DAMAGE POTENTIALITY AND ECO-FRIENDLY MANAGEMENT OF RED PUMPKIN BEETLE AND CUCURBIT FRUIT FLY ON SQUASH VEGETABLE

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CERTIFICATE

This is to certify that thesis entitled, "**DAMAGE POTENTIALITY AND ECO-FRIENDLY MANAGEMENT OF RED PUMPKIN BEETLE AND CUCURBIT FRUIT FLY ON SQUASH VEGETABLE**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MOHAMMAD RUBEL MIAH, Registration No. 12-4911** 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: June, 2019
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DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

The experiment was conducted to study the damage potentiality and eco-friendly management of red pumpkin beetle and cucurbit fruit fly on squash during the period from October, 2018 to March, 2019. The experiment consisted of seven different treatments vizT_1 = Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle); + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval.T_2 = Applying Sevin 50 WP @ 1.5g/pit + using vineger trap.T_3 = Mechanical control method at 7 days interval + using Pheromone trap.T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval.T_5 = Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap.T_6 = Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap.T_7 = Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data obtained from experiment on various parameters were statistically analyzed and means were separated by the Least Significant Differences (LSD). At 5, 15, 25, 35, 45 and 55 DAT the minimum number of red pumpkin beetle plant^{-1} (2.27, 2.00, 1.73, 1.47, 1.07 and 0.47) was recorded from treatment T_4. The lowest percentage of leaf infestation and long petiole plant^{-1} was (9.38, 10.29, 10.94, 12.04, 12.90 and 13.61) and (8.41, 9.37, 9.81, 10.95, 11.37 and 11.65) found in T_4 at 5, 15, 25, 35, 45 and 55 DAT. At 25,35,45 and 55DAT, the highest number of healthy flowers plant^{-1} (14.27, 14.27, 14.27 and 14.27) was recorded from T_4 and the lowest percentage of infested flowers (2.7, 2.73, 2.73 and 2.73) was found in T_4. At 45 and 55DAT, the highest number of healthy fruit plant^{-1} and lowest infestation was recorded from T_5. The highest control percentage of cucurbit fruit fly (80.42, 82.41 and 81.65) was recorded from T_5. The highest single fruit weight (460.00 g), length of fruit(23.10 cm), width of fruit (2.85 cm) fruit weight plant^{-1} (3.80 kg), fruit weight plot^{-1} (34.21 kg) and yield (57.02 t ha^{-1}) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap). There was strongly positive correlation between leaf infestation and number of RPB at different DAT. Correlation study was done to establish the relationship between the % fruit infestations and single fruit weight, total fruit weight and yield of squash among different management practices and observed negative correlation among the parameters. There was strongly positive correlation between healthy fruit length and yield of squash found. It can be concluded that T_4 was satisfactory for controlling Red pumpkin beetle and T_5 manifested better result and control for Cucurbit fruit fly with desired yield contributing characters than the other 6 treatments.

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CHAPTER I

INTRODUCTION

The agro-ecological condition of Bangladesh is highly favorable for the cultivation of cucurbit vegetables. The constraints to sustainable increased productivity of cucurbit vegetables are many. A major and common one is the high incidence of insect pests, and management practices. The extent of damage varies from year to year, season to season and locality to locality depending on the seasonal abundance of the pests affected by the influence of prevailing abiotic and biotic factors and impact of control measures adopted (Anon. 2001). Bangladesh has a long history of growing some cucurbits which include bottle gourd, water melon, squash and muskmelon as dessert crops, cucumber as salad and bitter gourd, snake gourd, sponge gourd, ribbed gourd as vegetables.In Bangladesh vegetables are grown in 2.63 percent of cultivable land (BBS, 2018). According to the Food and Agriculture Organization (FAO), Bangladesh holds the third position in world for vegetable production (FAO, 2017). According to The Daily Star(2018), the annual demand for vegetable production in Bangladesh is 13.25 million metric tons whereas theannual actual production is 3.7 million metric tons. According to United Nations(UN) and Food And Agricultural organization(FAO)an adult in the country on an average consumes only 60 to 70 grams of vegetable (except potato)each day,which is about one third of the amount (220gram).Cucurbits occupy 66 per cent of the land under vegetable production in Bangladesh and contribute 11 percent of total vegetable production in the country and 77 thousand tons in the summer season of 2006-2007 (BBS, 2010).Squash is primarily a winter vegetable but now days it is available also in summer. Now Squash is grown round the year, though Squash is newly introducing popular vegetable. They are grown in homestead for family consumption as well as in larger plots for commercial purpose. Unfortunately, cucurbits are infested by a number of insect pests, which are considered to be the significant obstacles for its economic production. Among them, cucurbit fruit fly, cut-worm and red pumpkin beetle are the major pests responsible for considerable damage of cucurbits (Butani and Jotwai 1984).

Among the different winter cucurbit vegetables, sweet gourd or pumpkin is a tender tendril bearing and vine like plant from genus Cucurbita belonging to the family Cucurbitaceae of gourd family. There are three common types of pumpkin worldwide, namely *Curcurbita pepo*, *C. maxima* and *C. moschata* and were originally domesticated in Mexico, South America, and the eastern U.S. (Tecson, 2001). Squash (*Cucurbita maxima)* commonly known in the Visayan language as *kalabasa*, have long been used in the Philippines as fleshy vegetables. They belong to the plant family that includes melon and cucumber, come in many varieties. Regardless of variety, all parts of the squash are edible, including the flesh, seeds and skin or rind. Like other cucurbits, squash is recognized as an important source of vitamins and minerals just like vitamins A and C; it also contains calcium and iron. It has very low calories, ideal to be a component in the diet plan. These fleshy vegetables are protected by a hard rind and grown in the country throughout the year. To gain the full nutritional benefits of this vegetable, the green skins or rinds must be eaten. It is usually grown in backyard and it is also marketable for its immature fruits, young shoots, flowers, and seeds. In some places, intercropping squash with other crops like corn, sugarcane and coconut is practiced (Pears, 2004; Sas, 1984; Dagoon, 2001; Shepherd, 2011; Kubo *et.al*, 2010).

Production constraints of squash include many pest and disease problems that affect yields (Powell *et al.*,1993; Webb and Tyson, 1997; Cradock *et al.*, 2001; Xu *et al*., 2004; Yandoc-Ables *et al*., 2007; Murphy *et al*., 2009). The squash varieties perform better in well drained, fertile soils with lots of sunshine. Cucurbit production is severely affected by a number of insect pests such as red pumpkin beetle, cucurbit fruit fly, epilachna beetle etc. Among them red pumpkin beetle, *Aulacophora foveicollis* (Lucas) is one of the major constraint to its production capable of 30-100% yield loss (Alam, 1969; Gupta and Verna, 1992 and Dillon *et al.*, 2005) especially at seedling stage (Rajak, 2001). It is polyphagous in nature and attacks more than 81 plant species including bottle gourd, sweet gourd, bitter gourd, ridged gourd, sponge gourd, teasel gourd, white gourd, ash gourd, cucumber, squash, water melon, etc. and a wide range of fruit crops (Doharey, 1983). In Bangladesh, red pumpkin beetle, *A. foveicollis* causes severe damage of cucurbitaceous vegetables (Alam, 1969; Azim, 1966 and Butani and Jotwani, 1984).

Red pumpkin beetle *Raphidopalpa foveicollis* L. and Cucurbit fruit fly viz., *Bactrocera* (Dacus) *cucurbitaae* and *Bactrocera* (Dacus) *caudatus* are the most damaging insect pests. Different pumpkin varieties are attacked by a number of insect pests and among the various insect pests, Cucurbit fruit fly viz., *Bactrocera cucurbitaae* and *B.caudatus* are *A. foveicollis* (Lucas) are commonly found in Bangladesh (Alam *et al*., 1964). Other species like *B. cucurbitae*, *B. tou* and *Dacus ciliata* have been currently identified in Bangladesh of which *Dacus ciliata* is a new recorded. Red pumpkin beetle, *R. foveicollis L.* which has been reported as the most destructive one by Butani and Jotwani (1984). The pest is common in the South-East Asia, Africa as well as in Mediterranean region towards west and Australia in the East (Mckinlay *et al*. 1992). The beetles may kill cucurbit seedlings and sometimes the crops have to be re-sown of 3-4 times (Azim 1996). It may cause up to 70% damage on leaves and 60% damage on flowers of cucurbits (Alam, 1969). The red pumpkin beetle, *A. 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. It is injurious to the crops and cause severe damage to almost all cucurbits (Hassan, 2012).

Fruit fly, *B.cucurbitae* (Coquillett) is another major pest causing yield loss in cucurbits, and infests all kinds of cucurbit vegetables grown in Bangladesh (Rakshit *et al.*, 2011). A major constraint of improved cucurbit production is high rate of fruit fly infestation. Fruit flies reduce yield as well as the quality of the fruits (Anon., 2004). The Cucurbit fruit fly, *B. cucurbitae* represents 74.5% of the total number of flies infesting different vegetables growing areas in Bangladesh (Akhtaruzzaman *et al.*, 1999). It prefers young, green, and tender fruits for egg laying. The females lay the eggs 2 to 4 mm deep in the fruit pulp, and the maggots feed inside the developing fruits. At times, the eggs are also laid in the corolla of the flower, and the maggots feed on the flowers. A few maggots have also been observed to feed on the stems (Narayanan 1953). The fruits attacked in early stages fail to develop properly, and drop or rot on the plant. Since, the maggots damage the fruits internally.

Farmers usually spray chemical pesticides many times during the crop season to control insect pests. This leads to environmental pollution with consequent of increased health hazard to the growers and consumers. Moreover, it also leads to the development of resistance to target pests with negative effects on natural enemies, other beneficials and causes disruption of biodiversity. So it is badly needed to explore different alternate method against these insect pests, which is relatively free from adverse side effects. Among the various alternatives, the exploitation of host plant resistant is perhaps the most effective, convenient, economical and environmentally acceptable method of insect pest control. At present, effective control techniques other than insecticide application against insect pests of agricultural crops are highly demanding. In view of this requirement an experiment was conducted to find the tolerant squash varieties against red pumpkin beetle and fruit fly with the following objectives.

- To assess the damage potentiality of Red pumpkin beetle and cucurbits fruit fly on squash
- To find out the efficiency of the different management practices against Red pumpkin beetle and fruit fly in squash
- To highlight the establishment of an environmentally safe control measures in cucurbit crops which help to reduce the use of chemical pesticides.

CHAPTER II

REVIEW OF LITERATURE

Squash an important vegetable crop in Bangladesh. Red pumpkin beetle and cucurbit fruit fly is most damaging insect pest of squash and other cucurbit vegetables. It causes great yield reduction, which is considered as an important obstacle for economic production of these crops. Substantial works have been done globally on this pest regarding their origin and distribution, host range, life cycle, nature of damage, rate of infestation and yield loss by Red pumpkin beetle and cucurbit fruit fly, seasonal abundance and management. But published literature on this pest especially on its infestation status and management are scanty in Bangladesh. Literatures cited below under the following headings and sub-headings reveal some information about the present study.

Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Chrysomelidae

Genus: *Raphidopalpa*

Species:*R. foveicollis*

2.1 Origin and distribution of red pumpkin beetle

Hutson (1972) reported that the red pumpkin beetle 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, *A. 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, *A. 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.

2.2 Host preference of red pumpkin beetle

Alam *et al* (1964) reported that bitter gourd, cucumber, snake gourd, sweet gourd, bottle gourd,squash and many other 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, Michelachampaca* 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.

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

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

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; sweet gourd, muskmelon and cucumber were susceptible to the pest. They also observed that banana squash, muskmelon, sweet gourd, 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, *Aulacophora foveicollis.*

The incidence of the red pumpkin beetle, *Aulacophora foveicollis* (Lucas), on three cucurbits remained throughout the crop growing season which was reported by Thapa and Neupane (1992). Infestation was high on watermelon (6-24 adults/plant) followed by bottle gourd (4-19 adults/plant) and pumpkin (5-10 adults/plant). Among ten species of cucurbits tested in seedling stage under free choice condition, bitter gourd seedlings were completely free from the beetle damage while muskmelon (80.63% damage) and longmelon (71.69% damage) were highly preferred and snake gourd (7.63% damage) and ash gourd (13.88% damage) seedlings were the least preferred. Bottle gourd, sweet gourd, cucumber, pumpkin, sponge gourd and water melon were intermediate types. Depending on the environmental conditions and susceptibility of the crop species, the extent of damage by red pumpkin beetle varies between 30 to 100% (Gupta and Verma, 1992; Dhillon *et al*, 2005).

Borah (1999) studied the seasonality and varietal preference of red pumpkin beetle on sweet gourd and recorded highest number of beetles in rainy season (June) in all the three varieties with 3.6 – 4.2 beetles/ plant and 39.2 – 46.6 per cent plant damage fallowed by summer crop with 2.8 beetles/ plant and 33.6 per cent plant damage and winter season with 2.1 beetles/ plant and 21.1 per cent plant damage.

Vandana *et al* (2001) studied the host preference of red pumpkin beetle, *A. foveicollis* among five cucurbits *viz.*, sweet gourd, ash gourd, sponge gourd, snake gourd and cucumber, in which sweet gourd was identified as the most susceptible and highly preferred host to red pumpkin beetle and cucumber was recognized as less susceptible and preferred host to the pest.

Gameel (2013) observed in a survey of arthropods associated with cucurbit crops during 2011 and 2012 at the New valley in Egypt and found the existence of insect species belong to 25 genera under 20 families of 9 orders. The important cucurbit fruit flies, *B. zonata*, *Dacus ciliatus*, *D. frontalis* and *Dacus* sp. (Tephritidae: Diptera) and *Baris granulipennis* (Curculionidae: Coleoptera) were recorded as pests on the fruits of cucurbit plants in the New Valley. The common associated natural enemies inhabiting cucurbit fields were *Coccinella septempunctata* L.; *Chrysoperla carnea* Steph. And *C. undecimpunctata aegyptiaca* Reiche. Whereas *Ooencyrtus* sp. was recorded as a key egg parasitoid of the black melon bug.

Picault (2014) reported that the aphid, *Aphis gossypii* and the thrips, *Thrips tabaci* can cause severe damage, the first on cucurbit vegetables and the second on *Allium* crops.Nath and Thakur (1965) conducted an experiment to evaluate the resistance of gourds against red pumpkin beetle, *A. foveicollis*, in which lines of ridge gourd were NR 1, NR 2, NR 4, NR 5 and NR 7, lines of sponge gourd were NS 7, NS 10, NS 11, NS 12, NS 14, NS 16 and NS 17, lines of sweet gourd were NB 19, NB 21, NB 22, NB 25, NB 28, NB 29, NB 30 and NB 33. All the lines were found response varies from each other against red pumpkin beetle, *A. foveicollis*.

Pal *et al* (1978) evaluated 287 indigenous and exotic pumpkin germplasm for resistance to red pumpkin beetle and observed that although no entry was immune, yet rate of damage varied from 1.0 to 5.0. Low cucurbitacin content of the cotyledonary leaves was found to impart resistance to this pest and the two lines/collection numbers 596-2 and 613 contained low cucurbitacin content as 0.005 and 0.010 per cent, respectively showed less susceptibility. Pareek and Kavadia (1993) evaluated seventeen sweet gourd varieties for resistance to red pumpkin beetle infestation and revealed that none of the variety showed resistance, but found significant variations. Among the varieties, Hales Best Jumbo, Jaune Canari, Faradin, Amco Sweet and Honey Dew Golden showed lower susceptibility. Sharma (1999) carried out studies on host preference by red pumpkin beetle and observed highest plant damage in musk melon (15.32%) followed by sweet gourd (7.11), long melon (6.1), and ridge gourd (3.10), whereas bitter gourd was found totally free from any damage by the beetle. Borah (1999) also evaluated three varieties for resistance to red pumpkin beetle and observed lower infestation and maximum yield in AAUC-1.

Satpathy (2002) conducted an experiment and screened sixteen bottle gourd (*Lagenaria siceraria*) germplasm for the degree of infestation by the red pumpkin beetle. In each germplasms, 5 male and 5 female flowers were randomly selected at the peak of the flowering period, and the numbers of red pumpkin beetles were counted. The average beetle population flower among all germplasm was 0.56, with the highest (1.34) and the lowest (0) values being recorded for VRBG-91 and VRBG-91, respectively. There were significant differences in the number of beetles recorded on male (1.04) and female (0.07) flowers, indicating that male flowers were preferred by red pumpkin beetles due to the pollens on which most of the adult survive.

Gill (2003) evaluated four melon cultivars *viz.* Punjab Sunehri, MM-28, Punjab Rasia and Hara Madhu under field conditions in Punjab, India against the hadda beetles (*Epilachna dodecastigma* and *Epilachna vigintioctopunctata*), red pumpkin beetle (*R. foveicollis*). The lowest adult populations of both hadda beetle and red pumpkin beetle were recorded on MM-28, and the highest on Punjab Rasila and Hara Madhu. Damage due to feeding by hadda beetles was observed at the early stage of plant growth in all the cultivars, but subsequently the plants grew well.

