EFFECTIVENESS OF DIFFERENT PHEROMONE-TRAP DESIGNS FOR MANAGEMENT OF CUCURBIT FRUIT FLY, *BACTROCERA CUCURBITAE* (Coquillett)

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BY

MD. SHAHRIAR HOSSEN

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BY

MD. SHAHRIAR HOSSEN

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Approved by:

(Prof. Dr. Mohammed Ali)
Supervisor

(Prof. Dr. Md. Abdul Latif)
Co-supervisor

(Assoc.Prof.Tahmina Akter)
Chairman

DEPARTMENT OF ENTOMOLOGY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Bangladesh

PABX: +88029144270-9
Ext. 309 (Off.)
Fax: +88029112649
e-mail: bioc_sau@ymail.com

Ref : **Date:**

CERTIFICATE

This is to certify that the thesis entitled, "Effectiveness of Different Pheromone-Trap Designs for Management of Cucurbit Fruit Fly, ***BACTROCERA CUCURBITAE*** **(Coquillett)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN ENTOMOLOGY, embodies the result of a piece of bonafide research work carried out by **Md. Shahriar Hossen, Registration No. 06- 2064** under my supervision and my 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 been duly acknowledged by him.

Dated:

(Professor. Dr. Mohammed Ali)

Dhaka, Bangladesh **Supervisor**

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University farm to find out the effectiveness of different pheromone-trap design for management of cucurbit fruit fly during January to July 2012. The treatments of the experiment were, T_1 = Pheromone trap (Conventional), T_2 = Pheromone trap with adhesive, T_3 = Pheromone trap with funnel, T_4 = Pheromone trap with adhesive + Bait trap, T_5 = Pheromone trap with funnel + Bait trap, T_6 = Pheromone trap with adhesive + Bait trap + Polybag and T_7 = Untreated (Control). The experiment was laid out in a Randomized Complete Block Design with three replications. Among the treatments the Pheromone trap with funnel +Bait trap(T_5) showed the best performance in controlling cucurbit fruit fly. Consequently highest yield (38.44 t/ha),highest healthy fruit (35.23 t/ha) and lowest infested fruit(3.21 t/ha) were achieved from the treatment. Also the highest number of fruit fly was trapped in T_5 at early,mid and late fruiting stage while lowest performance showed by T_1.The performance of Pheromone trap with funnel(T_3) was superior to other treatments but significantly lower than T_5 treatment. The experiment revealed that pheromone trap with funnel could be effectively utilized in fruit fly management.

CHAPTER I

INTRODUCTION

Vegetables are very important for human diet on account of its nutritional value. It is a cheaper source of vitamins and minerals which are essential for maintaining sound health. Bangladesh has a serious deficiency in vegetables. The daily reuirement of vegetables for a ful grown person is 285 gm (Ramphall and Gill, 1990). But in Bangladesh the percapita consumption of vegetable is only 50 gm per day, which is the lowest among the countries of Sout and South East Asia (Rekhi, 1997). As a result, chronic malnutrition is commonly seen in Bangladesh.

The annual production of vegetables is only 610 thousand tons including potato and sweet potato (Annon, 2001). In Bangladesh, the vegetables production is not evenly distributed throughout the year. Most of the important vegetables are produced in winter, which amount 367 thousand tones. In summer only 243 thousand tones vegetables are produced (Annon, 2001) although all vegetables cannot be grown in Kharif season due to the climatic condition, all the cucurbits can be grown easily in Kharif season. As a result, cucurbitaceous vegetables play an important role to supplement this shortage during the lag period (Rashid, 1993). Sweet gourd grows both in summer and winter. In 2001-2002 cropping year 114 metric tons of sweet gourd produced in Bangladesh (BBS, 2004).

Several cucurbitaceous vegetables are grown in Bangladesh and Cucurbit fruit fly, *Bactrocera cucurbitae* (Coquillett), is the most important pests of cucurbit crops. In the year 2010 EU team reported on “Pest risk analysis” of cucurbits of Bangladesh listing cucurbit fruit fly as a quarantine pest. Cucurbits have high potentiality for export .in Europe and Middle East and are highly prone to damage by this pest in Bangladesh From previous 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, including chemical insecticides 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. Considering the impact of chemicals on crops, and the environment, efficacy of different control measures aiming to develop an eco-friendly and sustainable pest management system in cucurbits is urgently needed.

The dipteran family Tephritidae consists of nearly 250 species of economic importance, and are distributed widely in temperate, sub-tropical, and tropical regions of the world (Christenson and Foote, 1960). Amongst these, *Bactrocera cucurbitae* (Coquillett) is a major threat to cucurbits (Shah *et al*., 1948). For cucurbits, the cucurbit fruit fly damage is the major limiting factor in obtaining good quality fruits and high yield (Rabindranath and Pillai, 1986). 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 (Weems and Heppner, 2001). The fruits attacked in early stages fail to develop properly, and drop or rot on the plant. Since, the maggots damage the fruits internally; it is difficult to control this pest with insecticides. Therefore, there is a need to explore alternative methods of control, and develop an integrated control strategy for effective management of this pest.

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*., 2005b). The extent of losses vary between 30 to 100%, depending on the cucurbit species and the season. The melon fruit fly remains active throughout the year on one or the other host.

The fruits of cucurbits, of which the fruit fly is a serious pest, are picked up at short intervals for marketing and self-consumption. Therefore, it is difficult to rely on insecticides as a means of controlling this pest. In situations where chemical control of fruit fly becomes necessary, one has to rely on soft insecticides with low residual toxicity and short waiting periods. Therefore, keeping in view the importance of the pest and crop, the cucurbit fruit fly management could be done using local area management or wide area management. Local area management means the minimum scale of pest management over a restricted area such as at field level/crop level/village level, which has no natural protection against reinvasion. The aim of local area management is to suppress the pest, rather than eradicate it. Under this management option a number of methods such as bagging of fruits, field sanitation, protein baits and cue-lure traps, host plant resistance, biological control, and soft insecticides, can be employed to keep the pest population below economic threshold in a particular crop over a period of time to avoid the crop losses without health and environmental hazards, which is the immediate concern of the farmers.

The methods used for a wide area management approach include male-sterile insect release, insect transgenesis, and quarantine control techniques in combination with available local area management options. The research program will help in developing eco-friendly management practice for controlling cucurbit fruit fly avoiding much reliance on toxic chemical insecticides. It will increase the production of cucurbit vegetables and bring profits to the vegetable farmers. It will certainly help in producing safe (pesticide residue free) cucurbit vegetables, which is urgently needed for national health as well for exporting the produce which has great prospect. Vegetable farmers of the country will be directly benefited gaining knowledge of safe vegetable production.

Objectives:

i) To find out the effective trap design for catching cucurbit fruit fly.
ii) To evaluate the effectiveness of cue-lure traps for fruit fly management.

CHAPTER II

REVIEW OF LITERATURE

Fruit fly is the most damaging insect pest of 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, distribution, biology, seasonal abundance, host range, nature of damage, yield loss, rate of infestation and control measures. The information related to the studies reviewed is given below under the following sub-headings.

2.1 Origin and Distribution of fruit fly

Fruit flies are distributed all over the world and infest a large number of host plants. 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 speciesmay become widely distributed when their host plants are widespread, either naturally or cultivation by man (Kapoor 1993). Two of the worlds most damaging tepphritids. Bactrocera dorsalis and Bactrocera cucurbitae, are widely distributed in Malaysia and other South East Asian countries (Vijaysegaran 1987). Gapud (1993) has cited references of five species of fruit fly in Bangladesh e.g., *Bactrocera brevistylus* (melon fruit fly), *Bactrocera caudatus* (fruit fly) (strumeta), *Bactrocera cucurbitae* (melon fly), *Bractrocera dorsalis* Hendel (mango fruit fly) and *Bractroceru zonatus* (zonata fruit fly).

According to Akhtaruzzaman (1999) *Bactrocera cucurbitae Bactrocera tau* and *Bactrocera ciliatus* have been currently identified in Bangladesh of which *Bactrocera ciliatus* is a new record. *Bactrocera cucurbitae* is dominant in all the locations of Bangladesh followed by *Bactrocera tau* and *Bactrocera cilialus*. 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 (Atwal 1993 and Alam 1965). It is also a serious pest in Mediterranean region (Andrewartha and Birch 1960). Although, this pest is widely distributed but it does not occur in the UK, central Europe and continental USA (Mckinlay *et al*. 1992). Kapoor (1993) reviewed that fruit fly was originally reported from Hawaii and now widely distributed throughout the oriental region including China, Japan, much of the pacific region including New Guinea, Soloman and Bismark islands, Australia, Mauritius, East Africa, Kenya and Tanzania.

2.2 Host Range of fruit fly

Many fruit fly species do serious damage to vegetables, oil-seeds, fruits and ornamental plants. In Bangladesh, Alam (1962) recorded ten cucurbit vegetables as the host of fruit fly. Tomato, green pepper, papaya, cauliflower, mango, guava, citrus, near. fig and peaches are also infested by fruit fly (Atwal 1993 and Anon 1987).

Sixteen species of plants act as the host of fruit flies among which sweet gourd was the most preferred host of both *Bactrocera cucurbitae* and *Bactrocera tau*. Among flowers, the rate of infestation was greater in sweet gourd but the intensity was higher in bottle gourd (Kabir *et al*. 1991). Batra (1953) listed as many as 70 hosts of fruit fly species whereas Christenson and Foote (1960) reported more than 80 kinds of vegetables and fruits as the hosts. Lawrece (1950) recorded that cucurbit vegetables are the most favourite host of *Bactrocera cucurbitae*. Batra (1968) observed that the male flowers and flowers bud of sweet gourd were found to serve as usual host with anthers being the special food for the larvae and only occasionally small sweet gourd fruits being attacked perhaps through the female flower. Kapoor (1993) reported that more than One hundred vegetables and fruits are attacked by *Bactrocera* sp. Atwal (1993) and Mckinlay *et al*. (1992) reported that cucurbits as well as 70-100 non-cucurbitaceous vegetables and fruits are the host of fruit fly.

