T_6 (21.77%) treated plots at mid stage of crop growth.

4.6.3 Late stage

Among the treatments applied significant variation was found for controlling leaf infestation (Table 6). Results revealed that the lowest percent leaf infestation (4.63%) was recorded in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (8.12%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (9.34%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (13.39%), T_4 (Ripcord 10 EC @ 1.0 mll-1 of water at the 7 days interval) (14.29%) and T_6 (Mechanical and Cultural practices at the 7 days interval) (14.95%). The highest percent leaf infestation at late stage (19.05%) was recorded in T_7 (Untreated control) plot.

In terms of healthy leaves $plot^{-1}$ by number at late stage, significant variation was obesrved among the treatments (Table 6). The highest number of healthy leaves/plot (48.00) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_1 (45.33), T_3 (37.67), T_5 (36.67), T_4 (36.00) and T_6 (36.00). The lowest number of healthy leaves $plot^{-1}$ (34.00) at late stage of cropping was recorded in untreated control plot (T_7).

In terms of percent leaf infestation reduction over control at late stage, all treatments reduced leaf damage over control considerably (Table 6). The highest percent reduction of leaf infestation over control (70.88%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_3 (58.38%), T_1 (41.63%), T_5 (29.13%), T_4 (25.00%) and T_6 (20.88%) treated plots at late stage of crop growth.

Table 6. Effectiveness of treatments on leaf infestation of sweet gourd by whitefly at early, mid & late stage of crop growth

Treatments	Leaf infestation by whitefly											
	Early stage				Mid stage				Late stage			
	Number of infested leaves plot^{-1}	Number of healthy leaves plot^{-1}	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves plot^{-1}	Number of healthy leaves plot^{-1}	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves plot^{-1}	Number of healthy leaves plot^{-1}	Percent infestation (%)	Percent reduction over control (%)
T_1	3.33 c	8.67 b	27.75 e	16.75	4.00 c	17.67 b	18.46 e	47.85	4.67d	45.33 b	9.34 d	41.63
T_2	1.00 e	9.33 a	9.68 g	75.00	2.33 d	19.00 a	10.92 g	69.62	2.33 f	48.00 a	4.63 f	70.88
T_3	1.33 d	7.33 d	15.36 f	66.75	3.00 d	14.67 e	16.98 f	60.89	3.33 e	37.67 c	8.12 e	58.38
T_4	3.33 c	7.67 c	30.27 d	16.75	4.67 c	16.33 c	22.24 d	39.11	6.00 b	36.00 c	14.29 b	25.00
T_5	3.67 b	7.67 c	32.36 c	8.25	5.67 b	15.67 d	26.57 c	26.08	5.67 c	36.67 c	13.39 c	29.13
T_6	3.67 b	7.00 e	34.40 b	8.25	6.00 b	14.33 e	29.51 b	21.77	6.33 b	36.00 c	14.95 b	20.88
T_7	4.00 a	7.00 e	36.36 a	--	7.67 a	12.67 f	37.71 a	--	8.00 a	34.00 d	19.05 a	--
$LSD_{0.05}$	0.23	0.24	0.21	1.24	0.58	0.65	0.56	2.33	0.34	1.78	0.68	3.66
Level of significance	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	5.77	6.38	11.59	5.33	7.39	9.22	9.41	6.44	7.22	7.39	8.11	5.99

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

From the above findings it was revealed that T_2 comprising Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval performed well in reducing leaf infestation of whitefly followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) and T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval). The trend of results in terms of reducing the leaf infestation is $T_2 > T_3 > T_1 > T_4 > T_5 > T_6$ at early and mid stage, and $T_2 > T_3 > T_1 > T_5 > T_4 > T_6$ at late stage of plant growth. More or less similar results were also reported by several researchers as Marcano and Gonzalz (1993).

4.7 Effectiveness of treatments on leaf infestation by aphid

The comparative effectiveness of various treatments on leaf infestation by aphid at early stage, mid stage and late stage have been evaluated in terms of leaf infestation by number, number of healthy leaves, percent leaf infestation and percent reduction over control (Table 7).

4.7.1 Early stage

Among the seven tested treatments, significant difference was found in controlling leaf infestation (Table 7). Results revealed that the lowest leaf infestation (12.09%) was found in the plots treated with T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) followed by T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) (18.74%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (22.88%), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (24.27%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (31.57%) and T_6 (mechanical and cultural practices at the 7 days interval) (34.20 %). The highest percent leaf infestation by aphid at early stage (44.42 %) was recorded in untreated control plot.

In terms of healthy leaves plot^{-1} by number at early stage, significant variation was found among the treatments (Table 7). The highest number of healthy leaves plot^{-1} (9.67) was found in T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) treated plot followed by T_1 (9.00), T_2 (8.67), T_5 (8.67), T_4 (8.33) and T_6 (8.33). The lowest number of healthy leaves/plot (6.67) was recorded in T_7 (Untreated control).

In terms of percent leaf infestation reduction over control at early stage, all treatments reduced leaf damage over control considerably (Table 7). The highest percent reduction of leaf infestation over control (75.05%) was recorded in T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) treated plots followed by T_2 (62.48%), T_1 (49.91%) T_4 (49.91%), T_5 (24.95%) and T_6 (18.76%).

