EFFECT OF DIFFERENT TRAPS ON INCIDENCE AND MANAGEMENT OF CUCURBIT FRUIT FLY, *BACTROCERA CUCURBITAE*

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CERTIFICATE

This is to certify that thesis entitled, EFFECT OF DIFFERENT TRAPS ON INCIDENCE AND MANAGEMENT OF CUCURBIT FRUIT FLY, *BACTROCERA CUCURBITAE* submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **ENTOMOLOGY,** embodies the result of a piece of bona fide research work carried out by Marufa Islam, Registration No. 07-2312 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2013
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Prof. Dr. Md. Abdul Latif
Supervisor

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ABSTRACT

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, *Bactrocera cucurbitae* during November 2012 to April 2013. The treatments of the experiment were T_1 = Pheromone Trap (Plastic pot), T_2 = GME pheromone water Trap, T_3 = Sticky Trap, T_4 = Bait Trap, T_5 = Funnel pheromone Trap, T_6 = Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot) and T_8 = Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that, T_7 (Bait trap + pheromone trap (plastic pot)) was the most effective treatment for early (1.88), mid (3.00), late (1.92) fruiting stages and total (6.80) cropping period in terms of adult trapped/plot and no adult was caught in T_8 (Control plot), T_3 (Sticky trap) and T_6 (Light trap). Bait trap in combination with Pheromone trap (plastic pot) (T_7) gave the best result for total number of healthy fruits/plot (6.33), highest per cent increase of yield by number (111.11%), weight of healthy fruits/plot (8.61kg) and per cent increase of yield by weight (438.9%). Funnel pheromone trap (T_5) also showed similar result and intermediate result was found in T_1 (Pheromone trap (plastic pot)), T_4 (Bait trap) and T_2 (GME water pheromone trap). The lowest number of healthy fruits/plot (3.00/plot) and healthy fruit weight (1.64 kg/plot) was obtained from control plot. T_3 (Sticky trap) and T_6 (Light trap) had no effect on capturing adult fruit fly and gave the similar yield to control. Pheromone trap (plastic pot) in combination with Bait trap may be used for the management of fruit fly attacking cucurbitaceous vegetables.

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CHAPTER I
INTRODUCTION

Bangladesh is predominantly an agriculture based country. But it has a huge deficit in vegetable production. The annual production of vegetables is 8685,000 million tons (BBS, 2010). The optimum requirement of vegetable for a full grown person is 285g but in Bangladesh it is only 32g (Ramphall and Gill, 1990). Vegetables are not equally produced throughout the year in the country. Most of the important vegetables are produced in winter and the production in summer is tremendously low (Anon., 1993). A large number of cucurbit vegetables, viz., bottle gourd, bitter gourd, sweet gourd, snake gourd, white gourd, ridge gourd, sponge gourd, kakrol, cucumber etc. are grown in Bangladesh. Cucurbits occupy 66 per cent of the land under vegetable production in Bangladesh and contribute 11 per cent of total vegetable production in the country season and 77 thousand tons in the summer season of 2006-2007 (BBS, 2010).

Insect pest infestation is a major problem of crop production in Bangladesh. It reduces yield and marketable quality of the produce and thereby farmers incur huge financial loss. High temperature and humidity in summer favor insect reproduction. Fruit fly, *Bactrocera cucurbitae* (Coquillett) is a major pest causing yield loss in cucurbits, and infests all 15 kinds of cucurbit vegetables grown in Bangladesh (Rakshit *et al.,* 2011). A major constraint improved cucurbit production is high rate of fruit fly infestation. Fruit flies reduce yield as well as the quality fruit (Anon., 2004). The Cucurbit fruit fly, *B. cucurbitae* represents 74.5% of the total number of flies infesting different vegetables growing areas in Bangladesh (Akhtaruzzaman *et al.,* 1999). It prefers young, green, and tender fruits for egg laying. The females lay the eggs 2 to 4 mm deep in the fruit pulp, and the maggots feed inside the developing fruits. At times, the eggs are also laid in the corolla of the flower, and the maggots feed on the flowers. A few maggots have also been observed to feed on the stems (Narayanan, 1953). The fruits attacked in early stages fail to develop properly, and drop or rot on the plant. Since, the maggots damage the fruits internally. Due to its nature of infestation, it is very difficult to control the pest. A cluster method have been developed and suggested by Kapoor (1993) to control these pests using various cultural, physical, chemical, biological and legal methods.

Each and every method has its positive and negative effects. Among all these methods, the chemical control method is still popular to the Bangladeshi farmers because of its quick and visible results. Nasiruddin and Karim (1992) found that 61.92% reduction of fruit fly infestation over control by spraying Dipterex 80SP in snack gourd, but Dipterex 80SP is not recently available in market for farmer use. Protein hydrolysate insecticide formulations and other insecticides (Malathion 57EC, and Diazinon 60EC) with molasses as attractant are being widely used for the control of fruit fly (Kapoor, 1993; Nasiruddin and Karim, 1992; Smith, 1992). Some insecticides have been used satisfactorily in minimizing the damage to fruits and vegetables against fruit fly (Kapoor, 1993; York, 1992; Nair, 1986; Hameed *et al.*, 1980).

The increasing use of synthetic insecticides has led to a number of problems such as development of resistance to insecticides in some insect pests, high insecticide residues in market produce, resurgence or increased infestation by some insect species due to the destruction of natural predators and parasitoids, changing pest status of mites and other minor insect pests, ecological imbalance and danger to health of the pesticide applicator.
Considering the alarming consequences of pesticide usage and residual effect on the environment, pragmatic programme is now needed worldwide to minimize the dependency on insecticides without hampering crop production. IPM, undoubtedly since last few years has been a much talked scientific phenomenon in Bangladesh, particularly in the area of the agricultural policy makers.

Considering previous facts and reports, it is apparent that more than 50% of the cucurbits are either partially or totally damaged by fruit flies and are unsuitable for human consumption. Although, several management options, such as hydrolyzed protein spray, para-pheromone trap, spraying of ailanthus and cashew leaf extract, neem products, bagging of fruits, field sanitation, food baits, and spray of chemical insecticides (Dhillon *et al*., 2005; Neupane, 2000; Akhtaruzzaman *et al.*, 2000; YubakDhoj and Mandal, 2000; Pawar *et al*., 1991) have been in use for the management of cucurbit fruit fly, some of them either fail to control the pest and/or are uneconomic and hazardous to non-target organisms and the environment (Dhillon *et al.*, 2005; Neupane, 2000). In mid hill district of Nepal, farmers attempted different methods of management, like indigenous (70%), chemical (32%), mechanical (80%) and combination of two or more methods (68%) to combat the problems of fruit fly (Sapkota, 2009). Considering the hazardous impact of chemicals on non-target organisms and the environment, present studies were undertaken to assess the losses caused by *B. cucurbitae* and efficacy of different control measures aiming to develop an eco-friendly and sustainable pest management system in cucurbits .

However, an effective and cheap management strategy against this pest has already been developed, which comprises of sanitation and use of pheromone mass trapping. Scientists at the Bangladesh Agricultural Research Institute (BARI) in collaboration with the USAID funded Integrated Pest Management Collaborative Research Support Program (IPM CRSP) conducted field experiments which indicate that bait trapping for fruit fly control in cucurbits with a synthetic pheromone called Cuelure and mashed sweet gourd (MSG) is highly effective. Fruit fly infestation was reduced by 53 to 73 per cent and yields were raised 1.4 to 2.3 times using the traps (Anon., 2002-2003). Farmers in Bangladesh have shown strong interest in adopting the pheromone lure for monitoring of peak pest infestation periods as well as for mass trapping. They are able to minimize fruit fly damage, and reduce the use of toxic insecticides. To monitor the fruit fly population pheromone trappings have been successfully used in different countries (Gillani *et al.*, 2002; Marwat and Baloch, 1986).

Objectives

- To identify the most effective trap for the management of fruit fly in field
- To establish an environmentally safe control measure in cucurbit crops by using different traps.

CHAPTER II

REVIEW OF LITERATURE

Sweet gourd is an important vegetable crop in Bangladesh. Fruit fly is most damaging insect pest of Sweet gourd and other cucurbit fruits and vegetables. It causes great yield reduction, which is considered as an important obstacle for economic production of these crops. Substantial works have been done globally on this pest regarding their origin and distribution, Host range, Life cycle, Nature of damage, Rate of infestation and yield loss by fruit fly, Seasonal abundance and Management. But published literature on this pest especially on its infestation status and management are scanty in Bangladesh. Literatures cited below under the following headings and sub-headings reveal some information about the present study.

2.1 Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Section: Schizophora

Family: Tephritidae

Genus: *Bactrocera*

Species: *B. curcurbitae*

Synonyms

Chaetodacus cucurbitae (Coquillett)

Dacus cucurbitae (Coquillett)

Strumeta cucurbitae (Coquillett)

Zeugodacus cucurbitae (Coquillett)

2.2 Origin and distribution

Fruit fly is considered to be the native of oriental, probably India and south east Asia and it was first discovered in the Yaeyama Island of Japan in 1919 (Anon., 1987). However, the fruit fly is widely distributed in India, Bangladesh, Pakistan, Myanmar, Nepal, Malaysia, China, Philippines, Formosa(Taiwan), Japan, Indonesia, East Africa, Australia, and Hawaiian Island (Alam, 1965). It was discovered in Solomon Islands in 1984, and is now widespread in all the provinces, except Makira, Rennell-Bellona and Temotu (Eta, 1985). In the Commonwealth of the Northern Mariana Islands, it was detected in 1943 and eradicated by sterile-insect release in 1963 (Steiner *et al.*, 1965; Mitchell, 1980), but re-established from the neighboring Guam in 1981 (Wong *et al.*, 1989). It was detected in Nauru in 1982 and eradicated in 1999 by male annihilation and protein bait spraying, but was re-introduced in 2001 (Hollingsworth and Allwood, 2002). Although it is found in Hawaii, it is absent from the continental United States (Weems and Heppner, 2001). In July 2010, fruit flies were discovered in traps in Sacramento and Placer counties.