Saljoqi and Khan (2007) carried out a study that the relative abundance of red pumpkin beetle, *A. foveicollis* L. on different cucurbitaceous vegetables. Out of eleven varieties, squash and cucumber varieties were found more population of red pumpkin beetle during the cropping season. Two cucumber (*Cucumis sativus*) varieties, F1-beitalpha, SK-marketmore and two squash (*Cucurbita pepo*) varieties, light green zucchini, local round green were found susceptible to the attack of the red pumpkin beetle.

Rathod *et al.* (2009) carried out an experiment on red pumpkin beetle, *A. foveicollis* Lucas to check out the susceptibility of pumpkin cultivars. They tested six different cultivars against the beetle for their susceptibility; cultivars were APKL-2, APKL-4, APKL-6, APKL-7, APKL-00-06 and local variety. Among six genotypes of pumpkin screened, genotype APKL-7 and APKL-attacked by less number of beetles, whereas the cultivars APKL-6 and APKL-4 received more number of red pumpkin beetle.

Pal *et al.* (1978) evaluated 287 indigenous and exotic pumpkin germplsam for resistance to red pumpkin beetle and observed that although no entry was immune, yet rate of damage varied from 1.0 to 5.0. Low cucurbitacin content of the cotyledonary leaves was found to impart resistance to this pest and the two lines/collection numbers 596 and 613 contained low cucurbitacin content as 0.005 and 0.010 per cent, respectively showed less susceptibility.

Sandhu and Grewal (1985) tested the cucurbits for infestation by red pumpkin beetle and reported that cucurbits exhibited higher injury ratings under multiple choice test except for the pumpkin which showed higher injury under no choice test, whereas 16 musk melon variety Bangan Muktsar and summer squash variety Australian Green showed minor injury under no choice test. Among cucurbits, bitter gourd was found highly resistant; cucumber, musk melon and water melon moderately resistant; round melon and wild melon susceptible to this pest. Summer squash and pumpkin were found more preferred.

Roy and Pande (1991) observed red pumpkin was the most preferred and sponge gourd the least out of seven cucurbits offered red pumpkin beetle. In a study on influence of cucurbitacins on the feeding activity of red pumpkin beetle under laboratory conditions.

Singh *et al.* (2000) revealed that the maximum beetle intensity (0.49) was on musk melon followed by on round gourd (0.44), on cucumber (0.40), water melon (0.40) and long melon (0.40), but bitter gourd was found free from infestation. Among eleven cucurbit vegetables, bitter gourd was not preferred and musk melon most preferred food by the beetle.

Host preference of red pumpkin beetle *A. foveicollis* (Lucas) was studied on sixty-eight (68) indigenous germplasm lines of sweet gourd. These germplasm lines were grown in randomized block design with three replications. Data were collected on 12 infestation by red pumpkin beetle on plants at different stages like cotyledonary, true leaf, flowering and fruiting of crop. Eight germplasm lines (PCUC7, PCUC36, PCUC47, PCUC66, PCU99, PCUC102, PCUC108 and PCUC110) showed resistance against red pumpkin beetle. These genotypes may be for used in future resistance breeding in sweet gourd (Deepak *et al.* 2004).

Aslam *et al* (2017) examined for the evaluation of different pumpkin cultivars against Red Pumpkin Beetle, *A. foveicollis* L. (Chrysomelidae: Coleoptera). The data regarding number of eggs, larvae and adult population on Bottle Gourd Lattu and Bottle Gourd varieties with 0.26 and 0.23 number of eggs per leaf while 0.31 and 0.22 larvae population per leaf and maximum population of adults with 0.26 and 0.18 per leaf were recorded respectively. The minimum population of eggs, larvae and adult were recorded on Round Gourd Hybrid-F1 with 0.08, 0.06 and 0.05 per leaf, respectively.

Kamal *et al* (2013) studied the effect of host and temperature on oviposition and food consumption of red pumpkin beetle, *A. foveicollis* (Lucas). Three cucurbitaceous vegetables viz. sweet gourd (BARI Misti Kumra-1, BARI Misti Kumra-2 and Local Misti Kumra), bitter gourd (BARI Karola-1, Taj Karola-88 and Local Karola) and bottle gourd (BARI Lau-3, BARI Lau -4 and Local Lau) were selected to conduct this research. Host plants had the clear role on the feeding of red pumpkin beetle. Due to feeding of *A. foveicollis*, the highest percentage of weight loss of leaf was recorded from sweet gourd among the selected cucurbits while Local Misti Kumra was found the most preferred host by beetle considering their feeding efficacy compared to other varieties. Percentage weight loss of leaves due to the feeding of red pumpkin beetle on nine selected varieties showed that the highest percentage of weight loss was on Local Misti Kumra (15.34%) followed by BARI Misti Kumra-1 (12.92%) and BARI Misti Kumra-2 (12.78%).

2.3 Damage caused by red pumpkin beetle

Khan (2013) studied to determine the biochemical composition of cucurbit leaves and their influence on red pumpkin beetle. Result revealed that the highest nitrogen content was found in young leaf (6.79%) of sweet gourd. The highest quantity of reducing sugar was estimated from mature leaves (4.01%) of sweet gourd. A positive correlation was found between Red Pumpkin Beetle population per leaf with the percent nitrogen, total and reducing sugar content of mature leaves of cucurbits.

Kabir *et al.* (1991) was observed that yield losses due to red pumpkin beetle infestation at seedlings stage varies in different fruits and vegetables and it was minimum in bitter gourd (19.19%) and maximum in sweet gourd (69.96%). Atwal (1993) found that the red pumpkin beetle, *A. foveicollis* Lucas (Coleoptera: Chrysomelidae) was common and serious pest of a wide range of cucurbits, such as ash gourd (*Benincasa hispida*), pumpkin (*Cucurbita pepo* L.), tinda (*Citrullus vulgaris* var. *fisulosus*), ghia tori (*Luffa aegyptica*), cucumber and melon.

Anonymous (1930) found that it becomes sporadically serious on young tender shoots, leaves and flowers of various cucurbits. Experiment was carried out to check the damage, different life stages and effective control measures of the red pumpkin beetle on cucurbitaceous vegetable, those are comparatively safe, health friendly and easily available in local eco-system. In the experiment the span of different stages of the pest was monitored at field conditions under laboratory conditions at variable temperatures and humidities conditions. Different agronomic, chemical and non- chemical control measures were applied for the control of *A. foveicollis*. These control measures were ploughing and planking operations, application ofkerosine oil, road dust, wood dust, fine tobacco dust or snuff, wood and cowdung ash, spray of led-arsenate and water spray for the control.

Melamed-Madjae, V., (1960) reported that melamed-Madjae performs an experiment to study *Aulacophora (Rhaphidopalpa) foveicollis* (Lucas) adults feeding on the fruits and leaves of cucurbits in Israel, as in other Mediterranean countries. An investigation was done during 1955-57 and revealed that the adults of this beetle hibernate. Females beetle oviposit in May-August and egg stage last about 10, larval stage about 20 andpupal stage 16 days at 28 °C. Egg laying capacityof female ranges from 100 to 800.

2.4 Seasonal abundance of Red Pumpkin Beetle

Khan *et al.* (2012) found that the highest population of Red Pumpkin Beetle was recorded in the month of May. In March, food availability was the lowest because plant were young. In May, plant growth was maximal in covering largest canopy. In June, plants were at their senescent stage causing food scarcity. It was also found from the present study, 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 was recorded in the month of May.

Begum (2002) studied on sweet gourd, ash gourd, sponge gourd, snake gourd and cucumber against the fruit fly and red pumpkin beetle to identify the less and most preferred cucurbit host. The incidence of red pumpkin beetle was evident from early morning to sunset with the maximum number occurring within 8:00-9:00 am with the highest peak at 9:00 am on all the cucurbit plants. Their population gradually declined with lowest beetle density at noon up to 2:00 pm. The number of beetle density gradually increased with gradual progress of the day time towards sunset. In the afternoon the maximum occurrence of red pumpkin beetle was observed within 5:00-6:00 PM with the highest peak at 6:00. On the contrary, cucumber was recognized as less susceptible and less preferred host for both the pests with significantly lower damage inflicted.

Yamaguchi (1983) Reported that the Cucurbits; Cucumber, Muskmelon, Watermelon, Gourd Squash (*Cucurbita pepo*), Bitter Gourd are tender annuals, grown for their fruits, thrive only in hot weather and would not with stand frost. All these vegetables belong to the family Cucurbitaceae, having homogenous cultural requirements and almost, same diseases and same insect pests. Most of them are monoecious and some are dioecious. They thrive well with mean optimum temperature of 18-30 ºC. All are harvested as immature fruits and are ready for harvest within 3-7 days. Usual storage temperature require 7-13 ºC with relative humidity 85-95% for 14 days to 4-6 months. Cucurbits are attacked by a number of insect pests, including striped cucurbit beetle, 12 spotted cucumber beetles, squash bug, squash vine borers, melon aphids and Red Pumpkin Beetle. The Red Pumpkin Beetle, *A. 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.

Kamal *et al*. (2012) reported that effect of temperature on oviposistion of red pumpkin beetle among different crops. The egg laying performance on three cucurbits at different controlled temperatures varied significantly. The maximum number of egg was laid at 30 ºC temperature followed by 25 ºC and the lowest at 15 ºC. At 30 ºC temperature, the maximum number of egg was laid on the sweet gourd (19.89) followed by bottle gourd (14.78) and minimum egg was laid on the bitter gourd (8.89). At 25 ºC temperature, no egg was laid on bitter gourd whereas the highest number of eggs (17.0) was laid on sweet gourd followed by bottle gourd (11.11). At 15 ºC temperature, no egg was laid on bitter gourd by RPB and the highest (9.78) was found on sweet gourd followed by bottle gourd (7.67). Among three temperature 30 ºC was the optimum temperature for the beetle oviposition where they laid maximum number of eggs. **2.2 Cucurbit Fruit Fly**

2.2.1 Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Section: Schizophora

Family: Tephritidae

Genus: *Bactrocera*

Species*: B. curcurbitae*

Synonyms: *Chaetodacus cucurbitae* (Coquillett)

Dacus cucurbitae (Coquillett)

Strumeta cucurbitae (Coquillett)

Zeugodacus cucurbitae (Coquillett)

2.2.2 Origin and distribution

Fruit fly is considered to be the native of oriental, probably India and south east Asia and it was first discovered in the Yaeyama Island of Japan in 1919 (Anon., 1987). However, the fruit fly is widely distributed in India, Bangladesh, Pakistan, Myanmar, Nepal, Malaysia, China, Philippines, Formosa(Taiwan), Japan, Indonesia, East Africa, Australia, and Hawaiian Island (Alam, 1965). It was discovered in Solomon Islands in 1984, and is now widespread in all the provinces, except Makira, Rennell-Bellona and Temotu (Eta, 1985). In the Commonwealth of the Northern Mariana Islands, it was detected in 1943 and eradicated by sterile-insect release in 1963 (Steiner *et al.*, 1965; Mitchell, 1980), but re-established from the neighboring Guam in 1981 (Wong *et al.*, 1989). It was detected in Nauru in 1982 and eradicated in 1999 by male annihilation and protein bait spraying, but was re-introduced in 2001 (Hollingsworth and Allwood, 2002). Although it is found in Hawaii, it is absent from the continental United States (Weems and Heppner, 2001). In July 2010, fruit flies were discovered in traps in Sacramento and Placer counties. The distribution of a particular species is limited perhaps due to physical, climatic and gross vegetational factors but most likely due to host specificity. Such species may become widely distributed when their host plant are widespread, either naturally or cultivation by man (Kapoor, 1993). The dipteran family Tephritidae consists of over 4000 species, of which nearly 700 species belong to Dacine fruit flies (Fletcher, 1987). Nearly 250 species are of economic importance, and are distributed widely in temperate, sub-tropical, and tropical regions of the world (Christenson and Foote, 1960). The first report on melon fruit flies was published by Bezzi (1913), who listed 39 species from India. Forty-three species have been described under the genus *Bactrocera* including *cucurbitae, dorsalis, zonatus, diversus, tau, oleae, opiliae, kraussi, ferrugineus, caudatus, ciliatus, umbrosus, frauenfeldi, occipitalis, tryoni, neohumeralis, opiliae, jarvisi, expandens, tenuifascia, tsuneonsis, latifrons, cucumis, halfordiae, cucuminatus, vertebrates, frontalis, vivittatus, amphoratus, binotatus, umbeluzinus, brevis, serratus, butianus, hageni, scutellaris, aglaia, visendus, musae, newmani, savastanoi, diversus, and minax,* from Asia, Africa, and Australia (Fletcher, 1987; Cavalloro, 1983; Drew and Hooper, 1983; Munro, 1984).

Amongst these, *Bactrocera cucurbitae* (Coquillett) is a major threat to cucurbits (Shah *et al.*, 1948). Senior-White (1924) listed 87 species of Tephritidae in India. Amongst these, the genus, *Bactrocera (Dacus*) causes heavy damage to fruits and vegetables in Asia (Nagappan *et al.*, 1971). The melon fruit fly is distributed all over the world, but India is considered as its native home. Two of the world most damaging tephritids, *B. dorsalis* and *B. cucurbitae*, are widely distributed in Malaysia and other South East Asian countries (Vijaysegaran, 1987). According to Aktheruzzaman (1999*) B. cucurbitae B. tau and B. ciliates* have been currently identified in Bangladesh of which *Bactrocera ciliates* is a new record. *B. cucurbitae* is dominant in all the locations of Bangladesh followed by *B. tau and B. ciliates*.

Host range

The melon fly, *B. cucurbitae* (Coq.) is a polyphagous fruit fly that infests as many as 125 plant species most of them belong to Cucurbitaceae and Solanaceae (Dhillon *et al.*, 2005; Doharey, 1983; Bezzi, 1913). Presently, four Asian *Bactrocera* species- *Bactrocera cucurbitae, B. invadens, B. latifrons and B.zonata* Invaded Africa (Mwatawala, *et al.*, 2010; White, 2006; Lux *et al.*, 2003). Studies so far have shown that although these invasive *Bactrocera* species are polyphagous, they show preference in host utilization. the host range of *B. invadens* in Africa comprises 72 plant species spread across 28 families (Goergen *et al.*, 2011; Ekesi *et al.*, 2006; Vayssieres *et al.*, 2005). In West and Central Africa, *B. invadens* is highly polyphagous, infesting wild and cultivated fruit of at least 46 species from 23 families with guava, mango and citrus being the preferred hosts. *Terminalia catappa* (Tropical almond), *Irvingia gabonensis* (African wild mango), and *Vitellaria paradoxa* (Sheanut) are important wild hosts with high infestations (Goergen *et al*., 2011). In Tanzania, *B. invadens* was found to infest 15 fruit species of which the major commercial fruits: Mango, Loquat and guava were the preferred hosts. Other major hosts were *Flacourtia indica* (Governor's plum) and *Annona muricata* (Soursop) (Mwatawala *et al.,* 2006). *B. latifrons* have been found to utilize 12 Solanaceous fruit species and 3 cucurbit species in Tanzania (Mziray *et al*., 2010). According to them, *Solanum incanum, S. sodomeum* (Sodom apple) and *Lycopersicon pimpinellifolium* (Cherry tomato) were recorded as wild hosts, the rest were cultivated hosts.

Vayssieres *et al.,* (2007) reported *B. cucurbitae* to be polyphagous in West Africa infesting 17 fruits species however in Reunion Island they found *B. curcubitae* to be oligophagous depending primarily on Cucurbitaceae family. Generally, there preferred hosts are members of Cucurbitaceae. In Tanzania, Mwatawala *et al.* (2010) found B. cucurbitae to be polyphagous utilizing 19 hosts out of which 11 belong to Cucurbitae family. According to them, melon (*Cucumis melo*) is the most preferred host while *Momordica cf trifoliate* was the most important wild host. For all others both cultivated and wild hosts, infestation rate ranged from 37 to 157 flies/Kg fruit. The fruiting season of these plants were also the period of highest population density for *B. cucurbitae***.** 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 (Allwood *et al.,* 1999). Doharey (1983) reported that it infests over 70 host plants, amongst which, fruits of bitter gourd (*Momordica charantia*), muskmelon (*Cucumis melo*), snap melon (*Cucumis melo var. momordica*) and snake gourd (*Trichosanthes anguina* and *T. cucumeria*) are the most preferred hosts. However, White and Elson-Harris (1993) stated that many of the host records might be based on casual observations of adults resting on plants or caught in traps set in non-host plant species. In the Hawaiian Islands, melon fruit fly has been observed feeding on the flowers of the sunflower, Chinese bananas and the juice exuding from sweet corn.

The melon fly has a mutually beneficial association with the Orchid, Bulbophyllum paten, which produces zingerone. In Bangladesh, fruits of melon (*Cucumis melo),* sweet gourd (*Cucurbita maxima)*, snake gourd (*Trichosanthes cucumerina, Benincasa hispida),* watermelon (*Citrullus lanatus),* ivy gourd (*Coccinia grandis),* cucumber (*Cucumis sativus, Cucumis trigonus),* white-flowered gourd (*Lagenaria siceraria),* luffa (*Luffa aegyptiaca)* balsam-apple (*Momordica balsamina),* bitter gourd (*Momordica charantia)* etc. are infested by this pest species (Khan *et al.*, 2007; Saha *et al.*, 2007; Wadud *et al.*, 2005). Losses due to this fruit fly infestation were estimated from 10 to 30% of annual agricultural produces in the country (Naqvi, 2005).