4.7.2 Mid stage

Among the six treatments, significant variation was found in controlling leaf infestation by aphid (Table 7) at mid stage. Results revealed that the lowest percent leaf infestation (5.45 %) was recorded in the plots treated with T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) followed by T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) (6.59 %), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (11.70 %), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (11.92%), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (12.18%) and T_6 (mechanical and cultural practices at the 7 days interval) (13.64%). The highest percent leaf infestation at mid stage (16.20%) was recorded in T_7 (Untreated control) plot.

In terms of healthy leaves $plot^{-1}$ by number at mid stage, significant variation was found among the treatments (Table 7). The highest number of healthy leaves $plot^{-1}$ (34.67) was found in T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) followed by T_1 (33.67), T_2 (33.00), T_5 (32.67), T_4 (32.00) and T_6 (31.67). The lowest number of healthy leaves $plot^{-1}$ (29.33) at mid stage was recorded in untreated control plot.

In terms of percent leaf infestation reduction over control at mid stage, all treatments reduced leaf infestation considerably over control (Table 7). The highest percent reduction of leaf infestation over control (64.73%) was recorded in T_3 treated plots followed by T_2 (58.91%), T_4 (23.63%), T_5 (23.63%), T_1 (17.64%), and T_6 (11.82%) treated plots at mid stage of crop growth.

4.7.3 Late stage

Among the treatments, significant difference was found in controlling leaf infestation by aphid at late stage (Table 7). Results revealed that the lowest percent leaf infestation (5.10%) was in the plots treated with T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) followed by T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) (6.62 %), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (8.98 %), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (9.40%), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (9.40 %) and T_6 (mechanical and cultural practices at the 7 days interval) (10.42%). The highest percent leaf infestation at late stage (13.90%) was recorded in untreated control plot.

In terms of healthy leaves $plot^{-1}$ by number at late stage, significant variation was found among the treatments (Table 7). The highest number of healthy leaves $plot^{-1}$ (49.67) was found in T_3 followed by T_1 (47.33), T_2 (47.00), T_4 (45.00), T_5 (45.00) and T_6 (43.00). The lowest number of healthy leaves $plot^{-1}$ (41.33) at late stage of crop growth was recorded in untreated control plot (T_7).

In terms of percent leaf infestation reduction over control by aphid at late stage, all treatments reduced leaf damage considerably over control (Table 7). The highest percent reduction of leaf infestation over control (59.97%) was recorded in T_3 treated plots followed by $T2_3$ (50.07%), T_1 (29.99%), T_4 (29.99%), T_5 (29.99%), and T_6 (25.04%) treated plots at late stage of crop growth.

Table 7. Effectiveness of treatment on leaf infestation of sweet gourd by aphid at different stages of crop growth

Treatments	Leaf infestation by aphid											
	Early stage				Mid stage				Late stage			
	Number of infested leaves plot^{-1}	Number of healthy leaves plot^{-1}	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves plot^{-1}	Number of healthy leaves plot^{-1}	Percent infestation (%)	Percent reduction over control (%)	Number of infested leaves plot^{-1}	Number of healthy leaves plot^{-1}	Percent infestation (%)	Percent reduction over control (%)
T_1	2.67 c	9.00 b	22.88 e	49.91	4.67 c	33.67 ab	12.18 c	17.64	4.67 c	47.33 b	8.98 c	29.99
T_2	2.00 c	8.67 c	18.74 f	62.48	2.33 e	33.00 bc	6.59 e	58.91	3.33 d	47.00 b	6.62 d	50.07
T_3	1.33 c	9.67 a	12.09 g	75.05	2.00 f	34.67 a	5.45 f	64.73	2.67 e	49.67 a	5.10 e	59.97
T_4	2.67 c	8.33 d	24.27 d	49.91	4.33 d	32.00 c	11.92 d	23.63	4.67 c	45.00 c	9.40 c	29.99
T_5	4.00 b	8.67 c	31.57 c	24.95	4.33 d	32.67 bc	11.70 d	23.63	4.67 c	45.00 c	9.40 c	29.99
T_6	4.33 b	8.33 d	34.20 b	18.76	5.00 b	31.67 c	13.64 b	11.82	5.00 b	43.00 d	10.42 b	25.04
T_7	5.33 a	6.67 e	44.42 a	--	5.67 a	29.33 d	16.20 a	--	6.67 a	41.33 d	13.90 a	--
$LSD_{0.05}$	0.47	0.31	0.74	1.17	0.46	1.33	0.24	1.52	0.25	1.75	0.67	1.27
Level of significance	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	4.22	6.87	10.92	8.33	9.66	10.33	7.39	4.11	6.11	9.64	8.22	6.22

In column, means containing same letters indicate significantly similar result by DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

From the above findings it was revealed that T_3 comprising Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval performed as the best treatment in reducing leaf infestation by aphid followed by T_2 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) and T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval). As a result, the trend of results in terms of reducing the leaf infestation is $T_3 > T_2 > T_1 > T_4 > T_5 > T_6$ at early stage, $T_3 > T_2 > T_4 > T_5 > T_1 > T_6$ at mid stage and $T_3 > T_2 > T_1 > T_4 > T_5 > T_6$ at late stage.