The distribution of a particular species is limited perhaps due to physical, climatic and gross vegetational factors but most likely due to host specificity. Such species may become widely distributed when their host plant are widespread, either naturally or cultivation by man (Kapoor, 1993). The dipteran family Tephritidae consists of over 4000 species, of which nearly 700 species belong to Dacine fruit flies (Fletcher, 1987). Nearly 250 species are of economic importance, and are distributed widely in temperate, sub-tropical, and tropical regions of the world (Christenson and Foote, 1960). The first report on melon fruit flies was published by Bezzi (1913), who listed 39 species from India. Forty-three species have been described under the genus *Bactrocera* including *cucurbitae, dorsalis, zonatus, diversus, tau, oleae, opiliae, kraussi, ferrugineus, caudatus, ciliatus, umbrosus, frauenfeldi, occipitalis, tryoni, neohumeralis, opiliae, jarvisi, expandens, tenuifascia, tsuneonsis, latifrons, cucumis, halfordiae, cucuminatus, vertebrates, frontalis, vivittatus, amphoratus, binotatus, umbeluzinus, brevis, serratus, butianus, hageni, scutellaris, aglaia, visendus, musae, newmani, savastanoi, diversus, and minax*, from Asia, Africa, and Australia (Fletcher, 1987; Cavalloro, 1983; Drew and Hooper, 1983; Munro, 1984).

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

2.3 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).

2.4 Seasonal abundance

The population of fruit fly fluctuates throughout the year and the abundance of fruit fly population varies from month to month, season to season, even year to year depending upon various environmental factors, The fly has been observed to be active in the field almost throughout the year where the weather is equable (Narayan and Batra, 1960). Narayn and Batra (1960) reported that most of the fruit fly species are more or less active at temperatures ranging between 12°C - 15°C and become inactive below 10° C. Cucurbit fruit flies normally increases their multiplication when the temperatures goes below 15°C and relative humidity varies from 60-70% (Alam, 1965). The abundance of fruit fly in cuelure baited trap was observed throughout the year, with two peaks in summer and kharif coinciding with 14 SW (standard week) and 43 SW, respectively in bitter gourd. In kharif, maximum damage (62.70%) occurred in 15, 45 SW, and second peak with 49.70% damage observed during 45, 15 SW periods. The temperature (maximum and minimum) had significantly positive correlation with abundance, damage and pupal population; temperature during one, two and three preceding weeks had slightly greater impact than that of the prevailing week. Other abiotic factors had non-significant effect on adult activity, damage and pupal population. (Raghuvanshi *et. al.,* 2010)

Bangladesh is a tropical country and the air temperature remains quite high in summer but not very cold in winter. The optimal temperature for the development of *B. cucurbitae* ranged from 20^{o}C to 28^{o}C (Wu *et al*., 2000; Vargas *et al*., 1996). Studies on the population dynamics of *C. capitata* have shown that the main factor affecting population build up in the tropics is fruit abundance and availability, whereas in temperate areas low winter temperatures also play a major role (Papadopoulos, 1999; Katsoyannos *et al.,* 1998; Israely *et al.,* 1997; Harris *et al.,* 1993; Nishida *et al.,* 1985; Vargas *et al.,* 1983). The presence of abundant backyard garden cucurbit vegetables during winter season in Ganakbari area was responsible for the presence of high level melon fly population. Ye (2001) reported that the area planted with fruit trees, the fruit production yields, and the fruiting period can all affect oriental fruit fly population size. In the field without pesticide treatments 50-70% of the cucurbit fruits were infested (Singh *et al.,* 2000; Hollingworth *et al.,* 1997; Gupta and Verma, 1978). The infested fruits in the field may serve as reservoir for continuous presence of the fly if not treated the fruits or removed or bagged the infested fruits.

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

2.5 Nature of damage

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

Miyatake *et al.* (1993) reported more than 1% damage by pseudo-punctures by the sterile females in cucumber, sponge gourd and bitter gourd. After egg hatching, the maggots bore into the pulp tissue and make the feeding galleries. The fruit subsequently rots or becomes distorted. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition. The vinegar fly, *Drosophilla melanogaster* has also been observed to lay eggs on the fruits infested by melon fly, and acts as a scavenger (Dhillon *et al.*, 2005). The extent of losses varies between 30 to 100%, depending on the cucurbit species and the season. Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89% (Rabindranath and Pillai, 1986; Gupta and Verma, 1978; Kushwaha *et al.*, 1973; Narayanan and Batra, 1960; Lall and Sinha, 1959). The melon fruit fly has been reported to infest 95% of bitter gourd fruits in Papua (New Guinea), and 90% snake gourd and 60 to 87% pumpkin fruits in Solomon Islands (Hollingsworth *et al.*, 1997). Singh *et al.* (2000) reported 31.27% damage on bitter gourd and 28.55% on watermelon in India.

2.6 Rate of infestation and yield loss by fruit fly

Shah *et al.* (1948) reported that the damage done by fruit flies in North West Frontier Province (Pakistan) cost an 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).

2.7 Lifecycle of Cucurbit fruit fly

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

Eggs

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

Larvae

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

The full-grown larvae come out of the fruit by making one or two exit holes for pupation in the soil. The larvae pupate in the soil at a depth of 0.5 to 15 cm. The depth up to which the larvae move in the soil for pupation, and survival depend on soil texture and moisture (Jackson *et al.,* 1998).

Pupae

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

Adults

The adults survive for 27.5, 30.71 and 30.66 days at 27 ± 1° C on pumpkin, squash gourd and bitter gourd, respectively (Doharey, 1983). Khan *et al.* (1993) reported that the males and females survived for 65 to 249 days and 27.5 to 133.5 days respectively. The pre-mating and oviposition periods lasted for 4 to 7 days and 14 to 17 days, respectively. The females survived for 123 days on papaya in the laboratory (24° C, 50% RH and LD 12: 12) (Vargas *et al.,* 1992), while at 29° C they survived for 23.1 to 116.8 days (Vargas *et al.,* 1997). Mean single generation time is 71.7 days, net reproductive rate 80.8 births per female, and the intrinsic rate of increase is 0.06 times (Vergas *et al.,* 1992). Yang *et al.* (1994) reported the net reproductive rate to be 72.9 births per female. *Bactrocera cucurbitae* strains were selected for longer developmental period and larger body size on the basis of pre-oviposition period, female age at peak fecundity, numbers of eggs at peak fecundity, total fecundity, longevity of males and females, age at first mating, and number of life time mating (Miyatake, 1995). However, longer developmental period was not necessarily associated with greater fecundity and longevity (Miyatake, 1996).

2.8 Management of fruit fly

Fruit fly is the most damaging factor of cucurbits almost all over the world. Although there are various methods are available to combat this cost, there is not a single such method which has so far been successfully reduced the damage of fruit fly. This perhaps, is mainly due to the polyphagous nature of these pests that helps their year round population build up. The available literatures on the measures for the controlling of these flies are discussed under the following sub-headings:

A. Cultural control

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

A.a. Ploughing of soil

In the pupal stage of fruit fly, it pupates in soil and also over winter in the soil. In the winter period, the soil in the field s turned over or given a light ploughing; the pupae underneath are exposed to direct sunlight and killed. They also become a prey to the predators and parasitoids. A huge number of pupae are died due to mechanical injury during ploughing (Kapoor, 1993; Nasiruddin and Karim, 1992; Chattopadhyay, 1991; Agarwal *et al.,* 1987). The female fruit fly lays eggs and the larvae hatch inside the fruit, it becomes essential to look for the available measures to reduce their damage on fruit. One of the Safety measures is the field sanitation (Nasiruddin and Karim, 1992).

A.b. Field sanitation

Field sanitation is an essential pre requisite to reduce the insect population or defer the possibilities of the appearances of epiphytotics or epizootics (Reddy and Joshi, 1992). According to Kapoor (1993), in this method of field sanitation, the infested fruits on the plant or fallen on the ground should be collected and buried deep into the soil or Cooked and fed to animals. Systematic picking and destruction of infested fruits in Proper manner to keep down the population is resorted to reduce the damages caused by fruit flies infesting cucurbits, Guava, mango, peach etc. and many borers of plants (Chattopadhyay, 1991).

B. Biological Control

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

C. Mechanical control

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

C.a. Bagging of fruits

Sometimes each and every fruit is covered by a paper or cloth bag to block the contact of flies with the fruit thereby protecting from oviposition by the fruit fly and it is quite useful when the flies are within the reach and the number of fruits to be covered and less and it is a tedious task for big commercial orchards (Kapoor, 1993). Bagging of the fruits against *Bactrocera cucurbitae* greatly promoted fruit quality and the yields and net income increased by 45 and 58% respectively in bitter gourd and 40 and 45% in sponge gourd (Fang, 1989). Amin (1995) obtained significantly lowest fruit fly infestation (4.61%) in bagged cucumber compared to other chemical and botanical control measures. Covering of fruits by polythene bag is an effective method to control fruit fly in teasel gourd and the lowest fruit fly incidence in teasel gourd occurred in bagging. Fruits (4.2%) while the highest (39.35) was recorded in the fruits of control plot (Anon., 1988).

C.b. Fruit picking

Systematic picking and destruction of infested fruits in proper manner to keep down the population is resorted to reduce the damages caused by fruit flies infesting cucurbits, guava, mango, peach etc. and many borers of plants (Chattopadhyay, 1991).

C.c. Wire Netting

Kapoor (1993) reviewed that fine wire netting may sometimes be used to cover small garden. Though it is a costly method, but it can effectively reduce the fruit fly infestation and protect the fruit from injury and deform, and also protects fruit crops against vertebrate pest.

D. Chemical control

The method of insecticide application is still popular among the farmers because of its quick and visible results but insecticide spraying alone has not yet become a potential method in controlling fruit flies. There are number of studies on the application of chemical insecticide in the form of cover sprays, bait sprays, attractants and repellents have been undertaken globally. Available information relevant these are given below:

D.a. Cover spray of insecticide

A wide range of organophosphoras, carbamate and synthetic pyrethroids of various formulations have been used from time to time against fruit fly (Kapoor, 1993; 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, different 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).

YubakDhoj (2001) reported that Fruit fly (*Bactrocera cucurbitae* Coquilet. Diptera: Tephritidae) is considered one of the production constraints in Nepal. Elsewhere integrated pest management of fruit flies (*B. cucurbitae*) is achieved by using combined control methods such as male annihilation, using cue lure and malathion in Steiners traps by disrupting mating with appropriate field sanitation, bagging of individual fruits, using pesticides in soils and with bait spraying along with hydrolysed protein. Babu and Viraktamath (2003a) reported that highest number of *B. dorsalis* was trapped in 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).

