EVALUATION OF DIFFERENT TRAPS AND SOME NON-CHEMICAL OPTIONS AGAINST THE INFESTATION OF FRUIT FLY AND RED PUMPKIN BEETLE ON RIDGE GOURD

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JUNE, 2018

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A Thesis

Submitted to the Department of Entomology, Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE (MS)

IN

ENTOMOLOGY

SEMESTER: JANUARY-JUNE, 2018

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CERTIFICATE

This is to certify that thesis entitled, ***"*****Evaluation of different traps and some non-chemical options against the infestation of fruit fly and red pumpkin beetle of ridge gourd*****"*** *submitted to the Department of* Entomology, *Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in*** **ENTOMOLOGY**, *embodies the result of a piece of bona-fide research work carried out by* **MD. MOTIUR RAHMAN**, *Registration No.* **12-04894** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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DEDICATED TO MY BELOVED PARENTS AND FAMILY MEMBERS

ACKNOWLEDGEMENTS

All the praises and gratitude are due to the omniscient, omnipresent and omnipotent God Almighty the merciful, who has created everything in this universe and kindly enabled me to present this thesis for the degree of Master of Science (M.S.) in Entomology.

The author expresses his deepest gratitude, deep sense of respect and immense indebtedness to his research supervisor, **Prof. Dr. Md. Mizanur Rahman**, Department of Entomology, Sher-e-Bangla Agricultural University, for his constant supervision, invaluable suggestion, scholastic guidance, continuous inspiration, constructive comments and encouragement during my research work and guidance in preparation of manuscript of the thesis.

The author also expresses his sincere appreciation, profound sense, respect and immense indebtedness to my respected co-supervisor **Prof. Dr. Md. Razzab Ali**, the Department of Entomology, Sher-e-Bangla Agricultural University for extending his generous help, scholastic guidance, constructive criticism, continuous inspiration and valuable suggestions during the research work and preparation of the manuscript of the thesis.

The author would like to express his deepest respect and boundless gratitude to all respected teachers of the Department of Entomology, Sher-e-Bangla Agricultural University for their sympathetic co-operation and inspirations throughout the course of this study and research work.

Cordial thanks are also due to all stuffs of the Dept. of Entomology and field workers of SAU farm for their co-operation to complete the research work in the field.

The author would like to express his last but not least profound gratitude to his beloved mother and brother. He is grateful to all of his relatives for their inspiration, blessing and encouragement that opened the gate of his higher studies in his life.

The Author

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ABSTRACT

The experiment was conducted in the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during rabi season from November, 2017 to April, 2018 to find out the efficacy of different traps and some non-chemical options against insect pest of ridge gourd. There were six treatments in the study comprising with T_0 = Control, T_1=Poison bait trap, T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Among the treatments, covering fruits with polythene (T_5) showed the lowest per cent of fruit infestation per plot (5.64%) over control followed by neem oil (T_4) (12.90%) and T_5 showed the highest yield of total fruit weight per plot (7.48 kg) over control followed by T_4 (6.12 kg). In case of per cent increase of healthy fruit weight over control T_5 showed the highest result (939.24 %) followed by T_4 (685.12 %) at late fruiting stage of ridge gourd against fruit fly and red pumpkin beetle. Finally, the highest yield increase over control was achieved in covering with polythene, whereas the lowest increase showed in banana pulp trap over control. All traps and non-chemical options have great impact on ridge gourd yield and significant impact on fruit fly and red pumpkin beetle reduction.

Key word: Ridge gourd, Fruit fly, Red pumpkin beetle, Poison bait, Banana pulp trap, Pheromone trap, Covering fruits with polythene.

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CHAPTER I

INTRODUCTION

Ridge gourd (*Luffa acutangula* L.) has a place with the family Cucurbitaceae is a standout amongst the most essential cucurbitaceous vegetable harvests and developed broadly all through the tropical and subtropical areas of the world. The name "Luff" or "Loofah" is an Arabic origin and alludes to the sponge for the fruit (Bose and Som, 1986). Its starting point isn't known, albeit wild structures are accessible in India, the Sunda Island and Java (Yawalkar, 1985). Previously, it is developed in Bangladesh, China and distinctive area of India, for example, Asam, West Bengal, Uttar Pradesh and in some different nations (Bose and Som, 1986). It is cultivated in Bangladesh for years; in 2016-17 it has been cultivated in 25,034 acres of land and the production was 48,851 metric tonnes (BBS, 2017).

There are eight types of Cucurbits cultivated in Indian Sub-continent of which just two *L. acutangula* and *L. cylindrica* are imperative vegetable harvests, while alternate species are wild sort. The delicate fruit of ridge gourd is a famous and surely understood for culinary vegetable in our nation with great nutritive esteem and high return potential. The tender fruits contain Vitamin A, C and iron. Its utilization is prescribed for the individuals who experience the ill effects of intestinal sickness and other occasional fever for its simple absorbability and extremely tantalizing quality (Yawalkar, 1985).

1,8-dihydroxy-4-methylanthracene-9,10-dione (DHMA) from *L. acutangula* has therapeutic potential for lung cancer treatment (Yawalkar, 1985). Varalakshmi and Rao (2012) demonstrated antioxidant and anticancer activities of extracts from *L. acutangula*, while Herowati *et al*. (2013) reported that a seed infusion of *L. acutangula* lowers blood glucose levels and is thus beneficial against diabetes. Other medicinal uses reported for the plant include treatment of gonorrhea, eczema and conjunctivitis (Useful Tropical Plants, 2016).

Like other cucurbits, ridge gourd is also being subjected to damage by wide array of insect pests, major being melon fruit fly (*Bactrocera curcurbitae* Coq.), epilachna beetle (*Epilachna dodecastigma*), red pumpkin beetle (*Aulacophora foveicolis* Lucas) right from the initial stages of the crop to harvest of the products in Bangladesh. Due to melon fruit fly infestation, 75.65% damage was reported from ridge gourd (Krishna Kumar *et al.,* 2006). Ryckewaert *et al*. (2010) reported 100% yield losses by fruit fly to cucurbits. Along with melon fruit fly, epilachna beetle and red pumpkin beetle also earlier reported as destructive pests of other cucurbits along with ridge gourd (Khan, 2012). From these reports, it is evident that the attack of these insect pests is a key factor in reducing the quality and quantity of the ridge gourd. Unfortunately report on infestation on insect pests on the ridge gourd in Bangladesh is scanty.

The use of conventional insecticides has raised some concern about their threat to the environment and development of insecticide resistance in insects (Huang *et al.,* 1998). There is an imperative need for the development of safer, alternative crop protectants such. Current pest control technology is based largely on imported synthetic insecticides, which are frequently priced beyond easy reach of small farmers, who constitute a very large proportion of the farming population in Bangladesh.

Moreover, many insects have been reported to be resistant to chemical insecticides like malathion, DDT, lindane, demeton methyl, pyrethroids etc. (Champ and Cribb, 1985). The problems caused by pesticides and their residues have increased the need for effective, biodegradable pesticides with greater selectivity. Alternative strategies include the search for new types of insecticides and the re-evaluation and use of traditional botanical pest control agents. Bangladesh and many other Asian countries are rich in plant products and traditionally used by the rural inhabitants for medicinal purpose and in some instance as preparations for insect control. Botanical insecticides tend to have broad spectrum activity, are relatively specific in their mode of action, and easy to process and use in farm levels. They are also safe for higher animals and the environment (Talukder and Howse, 1993). Botanical insecticides can often be easily produced by farmers and small-scale industries, indigenous plant materials are cheaper and hazard free in comparison to chemical insecticides. Plants are rich sources of natural substances that can be utilized in the development of environmentally safe methods for insect control. Certain plant families, particularly Meliaceae, Rutaceae, Asteraceae, Labiatae, Piperaceae and Annonaceae were viewed as exceptionally promising sources of plant-based insecticides.

Mass trapping of insect pests is done through pheromone and other poison traps. Basically, the traps and dispensers remain the same as that of monitoring, but the number of traps per unit area is increased to effectively trap more insects. In essence, monitoring is used for estimating the pest population along with resultant management decisions, whereas mass trapping is for total eradication of insect populations. Pheromone dosage in some exceptional cases is reduced to half with a view to reduce the cost of the technology. However, the number of traps and their placement is vital for efficient trapping. In Bangladesh, fragmentary works have been done to assess the efficacy of traps, poison baits and botanicals in controlling the insect pests of ridge gourd.

Sequel to the above, the present study has been conducted to accomplish following objectives-

i. To evaluate the comparative damage caused by fruit fly and red pumpkin beetle on ridge gourd.
ii. To identify the best treatment to control fruit fly and red pumpkin beetle for cultivation of ridge gourd.

CHAPTER II

REVIEW OF LITERATURE

2.1. Ridge gourd

2.1.1. Taxonomic position of ridge gourd

Domain: Eukaryota

Kingdom: Plantae

Phylum: Spermatophyta

Subphylum: Angiospermae

Class: Dicotyledonae

Order: Violales

Family: Cucurbitaceae

Genus: *Luffa*

Species: *Luffa acutangula*

Luffa is a genus of tropical and subtropical vines in the cucumber (Cucurbitaceae) family, with five accepted species. Phenetic and cladistic analyses of 10 *Luffa* accessions belonging to five species indicated that the species are well differentiated, with *L. echinata* the most distinct. The cladistic analyses also revealed two phyletic lines, one comprised of *L. aegyptiaca* and *L. acutangula* and the other of *L. echinata*, *L. graveolens* and *L. operculata* (Heiser and Schilling, 1988). These results were later corroborated in a phylogenetic analysis based on molecular data (Filipowicz *et al.,* 2014).

In *L. acutangula*, three botanical varieties have been distinguished: var. *acutangula*, the large-fruited cultivated types; var. *amara* (Roxb.) C.B. Clarke, a wild or feral type with extremely bitter fruits and confined to India; and var. *forskalii* (Harms) Heiser & E.E. Schill., confined to Yemen, where it occurs wild or possibly as an escape (PROTA, 2016). Heiser and Schilling (1988) suggest that var. *forskalii* could have developed from var. *acutangula* after this was introduced to Yemen as a cultivated plant.

2.1.2. Biology and ecology of ridge gourd

L. acutangula grows from the start of the rainy season. Flowering and fruiting take place throughout the rainy season, while fruits mature and seed dispersal commences as the whole plants become dry at the peak of the dry season. When the plant is cultivated, flowering starts 6-10 weeks after sowing, with male flowers being produced before the female ones. Flowers open in the evenings. Immature fruits can be harvested for food within two months of planting the seeds. The plant is pollinated by a wide range of insects, including bees, butterflies and moths (PROTA, 2016).

L. acutangula prefers seasonal climates because dry season planting is more successful than in wet season planting. It prefers well-drained soil with high organic matter and a pH of 6.5 to 7.5, but can tolerate pH as low as 4.5. It typically grows up to about 500 m altitude (National Parks Board, 2016). It grows best in areas where annual daytime temperatures are within the range 20 - 32°C, but can tolerate 15 - 38°C. It is intolerant of frost (PROTA, 2016). It prefers a mean annual rainfall in the range 1200 – 2000 mm, but tolerates 700 – 3000 mm.

2.1.3. Benediction of ridge gourd

The mesocarp, also called "loofah ", is mainly used for personal hygiene use. Due to its fibrous characteristics the fruit is used as an exfoliant (PROTA, 2004). The plant is known for its purgative and diuretic capabilities, and it is used against oedema, splenic enlargement, coughs and asthma (Khare, 2007).

The young fruit of some cultivars are used as cooked vegetables or pickled or eaten raw, and the shoots and flowers are sometimes also used. The flavour of the immature fruit varies from very bitter to sweet, giving a variety of culinary uses from eating the sweet forms raw in salads, to using more bitter forms in soups or curries. Like *Luffa cylindrica*, the mature fruits are harvested when dry and processed to remove all but the fruit fibre, which can then be used as a sponge or as fibre for making hats (Encyclopedia of Life, 2016). The plant, including the seed, is also insecticidal (Useful Tropical Plants, 2016).