4.8. Effectiveness of treatments on fruit infestation caused by fruit fly

Plate 06. Fruit fly infested sweet gourd

Fruit infestation by fruit fly (plate 6) in terms of fruit infestation by number, number of healthy fruits, percent fruit infestation and percent reduction of infested fruit over control have been evaluated (Table 8).

Among the applied treatments, significant difference was found in controlling fruit infestation (Table 8). Results revealed that the lowest fruit infestation (15.20%)

was found in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (23.24%) and T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (24.98%), The highest percent fruit infestation (50.00%) was recorded in untreated control plot followed by T_6 (Mechanical and Cultural practices at the 7 days interval) (41.18%).

In terms of healthy fruits plot^{-1} by number, significant variation was found among the treatments (Table 8). The highest number of healthy fruits plot^{-1} (13.00) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (11.00). The lowest number of healthy fruits/plot (5.67) was recorded in T_7 (Untreated control) followed by T_6 (Mechanical and Cultural practices at the 7 days interval) (6.67).

In terms of percent fruit infestation reduction over control, all treatments reduced damage considerably over control (Table 8). The highest percent reduction of fruit infestation over control (58.91%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_5 (47.09%), T_3 (41.27%), T_1 (41.27%) T_4 (35.27%) and T_6 (17.64%).

From the above findings it was revealed that T_2 comprising Sevin 85 SP @ 1.5gl^{-1} of water at 7 days interval performed to be the best treatment in reducing fruit infestation by fruit fly followed by T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval). As a result, the trend of results in terms of reducing the fruit infestation is $T_2 > T_5 > T_1 > T_3 > T_4 > T_6$.

Table 8. Effectiveness of treatments on fruit infestation of sweet gourd caused by fruit fly

Treatments	Fruit infestation by fruit fly			
	Number of Infested fruits plot^{-1}	Number of healthy fruits plot^{-1}	Percent infestation (%)	Percent reduction over control (%)
T_1	3.33 cd	10.00 c	24.98 d	41.27
T_2	2.33 e	13.00 a	15.20 e	58.91
T_3	3.33 cd	11.00 b	23.24 d	41.27
T_4	3.67 c	9.33 c	28.23 c	35.27
T_5	3.00 d	10.00 c	23.08 d	47.09
T_6	4.67 b	6.67 d	41.18 b	17.64
T_7	5.67 a	5.67 e	50.00 a	--
$LSD_{0.05}$	0.38	0.81	1.99	2.55
Level of significance	0.05	0.05	0.05	0.05
CV(%)	6.33	9.22	11.75	6.22

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance.

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

4.9 Effectiveness of treatments on the infection of yellow mosaic virus transmitted by whitefly

4.9.1 Leaf infestation

Plate 7: Yellow mosaic virus infected leaf of sweet gourd transmitted by White fly.

Significant variation was found for controlling leaf infestation by tested treatments on the incidence of yellow mosaic virus (Plate 7) (Table 9). Results revealed that the lowest leaf infection (4.74%) was found in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (6.36%). The highest percent leaf infestation (11.84%) was recorded in T_7 (Untreated control) plot followed by T_6 (Mechanical and cultural practices at the 7 days interval) (9.87%).

In terms of healthy leaves plot^{-1}, significant variation was found among the treatments (Table 9). The highest number of healthy leaves/plot (53.67) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (51.33). The lowest number of healthy leaves plot^{-1} (44.67) was recorded in T_7 (Untreated control) followed by T_6 (Mechanical and Cultural practices at the 7 days interval) (48.67).

In terms of percent reduction over control, all treatments reduced considerably the virus infection over control (Table 9). The highest percent reduction of leaf infection over control (55.50%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_1 (44.50%), T_3 (44.50%), T_4 (38.83%) T_5 (27.83%) and T_6 (11.17%).

From the above findings it was revealed that treatment T_2 comprising Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval performed the best in reducing leaf infection by yellow mosaic virus transmitted by whitefly followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) and T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval). The trend of results in terms of reducing the leaf infestation is $T_2 > T_1 > T_3 > T_4 > T_5 > T_6$.

4.9.2 Fruit infection

Significant variation was found in controlling fruit infection of yellow mosaic virus by the tested treatments as shown in Table 9. Results revealed that the lowest fruit infection (7.98%) was found in the plots treated with T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (13.96%). The highest percent fruit infection (25.62%) was recorded in T_7 (Untreated control) plot followed by T_6 (Mechanical and cultural practices at the 7 days interval) (920.01%).

In terms of healthy fruits plot^{-1} by number, significant variation was found among the treatments (Table 9). The highest number of healthy fruits plot^{-1} (15.33) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (12.33). The lowest number of healthy fruits plot^{-1} (9.66) was recorded in T_7 (Untreated control) followed by T_6 (Mechanical and Cultural practices at the 7 days interval) (10.67).

The percent fruit infection reduction over control, all the tested treatments reduced damage considerably over control (Table 9). The highest percent reduction of fruit infection over control (60.06%) was recorded in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plots followed by T_1 (39.94%), T_3 (39.94%), T_4 (19.92%) T_5 (19.92%) and T_6 (19.92%).

