MANAGEMENT OF CUCURBIT FRUIT FLY ON SWEET GOURD

BY
MUHAMMAD AKKAS ALI

REGISTRATION NO. 26199/00775

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

IN

ENTOMOLOGY
SEMESTER: JULY-DECEMBER 2007

Approved by:

(Prof. Dr. Mohammed Ali)	**(Md. Mizanur Rahman)**
Supervisor	Co-Supervisor

(Prof. Jahanara Begum)
Chairman

CERTIFICATE

This is to certify that the thesis entitled, "**MANAGEMENT OF CUCURBIT FRUIT FLY ON SWEET GOURD**" a **submitted** to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN ENTOMOLOGY,** embodies the result of a piece of bonafide research work carried out by, **Muhammad Akkas Ali,** Registration No. 26199/00775 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 duly been acknowledged.

Mohammed Ali

(Prof. Dr. Mohammed Ali)

Supervisor

Dated: December, 2007

Dhaka, Bangladesh

ACKNOWLEDGEMENT

All praises goes to Almighty Allah, the Supreme Ruler of the universe who enables me to complete this present piece of work.

He would like to express his heartiest gratitude, sincere appreciation and immense indebtedness to my supervisor **Professor Dr.Mohammed Ali,** Department of Entomology Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, for his scholastic guidance, planning, valuable suggestions, continuous encouragements and all kinds of support and help throughout the period of research work and preparation of this manuscript of thesis.

Heartiest gratitude is due to the respectable Co-supervisor, MD.Mizanur Rahman,Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, for his valuable suggestions, kind co-operation and dynamic guidance throughout the study and research works.

The author also expresses his cordial thanks and grateful to all other respected teachers of the Department of Entomology,, Sher-e-Bangla Agricultural University for their valuable advices, suggestions and constructive criticism.

He also wishes to acknowledge his indebtedness to Farm Division of SAU and other staff of the Department of Entomology for their co-operation in the implementation of research works.

He is also thankful to Md.Abdur Razzak, Md.Abu Talha, Md. Salah Uddin Md. Mazharul Islam, Md Sahadat Hosain., Zaman, Farid & Alo for their constant encouragement.

At last but not the least, he feels indebtedness to his beloved parents whose sacrifice, inspiration, encouragement and continuous blessing paved the way to my higher education. He is also grateful to my brother Md. Abdar Ali and Sister Miss Nasima and other members of the family for their forbearance, inspirations, sacrifices and blessings.

The Author

CONTENTS

LIST OF TABLES

LIST OF APPENDIX

THESIS ABSTRACT

MANAGEMENT OF CUCURBIT FRUIT FLY ON SWEET GOURD

By

Muhammad Akkas Ali

A study was conducted in the Experimental field at Dhaka, Sher-e-Bangla Agricultural University during November, 2006 to April, 2007 to evaluate the comparative effectiveness of different treatments (viz. Marshal 20EC, sumialpha 5EC, Bait trap + hand picking (IF) Pheromone trap + hand picking (IF), Marshal 20 EC + bagging of fruits at 3 days after anthesis and left for 5 days, bagging of fruits + sumialpha 5 EC, Bagging of fruits + hand picking (IF) for the management of cucurbit fruit fly, *Bactrocera cucurbitae* on sweet gourd. The study revealed that the treatment T_7 comprising of polythene bagging of fruits at 3 days after anthesis and left for 5 days + hand picking of infested fruit had the lowest level of fruit fly infestation in fruit both by number and weight at early, mid and late fruiting stages. Fruit yield of T_7 treatment was significantly highest, followed by T_6 treatment comprising of Sumialpha 5EC @ 1ml/lL of water at 10 days interval + polythene bagging of fruits at 3 days after anthesis and left for 5 days. The lowest 17.25% and the highest 74.25% fruit infestation were recorded in treatments T_6 and T_8 treated plots respectively.

CHAPTER 1

INTRODUCTION

Vegetables are cheaper source of vitamins and minerals which are essential for maintaining sound health. Bangladesh has a serious deficiency in vegetables. The daily requirement of vegetables for a full 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 South 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 (Anon 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 tons. In summer only 243 thousand tons vegetables are produced (Anon 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 thousand metric tones of sweet gourd produced in Bangladesh (BBS 2004).