It is necessary to point out that, since the cue lure that used in the present study which only attracts *B. cucurbitae* male adults, the fly population studied in the present research was for the male population. Regarding the 1:1 sex rate for *B. cucurbitae* adults (He *et al*., 2002), the entire *B. cucurbitae* population could be estimated based on the size of the male adult populations.

2.5 Nature of damage

Maggots feed inside the fruits, but at times, also feed on flowers, and stems. Generally, the females prefer to lay the eggs in soft tender fruit tissues by piercing them with the ovipositor. A watery fluid oozes from the puncture, which becomes slightly concave with seepage of fluid, and transforms into a brown resinous deposit. Sometimes pseudo-punctures (punctures without eggs) have also been observed on the fruit skin. This reduces the market value of the produce. In Hawaii, pumpkin and squash are heavily damaged even before fruit set. The eggs are laid into unopened flowers, and the larvae successfully develop in the taproots, stems, and leaf stalks (Weems and Heppner, 2001). Miyatake *et al.* (1993) reported more than 1% damage by pseudo-punctures by the sterile females in cucumber, sponge gourd and bitter gourd. After egg hatching, the maggots bore into the pulp tissue and make the feeding galleries. The fruit subsequently rots or becomes distorted. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition. The vinegar fly, *Drosophilla melanogaster* has also been observed to lay eggs on the fruits infested by melon fly, and acts as a scavenger (Dhillon *et al.,* 2005). The extent of losses varies between 30 to 100%, depending on the cucurbit species and the season. Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89% (Rabindranath and Pillai, 1986; Gupta and Verma, 1978; Kushwaha *et al.*, 1973; Narayanan and Batra, 1960; Lall and Sinha, 1959). The melon fruit fly has been reported to infest 95% of bitter gourd fruits in Papua (New Guinea), and 90% snake gourd and 60 to 87% pumpkin fruits in Solomon Islands (Hollingsworth *et al.*, 1997). Singh *et al.* (2000) reported 31.27% damage on bitter gourd and 28.55% on watermelon in India.

2.6 Rate of infestation and yield loss by fruit fly

Shah *et al.* (1948) reported that the damage done by fruit flies in North West Frontier Province (Pakistan) cost an annual loss of over $655738. Lee (1972) observed that the rate of infestation in bottle gourd and sweet gourd flowers were 42.2± 8.6% and 77.1±3.5%, respectively the highest occuring in sweetgourd (32.5±3.9) and the lowest in sponge gourd (14.7±4.0).York (1992) reviewed that the loss of cucurbits caused by fruit fly in South East Asia might be up to 50%. 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, cucumber, and sponge gourd, respectively, in Nepal (Pradhan, 1976). According to the reports of Bangladesh Agricultural Research Institute, fruit infestations were 22.48, 41.88 and 67.01 per cent for snake gourd, bitter gourd, and musk melon, respectively (Anon., 1988). Kabir *et al.* (1991) reported that yield losses due to infestation varies n different fruits and vegetables and it is minimun in cucumber (19.19%) and maximum in sweet gourd (69.96%). The damage caused by fruit fly is the most serious in melon after the first shower in monsoon when it often reaches up to 100%. Other cucurbit might also be infested and the infestation might be gone up to 50% (Atwal, 1993). Borah and Dutta (1997) studied the infestationof tephritids on the cucurbits in Assam, India and obtained highest fruit fly infestation rate in snake gourd (62.02%). Larger propotion of marketable fruits was obtained from ash gourd in and bottle gourd in summer season. Depending on the environmental conditions and susceptibility of the crop species, the extent of losses varies between 30 to 100% (Shooker *et al*., 2006; Dhillon *et al.*, 2005; Gupta and Verma, 1992).

2.7 Lifecycle of Cucurbit fruit fly

The life cycle from egg to adult requires 14-27 days. Insects are able to grow and develop on a variety of host species which effect on their growth, reproduction and development (Tikkanen *et al*., 2000). Mukherjee *et al.* (2007) studied the life history of *B. cucurbitae* on sweet gourd and reported pre-oviposition, oviposition, incubation, larval and pupal periods, and adult male and female longevity 11.25, 9.75, 0.81, 12.25, 7.75, 18.25, and 23.50 days, respectively. They also reported that the mean fecundity of fruit fly on this crop was 52.75 female-1.

Eggs

The eggs of the melon fly are slender, white and measure 1/12 inch in length. Eggs are inserted into fruit in bunches of 1 to 37. They hatch in 2 to 4 days. The melon fruit fly remains active throughout the year on one or the other host. During the severe winter months, they hide and huddle together under dried leaves of bushes and trees. During the hot and dry season, the flies take shelter under humid and shady places and feed on honeydew of aphids infesting the fruit trees. The lower developmental threshold for melon fruit fly was recorded as 8.1° C (Keck, 1951). The lower and upper developmental thresholds for eggs were 11.4 and 36.4° C (Messenger and Flitters, 1958). The accumulative day degrees required for egg, larvae, and pre-egg laying adults were recorded as 21.2, 101.7, and 274.9 day degrees, respectively (Keck, 1951). This species actively breeds when the temperature falls below 32.2° C and the relative humidity ranges between 60 to 70%. The egg incubation period on pumpkin, bitter gourd, and squash gourd has been reported to be 4.0 to 4.2 days at 27 ± 1° C (Doharey, 1983), 1.1 to 1.8 days on bitter gourd, cucumber and sponge gourd (Gupta and Verma, 1995), and 1.0 to 5.1 days on bitter gourd (Koul and Bhagat, 1994; Hollingsworth *et al.*, 1997).

Larvae

Refer to Heppner (1989) for a detailed description of larvae. The larval period lasts from 6 to 11 days, with each stage lasting 2 or more days. Duration of larval development is strongly affected by host. The larval period lasts for 3 to 21 days (Renjhan, 1949; Narayanan and Batra, 1960; Hollingsworth *et al.*, 1997), depending on temperature and the host. On different cucurbit species, the larval period varies from 3 to 6 days (Gupta and Verma, 1995; Koul and Bhagat, 1994; Doharey, 1983; Chelliah, 1970; Chawla, 1966). Larval feeding damage in fruits is the most damaging (Wadud *et al.,* 2005). Mature attacked fruits develop a water soaked appearance (Calcagno *et al.,* 2002). Young fruits become distorted and usually drop. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot (Collins *et al.,* 2009). These maggots also attack young seedlings, succulent tap roots, stems and buds of host plants such as mango, guava, cucumber, custard apple and others (Weldon *et al.,* 2008). Egg viability and larval and pupal survival on cucumber have been reported to be 91.7, 86.3, and 81.4%, respectively; while on pumpkin these were 85.4, 80.9, and 73.0%, respectively, at 27 ± 1° C.The full-grown larvae come out of the fruit by making one or two exit holes for pupation in the soil. The larvae pupate in the soil at a depth of 0.5 to 15 cm. The depth up to which the larvae move in the soil for pupation, and survival depend on soil texture and moisture (Jackson *et al.,* 1998).

Pupae

Doharey (1983) observed that the pupal period lasts for 7 days on bitter gourd and 7.2 days on pumpkin and squash gourd at 27 ± 1° C. In general, the pupal period lasts for 6 to 9 days during the rainy season, and 15 days during the winter (Narayanan and Batra, 1960). Depending on temperature and the host, the pupal period may vary from 7 to 13 days (Hollingsworth *et al.,* 1997). On different hosts, the pupal period varies from 7.7 to 9.4 days on bitter gourd, cucumber, and sponge gourd (Gupta and Verma, 1995), and 6.5 to 21.8 days on bottle gourd (Koul and Bhagat, 1994; Khan *et al.,* 1993).

Adults

The adults survive for 27.5, 30.71 and 30.66 days at 27 ± 1° C on pumpkin, squash gourd and bitter gourd, respectively (Doharey, 1983). Khan *et al.* (1993) reported that the males and females survived for 65 to 249 days and 27.5 to 133.5 days respectively. The pre-mating and oviposition periods lasted for 4 to 7 days and 14 to 17 days, respectively. The females survived for 123 days on papaya in the laboratory (24° C, 50% RH and LD 12: 12) (Vargas *et al.,* 1992), while at 29° C they survived for 23.1 to 116.8 days (Vargas *et al.,* 1997). Mean single generation time is 71.7 days, net reproductive rate 80.8 births per female, and the intrinsic rate of increase is 0.06 times (Vergas *et al.,* 1992). Yang *et al.*

(1994) reported the net reproductive rate to be 72.9 births per female. *Bactrocera cucurbitae* strains were selected for longer developmental period and larger body size on the basis of pre-oviposition period, female age at peak fecundity, numbers of eggs at peak fecundity, total fecundity, longevity of males and females, age at first mating, and number of life time mating (Miyatake, 1995). However, longer developmental period was not necessarily associated with greater fecundity and longevity (Miyatake, 1996).

2.8 Management of 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. This perhaps, is mainly due to the polyphagous nature of these pests that helps their year round population build up. The available literatures on the measures for the controlling of these flies are discussed under the following sub-headings:

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

A.a. Ploughing of soil 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 s 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; Agarwal *et al.*, 1987). The female fruit fly lays eggs and the larvae hatch inside the fruit, it becomes essential to look for the available measures to reduce their damage on fruit. One of the Safety measures is the field sanitation (Nasiruddin and Karim, 1992).

A.b. Field sanitation 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 into 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 cucurbits, Guava, mango, peach etc. and many borers of plants (Chattopadhyay, 1991).

B. Biological Control Thirty-two species and varieties of natural enemies to fruit flies were introduced to Hawaii between 1947 and 1952 to control the fruit flies. These parasites lay their eggs in the eggs or maggots and emerge in the pupal stage. Only three, *Opius longicaudatus* var. *malaiaensis* (Fullaway), *O. vandenboschi* (Fullaway), and *O. oophilus* (Fullaway), have become abundantly established. These parasites are primarily effective on the oriental and Mediterranean fruit flies in cultivated crops. The most efficacious parasite of the melon fly is *O. fletcheri* (Silvestri). It was introduced in 1916 from India. This parasite attacks the melon fly during the larval stage. Bess *et. al.*, (1961) reported that this parasite killed 20 - 40 per cent of fruit fly larvae. It is more effective in reducing populations in wild areas than in cultivated crops.

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

C.a. Bagging of fruits 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). Bagging 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).

C.b. Fruit picking 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).

C.c. Wire Netting 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.

D. 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. There are number of studies on the application of chemical insecticide in the form of cover sprays, bait sprays, attractants and repellents have been undertaken globally. Available information relevant these are given below:

D.a. Cover spray of insecticide

A wide range of organophosphoras, carbamate and synthetic pyrethroids of various formulations have been used from time to time against fruit fly (Kapoor,1993). Spraying of conventional insecticide is preferred in destroying adults before sexual maturity and oviposition (Williamson, 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% Phosalone were very effective against the fruit fly. Fenthion, Dichlorovos, Phosnhamidon and Endosulfan are effectively used for the control of melon fly (Agarlwal *et al.*, 1987). In field trials in Pakistan in 1985-86, the application of Cypermethrin 10 EC and Malathion 57 EC at 10 days intervals (4 sprays in total) significantly reduced the infestation of *B. 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 *B. 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 (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 (22.48%). Pawer *et al.* (1984) reported that 0.05% Monocrotophos was very effective in controlling *B. cucurbitae* in muskmelon. Rabindranath and Pillai (1986) reported that Synthetic pyrethroids, Permethrin, Fenvelerate, Cypermethrin and Deltamethrin (at 15g a.i/ha) were very useful in controlling *B.cucurbitae*, in bitter 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.

D.b. Bait Spray: Protein hydrolysate insecticide formulations are now used against various fruit fly species (Kapoor, 1993). Now a days, different poison baits are used against various *Bactrocra* species which are 20 g Malathion 50% Or 50 ml of Diazinon plus 200 g of molasses in 2 liters of water kept in flat containers or applying the bait Spray containing Malathion 0.05% plus 1 % sugar/molasses or 0.025% of protein water) or spraying plants with 500 g molasses plus 50 g Malathion in 50 liters of water or 0.025% Fenitrothion plus 0.5% molasses. This is repeated at weekly intervals where the fruit fly infestation is serious (Kapoor, 1993). Nasiruddin and Karim (1992) reported that bait spray (1.0 g Dipterex 80SP and 100 g of molasses per liter of water) on snake gourd against fruit fly (*B. cucurbitae*) showed 8.50% infestation compared to 22.48% in control. Agarwal *et al.* (1987) achieved very good results for fruit fly (*B.cucurbitae*) management by spraying the plants with 500 g molasses and 50 litres 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 SOEC) 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).

E. Use of attractants and others: 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 Methyl eugenol, from 1977 to 1979, reduced the infestation of *Bactrocera zonata* below economic injury levels (Qureshi *et al.*, 1981). *B. dorsalis* was eradicated from the island of Rota by male annihilation using Methyl 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 per cent Methyl eugenol plus 0.5 per cent Malathion (Lakshmann *et al.*, 1973) or 0.1 per cent Methyl eugenol plus 0.25 per cent Malathion (Bagle and Prasad, 1983) have been used for the trapping the oriental fruit fly, *B. dorsalis* and *B. zonata*. Neem beriatives have been demonstrated as repellents', antifeedants, growth inhibitors and chemosterilant (Steets, 1976; Leuschner, 1972, Butterworth and Morgan, 1968). Singh and Srivastava (1985) found that alcohol extract of neem oil *Azadirachta indica* reduced oviposition per centage of *B. cucurbitae* on bitter gourd completely and its 20% concentration was highly effective to inhibit ovipositon 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*.

F. Use of Sex pheromone in management of fruit fly

Males of numerous *Bactrocera* and *Dacus* species are known to be highly attracted to either methyl eugenol or cuelure (Metcalf and Metcaclf, 1992). In fact, at least 90 per cent species are strongly attracted to either of these attractants (Hardy, 1979). Pheromone traps are important sampling means for early detection and monitoring of the fruit flies that have become an integrated component of integrated pest management. Cuelure and ENT 31812 lures were placed on the ground and at 2 and 5 feet above the ground to evaluate the effect on the response of *B. cucurbitae*.Both the attractants were found at least as attractive at ground level as at higher levels and cuelure was found more attractive than ENT 31812 (Hart *et al.*, 1967). Sixty compounds related to methyl eugenol were evaluated for their attractiveness against oriental fruit fly, *B. dorsalis* and melon fruit fly, *B. cucurbitae* by Lee and Chen (1977) who reported that methyl isoeugenol, veratric acid, methyl eugenol and eugenol to be most effective attractants against *B. dorsalis* among the tested compounds. However,none of the tested chemicals was found to be significantly attractive against *B. cucurbitae.* According to Metcalf *et al.*

(1983), *B. cucurbitae* was extreamly responsive to cuelure, but nonresponsive to methyl eugenol, whereas, *B. dorsalis* extremely responsive to methyl eugenol, but non-responsive to cuelure. In an experiment in melon field, commercially produced attractants Flycide C (80% cuelure content), Eugelure 20 (20%), Eugleure DB (8%), cuelure (80%) + naled cuelure (80%) + diazinon and cuelure (90%) + naled were tested against *B. cucurbitae* showed no significant difference in captured flies (Iwaizumi *et al.*, 1991).

A study carried out by Wong *et al.* (1991) on age related response of laboratory and wild adults of melon fly, *B. cucurbitae* to cuelure revealed that response of males increased with increase in age and corresponded with sexual maturity for each strain. They failed to eradicate the pest with male annihilation programmes against *B. cucurbitae*, which might be because of the fact that only older males, which may have already mated with gravid females, responded to cuelure. Pawar *et al.* (1991) used cuelure (sex attractant) and tephritlure (food attractant) for the monitoring of *B. cucurbitae* and found cuelure traps more efficient in trapping fruit flies as compared to tephritlure. Gazit *et al.* (1998) studied the four trap types viz., IP-McPhail trap, Frutect trap, Cylinderical trap and Ga' aton trap with three female attractant baits viz., naziman, a proprietary liquid protein and a three component based synthetic attractant compound of ammonium acetate, putrescine and trimethylamine for Mediterranean fruit fly, Ceratitis capitata (Wiedemann). Their results ranked the trap and attractant performance as IP-McPhail trap baited with synthetic attractant > Frutect trap baited with proprietary lure > Cylinderical trap baited with synthetic attractant > IP-McPhail trap baited with naziman and Ga' aton trap baited either with synthetic attractant or nazimaAkhtaruzzaman *et al.* (2000) conducted a field study with cucumber cv. Lamba Shasha in Bangladesh, from April to July 1998, to evaluate the efficacy of some bait sprays against fruit fly (*Bactrocera cucurbitae*) in comparison with a standard insecticide and a bait trap. The treatments comprised 0.5 ml diazinon 60EC mixed with 2.5 g molasses and 2.5 litres water at a ratio of 0.2:1:100 (T1), fenitrothion (Sumithion 50EC) mixed with molasses (same preparation as T1; T2), 25 g molasses + 2.5 ml malathion (Limithion 50EC) and 2.5 litres water at 1:0.1:100 (T3), 0.5 ml Nogos 100EC mixed with 100 g sweet gourd mash and 100 ml water (T4), cover spray with 2.0 ml malathion/litre of water as standard insecticide (T5), and untreated control (T6). The bait sprays were applied at intervals of 15 days starting from the fruit initiation stage until 15 days before the final harvest. The effect of bait sprays on the infestation intensity per fruit was expressed in terms of per centages of fruit with infestation intensities corresponding to any of the 4 grades: low infestation intensity, 1 puncture per fruit (grade-I), moderate infestation intensity, 2 punctures per fruit (grade II), high infestation intensity, 3 punctures per fruit (grade III), and very high infestation intensity, >=4 punctures per fruit (grade IV). T_3 satisfactorily reduced infestation and minimized the reduction in edible yield. According to Vargas *et al.* (2000) methyl eugenol and cuelure were highly attractive kairomone lures to oriental fruit fly, *B. dorsalis* and melon fly, *B. cucurbitae*, respectively. They used these lures at different concentrations and found significantly highest *B. dorsalis* captures in 100 per cent methyl eugenol traps than 25, 50 and 75 per cent. However, *B. cucurbitae* captures with 25, 50 and 75 per cent cuelure were not significantly different. Bait traps of cuelure pheromone and mashed sweet gourd (MSG) in bitter gourd crop attracted large numbers of fruit flies effecting 40% to 65% reduction in fruit fly infestation and damage to the fruits and producing 2-4 times higher yields as compared to the non-baited fields. The technique was highly effective for the control of fruit fly and production of cucurbit crops free of pesticides (Anon., 2002-2003).