From the above findings it was revealed that treatment T_2 comprising Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval performed the best in reducing fruit infection by yellow mosaic virus transmitted by whitefly followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) and T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval). Result indicated the trend of reducing virus infection of fruit is $T_2 > T_1 > T_3 > T_4 > T_5 > T_6$.

Table 9. Infected leaves and shoots with yellow mosaic virus in sweet gourd transmitted by whitefly

Treatments	Leaf and fruit infestation by yellow mosaic virus							
	Leaf infestation				Fruit infestation			
	Number of virus infected leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent of virus infection (%)	Percent reduction over control (%)	Number of virus infected fruit $plot^{-1}$	Number of healthy fruit $plot^{-1}$	Percent of virus infection (%)	Percent of virus infection reduction over control (%)
T_1	3.33 e	48.00 c	6.49 d	44.50	2.00 c	12.33 b	13.96 d	39.94
T_2	2.67 f	53.67 a	4.74 e	55.50	1.33 d	15.33 a	7.98 e	60.06
T_3	3.33 e	49.00 c	6.36 d	44.50	2.00 c	11.00 d	15.38 c	39.94
T_4	3.67 d	51.33 b	6.67 d	38.83	2.67 b	11.00 d	19.53 b	19.82
T_5	4.33 c	46.00 d	8.60 c	27.83	2.67 b	12.00 c	18.20 b	19.82
T_6	5.33 b	48.67 c	9.87 b	11.17	2.67 b	10.67 e	20.01 b	19.82
T_7	6.00 a	44.67 d	11.84 a	--	3.33 a	9.667 f	25.62 a	--
$LSD_{0.05}$	0.27	1.92	0.42	2.55	0.42	0.31	1.84	2.55
Level of significance	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	5.87	10.59	6.93	6.55	4.88	6.39	7.99	7.22

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

4.10 Incidence of natural enemies

4.10.1 Number of lady bird beetle plant^{-1}

Incidence of lady bird beetle (Plate 8) plant^{-1} was significant among the treatments (Table 10). Results showed that the highest number of lady bird beetle plant^{-1} (3.00) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) and T_6 (Mechanical and Cultural practice) where the lowest number of lady bird beetle plant^{-1} (1.33) was found in T_7 (Untreated control). From the present findings it was observed that lady bird beetle was not affected significantly by the treatments having chemical insecticides.

Plate 8: Lady bird beetle on the leaf of sweet gourd

4.10.2 Number of ant plant^{-1}

Incidence of ant plant^{-1} was significant among the treatment (Table 10). Results showed that the highest number of ant plant^{-1} (4.67) was found in T_6 (Mechanical and Cultural practice) followed by T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval), T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval), T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) and where the lowest number of ant plant^{-1} (3.00) was found in T_7 (Untreated control). From the present findings it was observed that presence of ant was reduced in chemical treated plots. Use of chemical insecticides significantly reduce harmful insect and also reduce natural enemies like ant.

4.10.3 Number of spider plant^{-1}

Incidence of spider plant^{-1} was significant among the treatment (Table 10). Results showed that the highest number of spider plant^{-1} (2.00) was found in T_7 (Untreated control) followed by T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) where the lowest number of spider plant^{-1} (0.33) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) which was statistically similar to that of T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval). From the present findings it was observed that the incidence of spider was reduced significantly in the treated plots having chemical insecticides. Use of chemical insecticides significantly reduce harmful insect and also reduce natural enemies like spider.

Table 10. Impact of treatments with chemical insecticides on the incidence of natural enemies

Treatments	Incidence of natural enemies by number		
	Number of lady bird beetle plant^{-1}	Number of ant plant^{-1}	Number of spider plant^{-1}
T_1	2.33 c	4.00 b	0.67 d
T_2	3.00 a	4.33 b	0.33 e
T_3	2.67 b	4.33 b	0.33 e
T_4	2.67 b	4.00 b	1.67 b
T_5	2.67 b	4.33 b	1.33 c
T_6	2.67 b	4.67 a	1.33 c
T_7	1.33 d	3.00 c	2.00 a
$LSD_{0.05}$	0.21	0.31	0.23
Level of significance	0.01	0.01	0.05
CV(%)	6.37	8.24	5.93

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

4.11 Yield parameters

4.11.1 Infested fruit yield by number

Significant variations among different tested treatments were observed in respect of percent fruit infestation of sweet gourd by number throughout the cropping season (Table 11). All the treated plots showed promising effect on crop yield. The percent fruit infestation by number was the lowest (12.00%) in the plots treated with Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval (T_2) followed by T_6 (Mechanical and Cultural practice) (19.00%), T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (23.07%) and T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (24.01%) being statistically different. On the other hand, the highest fruit infestation by number (57.14%) was found in untreated control plot (T_7) followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (31.79%).

In terms of percent decrease of fruit infestation over control by number, the highest (75.00%) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plot followed by T_6 (Mechanical and Cultural practice) (66.75%), T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (50.00%) and T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (50.00%). The lowest percent decrease of fruit infestation over control (41.75%) was obtained in T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) and T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (Table 11).

From the above findings it was revealed that T_2 performed as the best in reducing infested fruit yield followed by T_1 and T_3. The trend of results in terms of reducing the fruit infestation is T_2>T_6>T_3>T_4>T_1>T_5.