Unfortunately, cucurbits are infested by a number of insect pests, which are considered to be the significant obstacles for its economic production. Among them, cucurbit fruit fly and red pumpkin beetle are the major pests responsible for considerable damage of cucurbits (Butani and Jotwai 1984) Fruit fly is one of the most serious pests of cucurbits in Bangladesh (Alam 1969, Akhtaruzzaman 1999). This pest is also known as melon fly and sometimes as cucurbit fruit fly. It was reported that *Bactrocera cucurbitae* and *Bactrocera cudata* are two species of cucurbit fruit fly which are commonly found in Bangladesh (Alam *et al.* 1969). *Bactrocera tau* and *Bactrocera ciliates* have been currently identified in Bangladesh of which *Bactrocera ciliates* is a new record. *Bactrocera cucurbitae* is dominant in all the locations of Bangladesh followed by *Bactrocera tau* and *Bactrocera ciliates* (Akhtaruzzaman *et al.* 1999).

The quantitative and qualitative damages due to this pest cause great economic loss to cucurbit vegetables growers almost all over the world. The damage caused by fruit fly is the most serious in melon and this may be up to 100 percent. Other cucurbitaceous fruits may also be infested upto 50 percent (Atwal 1993). Yield losses due to fruit infestation vary from 19 to 70 percent in different cucurbits (Kabir *et al.* 1991).

Shah *et al.* (1948) observed the symptom of infestation as the formation of brown resinous deposit on the attracted fruits. The female fly drums on the skins of young fruits by her ovipositor and sometimes on the young leaves or stems of the host plants and makes punctures for laying eggs.

Afterward, fruit juice oozes out which transforms into resinous brown deposit. After hatching in the fruit, the larvae feed into pulpy tissue and make tunnels in fruits and cause direct damage. They also damage the fruits indirectly by contaminating with frass and accelerated rotting of fruits by pathogenic infection. Infested fruits if not rotten, become deformed and hardy which make it unfit for consumption.

In Bangladesh where the production of vegetables is much below the requirements, the damage due to cucurbit fruit flies is undesirable. It is therefore, extremely important to devise means to reduce the extent of damage due to fruit flies without affecting the agroecosystem.

A cluster of methods have been developed and suggested by Kapoor (1993) to control this pest using various cultural, physical, chemical, biological and legal methods; components of these methods are not always feasible and all these are not used by the growers. Each and every method has its positive and negative effects. Several authors and scientists have described and evaluated these methods in different ways with partial success. (Kapoor 1993, Narayanan and Batra 1960, Nayar *et al.* 1985).

Nasiruddinn and Karim (1992) found that 61.92% reduction of fruit fly infestation over control by spraying Dipterex 80 SP in snake gourd, but Dipterex 80 SP is not easily available in market for farmer use. Protein hydrolysate insecticide formulations and other insecticides (Malathion 57EC, and Diazinon 60EC) with molasses as attractant are being widely used for the control of fruit fly (Kapoor 1993, Nasiruddin and Karim 1992, Smith 1992). Some insecticides have been used satisfactorily in minimizing the damage to fruits and vegetables against fruit fly (Kapoor 1993, York 1992, Nair 1986 and Hameed *et al.* 1980)

Poison bait trap is the recent development of Bangladesh Agricultural Research Institute. The trap consists of 100 gm mashed sweet gourd with 10-12 drops of Dipterex 80 SP to attract and kill the adult flies causing 61.92-78.38% reduction of fruit fly-infestation in cucurbits. (Nasiruddin and Karim 1992). Mechanical, physical and cultural controls consisting of field sanitation, infested fruit picking, bagging of fruits, ploughing of soils were found effective to some extent against cucurbit fruit fly. (Kapoor 1993, Smith 1992 and Agarwal *et al.* 1987). Covering of fruits by polythene bag is an effective control of fruit fly in Sweet gourd. The lowest fruit fly incidence in Sweet gourd occurred in bagging fruits (4.2%) while the highest (39.38%) was recorded in the fruits of control plots (Anon 1988) collection and destruction of infested fruits with the larvae inside helped population reduction of fruit flies (Nasiruddin and Karim 1992). Unfortunately no single method had been proved to be effective and reliable against fruit fly Kapoor (1993).

Effective and Environmentally safer control methods and IPM package are needed against fruit fly of cucurbits. For the proper management of this important insect pest of cucurbit, it demands to look for ecofriendly IPM package(s) because lot of insecticides being s used for the control of this pest adverse affect on the environment. Uddin (1996) tried to developed IPM package using two or three methods as its components.