A comparative analysis of the cytotoxic effects of the aqueous and organic solvent extracts of the vegetable plants *Cucumis sativus* (cucumber), *Benincasa hispida* (ash gourd), *Coccinia indica*, *Cucurbita maxima* (pumpkin) and *Luffa acutangula* (ridge gourd) has shown inhibitory effects on the cervical cancer cell line HeLa at very low concentrations. It is suggested that these vegetables are beneficial to consume, but that further studies are required to establish the right dosages of these dietary components (Varalakshmi and Rao, 2012).

2.1.4. Insect pests of ridge gourd

Ridge gourd (*Luffa acutangula*) is highly grown cucurbitaceous vegetable crop in Bangladesh. Dhillon *et al.* (2005) reported that Extent of yield loss caused by the insect pests to cucurbitaceous vegetables ranged from 30 to 100% depending upon cucurbit species and the season in different parts of the world. Like other cucurbits, ridge gourd is also being subjected to damage by wide array of insect pests, major being melon fruit fly (*Bacrocera curcurbitae* Coq.), epilachna beetle (*Henosepilachna septima* Dieke), red pumpkin beetle (*Aulacophora foveicolis* Lucas) right from the initial stages of the crop to harvest of the products in Bangladesh. Due to melon fruit fly infestation, 75.65% damage was reported from ridge gourd (Krishna kumar *et al*., 2006). Ryckewaert *et al*.(2010) reported 100% yield losses by fruit fly to cucurbits. Along with melon fruit fly, Epilachna beetle and red pumpkin beetle also earlier reported as destructive pests of other cucurb-its along with ridge gourd (Barma and Jha, 2013, Khan *et al.*, 2013). From these reports, it is evident that the attack of these insect pests is a key factor in reducing the quality and quantity of the ridge gourd. Unfortunately report on infestation on insect pests on the ridge gourd in West Bengal in scanty. Keeping these facts in mind, it was thought worth while to conduct study on periodicity of occurrence and finding out factors responsible for their periodicity to evolve an effective and economical strategy of management of these insect pests.

Cucurbits are attacked by several pests which affect the quality and quantity of produce adversely. Most of the insect-pests cause damage at any stage of plant growth, but some of them are serious at seedling stage *viz*., red pumpkin beetle, leaf miner, flea beetle, while fruit fly appears at fruiting stage (Ram *et al*., 2009).

Damage caused by cucurbit pests depends mostly on the prevailing climatic conditions and the diversity of hosts in a particular agro-ecosystem. Therefore, it is necessary to study the seasonal incidence of the pest species which helps in determining appropriate time of action and suitable method of management (Vignesh and Viraktamath, 2015).

2.2. Fruit fly

2.2.1. Life cycle 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 to1.8 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).

2.2.2. 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.

The study revealed that *S. nigrum* (Black nightshade), *S. anguivi* (African eggplant) and *S. scabrum* was the preferred host; however *S. scabrum* was the most preferred host among the cultivated Solanaceae. Vayssieres *et al.,* (2007) reported *B. cucurbitae* to be polyphagous in West Africa infesting 17 fruits pecies 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).

2.2.3. Nature of damage

Maggots feed inside the fruits, but at times, also feed on flowers, and stems. Generally, the females prefer to lay the eggs in soft tender fruit tissues by piercing them with the ovipositor. A watery fluid oozes from the puncture, which becomes slightly concave with seepage of fluid, and transforms into a brown resinous deposit. Sometimes pseudo- punctures (punctures without eggs) have also been observed on the fruit skin. This reduces the market value of the produce. In Hawaii, pumpkin and squash are heavily damaged even before fruit set. The eggs are laid into unopened flowers, and the larvae successfully develop in the taproots, stems, and leaf stalks (Weems and Heppner, 2001).

Miyatake *et al.* (1993) reported more than 1% damage by pseudo-punctures by the sterile females in cucumber, sponge gourd and bitter gourd. After egg hatching, the maggots bore into the pulp tissue and make the feeding galleries. The fruit subsequently rots or becomes distorted. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition. The vinegar fly, *Drosophilla melanogaster* has also been observed to lay eggs on the fruits infested by melon fly, and acts as a scavenger (Dhillon *et al.,* 2005). The extent of losses varies between 30 to 100%, depending on the cucurbit species and the season. Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89% (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.

2.2.4. Extent of damage 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 annul 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 assesment 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 flt nfestation 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 infected 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).

2.2.5. 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 organo-phosphorus, carbamate and synthetic pyrethroids of various formulations have been used from time to time against fruit fly (Kapoor, 1993; Nayar *et al.*, 1989; Gruzdyev *et al.*, 1983; Canamas and Mendoza, 1972). 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% Phesalone 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 *Bactrocera cucurbitae* on Melon (4.8-7.9) compared with untreated control. Malathion was the most effective insecticide (Khan *et al.,* 1992).

Hameed *et al.* (1980) observed that 0.0596 Fenthion, Malathion, Trichlorophos and Fenthion with waiting period of five, seven and nine days respectively was very effective in controlling *Bactrocera cucurbitae* on cucumber in Himachal Pradesh, Various insecticide schedules were tested against *Bactrocera cucurbitae* on pumpkin in Assam during 1997. The most effective treatment in terms of lowest pest incidence and highest yield was carbofuran at 1.5 kg a.i/ha (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 *Bactrocera 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 *Bactrocera 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 dacine fruit fly species (Kapoor, 1993). New a day, poison baits are used against various *Batrocra* species which are 20 g Malathion 50% Or 50 ml of Diazinon plus 200 g of molasses in 2 liters of water kept in flat containers or applying the bait Spray containing Malathion 0.05% plus 1 % sugar/molasses or 0.025% of protein water) or spraying plants with 500 g molasses plus 50 g Malathion in 50 liters of water or 0.025% Fenitrothion plus 0.5% molasses. This is repeated at weekly intervals where the fruit fly infestation is serious (Kapoor, 1993).

Nasiruddin and Karim (1992) reported that bait spray (1.0 g Dipterex 80SP and 100 g of molasses per liter of water) on snake gourd against fruit fly (*Bactrocera cucurbitae*) showed 8.50% infestation compared to 22.48% in control. Agarwal *et al.* (1987) achieved very good results for fruit fly (*Bactrocera 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 (*Bactrocera 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). *Bactrocera 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, *Bactrocera dorsalis* and *Bactrocera 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 *Bactrocera cucurbitae* on bitter gourd completely and its 20% concentration was highly effective to inhibit ovipositon of *Bactrocera zonata* on guava. Stark *et al.* (1990) studied the effect of Azadiractin on metamorphosis, longevity and reproduction of Ceratilis Capitala (Wiedemann), *Bactrocera cucurbitae* and *Bactrocera 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 naziman.

Akhtaruzzaman *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 (T_1), fenitrothion (Sumithion 50EC) mixed with molasses (same preparation as T_1; T_2), 25 g molasses + 2.5 ml malathion (Limithion 50EC) and 2.5 litres water at 1:0.1:100 (T_3), 0.5 ml Nogos 100EC mixed with 100 g sweet gourd mash and 100 ml water (T_4), cover spray with 2.0 ml malathion/litre of water as standard insecticide (T_5), and untreated control (T_6). 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).

Yubak Dhoj (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 methyl eugenol 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 fliy 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.

Vargas *et al.* (2011) reported that Phenyl propanoids are attractive to numerous species of Dacinae fruit flies. Methyl eugenol (ME) (4-allyl-1, 2-dimethoxybenzene- carboxylate), cue-lure (C-L) (4-(p-acetoxyphenyl)-2-butanone), and raspberry ketone (RK) (4-(p-hydroxyphenyl)-2-butanone) are powerful male-specific lures. Most evidence suggests a role of ME and C-L/RK in pheromone synthesis and mate attraction. ME and C-L/RK are used in current fruit fly programs for detection, monitoring, and control. During the Hawaii Area-Wide Pest Management Program in the interest of worker safety and convenience, liquid C-L/ME and insecticide (i.e., naled and malathion) mixtures were replaced with solid lures and insecticides.

Hossen (2012) reported that the highest performance was achieved from Pheromone trap with funnel + Bait trap where Pheromone trap with funnel showed the second highest performance in terms of healthy, infested and total fruit yield by controlling cucurbit fruit fly and control treatment showed the lowest performance along with the treatment of T_1 (Only pheromone trap).

2.3 Red pumpkin beetle

The red pumpkin beetle, *Aulacophora foveicollis* (Lucas) is a common, serious and major destructive insect pest of a wide range of cucurbitaceous vegetables and plays a vital role on their yield reduction. It is injurious to the crops and cause severe damage to almost all cucurbits.

2.3.1 Host range of red pumpkin beetle

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

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

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

2.3.2 Host preference and nature of damage

Shivalingaswamy *et al.* (2008), perform a study on bottle gourd varietal screening against red pumpkin beetle during 2008. During the study 27 different cultivars of bottle gourd was screened against the pest and their respective damage was noted and undergoes statistical analysis. Different cultivars used by them were DVBG-1, DVBG-2(1), PSPL, NDBG-56, VRBG-17, VRBG-36, VRBG-26-1, VRBG-33, VRBG-42, VRBG-43, VRBG-46, VRBG-47, VRBG-48, VRBG-50, VRBG-55, VRBG-103, VRBG-108, VRBG-109, VRBG-111, VRBG-112, BRBG-17, VBGH-1, VBGH-2,VBGH-3, BGH-8, BGH-9, BGH-7. Percent damage was fluctuating for different plant species, but the average %age damage recorded at lowest was 17.45% in VRBG-50 and highest damage was 34.32% in NDBG-56. Data was recorded from the leaves based on percentage damage. Data collection initiation was done after 15 days of sowing.

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 long melon (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, cucumber, sweet gourd, sponge gourd and water melon were of intermediate types. Among the various insecticidal sprays evaluated on watermelon seedlings, synthetic pyrethroids (deltamethrin at 0.004%, cypermethrin at 0.012%, and fenvelerate at 0.01%) were effective in controlling the beetle (8.188-96.88% mortality) for about a week. Water melon seed soaking with carbofuran (Furadan 3 G) @ 1 g a.i./L was found effective for only two days after germination, while its application as soil treatment @ 0.12 – 0.36 g a.i./plant was the most effective as indicated by high mortality of beetle and minimum feeding damage for about three weeks.

The damaged roots and infested underground portion of stems start rotting due to secondary infection by saprophytic fungi. The young fruits of such vines dry up. Infested fruits become unfit for human consumption. Ground-spreading cucumber plants grown in experimental plots at BARI farm in April, 1986 were found to be killed entirely with dried-up vines, leaves, flower and fruits due to severe damage of underground roots by the grubs of the RPB.

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

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

An analysis of the host plant relationships with respect to the red pumpkin beetle, *Raphidopalpa foveicollis* Lucas is presented by Rahman and Annadurai (1985) based on the role of receptors involved in host selection, the quantitative food utilization on different cucurbitaceous host plants and the biochemical parameters involved in food plant selection. Orientation of

the beetles towards the host plants appeared to be profoundly affected when the receptors present on the antennae and mouthparts were ablated or coated. Though significant differences were observed with regard to the quantity of food ingested among different host plants, ingestion of food was higher for mature leaves and flowers compared to young and senescent leaves. Accordingly, mature leaves and flowers showed high nitrogen and proteins, low sugars, moderately high phenols and narrow *C/N* ratio compared to other plant parts. The chemosensory receptors present on the antennae and mouthparts were also studied using scanning electron microscope.

Fifteen crop plants were evaluated by Hwa-Jen Teng *et al*. (1984) to determine performance and host preference of adult banded cucumber beetles (BCB), *Diabrotica balteal. a* Le Conte. They prefer broccoli, cauliflower (Cruciferae), potato, bell pepper and tomato (Solanaceae), bush bean, hyacinth bean, soybean, and peanut (Leguminosac), sweet corn (Graminae), beet (Chenopodiaceae), and three varieties of sweet potato (Convolvulaceae). In no-choice tests, greatest fecundity and longevity occurred on broccoli, cauliflower, and potato, even though equal or greater amounts of leaf tissue were consumed on soybean, three varieties of sweet potato, bell pepper, bush bean, and tomato. No eggs were laid on sweet corn, peanut, or hyacinth bean. In multiple·choice tests, broccoli, bell pepper, cauliflower, and bush bean were more preferred for feeding by BCB adults than potato and the other plants, but BCB adults laid most eggs on potato, tomato, sweet corn, bush bean, and 'Morado' (sweet potato). Elytral color remained yellow for adults feeding on the legumes and on beet, but on the other plants the elytra turned green among various percentages of adults.