4.11.2 Healthy fruit yield by number

Significant variations among different treatments were observed in respect of percent healthy fruit of sweet gourd throughout the cropping season (Table 11). Among the treatments, treated plots showed positive effects on yield. The percent healthy fruits by number was the highest (88.00%) in the plot treated with Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval (T_2) followed by T_6 (Mechanical and Cultural practice) (81.00%), T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (76.93%) and T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (75.99%) being statistically different. On the other hand, the lowest percent of healthy fruits (42.86%) was found in untreated control plot (T_7)

followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (68.21%) and T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (70.88%).

In terms of percent increase of healthy fruits over control by number, the highest (144.33%) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plot followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (122.33%) and T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) (111.00%). The lowest percent increase of healthy fruits over control (66.67%) was obtained from T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) and T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (89.00%) and T_6 (Mechanical and Cultural practice) (89.00%) (Table 11).

From the above findings it was revealed that T_2 performed as the best treatment in increasing healthy fruit yield over control followed by T_3 and T_1. Therefore, the trend of reducing the fruit infestation is T_2>T_3>T_1>T_4>T_5>T_6.

Table 11. Effectiveness of treatments on yield performance of sweet gourd by Number

Treatment	Total number of healthy fruits $plot^{-1}$	Total number of infested fruits $plot^{-1}$	Total number of fruits $plot^{-1}$	percent of healthy fruits	percent of infested fruits	% increase of healthy fruits over control	% decrease of infested fruits over control
T_1	5.00 c	2.33 b	7.33 bc	68.21 d	31.79 b	66.67 e	41.75 d
T_2	7.33 a	1.00 d	8.33 a	88.00 a	12.00 f	144.33 a	75.00 a
T_3	6.67 ab	2.00 bc	8.67 a	76.93 c	23.07 d	122.33 b	50.00 c
T_4	6.33 ab	2.00 bc	8.33 a	75.99 c	24.01 d	111.00 c	50.00 c
T_5	5.67 bc	2.33 b	8.00 ab	70.88 d	29.13 c	89.00 d	41.75 d
T_6	5.67 bc	1.33 cd	7.00 a	81.00 b	19.00 e	89.00 d	66.75 b
T_7	3.00 d	4.00 a	7.00 c	42.86 e	57.14 a	--	--
$LSD_{0.05}$	1.14	0.84	0.73	2.83	1.06	4.55	3.67
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	7.33	6.67	7.14	9.23	8.52	6.33	7.44

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control]

4.11.3 Weight of single healthy fruit (kg)

Significant variations among different treatments were observed in respect of weight of single healthy fruit of sweet gourd (Plate 9) throughout the cropping season (Table 12). Among the treatments, T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) gave the highest weight of single healthy fruit (5.00 kg) followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (4.80 kg). On the other hand, the lowest weight of single healthy fruit (2.47 kg) was harvested from untreated control plot (T_7) followed by T_6 (Mechanical and Cultural practice).

Plate 9: Healthy sweet gourd in the field

4.11.4 Healthy fruit yield tha^{-1}

Significant variations among different treatments were observed in respect of healthy fruit yield ha^{-1} of sweet gourd throughout the cropping season (Table 12). Among the treatments, T_2 (Sevin 85 SP @ $1.5gl^{-1}$ of water at the 7 days interval) produced the highest healthy fruit yield (61.08 t ha^{-1}) followed by T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) (48.92 t ha^{-1}). On the other hand, the lowest healthy fruit yield (12.35 t ha^{-1}) was found in untreated control plot (T_7) followed by T_6 (Mechanical and Cultural practice) (24.57t ha^{-1}).

4.11.5 Percent healthy fruit yield by weight

Significant variations among different treatments were observed in respect of percent healthy fruit yield by weight of sweet gourd throughout the cropping season (Table 12). Among the entire treatments, T_2 (Sevin 85 SP @ $1.5gl^{-1}$ of water at the 7 days interval) gave the highest percent healthy fruit yield by weight (91.85%) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (83.07%). On the other hand, the lowest healthy fruit yield (38.33%) was found in untreated control plot (T_7) which was significantly lower than all other treatments.

In terms of percent increase of healthy fruit by weight over control, the highest (394.60%) was found in T_2 (Sevin 85 SP @ $1.5gl^{-1}$ of water at the 7 days interval) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval), T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) and T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval). Again, the lowest percent increase of healthy fruit by weight over control (98.92%) was obtained from T_6 (Mechanical and Cultural practice) (Table 12).

4.11.6 Percent infested fruit yield by weight

Significant variations among different tested treatments were observed in respect of percent infested fruit yield by weight of sweet gourd throughout the cropping season (Table 12). Among the entire treatments, T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) gave the lowest percent infested fruit yield by weight (8.15%) followed by T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) (16.93%). On the other hand, the highest infested fruit yield (61.67%) was found in untreated control plot (T_7) which was significantly higher than all other treatments.

In terms of percent reduction of infested fruit by weight over control, the highest (72.73%) was found in T_2 (Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) followed by T_6 (Mechanical and Cultural practice), T_3 (Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval), T_4 (Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval) and T_1 (Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval). Again, the lowest percent reduction of infested fruit by weight over control (39.77%) was obtained from T_5 (Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) (Table 12).