CHAPTER III

MATERIALS AND METHODS

The present study was conducted to evaluate the effectiveness of different trap for incidence and management of cucurbit fruit fly *(Bactrocera cucurbitae*) in the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, during November 2012 to April 2013. The materials and methods adopted in the study are discussed under the following heading and sub-headings-

3.1 Experimental Site

The experimental field was located at 90º 33.5´ E longitude and 23º 77.4´ N latitude at an altitude of 9 meter above the sea level. The field experiment was set up on the medium high land of the experimental farm.

3.2 Soil

The soil of the experiment site was a medium high land, clay loam in texture and having P^H 5.47-5.63. It had shallow red brown terrace soil. The land was located in Agro-ecological Zone of ‘Madhupur Tract’ (AEZ Number 28).

3.3 Climate

The climate of the experimental site is subtropical in nature with low temperature and scanty rainfall during November to April.

3.4 Design of the experiment and layout

The study was conducted with eight treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD). The entire experimental field was divided into three blocks. Each block was divided into eight plots. Two adjacent unit plots and blocks were separated by 1m apart. Each experimental plot comprised of 3m x 3m area and the total area covered 12m x 20.5m. Each treatment was allocated randomly within the block and replicated three times (Plate 1).

Plate 1. The experimental plot at SAU, Dhaka

3.5 Land Preparation

The experimental plot was ploughed thoroughly by a tractor drawn disc plough followed by harrowing. During land preparation, cow dung was incorporated into the soil at the rate of 10 t/ha. 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 Manures, Fertilizer and their Methods of Application

Manures and fertilizers with their doses and their methods of application followed in this study are shown in Table 1:

Table 1. Doses of manures and fertilizer and their methods of application used for this experiment

Manure/Fertilizer	Dose per ha (kg)	Basal dose (kg/ha)	Top dressing (kg/ha) First dose*	Top dressing (kg/ha) Second dose**
Cow dung	5 ton	Entire amount	------	------
Urea	130 kg		53	53
TSP	50 kg	Entire amount	------	------
MP	50kg	Entire amount	------	------
Gypsum	13kg	Entire amount	------	------

*30 days after sowing, **60 days after sowing

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 Collection and sowing of seeds

Seeds of sweet gourd (local) were collected from Agargoan Bazar, Dhaka. Seeds were sown in the experimental plots at the rate of 6 seeds/plot (3 seeds/pit and 2 pits/plot). Regular irrigation was done after sowing. Finally three healthy plants were kept in each pit. Damaged and virus infected seedlings were replaced by new one.

3.8 Cultural practices

After sowing the seeds, a light irrigation was applied to the plots. Subsequent irrigation was done and when needed. Sevin 85WP @ 1.5 kg/ha followed by a light irrigation was applied in soil around each plant in ring method and then covered with soil to avoid cutworm infestation. After germination of seedlings, soil of each plot was drenched with 1 % solution of Vitavax 200 to recover the plants from the anthracnose disease. Weeding and drainage facilities were provided as needed. Infestation of red pumpkin beetle was managed mechanically by hand picking. Dithane M-45@ 2.5 g/liter of water was applied at the flower initiation stage for controlling the prevailing anthracnose and downy mildew diseases.

3.9 Treatments

The comparative effectiveness of the following eight treatments for Cucurbit fruit fly was evaluated on the basis of reduction of this pest

T_1 = Pheromone Trap (Plastic pot)

T_2 = GME pheromone water Trap

T_3 = Sticky Trap

T_4 = Bait Trap

T_5 = Funnel pheromone Trap

T_6 = Light Trap

T_7 = Bait Trap + Pheromone Trap (Plastic pot)

T_8 = Only water in plastic pot (control)

Collection of trap and trap materials

The pheromone, Cuelure and GME pheromone water trap was collected from SAFE Agro Ltd. and other trap materials were collected from local market.

3.10 Preparation of the treatments

The pheromone, 'cuelure', which mimics the scent of female flies, attracts the male flies and traps them in large numbers resulting in mating disruption. Simple plastic containers developed by BARI scientists known as 'BARI trap' or popularly known as 'Magic trap' were used for deployment of the pheromones.

3.10.1 Pheromone Trap (Plastic pot)

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 3). 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 3: Pheromone trap (Plastic pot) **Plate 4:** GME Pheromone water trap

3.10.2 GME Pheromone water Trap: GME pheromone water trap was collected from Safe Agro limited (Plate 4).

3.10.3 Sticky Trap

Sticky trap was prepared with a yellow hard paper and cuelure used inside the hard paper (Plate 5). Grease was used as a sticky substances and it was applied on the hard paper twice in a week.

Plate 5: Sticky trap

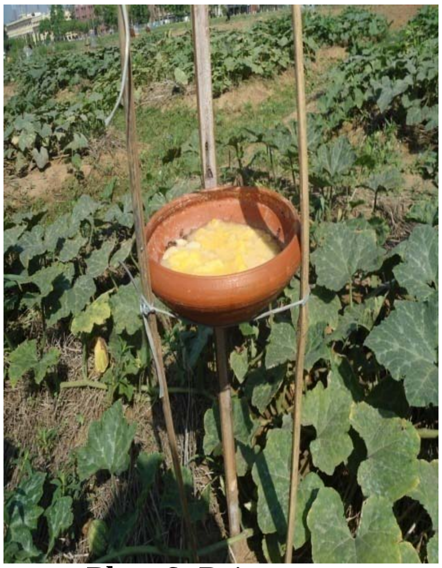


Plate 6: Bait trap

3.10.4. Bait Trap:

This poison bait was prepared from mashed sweet gourd mixed with water and Sevin 50WP at the rate of 2g per 100g of mashed sweet gourd (Plate 6). Freshly prepared baits in earthen pots were placed at plant height in sweet gourd field with the help of bamboo supports. Used baits were changed by freshly prepared baits within 2-3 days to attract more fruit flies.

3.10.5 Funnel pheromone Trap:

Pheromone trap was made up of a plastic bottle of with its both sides had two funnel. Cuelure was hanged inside the plastic bottle (Plate 7).

3.10.6 Light Trap:

Light trap was prepared from local market and florescent type light is used at whole night the fruiting stage (Plate 8).

3.10.7 Bait Trap+ Pheromone Trap (Plastic pot)

Both the bait trap and Pheromone trap (Plastic pot) used combinedly in a plot (Plate 9).

3.10.8 Only Water in plastic pot (Untreated control)

The plots under the untreated control were left only water in plastic pot. All other intercultural operations were similar to those of other treatments.

3.11 Application of the Treatments

Cuelure was set for three months, mashed sweet gourd and grease was changed twice in a week. The soap water in the pheromone traps was changed in every week.

3.12 Data collection

The whole reproductive period of sweet gourd was divided into three stages viz., early, mid and late fruiting stages. First flower initiation to 20 days was treated as early fruiting stage; 20 days to 40 days was called mid fruiting stage and after 40 days to the end of the final harvest was called late fruiting stage. The results of the effectiveness of different treatments were explained and discussed on the basis of some parameters The following parameters were considered and detailed methodology was given below:

The number of adult fly captured twice per week in different traps was recorded. The data on the number of healthy and infested fruits were recorded from each treatment.

After Harvesting the healthy fruits (HF) (Plate 10) and the infested fruits (IF) (Plate 11) were separated by visual observation.

Plate 11: Infested fruit

The effectiveness of each treatment was evaluated on the basis of some parameters. The following parameters were considered during data collection at each stage of reproduction.

3.13 Per cent fruit infestation by number

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:

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

3.14 Fruit yield

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

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

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

3.15 Statistical analysis

Data were analyzed by MSTAT-C software for proper interpretation. The data recorded on different parameters were subjected to analysis of variance (ANOVA) and the means were compared according to Duncan’s Multiple Range Test (DMRT) at 5% level of significance. Moreover, the graphical work was done using Microsoft Excel program.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment on the effect of different traps on incidence and management of cucurbit fruit fly in sweet gourd was conducted during November 2012 to April 2013 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 Effect of different traps on capturing adult cucurbit fruit fly

Trends of adult fruit fly captured in different traps

The number of adult fruit fly captured/trap in the experimental plot against different traps shown in Figure 1. The graph demonstrated that T_7 (Bait Trap + Pheromone Trap (Plastic pot)) showed the best performance in capturing adult fruit fly throughout cropping period. Almost same level of adult fruit fly was caught in T_5 (Funnel pheromone Trap). T_1 (Pheromone Trap (Plastic pot)), T_2 (GME pheromone water trap) and T_4 (Bait Trap) showed intermediate result among the different traps. No adult fruit fly was caught in T_3 (Sticky Trap) and T_6 (Light Trap) during the study period.

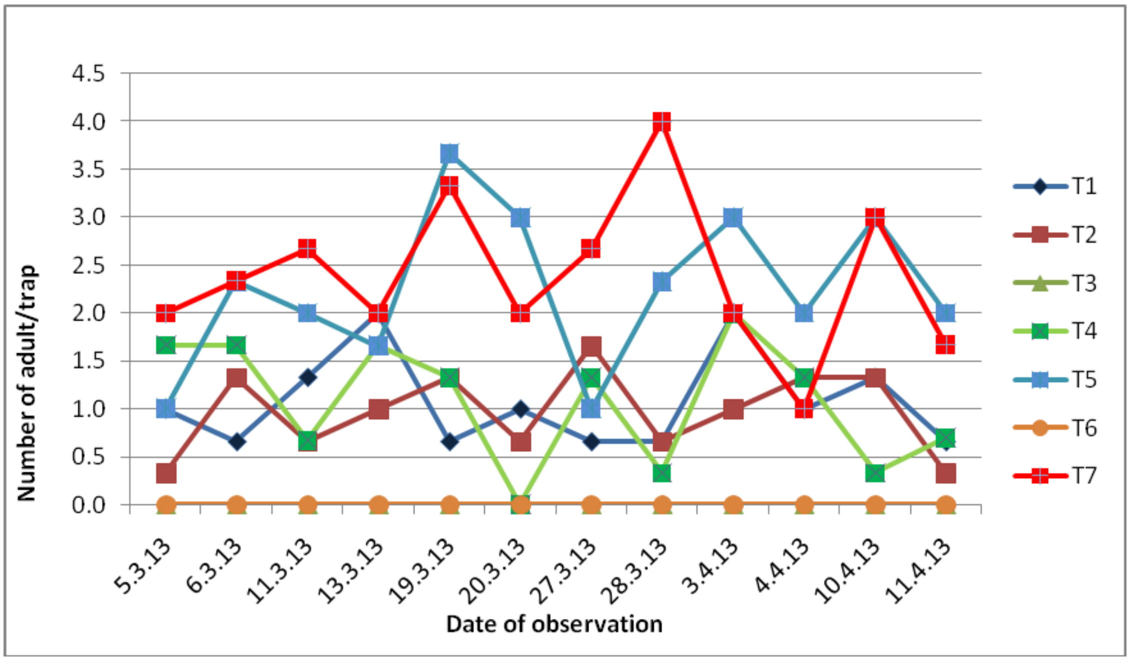


Figure 1. Trends of adult fruit fly captured in different traps.