Therefore, the effective control of fruit fly in cucurbit deserves some new approaches which are eco-friendly, economically and socially acceptable.

Use of several tactics as used by the previous workers may be incorporated to develop a sound IPM packages against the pest. Thus, the present study was undertaken with the following objectives.

- To study the abundance and infestation level of cucurbit fruit fly during the growing season.
- To find out a suitable management package against cucurbit fruit fly.

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.

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 species may become widely distributed when their host plants are widespread, either naturally or cultivation by man (Kapoor 1993). Two of the worlds most damaging tephritids. *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 *Bractrocera 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.

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, pear, 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.

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 12°C-15°C 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.

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 (BARI), 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 x 0.78 cm to 3.53 x 2.07 cm and 2.13x1.18 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 2.03x1.08 cm. In teasel gourd, it was 19.28% on 8th day after fruit setting when average fruit size was 4.57 x 2.91 cm (Anon. 1988). Amin (1995) and Uddin (1996) observed 42.08 and 45.14% fruit fly infestation in cucumber, respectively.

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 hest 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.

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 3rd 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 @ 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).

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, Phosnhamidon and Endosulfan are effectively used for the control of melon fly (Agarlwal *et al.* 1987). In field trials in Pakistan in 1985-86, the application of Cypermethrin 10 EC and Malathion 57 EC at 10 days intervals (4 sprays in total) significantly reduced the infestation of *Bactrocera cucurbitae* on Melon (4.8-7.9) compared with untreated control. Malathion was the most effective insecticide (Khan *et al.* 1992).

Hameed *et al.* (1980) observed that 0.0596 Fenthion, Malathion, Trichlorophos and Fenthion with waiting period of five, seven and nine days respectively was very effective in controlling *Bactrocera cucurbitae* on cucumber in Himachal Pradesh, Various insecticide schedules were tested against *Bactrocera cucurbitae* on pumpkin in Assam during 1997. The most effective treatment in terms of lowest pest incidence and highest yield was carbofuran at 1.5 kg a.i/ha (Borah 1998).

Nasiruddin and Karim (1992) reviewed that comparatively less fruit fly infestation (8.56%) was recorded in snake gourd sprayed with Dipterex 80SP compared to those in untreated plot (22.48%). Pawer *et al.* (1984) reported that 0.05% Monocrotophos was very effective in controlling *Bactrocera cucurbitae* in muskmelon. Rabindranath and Pillai (1986) reported that Synthetic pyrethroids, Permethrin, Fenvelerate, Cypermethrin (ail at 100g 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 *Batrocra* species which are 20 g Malathion 50% Or 50 ml of Diazinon plus 200 g of molasses in 2 liters of water kept in flat containers or applying the bait Spray containing Malathion 0.05% plus 1% sugar/molasses or 0.025% of protein water) or spraying plants with 500 g molasses plus 50 g Malathion in 50 liters of water or 0.025% Fenitrothion plus 0.5% molasses. This is repeated at weekly intervals where the fruit fly infestation is serious (Kapoor 1993).

Nasiruddin and Karim (1992) reported that bait spray (1.0 g Dipterex 80SP and 100 g of molasses per liter of water) on snake gourd against fruit fly (*Bactrocera cucurbitae*) showed 8.50% infestation compared to 22.48% in control. Agarwal *et al.* (1987) achieved very good results for fruit fly (*Bactrocera cucurbitae*) management by spraying the plants with 500 g molasses and 50 litres of water at 7 days intervals. According to Steiner *et al.* (1988), poisoned bait containing Malathion and protein hydrolysate gave better results in fruit fly management program in Hawaii.

A field study was conducted to evaluate the efficacy of some bait sprays against fruit fly (*Bactrocera cucurbitae*) in comparison with a standard insecticide and bait traps. The treatment comprised 25 g molasses + 2.5 ml Malathion, (Limithion 50EC) and 2.5 litres water at a ratio of 1: 0.1: 100 satisfactorily reduced infestation and minimized the reduction in edible yield (Akhtaruzzaman *et al.* 2000).

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).

Brinjal Shoot and fruit Borer (BSFB) is a severe problem in Jessore region. To control the BSFB a program is made by Bangladesh Agricultural Research Institute (BARI) in collaboration with Asian Vegetable Research and Development Centre (AVRDC). They used four types of pheromone traps to control the BSFB in Jessore region, such as Wing pheromone trap, Delta pheromone trap, Water pheromone traps. Funnel shaped pheromone trap Anon (1983).