According to Narayanan and Batra (1960), different species of fruit fly attack a wide variety of fruits and vegetables such as mango, guava, loquat plum, peach, pear, fig, apple, quince, persimmon, banana, pomegranate, jujube, sweet lime, orange, chilies, jack fruit, carambola, papaya, avocado, bread fruit, coffees, berries, passion fruit, star apple, Spanish pepper, cucurbit fruit, cherries, black berry, grapes etc. Nasiruddin (1991) observed that the incidence of fruit flies was the highest in February and the lowest in September.

2.3 Seasonal abundance of fruit fly

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). Tanaka *et al*. (1978) reported that population of melon fly was increased in autumn and decreased in winter in Kikai islands Japan. Narayan and Batra (1960) reported that most of the fruit fly species are more or less active at temperatures ranging between 12ºC-15ºC and become inactive below 10°C. Cucurbit fruit flies normally increases their multiplication when the temperature goes below 15°C and relative humidity varies from 60-70 % (Alam 1966).

The fruit fly population is generally low during dry weather and increases with adequate rainfall (Butani and Jotwani 1984). The peak population of fruit fly in India is attained during July and August in rainy months and January and February in cold months (Nair 1986). The adults of melon fly Bactrocera cucurbitae over winter November to December and the fly is the most active during July to August (Agarwal *et al*. 1987). Fruit fly populations were in general positively correlated with temperature and relative humidity. Amin (1995) observed the highest population incidence at ripening stage of cucumber in Bangladesh.

2.4 Nature of damage of fruit fly

According to Janjua (1948) the nature of infestation of fruit fly varies with the Kinds of fruits. Shah et al. (1948) and York (1992) observed the formation of brown resinous deposits on fruits as the symptom of infestation. The insertion of the ovipositor causes wounds on the fruits or vegetables in the form of puncture. The adult female lays eggs just below the epidermis or sometimes a little deeper in the pulp, and/or sometimes on young leaves or stems of the host plants. After that fluid substance oozes out which transforms into a brown resinous deposit. After hatching, the larva feeds into pulpy tissues and makes tunnels in fruits causing direct damage.

The larvae also indirectly damage the fruits by contaminating it with frass and accelerate rotting of fruits by pathogenic infection. Infested fruits if not rotten, become deformed and hardy, which make it unfit for consumption. The fly also attacks flowers and the infested flowers often become juicier and drop from the stalk at slight jerk (Kabir *et al*. 1991).

According to Kapoor (1993), some flies make mines and a few form galls on different parts of the plants. Singh (1983) reviewed that the maggots bore and feed inside the fruits causing sunken discolored patches, distortion and open cracks. Affected fruits prematurely ripe and drop from the plants. The cracks on fruits serve as the predisposing factor to cause pathogenic infection resulting in decomposition of fruits.

According to the reports of Bangladesh Agricultural Research Institute (BARD) rate of fruit fly infestation were 22.45, 41.88 and 67.01 % for snake gourd, Bitter gourd and musk melon, respectively (Anon. 1988). Experiment revealed that fruit flies attack melon and teasel gourd within 1 to 11 and 3 to 11 days after fruit setting when the average fruit size ranged from 1.38 × 0.78 cm to 3.53 × 2.07 cm and 2.13 × 1.18 cm to 4.98 × 3.1 cm respectively (Anon. 1988). Maximum infestation (26.67%) in melon occurred in the 4th day after fruit setting when average fruit size was 2.03 × 1.08 cm. In teasel gourd, it was 19.28% on 8th day after fruit setting when average fruit size was 4.57 × 2.91 cm (Anon. 1988). Amin (1995) and Uddin (1996) observed 42.08 and 45.14% fruit fly infestation in cucumber, respectively.

2.5 Rate of infestation & yield loss by fruit fly

Borah and Dutta (1997) studied the infestation of tephritids on the cucurbits in Assam, India and obtained the highest best fruit fly infestation rate in snake gourd (62.02%). Larger proportion of marketable fruits was obtained from ash gourd in and bottle gourd in summer season. Snake gourd and pumpkin yielded the lowest proportion of marketable fruits. Gupta (1992) investigated the rate of infestation of (*Bactrocera cucurbitae*) and *Bactrocera tau* on cucurbit in India during 1986-87 and recorded that 80% infestation on cucumber and bottle gourd in July-August and 50% infestation on bitter gourd, 50% infestation on sponge gourd in August-September. 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 occurring in sweet gourd (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%. Kabir *et al*. (1991) reported that yield losses due to fly infestation varies in different fruits and vegetables and it is minimum 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). Shah et al. (1948) reported that the damage done by fruit flies in North West Frontier Province (Pakistan) cost an annual loss of over $ 655738.

2.6 Life history of fruit fly

The adult fly (*Bactrocera cucurbitae*) is about 8 mm in body length; reddish brown with yellow stripes on its dorsal thorax and has brown spots along the veins otherwise clear wings. In late ours of the day, the female flies lay eggs on the tender fruits. The eggs lay by *Bactrocera cucurbitae* inside the fruit, which are creamy, white in color; oblong; banana shaped and is about 1.3 mm in length (Anon 1987).

Eggs are normally inserted under the skin of the fruits, vegetables, nuts or fleshy parts of plants, stems or flowers where they are protected from sun (Feron *et al*. 1958). The maggots feed inside after hatching from the eggs.

The creamy white maggot gradually becomes darker as it matures. The length of the mature larvae is about 12 mm; the full grown larvae come out of the bores and make a loop holding the last abdominal segment by mouth hook and drop forcely on the soil by releasing their mouth hook for pupation.

This phenomena takes place usually in the early morning between 6:00 am to 9:00 am. The most of the full grown larvae penetrate the soil rapidly and pupate under the soil surface. The larval period is 4-7 days, varying with temperature, nutritional condition, larval rearing density etc. (Anon 1987). Puparium formation may require as little as one hour and complete pupal formation occurs within the puparium by less than 48 hours (Christenson and Foote 1960). The larvae spend 4th instars in the puparium formed by the exuviae's of the 3^{rd} instar and subsequently become pupae. The puparium is 4.8 to 6.0 mm in length. At 23-25 °C the pupal stage lasts for 8-12 days. At 27 °C the mean pupal period for *Bactrocera dorsalis* and *Ceratitis capitata* (Wiedemann) is 10 days and that for *Bactrocera cucurbitae* is 9 days (Mitchell et al. 1965).

Mating between the adult melon fruit flies generally takes place at about dusk and last for about an hour or more (Narayan and Batra, 1960). Mating starts in the evening and continues till dawn. Melon Flies may mate every 4-5 days. Females found to lay eggs up to 7-10 days. Eggs are laid a~ 7-10 per female per day. A female melon fly can lay a total of 800-9000 eggs during her life span with approximately 50% fertility (Vargas *et al*. 1984).

According to Janjua (1948) the pre-oviposition period of Bactrocera ferrugeneus is two to five days but it may range from ten to fifteen days or longer in varying conditions of climate and diet.

A single life cycle is completed in 10 to 18 days but it takes 12 to 13 weeks in winter. Adult longevity is 2 to 5 months; females live longer than males. Generally, males die soon after fertilizing the females, whereas, females die after Nair (1986) reported that the flies, which emerge in the morning hours, oviposit for four days in autumn and nine to thirty days in winter.

Adults begin to copulate 9-12 days after emergence and the longevity of adult fly is one to five months in the laboratory and under the optimum condition, the length of one generation is around one month (Anon 1987).

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

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 files infesting cucurbits, Guava, mango, peach etc. and many borers of plants (Chattopadhyay 1991).

B. 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 (Kapoor 1901). Collection and destruction of infested fruits with the larvae inside helped population reduction of fruit flies (Nasiruddin and Karim 1992).

B.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 (Anonymous 1988).

B.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).

B.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.

C. 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:

C.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, Grazdyev *et al.* 1983 and 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, Phosphamidon 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 (ail at 1008 a.i/ha) 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.

C.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 Batrocera 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, 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).

D. 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 percent Methyl eugenol plus 0.5 percent Malathion (Lakshmann *et al*. 1973) or 0.1 percent Methyl eugenol plus 0.25 percent 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 repelients, antifeeedants, 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 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*.

E. Use of Sex pheromone in management of fruit fly

Results of an experiment on monitoring the sweet potato weevil in the farmers' field by sex pheromones at the river belt of Jamalpur revealed that sweet potato weevils were a problem in this area. The idea on the weevil population density in the field can guide the farmers to schedule their proper management Anon (1993) Cheng and Struble (1982) conducted an experiment on field evaluation of black light, sex attractant traps for monitoring seasonal distribution of the dark sided cutworm (Lepidoptera Noctuidae) in Ontario. Of these, the dark sided cutworm, *Euxoa messoria*, as expected, was the most numerous over the 5- year study. These results proved, further, that the sex attractant trap is highly specific.

The effect of the height of sex attractant traps on catches of male E. messoria moths in the field was consistent among the years. In general, all baited traps, regardless of the height, caught significantly more moths as compared with the unbaited traps. Although there were no significant differences between the catches of traps set at 1.0 m and 0.5 m above !he ground level, traps set at 0.5 m tented to capture more moths than the traps at 1.0 m above the ground level. The unbaited traps occasionally captured a moth by chance.

Results of initial test comparing sex attractant with black light traps are presented. In the 5-year test, all sex attractant trap catches, regardless of the height, were much greater than black light trap catches. During the study period, the sex attractant traps captured 3155 male E. messoria moths, while the black light traps captured 205 E. messoria moths. The data clearly indicate that the sex attractant traps were more effective than the black light traps for trapping moths of E. messoria in an open field.

This make them superior to black light traps for monitoring population of this species especially considering their species specificity, low cost and convenience (Cheng and Struble 1982) The sex attractant traps provide more exact information about the activity of the *E. messoria* populations than the black light traps and they should be valuable aid in predicting outbreaks of this pest. In addition this technique can easily be fitted into a system of integrated pest management program the monitoring station or farm level.