Table 12. Effectiveness of treatments on the yield performance of sweet gourd by weight (single fruit)

Treatment	Weight of healthy single fruits (kg)	Weight of healthy fruits $plot^{-1}$ (kg)	Weight of infested fruits $plot^{-1}$ (kg)	Healthy fruit yield ha^{-1} (t)	% healthy fruits yield by weight	% infested fruits yield by weight	% increase of healthy fruit by weight over control	% reduction of infested fruit by weight over control
T_1	4.80 b	24.00 c	7.02 b	40.00 c	77.37 c	22.63 b	223.89	41.11
T_2	5.00 a	36.65 a	3.25 d	61.08 a	91.85 a	8.15 d	394.60	72.73
T_3	4.40 c	29.35 b	5.98 c	48.92 b	83.07 b	16.93 c	296.09	49.83
T_4	3.77 d	23.86 c	6.12 c	39.77 c	79.59 c	20.41 b	222.00	48.66
T_5	4.17 c	23.64 c	7.18 b	39.40 c	76.70 c	23.30 b	219.03	39.77
T_6	2.60 e	14.74 d	4.10 e	24.57 d	78.24 c	21.76 b	98.92	65.60
T_7	2.47 e	7.41 e	11.92 a	12.35 e	38.33 d	61.67 a	--	--
$LSD_{0.05}$	0.38	1.84	0.16	2.34	2.96	2.94	4.44	4.31
Level of significance	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	6.22	9.34	5.27	8.66	10.49	7.24	7.38	6.11

In column, means containing same letters indicate significantly similar result under DMRT at 5% level of significance. Values are the means of three replications

[T_1 = Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, T_2 = Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, T_3 = Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, T_4 = Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, T_5 = Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, T_6 = Mechanical and Cultural practices at the 7 days interval and T_7 = Untreated control.

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted to know the incidence and management practices of insect pest complex of sweet gourd and their effect on natural enemies during the period from October 2015 to July 2016. The variety suprima (Lalteer) of Sweet gourd was selected for the study. The seed of this variety was collected from local market. There were six treatments used for the present study *viz*. (i) T_1 = Spraying Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval, (ii) T_2 = Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval, (iii) T_3 = Spraying Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval, (iv) T_4 = Spraying Ripcord 10 EC @ 1.0 mll^{-1} of water at the 7 days interval, (v) T_5 = Spraying Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval, (vi) T_6 = Mechanical and Cultural practices at the 7 days interval and untreated control (T_7). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The field with good tilth was divided into 3 blocks. Each block was sub-divided into 7 sub plots of size 3 m × 2 m maintaining 1.0 m border.

Data were collected on the incidence of different insect pests and natural enemies and also healthy and infested fruits of sweet gourd at early, mid and late stages of crop growth. The incidence of insect pests as red pumpkin beetle, epilachna beetle, whitefly, fruit fly were recorded in the field. Natural enemies found in the experiment field were lady bird beetle, ant and spider.

Results revealed that infestation of red pumpkin beetle on leaf and shoot was reduced by the treatment T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) satisfactory at early, mid and late stage of crop growth in terms of healthy leaves and shoots $plot^{-1}$, percent infestation of leaf and shoot and percent reduction over control. The highest healthy leaves $plot^{-1}$ (9.33, 28.00 and 36.67 at early, mid and late stage respectively), lowest percent leaf infestation (9.68%, 15.15% and 12.69% at early, mid and late stage respectively) were obtained by T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) where the lowest healthy leaves $plot^{-1}$ (6.67, 21.67 and 29.33 at early, mid and late stage, respectively), highest percent leaf infestation (39.39%, 44.44% and 38.03% at early, mid and late stage, respectively) were obtained from untreated control. In case of percent leaf infestation reduction over control, the highest (76.92%, 71.15% and 70.39% at early, mid and late stage respectively) was also found in T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plot where the lowest (7.69%, 7.67% and 20.39% at early, mid and late stage, respectively) was recorded in T_6 (Mechanical and Cultural practices at the 7 days interval) treated plot.

Similar trend was also observed in terms of leaf infestation by epilachna beetle and leaf infestation by whitefly. In each case, the highest healthy leaves plot^{-1} and lowest percent leaf infestation were obtained by T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) where the lowest healthy leaves plot^{-1} and highest percent shoot infestation were obtained in T_7 (Untreated control) plot. In case of percent leaf infestation reduction over control, the highest was also found from T_2 where the lowest was observed from T_6 (Mechanical and Cultural practices at the 7 days interval) treated plot.

In terms of shoot infestation by red pumpkin beetle, the highest healthy shoots plot^{-1} and lowest percent shoot infestation were obtained in T_2 treated plot. The lowest healthy shoots plot^{-1} and highest percent shoot infestation were obtained in untreated control plot. In case of percent shoot infestation reduction over control, the highest was also received from T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) where the lowest was observed in T_6 (Mechanical and Cultural practices at the 7 days interval) treated plot.