To make the pheromone component, E-11 hexadacenyle acetate and E-11-hexadacene-1.ol 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 @ 2ml/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 1996-97, a survey among 32 farmers indicated the great loss in the productivity of cucurbit vegetables.

CHAPTER III

MATERIALS AND METHODS

The study was conducted to evaluate a suitable IPM approach to suppress the infestation level of cucurbit fruit fly on sweet gourd the study was undertaken in the experimental field of Department of Entomology, S.A.U. farm, Dhaka, Bangladesh during November 2006 to April 2007. The treatments and their application procedures adopted in the study are discussed below.

Selection of Treatments

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

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval

T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval

T_3 = Bait trap+ Hand picking (Infested fruit) at 7 days interval

T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval

T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene bagging

T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene bagging

T_7 = Polythene bagging+ Hand picking (Infested fruit) at 7day interval

T_8 = Untreated control

Design of Experiment

Study was conducted utilizing those seven treatments laid out in a Randomized Complete Block Design (RCBD) with three replications arranged in the plots. Each plot had one pit and each pit contains three sweet gourd plants representing a replication.

Cultivation of sweet gourd

Land preparation

The land of the experimental field was prepared as recommended by Rashid (1993). The soil of the experimental field belongs to the Madhupur tract and was loamy with fine texture having P^H from 5.5 to 6.2. The soil of the experimental plot was well prepared ensuring good tilt. The whole experimental land was divided into 24 equal plots (3.5m × 3.5m). Length wise plot to plot distance was 1m and block to block distance was 2m.

Fertilizer application

Standard doses of cowdung and fertilizers were applied as recommended by Rashid (1993) for sweet gourd at the rate of 15000, 150, 125 and 100 kg/ha of cowdung, Urea, TSP and MP respectively. The half of the cowdung, TSP, MP and one third of urea were applied as basal dose during the land preparation. The remaining cowdung, TSP and MP were applied in the pits 15 days before sowing the seeds. The rest of urea was applied as top dressing after each flush of flowering and fruiting in three equal splits.

Sowing of seeds

Seeds of sweet gourd (variety-suprme) were collected from the East west Seed Company, Gazipur and varitey supreme. Five seeds per pit were sown directly (Nov' 15 of 2006) in the pit of the experimental plots. 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.

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.

Treatment application

Treatments and their application procedures are described below:

Hand picking of infested fruits

Regular visual checking of infested fruits of each plant of each plot, where this technique was included did this mechanical control. The infested fruits of the relevant plots were picked up and the numbers of infested fruits ere recorded.

Bagging of fruits at 3 days after anthesis (DAA) and left for 5 days

The bagging of fruits was applied by using transparent polythene bags provided with few holes made by an ordinary pin. These tiny holes were provided for aeration. The size of the perforated polythene bags was large (30cmx20cm) enough for normal growth and provides sufficient aeration. The sweet gourd is a cross-pollinated crop and both male and female flowers are generally open in tile morning and fertilized naturally by cross-pollination.

All the full-bloomed female flowers of the plant under the treatment were visually checked everyday and tagged. In the morning hours (8:00 to 9:30) before the beginning of frequent visit of fruit fly, the tagged female flowers were bagged individually with perforated polythene bags at 3 days after anthesis (DAA) and left for five days. The open mouth of the bag was wrapped and closed by jams clip near the peduncle of the fruit. After 5 days the polythene bags were removed. Regular observation was done to check the fruit fly infestation on these tagged fruits and the operations were continued till the late fruiting stage.

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 0.5ml (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.

Preparation of pheromone trap with detergent in it

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.

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.

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.

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

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

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

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

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:

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

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

Percent reduction over control

The Percent Reduction over control were calculated by using the following formula

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

CHAPTER IV

RESULTS AND DISCUSSIONS

The comparative study on the effectiveness of different management practices comprising various control tactics in suppressing the infestation level of fruit fly on sweet gourd was conducted in 2006-07, 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:

Effect of different treatments on number and weight of healthy fruits, infested fruits, percent infestation and percent reduction over control.

At early fruiting stage

At early fruiting stage the percent of fruit infestation (by number) among the treatments varied significantly (Table 1). The fruits under the treatment T_6 comprising of Sumilalpha 5EC @ 1ml/L of water at 10 days interval + bagging of fruits at 3 days after anthesis and left for five days resulted significantly the lowest level of infestation (17.25%) as compared to untreated control plot (74.02%) (Table1)

The highest level of infestation was obtained in the fruits harvested from the untreated control plot T_8 (74.02%) which was significantly higher than all other treatments.