Kehat *et al*. (1998) observed that suppression of mating of H. armigera females was high throughout the entire test (49 days), even at high population levels, particularly with the two-component blend (mixture of two pheromone component) and it was significantly better than that obtained with the five-component (mixture of five pheromone component) blend. When percentage mating was determined by using six to eight mating tables per plot each containing one female, the two-component blend was, again, very effective but on two occasions (days 26, 34) there was a low percentage of mating.

The five component blend was, in this case, clearly inferior to the two-component blend and low percentages of mating (15-30%) were observed more often. Statistical analysis indicated that the use of six to eight mating table each containing one female per table, was significantly more sensitive in detecting percent mating than the use of two mating tables, each containing five to seven females. Each of the two methods showed that the binary blend was significantly better in disrupting mating of *H. armigera* than the five- component blend. On test 2 mating of *P. gossypiella* females in the HPROPE treated plot was completely suppressed throughout the entire test (161 days). Mating percentages of sentine females in the control were low in this test. On test 3, this mating disruption test was conducted only against *P. gossypiella*, using "PBW rope L" pheromone. It was sufficient to achieve complete suppression of male captures and of mating during the 75 days of the field experiment.

Mating disruption of Yellow Stem Borer (YSB) by pheromone was tested by Cork *et al*. (1992) and they observed the tiller and particle assessments and the effects of mating on final yield. In order to compare damage estimates for the treatment plot for DH (Dead heart), and WH (White heads), data from 21 to 41 DAT and 69 to DAT respectively, were used. The results show that the level of DH damage in the farmers' practice plot was lower than that in either the untreated control pheromone treated plots, but the differences were not statistically significant. However, the levels of WH damage recorded in the farmers' practice and the untreated control plots were significantly higher than that observed in the pheromone treated plot Islam (1994) conducted an experiment on trapping of the male pulse beetle, *Callosobruchus chinensis* (L) (Coleoptera: Bruchidae), in the laboratory using crude extract of female sex pheromone and observed the trapping efficiency of a new plastic trap developed for *Callosobruchus chinensis* On the result of male response to pheromone baited traps Containing crude female extract or live females he observed that there was no significant difference between the number of males caught with crude female extract or live females.

Tamaki *et al*. (1983) conducted an experiment on impact of removal of males with sex pheromone baited traps on suppression of the peach twig borer, *Anarsia lineatella* (Zeller). Male removal sex pheromone - baited traps has been successful in reducing damage caused by the red banded leafroller, *Agrotaenia velutinana* (Walker) (Trammel *el al*. 1974), the grapeberry moth, *Endopiza viteana* Clemens (Taschenberg *et al*. 1974). However, in few of these cases has the amount of damage observed been at or below corn commercially acceptable levels.

In Bangladesh the adoption of sex pheromone traps by Syngenta Bangladesh Ltd. has been paralled by the govt. of Bangladesh's adoption of the concept of IPM (Integrated Pest management) whereby the more toxic pesticides are replaced by sustainable and environmentally benign mean of pest and disease control.

IPM provides a role for alternative approaches such as cultural methods, use of predators, viruses and use of sex pheromone etc. Syngenta in Bangladesh in collaboration with UK’s Department for International Development (DFID) and BRRI (Bangladesh Rice Research Institute) made program on mass trapping by sex pheromone to control Yellow Stem Borer (YSB) of rice in Comilla and Mymensingh districts for 2001-2003. The traps used in their program are inexpensive, easy to maintain and catch only male YSB. Farmers involved in the trials were so enthusiastic that they wanted pheromone for use on their other crops Anon (1983).

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 percentages 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 der 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.

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 percent. 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.

To make the pheromone component, E-11 hexadacenyle acetate and E-1hexadacene- l.0l were used from 10:1 to 100:1 ratio. A tube filled with 2-3 mg of mixture was used in a trap for 6 weeks and it proved a significant result to reduce the BSFB population bellow the economic injury level.

F. Integrated management of fruit fly

An attempt for developing IPM programme or packages(s) related experiments are very few almost everywhere in the world. Uddin (1996) studied the comparative effectiveness of three IPM packages vix., the IPM package 1 consisting of barrier+yellow pan trap+bagging of fruits. IPM package 2 comprising Malathion spray (Hilthion 57EC @ 2m1/liter fo water) plus mechanical control and IPM package 3 containing bait spray (@ 25g of molasses, 2.5 ml of Hilthion 57EC and 2.5 liter of water) Plus treating soil with Diazinon 14G (@2g/plot) in reducing the infestation level of fruit fly, red pumpkin beetle and aphids on cucumber. To investigate *Bactrocera cucurbitae* control at different places of Nepal during 199697, a survey among 32 farmers indicated the great loss in the productivity of cucurbit vegetables.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January to July 2012 to study the effectiveness of different pheromone-trap design for management of cucurbit fruit fly in sweet gourd. The materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Experimental site

The present experiment was conducted at the Agricultural Research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^{0}74'$N latitude and $90^{0}35'$ E longitude and at an elevation of 8.2 m from sea level. Appendix I.

3.2 Climate

The climate is subtropical in nature with moderate temperature and scanty rainfall. The soil of the experimental land belongs to the Madhupur tract and was silty clay in nature having pH ranging from 5.5 to 6.2. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.3 Characteristics of Soil

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon. Details of the recorded soil characteristics were presented in Appendix III.

3.4 Treatments

Seven treatments including with an untreated control were selected with a view to suppress the fruit fly infestation in sweet gourd are as follows:

i. T_1 = Pheromone trap (Conventional)

ii. T_2 = Pheromone trap with adhesive

iii. T_3 = Pheromone trap with funnel

iv. T_4 = Pheromone trap with adhesive + Bait trap

v. T_5 = Pheromone trap with funnel + Bait trap

vi. T_6 = Pheromone trap with adhesive + Bait trap + Polybag

vii. T_7 = Untreated (Control)

3.5 Design of experiment

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 3m × 3m. The distance between plots and blocks was 1m and 1m respectively.

3.6 Land preparation and fertilization

The experimental plot was ploughed thoroughly by a tractor drawn disc plough followed by harrowing. The land was then labeled prior to transplanting. During land preparation, cowdung was incorporated into the soil at the rate of 10 t/ha. Recommended doses of fertilizer comprising urea, TSP and MP at the rate of 150, 125 and 100 kg/ha respectively were applied. TSP and MP were applied as basal dose at the time of sowing in all the treatments (BARC, 1997) except untreated control. The N in the form of urea was applied in 3 equal splits at basal, 30 days after sowing (DAS) and 50 DAS.

3.7 Plant materials

Crop: Sweet gourd was considered as test crop under the present study. Lal Teer variety was used for the experiment. Advanced winter variety. Inside is attractive deep orange color. Average yield is 35-40 t/ha.

3.8 Seed source and sowing

The seeds of sweet gourd were collected from Lal Teer seed Company, Dhaka. Seeds were sown in the field on 2^{nd} January 2012. Five seeds per pit were sown directly. Before sowing, the seeds were treated with Vitavax 200 @ 2 gm per kg of seed. 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.

3.9 Cultural practices

After sowing the seeds, a light irrigation was applied to the plots. Subsequent irrigation was done and when needed. Sevin 85 WP @ 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 recommended by Rashid (1993). 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.

3.10 Treatment application

3.10.1 Preparation of bait trap

As standard practices, bait trap was considered as a treatment for comparing its effectiveness with those of bait sprays the trap was developed by Nasiruddin and Karim (1992) consisted of O.5mI (10-15drop) of Nogos 100EC, mixed with 100g of sweet gourd mash and 100 ml of water. However in the present study Sevin85wp was used instead of Nogos 100EC. The bait was kept in small earthen pot placed within a three split bamboo sticks, 50cm above the ground. The old bait materials were replaced by fresh ones at an in interval of 2 to 3 days. Each set of bait trap as placed in the middle of the random selected three plots.

Fig. 1: **Bait trap**

3.10.2 Preparation of pheromone trap with conventional method

Pheromone trap was made up of a plastic bottle of with its both sides had a triangular Cutting. A peace of small cotton ball was hanged inside the plastic bottle. Sides of it cotton ball was soaked with 5-6 drops pheromone. After 16 days again both side of cotton ball was provided with5-6 drop pheromone.

Fig. 2: **Pheromone trap with conventional method**

3.10.3 Preparation of pheromone trap with adhesive

Pheromone trap was made up of a plastic bottle of with its both sides had a triangular Cutting. A peace of small cotton ball was hanged inside the plastic bottle. Sides of it cotton ball was soaked with 5-6 drops pheromone. After 16 days again both side of cotton ball was provided with5-6 drop pheromone.At the treatment additionaly adhesive material was added.Therefore the insects were stuck with adhesive so that insect could not move.

Fig.3: **Pheromone trap with adhesive**

3.10.4 Preparation of pheromone trap with funnel

Pheromone trap was made up of a plastic bottle of with its both sides had a triangular Cutting. A peace of small cotton ball was hanged inside the plastic bottle. Sides of it cotton ball was soaked with 5-6 drops pheromone. After 16 days again both side of cotton ball was provided with5-6 drop pheromone.Additionaly two small plastic funnel with jar in the triangular cutting.Advantage of the treatment of the insect can inter the jar but there was no way to move out.

Fig. 4**: Pheromone trap with funnel**

3.10.5 Untreated control

The plots under the untreated control were left without any control measures. All other intercultural operations were similar to those of other treatments. The infestation of red pumpkin beetles appeared before flowering was controlled by hand picking.

3.11 Data collection and analysis

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 40days was called mid fruiting stage and after 40day to the end of the final harvest was called late fruiting stage.