Again, in case of leaf infestation by aphid, the highest healthy leaves plot^{-1} (9.67, 34.67 and 49.67 at early, mid and late stage, respectively), lowest percent leaf infestation (12.09%, 5.45% and 5.10% at early, mid and late stage, respectively) were obtained from T_3 (Spraying Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) where the lowest healthy leaves plot^{-1} (6.67, 29.33 and 41.33 at early, mid and late stage, respectively), highest percent leaf infestation (44.42%, 16.20% and 13.90% at early, mid and late stage, respectively) were obtained in T_7 (Untreated control) treated plot. In case of percent leaf infestation reduction over control by aphid, the highest (75.05%, 64.73% and 59.97% at early, mid and late stage, respectively) was also found from T_3 (Spraying Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) where the lowest (18.76%, 11.82% and 25.04% at early, mid and late stage, respectively) was observed from T_6 (Mechanical and Cultural practices at the 7 days interval) treated plot.

Considering fruit infestation by fruit fly, the highest healthy fruits plot^{-1} (13.00) and lowest percent fruit infestation (15.20%) were obtained from T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plot where the lowest healthy fruits plot^{-1} (5.67) and highest percent fruit infestation (50.00%) were found in T_7 (Untreated control) treated plot. In case of percent fruit infestation reduction over control, the highest (58.91%) was also found from T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) where the lowest (17.64%) was observed from T_6 (Mechanical and Cultural practices at the 7 days interval) treated plot.

Considering fruit and leaf infection by yellow mosaic virus, T_2 (Spraying Sevin 85 SP @ 1.5g/L of water at the 7 days interval) showed best performance in terms of highest healthy leaves and fruit. Untreated control plot showed the lowest performance. In case of percent infestation reduction over control, for both leaf and fruit, T_2 was the best where the lowest was observed in T_6 treated plot.

In terms of yield parameters, the highest healthy fruit yield (61.08 tha^{-1}) and lowest percent infested fruits yield by weight (8.15%) were achieved from T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) treated plot where the lowest healthy fruit yield (12.35 tha^{-1}) and highest percent infested fruits yield by weight (61.67% tha^{-1}) was obtained from T_7 (Untreated control) plot. The highest percent reduction of infested fruit by weight over control (72.73%) was also obtained from T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) where T_5 (Spraying Sumialpha 5EC @ 1.0 mll^{-1} of water at the 7 days interval) gave the lowest (39.77%) percent reduction of infested fruit by weight over control. In the most cases, T_3 (Spraying Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) and T_1 (Spraying Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) also gave comparatively better performance in respect of reduced leaf, shoot and fruit infestation and increased healthy fruit yield.

CONCLUSION

From the above findings it can be concluded that among the treatments, T_2 (Spraying Sevin 85 SP @ 1.5gl^{-1} of water at the 7 days interval) was considered as the best treatments followed by T_1 (Spraying Phytoclean @ 1.0 mll^{-1} of water at the 7 days interval) and T_3 (Spraying Suntaf 50 SP @ 1.5 gl^{-1} of water at the 7 days interval) in respect of higher healthy fruit yield by reducing leaf, shoot and fruit infestation.

RECOMMENDATIONS

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

- 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.
- Integrated pest management practices may be introduced for effective control of insect pest complex of sweet gourd.

CHAPTER VI

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CHAPTER VII

APPENDICES

Appendix I. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Aman rice- Potato

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20
Exchangeable K (mel 1 00 g	0.1
Available S (ppm)	45

Source: SRDI, 2014

Appendix II. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from October 2015 to July 2016

Month	Average air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
	Maximum	Minimum	Mean			
October, 2015	29.18	18.26	23.72	81	39	6.5
November, 2015	29.7	20.1	24.9	65	5	6.4
December, 2015	26.9	15.8	21.35	68	0	7.0
January, 2016	24.6	12.5	18.70	66	0	5.5
February, 2016	36.0	24.6	30.30	83	37	4.1
March, 2016	36.0	23.6	29.80	81	45	3.9
April, 2016	32.5	23.00	27.75	66.00	88	7.9
May, 2016	33.3	22.50	27.50	65.70	180	7.6
June, 2016	31.0	24.95	27.98	82.27	210	7.7
July, 2016	31.50	24.00	27.75	82.00	220	6.8

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

Appendix III. Effectiveness of different tested treatment on leaf infestation of sweet gourd by red pumpkin beetle at different stages of crop growth.

Source of variation	Degrees of freedom	Mean squire of Leaf infestation by red pumpkin beetle								
		Early stage			Mid stage			Late stage		
		Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)
Repl.	2	0.143	0.905	0.563	12.905	2.476	3.034	1.476	5.571	1.043
Fac.A	6	2.556*	2.635*	3.032*	17.937*	11.381*	7.548*	10.635*	23.746*	0.543*
Error	12	0.198	0.849	0.234	1.460	3.476	2.435	1.254	2.794	0.156

Appendix IV. Effectiveness of different tested treatment on shoot infestation of sweet gourd by red pumpkin beetle at different stages of crop growth.