Table 1. Effect of different treatments applied against cucurbit fruit fly on healthy, infested fruits, percent infestation and percent reduction over control of sweet gourd (by number) at early fruiting stage.

Treatments	Number of fruits/plot Healthy	Infested	% infestation (by number)	%Reduction over control
T_1	6.66 cd	4.33 cde	39.39 d	46.78
T_2	9.00 b	3.66 de	28.53 e	61.45
T_3	5.33 d	7.66 ab	59.21 b	20.00
T_4	7.33 c	5.00 cd	40.29 d	45.56
T_5	6.33 cd	6.66 bc	52.79 c	28.68
T_6	13.00 a	2.33 e	17.25 g	76.69
T_7	13.33 a	3.66 de	22.07 f	70.18
T_8	3.51 e	10.00 a	74.02 a	--
Level of significance	**	**	**	--
CV (%)	10.95	15.60	5.01	--

In a column, numeric data represents the mean value of 3 replications

** Significant at 0.01 level of probability.

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval
T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval
T_3 = Bait trap+Hand picking (Infested fruit) at 7 days interval
T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval
T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene bagging
T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene bagging
T_7 = Polythene bagging+ Hand picking (Infested fruit) at 7 days interval
T_8 = Untreated control

Regarding of healthy fruit production, the highest number of healthy fruits (13.33) were harvested from T_7 Treatment (bagging of fruits at 3 days after anthesis and left for five days + hand picking of Infested fruits (13.33), which was statistically similar with that of the T_6 treatment as Sumialpha 5EC @ 1ml/1L of water (T_6) treated plots (13.00) However lowest number of healthy fruits (3.51) were harvested from untreated control plots T_8.

Significant variation was also observed in respect to the number of infested fruits caused by fruit fly at early fruiting stage (Table 1). The minimum number of infested fruit (2.33) was obtained from the T_6 plots. The T_2 sumialpha (3.66) and T_7 (bagging of fruits +hand picking of infested fruits) treated plots also had lower number of infested fruits.

The maximum number of infested fruit (10.00) was occurred in the control plots (T_8) which was statistically higher than that of all other treatments.

The highest percent reduction of fruit infestation over control (by number) was recorded from T_6 comprising of sumialpha 5EC + bagging of fruits (76.69%), followed by70.18% in T_7 treated plots.

Table 2. Effect of different treatments applied against cucurbit fruit fly on healthy fruits, infested fruits, percent infestation and percent reduction over control of sweet gourd (by weight) at early fruiting stage

Treatments	Weight of fruits (Kg)			
	Healthy	Infested	%Infestation	% Reduction over control
T_1	4.36 c	3.40 b	43.01 b	25.40
T_2	7.50 b	2.95 c	28.22 d	51.95
T_3	4.15 c	3.45 b	45.34 b	22.79
T_4	7.50 b	2.35 de	23.85 de	59.39
T_5	4.70 c	2.52 d	34.94 c	40.50
T_6	8.86 a	2.22 ef	20.03 ef	65.89
T_7	9.16 a	2.10 f	18.65 f	68.24
T_8	3.50 d	4.98 a	58.73 a	--
Level of significance	**	**	**	--
CV (%)	13.73	9.34	8.10	--

In a column, numeric data represents the mean value of 3 replications

** Significant at 0.01 level of probability.

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval

T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval

T_3 = Bait trap+Hand picking (Infested fruit) at 7 days interval

T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval

T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene agging

T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene agging

T_7 = Polythene bagging+ Hand picking (Infested fruit) at 7 days interval

T_8 = Untreated control

At early fruiting stage, the highest amount of healthy fruit (9.16kg) was observed in the T_7 treatment which was statistically identical with T_6 (8.86 kg) treatment. T_2 (7.50 kg) and T_4 (7.50 kg) treatment also showed good performance compared to T_8 (3.50 kg).

The lowest amount of healthy fruit weight (3.50kg) was observed T_8 (3.50 kg) untreated control plots. The weight of infested fruit differed significantly in control plots (T_8) compared to other treatments. The lowest quantity of infested fruit weight (2.10 kg) was obtained from T_7 (Bagging +hand picking treated plot followed by 2.22 kg in T_6. The highest amount of infested fruit weight (4.98 kg) was observed in the T_8 (untreated control) the mean percentages of fruit infestation (by weight) varied significantly among the treatments .The lowest percent of fruit infestation by weight (18.65)was observed from treatment T_7 followed by 20.03% in T_6. The control plots had the highest fruit infestation 58.73% which differed significantly from all other treatments.