YubakDhoj (2001) reported that Fruit fly (*Bactrocera cucurbitae* Coquilet. Diptera: Tephritidae) is considered one of the production constraints in Nepal. Elsewhere integrated pest management of fruit flies (*B. cucurbitae*) is achieved by using combined control methods such as male annihilation, using cue lure and malathion in Steiners traps by disrupting mating with appropriate field sanitation, bagging of individual fruits, using pesticides in soils and with bait spraying along with hydrolysed protein. Babu and Viraktamath (2003a) reported that highest number of *B. dorsalis* was trapped in methyleugenol traps followed by *B. zonata* and *B. correcta* whereas; lowest number of *B. cucurbitae* was also trapped in a mango orchard. Similarly same four species of fruit flies were recorded in methyl eugenol traps in cucurbit field by Babu and Viraktamath (2003b).The most predominant fruit fly species was *B. dorsalis* (48%) followed by *B. cucurbitae* (21%), *B. correcta* (16%) and *B. zonata* (15%). Thomas *et al.* (2005) evaluated two parapheromones viz., cuelure and methyl eugenol for their attraction to *B. cucurbitae* in a bitter gourd field and revealed that melon flies were attracted to only cuelure traps. Response of fruit flies to the traps which differed in size, shape and colour containing methyl eugenol were evaluated in mango orchard by Ranjitha and Viraktamath (2005) and observed that fruit flies showed greater response to spheres than bottles and cylinders. However, response to different colours varied among different species.

Verghese *et al.* (2005) studied the comparative attractiveness of three indigenous lures/baits with three established attractants in fruit flies and reported that meyhyl eugenol attracted highest number of flies (18.25 flies/day/trap) followed by cuelure (13.5 flies/day/trap) and tulsi (5.88 flies/day/trap) whereas, flies attracted to banana, jaggery and protein hydrolysate were negligible. The number of species attracted was also higher in methyl eugenol, which attracted four species viz., *B. dorsalis, B. correcta B. zonata* and *B. verbascifoliae* (Drew and Hancock) followed by ocimum with two species viz., *B. dorsalis, B. correcta*. However, cuelure attracted only *B. cucurbitae*. Three species of fruit flies namely, *B. dorsalis, B. correcta* and *B. zonata* were recorded in methyl eugenol traps in guava and mango orchard by (Ranjitha and Viraktamath, 2006; Ravikumar and Viraktamath, 2006). Studies on the ability of different plant extracts to attract male fruit flies carried out by Hasyim *et al.* (2007) indicated that the major compound camphor present in Elsholtzia pubescens (Bith) was atleast as efficient as the standard cuelure in trapping males of *B. tau* in passion fruit orchard. Singh *et al.* (2007) tested sex attractant methyl eugenol, cuelure and food attractant protein hydrolysate for attraction to fruit flies and reported that five fly species viz., *B. zonata, B. affinis* (Hardy), *B. dorsalis, B. correcta and B. diversa* (Coquillett) were attracted to methyl eugenol traps and two species viz., *B. cucurbitae* and *B. nigrotibialis* (Perkins) to cuelure traps and two species namely, *B. cucurbitae* and *B. zonata* to protein hydrolysate traps.

Vargas *et al.* (2009) evaluated various traps with methyl eugenol and cuelure for capturing fruit flies and observed that *B. dorsalis* was captured in methyl eugenol traps and *B. cucurbitae* in cuelure traps. Sapkota *et al.* (2010) reported that a participatory field experiment was conducted under farmer field conditions to assess losses and to measure the efficacy of different local and recommended management options to address the problem of it in squash var. Bulam House (F1). The experiment consisted of six different treatments including untreated control, and there were four replications. All the treatments were applied 40 days after transplanting. Cucurbit fruit fly preferred young and immature fruits and resulted in a loss of 9.7% female flowers. Out of total fruits set, more than one-fourth (26%) fruits were dropped or damaged just after set and 14.04% fruits were damaged during harvesting stage, giving only 38.8% fruits of marketable quality. Application of locally made botanical pesticide ‘Jholmal’ was found superior in terms of fruit size (895 g), quality and yield (62.8 t/ha), and reduced fruit fly infestation in squash as compared to other treatments. Pheromone traps attract only male fruit flies but this could be used as indicators of the total population. Pheromones are also increasingly efficient at low population densities, they do not adversely affect natural enemies, and they can, therefore, bring about a long-term reduction in insect populations that cannot be accomplished with conventional insecticides (Toledo *et al.*, 2010*).*

Rakshit *et al.* (2011) assessed the economic benefits of managing fruit flies infecting sweet gourd using pheromones. In this study, a pheromone called Cuelure imported by the Bangladesh Agricultural Research Council (BARC) was used for suppressing fruit fly infesting sweet gourd. Analysis of the potential benefits of farmers adopting the Cuelure technology projects that benefits over 15 years range from 187 million Taka or $2.7 million to 428 million Taka or $6.3 million, depending on assumptions. The projected rate of return on the BARI investment in pheromone research ranges from to 140 to 165 per cent. The size of these returns implies that pheromone research at BARI has a high economic return and that Bangladesh benefits significantly as Cuelure becomes more widely available to farmers.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to study the damage potentiality and eco-friendly management of red pumpkin beetle and cucurbit fruit fly on squash during the period from October, 2018 to March, 2019. A brief description of the experimental site, climatic conditions, soil characteristics, experimental design, treatments, cultural operations, data collection and analysis of different parameters were used for conducting this experiment are presented under the following headings:

3.1 Location of the experimental field

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October,2018to March, 2019. The location of the experimental site was at 23^0 $46^{'}$ N latitude and 90^0 $22^{'}$ E longitudes with an elevation of 8.24 meter from sea level (Khan, 1997).

3.2 Climate condition during the experiment

The experimental area is characterized by subtropical rainfall during the month of October to March and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented in Appendix I.

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) (UNDP and FAO, 1988) with pH 5.8-6.5, ECE-25.28 (Haider, 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Planting material

The variety BARI squash 1 was selected for the experiment during Rabi season 2018-2019. The seed of this variety was collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.5 Experimental design and layout

The experiment consisted of seven vegetable of cucurbitaceous and was laid out in Randomized Complete Block Design (RCBD) with three replications. Experimental plot was sub-divided into three blocks where nine(9) pits were in each plots. Thus there were 21 (3 × 7) unit plot and altogether in the experiment. The size of each plot was 3.0 m × 2.0 m. The treatments of the experiment were randomly distributed in the experimental plots.

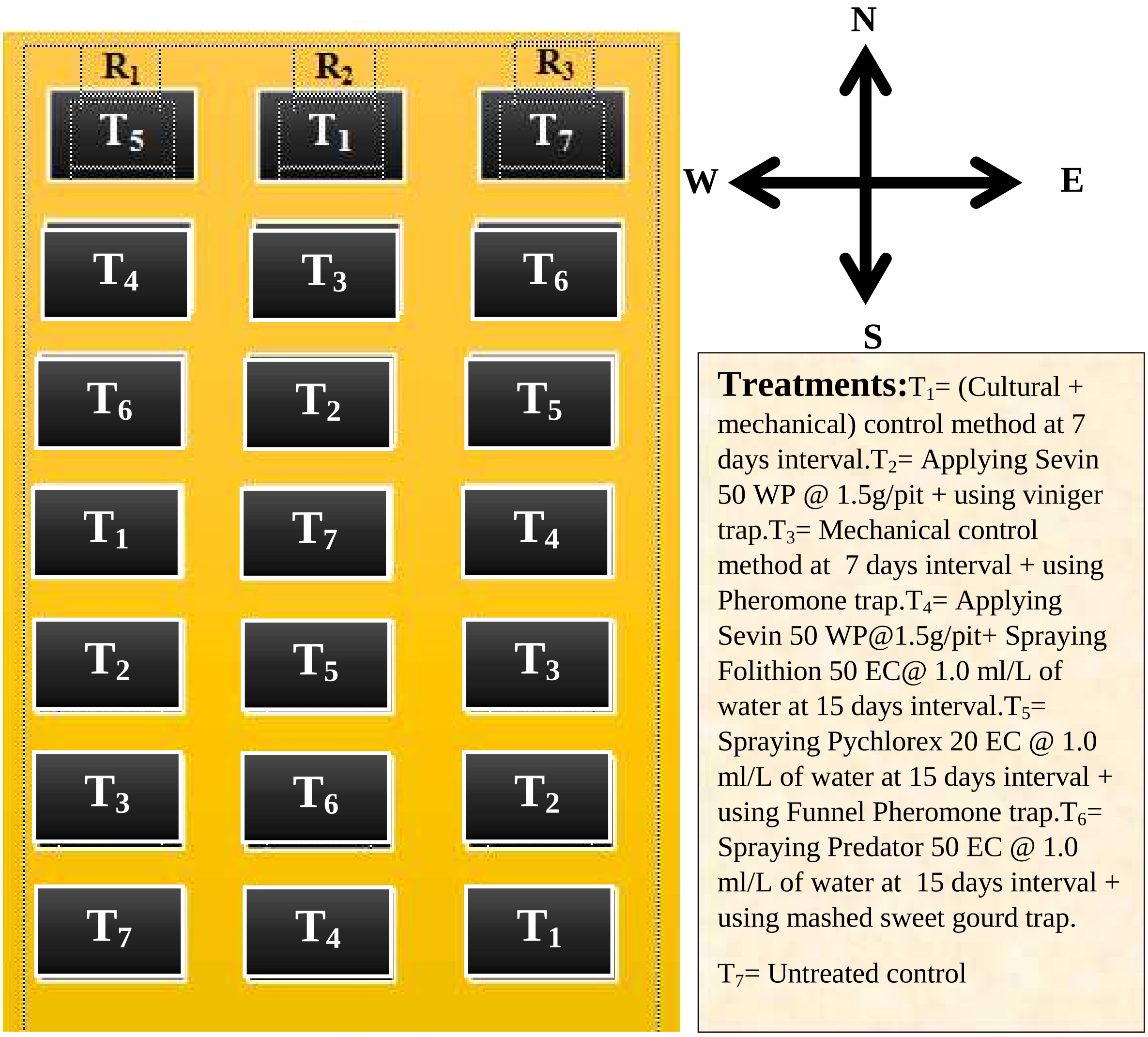

Figure:Layout of the experimental plot

3.6 Cultivation procedure

3.6.1 Land preparation

Power tiller was used for the land preparation of the experimental field. Then it was exposed to the sunshine for 7 days before to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. The soil was treated with furadan 5G insecticide to control the young plants from the attack of soil insect such as cutworm and mole cricket.Thus the experimental plot was well prepared. The size of the experiment plot was 3.0 m × 2 m. There are 1 plants in each pit and total 9 plants per plot.Irrigation was done over the plot by manually.

3.6.2 Manures and fertilizers and its methods of application

Fertilizer	Quantity	Application method
Cow dung	10 t /ha	Basal dose
Urea	69 kg/ha	20, 35 and 50 DAT
TSP	60 kg/ha	Basal dose
MOP	60 kg/ha	Basal dose

Rashid (1993).

The half of cow dung, TSP and MP and one third of urea were applied as basal dose during land preparation. The remaining cowdung, TSP and MP were applied in the pit 15 days before seed sowing. The rest of urea was top dressed after each flush of flowering and fruiting in three equal splits.

3.6.3 Seed sowing: Collecting seeds of BARI squash 1 were soaked for 12 hours in water for rapid and uniform germination. Then seeds were sown in the polyethylene bags (12cm x 18cm) containing a mixture of equal proportion of well decomposed cowdung and loam soilin 3rd weeks of October 2018 and irrigated regularly. After germination, the seedlings were sprayed with water by hand sprayer and sprayed was done once a day for two weeks. Seedlings were placed in a shady place.After 23 days of sowing with 4 young leaves, Seedlings were transplanted on 11th November, 2018 in the pits of the experimental field (one seedlings per pit and 9 pits plot^{-1}). At the time of transplanting, polyethylene bags was cut and removed carefully in order to keep the soil intact with root of the seedling. Damaged seedlings were replaced by new one from the seedlings of border pits around the experimental plot.

Plate 1: Seedling in polyethene bag

3.6.4 Cultural practices

After sowing the seeds, a light irrigation was applied to the plots. Subsequent irrigation was done whenever needed. Sevin 85WP @ 1.5 kg/ha followed by a light irrigation was applied in soil around each plant in ring method and then covered with soil to avoid cutworm infestation. After germination of seedlings, soil of each plot was drenched with 1 % solution of Vitavax 200 to protect the plants from the anthracnose disease. Weeding and drainage facilities were provided as needed.

3.6.5 Seeds sowing, raising of seedlingand transplanting in the field

Direct sowing of seed followed by watering into the perforated polythen was executed @ Two seeds of BARI squash 1 variety per polythen bags containing a mixture of equal proportion of well-decomposed cowdung and loamy soil. Seedlings were placed to partly sunny place for acclimatization. Finally, 23 days old seedlings with 4 vigorous leaveswere transplanted to the experimental plots as sown one seed pit^{-1} on 3rd weeks of October, 2018. At the time of transplanting the polybags were cut and removed carefully in order to keep the soil intact with the root of the seedlings. The seedlings were watered until they got established.

3.6.6 Intercultural operations

After transplanting the plants were initially irrigated by watering cane. Irrigation at an interval of 2-3 days, replacement of dead or damaged seedlings by healthy one. After 7 days of transplanting, each plant by bamboo sticks was provided on about 0.6 m high from ground level for additional support. MP(muriate of potash) and urea were top dressed in 3 splits. Weeding and mulching in the plots were done, whenever necessary.

Plate 2: Experimental field in central farm of SAU during the study period

3.7Treatments of the experiment

T_1 = Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle); + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval.T_2 = Applying Sevin 50 WP @ 1.5g/pit + using vineger trap.T_3 = Mechanical control method at 7 days interval + using Pheromone trap.T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval.T_5 = Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap.T_6 = Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap.T_7 = Untreated control.

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

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

3.7.2 Pheromone trap: A pheromone trap is a type of insect trap that uses pheromones 'cuelure' which mimics the scent of female flies, attracts the male flies and traps them which results in mating disruption. The commercial formulation of Q-lure (Sex pheromone) were collected from Gulistan, Siddique bazar, (Dhaka)The pheromonetraps were hung up with bamboo scaffold, 60 cm above the ground. The former soap water was being replaced by new soap water at an interval of 8 days each.The lure must be kept above the water level in the trap so that it cannot be getting moist.

Plate 3: Pheromone trap in the experimental field during the study period

3.7.3 Bait trap with sweet gourd mash

The poison bait trap was prepared using mashed sweet gourd mixed with water and Sevin 50WP at the rate of 2gm per 100 gm of mashed sweet gourd. The bait was kept in a small earthen pot placed within a four splitted bamboo sticks, 50 cm above the ground an earthen cover plate was placed 20 cm above the bait container to protect the bait material from sun and rain. The number of adult fruit flies (male and female) trapped in those bait traps were recorded at each four days interval in the morning. The old bait materials were changed at the interval of 4-5 days each and fresh ones were placed there for further use.

Plate 4: Bait trap with sweet gourd mashed in the experimental field during the study period

3.7.4 Vinegar trap with rotted or overripe fruit trap

It is a simple trap. This type of trap was prepared using vinegar 200ml with 2ml liquid dish soap and a piece of ripe or overripe fruit (papaya) 100gm and rotted banana along with rotted apple. (At first, a plastic bottle was cutoff upper portion then all materials was kept in this plastic bottle and another cut portion inverted and insert into the mouth of the lower cut-portion of plastic bottle to form a makeshift funnel. Fruit fly entry by this funnel into vinegar trap and would not escape/ get out from the trap. Vinegar traps were placed at 50 cm above the ground with the help of bamboo supports.