Butani and Jotwani (1984) have reported that the adult beetles feed voraciously on leaf lamina making irregular holes. They prefer young seedlings and tender leaves and the damage at this stage may even kill the seedlings. Butani and Jotwani (1984) have also reported that the female RPB lays eggs in the moist soil usually around the host plant. On hatching, the grubs feed on the roots and underground portion of host plants as well as fruits touching the soil.

2.3.3. Extent of damage and yield loss by red pumpkin beetle

Singh and Gill carried out field trials in the Punjab, India, between March and May 1978 on losses in growth and yield of muskmelon in plots sprayed with carbaryl at between 100 and 1000 g a.i./ha against *Aulacophora foveicollis* (Lucas) according to the stage of the crop and in control plots. Mean number of beetles killed on each plant in the plots treated with carbaryl ranged from 11.0 to 44.3, whereas there was no mortality in the untreated ones. Percentage infestation to the leaves, measured by leaf perforation and it was ranged from 0.26 to 1.33 in the treated plots and from 4.66 to 17.00 in the check plots. Mean number of branches per plant, mean number of leaves per plant and mean length of stem per plant were also higher in the treated plots than in the untreated ones.

Different host plants of red pumpkin beetle, *Aulacophora foveicollis* Lucas was observed in addition to pumpkin (*Cucurbita moschata*) by [34] Das and Ishahaque during 1998 in north India, around and inside Assam Agriculture University. Different host plants recorded were bottle gourd (*Lagenaria siceraria*), cucumber (*Cucumis sativus*), watermelon (*Citrullus lanatus*), ridge gourd (*Luffa acutangula*), pointed gourd (*Trichosanthes dioica*) and ash gourd (*Benincasa hispida*). Infestation of the beetle was observed in variation during the different time of the year and ranging from 3-20%. Other plant which were recorded as collateral host of the pest are, okra (*Abelmoschus esculentus*), sweet potato (*Ipomoea batatas*) and green gram (*Phaseolus aureus* [*Vigna radiata*]).

Rajak conduct some trials on population variation of the red pumpkin beetle (*Aulacophora foveicollis*) on muskmelon in India. Experiment revealed that hibernating beetle becomes active at an ordinary temperature of 20°C and relative humidity of 89%. Beetle's population was found to be at an average temperature of 28.8°C. Relationship of pest population with temperature was positive and that with relative humidity was negative. Regression analysis done to check the effect of temperature and relative humidity and it revealed that there was a non-significant effect of relative humidity on the pest population and significant effect of temperature.

Khan *et al.* (2008) , in a study on cucurbits checked out the influence of red pumpkin beetle, *Aulacophora foveicollis* and influence of different plant stages to the incidence of beetle. Experiment was performed in Ghazipur, Bangladesh. Ten different cucurbitaceous crops named as; sweet gourd, bottle gourd, ash gourd, bitter gourd, sponge gourd, ribbed gourd, snake gourd, cucumber, khira and muskmelon were cultivated in the experiment. Data regarding beetle count was divided into three aspects; beetles at seedling stage, beetles as vegetative stage, beetles at reproductive stage. Maximum number of red pumpkin beetle was recorded in muskmelon at seedling stage and population was 3.75 per plant and lowest was in snake gourd, 0.25. Similarly beetles recorded at vegetative stages were more on muskmelon (4.5/ plant) and minimum was 0.00 in snake gourd, whereas the population of beetle recorded at reproductive stage were 8.74 in muskmelon at highest and 0.75 at minimum in bitter gourd, ribbed gourd and snake gourd. Leaf infestation percentage recorded during the experiment was 89.25 % in muskmelon and lowest was 0.00 in bitter gourd.

Rathod and Borand perform an experiment, to study the population dynamics of red pumpkin beetle (*A. foveicollis*) in relation to weather parameters by using pumpkins as host crop. Field trials were conducted during kharif 2004 and summer 2005 in Anand, Gujarat, India. The highest attack of the beetle was noticed during August to September in kharif and March to April in summer. Relative humidity and vapour pressure had significant positive relationship with the beetle population during kharif, while they were negatively correlated in summer on pumpkin. Increase in temperature had significant positive correlation with the beetle population on pumpkin crop during summer. Rainfall, vapour pressure, sunshine hours and wind speed were negatively and non-significantly correlated with the pest population.

2.3.4. Management of red pumpkin beetle

A. Use of plant extracts for controlling red pumpkin beetle

Chandravadana performs an experiment to test the effectiveness of teriterpenoid (bio chemical) extracted from *Momordica charantia* against *Aulacophora* foveicollis (Lucas) (*Raphidopalpa foveicollis*). Severe damage caused by red pumpkin beetle to the cotyledons and tender leaves of many cucurbits in India but not to those of bitter gourd (*Momordica charantia*). In laboratory, beetles were exposed to feed on pumpkin leaves which were treated with extracts of the leaves and cotyledons of this plant. Triterpenoid glucoside was identified as feeding deterrent that was different from known momordicosides; it had a bitter taste and concentrations above 2 mg completely inhibited feeding by *A. foveicollis*.

Chandravadana (1987) conducted a study on red pumpkin beetle for its management using some deterrents as repelling agent. The study was performed to keep the population of the pest under limit by reducing its feed source. *Momordica charantia* was the principle plant used for the extraction of repellent chemical. Triterpenoid were the chemicals which were identified by the scientist to act as feeding inhibitor for red pumpkin beetle. Among Triterpenoids the deterrents identified were momordicine II, 23-O-glucopyranoside of 3, 7, 23-trihydroxycucurbita-5,24-dien-19-al. A concentration of 3200 g/ml and above of the triterpenoids caused significant reduction of feeding by red pumpkin beetles in in vitro bioassay experiments.

Pande *et al.*, (1987) performs an experiment to check the effect of different concentrations of leaf extracts against red pumpkin beetle. Adult beetles which were collected from local field fed on fresh leaves of a local pumpkin variety treated with 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6% of *Ageratum conyzoides* leaf extract. Mortalities of insects were assessed every 12 h up to 84 h. No mortality was caused when concentration of leaf extract lower than 0.2% was used and no mortalities were recorded at any concentration up to 24 h. Mortalities recorded after usage at 0.3, 0.4 and 0.5% concentration were not significantly different at 24, 36, 48, 60, 72 and 84 h. Highest mortality (100% after 84 h) was observed at the 0.6% concentration and this rate was significantly higher than mortalities recorded for the other concentration at all-time intervals. Results concluded from the trials were that the 0.6% concentration possesses good insecticidal properties and could be used to control a variety of insect pests.

Gujar and Mehrotra performed an experiment on the management of red pumpkin beetle (*Aulacophora foveicollis*) by using plant extract especially neem (*Azadirachta indica*) extract. Experiment was performed during 1988 on muskmelon crop as feeding host. Different forms of neem (*Azadirachta indica*) was applied, *i.e.* as neem seed kernel extract, as neem oil. Plant extracts was used as repellent and repellency was measured by 50% anti-feeding activity of red pumpkin beetle. Percentage of neem (*Azadirachta indica*) extracted from neem seed kernel extract was 0.1% which reduce the feeding activity upto 50% percent and the percentage of neem oil to obtain similar results was 0.4%. Whereas the other aspect of this experiment was, to test neem (*Azadirachta indinca*) as killing pupose. For this purpose, muskmelon leaves was treated with 0.5-2.0% neem seed kernel extract and up to 50% of the population was undergoes mortality, when no-choice feeding was done within 7 days. But there was no effect of neem oil on the mortality of the pest until 11 days.

Kemper and Chiou conducted a study on the benefits and other useful aspects of *Aloe vera*. They reported that *Aloe vera* is useful for human being as treatment for many diseases/mishaps like burns, abrasions, canker sore, laxative as topical treatment and ulcer, HIV and immune-stimulant as experimental treatment. It is also discussed that plant is also prevalent for the microbial control. It is a major part of some health and environment friendly pesticides, used to control annoying pests.

Abe and Matsuda performed an experiment using four different species two were from *Aulacophora* and two from *Epilachna*. During 2000, the study was aimed to test the methanolic extract of *Momordica charantia*. Methanolic extract of leaves of this plant recorded as highly feeding deterrent in nature. Firstly, the methanolic extract was partitioned into water and organic solvent and cholorform fraction. Then cholorform fraction was chromatographed with silica gel to have momordicines I and II. Effect of momordicine I and II was observed on four species. Strong deterrence was observed by *Aulacophora nigripennis* towards momordicine I than mormordicin II while the reaction of *Aulacophora femoralis* was observed reverse. But the feeding of *Epilachna admirabilis* and *Epilachna boisduvali* was not deterred by any of two chemicals.

Lewis and Metcalf used some attractant to check the response of *Aulacophora* spp. They used kairomones and parakairomones those act as effective lure for *Diabrotica* and *Acalymma* were investigated. No apparent result were found on beetles captured on sticky traps baited with single and multicomponent lures from the control traps for two species of *Aulacophora*. Yellow colored traps and squash blossoms were attractive to *Aulacophora* beetles those detect sub-microgram quantities of cucurbitacins on silica gel. Leaf feeding behavior and flight activity data was correlated with varietal preference of three *Aulacophora* species. The common response by *Diabrotica* and *Aulacophora* to cucurbitacins was almost same.

Khan and Wasim (2001) conduct a study on muskmelon (*Cucumis melo* L.) to evaluate the repellency of different botanical extracts against red pumpkin beetle. They was having seven treatments like neem extract in ethanol and benzene, bakain extract in ethanol and benzene, hermal extract in ethanol and benzene and check. Among these treatments, the maximum repellency was reported, in plots treated with neem mixing with bezene and repellency percentage was 60%.

Chandel *et al.* (2009) conducted a study on red pumpkin beetle to check the bio-efficacy of different indigenous plant extracts. The experiment was executed during 2008. Experiment was conducted to test the anti-feedant efficacy of selected indigenous plant extract of family Lamiaceae viz. leaves of *Ocimum basilicum, Ocimum canum, Pogostemon heyneanus, Salvia officinalis, Coleus amboinicus* and aerial part of *Mentha longifolia*, *Mentha piperita* and *Mentha spicata*. Third instar 24 hrs starved grubs and adults of red pumpkin beetle, *Aulacophora foveicollis* under laboratory trials were treated. Among all plant extracts, *Coleus amboinicus* (AI 50= 0.013) had highest anti-feedant activity than the other plant extracts. Order of anti-feedancy index can be arranged in the following descending order on the basis of their respective AI 50 values, *i.e.*, *Mentha piperata* (0.018) > *Pogostemon heyneaus* (0.141) > *Mentha longifolia* (0.213), *Mentha spicata* (0.375) > *Ocimum canum* (0.452) *Ocimum basilicum* (0.477) > *Salvia offficinalis* (0.626) and *Coleus amboinicus* (0.013), respectively.

Vishwakarma *et al.*, (2011) were conducted to assess the bio-efficacy of two indigenous plant products, viz. seed extracts of *Strychnos nuxvomica* and *Pachyrrhizus erosus*, using petroleum ether as solvent and two entomopathogenic fungi, viz. *Beauveria bassiana* and *Metarhizium anisopliae*, in controlling red pumpkin beetle, *Raphidopalpa foveicollis* on bottle gourd (cv. Narendra Rashmi). Botanicals were used @ 2.0, 3.0 and 4.0 ml/lit. of water while the entomopathogenic fungi, were used @ 2.0 g, 2.5 g and 3.0 g/lit. of water. Significant reduction in damage (70.2%) was achieved in treatment with *B. bassiana*, when used @ 3.0 g/lit of water as compared to untreated control, followed by *S. nuxvomica* (65.4% at 4.0 ml/lit), *M. anisopliae*(64.7% at 3.0 g/lit.) and *P. erosus* (60.9% at 4.0 ml/lit.), respectively. *B. bassiana*@ 3.0 g/lit. of water recorded to be most economic control measure during the experiment.