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

4.1 Adult fruit fly captured at different fruiting stage

The data on the effect of different traps in capturing adult cucurbit fruit fly at early fruiting stage has been presented in Table 2. It was observed that the highest number of adult fruit fly (1.88) was captured in T_7 (Bait Trap+ Pheromone Trap (Plastic pot)) followed by 1.57 in T_5 (Funnel pheromone Trap), 1.42 in T_4 (Bait trap) and 1.25 in T_1 (Pheromone trap (plastic pot)) having no significant difference among them. Moreover, no adult fruit fly was trapped in T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot). Only 0.83 adult fruit fly was captured in T_2 (GME pheromone water trap) which was significantly higher than T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot) but lower than other treatments.

The data in Table 2 also expressed that the highest number of adult fruit fly (3.00) was captured in T_7 (Bait Trap+ Pheromone Trap (Plastic pot)) followed by 2.50 in T_5 (Funnel pheromone Trap) and 1.50 in having no T_4 (Bait trap) significant difference among them. In contrast no adult fruit fly was trapped in T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot). The intermediate number of adult fruit fly (1.08) was captured in T_2 (GME pheromone water trap) followed by 0.75 in T_1 (Pheromone trap (plastic pot)) which were significantly higher than T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot) and lower than other treatments.

Similarly, the highest number of adult fruit fly (2.50) was captured in T_5 (Funnel pheromone Trap) during late fruiting stage followed by 1.92 in T_7 (Bait Trap + Pheromone Trap (Plastic pot)) and 1.25 in T_1 (Pheromone trap (plastic pot)) having no significant difference among them. But no adult fruit fly was trapped in T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot). However, the intermediate number of adult fruit fly (1.08) was captured in T_4 (Bait trap) followed by 1.00 in T_2 (GME pheromone water trap) which were significantly higher than T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot) and similar with T_1 and $T_{7.}$

During the total cropping period, the highest number of adult fruit fly (6.80) was captured in T_7 (Bait Trap + Pheromone Trap (Plastic pot)) followed by 6.57 in T_5 (Funnel pheromone Trap) and 4.00 in T_4 (Bait trap) having no significant difference among them. The intermediate number of adult fruit fly (3.25) recorded from T_1 (Pheromone trap (plastic pot)) which is significantly similar with the T_2 and T_4, higher than T_3, T_6 and T_8 and lower than T_7 and $T_{5.}$ No adult fruit fly was trapped in T_3 (Sticky Trap), T_6 (Light

Trap) and T_8 (Control plot) which was statistically similar with T_2 (2.92) comprised of GME pheromone water trap.

The result of the study indicates that the treatment T_7 (Bait Trap+ Pheromone Trap (Plastic pot)) showed the best performance in capturing adult fruit fly and T_5 (Funnel pheromone Trap) also gave the same result. Moreover, T_4 (Bait trap), T_1 (Pheromone trap (plastic pot)) and T_2 (GME pheromone water trap) captured intermediate level of adult fruit fly during the study period. But T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot) had no effect on capturing the adult fly. 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.

Table 2: Number of adult fruit fly captured in various traps at different stages of sweet gourd

Treatments	Number of adult/ plot at early fruiting stage	Number of adult/ plot at mid fruiting stage	Number of adult/ plot at late fruiting stage	Total number of adult/ plot
T_1	1.25 ab	0.75 cd	1.25 abc	3.25 b
T_2	0.83 b	1.08 cd	1.00 bc	2.92 bc
T_3	0.00 c	0.00 d	0 .00 c	0.00 c
T_4	1.42 ab	1.50 bc	1.08 bc	4.00 ab
T_5	1.57 a	2.50 ab	2.50 a	6.57 a
T_6	0 .00 c	0.00 d	0 .00 c	0.00 c
T_7	1.88 a	3.00 a	1.92 ab	6.80 a
T_8	0.00 c	0.00 d	0.00 c	0.00 c
LSD (0.05)	**0.59**	**1.29**	**1.29**	**2.75**

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

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

4.2 Effect of different traps on production of healthy and infested fruits by number and fruit infestation

4.2.1 Early fruiting stage

The effect of different traps on production of number healthy fruits/plot at early fruiting stage of sweet gourd has been shown in Table 3. The highest number of healthy fruits/plot (2.33) was harvested from T_7 (Bait trap + Pheromone trap (plastic pot)) followed by 2.00 in T_4 (Bait trap), 1.67 in T_2 (GME pheromone water trap) and T_5 (Funnel pheromone trap) having no significance difference among them. The lowest number of healthy fruits/plot (1.00) was harvested from T_3 (Sticky trap), T_6 (Light trap) and T_8 (Control plot) which were statistically similar with T_2, T_5 and $T_{1.}$

The data on number of infested fruits/plot have shown Table 3. It was found that the lowest number of infested fruits/plot (0.33) were harvested from T_1 (Pheromone trap (plastic pot)), T_4 (Bait trap), T_5 (Funnel pheromone trap) and T_7 (Bait trap + Pheromone trap (plastic pot)) followed by 0.67 in T_2 (GME pheromone water trap) having no significant difference among them. The highest number of infested fruits/plot (1.33) were harvested from T_8 (Control plot) followed by 1.00 in T_3 (Sticky trap) and T_6 (Light trap). No significant difference was observed in terms of number of infested fruits/plot at early fruiting stage.

Similarly, the lowest level of infestation (11.11%) was recorded from T_4 (Bait trap), T_5 (Funnel pheromone trap) and T_7 (Bait trap +Pheromone trap (plastic pot)) followed by 16.67% in T_1 (Pheromone trap (plastic pot)) and 22.22% in T_2 (GME pheromone water trap) having no significant difference among them (Table 3). Moreover, the highest level of infestation was obtained in the fruits harvested from the control plot T_8 (55.55%) followed by 50.00% in T_3 (Sticky trap) and T_6 (Light trap) which was statistically similar with T_2 (22.22%) comprised of GME pheromone water trap and $T_{1.}$

Table 3: Effect of different traps on production of healthy fruits and fruit infestation by cucurbit fruit fly at early fruiting stage

Treatments	Number of		% fruit infestation
	Healthy fruits/plot	Infested fruits/plot	
T_1	1.33 bc	0.33	16.67 bc
T_2	1.67 abc	0.67	22.22 abc
T_3	1.00 c	1.00	50.00 ab
T_4	2.00 ab	0.33	11.11 c
T_5	1.67 abc	0.33	11.11 c
T_6	1.00 c	1.00	50.00 ab
T_7	2.33 a	0.33	11.11 c
T_8	1.00 c	1.33	55.55 a
LSD (0.05)	**0.76**	**---**	**31.20**
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} indicates non significant.

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

4.2.2 Mid fruiting stage

At the mid fruiting stage, the maximum number of healthy fruits/plot (2.33) was obtained from T_7 (Bait trap + Pheromone trap (plastic pot)) followed by 2.00 in T_5 (Funnel pheromone Trap), 1.67 in T_1 (Pheromone trap (plastic pot)), T_4 (Bait trap) and 1.33 in T_2 (GME pheromone water trap) having no significant difference among them (Table 4). The minimum number of healthy fruits/plot (1.00) was harvested from treatment T_8 (Control plot), T_3 (Sticky trap) and T_6 (Light trap). The result of the study indicates that control treatment, T_3 (Sticky trap) and T_6 (Light trap) had same level of result and no significant difference was observed in terms of number of healthy fruits/plot at mid fruiting stage.

The lowest number of infested fruits/plot (0.33) was harvested from T_2 (GME pheromone water trap) T_4 (Bait trap) and T_5 (Funnel pheromone trap) which had no significant difference among them (Table 4). The intermediate number of infested fruits/plot (0.67) was observed from T_7 (Bait trap + Pheromone trap (plastic pot)) and T_1 (Pheromone trap (plastic pot)). In contrast, the highest number of infested fruits/plot (1.00) was recorded from T_3 (Sticky trap), T_6 (Light trap) and T_8 (Control plot). No significant difference was observed in terms of number of infested fruits/plot.

The data in Table 4 also indicated that the lowest level of infestation (11.11%) was recorded from T_2 (GME pheromone water trap) and T_5 (Funnel pheromone Trap) followed by 27.77% in T_1 (Pheromone trap (plastic pot)) 16.67% in T_4 (Bait trap), 19.44% in T_7 (Bait trap + Pheromone trap (plastic pot)) having no significant difference among them (Table 4). The highest level of infestation (50.00%) was obtained from the T_8 (Control plot), T_3 (Sticky trap) and T_6 (Light trap). The result of the study indicates that T_8 (Control plot), T_3 (Sticky trap) and T_6 (Light trap) have same level of fruit infestation.

Table 4: Effect of different traps on production of healthy fruits and fruit infestation by cucurbit fruit fly at mid fruiting stage

Treatments	**Number of**		**% fruit infestation**
	Healthy fruits/plot	**Infested fruits/plot**	
T_1	1.67	0.67	27.77 ab
T_2	1.33	0.33	11.11 b
T_3	1.00	1.00	50.00 a
T_4	1.67	0.33	16.67 ab
T_5	2.00	0.33	11.11 b
T_6	1.00	1.00	50.00 a
T_7	2.33	0.67	19.44 ab
T_8	1.00	1.00	50.00 a
LSD (0.05)	**---**	**---**	**31.46**
Level of significance	**NS**	**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} indicates non significant.