Plate 5: Vinegar trap with rotted or overripe fruit in the experimental field during the study period

3.7.5 Funnel pheromone trap

Pheromone trap was made up of a plastic bottle in which of its both sides had two funnel. Cuelure was hanged inside the plastic bottle.

Plate 6: Funnel pheromonetrapin the experimental field during the study

3.8 Data collection

Data on different parameters were recorded for red pumpkin beetle and Fruit fly infestation attacking squash vegetable parts like leaves, long petiol,flower and fruits. Details of the data recording procedures are explained under the following sub-headings.

3.8.1Number of Red pumpkin beetle plant^{-1}

The number of Red Pumpkin Beetle per plant was manually counted at 5, 15, 25, 35, 45 and 55 days after sowing from randomly selected tagged plants. The average of four plants were computed and expressed in average number of Red pumpkin beetle per plant.

3.8.2Number of healthy leaves plant^{-1}

The number of healthy leaves per plant was manually counted at 5, 15, 25, 35, 45 and 55 days after sowing from randomly selected tagged plants. The average of four plants were computed and expressed in average number of leaves per plant.

3.8.3Percentage of leaves infestation

The percent of leaves infestation was manually counted at 5, 15, 25, 35, 45 and 55 days after sowing from randomly selected tagged plants. Mean number of infested leaves was calculated on the basis of the total infested leaves of the selected branch divided by the total number of leaves of the selected branch.

3.8.4Number of healthy long petiole plant^{-1}

The number of long petiole per plant was manually counted at 5, 15, 25, 35, 45 and 55days after sowing from randomly selected tagged plants. The average of four plants were computed and expressed in average number of long petiole per plant.

3.8.5Percentage of long petiole infestation

The percent of long petiole infestation was manually counted at 5, 15, 25, 35, 45 and 55 days after sowing from randomly selected tagged plants. Mean number of infested long petiole was calculated on the basis of the total infested long petiole of the selected plant divided by the total number of long petiole of the selected plant.

3.8.6Number of healthy flower

Data on number of healthy flower was recorded at 10 days interval which was started from 25 days after sowing and continued up to 55 DAT.

3.8.7Percentage of flower infestation

The percent of flower infestation was manually counted at 25, 35, 45 and 55 days after sowing from randomly selected tagged plants. Mean number of infested flower was calculated on the basis of the total infested flower of the selected branch divided by the total number of flower of the selected branch.

3.8.8 Number of healthy fruit

Data on number of healthy flower was recorded at 10 days interval which was started from 45 days after sowing and continued up to 55 DAT.

3.8.9Number of cucurbit fruit fly fruit^{-1}

The number of cucurbit fruit fly per plant was manually counted at 35, 45 and 55 days after flowering from (T_2 ,T_3 ,T_5,T_6)and through sweeping from (T_1 , T_4 ,T_7).average of nine plants were computed and expressed in average number of cucurbit fruit fly per plant

3.8.10Effect of different treatments on yield contributing characters and yield of squash

3.8.11 Single fruit weight

3.8.12Length of fruit

3.8.13Width of fruit

3.8.14Fruit plant^{-1}

3.8.15Fruit weight plant^{-1}

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

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

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

3.9 Statistical Analysis

The data obtained from experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values for all the parameters were calculated and the analysis of variance for the characters was accomplished and means were separated the significance of difference between pair of means was tested by the Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984).

Plate 7: Healthy fruit in the experimental field during the study period

Plate 8: Healthy fruit after harvest during the study period

Plate 9: Infested fruit by cucurbit fruit fly of squash in experimental field

Plate 10: Infested mature leaf and young leaf of squash by Red pumpkin beetle

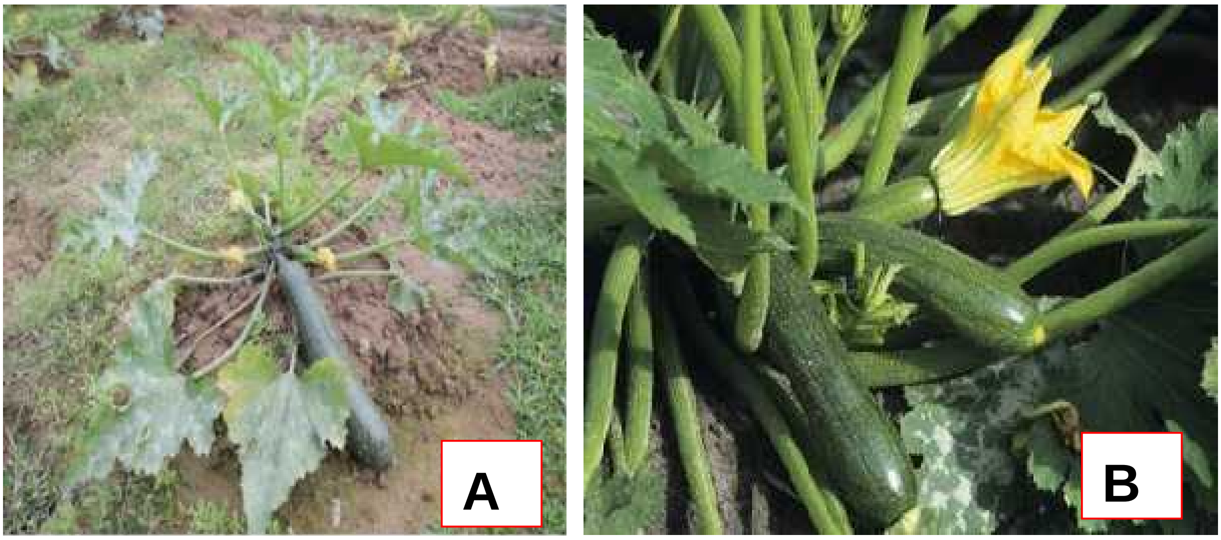

Plate 11: Infested mature Plant (A) by Red pumpkin beetle and Squash plant with healthy leaf, flower & fruits (B)

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to find the effect of different varieties on number of infested plants plot^{-1} at different days after transplanting. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in Appendix III-XII. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

4.1 Number of red pumpkin beetle plant^{-1}

The significant difference was observed in number of red pumpkin beetle plant^{-1}due to different treatment of squash at 5, 15, 25, 35, 45 and 55 DAT (Appendix IX). At 5DAT, the maximum number of red pumpkin beetle plant^{-1} (4.40) was recorded from T_7(Untreated control) and the minimum number of red pumpkin beetle plant^{-1} (2.27) was recorded from treatment T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) (Table 4.1).

At 15DAT, the maximum number of red pumpkin beetle plant^{-1} (4.40) was recorded from T_7 (Untreated control) and the minimum number of red pumpkin beetle plant^{-1} (2.00) was recorded from treatment T_4 (Applying Sevin 50 50 WP@1.5gpit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) (Table 4.1).

At 25DAT, the maximum number of red pumpkin beetle plant^{-1} (4.60) was recorded from T_7 (Untreated control) and the minimum number of red pumpkin beetle plant^{-1} (1.73) was recorded from treatment T_4 (Applying Sevin 50 WP@1.5gpit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) (Table 4.1).

At 35DAT, the maximum number of red pumpkin beetle plant^{-1} (4.20) was recorded from T_7 (Untreated control) and the minimum number of red pumpkin beetle plant^{-1} (1.47) was recorded from treatment T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) (Table 4.1).

At 45DAT, the maximum number of red pumpkin beetle plant^{-1} (3.80) was recorded from T_7 (Untreated control) and the minimum number of red pumpkin beetle plant^{-1} (1.07) was recorded from treatment T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) (Table 4.1).

At 55DAT, the maximum number of red pumpkin beetle plant^{-1} (3.60) was recorded from T_7 (Untreated control) and the minimum number of red pumpkin beetle plant^{-1} (0.47) was recorded from treatment T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) (Table 4.1).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. Khan (2013) studied to determine the biochemical composition of cucurbit leaves and their influence on red pumpkin beetle. Result revealed that the highest nitrogen content was found in young leaf (6.79%) of sweet gourd. Khan *et al* (2011) observed that sweet gourd and wax gourd were found to be the most preferred host of red pumpkin beetle. Pareek and Kavadia (1993) evaluated seventeen sweet gourd varieties for resistance to red pumpkin beetle infestation and revealed that none of the variety showed resistance, but found significant variations. Saljoqi and Khan (2007) studied the relative abundance of red pumpkin beetle, *Aulacophora foveicollis* L. on different cucurbitaceous vegetables.

Hutson (1972) reported that the red pumpkin beetle occurs on various cucurbits in Ceylon. Pawlacos (1940) stated *Raphidopalpa foveicollis* (Lucas) as one of the most important pests of melon in Greece. According to York (1992), this insect pest is found in the Mediterranean region, Africa and Asia. Vandana *et al* (2001) studied the host preference of red pumpkin beetle, *A. foveicollis* among five cucurbits *viz.*, sweet gourd, ash gourd, sponge gourd, snake gourd and cucumber, in which sweet gourd was identified as the most susceptible and highly preferred host to red pumpkin beetle.

Table 4.1 Effect of different treatments on number of red pumpkin beetle at different days after transplanting

Treatments	Number of Red Pumpkin Beetle					
	5 DAT	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
T_1	3.60b	3.40b	3.40b	3.40b	3.20b	2.80b
T_2	2.67d	2.13d	1.87d	1.80d	1.60e	1.60e
T_3	3.47b	3.27b	3.27b	3.40b	3.20b	2.80b
T_4	2.27e	2.00e	1.73e	1.47e	1.07f	0.47f
T_5	3.40bc	3.20b	2.80c	2.60c	2.60c	2.40c
T_6	3.13c	2.80c	2.80c	2.40c	2.43d	2.20d
T_7	4.40a	4.40a	4.60a	4.20a	3.80a	3.60a
$LSD_{0.05}$	0.335	0.338	0.113	0.243	0.08	0.077
CV (%)	7.48	8.13	7.36	4.62	1.78	4.93

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^1+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

4.2 Leaves infestation plant^{-1} by RPB at earlyvegetative stage of squash

At 5DAT, the highest number of healthy leaves plant^{-1} (11.60) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy leaves plant^{-1} (8.47) was recorded treatment T_7 (Untreated control) (Table 4.2). At 5DAT, the maximum number of infested leaves plant^{-1} (3.20) was recorded from T_7 (Untreated control) and the minimum number of infested leaves plant^{-1} (1.20) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested leaves was found (27.43) in T_7 (Untreated control) and the lowest percentage of infested leaves (9.38) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 5 DAT.

Table 4.2 Effect of different treatments on leaves infestation by RPB at early vegetative stage of squash

Treatments	5 DAT			15 DAT		
	No. of healthy leaves $plant^{-1}$	Infested leaves $Plant^{-1}$	% Leaves Infestation	No. of healthy leaves $plant^{-1}$	Infested leaves $Plant^{-1}$	% Leaves Infestation
T_1	9.80d	2.47c	20.11c	9.80c	2.63bc	21.17c
T_2	9.13e	2.07d	18.45d	8.53d	2.27d	20.99cd
T_3	8.20g	2.80b	25.45b	7.80e	2.73b	25.95b
T_4	11.60a	1.20f	9.38f	11.60a	1.40e	10.29f
T_5	10.20c	2.47c	19.47d	10.20b	2.53c	19.90d
T_6	10.47b	1.87e	15.14e	10.27b	2.20d	17.65e
T_7	8.47f	3.20a	27.43a	7.87e	3.20a	28.92a
$LSD_{0.05}$	0.132	0.109	1.32	0.126	0.150	1.454
CV (%)	3.42	5.69	5.43	3.42	3.49	3.65

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^{1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

At 15DAT, the highest number of healthy leaves plant^{-1} (11.60) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy leaves plant^{-1} (7.87) was recorded treatment T_7 (Untreated control) (Table 4.2). At 15DAT, the maximum number of infested leaves plant^{-1} (3.20) was recorded from T_7 (Untreated control) and the minimum number of infested leaves plant^{-1} (1.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested leaves was found (28.92) in T_7 (Untreated control) and the lowest percentage of infested leaves (10.29) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 15 DAT (Table 4.2).

4.3Leaves infestation plant^{-1} by RPB at mid vegetative stage of squash

At 25DAT, the highest number of healthy leaves plant^{-1} (11.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy leaves plant^{-1} (7.67) was recorded treatment T_7 (Untreated control) (Table 4.3).At 25DAT, the maximum number of infested leaves plant^{-1} (3.47) was recorded from T_7 (Untreated control) and the minimum number of infested leaves plant^{-1} (1.33) was recorded from T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval**.**The highest percentage of infested leaves was found (31.14) in T_7 (Untreated control) and the lowest percentage of infested leaves (10.94) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 25 DAT.

At 35DAT, the highest number of healthy leaves plant^{-1} (11.20) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 7 days interval) and the lowest number of healthy leaves plant^{-1} (7.47) was recorded treatment T_7 (Untreated control) in Table 4.3. At 35DAT, the maximum number of infested leaves plant^{-1} (3.47) was recorded from T_7 (Untreated control) and the minimum number of infested leaves plant^{-1} (1.53) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested leaves was found (31.71) in T_7 (Untreated control) and the lowest percentage of infested leaves (12.04) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 35 DAT (Table 4.3).

Table 4.3 Effect of different treatments on leaves infestation by RPB at mid vegetative stage of squash

Treatments	25 DAT			35 DAT		
	No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation	No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation
T_1	9.60d	2.60c	21.31c	9.40c	2.80c	22.95c
T_2	8.33e	2.20d	20.89d	8.13d	2.40d	22.78c
T_3	7.80f	2.80b	26.42b	7.40e	3.20b	30.19b
T_4	11.40a	1.33e	10.94f	11.20a	1.53e	12.04e
T_5	9.80c	2.60c	20.97d	9.80b	2.80c	22.22c
T_6	10.27b	2.27d	18.09e	9.87b	2.47d	20.00d
T_7	7.67g	3.47a	31.14a	7.47e	3.47a	31.71a
$LSD_{0.05}$	0.096	0.118	0.342	0.101	0.112	0.312
CV (%)	4.53	2.70	3.42	5.34	4.50	3.43

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^{1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

4.4 Leaves infestation plant^{-1} by RPB at late vegetative stage of squash

At 45DAT, the highest number of healthy leaves plant^{-1} (10.80) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy leaves plant^{-1} (7.27) was recorded treatment T_7 (Untreated control). At 45 DAT, the maximum number of infested leaves plant^{-1} (3.67) was recorded from T_7 (Untreated control) and the minimum number of infested leaves plant^{-1} (1.53) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested leaves was found (33.54) in T_7 (Untreated control) and the lowest percentage of infested leaves (12.90) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 45 DAT. (Table 4.4)

At 55DAT, the highest number of healthy leaves plant^{-1} (10.60) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy leaves plant^{-1} (6.87) was recorded treatment T_7 (Untreated control) (Table 4.4). At 55DAT, the maximum number of infested leaves plant^{-1} (3.67) was recorded from T_7 (Untreated control) and the minimum number of infested leaves plant^{-1} (1.53) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested leaves was found (34.81) in T_7 (Untreated control) and the lowest percentage of infested leaves (13.61) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 55 DAT. (Table 4.4)

Atwal (1993) found the red pumpkin beetle, *Aulacophora foveicollis* Lucas (Coleoptera: Chrysomelidae) was common and serious pest of a wide range of cucurbits, such as ash gourd (*Benincasa hispida*), pumpkin (*Cucurbita pepo* L.), tinda (*Citrullus vulgaris* var. *fisulosus*), ghia tori (*Luffa aegyptica*), cucumber and melon.

Table 4.4Effect of different treatments on leaves infestation by RPB at late vegetative stage of squash

Treatments	45 DAT			55 DAT		
	No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation	No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation
T_1	8.80d	2.80c	24.14d	8.60d	2.80c	24.56d
T_2	7.73e	2.40d	23.68d	7.60e	2.60d	25.49c
T_3	7.20f	3.20b	30.77b	6.80f	3.20b	32.00b
T_4	10.80a	1.53e	12.90f	10.60a	1.53e	13.61f
T_5	9.60c	3.20b	25.00c	9.60c	3.20b	25.00c
T_6	9.87b	2.47d	20.00e	9.87b	2.87c	22.51e
T_7	7.27f	3.67a	33.54a	6.87f	3.67a	34.81a
$LSD_{0.05}$	0.094	0.113	0.534	0.132	0.119	0.631
CV (%)	3.23	2.42	3.33	4.34	2.35	3.23

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^{1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

4.5 Long petioleinfestation by RPB at early vegetative stage of squash

At 5DAT, the highest number of healthy long petiole plant^{-1} (13.07) was recorded from T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy long petiole plant^{-1}(9.07) was recorded treatment T_7 (Untreated control).At 5DAT, the maximum number of infested long petiole plant^{-1} (1.67) was recorded from T_7 (Untreated control) and the minimum number of infested long petiole plant^{-1} (0.20) was recorded from T_4 (Applying Sevin 50 WP @1.5gpit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infestation in long petiole plant^{-1}was found (26.09) in T_7 (Untreated control) and the lowest was (8.41) in T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 5 DAT. (Table 4.5)

At 15DAT, the highest number of healthy long petiole plant^{-1} (12.87) was recorded from T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy long petioleplant^{-1} (8.87) was recorded treatment T_7 (Untreated control) (Table 4.5). At 15DAT, the maximum number of infested long petiole plant^{-1} (1.67) was recorded from T_7 (Untreated control) and the minimum number of infested long petiole plant^{-1} (0.20) was recorded from T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infestation in long petioleplant^{-1} was found (26.52) in T_7 (Untreated control) and the lowest was (9.37) in T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 15 DAT.