Source of variation	Degrees of freedom	Mean squire of Shoot infestation by red pumpkin beetle								
		Early stage			Mid stage			Late stage		
		Number of infested shoots $plot^{-1}$	Number of healthy shoots $plot^{-1}$	Percent infestation (%)	Number of infested shoots $plot^{-1}$	Number of healthy shoots $plot^{-1}$	Percent infestation (%)	Number of infested shoots $plot^{-1}$	Number of healthy shoots $plot^{-1}$	Percent infestation (%)
Repl.	2	0.048	1.000	1.067	0.190	3.762	1.078	1.333	0.619	2.876
Fac.A	6	0.651**	0.825**	2.543*	2.317*	1.968*	2.562*	1.857*	3.048*	0.562**
Error	12	0.103	0.111	0.548	0.579	0.540	1.342	0.333	0.286	1.674

Appendix V. Effectiveness of treatments on leaf infestation of sweet gourd by epilachna beetle at different stages of crop growth.

Source of variation	Degrees of freedom	Mean squire of Leaf infestation by epilachna beetle								
		Early stage			Mid stage			Late stage		
		Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)
Repl.	2	0.619	0.571	0.539	3.476	0.905	0.912	0.048	11.571	10.753
Fac.A	6	3.048*	4.095*	2.748*	1.048*	3.857*	3.016*	1.651*	18.984*	2.875*
Error	12	0.286	0.571	0.973	0.143	0.738	1.743	0.270	2.127	4.986

Appendix VI. Effectiveness of treatments on leaf infestation of sweet gourd by whitefly at different stages of crop growth.

Source of variation	Degrees of freedom	Leaf infestation by whitefly								
		Early stage			Mid stage			Late stage		
		Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)
Repl.	2	0.333	2.333	0.564	0.619	3.190	0.905	0.571	2.190	1.078
Fac.A	6	0.825**	2.317*	3.864*	6.413*	13.635*	3.857*	2.857*	25.635*	2.562*
Error	12	0.278	0.889	1.564	0.508	0.635	0.738	0.238	3.302	1.342

Appendix VII. Effectiveness of treatment on leaf infestation of sweet gourd by aphid at different stages of crop growth.

Source of variation	Degrees of freedom	Leaf infestation by aphid								
		Early stage			Mid stage			Late stage		
		Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)	Number of infested leaves $plot^{-1}$	Number of healthy leaves $plot^{-1}$	Percent infestation (%)
Repl.	2	0.571	0.762	0.681	1.000	2.286	1.983	0.143	1.190	0.443
Fac.A	6	3.857*	2.540*	3.057*	1.524**	8.635*	2.897*	1.778**	23.540*	2.978*
Error	12	0.571	0.706	0.851	0.167	6.563	2.876	0.421	0.968	1.921

Appendix VIII. Effectiveness of treatments on fruit infestation of sweet gourd caused by fruit fly

Source of variation	Degrees of freedom	Mean squire of Fruit infestation by fruit fly		
		Number of Infested fruits $plot^{-1}$	Number of healthy fruits $plot^{-1}$	Percent infestation (%)
Replication	2	0.143	0.333	0.433
Factor A	6	3.714*	1.811*	3.344*
Error	12	0.476	0.611	0.966

Appendix IX. infected leaves and shoots with yellow mosaic virus in sweet gourd transmitted by whitefly

Source of variation	Degrees of freedom	Mean squire of Leaf infestation and Fruit infestation by YMV					
		Leaf infestation			Fruit infestation		
		Infested leaves $plot^{-1}$	Healthy leaves $plot^{-1}$	Percent infestation (%)	Infested fruit $plot^{-1}$	Healthy fruit $plot^{-1}$	Percent infestation (%)
Repl.	2	0.333	0.333	0.148	4.333	0.143	0.429
Fac.A	6	4.302*	27.857*	1.250**	1.270**	9.937*	2.653*
Error	12	0.611	8.167	0.290	0.556	1.032	0.864

Appendix X. Impact of treatments with chemical insecticides on the incidence of natural enemies.

Source of variation	Degrees of freedom	Incidence of natural enemies by number		
		Number of lady bird beetle $plant^{-1}$	Number of ant $plant^{-1}$	Number of spider $plant^{-1}$
Replication	2	0.333	1.476	2.333
Factor A	6	0.873*	0.857**	1.302*
Error	12	0.444	1.310	0.278

Appendix XI. Effectiveness of treatments on yield performance of sweet gourd by number

Source of variation	Degrees of freedom	Number of healthy fruits $plot^{-1}$	Number of infested fruits $plot^{-1}$	Total number of fruits $plot^{-1}$	% number of healthy fruits	% number of infested fruits
Replication	2	0.333	0.000	0.239	1.740	2.286
Factor A	6	18.825*	0.714*	3.864*	3.674*	8.635*
Error	12	0.611	0.500	1.896	2.953	6.563

Appendix XII. Effectiveness of treatments on yield performance of sweet gourd by weight (single fruit)

Source of variation	Degrees of freedom	Weight of healthy single fruits (kg)	Weight of healthy fruits $plot^{-1}$ (kg)	Weight of infested fruits $plot^{-1}$ (kg)	Healthy fruit yield ha^{-1} (t)	% weight of healthy fruits	% weight of infested fruits
Replication	2	2.429	0.139	0.299	3.083	1.816	3.816
Factor A	6	10.095*	3.767**	5.980*	17.417*	29.204*	29.204*
Error	12	2.429	0.047	2.577	5.703	4.073	4.073