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

4.2.3 Late fruiting stage

The data on effect of different traps in number of healthy fruits/plot at late fruiting stage have been shown in Table 5. It was observed that no significant difference was observed among the different traps in terms of number of healthy fruits/plot at late fruiting stage. However, the highest number of healthy fruits/plot (2.00) was harvested from T_5 (Funnel pheromone trap) followed by 1.67 in T_7 (Bait trap + Pheromone trap (plastic pot)) and T_1 (Pheromone trap (plastic pot)) which had no significant difference among them (Table 5). The minimum number of healthy fruits/plot (1.00) was harvested from treatment T_8 (Control plot), T_3 (Sticky trap) and T_6 (Light trap). The intermediate number of healthy fruits/plot (1.33) was observer in T_2 (GME pheromone water trap).

Similarly no significant difference observed among the difference traps in terms of number of infested fruits/plot at late fruiting stage (Table 5). But the lowest number of infested fruits/plot (0.33) was harvested from T_7 (Bait trap + Pheromone trap (plastic pot)), T_1 (Pheromone Trap (Plastic pot) and T_5 (Funnel pheromone trap) followed by 0.67 in T_2 (GME pheromone water trap), T_3 (Sticky Trap), T_4 (Bait Trap). In contrast, the highest number of infested fruits/plot (1.00) was harvested from T_8 (control plot).

Similarly, the lowest level of infestation (11.11%) was recorded in Table 5 from T_7 (Bait trap + Pheromone trap (plastic pot)) followed by 16.67% in T_5 (Funnel pheromone trap) and T_1 (Pheromone Trap (Plastic pot)) and the highest per cent of infestation was obtained in the fruits harvested from the untreated control plot T_8 (50.00%) which was higher than that of all other treatments (Table 5). Among the treated plots, T_3 (Sticky trap), (Light trap) showed the highest per cent fruits infestation by number (50.00%).

Table 5: Effect of different traps on production of healthy fruits and fruit infestation by cucurbit fruit fly at late fruiting stage

Treatments	Number of		% fruit infestation
	Healthy fruits/plot	Infested fruits/plot	
T_1	1.67	0.33	16.67
T_2	1.33	0.67	33.33
T_3	1.00	0.67	33.33
T_4	1.00	0.67	33.33
T_5	2.00	0.33	16.67
T_6	1.00	0.67	33.33
T_7	1.67	0.33	11.11
T_8	1.00	1.00	50.00
Level of significance	**NS**	**NS**	**NS**

^{NS} indicates non significant.

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

4.2.4 Effect on increase of healthy fruit or decrease of infested fruit and per cent fruit infestation at different fruiting stages

The result on effect of different traps on per cent increase of healthy fruits has been presented in Figure 2. The graph (Figure 2) illustrated that the highest per cent increase of healthy fruit (152.8%) was found in T_7 (Bait trap+ pheromone trap [plastic pot]) at early stage. In contrast no increment was found in terms of per cent increase of number of fruits for T_3 (Sticky trap) and T_6 (Light trap). At mid stage, the highest per cent increase of healthy fruit (119.44%) was also obtained from the same treatment (Bait trap+ pheromone trap (plastic pot)) and similar result was found in T_3 (Sticky trap) and T_6 (Light trap). At late stage the highest per cent increase of healthy fruit (100.0%) was found in T_5 (Funnel pheromone trap) and no increment occurred for T_3 (Sticky trap) and T_6 (Light trap). Thus, T_7 (Bait trap+ pheromone trap (plastic pot)) gave the best result for increasing number of sweet gourd fruits over control at the end of the crops. T_3 (Sticky trap) and T_6 (Light trap) gave the same result as control plot. Other traps also increased number of fruits over untreated control.

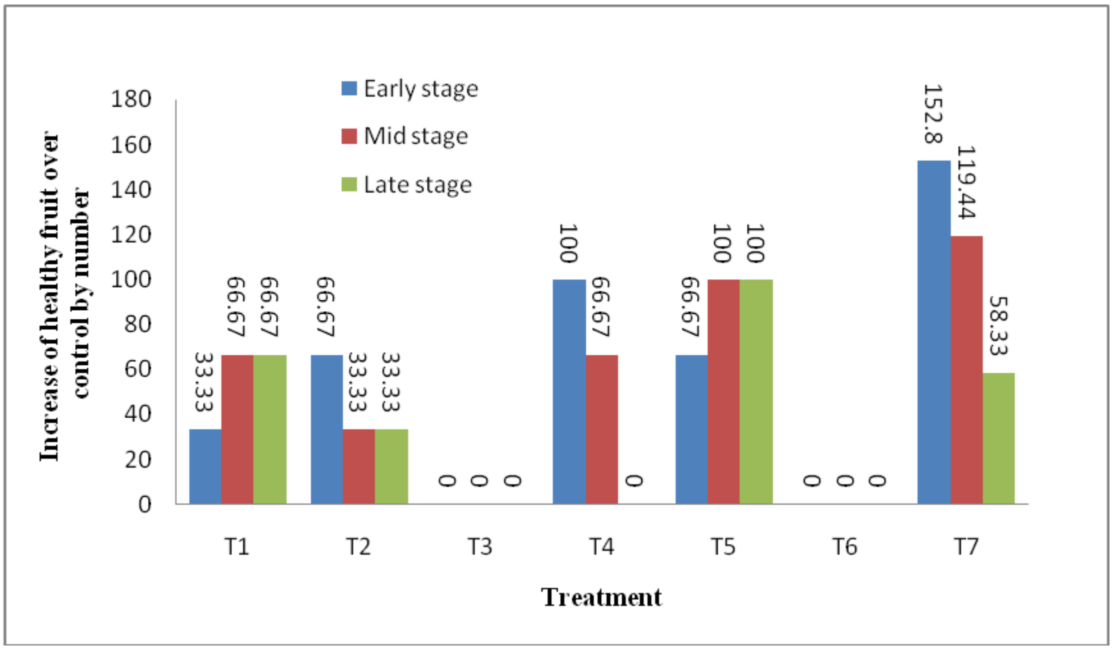


Figure 2: Effect of different traps on per cent increase of healthy fruit by number over control

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

Similarly, the effect of different traps on per cent decrease of fruit fly infested fruit over control has been shown in Figure 2. The highest per cent decrease of infested fruit (83.33%) was obtained in T_5 (Funnel pheromone trap) and T_1 (Pheromone trap (plastic pot)) at early stage and lowest per cent decrease of infested fruit (16.67%) was shown in T_3 (Sticky trap) and T_6 (Light trap). At mid stage, the best effect (66.67% decrease of infested fruit over control) was found in T_2 (GME pheromone water trap), T_4 (Bait trap), T_5 (and funnel pheromone trap) but T_3 (Sticky trap) and T_6 (Light trap) had no effect on per cent decrease of number of infested fruit over control. At late stage, the highest per cent decrease of infested fruit (77.78%) was shown in T_7 (Bait trap+ pheromone trap (plastic pot)) and lowest per cent decrease of infested fruit (33.33%) was shown in T_3 (Sticky trap) and T_6 (Light trap).

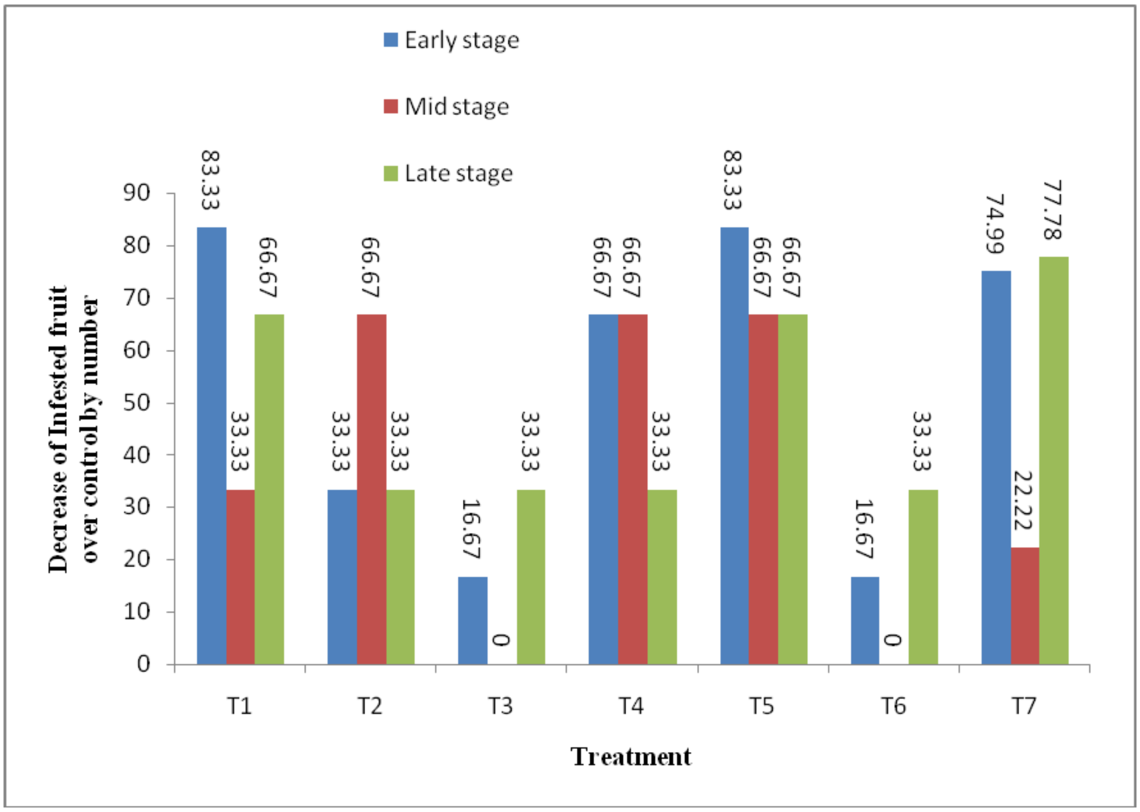


Figure 3: Effect of different traps on per cent decrease of infested fruit by number over control

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

The comparative effect of different traps (Treatment) on fruit infestation by fruit fly at early, mid and late fruiting stage has been demonstrated in Figure 4. The graph illustrated that the lowest level of fruit infestation was observed in T_4 (Bait trap) at early stage, T_5 (Funnel pheromone trap) and T_2 (GME pheromone water trap) at mid stage, and T_7 (Bait trap + Pheromone trap (plastic pot)) at late stage. More than 50% fruit infestation was observed in control plot (T_8) during fruiting stage of sweet gourd. Fifty per cent fruit infestation was also recorded from T_3 (Sticky trap) and T_6 (Light trap) at early and mid fruiting stages.