Begum (2002) studied on sweet gourd, ash gourd, sponge gourd, snake gourd and cucumber against the fruit fly and red pumpkin beetle to identify the less and most preferred cucurbit host. Depending on the environmental conditions and susceptibility of the crop species, the extent of damage by red pumpkin beetle varies between 30 to 100% (Gupta and Verma, 1992; Dhillon *et al*, 2005). Khan and Hajela (1987) determined that red pumpkin beetles preferred sweet gourd followed by cucumber, squash, sponge gourd and bottle gourd. Rathod *et al.* (2011) conducted an experiment on red pumpkin beetle, *Aulacophora foveicollis* Lucas to check out the susceptibility of pumpkin cultivars. According to Roy and Pande (1991) red pumpkin was the most preferred with sponge gourd.

Table 4.5 Effect of different treatments on long petiole infestation by RPB at early vegetative stage of squash

Treatments	5 DAT			15 DAT		
	No. of healthy long petiole plant^{-1}	Infested long petiolePlant^{-1}	% long petiole infestation	No. of healthy long petioleplant^{-1}	Infested long petiole Plant^{-1}	% long petiole infestation
T_1	10.00c	0.80c	19.79c	9.80d	0.80c	21.17c
T_2	11.00b	0.53d	15.82d	10.60c	0.53d	17.62e
T_3	11.07b	1.00b	20.19c	10.87b	1.00b	20.10d
T_4	13.07a	0.20f	8.41e	12.87a	0.20f	9.37f
T_5	9.00d	0.40e	21.51b	8.80e	0.40e	22.35b
T_6	10.00c	0.47de	15.73d	9.80d	0.47de	18.33e
T_7	9.07d	1.67a	26.09a	8.87e	1.67a	26.52a
LSD $_{0.05}$	0.042	0.116	0.503	0.203	0.106	0.494
CV (%)	4.43	9.21	6.35	5.45	9.12	4.53

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^{1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

4.6Long petioleinfestation by RPB at mid vegetative stage of squash

At 25DAT, the highest number of healthy long petiole plant^{-1} (12.87) was recorded from T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy long petiole plant^{-1} (8.47) was recorded treatment T_7 (Untreated control) (Table 4.6). At 25DAT, the maximum number of infested long petiole plant^{-1} (1.87) was recorded from T_7 (Untreated control) and the minimum number of infested long petiole plant^{-1} (0.20) was recorded from T_4 (Applying Sevin 50 WP @1.5g pit^{-1}pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infestation in long petiole plant^{-1} was found (29.05) in T_7 (Untreated control) and the lowest was (9.81) in T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 25 DAT.

At 35DAT, the highest number of healthy long petiole plant^{-1} (12.47) was recorded from T_4 (Applying Sevin 50 WP @1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy long petiole plant^{-1} (8.27) was recorded treatment T_7 (Untreated control). At 35DAT, the maximum number of infested long petiole plant^{-1} (1.87) was recorded from T_7 (Untreated control) and the minimum number of infested long petiole plant^{-1} (0.40) was recorded from T_4 (Applying Sevin 50 WP @1.5g pit^{-1} pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infestation in long petioleplant^{-1} was found (29.55) in T_7 (Untreated control) and the lowest was (10.95) in T_4 (Applying Sevin 50 WP @1.5g pit^{-1} pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 35 DAT (Table 4.6)

Table 4.6Effect of different treatments on long petiole infestation by RPB at mid vegetative stage of squash

Treatments	25 DAT			35 DAT		
	No. of healthy long petiole plant^{-1}	Infested long petiole Plant^{-1}	% long petioleinfestation	No. of healthy long petiole plant^{-1}	Infested long petiolePlant^{-1}	% long petiole infestation
T_1	9.80d	1.00b	20.97c	9.60d	1.00d	22.58d
T_2	10.40c	0.73c	17.46e	10.40c	0.73c	18.75f
T_3	10.87b	1.00b	20.49c	10.67b	1.20b	23.08c
T_4	12.87a	0.20e	9.81f	12.47a	0.40e	10.95g
T_5	8.73e	0.60d	22.81b	8.60f	0.80d	24.56b
T_6	9.60d	0.67cd	19.10d	9.40e	0.67cd	20.79e
T_7	8.47f	1.87a	29.05a	8.27g	1.87a	29.55a
LSD $_{0.05}$	0.253	0.105	0.696	0.183	0.105	0.495
CV (%)	4.35	7.69	4.34	3.24	6.42	5.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^{1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

4.7Long petioleinfestation by RPB at late vegetative stage of squash

At 45DAT, the highest number of healthy long petiole plant^{-1} (12.47) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy long petiole plant^{-1} (8.27) was recorded treatment T_7 (Untreated control). At 45DAT, the maximum number of infested long petiole plant^{-1} (2.07) was recorded from T_7 (Untreated control) and the minimum number of infested long petiole plant^{-1} (0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infestation in long petiole plant^{-1} was found (30.73) in T_7 (Untreated control) and the lowest was (11.37) in T_4 (Applying Sevin 50 WP@1.5gpit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 45 DAT (Table 4.7)

At 55DAT, the highest number of healthy long petiole plant^{-1} (12.67) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy long petiole plant^{-1} (7.87) was recorded treatment T_7 (Untreated control) (Table 4.7) At 55DAT, the maximum number of infested long petiole plant^{-1} (2.07) was recorded from T_7 (Untreated control) and the minimum number of infested long petiole plant^{-1} (0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5gpit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infestation in long petiole plant^{-1} was found (31.79) in T_7 (Untreated control) and the lowest was (11.65) in T_4 (Applying Sevin 50 WP@1.5gpit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 55 DAT.

Table 4.7 Effect of different treatment on long petiole infested by RPB at late vegetative stage of squash

Treatments	45 DAT			55 DAT		
	No. of healthy long petiole plant^{-1}	Infested long petiole Plant^{-1}	% long petiole infestation	No. of healthy long petiole plant^{-1}	Infested long petiole Plant^{-1}	% long petioleinfestation
T_1	9.40d	1.20b	22.95c	9.40c	1.20b	22.95e
T_2	10.20c	0.93c	19.05e	10.20b	0.93c	20.31f
T_3	10.47b	1.20b	23.41c	10.27b	1.20b	23.76d
T_4	12.47a	0.40f	11.37f	12.67a	0.40f	11.65g
T_5	8.20f	0.80d	28.07b	8.20e	0.80d	28.07b
T_6	9.20e	0.67e	21.14d	8.80d	0.87e	24.57c
T_7	8.27f	2.07a	30.73a	7.87f	2.07a	31.79a
$LSD_{0.05}$	0.157	0.113	0.623	0.186	0.113	0.205
CV (%)	3.55	6.25	5.61	5.43	6.24	4.53

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^{1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

4.8 Effect of different treatments on flower infestationof squash

At 25DAT, the highest number of healthy flowers plant^{-1} (14.27) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15days interval) and the lowest number of healthy flowers plant^{-1} (10.87) was recorded treatment T_7 (Untreated control) (Table 4.8). At 25DAT, the maximum number of infested flowers plant^{-1} (1.73) was recorded from T_7 (Untreated control) and the minimum number of infested flowers plant^{-1} (0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested flowers was found (13.75) in T_7 (Untreated control) and the lowest percentage of infested flowers (2.73) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 25 DAT (Table 4.8).

At 35DAT, the highest number of healthy flowers plant^{-1} (14.27) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy flowers plant^{-1} (10.67) was recorded treatment T_7 (Untreated control) (Table 4.8). At 35DAT, the maximum number of infested flowers plant^{-1} (1.73) was recorded from T_7 (Untreated control) and the minimum number of infested flowers plant^{-1} (0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested flowers was found (13.97) in T_7 (Untreated control) and the lowest percentage of infested flowers (2.73) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 35 DAT (Table 4.8).

Table 4.8 Effect of treatments on flower infestation of squash by RPB at different days after treatment

Treatments	25 DAT			35 DAT			45 DAT			55 DAT		
	No. of healthy flowers plant^{-1}	Infested flowers Plant^{-1}	% Flowers Infestation	No. of healthy flowers plant^{-1}	Infested flowers Plant^{-1}	% Flowers Infestation	No. of healthy flowers plant^{-1}	Infested flowers Plant^{-1}	% Flowers Infestation	No. of healthy flowers plant^{-1}	Infested flowers Plant^{-1}	% Flowers Infestation
T_1	13.40c	0.80b	5.63c	13.20c	1.20b	8.33b	13.20c	1.20b	8.33c	13.20c	1.60b	10.81c
T_2	12.40e	0.67c	5.10d	12.20e	0.67e	5.18e	12.20d	1.07c	8.04c	12.20e	1.07d	8.04e
T_3	12.67d	0.80b	5.94b	12.47d	0.80d	6.03d	12.27d	1.20b	8.91b	12.47d	1.60b	11.37b
T_4	14.27a	0.40d	2.73g	14.27a	0.40f	2.73f	14.27a	0.40f	2.73f	14.27a	0.40f	2.73g
T_5	12.40e	0.40d	3.13f	12.20e	0.80d	6.15d	12.20d	0.80e	6.15e	12.20e	0.80e	6.15f
T_6	13.60b	0.53cd	3.77e	13.40b	0.93c	6.51c	13.40b	0.93d	6.51d	13.40b	1.33c	9.05d
T_7	10.87f	1.73a	13.75a	10.67f	1.73a	13.97a	10.27e	1.73a	14.44a	10.27f	2.13a	17.20a
$LSD_{0.05}$	0.133	0.096	0.275	0.187	0.243	0.146	0.132	0.109	0.389	0.198	0.167	0.152
CV (%)	6.76	17.12	5.43	7.64	14.31	5.65	6.53	12.32	5.35	5.85	10.43	3.56

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

T_1 = Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle); + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval.T_2 = Applying Sevin 50 WP @ 1.5g/pit + using vineger trap.T_3 = Mechanical control method at 7 days interval + using Pheromone trap.T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval.T_5 = Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap.T_6 = Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap.T_7 = Untreated control.

At 45DAT, the highest number of healthy flowers plant^{-1} (14.27) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy flowers plant^{-1} (10.27) was recorded treatment T_7 (Untreated control) (Table 4.8).At 45DAT, the maximum number of infested flowers plant^{-1} (1.73) was recorded from T_7 (Untreated control) and the minimum number of infested flowers plant^{-1} (0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested flowers was found (14.44) in T_7 (Untreated control) and the lowest percentage of infested flowers (2.73) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 45 DAT. (Table 4.8)

At 55DAT, the highest number of healthy flowers plant^{-1} (14.27) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy flowers plant^{-1} (10.27) was recorded treatment T_7 (Untreated control) (Table 4.8). At 55DAT, the maximum number of infested flowers plant^{-1} (2.13) was recorded from T_7 (Untreated control) and the minimum number of infested flowers plant^{-1} (0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested flowers was found (17.20) in T_7 (Untreated control) and the lowest percentage of infested flowers (2.73) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 55 DAT (Table 4.8).

4.9 Number of cucurbit fruit fly fruit^{-1}

The significant difference was observed due to planting of squashat 35, 45 and 55 DAT (Table 4.9). At 35DAT, the maximum number of cucurbit fruit fly (2.40) was recorded from T_7 (Untreated control) and the minimum number of cucurbit fruit fly (0.47) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) in (Table 4.9). At 35DAT, the highest control percentage of cucurbit fruit fly (80.42) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) and the lowest control percentage of cucurbit fruit fly (0.00) was recorded T_7 (Untreated control) treatment (Figure 1).

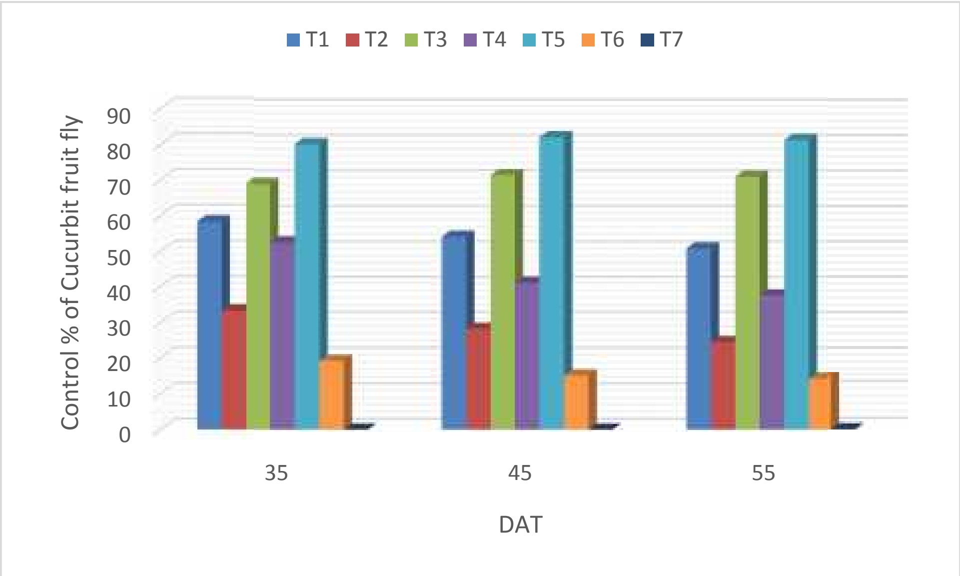

Figure 1:Effect of different treatments on control percentage of cucurbit fruit fly at different days after transplanting

[T_1= Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle) + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval; T_2= Applying Sevin 50 WP @ 1.5g pit^{-1}+ using viniger trap; T_3= Mechanical control method at 7 days interval + using Pheromone trap; T_4= Applying Sevin 50 WP@1.5gpit^{1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval; T_5= Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap; T_6= Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap and T_7= Untreated control]

At 45DAT, the maximum number of cucurbit fruit fly (3.07) was recorded from T_7 (Untreated control) and the minimum number of cucurbit fruit fly (0.54) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) in (Table 4.9). At 45DAT, the highest control percentage of cucurbit fruit fly (82.41) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) and the lowest control percentage of cucurbit fruit fly (0.00) was recorded treatment T_7 (Untreated control) (Figure 1).

At 55DAT, the maximum number of cucurbit fruit fly (3.27) was recorded from T_7 (Untreated control) and the minimum number of cucurbit fruit fly (0.60) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) in (Table 4.9). At 55DAT, the highest control percentage of cucurbit fruit fly (81.65) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) and the lowest control percentage of cucurbit fruit fly (0.00) was recorded treatment T_7 (Untreated control) (Figure 1).

Table 4.9 Effect of different treatments on number of cucurbit fruit fly and control percentage at different days after transplanting

Treatments	35 DAT		45 DAT		55 DAT	
	Number of insect plot^{-1}by three sweeping or per trap	% Control	Number of insect plot^{-1}	% Control	Number of insect plot^{-1}	% Control
T_1	1.00e	58.33	1.40e	54.40	1.60e	51.07
T_2	1.60c	33.33	2.20c	28.34	2.47c	24.57
T_3	0.74f	69.17	0.87f	71.66	0.94f	71.25
T_4	1.13d	52.78	1.80d	41.37	2.03d	37.82
T_5	0.47g	80.42	0.54g	82.41	0.60g	81.65
T_6	1.93b	19.44	2.60b	15.31	2.80b	14.37
T_7	2.40a	0.00	3.07a	0.00	3.27a	0.00
$LSD_{0.05}$	0.108		0.154		0.098	
CV (%)	5.76		6.45		3.69	

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1 = Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle); + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval.T_2 = Applying Sevin 50 WP @ 1.5g/pit + using vineger trap**.**T_3 = Mechanical control method at 7 days interval + using Pheromone trap**.**T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval**.**T_5 = Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap**.**T_6 = SprayingPredator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap**.**T_7 = Untreated control]

In Tanzania, Mwatawala *et al* (2010) found *B. cucurbitae* to be polyphagous utilizing 19 hosts out of which 11 belong to Cucurbitae family. According to them melon (*Cucumis melo*) is the most preferred host while *Momordica trifoliate* was the most important wild host. Cucurbit fruit fly preferred young and immature fruits and resulted in a loss of 9.7% female flowers. Out of total fruits set, more than one-fourth (26%) fruits were damaged just after set and 14.04% fruits were damaged during harvesting stage (Sapkota *et al*, 2010).