Ramanuj *et al.*, (2011) conducted field trials to assess the potential plant extract and entomopathogenic fungi for the control of red pumpkin beetle on bottle gourd from cucurbits. Research trials were conducted to determine the bio-efficacy of two indigenous plant products, viz. seed extracts of *Strychnos nuxvomica* and *Pachyrrhizus erosus*, using petroleum ether as solvent and two entomopathogenic fungi, viz. Beauveria bassiana and Metarhizium anisopliae, for the management of red pumpkin beetle, Aulacophora foveicollis on Narendra Rashmi bottle gourd. Both the botanicals were used @ 2.0, 3.0 and 4.0 ml/lit. of water while the entomopathogenic fungi, were used @ 2.0 g, 2.5 g and 3.0 g/lit. of water, keeping an untreated control. Significantly maximum decline in damage (70.2%) was achieved in treatment with *B. bassiana*, when used @ 3.0 g/lit of water along with crop yield of 315.36 q/ha, as compared to untreated control, followed by *S. nuxvomica* (65.4% at 4.0 ml/lit), *M. anisopliae* (64.7% at 3.0 g/lit.) and *P. erosus* (60.9% at 4.0 ml/ lit.), vis-a-vis crop yield of 298.18, 286.48 and 278.81 q/ha, correspondingly. *B. bassiana* @ 3.0 g/lit. of water recorded the highest economic return with a B:C ratio of 21.54:1 as compared to control plot.

Osman *et al.*, (2013) perform an experiment to determine the effect of Neem Oil, Mehagoni Oil, Bishkatali Leaf Extract, Larvin 75 WP and Diazinon 60 and their performance for the management of red pumpkin beetle, *Aulacophora foveicollis.* Bottle Gourd variety BARI Lau-4 was used as host plant and it was planted at Entomology Field of Bangladesh Agricultural University (BAU). Experiment was carried out following Randomized Complete Block Design (RCBD) with three replications. Effectiveness of each treatment against the pest was evaluated on the basis of beetle population per plant and leaf infestation at 24, 48, 72 HAT (hours at treatment) and 7 DAT (days after treatment) in field level. Since, the effects of both chemical insecticides, Larvin 75 WP and Diazinon 60 EC were found to be statistically alike and highly effective in reducing beetle population. Considering the effect of botanicals, Neem @7.5% respond better for beetle population whereas beetle population was relatively higher in Bishkatali Leaf Extract treated plots. Number of beetles per plant was minimum at 24 HAT (hours after treatment) that exhibited upward trends with increasing intervals. It was also noticed that percent leaf infestation declined only in the chemicals preserved plots other than few omissions.

Tandon and Sirohi conducted an experiment to evaluate the ethanol extracts of four plants in the laboratory for repellence property of the most destructive pests of melons, *Aulacophora foveicollis* Lucas (Coleoptera: Chrysomelidae). Its purpose is to further explore natural management program, a natural insecticide for control of red pumpkin beetle. Survey was done during June 2008, Department of Zoology Research Laboratory at Kanpur, India. Adults were exposed to 5% and 10% concentrations of extracts of *Azadirachta indica* (Neem), *Annona squamosa* (Sweat-pineapple), *Convolvulus microphyllus* (Sankhanushpi) and *Melia azedarach* (Bakain) in laboratory bioassays. Repellency analysis was conducted using the area preference method on filter papers. Result revealed that *Azadirachta indica* produced repellency of class IV (60.1-80%), *Anona squamosal* and *Melia azedarach* caused class III (40.1-60%) and *Convolvulus microphyllus* provoked repellency of class II (20.1-40%). All of these plant extracts were found significantly effective in repelling red pumpkin beetles.

Rathod *et al.*, (2010) perform an experiment to check the efficacy of neem (*Azadirachta indica*) based and synthetic insecticides for to the control of red pumpkin beetle while using bottle gourd as host plant. Different concentrations of neem were used, some comes from market in the form of commercial sold product and some by directly extracting spray able contents. 8 different sources with 8 different concentrations of neem were used, named as NeemAzal-F(0.1%), Gronim(0.5%), Vangaurd(0.5%), Econeem(0.1%), Achook(0.5%), Azadex(0.5%), NSKE(neem seed kernel extract)(5.0%), NLE (neem leaf extract)(10.0%). Highest mortality on average basis were recorded in Gronim (49.89) and minimum was recorded in NLE(20.16).

Mahmood *et al.*, (2010) conduct studies on the comparative efficacy of different plant extracts (neem seed, neem leaves and tobacco leaves) and insecticide permethrin dust alone and after mixing with dung. Experiment was conducted against red pumpkin beetle in the field at National Agricultural Research Centre, Islamabad during kharif 2008. Permethrin (0.5%) alone or mixed (0.05%) with dung ash as dust controlled the attack of *Aulacophora foveicollis* on the crop with no mortality of plants by the beetle. Peak mortality of plants due to foliage eaten by red pumpkin beetle (*Aulacophora foveicollis*) observed in control where no application of permethrin was done. Dust alone or mixed with dung was found most effective as compared to all other control measures in this study for controlling *Aulacophora foveicollis* attack. Permethrin dust (0.5%) alone and ash + permethrin dust (2000: 1 a.i. w/w) gave a significantly higher yield of 18.07 and 18.63 t per ha in cucumber, respectively.

B. Chemical control

Sinha and Chakrabarti carried out field trials in India in 1978-80 to compare the effectiveness of seed treatment against *Aulacophora foveicollis* (Lucas) (*Raphidopalpa foveicollis*) with carbofuran on muskmelon and bottle gourd [*Lagenaria siceraria*] seed with soil treatment. Results obtained from the trials indicated that seed treatment with a wettable or flowable powder formulation of carbofuran at 3 or 4% a.i. was as effective against the pest as soil treatment with a granular formulation of the compound at 0.5 kg a.i./ha and did not adversely affect germination.

Mavi and Bajwa (1984) used emulsifiable concentrates for the control of red pumpkin beetle, *Aulacophora foveicollis.* Effectiveness of 4 insecticides applied as sprays with a hand-held battery-operated sprayer at rates of 125 and 187.5 g a.i./ha 17, 24 and 34 days after sowing for the control of red pumpkin beetle, *Aulacophora foveicollis* on melon (muskmelon) was determined in field-plot tests in India. Both chemicals Phoxim and pirimiphos-methyl, at the higher rate, were the most effective treatments, protecting the crop from attack for 10 days.

Rahman and Prodhan (2007) conducted an experiment to check an effective control for red pumpkin beetle, the most destructive pest of the cucurbits. During the trials of the experiment farmer's field was selected at Jalchatra, Madhupur and Tangail in Bangladesh during 2007. All other agronomic practices were made according to the local standard. The experiment was having four different control measures including check. Treatments include effect of mosquito net barrier, application of carbofuran by mixing with soil and application of diazinon (60EC) as foliar spray application. The carbofuran gave outstanding results among other control measures. Diazinon was less effective than carbofuran but more effective than that of mosquito net barrier treatment.

An experiment was performed to study the efficacy of Malathion at different doses against red pumpkin beetle, *Aulacophora foveicollis* (Lucas) in field of Department of Entomology, Bangladesh Agricultural University, Mymensingh by Hasan *et al.,* in 2011. Sweet gourd (Var. BARI sweet gourd1), bitter gourd (Var. HybridNepali) and bottle gourd (Var. Kajla) were selected as cucurbit host to conduct the research with three different dose rates of Malathion viz. 0.4%, 0.5% and 0.6% of. Attack among three doses of Malathion was recorded as number of leaf attack per plant, number of twig attack per plant and minimum leaf area damage by red pumpkin beetle when plants were treated with 0.5% and the maximum damage was observed in case of 0.4% Malathion application. Efficacy of the insecticide reduced with increasing interims of spraying. Considering the efficacy in reducing the leaf area damage at all the time intervals spraying 5% Malathion was found as the most effective in controlling red pumpkin beetle in all three cucurbit hosts. Efficacy of Malathion was not affected by different cucurbit hosts.

Dhillon and Sharma (1987) conducted a study on summer squash (Cucubita pepo L.). They reported that the pest is serious and cause heavy infestation to different crops and can be controlled with different control measures among those chemical control is one. But they conducted a different aspect of pest control of this particular insect and that was through genetic resistance. They get through screening of available varieties in field and in laboratory for controlled feeding in feeding cages. Then inbreeding of F1 and then crosses in F2 were made basis on each variety will cross with other to get an optimum characteristics of the variety. After that they got line which was resistant to red pumpkin beetle. Twenty inbreed plant were used in F1 and same number was used in F2.

Pareek and Kavadia during field experiments in 1988 used two agroclimatic regions of Rajasthan (the semi-humid Udaipur in 1979 and 1981 and the semi-arid Jobner-Jaipur in 1980 and 1981) to evaluate the insecticides, chlorpyrifos at

0.05%, ethion at 0.05%, phosalone at 0.035%, dicofol at 0.1%, carbaryl at 0.2%, toxaphene at 0.1%, malathion at 0.05%, endosulfan at 0.07% and dimethoate at 0.03% for the control of the pumpkin beetle and the fruit fly damaging musk melon var. *Durgapura madhu.* Four spray applications of carbaryl @ 0.2% at 3, 5, 9 and 11 weeks after sowing proved most effective against both the pumpkin beetle and resulted in increased yield of between 79 and 89 q/ha, over the check. Sprays of dimethoate and phosalone were found to be effective against the pest and also gave higher benefit/cost ratios because of low costs.

Mehta and Sindhu carried out a study to monitor red pumpkin beetle by using cucurbitacin as kairomones using in poison baits. the kairomones responsible for bitterness are cucurbitacins and feeding stimulants for the red pumpkin beetle, *Aulacophora foveicollis*, a serious pest of cucurbits. Trials were conducted to explore the possibility of invading the beetle of utilizing cucurbitacin in poison baits. Carbaryl or malathion were used as seed treatment to cotyledons of melon cv. Hara Madhu and watermelon cv. Sugar Baby after standardizing. Number of beetles on an average trapped in the melon mixture alone was 1.75 compared with 6.75 and 3.25 when carbaryl and malathion, respectively, were added. Carbaryl and malathion when mixed with watermelon homogenate average number of trapped beetles were 8.19 and 5.37, respectively, compared with 2.75 in the control. Results revealed that poisoned baits were better than unpoisoned ones but they remained effective for only 24 hours.

Khan and Khattak performed an experiment to test the efficacy of different chemical control measures on muskmelon for the control of red pumpkin beetle (*Aulacophora foveicollis*). Experiment was carried out during 1992 in Faculty of Agriculture farm, Gomal University, Dera Ismael Khan, Pakistan. Research scheme was based on five different chemical control measures including Cropgard, Cypergard, Sunmerin, Stinger and Mavrik. Three different concentrations of these five chemicals was tested against the beetle, *i.e.* 0.1%, 0.5% and 1%. Cypergard was found to be the most effective among all the other control measures at each concentration. Data was collected by counting total number of beetles per plant.

Nine different cucurbitaceous crops (bitter gourd, bottle gourd, cucumber, muskmelon (B), muskmelon, round melon, small gourd, sponge gourd, water melon) were selected to test against red pumpkin beetle, *Aulacophora foveicollis* Lucas for its attack to the host plants in relation to cucurbitacin and other biochemical by Mehta and Sandhu (1992). Cucurbitacin content were different in each variety, the lowest value of the chemical was found in sponge gourd (0.177 mg/g) whereas the maximum was found in watermelon crop (0.29 mg/g). The attack of the beetle was compared with the amount of curcurbitacin present in respective plant and correlation was found positive. Correlation with between insect injury and total sugars, phenols, orthodihydroxy phenols flavonoids and total free amino acids were also positive but comparatively of lower order. These are effective for the damage/ attack of the beetle but cucurbitacin is more important as compared to these compounds. Effect was found positive while topical application of cucurbitacin B and E was done on non-preferred host. Hence, this experiment confirms the attack of red pumpkin beetle, *Aulacophora foveicollis* Lucas on the plant having cucurbitacin in it. Maximum attack was found on watermelon and minimum attack was found on bitter gourd which was less than the other of first.