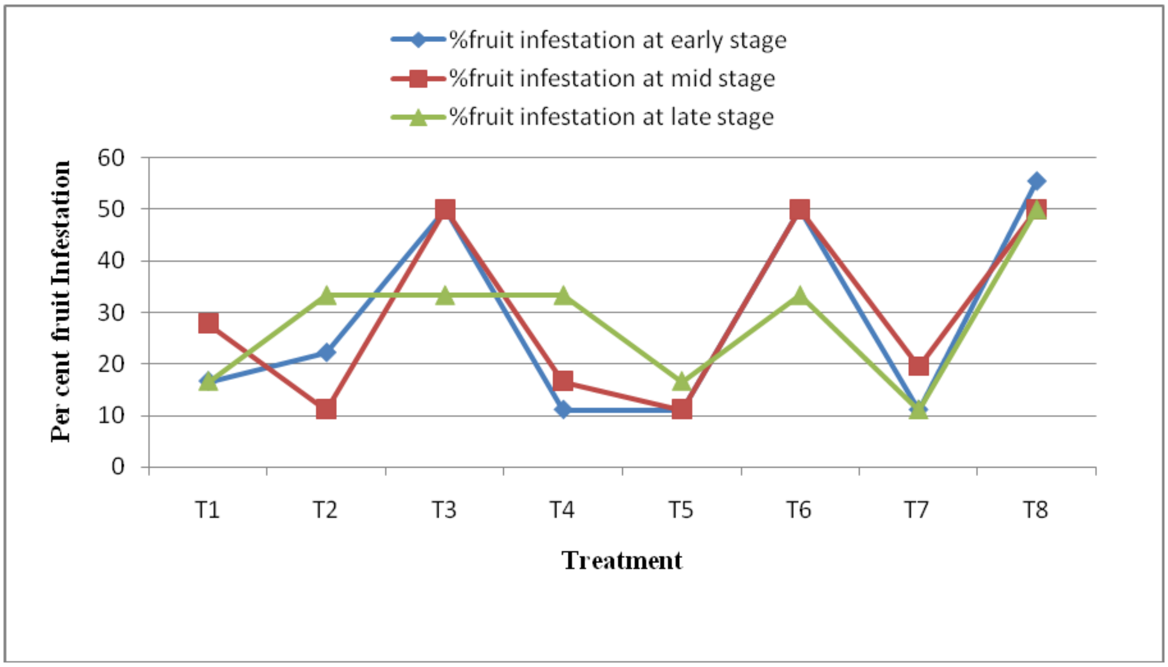


Figure 4: Effect of different traps on per cent fruit infestation at different fruiting stages.

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

4.2.5 Effect of different traps on healthy and infested fruit production during total cropping season

4.2.5.1 Effect on production of healthy fruits/plot by number

The data on effect of different traps on number of healthy fruits/plot during total cropping period have been presented in Table 6. It was found that he highest number of healthy fruits/plot (6.33) was recorded from T_7 (Bait trap + pheromone trap (plastic pot)) followed by 5.67 in T_5 (Funnel pheromone trap) with no significant difference between them. The intermediate number of healthy fruits/plot (4.33 - 4.67) was recorded from T_1 (Pheromone Trap (Plastic pot)), T_4 (Bait Trap) and T_2 (GME pheromone water trap) and 4.67 having no significant difference among them. The equal number of healthy fruits/plot (3.00) was obtained from T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (control) which was significantly lower than other treatments. Similarly in case of per cent increase of number of fruits over control by number, T_7 (Bait trap + pheromone trap (plastic pot)) gave the best result (111.1%) having no significant variation with T_5 (88.89%) (Table 6) but significantly differed with others.

On the other hand, no increment occurred in T_3 (sticky trap) and T_6 (light trap). Further, 55.55% increase of fruit over control was obtained from T_1 (Pheromone Trap (Plastic pot)), and T_4 (Bait Trap) which was statistically similar to T_2 (GME pheromone water trap) (44.44%) but significantly higher than T_3 and T_6 and lower than T_7 and $T_{5.}$

4.2.5.2 Effect on production of infested fruits/plot by number

The lowest number of infested fruits/plot was (1.33) recorded from T_7 (Bait trap + pheromone trap (plastic pot)), T_4 (Bait Trap), T_1 (Pheromone Trap (Plastic pot)) followed by 1.00 in T_5 (Funnel pheromone trap) having no significant difference among them (Table 6). The highest number of infested fruits/plot (3.33) was recorded in T_8 (Control plot). The intermediate number of infested fruits/plot (2.67) was recorded T_6 (Light Trap) and T_3 (Sticky plot) followed by 1.67 in T_2 (GME pheromone water trap) which is statistically similar. The data (Table 6) also expressed that the highest per cent decrease of fruit infestation (69.44%) was found in T_5 (Funnel pheromone trap) followed by 61.80% in T_7 (Bait trap + pheromone trap (plastic pot)), 61.11% in T_1 (Pheromone Trap (Plastic pot)) and T_4 (Bait Trap), and 47.22% T_2 (GME pheromone water trap) which were statistically same. The lowest result (16.67%) was observed in T_3 (sticky plot) and 19.44% was observed in T_6 (Light Trap) having no significant difference between them but significantly lower than others.

4.2.5.3 Effect on fruit infestation

The lowest per cent fruit infestation (15.59%) was observed in T_5 (Funnel pheromone trap) followed by 16.93% in T_7 (Bait trap + pheromone trap (plastic pot)), 22.22% in T_1 (Pheromone Trap (Plastic pot)) and T_4 (Bait Trap), 27.77 in T_2 (GME pheromone water trap) which are statistically same. The highest per cent fruit infestation (52.38%) was observed in T_8 (Control plot) followed by 46.67% in T_3 (Sticky trap) and T_6 (Light trap). It was also observed that T_3 (Sticky trap) and T_6 (Light trap) had same level (46.67%) of fruit infestation (Table 6).

The result of the study indicate that the treatment T_7 (Bait Trap+ Pheromone Trap (Plastic pot)) gave the best result for production of healthy sweet gourd fruit and reduction of fruit fly infested fruit. T_5 (Funnel pheromone Trap) also gave the similar results in producing healthy fruit and reducing infested fruit. Moreover, T_1 (Pheromone Trap (Plastic pot)), T_2 (GME pheromone water trap) and T_4 (Bait Trap) gave the intermediate result regarding the production of healthy and infested fruit against fruit fly infestation. T_3 (Sticky Trap) and T_6 (Light Trap) had no significant inhibitory effect on fruit fly attacking sweet gourd. Result of this experiment agrees 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 production by controlling cucurbit fruit fly.

Table 6: Effect of different traps on production of healthy fruits and fruit infestation by cucurbit fruit fly during total cropping season

Treatments	Number of healthy fruits/plot	% increase of healthy fruit over control by number	Number of infested fruits/plot	% decrease of infested fruit over control by number	% fruit infestation
T_1	4.67 b	55.55 b	1.33 c	61.11 a	22.22 b
T_2	4.33 b	44.44 b	1.67 bc	47.22 ab	27.77 b
T_3	3.00 c	0.00 c	2.67 ab	16.67 b	46.67 a
T_4	4.67 b	55.5 b	1.33 c	61.11 a	22.22 b
T_5	5.67 a	88.89 a	1.00 c	69.44 a	15.59 b
T_6	3.00 c	0.00 c	2.67 ab	19.44 b	46.67 a
T_7	6.33 a	111.1 a	1.33 c	61.8 a	16.93 b
T_8	3.00 c	----	3.33 a	------	52.38 a
LSD (0.05)	**0.81**	**29.42**	**1.00**	**30.48**	**13.10**
Level of significance	*	*	*	*	*

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

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

4.3 Effect of different traps on weight of healthy and infested fruits

4.3.1 Weight of healthy fruits/plot at early fruiting stage

The data on effect of different traps in fruit weight of healthy sweet gourd at early fruiting stage has been presented in Table 7. Significant variation was observed in terms of healthy fruit weight and increase of healthy fruit weight over control at early fruiting stage. Result showed that the highest amount of healthy fruits/plot (3.89 kg) was observed in T_7 (bait trap + pheromone trap (plastic pot)) followed by 2.52 kg in T_5 (Funnel pheromone trap) and 2.44 kg in T_4 (Bait trap) having no significant difference among them. The lowest amount of healthy fruits/plot (0.50 kg) was observed in control treatment (T_8). Among the other treatments, the lowest weight of healthy fruits/plot (0.58 kg) was recorded from T_3 (Sticky trap) followed by 0.91 kg in T_6 (Light trap), 1.88 kg in T_2 (GME pheromone water trap) and 1.98 kg in T_1 (Pheromone Trap (Plastic pot)) with no significant difference among them. Similarly, the per cent increase of healthy fruit weight over control at early fruiting stage was 719.8% in treatment T_7 (Bait trap + Pheromone trap (plastic pot)) followed by 410.2% in T_5 (Funnel pheromone trap) having no significance difference between them. The intermediate per cent increase of weight over control was found in T_4 (390.8%), T_1 (288.6%) and T_2 (270.6%) having no significant difference (Table 7). Plots treated with other traps gave the lowest result (16.25% in T_3 and 81.67% in T_6) in terms of per cent increase of healthy fruit weight per plot.

4.3.2 Weight of healthy fruits/plot at mid fruiting stage

At mid flowering stage, the highest weight of healthy fruit (2.50kg) was observed from T_7 (Bait trap + Pheromone trap (plastic pot)) followed by 2.17kg in T_5 (Funnel pheromone trap) 2.13kg in T_1 (Pheromone trap) and 1.52kg in T_4 (Bait trap) having no significance difference among them (Table 7). The lowest weight of healthy fruit (0.50kg) was obtained from control plot followed by 0.73kg in T_6 (Light trap), 0.96 in T_3 (Sticky trap) and 1.06kg in T_2 (GME pheromone water trap) which have no significance difference among them. The per cent increase of yield over control by weight at mid fruiting stage (332.40%) was obtained from treatment T_7 (Bait trap + Pheromone trap (plastic pot)) followed by 282.17% in T_5 (Funnel pheromone trap), 262.2% in T_4 (Bait trap) and (282.17%) in T_1 (Pheromone trap) having no significance difference among them (Table 7). The lowest per cent increase of healthy fruit weight over control

(38.62%) was obtained from T_6 (Light trap) followed by 96.19% in T_2 (GME pheromone water trap) and 137.54% in T_3 (Sticky trap) which were statistically similar.