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

3.12 Percent 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 percent fruit Infestation for each treatment was calculated by using the following formula

$$\% \text{ Fruit Infestation by number} = \frac{\text{No. of infested fruits (IF)}}{\text{No. of healthy fruits (HF)} + \text{No. of infested fruits}} \times 100$$

3.13 Percent fruit infestation by weight

After sorting of healthy fruits (HF) and the infested fruits (IF), the weight was taken for healthy infested and total one separately. The percent infested fruit by weight for each treatment was calculated by using the following formula

$$\% \text{ Fruit Infestation by weight} = \frac{\text{Weight of infested fruits (IF)}}{\text{Weight of healthy fruits (HF)} + \text{wt. of infested fruits}} \times 100$$

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 (ton/ha). The percent increase and decrease of yield over control was computed by using the following formula:

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

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

3.15 Percent reduction over control

The Percent Reduction over control was calculated by using the following formula:

$$\text{Reduction over control} = \frac{\text{\% Infestation of treated plot -\% infestation of control plot}}{\text{\% infestation of control plot}} \times 100$$

3.16 Statistical analysis

Data were analyzed by MSTAT software for proper interpretation. The data recorded on different parameters were subjected to analysis of variance (ANOVA) and the means were compared according to Least Significant Difference Test (LSD) at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

The comparative study on the effectiveness of different pheromone-trap designs for management of cucurbit fruit fly on sweet gourd was conducted in 2012, Rabi season at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. The results obtained from the study are discussed under the following headings:

4.1 Effect of different treatments at early stage

4.1.1 Number of fruits

At early fruiting stage the percent of fruit infestation (by number) among the treatments varied significantly (Table 1). The % fruits infestation by number under the treatment T_5 comprising of Pheromone trap with funnel + Bait trap of fruits resulted significantly the lowest level of infestation (20.08%) as compared to untreated control plot (74.72%) (Table 1). The highest level of infestation was obtained in the fruits harvested from the untreated control plot T_7 (74.72%) which was significantly higher than that of all other treatments. Among the treated plots, T_1 treatment comprised of conventional pheromone trap showed the highest % fruits infestation by number (60.99%).

Regarding of healthy fruit production per plot, the highest number of healthy fruits/plot (14.67) were harvested from T_5 (Pheromone trap with funnel + Bait trap) Treatment, which was significantly different from all other treatments. The treatment, T_3 (Pheromone trap with funnel) also showed higher number of fruits/plot (12.30) but significantly different from T_5. However, the lowest number of healthy fruits/plot (3.33) were harvested from untreated control plots T_7. But among the treated plots, T_1 treatment comprised of conventional pheromone trap showed the lowest healthy fruits/plot by number (5.33).

Significant variation was also observed in respect to the number of infested fruits/plot caused by fruit fly at early fruiting stage (Table 1). The minimum number of infested fruits/plot (3.67) was obtained from the T_5 plots. The T_3 treatment (Pheromone trap with funnel) also had the lower number of infested fruits/plot (4.00). The maximum number of infested fruits/plot (9.33) was occurred in the control plots T_7 which was statistically higher than that of all other treatments except T_1 treatment. Within the treated plots, T_1 (conventional pheromone trap) gave the highest number of infested fruits/plot (8.33).

In terms of total fruits/plot at early stage, the highest (18.33) was obtained from T_5 (Pheromone trap with funnel + Bait trap) where the lowest (12.67) was found in T_7 (Untreated Control). But within the treated plots, T_1 (Conventional pheromone trap) and T_2 (Pheromone trap with adhesive) showed the lowest total fruits/plot (13.67).

In conditions of percent reduction of fruit infestation over control, the highest percent reduction over control (by number) was recorded from T_5 comprising of Pheromone trap with funnel + Bait trap (60.66%) followed by 57.13% in T_3 treated plot.

Table 1: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of infestation by number at early fruting stage

Treatments	Number of fruits/plot			percent infestation by number	percent reduction over control
	Healthy	Infested	Total fruit		
T_1	5.33 e	8.33 a	13.67 de	60.99 b	10.72
T_2	7.33 d	6.33 b	13.67 de	46.34 c	32.15
T_3	12.3 b	4.00 c	16.33 b	24.31 f	57.13
T_4	9.67 c	5.67 b	15.33 bc	36.94 e	39.23
T_5	14.67 a	3.67 c	18.33 a	20.08 g	60.66
T_6	8.33 d	6.00 b	14.33 cd	41.75 d	35.69
T_7	3.33 f	9.33 a	12.67 e	74.72 a	--
$LSD_{0.05}$	1.327	1.537	1.258	2.870	--
CV(%)	8.55	13.95	8.74	11.61	--

In a column, numeric data represents the mean value of 3 replications.Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)

T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.1.2 Weight of fruit

Significant variation was observed in terms of healthy fruit weight, infested fruit weight and total fruit weight per plot and also % infestation of fruit by weight at early fruiting stage (Table 2).

Results showed that the highest amount of healthy fruits/plot (9.67 kg) was observed in the T_5 treatment (Pheromone trap with funnel + Bait trap) which was significantly different from all other treatments. T_3 comprised of Pheromone trap with funnel (7.86 kg) also showed good performance compared to T_5. The lowest amount of healthy fruit weight/plot (1.83 kg) was observed in Untreated Control treatment, T_7. Among the treated plots, the lowest healthy weight of fruits/plot (3.08 kg) was found from T_1 (Conventional pheromone trap) treatment followed by T_2 (4.27 kg) treatment comprised of Pheromone trap with adhesive.

The weight of infested fruits/plot differed significantly in control plots (T_7) compared to other treatments. The lowest weight of infested fruits/plot (2.12 kg) was obtained from T_5 (Pheromone trap with funnel + Bait trap) which was statistically identical with T_3 (2.27 kg) comprised of Pheromone trap with funnel. The highest amount of infested fruit weight/plot (4.43 kg) was observed in the T_7 (untreated control) which was also significantly different from all other treatments except T_4 (Pheromone trap with adhesive + Bait trap) treatment. Within the treated plots, the highest amount of infested fruit weight/plot (4.00 kg) was observed in the T_1 (Conventional pheromone trap) which was statistically similar with Untreated Control treatment (T_7).

In terms of total fruit weight/plot, the highest (11.77 kg) was achieved from T_5 (Pheromone trap with funnel + Bait trap) at early fruiting stage of crop followed by T_3 (10.13 kg) comprised of Pheromone trap with funnel where the lowest (6.27 kg) was obtained from Untreated Control (T_7) treatment. Among the treated plots, the lowest total weight of fruits/plot (7.08 kg) was found from T_1 (Conventional pheromone trap) which was statistically identical with T_2 (7.45 kg) comprised of Pheromone trap with adhesive.

In case of % fruit infestation by weight, the lowest percent fruit infestation by weight (18.07%) was observed from treatment T_5 followed by 22.22% in T_3. The control plots had the highest fruit infestation (70.94%) which differed significantly from all other treatments. Among the treated plots, the highest % fruit infestation by weight was observed in T_1 (56.58%) followed by T_2 (42.72%).

The highest fruit infestation reduction over control by weight (52.14 %) was obtained from the treatment T_5 followed by 48.76 %, 29.35% and 28.22% in T_3, T_4 and T_2 respectively(Table2).

Table 2: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of infestation by weight at early fruiting stage

Treatments	Weight of fruits/plot (kg)			Percent infestation	Percent reduction
	Healthy	Infested	Total fruit	by weight	over control
T_1	3.08 e	4.00 ab	7.08 e	56.58 b	9.71
T_2	4.27 d	3.18 b	7.45 e	42.72 c	28.22
T_3	7.86 b	2.27 c	10.13 b	22.22 f	48.76
T_4	6.13 c	3.13 b	9.27 c	33.77 e	29.35
T_5	9.67 a	2.12 c	11.77 a	18.07 g	52.14
T_6	5.05 d	3.17 b	8.22 d	38.41 d	28.44
T_7	1.83 f	4.43 a	6.27 f	70.94 a	--
$LSD_{0.05}$	0.8035	0.8249	0.712	2.528	--
CV(%)	8.35	9.57	7.65	12.13	--

In a column, numeric data represents the mean value of 3 replications. Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)
T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.2 Effect of different treatments at mid fruiting stage

4.2.1 Number of fruits

At mid fruiting stage the percent of fruit infestation (by number) among the treatments varied significantly (Table 3). The % fruits infestation by number under the treatment of T_5 comprising of Pheromone trap with funnel + Bait trap of fruits resulted significantly the lowest level of infestation (23.33%) as compared to untreated control plot (85.98%) (Table 3). The highest level of infestation was obtained in the fruits harvested from the untreated control plot T_7 (85.98%) which was significantly higher than that of all other treatments. Among the treated plots, T_1 treatment comprised of conventional pheromone trap showed the highest % fruits infestation by number (60.71%) followed by T_2 (55.135) comprised of Pheromone trap with adhesive.

Regarding of healthy fruit production per plot, the highest number of healthy fruits/plot (14.33) were harvested from T_5 (Pheromone trap with funnel + Bait trap) Treatment, which was significantly different from all other treatments. The treatment, T_3 (Pheromone trap with funnel) and T_4 (Pheromone trap with adhesive + Bait trap) also showed higher number of fruits/plot (12.00 and 10.00 respectively) but significantly different from T_5. However, the lowest number of healthy fruits/plot (1.67) was harvested from untreated control plots T_7. But among the treated plots, T_1 treatment comprised of conventional pheromone trap showed the lowest healthy fruits/plot by number (5.00) which was significantly same with T_2 (6.00) comprised of Pheromone trap with adhesive.

Significant variation was also observed in respect to the number of infested fruits/plot caused by fruit fly at mid fruiting stage (Table 3). The minimum number of infested fruits/plot (4.33) was obtained from the T_5 plots. The T_3 treatment (Pheromone trap with funnel) and T_4 (Pheromone trap with adhesive + Bait trap) also had the lower number of infested fruits/plot (5.33). The maximum number of infested fruits/plot (10.00) was occurred in the control plots T_7 which was statistically higher than that of all other treatments. Within the treated plots, T_1 (Conventional pheromone trap) gave the highest number of infested fruits/plot (7.67) which was statistically identical with T_2 (7.33) comprised of Pheromone trap with adhesive.

In terms of total fruits/plot at mid stage, the highest (18.67) was obtained from T_5 (Pheromone trap with funnel + Bait trap) where the lowest (11.67) was found in T_7 (Untreated Control). But within the treated plots, T_1 (Conventional pheromone trap) showed the lowest total fruits/plot (12.67) which was closely followed by T_2 (13.33) (Pheromone trap with adhesive).