A study on the efficacy of different concentration of Seven Dust for management of red pumpkin beetle (*Aulacophora foveicollis*) on muskmelon (*Cucumis melo*) was done by Khan and Jehangir. Research was carried out at farm of Agriculture, Gomal University, D. I. Pakistan under controlled conditions. Though seven dust is one the most effective chemical control against red pumpkin beetle, therefore different concentrations of this chemical was tested to have economic, safer and effective concentration. Three different concentration used in the experiment as insecticides were 2.0, 1.0 and 0.5%. Muskmelon variety Bukhara, was used in the experiment and RCBD was used as default experimental design. Data was recorded, number of red pumpkin beetle/ plant basis after one, three, five and seven of dust application. Result obtained in their experiment can be briefed as; although high concentration of seven-dust show high control but less concentration, which was quite safer, was also better than check even after 7 days of insecticide application.

C. Polyethylene cages

Chaudhary (1995) carried out some field trials to test the efficacy of polyethylene cages for the protection of cucurbitacecous crops against red pumpkin beetle. Field trials were carried out in Uttar Pradesh, India, in 1989-91 and use of polyethylene sheet was done as preventive against *Aulacophora fovicollis* at different heights. Result revealed that polyethylene cages protected cucumber seedlings were protected effectively against infestation by *Aulacophora foveicollis* for up to 1 month after germination. 3 different cage heights were used as control measures and were 30, 45 and 60 cm. Among these three cage heights tested against the beetle, 30 cm (with a 120 cm perimeter) height of polyethylene sheet act as most effective and economic control measure against this pest.

D. IPM practice

Rivera conducted a study of natural extracts, their effect on the control of different kinds of insects and their way of use as bio-chemicals. Study was based on the different control measures either these were biological, non-chemicals, cultural practices and mechanical control measures. Chemical was only involved in study as sex attractants; else use of chemicals was avoided. Naturally existing chemicals *Aloe vera*, Neem, Garlic, Tobacco, Ginger, etc products as extracts were the part of study. All of the biochemical was used as extract application separately and in combination with other biological ingredients. Descriptions of different pest species was done, in which it was elaborated that what is the extent of each species presence on each plot treated with extracts. Almost 20 beetle species were controlled by Neem extract.

Lakshmi *et al.*, (2005) conducted studies in Bapatla andhra Pradesh, India, during rabi 2003-04 to evaluate some eco-friendly pesticides for the management of red pumpkin beetle, *R. foveicollis*, on pumpkin (*C. maxima*) crop. The treatments comprised of carbaryl at 0.2%, monocrotophos at 0.54%, chlorpyriphos at 0.05%, Nimbecidine (a neem [*Azadirachta indica*] formulation) at 0.2%, *Bacillus thuringiensis* at 0.20%, thiodicarb at 0.075%, Bt at 0.1%+thiodicarb at 0.0375%, Nimbecidine+thiodicarb, spinosad at 0.015% and untreated control. Two sprays at fortnightly interval were done and carbaryl (46.53%) was found to be the most effective control measure in reducing the beetle population as well as in reducing the leaf damage (10.61%) followed by monocrotophos (39.93%), chlorpyriphos (35.02%) and Nimbecidine (28.66%).

Fusire conducted Integrated Pest Management techniques for control routine crops pests. Different techniques involved in his Integrated Pest Management program were cultural and mechanical control measures, biological control measures, treatment in storage and precautionary measures. Regarding biological control measures, he used different non-chemical control strategies. Forty five different biological techniques were involved in his biological control list. *Aloe vera*, Ginger, Chilies, Pyrethrum, Tobacco and similar plants were used.

E. Cultural control

Atwal and Dhaliwal suggest the management of red pumpkin beetle using agronomic practices and chemical control methods. In agronomic practice they discussed deep ploughing, to kill the grubs in soils and winter season sowing in November, while in chemical control, carbofuran after germination in soil or spray or irrigation application of carbaryl 50WP for effective control of the pests.

Khorsheduzzaman *et al*. (2010) conduct a research on red pumpkin beetle on sweet gourd in vegetable research field of Horticulture Research Centre in Joydeb pur during 2006-07 and 2007-2008 cropping seasons. Their six treatments were, soil application with Furadan 5G @ 5 g/plant at 3 days before planting, mechanical control with sweeping net at 3 days interval for 45 days, spraying neem seed oil @l0ml/l+5m1 trix (detergent) at 7 days interval, spraying neem seed karnel extract @ 50g/l of water at 7 days interval, seedling bed covered with mosquito net barrier upto 45 days old seedlings, control. Results obtained from the study revealed that mosquito net barrier provides the best control whereas among extract neem kernel extract perform outstandingly.

Saleem and Shah recommended the use of carbaryl, deltamethrin, endosulfan and dichlorvos as chemical and deep plough & winter cultivation of vegetables as non-chemical control method for the control of red pumpkin beetle (*Aulacophora foveicollis* Lucas.)

CHAPTER III

MATERIALS AND METHODS

The present study was conducted to evaluate the different traps and some non-chemical options in controlling the infestation of fruit fly and red pumpkin beetle on ridge gourd in the experimental farm of Sher-e-Bangla Agricultural University. The materials and methods adopted in the study are discussed under the following:

3.1 Experimental site and duration

The experiment was conducted in the department of Entomology of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, during November 2017 to April 2018.

3.2 Soil

The soil of the plot of the experimental plot was silty loamy. This soil was non calcareous dark grey floodplain under the Agro-ecological zone. Every plot was well drained medium high land.

3.3 Experimental materials

Ridge gourd was used as plant materials for combating with fruit fly and red pumpkin beetle using different agricultural management practices.

3.4 Experiment design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Total plot was 24 and size of each plot is 1.5 m^2

Plate 1. The experimental plot, SAU, Dhaka

Treatment

Treatment	Item	Dose/Rate
T_0	Untreated control	No treatment was used.
T_1	Poison bait trap	Setting up of poison bait trap @ 2 gm Sevin (1-Napthyl methylcarbamate) 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval.
T_2	Pheromone trap	One pheromone trap per plot replaced at four days interval
T_3	Banana pulp trap	Setting up of banana pulp trap @ 2ml Ripcord 10EC mixed with 100 g mashed banana pulp at 4 days interval.
T_4	Neem oil	Spraying of neem oil @ 3 ml neem oil & 10 ml Trix mixed with 1 liter of water @ 7 days interval.
T_5	Covering fruits with polythene	Every fruit was covered by polythene bag to block the contact at 4 days interval.

3.5 Land preparation

The experimental plot was ploughed thoroughly by a tractor drawn disc plough by harrowing. During land preparation, cow dung was incorporated into the soil at the rate of 10 t ha^{-1}. The stubbles of the crops and uprooted weeds were removed from the field and the land was properly leveled. The field layout was done on accordance to the design, immediately after land preparation. The plots were raised by 10 cm from the soil surface keeping the drain around the plots.

3.6 Fertilizer application

Manures and fertilizers were used in the experimental field. Dose of cow dung 5 Ton. Urea 150Kg, TSP 50 Kg, MOP 50 Kg and Gypsum 12 Kg was used (Fertilizer Recommendation Guide 2016). Entire amount of cow dung, TSP and MP were applied during final land preparation. The entire amounts of urea were applied as top dressing in two equal splits at 30, 60 days after seed sowing.

3.7 Raising the seedlings

Seeds were sown in a permanent seedbed at experimental farm of Sher-e-Bangla Agricultural Farm on 12 November, 2017. Complete germination of seeds took place within 5 days of sowing. The seedlings were allowed in the seedbed for 30 days. After 30 days of emergence the seedlings were transplanted into main field.

3.8 Transplanting of seedlings

Thirty days old healthy and uniform seedlings were transplanted in the experimental plots on 12 December, 2017, maintaining a spacing of 60 cm x 40 cm. Seedbeds were watered in the morning before uprooting the seedlings to avoid damage of the roots. The seedlings were uprooted carefully from the seedbed to ensure minimum injury to the root systems. Transplanting was done in the afternoon and watered lightly with a watering can immediately after transplanting for better establishment. The transplanted seedlings were kept under shade with pieces of banana leaf sheaths during the day time to protect those from the scorching sunshine. At night seedlings were kept open to receive dew. Shading and watering were continued for 3 days until the seedlings were established. A few of seedlings were planted at the same time in the border of the experimental plot for gap filling.

3.9 Intercultural operation

Necessary intercultural operations were done during cropping season to obtain desirable output of the experiment.

Thinning

When the seedlings got reached it optimum stage, one healthy seedling in each location was kept and other seedlings were removed.

Gap filling

Dead, injured and weak seedlings were replaced by new vigor seedling from the stock on the border line of the experiment.

Weeding

Four weeding were done manually at 15, 30, 45 and 60 DAS to keep the plots free from weeds.

Irrigation

Light overhead irrigation was provided with a watering can to the plots once immediately after sowing of seed and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings. When the soil moisture level was very low. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.10 Pheromone trap

The rectangular plastic container had around 3-liter capacity and 20-22 cm tall. A triangular hole measuring 10-12 cm height and 10-12 cm base was cut in any two opposite sides (Plate 2). The base of the hole should be 3 cm above the bottom. Water containing two-three drops of detergent should be maintained inside the trap throughout the season. Pheromone soaked cotton or lure was tied inside the trap with thin wire. Fruit fly adults enter the trap and fall into the water and die. Water inside the trap should be replenished often to make sure the trap is not dry. Pheromone dispensers should be continued throughout the cropping season. The pheromone bait traps should be in the cucurbit field at a distance of 12-15m^2 starting from first flower initiation and be continued till last harvest.

Plate 2. Pheromone trap

3.11 Spraying of neem oil

Neem oil (*Azadirachta indica*) was used as botanical insecticide in fruit fly management experiment. Neem oil was collected from the local market Siddique Bazar, Dhaka. The required spray volume was prepared by mixing 75 ml neem oil (3%), 1 ml Trix (liquid detergent as mixing agent) with 2.5 litres of water. The detergent was used to break the surface tension of water and to help the solubility of neem oil in water. This preparation might have repelling and antifeeding actions against fruit fly and red pumpkin beetle. The mixture was sprayed at each 7 days interval in the selected plots.

3.12 Data collection

Healthy fruit per plot

For the estimation of girth of 10 randomly selected healthy fruits per plot, fruits were randomly selected and girth recorded, from each plot, at each time of data collection.

Infested fruit per plot

For the estimation of girth of 10 randomly selected infested fruits per plot, fruits were randomly selected and girth recorded, from each plot, at each time of data collection

Plate 3. Healthy ridge gourd in the field.

Percentage fruit infestation

After harvesting the healthy fruits (HF) and the infested fruits (IF) were separated by visual observation. The number of healthy fruits (HF) and the infested fruits (IF) of early, mid and late fruiting stages were counted and the per cent fruit infestation for each treatment was calculated by using the following formula:

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

Weight of healthy fruits per plot

For the estimation of weight of 10 randomly selected fruits plot^{-1}, 10 fruits were randomly selected and weight recorded, from each plot, at each time of data collection.

Time of Data Collection

Early fruiting stage- 5 days after first flowering

Mid fruiting stage- 5 days after early fruiting stage

Late fruiting stage- 5 days after mid fruiting stage

3.13 Statistical analysis

The recorded data on various parameters under the study were statistically analyzed according to the principles of experimental design to find out the variation resulting from experimental treatments. Analysis of variance was done following the Randomized Complete Block Design with the help of SPSS package program .The means for all the treatments were calculated and analysis of variance for each parameter was performed by F- test (Gomez and Gomez, 1984) while means were adjusted by Least Significant Different test (LSD) at 5% level of significant.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment on the effect of different traps and some non-chemical options on incidence and management of cucurbit fruit fly and red pumpkin beetle in ridge gourd was conducted during November 2017 to April 2018 at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. The results have been presented and discussed under the following headings and sub-headings:

4.1. Incidence of fruit fly and red pumpkin beetle using different management practices

4.1.1 Number of fruit fly plot^{-1}

At the early fruiting stage, Table 1 showed that the maximum number of fruit fly plot^{-1} (5.75) was obtained from T_0 (Control) followed by 4.25 in T_1 and T_3 (Poison bait trap and banana pulp trap), 3.25 in T_2 (Pheromone trap), and 2.00 in T_4 (Neem oil).