The highest fruit infestation reduction over control by weight (68.24 %) was obtained from the treatment T_7, followed by 65.89 %, 59.39%., 51.95 %, 40.50 %, 25.40 %, 22.79 % in T_6, T_4, T_2, T_5, T_1 and T_3 respectively.

Table 3. Effect of different treatments applied against cucurbit fruit fly on healthy, infested fruits, percent infestation and percent reduction over control of sweet gourd (by number) at mid fruiting stage

Treatments	Number of fruits/ Plot		% Infestation (by number)	% Reduction over control
	Healthy	Infested		
T_1	6.33 c	7.33 bc	51.71 d	29.33
T_2	11.33ab	4.67 d	27.95 f	61.80
T_3	6.33 c	7.66 b	54.62 c	25.35
T_4	7.33 bc	6.33 c	44.64 e	38.99
T_5	6.00 c	9.00 a	61.85 b	15.47.
T_6	13.33 a	4.33 d	24.76 g	66.16
T_7	13.00 a	4.00 d	23.11 h	68.42
T_8	3.66 d	10.00 a	73.17 a	--
Level of significance	**	**	**	--
CV (%)	19.28	10.42	4.41	--

In a column, numeric data represents the mean value of 3 replications

** Significant at 0.01 level of probability.

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval
T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval
T_3 = Bait trap+Hand picking (Infested fruit) at 7 days interval
T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval
T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene bagging
T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene bagging
T_7 = Polythene bagging+ Hand picking (Infested fruit) at 7 days interval
T_8 = Untreated control

At mid fruiting stage

Similarly, the percent of fruit infestation (by number) among the treatments varied significantly (Table 3) at fruiting stage.

significantly the lowest level of infestation (23.11%) was observed under the treatment T_7 comprising of bagging of fruits at 3 days after anthesis and left for five days + hand picking of infested fruits 24.76% followed by treatment (T_6) with Sumilalpha 5EC @ 1ml/L of water at 10 days interval + bagging of fruits at 3 days after anthesis and left for five days.

The highest level of infestation (73.17%) was obtained in the harvested from the untreated control plot (T_8) which differed significantly from all other treatments.

In respect of healthy fruit production, the highest number of healthy fruits (13.33) was harvested from T_6 13.33 which was statistically identical with T_7 treated plots (13.00) the lowest number of healthy fruits was (3.66) harvested from untreated control plots (T_8).

The lowest number of infested (4.0) fruit was obtained from the T_7 treatment, followed by 4.33, 4.66 in T_6 and T_2 treatments respectively.

In the maximum number of infested fruit (10.00) was recorded in the control plots (T_8), which was statistically different from that of all other treatments. The highest percent reduction of fruit infestation over control (by number) was recorded from T_7 (68.42 %) treated plot followed by treatment 66.16% in T_6 treatment.

Table 4. Effect of different treatments applied against cucurbit fruit fly on healthy fruits, infested fruits, percent infestation and percent reduction over control of sweet gourd by weight at mid fruiting stage.

Treatments	Weight of fruits (kg)		% Infestation	% Reduction over control
	Healthy	Infested		
T_1	4.83 c	3.25 b	40.22 b	34.80
T_2	5.00 c	2.60cd	34.21 c	44. 54
T_3	5.03 c	3.27 b	39.39 b	36.15
T_4	6.33 bc	2.13 d	25.17 e	59.19
T_5	6.66 b	2.84 bc	29.89 d	51.55
T_6	7.33 b	2.48 cd	25.28 e	59.02
T_7	9.50 a	2.15 d	18.45 f	70.09
T_8	3.00 d	4.83 a	61.69 a	--
Level of significance	**	**	**	--
CV (%)	13.79	9.34	6.75	--

In a column, numeric data represents the mean value of 3 replications

** Significant at 0.01 level of probability.

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval
T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval
T_3 = Bait trap+Hand picking (Infested fruit) at 7 days interval
T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval
T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene dagging
T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene dagging
T_7 = Polythene bagging+ Hand picking (Infested fruit) at 7 days interval
T_8 = Untreated control