4.10 Effect of different treatments on fruit infestation of squash by cucurbit fruit fly

At 45DAT, the highest number of healthy fruit plant^{-1} (5.47) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) and the lowest number of healthy fruit plant^{-1} (3.47) was recorded treatment T_7 (Untreated control) (Table 4.10). At 45DAT, the maximum number of infested fruit plant^{-1} (1.20) was recorded from T_7 (Untreated control) and the minimum number of infested fruit plant^{-1} (0.33) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap). The highest percentage of infested fruit was found (35.53) in T_7 (Untreated control) and the lowest percentage of infested fruit (6.08) was found in T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) at 45 DAT (Table 4.10).

At 55DAT, the highest number of healthy fruit plant^{-1} (8.27) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap) and the lowest number of healthy fruit plant^{-1} (5.80) was recorded treatment T_7 (Untreated control) (Table 4.10). At 55DAT, the maximum number of infested fruit plant^{-1} (1.87) was recorded from T_7 (Untreated control) and the minimum number of infested fruit plant^{-1} (0.73) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap). The highest percentage of infested fruit was found (32.17) in T_7 (Untreated control) and the lowest percentage of infested fruit (8.87) was found in T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) at 55 DAT (Table 4.10).

Table 4.10 Effect of different treatments on fruit infestation of squash by cucurbit fruit fly

Treatments	45 DAT				55 DAT			
	Number of health fruit/plant	Number of infested fruit/plant	% Fruit infestation	Fruit infestation reduction over control	Number of health fruit	Number of infested fruit	% Fruit infestation	Fruit infestation reduction over control
T_1	4.53c	0.80c	17.59c	49.06	7.20c	1.20d	16.62d	48.34
T_2	4.27e	1.00b	23.38b	32.29	6.40e	1.40c	21.82c	32.17
T_3	5.00b	0.60d	11.91d	65.51	7.60b	1.00e	13.12e	59.22
T_4	4.40d	0.80c	18.07c	47.67	6.80d	1.20d	17.60d	45.29
T_5	5.47a	0.33e	6.08e	82.39	8.27a	0.73f	8.87f	72.43
T_6	4.07f	1.00b	24.52b	28.99	6.20f	1.60b	25.75b	19.96
T_7	3.47g	1.20a	34.53a	-	5.80g	1.87a	32.17a	-
$LSD_{0.05}$	0.112	0.072	1.892		0.773	0.012	1.675	
CV (%)	4.53	6.75	4.51		4.98	6.77	4.11	

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1 = Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle); + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval.T_2 = Applying Sevin 50 WP @ 1.5g/pit + using vineger trap.T_3 = Mechanical control method at 7 days interval + using Pheromone trap.T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval.T_5 = Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap.T_6 = Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap.T_7 = Untreated control]

4.11Effect of different treatments on yield contributing characters and yield of squash

4.11.1 Single fruit weight

There was a significant effect on single fruit weight of squash by different treatments. The highest single fruit weight (460.00 g) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + usingFunnel Pheromone trap) and the lowest Single fruit weight (350.00 g) was recorded treatment T_7 (Untreated control) (Table 4.11).

Table 4.11Effect of different treatments on yield contributing characters and yield of squash

Treatment	Single fruit weight (g)	Length of fruit (cm)	Width of fruit (cm)	Fruit plant^{-1}	Fruit weight plant^{-1} (kg)	Total fruit weight plot^{-1} (kg)	Yield (t ha^{-1})
T_1	400.00c	20.00c	2.35c	7.20c	2.88c	25.90c	43.16c
T_2	380.00e	18.00e	1.85e	6.40e	2.43e	21.87e	36.44e
T_3	415.00b	21.00b	2.60b	7.60b	3.15b	28.36b	47.27b
T_4	390.00d	19.50d	2.10d	6.80d	2.65d	23.84d	39.74d
T_5	460.00a	23.10a	2.85a	8.27a	3.80a	34.21a	57.02a
T_6	365.00f	17.75f	1.80f	6.20f	2.26f	20.35f	33.91f
T_7	350.00g	16.50g	1.65g	5.80g	2.03g	18.25g	30.42g
$LSD_{0.05}$	3.214	0.763	0.043	0.173	0.067	0.603	1.005
CV (%)	6.23	4.37	6.54	5.43	5.34	5.35	5.34

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

[T_1 = Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle); + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval.T_2 = Applying Sevin 50 WP @ 1.5g/pit + using vineger trap.T_3 = Mechanical control method at 7 days interval + using Pheromone trap.T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval.T_5 = Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap.T_6 = Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap.T_7 = Untreated control]

4.11.2 Length of fruit

Length of fruit showed statistically significant variation due to different treatments. The highest length of fruit(23.10 cm) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) and the lowest Single fruit weight (16.50 cm) was recorded treatment T_7 (Untreated control) (Table 4.11).

4.11.3 Width offruit

There was a significant effect on width of fruit of squashby different treatments.The highest width of fruit (2.85 cm) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap)and the lowest width of fruit (1.65 cm) was recorded treatment T_7 (Untreated control) (Table 4.11).

4.11.4 Fruit plant^{-1}

Fruit plant^{-1}showed statistically significant variation due to different treatments. The highest fruit plant^{-1}(8.27) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 7 days interval + using Funnel Pheromone trap)and the lowest fruit plant^{-1}(5.80) was recorded treatment T_7 (Untreated control) (Table 4.11).

4.11.5 Total Fruit weight plot^{-1}

Fruit weight plot^{-1}showed statistically significant variation due to different treatments. The highest fruit weight plot^{-1}(34.21 kg) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 7 days interval + using Funnel Pheromone trap) and the lowest weight fruit plot^{-1}(18.25 kg) was recorded treatment T_7 (Untreated control) (Table 4.11)

4.11.6Yield (t ha^{-1})

Yieldshowed statistically significant variation due to different treatments. The highest yield (57.02 t ha^{-1}) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap) and the lowest yield (30.42 t ha^{-1}) was recorded treatment T_7 (Untreated control) (Figure 2).

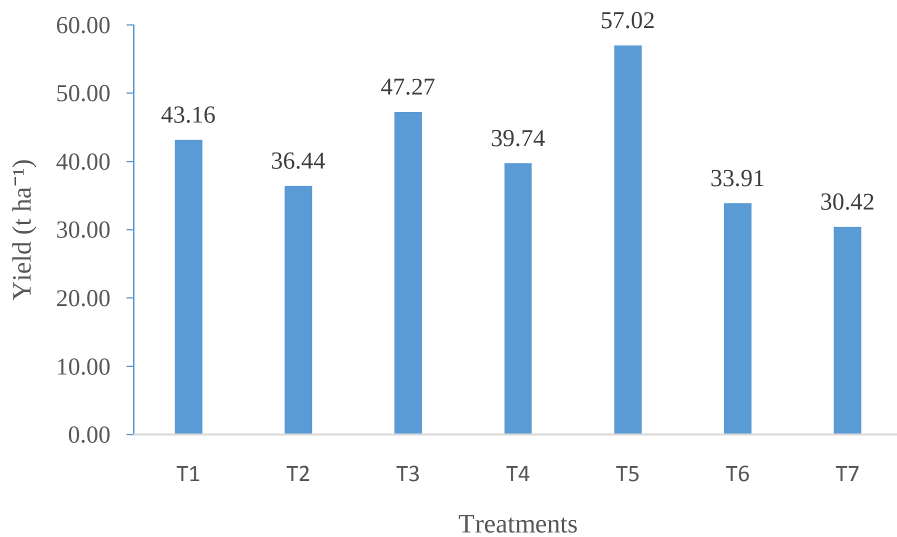

Figure 2: Effect of different treatments on yield (t ha^{-1}) of squash

[T_1 = Cultural method (clean cultivation to keep the plot free from weeds and debris to discourage pupation of fruit fly & collect grub of Red pumpkin beetle); + mechanical control method (removal of infested roots, shoots and fruits) at 7 days interval.T_2 = Applying Sevin 50 WP @ 1.5g/pit + using vineger trap.T_3 = Mechanical control method at 7 days interval + using Pheromone trap.T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval.T_5 = Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Funnel Pheromone trap.T_6 = Spraying Predator 50 EC @ 1.0 ml/L of water at 15 days interval + using mashed sweet gourd trap.T_7 = Untreated control]

4.12 Relationship between percent leaf infestation and number of RPB at different DAT

Correlation study was done to establish the relationship between the `percent leaf infestations and number of RPB at different DAT among different management practices. From the figure 3-8, it was revealed that positive correlation was observed between the parameters. It was evident that the equation $y = 0.8818x - 0.5937$, $y = 0.6172x + 0.5542$, $y = 0.5906x + 0.7399$, $y = 0.594x + 1.0318$, $y = 0.6629x + 1.0571$, $y = 0.6329x + 1.4035$ gave a good fit to the data and the co-efficient of determination ($R^2 = 0.8571$, $R^2 = 0.8155$, $R^2 = 0.7847$, $R^2 = 0.845$, $R^2 = 0.8286$ and $R^2 = 0.8948$) fitted regression line had a significant regression co-efficient at 5, 15, 25, 35, 45 and 55 DAT, respectively.It may be concluded from the figure that number of RPB at different DAT was strongly as well as positively correlated with % leaf infestation. So, it can be said that there was strongly positive correlation between leaf infestation and number of RPB.That means the percent infestation was increased with increase of red pumpkin beetle incidences.

4.13 Relationship between percent fruit infestation and single fruit weight

Correlation study was done to establish the relationship between the % fruit infestations and single fruit weight of squash among different management practices.From the figure 4, it was revealed that negative correlation was observed between the parameters. It was evident that the equation y = -4.362x + 479gave a good fit to the data and the co-efficient of determination (R^2 = 0.9014) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that single fruit weight of squash was strongly as well as negatively correlated with percent fruit infestation.It was revealed that when the fruit infestation (8.87%) decreased the single fruit weight(460 g) of squash was increased. On the contrary, when the fruit infestation (32.17 %) was increased then the single fruit weight(350g) of squash was decreased. So, it can be said that there was strongly negative correlation between fruit infestation and single fruit weight of squash.That means the fruit infestation was decreased with the single fruit weight increase.

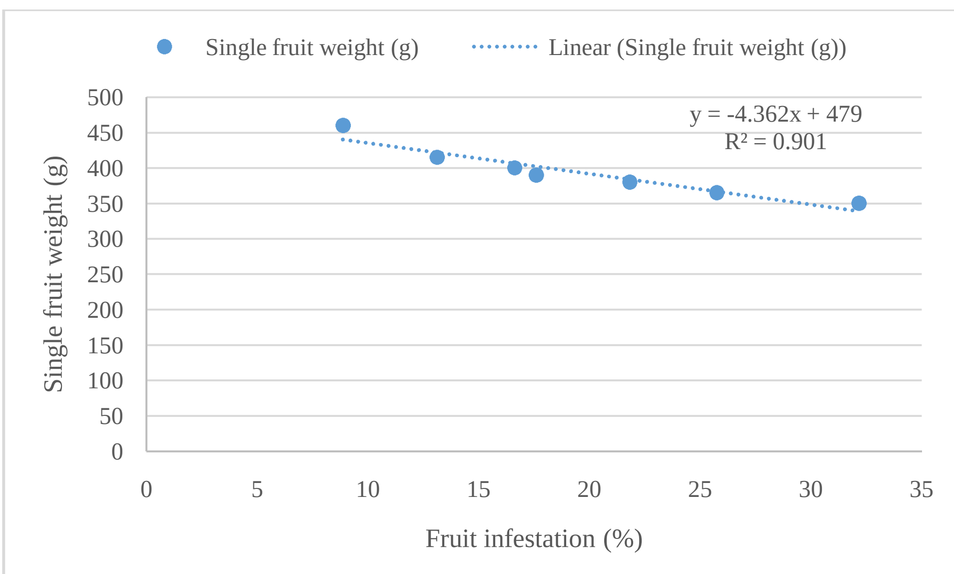

Figure 4.Relationship between percent fruit infestation and single fruit weight at different management

4.14 Relationship between percent fruit infestation and total fruit weight

Correlation study was done to establish the relationship between the percent fruit infestations and total fruit weight of squash among different management practices.From the figure 5, it was revealed that negative correlation was observed between the parameters. It was evident that the equation y = -0.6524x + 37.354gave a good fit to the data and the co-efficient of determination (R^2 = 0.9036) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that toal fruit weight of squash was strongly as well as negatively correlated with % fruit infestation.It was revealed that when the fruit infestation (8.87%) decreased the toal fruit weight(460 g) of squash was increased. On the contrary, when the fruit infestation (32.17 %) was increased then the total fruit weight(350g) of squash was decreased. So, it can be said that there was strongly negative correlation between fruit infestation and total fruit weight of squash.That means the percent fruit infestation was decreased with the increase of total fruit weight.

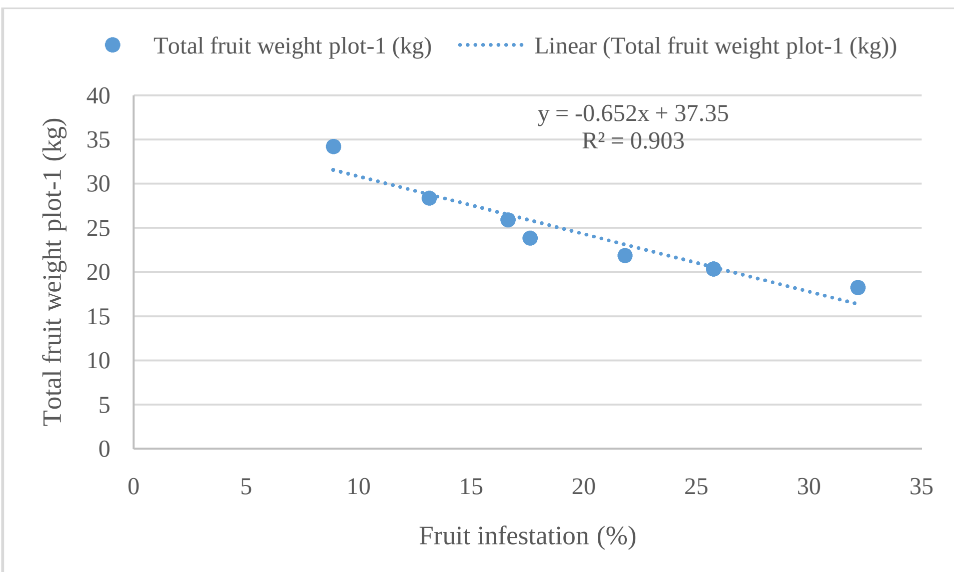

Figure 5.Relationship between percent fruit infestation and total fruit weight at different management

4.15 Relationship between percent fruit infestation and yield

Correlation study was done to establish the relationship between the percent fruit infestations and yield of squash among different management practices.From the figure 6, it was revealed that negative correlation was observed between the parameters. It was evident that the equation y = -0.0725x + 4.1507 gave a good fit to the data and the co-efficient of determination (R^2 = 0.9037) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that yield (tha^{-1}) of squash was strongly as well as negatively correlated with % fruit infestation.It was revealed that when the fruit infestation (8.87%) decreased the yield (57.02 t ha^{-1}) of squash was increased. On the contrary, when the fruit infestation (32.17 %) was increased then the yield (30.42 tha^{-1}) of squash was decreased. So, it can be said that there was strongly negative correlation between fruit infestation and yield of squash.That means the fruit infestation was increased with the decrease of yield.

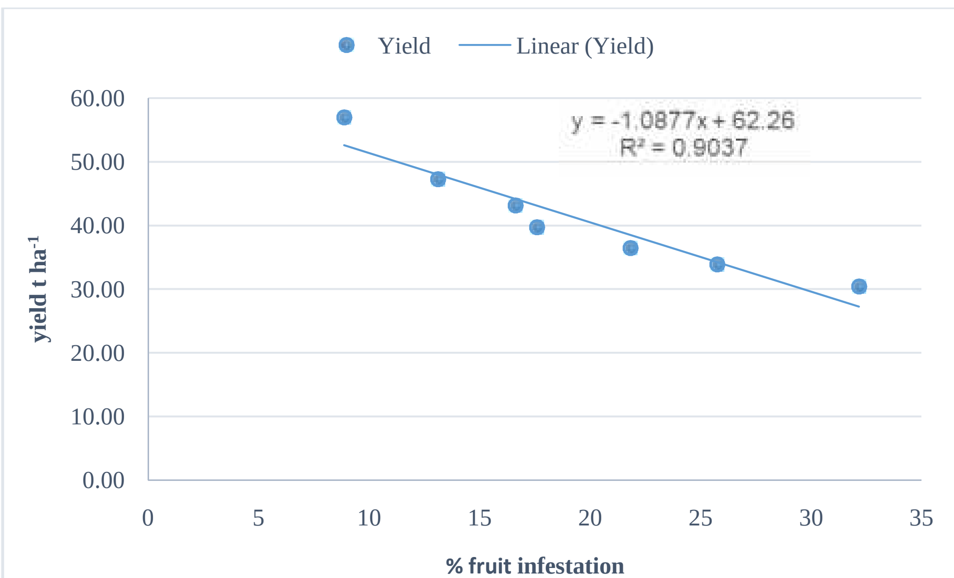

Figure 6.Relationship between percent fruit infestation and yield of squash among different managements

4.16 Relationship between healthy fruit length and yield

Correlation study was done to establish the relationship between the healthy fruit length and yield of squash among different management practices. From the figure 7, it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = 4.013x - 36.74gave a good fit to the data and the co-efficient of determination (R^2 = 0.9864) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that yield (tha^{-1}) of squash was strongly as well as positively correlated with healthy fruit length. It was revealed that when the healthy fruit length(23.10) increased the yield (57.02 t ha^{-1}) of squash was increased. On the contrary, when the healthy fruit length(16.50) was decreased then the yield (30.42 t ha^{-1}) of squash was decreased. So, it can be said that there was strongly positive correlation between healthy fruit length and yield of squash.That means the healthy fruit length was increased with the increase of yield.