4.3.3 Weight of healthy fruits/plot at late fruiting stage

At late fruiting stage, the highest weight of healthy fruit (2.36kg) was observed from T_5 (Funnel pheromone trap) followed by 2.22kg in T_7 (Bait trap + Pheromone trap (plastic pot)) and 2.03kg in T_1 (Pheromone trap) having no significant differences among them (Table 7). The lowest weight of healthy fruit observed from the control plot followed by T_6 (Light trap) and T_3 (Sticky trap) having no significant differences among them. The per cent increase of yield over controlled by weight at late fruiting stage (368.68%) was obtained from treatment T_5 (Funnel Pheromone trap) followed by 367.37% in T_7 (Bait trap + Pheromone trap (plastic pot)), 250.37% in T_1 (Pheromone trap) having no significant differences among them. Among the plot, the lowest per cent increase of yield over control (38.91%) was obtained from T_3 (Sticky trap) followed by 66.00% in T_6 (Light trap) having no significant differences among them (Table 7).

4.3.4 Yield of healthy fruits/plot during total cropping season

Data in Table 7 also expressed that significant variation was observed in terms of total weight of healthy fruits/plot. It was observed that the highest weight of healthy fruits/plot (8.61kg) was obtained from treatment T_7 (Bait trap + pheromone trap (plastic trap)) followed by 7.05 kg from T_5 (Funnel pheromone trap) having no significant difference between them (Table 7) but variation was existed with other treatments. Intermediate result was obtained from T_1 (6.15kg), T_4 (5.57kg) and T_2 (4.59 kg). No significant variation was found among them in terms of producing healthy fruits/plot. Statistically similar result was found in T_8 (1.64kg) (control plot), T_3 (2.38kg) (sticky trap) and T_6 (2.65kg) (light trap) which was significantly lower than other treatments.

4.3.5 Increase of healthy fruit yield/plot over control during total cropping season

The total per cent increase of weight over control (438.9%) was obtained from T_7 (Bait trap + pheromone trap (plastic pot)) followed by 330.6% in T_5 (Funnel pheromone trap) having no significance difference between them (Table 7). The intermediate result was shown in T_1 (278.5%) (Pheromone trap (plastic pot)) and T_4 (242.1%) (Bait trap) which was statistically similar with T_5. The lowest result (44.89% increase of healthy fruit weight) was found in T_3 (sticky trap) followed by (62.12%) in T_6 (light trap) having no significant difference among them but significantly lower than all other treatments.

The result of the study indicate that the treatment T_7 (Bait Trap + Pheromone Trap (Plastic pot)) and T_5 (Funnel pheromone Trap) gave the best result for production of healthy fruit. T_1 (Pheromone Trap (Plastic pot)), T_2 (GME pheromone water trap) and T_4 (Bait Trap) gave the intermediate result regarding the production of healthy fruit against fruit fly infestation. Moreover, T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot) had lowest effect on fruit weight among the treatments. 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 effecting 40% to 65% reduction in fruit fly infestation and damage to the fruits and producing 2-4 times higher yields.

Table 7. Effect of different traps on fruit weight, per cent increase and decrease of yield over control by weight of sweet gourd at total, early, mid and late fruiting stage

Treatments	**At early fruiting stage**		**At mid fruiting stage**		**At late fruiting stage**		**Total**	
	Weight of healthy fruits/plot (kg)	**% increase of healthy fruit weight over control**	**Weight of healthy fruits/plot (kg)**	**% increase of healthy fruit weight over control**	**Weight of healthy fruits/plot (kg)**	**% increase of healthy fruit weight over control**	**Weight of healthy fruits/plot (kg)**	**% increase of healthy fruit weight over control**
T_1	1.98 bc	288.6 bc	2.13	281.27	2.03	250.37	6.15 bc	278.5 bc
T_2	1.88 bc	270.6 bc	1.06	96.19	1.64	189.75	4.59 c	181.5 c
T_3	0.58 c	16.25 c	0.96	137.54	0.83	38.91	2.38 d	44.89 d
T_4	2.44 ab	390.8 b	1.52	262.42	1.62	218.39	5.57 bc	242.1 bc
T_5	2.52 ab	410 ab	2.17	282.17	2.36	368.68	7.05 ab	330.6 ab
T_6	0.91 bc	81.67 bc	0.73	38.62	1.02	66.00	2.65 d	62.12 d
T_7	3.89 a	719.8 a	2.50	332.40	2.22	367.37	8.61 a	438.9 a
T_8	0.50 c	-------	0.50	------	0.63	------	1.64 d	-------
LSD(0.05)	**1.59**	**314.9**	**----**	**-------**	**------**	**-------**	**1.72**	**118.9**
Level of significance	*	*	NS	NS	NS	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} indicates non significant.

T_1= Pheromone Trap (Plastic pot), T_2= GME pheromone water trap, T_3= Sticky Trap, T_4= Bait Trap, T_5= Funnel pheromone Trap, T_6= Light Trap, T_7 = Bait Trap+ Pheromone Trap (Plastic pot), T_8= Only water in plastic pot (Control).

Relationship between number of adult trapped/plot and total fruit yield among different traps

The relationship between the number of adult trapped/plot and total fruit yield in different traps is shown in Figure 5. The graph demonstrated that there was strong positive relationship between the number of adult trapped/plot and total fruit yield in different traps which suggested that with the increase in number of adult trapped there was a significant influenced on total fruit yield. It was also evident that the equation y = 0.848x+ 2.334 gave a good fit to the data and the co-efficient of determination (R^2 = 0.934) fitted regression line had a significant regression co-efficient.

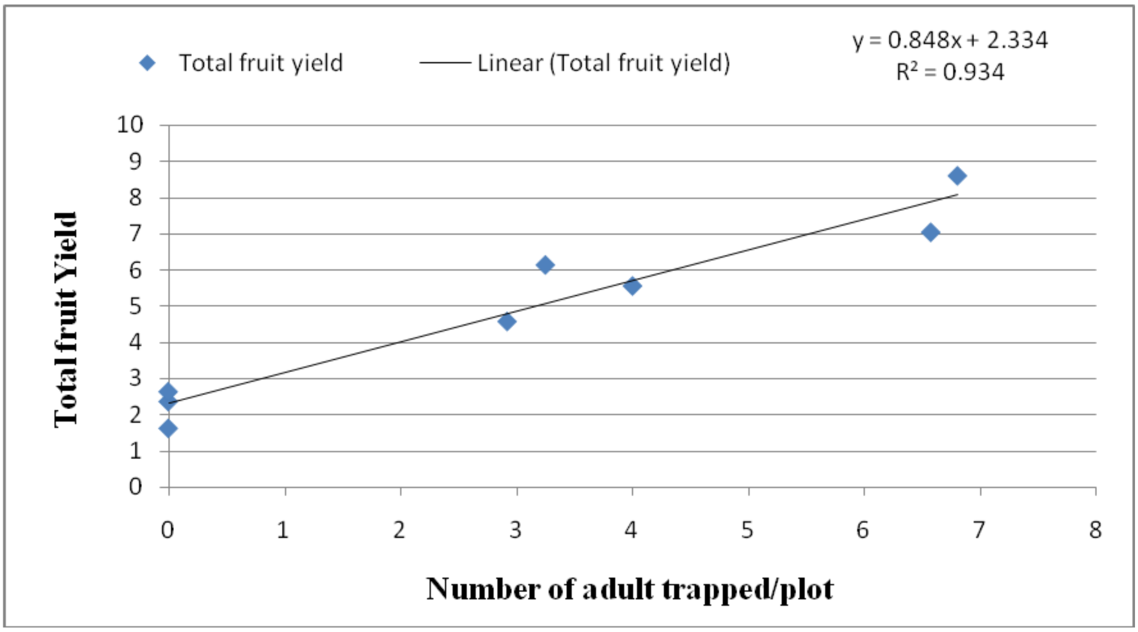
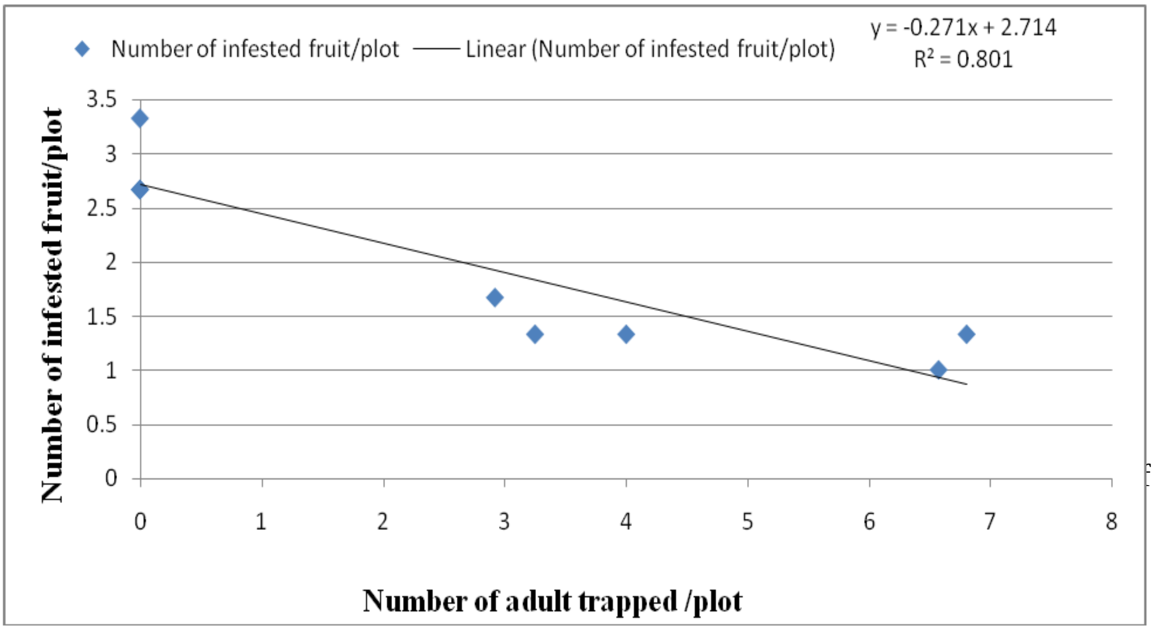


Figure 5: Relationship between number of adult trapped/plot and total fruit yield among different traps.