In conditions of percent reduction of fruit infestation over control, the highest percent reduction over control (by number) was recorded from T_5 comprising of Pheromone trap with funnel + Bait trap (56.70%) followed by 46.70% in T_3 and T_4 treated plot.

Table 3: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of infestation by number at mid fruting stage

Treatments	Number of fruits/plot			Percent infestation by number	Percent reduction over control
	Healthy	Infested	Total fruit		
T_1	5.00 e	7.67 b	12.67 de	60.71 b	23.30
T_2	6.00 e	7.33 b	13.33 d	55.13 c	26.70
T_3	12.00 b	5.33 d	17.33 b	30.79 f	46.70
T_4	10.00 c	5.33 d	15.33 c	34.86 e	46.70
T_5	14.33 a	4.33 e	18.67 a	23.33 g	56.70
T_6	7.67 d	6.33 c	14.00 d	45.56 d	36.70
T_7	1.67 f	10.00 a	11.67 e	85.98 a	--
$LSD_{0.05}$	1.014	0.5396	1.331	3.252	--
CV(%)	7.05	10.60	9.81	6.36	--

In a column, numeric data represents the mean value of 3 replications. Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)

T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.2.2 Weight of fruit

Significant variation was observed in terms of healthy fruit weight, infested fruit weight and total fruit weight per plot and also % infestation of fruit by weight at mid fruiting stage (Table 4).

Results showed that the highest amount of healthy fruits/plot (12.47 kg) was observed in the T_5 treatment (Pheromone trap with funnel + Bait trap) which was significantly different from all other treatments. T_3 comprised of Pheromone trap with funnel (10.26 kg) also showed good performance compared to T_5. The lowest amount of healthy fruit weight/plot (1.58 kg) was observed in Untreated Control treatment, T_7. Among the treated plots, the lowest healthy weight of fruits/plot (4.18 kg) was found from T_1 (Conventional pheromone trap) treatment followed by T_2 (5.13 kg) treatment comprised of Pheromone trap with adhesive.

The weight of infested fruits/plot differed significantly in control plots (T_7) compared to other treatments. The lowest weight of infested fruits/plot (3.35 kg) was obtained from T_5 (Pheromone trap with funnel + Bait trap) which was closely followed by T_3 (4.09 kg) comprised of Pheromone trap with funnel and T_4 (3.97 kg) comprised of Pheromone trap with adhesive + Bait trap. The highest amount of infested fruit weight/plot (7.02 kg) was observed in the T_7 (untreated control) which was also significantly different from all other treatments. Within the treated plots, the highest amount of infested fruit weight/plot (5.39 kg) at mid fruiting stage was observed in the T_1 (conventional pheromone trap) which was statistically identical with T_2 (5.23) comprised of Pheromone trap with adhesive.

In terms of total fruit weight/plot, the highest (15.80 kg) was achieved from T_5 (Pheromone trap with funnel + Bait trap) at mid fruiting stage of crop followed by T_3 (14.34 kg) comprised of Pheromone trap with funnel where the lowest (8.60 kg) was obtained from Untreated Control (T_7) treatment. Among the treated plots, the lowest total weight of fruits/plot (9.57 kg) was found from T_1 (Conventional pheromone trap) followed by T_2 (10.36 kg) comprised of Pheromone trap with adhesive.

In case of % fruit infestation by weight, the lowest percent fruit infestation by weight (21.32%) was observed from treatment T_5 followed by 28.46% in T_3 and 32.10 in T_4. The control plots had the highest fruit infestation (81.79%) by weight which differed significantly from all other treatments. Among the treated plots, the highest % fruit infestation by weight was observed in T_1 (56.58%) followed by T_2 (50.57%).

The highest fruit infestation reduction over control by weight (52.28 %) was obtained from the treatment T_5 followed by 43.45 %, 41.74% and 33.76% in T_4, T_3 and T_6 respectively (Table 4).

Table 4: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of infestation by weight at mid fruting stage

Treatments	Weight of fruits/plot (kg)			Percent infestation by weight	Percent reduction over control
	Healthy	Infested	Total fruit		
T_1	4.18 e	5.39 b	9.57 ef	56.58 b	23.22
T_2	5.13 e	5.23 b	10.36 de	50.57 c	25.50
T_3	10.26b	4.09 cd	14.34 b	28.46 f	41.74
T_4	8.44 c	3.97 cd	12.40 c	32.10 e	43.45
T_5	12.47 a	3.35 d	15.80 a	21.32 g	52.28
T_6	6.52 d	4.65 bc	11.17 d	41.89 d	33.76
T_7	1.58 f	7.02 a	8.60 f	81.79 a	--
$LSD_{0.05}$	0.9630	0.9036	1.088	3.540	--
CV(%)	7.80	10.56	6.20	7.06	--

In a column, numeric data represents the mean value of 3 replications. Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)

T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.3 Effect of different treatments at late fruting stage

4.3.1 Number of fruits

At late fruiting stage the percent of fruit infestation (by number) among the treatments varied significantly (Table 5). The % fruits infestation by number under the treatment of T_5 comprising of Pheromone trap with funnel + Bait trap of fruits resulted significantly the lowest level of infestation (20.47%) as compared to untreated control plot (Table 5). The highest level of infestation was obtained from the untreated control plot, T_7 (77.68%) which was significantly higher than that of all other treatments. Among the treated plots, T_1 treatment comprised of conventional pheromone trap showed the highest % fruits infestation by number (57.50%) which was statistically identical with T_2 (59.00%) comprised of Pheromone trap with adhesive.

Regarding of healthy fruit production per plot, the highest number of healthy fruits/plot (9.00) were harvested from T_5 (Pheromone trap with funnel + Bait trap) Treatment, which was significantly different from all other treatments. However, the lowest number of healthy fruits/plot (1.25) was harvested from untreated control plot, T_7. But among the treated plots, T_1 treatment comprised of conventional pheromone trap showed the lowest healthy fruits/plot by number (2.33) which was significantly same with T_2 (3.00) comprised of Pheromone trap with adhesive.

Significant variation was also observed in respect to the number of infested fruits/plot caused by fruit fly at late fruiting stage (Table 5). The minimum number of infested fruits/plot (2.33) was obtained from the T_5 plots. On the other hand, the highest number of infested fruits/plot (4.35) was obtained from T_7 (Untreated Control) which was statistically identical with T_2 (4.33) and T_4 (4.33) and closely followed by T_3 (4.00) treatment at late fruiting stage. Within the treated plots, T_2 (Pheromone trap with adhesive) and T_4 (Pheromone trap with adhesive + Bait trap) showed the lowest performance in terms of infested fruits/plot at late fruiting stage.

In terms of total fruits/plot at late fruiting stage, the highest (11.33) was obtained from T_5 (Pheromone trap with funnel + Bait trap) where the lowest (5.60) was found in T_7 (Untreated Control). But within the treated plots, T_1 (Conventional pheromone trap) showed the lowest total number of fruits/plot (5.67) which was statistically identical with T_7 (Untreated Control).

In conditions of percent reduction of fruit infestation over control, the highest percent reduction over control (by number) was recorded from T_5 comprising of Pheromone trap with funnel + Bait trap (46.44%) followed by 23.45% in T_1 and T_6 treated plot where the lowest percent reduction of fruit infestation over control (0.46%) was observed from T_2 and T_4 treated plot.

Table 5: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of infestation by number at late stage

Treatments	Number of fruits/plot			percent infestation by number	percent reduction over control
	Healthy	Infested	Total fruit		
T_1	2.33 c	3.33 c	5.67 e	57.50 b	23.45
T_2	3.00 c	4.33 a	7.33 d	59.00 b	00.46
T_3	5.67 b	4.00 ab	9.67 b	41.29 d	08.05
T_4	5.00 b	4.33 a	9.33 bc	47.31 c	00.46
T_5	9.00 a	2.33 d	11.33 a	20.71 e	46.44
T_6	5.00 b	3.33 c	8.33 cd	40.12 d	23.45
T_7	1.25 d	4.35 a	5.60 e	77.68 a	--
$LSD_{0.05}$	0.938	0.4807	1.185	2.924	--
CV(%)	11.77	10.82	8.24	14.96	--

In a column, numeric data represents the mean value of 3 replications. Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)

T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.3.2 Weight of fruit

Significant variation was observed in terms of healthy fruit weight, infested fruit weight and total fruit weight per plot and also % infestation of fruit by weight at late fruiting stage (Table 6).

Results showed that the highest amount of healthy fruits/plot (12.27 kg) was observed in the T_5 treatment (Pheromone trap with funnel + Bait trap) which was significantly different from all other treatments. Treatment, T_3 (7.60 kg) comprised of Pheromone trap with funnel and T_4 (6.60 kg) comprised of Pheromone trap with adhesive + Bait trap also showed good performance compared to T_5. The lowest amount of healthy fruit weight/plot (1.40 kg) was observed in Untreated Control treatment, T_7. Among the treated plots, the lowest healthy weight of fruits/plot (2.97 kg) was found from T_1 (Conventional pheromone trap) treatment followed by T_2 (4.07 kg) treatment comprised of Pheromone trap with adhesive.

The weight of infested fruits/plot differed significantly in control plots (T_7) compared to other treatments. The lowest weight of infested fruits/plot (2.95 kg) was obtained from T_5 (Pheromone trap with funnel + Bait trap) followed by T_1 (3.83 kg) comprised of conventional pheromone trap and T_6 (4.03 kg) comprised of Pheromone trap with adhesive + Bait trap + Polybag at late fruiting stage. The highest amount of infested fruit weight/plot (5.35 kg) was observed in the T_7 (untreated control) which was statistically identical with T_2 (5.05 kg), T_3 (5.00 kg) and T_4 (5.30 kg). Within the treated plots, the highest amount of infested fruit weight/plot (5.30 kg) at late fruiting stage was observed in the T_4 (Pheromone trap with adhesive + Bait trap).