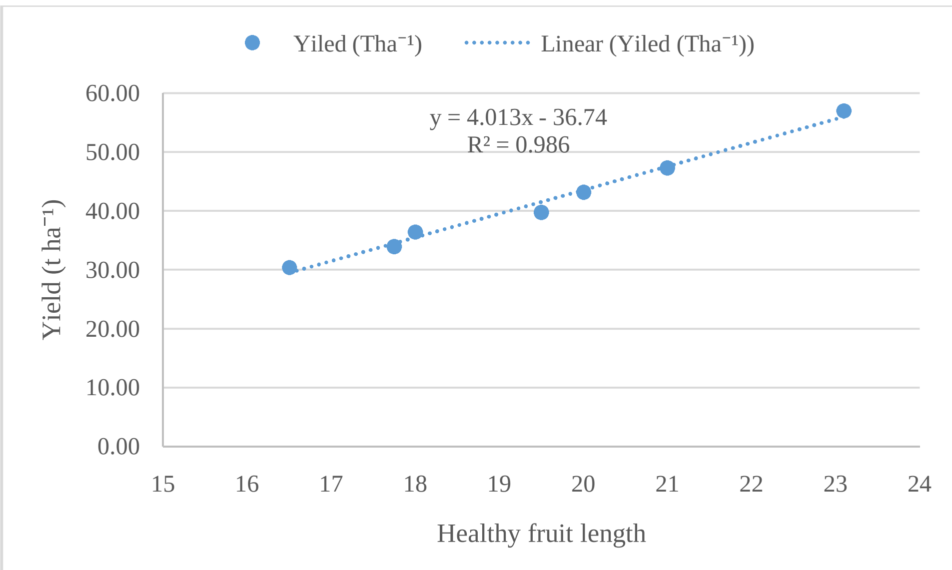

Figure 7.Relationship between healthy fruit length and yield of squash at different management

CHAPTER V
SUMMARY AND CONCLUSION

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The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data obtained from experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986) and means were separated by the Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984).

Data collection were collected on number of red pumpkin beetle plant^{-1} and cucurbit fruit fly, number of healthy leaves plant^{-1}, percentage of leaves infestation,number of healthy long petiole plant^{-1}, percentage of long petiole infestation, number of healthy flower, percentage of flower infestation, number of healthy fruit percentage of flower infestation, number of cucurbit fruit fly fruit^{-1},single fruit weight, length of fruit, width of fruit, fruit plant^{-1},Fruit weight plant^{-1}

The significant difference was observed in number of red pumpkin beetle plant^{-1}due to different treatment of squash at 5, 15, 25, 35, 45 and 55 DAT. At 5, 15, 25, 35, 45 and 55 DAT the maximum number of red pumpkin beetle plant^{-1} (4.40, 4.40, 4.60,4.20, 3.80 and 3.60) was recorded from T_7 (Untreated control) and the minimum number of red pumpkin beetle plant^{-1} (2.27, 2.00, 1.73, 1.47, 1.07 and 0.47) was recorded from treatment T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval).

At 5, 15, 25, 35, 45 and 55 DAT, the highest number of healthy leaves plant^{-1} (11.60, 11.60, 11.40, 11.20, 10.80 and 10.60) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy leaves plant^{-1} (8.47, 7.87, 7.67, 7.47, 7.27 and 6.87) was recorded treatment T_7 (Untreated control). At 5, 15, 25, 35, 45 and 55DAT, the maximum number of infested leaves plant^{-1} (3.20, 3.20, 3.47, 3.47, 3.67 and 3.67) was recorded from T_7 (Untreated control) and the minimum number of infested leaves plant^{-1} (1.20, 1.40, 1.33, 1.53, 1.53 and 1.53) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50

EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested leaves was found (27.43, 28.92, 31.14, 31.71, 33.54 and 34.81) in T_7 (Untreated control) and the lowest percentage of infested leaves (9.38, 10.29, 10.94, 12.04, 12.90 and 13.61) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 5, 15, 25, 35, 45 and 55 DAT.

At 5, 15, 25, 35, 45 and 55DAT, the highest number of healthy long petiole $plant^{-1}$ (13.07, 12.87, 12.87, 12.47, 12.47 and 12.67) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy long petiole $plant^{-1}$ (9.07, 8.87, 8.47, 8.27, 8.27 and 7.87) was recorded treatment T_7 (Untreated control). 5, 15, 25, 35, 45 and 55 DAT, the maximum number of infested long petiole $plant^{-1}$ (1.67, 1.67, 1.87, 1.87, 2.07 and 2.07) was recorded from T_7 (Untreated control) and the minimum number of infested long petiole $plant^{-1}$ (0.20, 0.20, 0.20, 0.40, 0.40 and 0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infestation in long petiole $plant^{-1}$ was found (26.09, 26.52, 29.05, 29.55, 30.73 and 31.79) in T_7 (Untreated control) and the lowest was (8.41, 9.37, 9.81, 10.95, 11.37 and 11.65) in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 5, 15, 25, 35, 45 and 55 DAT.

At 25, 35, 45 and 55 DAT, the highest number of healthy flowers $plant^{-1}$ (14.27, 14.27, 14.27 and 14.27) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) and the lowest number of healthy flowers $plant^{-1}$ (10.87, 10.67, 10.27 and 10.27) was recorded from treatment T_7 (Untreated control). At 25, 35, 45 and 55 DAT, the maximum number of infested flowers $plant^{-1}$ (1.73, 1.73, 1.73 and 2.13) was recorded from T_7 (Untreated control) and the minimum number of infested flowers $plant^{-1}$ (0.40, 0.40, 0.40 and 0.40) was recorded from T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval). The highest percentage of infested flowers was found (13.75, 13.97, 14.44 and 17.20) in T_7 (Untreated control) and the lowest percentage of infested flowers (2.7, 2.73, 2.73 and 2.73) was found in T_4 (Applying Sevin 50 WP@1.5g pit^{-1}+ Spraying Folithion 50 EC@ 1.0 ml L^{-1} of water at 15 days interval) at 25, 35, 45 and 55 DAT.

At 45 and 55DAT, the highest number of healthy fruit plant^{-1} (5.47 and 8.27) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap) and the lowest (3.47 and 5.80) was recorded treatment T_7 (Untreated control). At 45and 55DAT, the maximum number of infested fruit plant^{-1} (1.20 and 1.87) was recorded from T_7 (Untreated control) and the minimum (0.33 and 0.73) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap). The highest percentage of infested fruit was found (35.53 and) in T_7 (Untreated control) and the lowest (6.08 and 8.87) was found in T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap) at 45and 55 DAT.

The significant difference was observed due to planting different treatments on number of cucurbit fruit fly of squash at 35, 45 and 55 DAT. The maximum number of cucurbit fruit fly (2.40, 3.07 and 3.27) was recorded from T_7 (Untreated control) and the minimum (0.47, 0.54 and 0.60) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap) at 35, 45 and 55 DAT, respectively. The highest control percentage of cucurbit fruit fly (80.42, 82.41 and 81.65) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap) and the lowest control percentage of cucurbit fruit fly (0.00, 0.00 and 0.00) was recorded treatment T_7 (Untreated control) 35, 45 and 55 DAT, respectively.

There was a significant effect on single fruit weight of squashby different treatments.The highest single fruit weight (460.00 g), length of fruit(23.10 cm), width of fruit (2.85 cm) and fruit weight plant^{-1}(3.80 kg) was recorded from T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 7 days interval + using Pheromone trap) and the lowest single fruit weight (350.00 g), length of fruit(16.50 cm), width of fruit (1.65 cm), fruit plant^{-1}(5.80) and weight fruit plant^{-1}(2.03 kg) was recorded treatment T_7 (Untreated control).

It was found that number of RPB at 5, 15, 25, 35, 45 and 55 DAT, respectively was strongly as well as positively correlated with % leaf infestation. So, it can be said that there was strongly positive correlation between leaf infestation and number of RPB.Correlation study was done to establish the relationship between the % fruit infestations and single fruit weight, total fruit weight and yieldof squash among different management practices and found negative correlation was observed between the parameters. It was evident that the equation $y = -4.362x + 479$, $y = -0.6524x + 37.354$ and $y = -0.0725x + 4.1507$ gave a good fit to the data and the co-efficient of determination (R^2 = 0.9014, R^2 = 0.9036 and R^2 = 0.9037) fitted regression line had a significant regression co-efficient. It was revealed that when the fruit infestation (8.87%) decreased the yield (57.02 t ha^{-1}) of squash was increased. On the contrary, when the fruit infestation (32.17 %) was increased then the yield (30.42 t ha^{-1}) of squash was decreased. Correlation study was done to establish the relationship between the healthy fruit lengthand yield of squash among different management practices and found positive correlation was observed between the parameters. It was evident that the equation y = 4.013x - 36.74gave a good fit to the data and the co-efficient of determination (R^2 = 0.9864) fitted regression line had a significant regression co-efficient.

CONCLUSION

In a nutshell it can be concluded that

i) T_4 = Applying Sevin 50 WP@1.5g/pit+ Spraying Folithion 50 EC@ 1.0 ml/L of water at 15 days interval was suitable for control Red pumpkin beetle .

ii) Treatment T_5 (Spraying Pychlorex 20 EC @ 1.0 ml/L of water at 15 days interval + using Pheromone trap) is better result and control for Cucurbit fruit fly and better yield contributing characters than the other 6 treatments.

iii) There was strongly negative correlation between % fruit infestations and single fruit weight, total fruit weight and yield of squash among different management practices but strongly positive correlation between healthy fruit length and yield of squash found.

Recommendation

Due to some limitations only 7 treatments were included in this experiment. More no of treatments with potentiality needs to be demonstrated to disseminate this crop throughout the country. High land should be choosen otherwise it will instigate severe pathogenic attack on squash due to the highly susceptible nature of this vegetable to disease. Further research should be conducted by taking more squash varieties for better adaptibility towards the ambient climate for acclimatization of the suitable one perpetually like a native crop.

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CHAPTER VI

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CHAPTER VII

APPENDIX

Appendix I: Soil characteristics of experimental farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Farm, SAU, Dhaka
AEZ	Modhupur 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	**N/A**

B. Physical and chemical properties of the initial soil

B. Physical and chemical properties of the initial soil Characteristics	**Value**
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	1.00
Total N (%)	0.06
Available P (μ gm/g soil)	42.64
Available K (me/100 g soil)	0.13

Source: SRDI

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2018 to March 2019

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
october,18	21.15	13.72	56	4
November,18	20.13	14.47	54	0
December,19	17.45	11.44	43	0
January,19	27.34	16.71	67	3
February,19	31.43	19.63	54	12
March, 19	36.44	22.51	63	18

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix III Analysis of variance (ANOVA) of number of red pumpkin beetle at different days after transplanting

Source of variance	Degree of freedom	Mean Square of Number of Red Pumpkin Beetle					
		5 DAT	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Replication	2	0.121	0.120	0.120	0.120	0.119	0.119
Treatment	6	1.241**	1.240**	1.237**	1.232**	1.213**	1.144**
Error	12	0.004	0.004	0.004	0.004	0.003	0.003
Total	20						

Appendix IV Effect of different treatments on leaves infestation by RPB at early vegetative stage of squash

Source of variance	Degree of freedom	5 DAT			15 DAT		
		No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation	No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation
Replication	2	0.425	0.423	78.234	0.411	0.423	71.211
Treatment	6	3.544**	0.876**	247.843**	3.444**	0.879**	254.11**
Error	12	0.002	0.001	2.344	0.002	0.001	2.311
Total	20						

Appendix V Effect of different treatments on leaves infestation by RPB at mid vegetative stage of squash

Source of variance		25 DAT			35 DAT		
		No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation	No. of healthy leaves plant^{-1}	Infested leaves Plant^{-1}	% Leaves Infestation
Replication	2	0.414	0.412	72.234	0.401	0.423	78.200
Treatment	6	3.511**	0.823**	233.843**	3.114**	0.879**	265.983**
Error	12	0.002	0.001	2.122	0.002	0.001	2.456
Total	20						

Appendix VI Effect of different treatments on leaves infestation by RPB at late vegetative stage of squash

Source of variance	Degree of freedom	45 DAT			55 DAT		
		No. of healthy leaves $plant^{-1}$	Infested leaves $Plant^{-1}$	% Leaves Infestation	No. of healthy leaves $plant^{-1}$	Infested leaves $Plant^{-1}$	% Leaves Infestation
Replication	2	0.400	0.513	77.267	0.398	0.421	92.253
Treatment	6	3.102**	0.891**	241.22**	3.114**	0.879**	26.981**
Error	12	0.002	0.001	2.122	0.002	0.001	2.456
Total	20						

Appendix VII Analysis of variance (ANOVA) of long petiole infestation by RPB at early vegetative stage of squash

Source of variance	Degree of freedom	Mean Square value of					
		5 DAT			15 DAT		
		No. of healthy long petiole $plant^{-1}$	Infested long petiole $Plant^{-1}$	% long petiole infestation	No. of healthy long petiole $plant^{-1}$	Infested long petiole $Plant^{-1}$	% long petiole infestation
Replication	2	0.221	0.221	56.221	0.225	0.211	66.212
Treatment	6	2.569**	0.229**	213.229**	2.120**	0.220**	201.2123**
Error	12	0.002	0.001	2.314	0.002	0.001	2.097
Total	20						

Appendix VIII Analysis of variance (ANOVA) of long petiole infestation by RPB at mid vegetative stage of squash

Source of variance	Degree of freedom	25 DAT			35 DAT		
		No. of healthy long petiole plant^{-1}	Infested long petiole Plant^{-1}	% long petiole infestation	No. of healthy long petiole plant^{-1}	Infested long petiole Plant^{-1}	% long petiole infestation
Replication	2	0.212	0.219	66.223	0.214	0.111	71.212
Treatment	6	2.234**	0.229**	201.212**	2.120**	0.220**	187.23**
Error	12	0.002	0.001	2.005	0.002	0.001	2.011
Total	20						

Appendix IX Effect of different treatment on long petiole infested by RPB at late vegetative stage of squash

Source of variance	Degree of freedom	45 DAT			55 DAT		
		No. of healthy long petiole plant^{-1}	Infested long petiole Plant^{-1}	% long petiole infestation	No. of healthy long petiole plant^{-1}	Infested long petiole Plant^{-1}	% long petiole infestation
Replication	2	0.210	0.234	75.223	0.214	0.109	69.235
Treatment	6	2.211**	0.129**	189.212**	2.111**	0.232**	187.2123**
Error	12	0.001	0.001	1.896	0.002	0.001	1.976
Total	20						

Appendix X Effect of treatments on flower infestation of squash by RPB at different days after treatment

Source of variance	Degree of freedom	25 DAT			35 DAT			45 DAT			55 DAT		
		No. of healthy flowers $plant^{-1}$	Infested flowers $Plant^{-1}$	% Flowers Infestation	No. of healthy flowers $plant^{-1}$	Infested flowers $Plant^{-1}$	% Flowers Infestation	No. of healthy flowers $plant^{-1}$	Infested flowers $Plant^{-1}$	% Flowers Infestation	No. of healthy flowers $plant^{-1}$	Infested flowers $Plant^{-1}$	% Flowers Infestation
Replication	2	0.634	0.213	1.267	0.612	0.210	1.467	0.602	0.287	1.498	0.600	0.294	1.556
Treatment	6	32.143**	1.045**	12.22**	31.110**	1.145**	14.22**	29.176**	1.165**	14.876**	28.143**	1.188**	14.876**
Error	12	0.017	0.002	0.156	0.064	0.132	0.057	0.087	0.034	0.217	0.086	0.091	0.065
Total	20												

Appendix XI Effect of different treatments on number of cucurbit fruit fly and control percentage at different days after transplanting

Treatments	Degree of freedom	35 DAT	45 DAT	55 DAT
		Number of insect plot^{-1}	Number of insect plot^{-1}	Number of insect plot^{-1}
Replication	2	0.287	0.301	0.322
Treatment	6	2.165**	2.987**	3.034**
Error	12	0.065	0.073	0.044
Total	20			

Appendix XII Effect of different treatments on fruit infestation of squash by cucurbit fruit fly

Source of variance	Degree of freedom	45 DAT			55 DAT		
		Number of health fruit/plant	Number of infested fruit/plant	% Fruit infestation	Number of health fruit	Number of infested fruit	% Fruit infestation
Replication	2	1.546	0.243	2.546	1.242	0.244	2.511
Treatment	6	79.698**	2.899**	139.222**	83.091**	2.033**	132.192**
Error	12	0.056	0.032	0.987	0.453	0.006	0.846
Total	20						