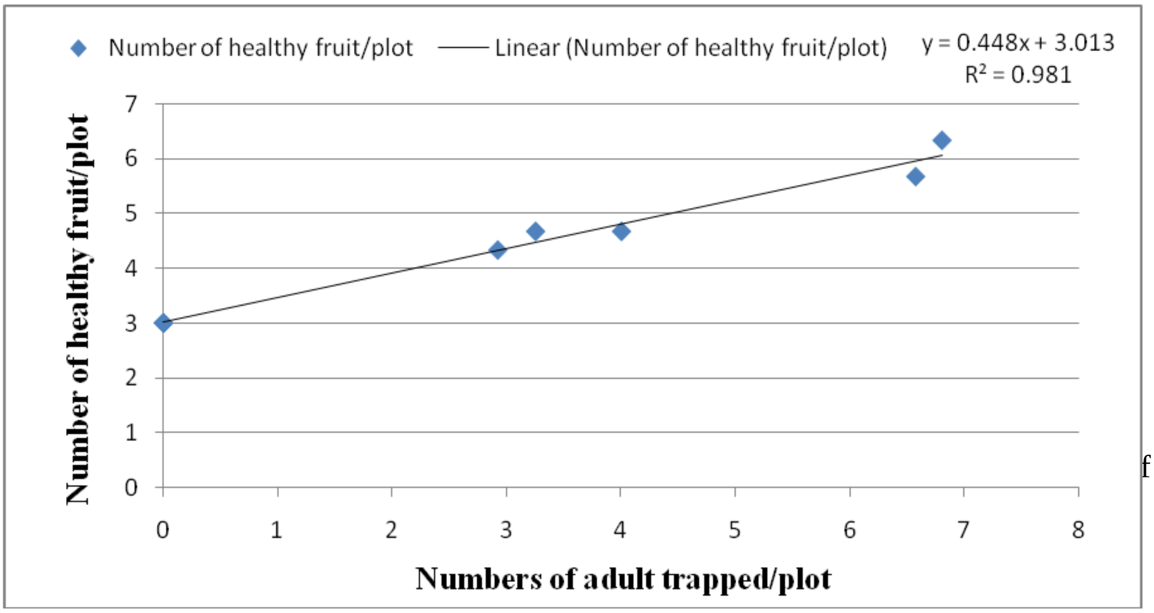
Relationship between numbers of adult trapped/plot and total number of infested fruit by different traps

The relationship between the number of adult trapped/plot and total number of infested fruit in different traps is shown in Figure 6. The result revealed that there was negative relationship between the number of adult trapped/plot and total number of infested fruit in different traps which suggested that with the increase of average insect trapped by different traps there was a decrease of total number of infested fruit (Fig: 6) It was evident that the equation y = -0.271x+2.714 gave a good fit to the data and the co-efficient of determination (R^2 = 0.801) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that total number of infested fruit was strongly as well as negatively related with the adult fruit fly trapped by different traps.



Relationship between number of adult trapped/plot and number of healthy fruit by different traps

The relationship between the number of adult trapped/plot and total number of healthy fruit in different traps is shown in Figure 7. The graph (Figure 7) revealed that strong positive relation was observed between the number of adult trapped/plot and total number of healthy fruit in different traps, which suggested that with the increase of adult fruit fly trapped there, was increase of total number of healthy fruit. It was evident that the equation $y = 0.448x + 3.013$ gave a good fit to the data and the co-efficient of determination ($R^2 = 0.981$) fitted regression line had a significant regression co-efficient. In the presented study, it was observed that cucurbit fruit fly passively prevented plants to produce healthy fruit.



CHAPTER V

SUMMARY

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, *Bactrocera cucurbitae* during November 2012 to April 2013. The treatments of the experiment were T_1 = Pheromone Trap (Plastic pot), T_2 = GME pheromone water Trap, T_3 = Sticky Trap, T_4 = Bait Trap, T_5 = Funnel pheromone Trap, T_6 = Light Trap, T_7 = Bait Trap + Pheromone Trap (Plastic pot) and T_8 = Only water in plastic pot (Control). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole reproductive period of sweet 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 at early, mid and late fruiting stage, total yield and presence of cucurbit fruit fly at different fruiting stage. Healthy fruits/plot, infested fruits/plot, per cent fruit infestation, per cent increase over control and per cent decrease over control was considered at each of the stage.

Among the eight treatments, it was observed that T_7 (Bait trap + pheromone trap (plastic pot)) was the most effective treatment for early (1.88), mid (3.00), late (1.92) and total (6.80) number of adult trapped/plot respectively. T_5 (Funnel pheromone trap) was also showed good result at early (1.57), mid (2.50), late (2.50) and total (657) number of adult trapped/plot respectively. But no adult fruit fly was trapped in T_3 (Sticky Trap), T_6 (Light Trap) and T_8 (Control plot).

The highest number of healthy fruits/plot (2.33), lowest number of infested fruits/plot (0.33) and lowest per cent fruit infestation by number (11.11%) at early fruiting stage was achieved from T_7 (Bait trap + Pheromone trap(plastic pot)). Funnel pheromone trap (T_5) also showed similar result and intermediate result was found in T_1 (Pheromone trap (plastic pot)), T_4 (Bait trap) and T_2 (GME pheromone water trap). On the other hand, lowest number of healthy fruits/plot(1.00), highest number of infested fruits/plot(1.33) and highest per cent fruit infestation by number (55.55%) were achieved from T_3 (Sticky trap), T_6 (Light trap)and T_8(Control plot).

The highest number of healthy fruits/plot at mid fruiting stage (2.33) was achieved from T_7 (Bait trap + Pheromone trap (plastic pot)). The lowest number of infested fruits/plot (0.33) and lowest per cent fruit infestation by number (11.11%) at mid fruiting stage was achieved from T_5 (Funnel Pheromone trap) and T_2 (GME pheromone water trap) which

have no significance difference among them. The lowest number of healthy fruits/plot (1.00), highest number of infested fruit/plot (1.00) and highest per cent fruit infestation by number (50.00%) were achieved from T_3 (Sticky trap), T_6 (Light trap) and T_8 (Control plot).

The highest number of healthy fruits/plot (2.00), lowest number of infested fruits/plot (0.33) was achieved from T_5 (Funnel Pheromone trap) and the lowest number of infested fruits/plot (0.33) and lowest per cent fruit infestation by number (11.11%) at late fruiting stage was achieved T_7 (Bait trap + Pheromone trap (plastic pot)) which have no significance difference. On the other hand, lowest number of healthy fruits/plot (1.00), highest number of infested fruits/plot (1.00) and highest per cent fruit infestation by number (50.00%) was achieved from T_8 (Control plot).

The highest number of healthy fruits/plot (6.33), and per cent increase of yield over control by number (111.1%) was achieved from T_7 (Bait trap + Pheromone trap (plastic pot)) and lowest number of infested fruits/plot (1.00), per cent decrease of yield over control by number (69.44) and lowest per cent fruit infestation (15.59%) was achieved from T_5 (Funnel Pheromone trap). The highest number of infested fruits/plot (3.33) and highest per cent fruit infestation by number (52.38%) was achieved from T_8 (Control plot) and lowest number of healthy fruits/plot (3.00), per cent increase of yield over control by number (0.00) and per cent decrease of yield over control by number (16.67%) was achieved from T_3 (Sticky trap) during total cropping season.

Among the eight treatments, the highest weight of healthy fruits/plot (3.89kg), highest per cent increase of yield over control (719.18%) at early stage, the highest weight of healthy fruits/plot (2.50kg), highest per cent increase of yield over control (332.40%) at mid stage and the total highest weight of healthy fruits/plot (8.61kg), total highest per cent increase of yield over control (438.9%) was observed from T_7 (Bait trap + pheromone trap (plastic pot)). The highest weight of healthy fruits/plot (2.22kg), highest per cent increase of yield over control (367.37%) at late stage was observed from T_5 (Funnel Pheromone trap). The lowest weight of healthy fruits/plot (0.50kg) at early stage, the lowest weight of healthy fruits/plot (0.50kg) at mid stage, the lowest weight of healthy fruits/plot (0.63kg) at late stage and lowest total weight of healthy fruits/plot (1.64kg) was observed from control plot. The lowest per cent increase of yield over control (16.25%) at early stage, lowest per cent increase of yield over control (38.91%) at late stage and total lowest per cent increase of yield over control (44.89%) was observed from T_3 (Sticky trap). The lowest per cent increase of yield over control (38.62%) at mid stage was observed from T_6 (Light trap).

The overall study revealed that the highest performance was achieved from T_7 comprised of Bait trap + Pheromone trap (plastic trap) where T_5 (Funnel Pheromone trap) showed the second highest performance in terms of healthy, infested and total fruit yield by controlling cucurbit fruit fly. T_1 (Pheromone Trap (Plastic pot)), T_2 (GME pheromone water Trap), T_4 (Bait Trap) showed intermediate level of performance and T_3 (Sticky trap) and T_6 (Light trap) showed least effectiveness against fruit fly.

CONCLUSION

From the present study, it may be concluded that incidence of cucurbit fruit fly and infestation of sweet gourd by cucurbit fruit fly was significantly varied among the treatments. The overall study revealed that the highest performance was achieved from T_7 comprised of Bait trap + Pheromone trap (plastic trap) where T_5 (Funnel Pheromone trap) showed the similar performance in terms of healthy, infested and total fruit yield by controlling cucurbit fruit fly and T_3 (Sticky trap) and T_6 (Light trap) showed least effectiveness against fruit fly.

Considering the results of the present study, it can be concluded that T_7 comprising Bait trap + Pheromone trap (plastic trap) and T_5 (Funnel Pheromone trap) may be used for the management of fruit fly attacking cucurbitaceous vegetables.

RECOMMENDATIONS

- To minimize the use of chemical insecticides in cucurbit fruit fly control programmes, Pheromone trap in combination with Bait trap can play a significant role. It should be adopted in large scale production of chemical free cucurbitaceous vegetables.
- GO/NGO collaboration is needed for adoption of Bait traps and/or Pheromone traps to the growers.

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