In terms of total fruit weight/plot, the highest (15.20 kg) was achieved from T_5 (Pheromone trap with funnel + Bait trap) at late fruiting stage of crop followed by T_3 (12.60 kg), T_4 (11.90 kg) and T_6 (10.55 kg) where the lowest (6.75 kg) was obtained from Untreated Control (T_7) treatment which was statistically identical with T_1 (6.80 kg). Among the treated plots, the lowest total weight of fruits/plot

(6.80 kg) was found from T_1 (Conventional pheromone trap) followed by T_2 (9.12 kg) comprised of Pheromone trap with adhesive.

In case of % fruit infestation by weight, the lowest percent fruit infestation by weight (19.52%) was observed from treatment T_5 which was significantly different from all other treatments. T_3 (39.80%), T_4 (45.40%) and T_6 (38.32%) also showed comparatively higher performance in terms of % fruit infestation by weight at late fruiting stage. The control plots had the highest fruit infestation (79.26%) by weight which differed significantly from all other treatments. Among the treated plots, the highest % fruit infestation by weight was observed in T_2 (55.25%) followed by T_1 (54.89%) at late fruiting stage.

The highest fruit infestation reduction over control by weight (44.86 %) was obtained from the treatment T_5 followed by 28.41% and 24.67% in T_1 and T_6 respectively where the lowest fruit infestation reduction over control by weight was obtained from T_4 (0.98%) followed by T_2 (5.61%) and T_3 (5.545) (Table 6). According to Tamaki *et al*. (1983) impact of removal of males with sex pheromone baited traps on suppression of the peach twig borer, *Anarsia lineatella* (Zeller). Male removal sex pheromone - baited traps has been successful in reducing damage caused by the red banded leaf roller.

Table 6: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of infestation by weight at late stage

Treatments	Weight of fruits/plot (kg)			Percent infestation by weight	Percent reduction over control
	Healthy	Infested	Total fruit		
T_1	2.97 cd	3.83 b	6.80 e	54.89 b	28.41
T_2	4.07 c	5.05 a	9.12 d	55.25 b	05.61
T_3	7.60 b	5.00 a	12.60 b	39.80 d	06.54
T_4	6.60 b	5.30 a	11.90 bc	45.40 c	00.93
T_5	12.27 a	2.95 c	15.20 a	19.52 e	44.86
T_6	6.52 b	4.03 b	10.55 c	38.32 d	24.67
T_7	1.40 d	5.35 a	6.75 e	79.26 a	--
$LSD_{0.05}$	1.19	0.8113	1.400	3.056	--
CV(%)	11.23	9.43	7.64	8.78	--

In a column, numeric data represents the mean value of 3 replications. Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)

T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.4 Effect on fruit yield

The effect of various treatments on yield was determined in terms of healthy, infested and total fruit yield and these were obtained during the entire reproductive stage of the crop. The findings thus obtained including the percent increase and decrease of yield over control was presented in (Table 7).

Significantly the highest total fruit yield (38.44 t/ha) was obtained from the plots treated with Pheromone trap with funnel + Bait trapt (T_5). The total fruit yield from T_3 (34.68 t/ha) comprising of Pheromone trap with funnel was the second highest which was statistically different from all other treatments (Table7). On the other hand, the lowest total fruit yield (19.16 t/ha) was obtained from control treatment (T_7). Among the treated plot, the lowest total fruit yield (23.12 t/ha) was obtained from T_1 (Conventional pheromone trap) which was also significantly different from all other treatments. The total fruit yield obtained from T_4 (31.46 t/ha) comprised of Pheromone trap with adhesive + Bait trap and from T_6 (28.12 t/ha) comprised of Pheromone trap with adhesive + Bait trap + Polybag gave comparatively higher yield but significantly lower than that of T_5. Again, T_2 (Pheromone trap with adhesive) treatment gave significantly lower total fruit yield (25.36 t/ha). In terms of % increase of total fruit yield over control, the highest result (100.63%) was obtained from T_5 (Pheromone trap with funnel + Bait trap) followed by 81% from T_3 (Pheromone trap with funnel). The lowest % increase of total fruit yield over control (20.67%) was found in T_1 (Conventional pheromone trap) treatment followed by 32.36% from T_2 (Pheromone trap with adhesive).

Significantly the highest healthy fruit yield (35.23 t/ha) was obtained from T_5 (Pheromone trap with funnel + Bait trap) which was significantly different from all other treatments. Again, the lowest healthy fruits yield (12.04 t/ha) was obtained from the untreated control plots (T_7) and this was also statistically different from all other treatments. Treatment T_3 (30.02 t/ha) and T_4 (26.57 t/ha) significantly higher healthy fruit yield where T_1 (17.60 t/ha) and T_2 (20.10 t/ha) gave comparatively lower healthy fruit yield. In case of % increase of healthy fruit yield over control, the highest (192.61%) was observed in T_5 where the lowest (46.18%) was observed in T_1 treatment. The treatment of T_3 (149.34%) and T_4 (120.68%) also gave promising results of % increase of healthy fruit yield over control compared to all other treatments.

In this study significantly the lowest infested fruits yield (3.21 t/ha) was obtained from the plots treated with Pheromone trap with funnel + Bait trap (T_5) which was significantly different from all other treatments. The plots treated with Pheromone trap with funnel (T_3) and Pheromone trap with adhesive + Bait trap (T_4) also showed lower infested fruits yield (4.66 and 4.89 t/ha respectively). On the other hand, the highest infested fruits yield (7.12 t/ha) was found in control treatment (T_7) followed by T_1 (5.52 t/ha) comprised of conventional pheromone trap. In terms of % decrease of infested fruit over control, the highest (54.92%) was achieved by T_5 where the lowest (22.47%) was obtained from T_1.

It is very difficult to correctly appraise the extent of damage in terms of yield caused by fruit fly (Narayanan and Batra 1960). The infestation of fruit fly on sweet gourd invariably causes deformation and retardation of the growth of fruits and cause damage in terms of quality, quantity and thus market value. Infested fruits reduced in size and weight as compared to the healthy fruits. Severe infestation involving a number of punctures and larvae inside the fruit causes decomposition of fruits accompanied by liquefaction of pulp with foul odor (Kabir *et al*. 1995, Mckinlay *et al*. 1992). Amin (1995) obtained significantly the lowest weight reduction (24.45%) when the fruits were bagged at fruit initiation stage.

Table 7: Effect of different treatments against cucurbit fruit fly in sweet gourd on the basis of yield/ha

Treatments	Fruit yield (t/ha)					
	Healty fruit yield (t/ha)	Percent increase over control	Infested fruit yield (t/ha)	Percent decrease over control	Total fruit yield (t/ha)	Percent increase over control
T_1	17.60 f	46.18	5.52 b	22.47	23.12 f	20.67
T_2	20.10 e	66.94	5.26 c	26.12	25.36 e	32.36
T_3	30.02 b	149.34	4.66 e	34.55	34.68 b	81.00
T_4	26.57 c	120.68	4.89 e	31.32	31.46 c	64.20
T_5	35.23 a	192.61	3.21 f	54.92	38.44 a	100.63
T_6	23.00 d	91.03	5.12 d	28.09	28.12 d	46.76
T_7	12.04 g	--	7.12 a	--	19.16 g	--
$LSD_{0.05}$	1.24	--	0.38	--	1.16	--
CV(%)	8.36	--	7.27	--	9.12	--

In a column, numeric data represents the mean value of 3 replications. Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)

T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.5 Presence of cucurbit fruit fly at different fruiting stages of sowing

4.5.1 Early fruiting stage

Presence of cucurbit fruit fly at early fruiting stage of different days after sowing of sweet gourd was significantly influenced by different treatments applied in the present study (Table 8). Here, 60 – 80 days after sowing (DAS) was considered at early fruiting stage. Results showed that the highest number of cucurbit fruit fly was trapped (6.33, 6.67 and 6.00 at 60, 70 and 80 DAS respectively) with the treatment of T_5 comprised of Pheromone trap with funnel + Bait trap which was significantly different from all other treatments. On the other hand, the lowest number of cucurbit fruit fly was trapped (2.33, 2.33 and 1.67 at 60, 70 and 80 DAS respectively) with the treatment of T_1 (Conventional pheromone trap). Results also showed that T_3 (Pheromone trap with funnel) and T_4 (Pheromone trap with adhesive + Bait trap) showed comparatively higher performance where T_2 (Pheromone trap with adhesive) showed comparatively lower performance in controlling cucurbit fruit fly at early stage.

4.5.2 Mid fruiting stage

Presence of cucurbit fruit fly at mid fruiting stage of different days after sowing of sweet gourd was significantly influenced by different treatments applied in the present study (Table 8). Here, 90 – 110 days after sowing (DAS) was considered at mid fruiting stage. Results showed that the highest number of cucurbit fruit fly was trapped (6.67, 5.67 and 6.67 at 90, 100 and 110 DAS respectively) with the treatment of T_5 comprised of Pheromone trap with funnel + Bait trap which was significantly different from all other treatments. On the other hand, the lowest number of cucurbit fruit fly was trapped (1.33, 1.67 and 1.00 at 90, 100 and 110 DAS respectively) with the treatment of T_1 (Conventional pheromone trap). Results also showed that T_3 (Pheromone trap with funnel) showed comparatively higher performance where T_2 (Pheromone trap with adhesive) showed comparatively lower performance in controlling cucurbit fruit fly at mid stage.

4.5.3 Late fruiting stage

Presence of cucurbit fruit fly at late fruiting stage of different days after sowing of sweet gourd was significantly influenced by different treatments applied in the present study (Table 8). Here, 120 – 140 days after sowing (DAS) was considered at mid fruiting stage. Results showed that the highest number of cucurbit fruit fly was trapped (7.33, 4.67 and 3.67 at 120, 130 and 140 DAS respectively) with the treatment of T_5 comprised of Pheromone trap with funnel + Bait trap which was significantly different from all other treatments. On the other hand, the lowest number of cucurbit fruit fly was trapped (1.33, 0.67 and 0.33 at 120, 130 and 140 DAS respectively) with the treatment of T_1 (Conventional pheromone trap). Results also showed that T_3 (Pheromone trap with funnel) showed comparatively higher performance where T_2 (Pheromone trap with adhesive) showed comparatively lower performance in controlling cucurbit fruit fly at late stage.