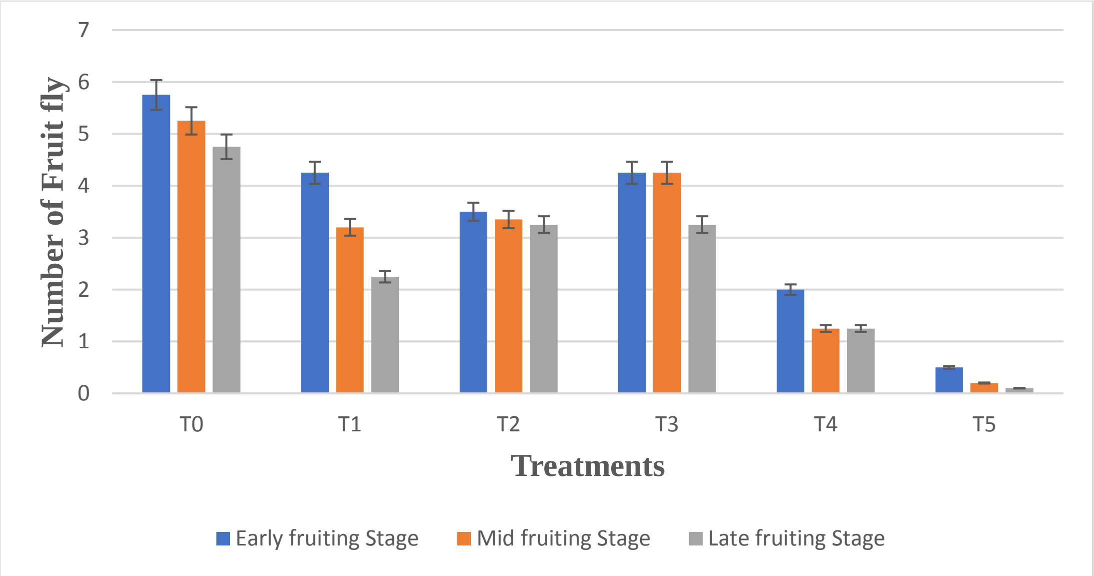

Fig. 1. Incidence of fruit fly using different management practices

[T_0 = Control, T_1=Poison bait trap,T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

At the mid fruiting stage, Table 1 showed that the maximum number of fruit fly plot^{-1}(5.25) was obtained from T_0 (Control) followed by 4.25 in T_3 (Banana pulp trap), 3.20 in $T_{1,}$ (Poison bait trap), and 3.00 in T_2 (Pheromone trap), 1.25 in $T_{4.}$

At the late fruiting stage, the maximum number of fruit fly plot^{-1}(4.75) was obtained from T_0 (Control) followed by 4.25 in T_2 (Pheromone trap), 3.25 in T_3 (Banana pulp trap), and 2.25 in T_1 (Poison trap) and 1.25 in T_4 (Neem oil). The highest total number of fruit fly plot^{-1} of all stages was 15.75 found in control plot and T_5 showed no fruit fly at the early mid and late fruiting stage due to all stages fruits were covered by polythene sheets (Table 1).

4.1.2. Percent reduction of fruit fly infestation over control

The data in table 1 showed that the percentage of reduction of fruit fly over control the maximum percentage of reduction of fruit fly is 100.00 in T_5 (Covering fruits with polythene) followed by 71.43 in $T_{4,}$ (Neem oil), 36.82 in T_1 (Poison trap), 33.33 in T_2 (Banana pulp trap), and lowest percentage of reduction of fruit fly was 25.39 in T_3 (Pheromone trap). The result partially agrees with the findings of Verghese *et al.* (2005) who reported that cuelure attracted the fruit flies @ 13.5 flies/day/trap and Hossen (2012) who reported that Pheromone trap with funnel + Bait trap was most effective in capturing the adult fruit fly and Pheromone trap with funnel showed the second highest performance. The result of the present study agree with the findings of Hossen (2012) who reported that, Pheromone trap with funnel + Bait trap showed best performance and Pheromone trap with funnel showed the second highest performance in terms of healthy, infested and total fruit yield by controlling cucurbit fruit fly and control treatment showed the lowest. It partially contradicts with the findings of Anon. (2002-2003) who mentioned that bait traps of cuelure pheromone and mashed sweet gourd (MSG) was affecting 40% to 65% reduction in fruit fly infestation and damage to the fruits and producing 2-4 times higher yields.

Table 1. Incidence of fruit fly using different management practices

Treatment	Number of fruit fly plot^{-1} at early fruiting stage	Number of fruit fly plot^{-1} at mid fruiting stage	Number of fruit fly plot^{-1} at late fruiting stage	Total No. of fruit fly at all stage plot^{-1}	% reduction of fruit fly over control
T_0	5.75 a	5.25 a	4.75 a	15.75 a	0.00 e
T_1	4.25 b	3.20 b	2.25 bc	9.95 b	36.82 c
T_2	3.25 bc	3.00 b	4.25 ab	10.5 b	33.33 c
T_3	4.25 b	4.25 ab	3.25 b	11.75 b	25.39 d
T_4	2.00 c	1.25 c	1.25 c	4.5 c	71.43 b
T_5	0.00 d	0.00 d	0.00 d	00 d	100 a
LSD (0.05)	1.05	1.25	0.95	1.24	3.87
CV (%)	2.45	4.87	1.93	4.95	6.34
Level of significance	*	*	*	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance. * indicates significant at 5% level

[T_0 = Control, T_1=Poison bait trap,T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.1.3. Number of red pumpkin beetle plot^{-1}

Table 2 showed that the number of red pumpkin beetle per plot at early fruiting stage. The maximum number of red pumpkin beetle plot^{-1} at early fruiting stage (22.25) was obtained from T_0 (Control) followed by 15.50 in $T_{1,}$ (Pheromone trap), 13.00 in T_3 (Banana pulp trap), 7.25 in T_2 (Pheromone trap), 6.00 in T_4 and they were statistically different (Table 2.) On the other hand T_5 showed no red pumpkin beetle plot^{-1} at early fruiting stage.

At the mid fruiting stage, the maximum number of red pumpkin beetle plot-1 (20.75) was obtained from T_0 (Control) and lowest number of red pumpkin beetle plot-1 5.25 was found in T_5 (Covering fruits with polythene). And other treatment showed intermediate result between highest and lowest (Table 2).
At the late fruiting stage the maximum number of red pumpkin beetle plot^{-1} was

18.00 in control (T_0) and lowest number of red pumpkin beetle plot^{-1} was 4.50 in T_5 (Covering fruits with polythene) and other treatment showed intermediate result that were statistically significant (Table 2).

Gujar and Mehrotra performed an experiment on the management of red pumpkin beetle (*Aulacophora foveicollis*) by using plant extract especially neem (*Azadirachta indica*) extract. Experiment was performed during 1988 on muskmelon crop as feeding host. Different forms of neem (*Azadirachta indica*) was applied, *i.e.* as neem seed kernel extract, as neem oil. Plant extracts was used as repellent and repellency was measured by 50% anti-feeding activity of red pumpkin beetle.

4.1.4. Percent reduction of red pumpkin beetle infestation over control

The data in table 2 showed that the percentage of reduction of red pumpkin beetle over control the maximum percentage of reduction of red pumpkin beetle is 100.00 in T_5 (Covering fruits with polythene) and T_4 (Neem oil) and T_2 (Pheromone trap) showed statistically same result (70.90, 66.80 respectively identical); and the lowest percentage of reduction of red pumpkin beetle over control was 31.55 in $T_{1,}$ (Poison bait). Other result showed intermediate result that are statistically significant.

Table 2. Incidence of red pumpkin beetle using different management practices

Treatment	Number of red pumpkin beetle plot^{-1} at early fruiting stage	Number of red pumpkin beetle plot^{-1} at mid fruiting stage	Number of red pumpkin beetle plot^{-1} at late fruiting stage	Total No. of red pumpkin beetle at all stage plot^{-1}	% reduction of red pumpkin beetle over control
T_0	22.25 a	20.75 a	18.00 a	61.00 a	0.00 e
T_1	15.50 b	13.75 b	12.50 b	41.75 b	31.55 d
T_2	7.25 d	7.00 c	6.00 c	20.25 d	66.80 b
T_3	13.00 bc	12.25 b	11.50 b	36.75 c	39.75 c
T_4	6.00 de	6.25 c	5.50 c	17.75 d	70.90 b
T_5	0.00 e	0.00 d	0.00 d	0.00	100 a
LSD(0.05)	2.19	3.97	3.45	3.59	5.79
CV (%)	4.56	6.17	5.98	7.45	9.14
Level of significance	*	*	*	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance. * indicates significant at 5% level
[T_0 = Control, T_1=Poison bait, T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.2. Effect of management practices at early fruiting stage of ridge gourd

4.2.1. The total number of fruits plot^{-1}

Table 3 showed the total number of fruits plot^{-1} at early fruiting stage. The maximum fruits were 13.50 found in T_5 treated plot (Covering fruits with polythene). The lowest number of fruits plot^{-1} at early fruiting stage was 6.00 found in control plot. Other treatments showed intermediated result between highest and lowest (Table 3).

Table 3: Effect of management practices on attributes of ridge gourd,s fruits content plot^{-1} against fruit fly and red pumpkin beetle at early fruiting stage

Treatment	Total No. of fruit/plot	Number of healthy fruits/plot	Number of infested fruits/plot	Percent fruit infestation
T0	6.00 e	3.00 f	3.00 a	50.71 a
T1	8.75 cd	6.75 cd	2.00 b	22.91 c
T2	10.00 bc	8.00 c	2.00 b	20.10 d
T3	7.50 d	4.75 e	2.75 a	37.05 b
T4	11.50 bc	10.50 b	1.00 c	8.77 e
T5	13.50 a	12.50 a	1.00 c	7.45 f
LSD(0.05)	1.57	1.39	0.89	3.34
CV (%)	2.67	4.93	2.92	5.36
Level of significance	*	*	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance. * indicates significant at 5% level
[T_0 = Control, T_1=Poison bait,T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.2.2. Number of healthy fruits plot^{-1}

The data on the table 3 showed the number of healthy fruits plot^{-1}. The highest number of healthy fruits plot^{-1} was 12.50 found in T_5 (Covering fruits with polythene) treated plot followed by treatments, T_1(Poison bait), T_2 (Pheromone trap) T_3 (Banana pulp trap), T_4 (Neem oil) and the lowest number of healthy fruits was 3.00 f found in control plot. They were statistically significant and different.

4.2.3. Number of infested fruits plot^{-1}

The number of infested fruits plot^{-1} was maximum in control and treatment T_3 (Banana pulp trap) that was statistically (3.00, 2.75 identical). The lowest number of infested fruit (1.00) was found in T_4 (Neem oil) & T_5 (Covering fruits with polythene) and they were also statistically similar.

4.2.4. Percent fruit infestation

Table 3 showed the percent of fruit infestation by fruit fly and red pumpkin beetle at early fruiting stage of ridge gourd. The data indicate the percentage of infestation of fruit in control plot was 50.71 maximum and the lowest percent of fruit infestation by fruit fly and red pumpkin beetle at early fruiting stage of ridge gourd was 7.45was the treated plot T_5. Other treatment showed the intermediated results.

4.2.5. Total fruit weight plot^{-1} (kg)

Table 4 showed the total fruit weight plot^{-1} (kg) at early fruiting stage. The maximum total fruit weight plot^{-1} 3.04 was found in T_5 (Covering fruits with polythene) followed 2.49 in T_4 (Neem oil), 1.21, 1.76 in T_1 (Poison bait), T_2 (pheromone trap) respectively, 85 in T_3 (Banana pulp trap). And the lowest total fruit weight plot^{-1} 0 .73 kg was found in control.

4.2.6. Weight of healthy fruit plot^{-1} (kg)

The weight of healthy fruit plot^{-1} (kg) 2.74 a was maximum found in T_5 (Covering fruits with polythene) followed by 2.11 in T_4 (Neem oil), 1.14 in T_2 (Pheromone trap), 0.68 in T_1 (Poison bait), 0.35 in T_3 (Banana pulp trap). The lowest weight of healthy fruit plot^{-1} (kg) 0.24 was found in control (T_0) that was statistically significant (Table 4).