Table 8: Number of cucurbit fruit fly captured by different method applied in the present study at different days after sowing of sweet gourd

Treatmens	Number of insects/plot at different days after sowing								
	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS	110 DAS	120 DAS	130 DAS	140 DAS
T_1	2.33d	2.33 f	1.67 f	1.33 f	1.67 f	1.00 f	1.33 f	0.67 f	0.33 f
T_2	3.00c	3.00 e	2.33 e	2.67 e	2.33 e	1.67 e	2.33 e	1.33 e	0.67 e
T_3	4.67b	5.00 b	4.67 b	5.00 b	5.33 b	4.33 b	5.00 b	3.67 b	2.33 b
T_4	4.33b	4.33 c	4.33 c	4.00 c	3.67 c	3.33 c	4.33 c	2.00 c	1.67 c
T_5	6.33a	6.67 a	6.00 a	6.67 a	5.67 a	6.67 a	7.33 a	4.67 a	3.67 a
T_6	3.33c	3.67 d	2.67 d	3.33 d	3.00 d	2.33 d	2.67 d	1.67 d	1.00 d
T_7	--	--	--	--	--	--	--	--	--
$LSD_{0.05}$	0.51	0.47	0.26	0.25	0.23	0.22	0.28	0.19	0.14
CV(%)	12.46	7.54	10.23	9.81	8.20	12.58	7.65	10.54	7.92

In a column, numeric data represents the mean value of 3 replications. Same lettering showed non-significant difference and different lettering showed significant difference.

T_1 = Pheromone trap (Conventional)

T_2 = Pheromone trap with adhesive

T_3 = Pheromone trap with funnel

T_4 = Pheromone trap with adhesive + Bait trap

T_5 = Pheromone trap with funnel + Bait trap

T_6 = Pheromone trap with adhesive + Bait trap + Polybag

T_7 = Untreated (Control)

4.5.4 Relationship between total infested fruit yield and total yield (t/ha)

The results revealed that there was strong negative correlation between total infested fruit yield and total yield/ha, which suggested that with the increase of total infested fruit yield there was a significant influence on total yield/ha. A linear regression was fitted between total yield/ha weight and total infested fruit yield (Fig.1). The correlation coefficient (r) was – 0.933 and the contribution of the regression (R^2) were 0.871. In the present study, it was observed that cucurbit fruit fly passively prevented plants to produce healthy and total fruit yield. The fruits became stunted with a reduced yield.

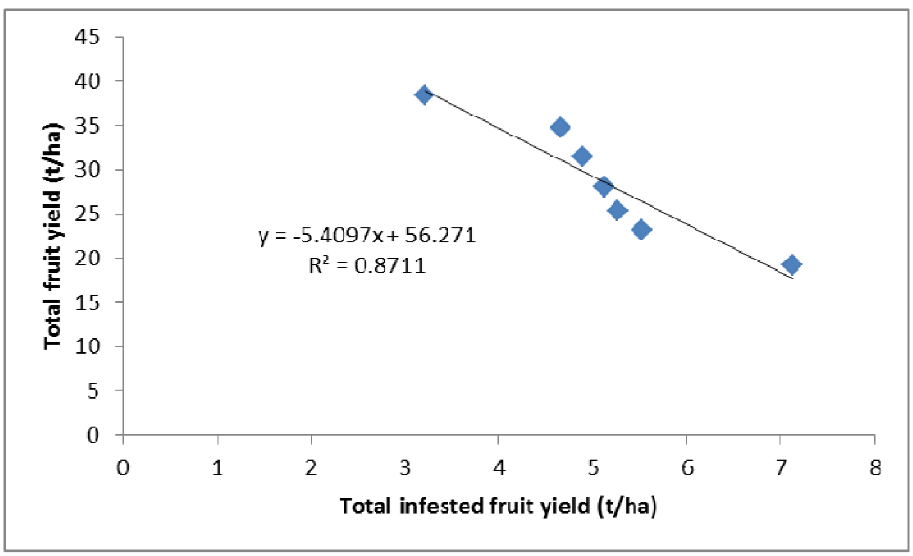

Fig. 1: Relationship between total infested fruit yield and total yield (t/ha) obtained from different treatments

4.5.5 Relationship between average insects trapped and total fruit yield

The results revealed that there was strong positive correlation between average insects trapped and total fruit yield, which suggested that with the increase of insects trapped there was a significant influenced on total fruit yield. A linear regression was fitted between total fruit yield and average insects trapped by different treatments (Fig.2). The correlation coefficient (r) was 0.996 and the contribution of the regression (R^2) was 0.9913. In the present study, it was observed that cucurbit fruit fly passively prevented plants to produce healthy fruit yield. The plants became stunted with a reduced yield.

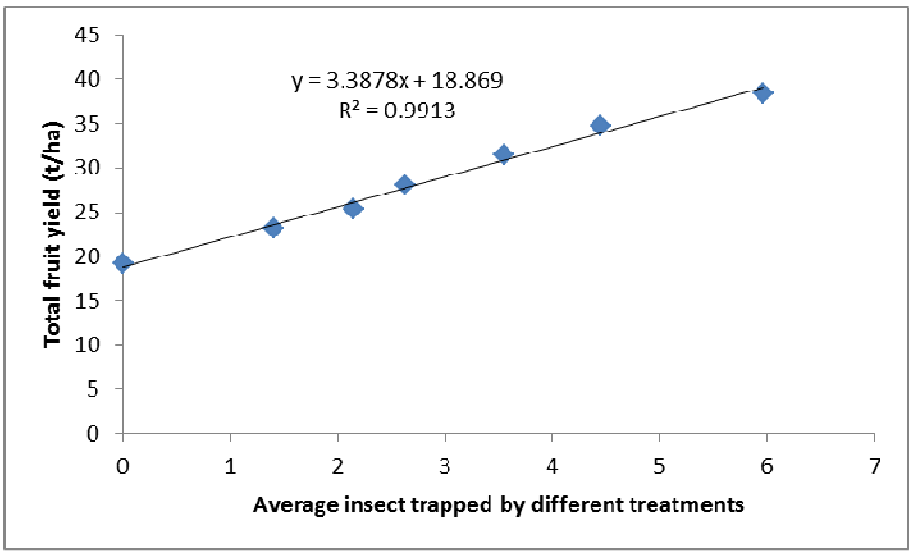

Fig. 2:Relationship between average insects trapped and total fruit yield obtained from different treatments

CHAPTER V

SUMMARY

A field experiment was conducted at Sher-e-Bangla Agriculture University farm to find out the effectiveness of different pheromone-trap designs for management of cucurbit fruit fly during January to July 2012. The treatments of the experiment were (i) T_1 = Pheromone trap (Conventional), (ii) T_2 = Pheromone trap with adhesive, (iii) T_3 = Pheromone trap with funnel, (iv) T_4 = Pheromone trap with adhesive + Bait trap, (v) T_5 = Pheromone trap with funnel + Bait trap, (vi) T_6 = Pheromone trap with adhesive + Bait trap + Polybag and (vii) T_7 = Untreated (Control). The experiment was laid out in a Randomized Complete Block Design with three replications.

Data were 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 days after sowing (DAS). Healthy fruit/plot, infested fruits/plot, % infestation and % reduction or increase over control was considered at each of the stage.
Results showed that the highest number of healthy fruits/plot (14.67), lowest number of infested fruits/plot (3.67), highest total number of fruits/plot (18.33), lowest % fruit infestation by number (20.08%) and highest % reduction of infested fruit over control by number (60.66%) at early fruiting stage were achieved from T_5 (Pheromone trap with funnel + Bait trap). On the other hand the lowest number of healthy fruits/plot (3.33), highest number of infested fruits/plot (9.33), lowest total number of fruits/plot (12.67) and highest % fruit infestation by number (74.72%) at early fruiting stage were achieved from control treatment (T_7). Among the treated plots, the lowest number of healthy fruits/plot (5.33), highest number of infested fruits/plot (8.33), lowest total number of fruits/plot (13.67), highest % fruit infestation by number (60.99%) and lowest % reduction of infested fruit over control by number (10.72%) at early fruiting stage were achieved from T_1 (Conventional Pheromone trap).

Again, the highest weight of healthy fruits/plot (9.67kg), lowest weight of infested fruits/plot (2.12kg), highest total weight of fruits/plot (11.77kg), lowest % fruit infestation by weight (18.07%) and highest % reduction of infested fruit over control by weight (52.14%) at early fruiting stage were achieved from T_5 (Pheromone trap with funnel + Bait trap). On the other hand the lowest weight of healthy fruits/plot (1.83kg), highest weight infested fruits/plot (4.43kg), lowest total weight of fruits/plot (6.27kg) and highest % fruit infestation by weight (70.94%) at early fruiting stage were achieved from control treatment (T_7). Among the treated plots, the lowest weight of healthy fruits/plot (2.99kg), highest weight of infested fruits/plot (4.00kg), lowest total weight of fruits/plot (7.08kg), highest % fruit infestation by weight (56.58%) and lowest % reduction of infested fruit over control by weight (9.71%) at early fruiting stage were achieved from T_1 (Conventional Pheromone trap).

Results also showed that the highest number of healthy fruits/plot (14.33), lowest number of infested fruits/plot (4.33), highest total number of fruits/plot (18.67), lowest % fruit infestation by number (23.33%) and highest % reduction of infested fruit over control by number (56.70%) at mid fruiting stage were achieved from T_5 (Pheromone trap with funnel + Bait trap). On the other hand the lowest number of healthy fruits/plot (1.67), highest number of infested fruits/plot (10.00), lowest total number of fruits/plot (11.67) and highest % fruit infestation by number (85.98%) at mid fruiting stage were achieved from control treatment (T_7). Among the treated plots, the lowest number of healthy fruits/plot (5.00), highest number of infested fruits/plot (7.67), lowest total number of fruits/plot (12.67), highest % fruit infestation by number (60.71%) and lowest % reduction of infested fruit over control by number (23.30%) at mid fruiting stage were achieved from T_1 (Conventional Pheromone trap).

Again, the highest weight of healthy fruits/plot (12.47kg), lowest weight of infested fruits/plot (3.35kg), highest total weight of fruits/plot (15.80kg), lowest % fruit infestation by weight (21.32%) and highest % reduction of infested fruit over control by weight (52.28%) at mid fruiting stage were achieved from T_5 (Pheromone trap with funnel + Bait trap). On the other hand the lowest weight of healthy fruits/plot (1.58kg), highest weight infested fruits/plot (7.02kg), lowest total weight of fruits/plot (8.60kg) and highest % fruit infestation by weight (81.79%) at mid fruiting stage were achieved from control treatment (T_7). Among the treated plots, the lowest weight of healthy fruits/plot (4.18kg), highest weight of infested fruits/plot (5.39kg), lowest total weight of fruits/plot (9.57kg), highest % fruit infestation by weight (56.58%) and lowest % reduction of infested fruit over control by weight (23.22%) at mid fruiting stage were achieved from T_1 (Conventional Pheromone trap).

Results also indicated that the highest number of healthy fruits/plot (9.00), lowest number of infested fruits/plot (2.33), highest total number of fruits/plot (11.33), lowest % fruit infestation by number (20.71%) and highest % reduction of infested fruit over control by number (46.44%) at late fruiting stage were achieved from T_5 (Pheromone trap with funnel + Bait trap). On the other hand the lowest number of healthy fruits/plot (1.25), highest number of infested fruits/plot (4.35), lowest total number of fruits/plot (5.60) and highest % fruit infestation by number (77.68%) at late fruiting stage were achieved from control treatment (T_7). Among the treated plots, the lowest number of healthy fruits/plot (2.33), highest number of infested fruits/plot (3.33), lowest total number of fruits/plot (5.67), highest % fruit infestation by number (57.50%) and lowest % reduction of infested fruit over control by number (23.45%) at late fruiting stage were achieved from T_1 (Conventional Pheromone trap).

Again, the highest weight of healthy fruits/plot (12.27kg), lowest weight of infested fruits/plot (2.95kg), highest total weight of fruits/plot (15.20kg), lowest % fruit infestation by weight (19.52%) and highest % reduction of infested fruit over control by weight (44.86%) at late fruiting stage were achieved from T_5 (Pheromone trap with funnel + Bait trap). On the other hand the lowest weight of healthy fruits/plot (1.40kg), highest weight infested fruits/plot (5.35kg), lowest total weight of fruits/plot (6.75kg) and highest % fruit infestation by weight (79.26%) at late fruiting stage were achieved from control treatment (T_7). Among the treated plots, the lowest weight of healthy fruits/plot (2.97kg), highest weight of infested fruits/plot (3.83kg), lowest total weight of fruits/plot (6.80kg), highest % fruit infestation by weight (54.89%) and lowest % reduction of infested fruit over control by weight (28.41%) at late fruiting stage were achieved from T_1 (Conventional Pheromone trap).

In terms of fruit yield/ha, the highest healthy fruit yield (35.23 t/ha), lowest infested yield (3.21 t/ha) and highest total yield (38.44 t/ha) were achieved from T_5 (Pheromone trap with funnel + Bait trap) where the lowest healthy fruit yield (12.04 t/ha), highest infested yield (7.12 t/ha) and lowest total yield (19.16 t/ha) were achieved from control treatment (T_7). Among the treated plots, the lowest healthy fruit yield (17.60 t/ha), highest infested yield (5.52 t/ha) and lowest total yield (23.12 t/ha) were achieved from T_1 (Conventional Pheromone trap) treatment.

Again, the highest % increase of healthy fruit yield over control (192.61%), % decrease of infested fruit yield over control (54.92%) and % increase of total fruit yield over control (100.63%) were achieved from T_5 (Pheromone trap with funnel + Bait trap) where the lowest % increase of healthy fruit yield over control (46.18%), % decrease of infested fruit yield over control (22.47%) and % increase of total fruit yield over control (20.67%) were achieved from T_1 (Conventional Pheromone trap) treatment.

Presence of cucurbit fruit fly at late fruiting stage of different days after sowing of sweet gourd was significantly influenced by different treatments. Results showed that the highest number of cucurbit fruit fly was trapped by T_5 (Pheromone trap with funnel + Bait trap) at early, mid and late fruiting stage where the lowest was achieve from T_1 (Conventional pheromone trap).

Conclusion

From the present study, it may be concluded that incidence of cucurbit fruit fly and infestation of sweet gourd by cucurbit fruit fly significantly varied among the treatments. The overall study revealed that the highest performance was obtained from T_5 (Pheromone trap with funnel + Bait trap), T_3 (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 (Conventional pheromone trap).

Considering the results of the present study, it may be concluded that T_5 (Pheromone trap with funnel + Bait trap) showed the best performance compared to other treatments in respect of reducing cucurbit fruit fly and yield of sweet gourd.

Further study is recommended to assess the environment friendly management practices of important agricultural pests in various practices prevailing in different agro-ecosystem of Bangladesh.

CHAPTER VI

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APPENDICES

Appendix I. Experimental site at Sher-e-Bangla Agricultural University, Dhaka-1207

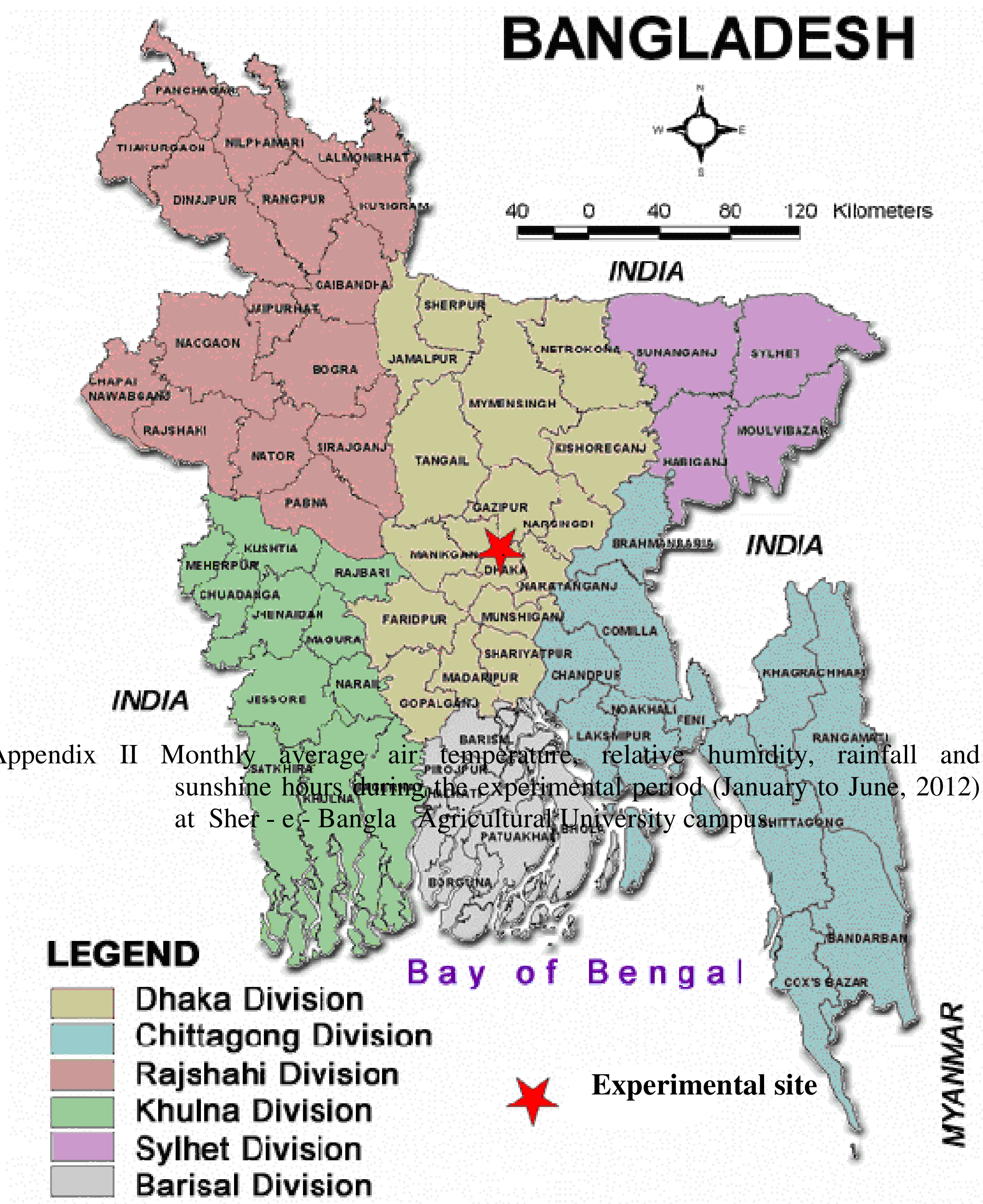

Figure: The map of Bangladesh showing experimental site

Appendix II Monthly average air temperature, relative humidity, rainfall and sunshine hours during the experimental period (January to June, 2012) at Sher - e - Bangla Agricultural University campus

Month	Year	Monthly average air temperature (^0C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
Jan.	2012	25.23	18.20	21.80	74.90	4.0	195.00
Feb.	2012	31.35	19.40	25.33	68.78	3.0	225.50
Mar.	2012	33.20	22.00	27.60	64.13	Trace	220.30
April	2012	35.00	23.81	29.41	61.4	185	232
May	2012	35.00	24.95	29.98	64.27	180	240
June	2012	32.50	23.00	27.75	66.00	181	238

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka – 1207.

Appendix III: Physical characteristics and chemical composition of soil of the experimental plot

Soil Characteristics	**Analytical results**
Agrological Zone	Madhupur Tract
P^H	5.47 – 5.63
Organic matter	0.82
Total N (%)	0.43
Available phosphorous	22 ppm
Exchangeable K	0.42 meq / 100 g soil

Source : Soil Research Development Institute(SRDI),Dhaka.