Table 4: Effect of management practices on attributes of ridge gourd's weight plot^{-1} against fruit fly and red pumpkin beetle at early fruiting stage

Treatment	Total fruit weight plot-1 (kg)	Weight of healthy fruit plot^{-1} (kg)	Weight of infested fruit plot^{-1} (kg)	% increase of healthy weight plot^{-1} over control
T_0	0.73 e	0.24 e	0.59	0.00 e
T_1	1.21 c	0.68 c	0.52	185.33 d
T_2	1.76 c	1.14 b	0.42	374.32 c
T_3	0.85 d	0.35 d	0.50	146.75 d
T_4	2.49 b	2.11 a	0.38	779.16 b
T_5	3.04 a	2.74 a	0.30	1036.66 a
LSD (0.05)	0.26	0.23	0.04	7.96
CV (%)	3.45	4.32	3.89	13.38
Level of significance	*	*	NS	*

[T_0 = Control, T_1=Poison bait trap, T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.2.7. Weight of infested fruit plot^{-1} (kg)

The table 4 also showed the weight of infested fruit plot^{-1} was maximum in 0.59 that found in control but T_1(Poison bait), T_3 (Banana pulp trap) showed the same result statistically (0.52, 0.50 respectively) that was non-significant. The lowest weight of infested fruit plot^{-1} was 0.30 found in T_5 (Covering fruits with polythene). Other treatment showed the intermediated results between highest and lowest.

4.2.8. Percent increase of healthy weight over control

The data on the table 4 also showed the percentage of increase of healthy weight over control (kg). The highest percentage of increase of healthy weight over control was 1036.66 found in T_5 (Covering fruits with polythene) followed by 768.08 in T_4 (Neem oil), 374.32 in T_2 (Pheromone trap), 181.49 in T_1 (Poison bait) and the lowest percentage of increase of healthy weight over control was 146.75 found in T_3 (Banana pulp trap) that showed all the results statistically significant and different.

Table 5: Effect of management practices on attributes of ridge gourd's fruits content plot^{-1} against fruit fly and red pumpkin beetle at mid fruiting stage

Treatment	Total No. of fruit plot^{-1}	Number of healthy fruits plot^{-1}	Number of infested fruits plot^{-1}
T_0	7.00 f	3.00 f	4.00 a
T_1	12.50 d	9.50 d	3.00 b
T_2	14.00 c	11.25 c	2.75 b
T_3	10.75 e	7.50 e	3.25 b
T_4	16.00 b	14.00 b	2.00 c
T_5	18.50 a	17.50 a	1.00 d
LSD (0.05)	2.13	1.95	0.23
CV (%)	4.35	2.67	2.14
Level of significance	*	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance. * indicates significant at 5% level

[T_0 = Control, T_1=Poison bait, T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.3. Effect of management practices at mid fruiting stage

4.3.1 Total No. of fruit plot^{-1}

The total number of fruits plot^{-1} at mid fruiting stage was maximum 18.50 was found in in T_5 (Covering fruits with polythene) followed by 16.00 in T_4 (Neem oil), 14.00 in T_2 (Pheromone trap), 12.50 in T_1 (Poison bait), 10.75 in T_3 (Banana pulp trap). And the lowest number of fruits per plot at mid fruiting stage was 7.00 found in control. All the data were statistically significant and different (Table 5).

4.3.2. Number of healthy fruits plot^{-1}

Number of healthy fruits plot^{-1} at mid fruiting stage was highest (17.50 a) in T_5 (Covering fruits with polythene) and the lowest 3.00 was found in control and other treatment showed intermediated result between highest and lowest (Table 5). All the data showed statistically significant

4.3.3. Number of infested fruits plot^{-1}

Number of infested fruits plot^{-1} by fruit fly and red pumpkin beetle at mid fruiting stage was (4.00) maximum in control. The treatment T_1 (Poison Bait), T_2 (Pheromone trap), T_3 (Banana pulp trap) showed same result (3.00, 2.75, 3.25 respectively) and it was statistically identical. The lowest number of infected fruits was recorded in T_5 (1.00) treated plot which was followed by T_4 (2.00) and they were statistically different (Table 5).

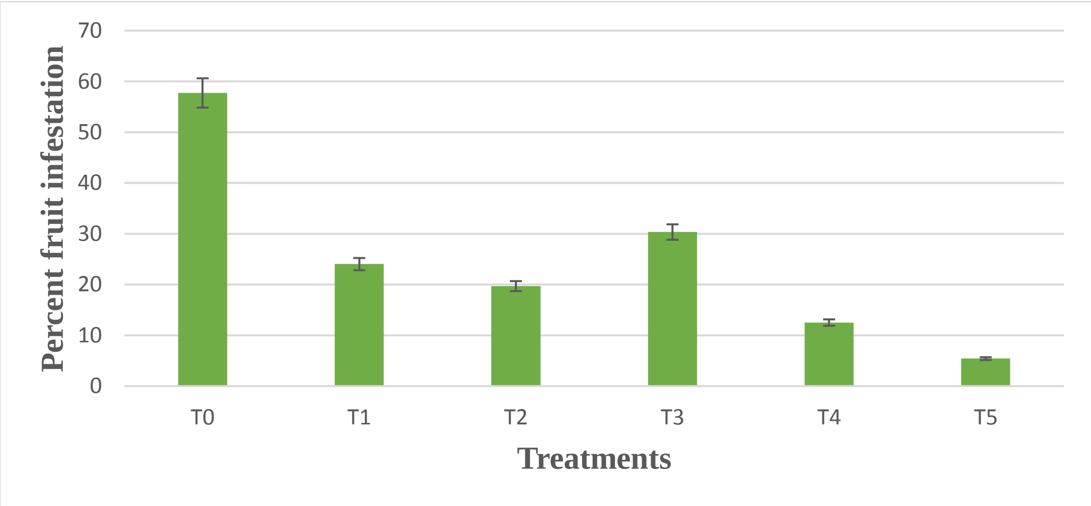

Fig 2: Effect of management practices on percent fruit infestation of ridge gourd's content plot^{-1} against fruit fly and red pumpkin beetle at mid fruiting stage

4.3.4. Percent fruit infestation

The percentage of fruit infestation at mid fruiting stage by fruit fly and red pumpkin beetle was highest in control (57.73) followed by 30.34 in T_3 (Banana pulp trap), 24.03 in T_1 (Poison bait), 19.69 in T_2 (Pheromone trap) and the lowest percentage of fruit infestation 12.52 found in T_5 (Covering fruits with polythene)treated plot. (Fig. 2).

4.3.5. Total fruit weight plot^{-1}

The total fruit weight plot^{-1} (kg) 5.46a was maximum found in T_5 (Covering fruits with polythene) followed by 4.40 in T_4 (Neem oil), 3.52 in T_2 (Pheromone trap), and treatment T_1, T_3 showed the same result statistically (2.64, 2.14). On the other hand control (T_0) showed the lowest total fruit weight plot^{-1} (kg) 1.48 (Table 6).

4.3.6. Weight of healthy fruit plot^{-1} (kg)

The data showed the weight of healthy fruit plot^{-1} (kg). The maximum weight of healthy fruit plot^{-1} 5.06 was found in T_5 (Covering fruits with polythene) and the lowest weight of healthy fruit plot^{-1} 0.74 was found in control. Other treatment showed intermediated result between highest and lowest (Table 6).

Table 6: Effect of management practices on attributes of ridge gourd's fruits content plot^{-1} against fruit fly and red pumpkin beetle at mid fruiting stage

Treatment	Total fruit weight plot^{-1} (kg)	Weight of healthy fruit plot^{-1} (kg)	Weight of infested fruit plot^{-1} (kg)	% increase of healthy weight over control (kg)
T_0	1.48 e	0.74 e	0.73	0.00 f
T_1	2.64 d	2.04 c	0.60	175.34 d
T_2	3.52 c	2.82 c	0.70	281.09 c
T_3	2.14 d	1.35 d	0.78	82.04 e
T_4	4.40 b	4.01 b	0.38	441.89 b
T_5	5.46 a	5.06 a	0.30	583.18 a
LSD (0.05)	0.87	0.67	0.06	7.94
CV (%)	2.45	3.27	2.98	12.47
Level of significance	*	*	NS	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance. * indicates significant at 5% level

[T_0 = Control, T_1=Poison bait, T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.3.7. Weight of infested fruit plot^{-1}

The table 6 also showed the weight of infested fruit plot^{-1} was maximum in 0.73 that found in control but T_2 (Pheromone trap), T_3 (Banana pulp trap) showed the same result statistically (0.70, 0.78 respectively) identical. The lowest weight of infested fruitplot-1 was 0.30 found in T_5 (Covering fruits with polythene).

4.3.8. Percent increase of healthy weight over control (kg)

The data on the table 6 also showed the percentage of increase of healthy weight over control (kg). The highest percentage of increase of healthy weight over control was 583.18 found in T_5 (Covering fruits with polythene) followed by 441.89 in T_4 (Neem oil), 281.09 in T_2 (Pheromone trap), 175.34 in T_1 (Poison bait) and the lowest percentage of increase of healthy weight over control was 82.04 found in T_3 (Banana pulp trap) that showed all the results statistically significant.

4.4. Effect of management practices at late fruiting stage

4.4.1. Total No. of fruits plot^{-1}

The total number of fruits was 17.70 maximum in T_5 (Covering fruits with polythene) followed by 15.34 in T_4 (Neem oil), 13.50 in T_2 (Pheromone trap), 11.10 in T_1 (Poison bait) and 9.35 in T_3 (Banana pulp trap). And the lowest total number of fruits was 6.05 found in control. All the data statistically significant (Table 7).

4.4.2. Number of healthy fruits plot^{-1}

Number of healthy fruits plot^{-1} 18.10 was maximum in T_5 (Covering fruits with polythene) and the lowest number was 2.85 from control plot. Other treatment showed intermediated result between highest and lowest (Table 7) and all the data statistically significant.

Table 7: Effect of management practices on attributes of ridge gourd's fruits content plot^{-1} against fruit fly and red pumpkin beetle at late fruiting stage

Treatment	Total No. of fruit plot^{-1}	Number of healthy fruits plot^{-1}	Number of infested fruits plot^{-1}	% fruit infestation plot^{-1}
T_0	6.05 f	2.85 f	3.85 a	63.63 a
T_1	11.10 d	10.00 d	2.95 b	26.57 c
T_2	13.50 c	10.98 c	3.00 c	22.22 d
T_3	9.35 e	8.10 e	3.55 b	37.96 b
T_4	15.34 b	13.75 b	1.98 c	12.90 e
T_5	17.70 a	18.10 a	1.00 d	5.64 f
LSD (0.05)	2.87	1.94	0.97	0.79
CV (%)	5.68	3.54	5.36	1.97
Level of significance	*	*	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance. * indicates significant at 5% level, NS= non-significant
[T_0 = Control, T_1=Poison bait trap, T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.4.3. Number of infested fruits plot^{-1}

The table 7 showed the number of infested fruits plot^{-1} was (3.85) maximum in control plot at late fruiting stage. The treatment T_1 (Poison bait) and T_3 (Banana pulp trap) showed the same results statistically (2.95, 3.00 respectively) identical. The treatment T_2 (pheromone trap), T_4 (Neem oil) also showed the same result statistically (2.95, 1.98 respectively). The lowest number of infested fruits plot^{-1} was 1.00 found in T_5 (Covering fruits with polythene).

4.4.4. Percent fruit infestation plot^{-1}

Percent fruit infestation plot^{-1} 63.63 was maximum in control plot where T_5 (Covering fruits with polythene) was lowest number 5.64. Other treatment showed intermediated result between highest and lowest (Table 7) and all the data statistically significant and different.

4.4.5. Total fruit weight $plot^{-1}$ (kg)

Table 8 showed the effect of different traps on fruits weight and increase of healthy fruit weight of ridge gourd by fruit fly and red pumpkin beetle at late fruiting stage. The total fruit weight $plot^{-1}$ (kg) 7.48 was maximum found in T_5 (Covering fruits with polythene) followed by 6.12 in T_4 (Neem oil), 4.94 in T_2 (Pheromone trap), and treatment T_1, T_3 showed the same result statistically (3.78, 3.06). On the other hand control (T_0) showed the lowest total fruit weight $plot^{-1}$ (kg) 1.72 (Table 8).

4.4.6. Weight of healthy fruit $plot^{-1}$ (kg)

The data showed the weight of healthy fruit $plot^{-1}$ (kg). The maximum weight of healthy fruit $plot^{-1}$ 7.08 was found in T_5 (Covering fruits with polythene) and the lowest weight of healthy fruit $plot^{-1}$ 0.74 was found in control. Other treatment showed intermediated result between highest and lowest (Table 8).

Table 8: Effect of management practices on attributes of ridge gourd's fruits weight $plot^{-1}$ against fruit fly and red pumpkin beetle at late fruiting stage

Treatment	Total fruit weight $plot^{-1}$ (kg)	Weight of healthy fruit $plot^{-1}$ (kg)	Weight of infested fruit $plot^{-1}$ (kg)	% increase of healthy weight over control (kg)
T_0	1.72 e	.74 e	0.98	.00 f
T_1	3.78 d	2.87 d	0.90	318.37 d
T_2	4.94 c	3.97 c	0.97	486.54 c
T_3	3.06 d	2.1 d	0.92	214.88 e
T_4	6.12 b	5.35 b	0.76	685.12 b
T_5	7.48 a	7.08 a	0.40	939.24 a
LSD(0.05)	1.20	1.04	0.09	9.46
CV (%)	2.78	3.24	4.89	14.78
Level of significance	*	*	NS	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance. * indicates significant at 5% level, NS= non-significant
[T_0 = Control, T_1=Poison bait, T_2= Pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene.]

4.4.7. Weight of infested fruit plot^{-1}

Table 8 also showed the weight of infested fruit plot^{-1} was maximum in 0.90a that found in control but T_1 (Poison bait), T_2 (pheromone trap), T_3 (Banana pulp trap) showed the same result statistically (0.90, 0.97, 0.92 respectively) that was non-significant. The lowest weight of infested fruit plot^{-1} was 0.40 found in T_5 (Covering fruits with polythene).

4.4.8. Percent increase of healthy weight over control (kg)

The data on the table 8 also showed the percentage of increase of healthy weight over control (kg). The highest percentage of increase of healthy weight over control was 939.24 found in T_5 (Covering fruits with polythene) followed by 685.12 in T_4 (Neem oil), 486.54 in T_2 (Pheromone trap), 318.37 in T_1 (Poison bait) and the lowest percentage of increase of healthy weight over control was 214.88 found in T_3 (Banana pulp trap) that showed all the results statistically significant.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agriculture University farm to find out effect of different traps on incidence and management of cucurbit fruit fly and red pumpkin beetle during November 2017 to April 2018. The treatments of the experiment were T_0 = Control, T_1=Poison bait trap, T_2= pheromone trap, T_3= Banana pulp trap, T_4= Neem oil, T_5= Covering fruits with polythene. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole reproductive period of ridge gourd was divided into three stages viz., early, mid and late fruiting stages. Data was collected on number of fruit and weight of fruits plot^{-1} at early, mid and late fruiting stage, total yield and presence of cucurbit fruit fly and red pumpkin beetle at different fruiting stage. Healthy fruits plot^{-1}, infested fruits plot^{-1}, per cent fruit infestation, per cent increase over control and per cent decrease over control was considered at each of the stage.

At the early fruiting stage, the maximum number of fruit fly plot^{-1} (5.75) was obtained from T_0 (Control) followed by 4.25 in T_1 and T_3 (Poison bait trap and banana pulp trap), 3.25 in T_2 (Pheromone trap), and 2.00 in T_4 (Neem oil).
At the mid fruiting stage, the maximum number of fruit fly plot^{-1}(5.25) was obtained from T_0 (Control) followed by 4.25 in T_3 (Banana pulp trap), 3.20 in $T_{1,}$ (Poison bait trap), and 3.00 in T_2 (Pheromone trap), 1.25 in $T_{4.}$ At the late fruiting stage, the maximum number of fruit fly plot^{-1}(4.75) was obtained from T_0 (Control) followed by 4.25 in T_2 (Pheromone trap), 3.25 in T_3 (Banana pulp trap), and 2.25 in T_1 (Poison trap) and 1.25 in T_4 (Neem oil). The highest total number of fruit fly plot^{-1} of all stages was 15.75 found in control plot and T_5 showed no fruit fly at the early mid and late fruiting stage due to all stages fruits were covered by polythene sheets.
The percentage of reduction of fruit fly over control the maximum percentage of

reduction of fruit fly is 100.00 in T_5 (Covering fruits with polythene) followed by 71.43 in $T_{4,}$ (Neem oil), 36.82 in T_1 (Poison trap), 33.33 in T_2 (Banana pulp trap), and lowest percentage of reduction of fruit fly was 25.39 in T_3 (Pheromone trap). Table 2 showed that the number of red pumpkin beetle per plot at early fruiting stage. The maximum number of red pumpkin beetle plot^{-1} at early fruiting stage (22.25) was obtained from T_0 (Control) followed by 15.50 in $T_{1,}$ (Pheromone trap), 13.00 in T_3 (Banana pulp trap), 7.25 in T_2 (Pheromone trap), 6.00 in T_4 and they were statistically different. On the other hand T_5 showed no red pumpkin beetle plot^{-1} at early fruiting stage. At the mid fruiting stage, the maximum number of red pumpkin beetle plot-1 (20.75) was obtained from T_0 (Control) and lowest number of red pumpkin beetle plot-1 5.25 was found in T_5 (Covering fruits with polythene). And other treatment showed intermediate result between highest and lowest.

At the late fruiting stage the maximum number of red pumpkin beetle plot^{-1} was18.00 in control (T_0) and lowest number of red pumpkin beetle plot^{-1} was 4.50 in T_5 (Covering fruits with polythene) and other treatment showed intermediate result that were statistically significant. The percentage of reduction of red pumpkin beetle over control the maximum percentage of reduction of red pumpkin beetle is 100.00 in T_5 (Covering fruits with polythene) and T_4 (Neem oil) and T_2 (Pheromone trap) showed statistically same result (70.90, 66.80 respectively identical); and the lowest percentage of reduction of red pumpkin beetle over control was 31.55 in $T_{1,}$ (Poison bait). Other result showed intermediate result that are statistically significant.

The total number of fruits plot^{-1} at mid fruiting stage was maximum 18.50 was found in in T_5 (Covering fruits with polythene) followed by 16.00 in T_4 (Neem oil), 14.00 in T_2 (Pheromone trap), 12.50 in T_1 (Poison bait), 10.75 in T_3 (Banana pulp trap). And the lowest number of fruits per plot at mid fruiting stage was 7.00 found in control. All the data were statistically significant and different.

Number of healthy fruits $plot^{-1}$ at mid fruiting stage was highest (17.50 a) in T_5 (Covering fruits with polythene) and the lowest 3.00 was found in control and other treatment showed intermediated result between highest and lowest.

Number of infested fruits $plot^{-1}$ by fruit fly and red pumpkin beetle at mid fruiting stage was (4.00) maximum in control. The treatment T_1 (Poison Bait), T_2 (Pheromone trap), T_3 (Banana pulp trap) showed same result (3.00, 2.75, 3.25 respectively) and it was statistically identical. The lowest number of infected fruits was recorded in T_5 (1.00) treated plot which was followed by T_4 (2.00) and they were statistically different.

The percentage of fruit infestation at mid fruiting stage by fruit fly and red pumpkin beetle was highest in control (57.73) followed by 30.34 in T_3 (Banana pulp trap), 24.03 in T_1 (Poison bait), 19.69 in T_2 (Pheromone trap) and the lowest percentage of fruit infestation 12.52 found in T_5 (Covering fruits with polythene)treated plot. The total fruit weight $plot^{-1}$ (kg) 5.46a was maximum found in T_5 (Covering fruits with polythene) followed by 4.40 in T_4 (Neem oil), 3.52 in T_2 (Pheromone trap), and treatment $T_{1,}$ T_3 showed the same result statistically (2.64, 2.14). On the other hand control (T_0) showed the lowest total fruit weight $plot^{-1}$ (kg) 1.48.

The data showed the weight of healthy fruit $plot^{-1}$ (kg). The maximum weight of healthy fruit $plot^{-1}$ 5.06 was found in T_5 (Covering fruits with polythene) and the lowest weight of healthy fruit $plot^{-1}$ 0.74 was found in control. Other treatment showed intermediated result between highest and lowest. The weight of infested fruit $plot^{-1}$ was maximum in 0.73 that found in control but T_2 (Pheromone trap), T_3 (Banana pulp trap) showed the same result statistically (0.70, 0.78 respectively) identical. The lowest weight of infested fruitplot-1 was 0.30 found in T_5 (Covering fruits with polythene). The percentage of increase of healthy weight over control (kg). The highest percentage of increase of healthy weight over control was 583.18 found in T_5 (Covering fruits with polythene) followed by 441.89 in T_4 (Neem oil), 281.09 in T_2 (Pheromone trap), 175.34 in T_1 (Poison bait) and the lowest percentage of increase of healthy weight over control was

82.04 found in T_3 (Banana pulp trap) that showed all the results statistically significant.

The total number of fruits was 17.70 maximum in T_5 (Covering fruits with polythene) followed by 15.34 in T_4 (Neem oil), 13.50 in T_2 (Pheromone trap), 11.10 in T_1 (Poison bait) and 9.35 in T_3 (Banana pulp trap). And the lowest total number of fruits was 6.05 found in control. Number of healthy fruits plot^{-1} 18.10 was maximum in T_5 (Covering fruits with polythene) and the lowest number was 2.85 from control plot. Other treatment showed intermediated result between highest and lowest and all the data statistically significant.

The effect of different traps on fruits weight and increase of healthy fruit weight of ridge gourd by fruit fly and red pumpkin beetle at late fruiting stage. The total fruit weight plot^{-1} (kg) 7.48 was maximum found in T_5 (Covering fruits with polythene) followed by 6.12 in T_4 (Neem oil), 4.94 in T_2 (Pheromone trap), and treatment $T_{1,}$ T_3 showed the same result statistically (3.78, 3.06). On the other hand control (T_0) showed the lowest total fruit weight plot^{-1} (kg) 1.72. The maximum weight of healthy fruit plot^{-1} 7.08 was found in T_5 (Covering fruits with polythene) and the lowest weight of healthy fruit plot^{-1} 0.74 was found in control. Other treatment showed intermediated result between highest and lowest.

The weight of infested fruit plot^{-1} was maximum in 0.90a that found in control but T_1 (Poison bait), T_2 (pheromone trap), T_3 (Banana pulp trap) showed the same result statistically (0.90, 0.97, 0.92 respectively) that was non-significant. The lowest weight of infested fruit plot^{-1} was 0.40 found in T_5 (Covering fruits with polythene). The highest percentage of increase of healthy weight over control was 939.24 found in T_5 (Covering fruits with polythene) followed by 685.12 in T_4 (Neem oil), 486.54 in T_2 (Pheromone trap), 318.37 in T_1 (Poison bait) and the lowest percentage of increase of healthy weight over control was 214.88 found in T_3 (Banana pulp trap) that showed all the results statistically significant.

CONCLUSION

Based on the above findings of the study it can be concluded that covering fruits with polythene was the best technique for the management of cucurbit fruit fly on ridge gourd. Neem oil showed also the promising performance against fruit fly and red pumpkin beetle in ridge gourd. Covering fruits with polythene and neem oil treatment against fruit fly and red pumpkin observed better result on all the parameters. Pheromone traps only effective for fruit fly control but it has no significance on control of red pumpkin beetle in ridge gourd.

RECOMMENDATIONS

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

- Covering fruits with polythene may be used for the management of fruit fly.
- Neem oil may be used for the management of fruit fly and red pumpkin beetle.
- Further intensive studies based on different treatments of different plant materials should be done.
- More techniques and botanicals should be included in further elaborative research for controlling of insect pest of ridge gourd.

CHAPTER VI

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