At mid fruiting stage, the highest amount of healthy fruit weight (9.50kg) was observed from T_7 treatment. The second highest amount of healthy fruit weight (7.33 kg) was observed from the T_6 treated plot followed by 6.66 kg and 6.33 kg in T_5 and T_4 treated plots respectively. The lowest amount of healthy fruit weight (3.00 kg) was observed the T_8 (untreated control plots). The mean percentages of fruit infestation (by weight) among the treatments varied significantly. The lowest fruit infestation by weight (18.45 %) was observed from treatment T_7 treatment followed by 25.28% in T_6. The control plots had the highest fruit infestation (61.69 %) which differed significantly from all other treatments. The second highest amount of fruit infestation was observed from the T_1 (40.22 %) and T_3 (39.39 %) treatments.

The weight of infested fruit differed significantly in control plots compared to other treatments the lowest quantity of infested fruit weight was obtained from (T_7) treated plot (2.15 kg) followed by 2.48 kg, 2.13 kg and 2.60 kg in T_6, T_4, and T_2 treated plots respectively. The highest amount of infested fruit weight was observed in the T_8 (4. 83 kg) untreated control plots.

The highest percent reduction of fruit infestation over control (by weight) was obtained from the treatment T_7 (70.09 %) followed by the treatment 59.02%, 59.1 %, 51. 55%, 44.54 %, 36.15 % and 34.80 % in T_6, T_4, T_5, T_2, T_3 and T_1 respectively (Table 5)

Table 5. Effect of different treatments applied against cucurbit fruit fly on healthy and infested fruits of sweet gourd (by number) at late fruiting stage

Treatments	Number of fruits/ plot		% Infestation	% Reduction over control
	Healthy	Infested		
T_1	3.43 ab	4.66 ab	57.68 c	23.09
T_2	4.00 ab	3.66 abc	48.14 b	35.81
T_3	4.66 ab	2.66 bc	36.94 v	50.75
T_4	3.33 ab	4.66 ab	62.65 b	16.51
T_5	3.33 ab	5.02 ab	60.02 b	19.97
T_6	5.66 a	3.00 bc	42.43 e	43.43
T_7	6.33 a	1.66 c	20.50 g	72.66
T_8	2.00 b	6.00 a	75.00 a	--
Level of significance	**	**	**	--
CV (%)	22.48	22.23	3.88	--

In a column, numeric data represents the mean value of 3 replications

** Significant at 0.01 level of probability.

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval

T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval

T_3 = Bait trap+Hand picking (Infested fruit) at 7 days interval

T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval

T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene bagging

T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene bagging

T_7 = Polythene bagging+ Hand picking (Infested fruit) at7 days interval

T_8 = Untreated control

At late fruiting stage

At late fruiting stage the percent of fruit infestation (by number) varied significantly among the treatments .The fruits under the treatment T_7 plots comprising of bagging of fruits at 3 days after anthesis and left for five days + hand picking resulted significantly the lowest level of infestation (20.50%) as compared to untreated control plots (75.00%).(Table 5).

The highest level of infestation was (75.00) obtained in the harvested from the untreated control plot which differed significantly from all other treatments.

In respect of healthy fruit production, the highest number of healthy fruits (6.33) who harvested from (T_7) treated plots which was statistically identical with the T_6 (5.66) treated plots. The lowest number of healthy fruits (2.00) was harvested from untreated control

Significant variation was observed in respect of number of infested fruits by fruit fly at late fruiting stage. The lowest of infested fruit (1.66) was obtained from the T_7 treated plots. In T_6 (3.00 kg) and T_3 (2.66 kg) treated plots also had lower number of infested fruits. The maximum number of fruit infestation (6.00) was observed from the control plots (T_8) which was statistically different from that of all other treatments. The highest percent reduction of fruit infestation over control (by number) was recorded from T_7 treatment (72.66%).

Table 6. Effect of different treatments applied against cucurbit fruit fly on healthy fruits, infested fruits, percent infestation and percent Reduction over control of sweet gourd by weight at late fruiting stage

Treatments	Weight of fruits (Kg)		% Infestation	% Reduction over control
	Healthy	Infested		
T_1	4.16 b	3.55 b	46.04 c	26.57
T_2	3.16 b	2.05 d	39.34 d	37.26
T_3	3.76 b	3.63 b	49.12 b	21.66
T_4	4.00 b	2.57 c	39.12 d	37.61
T_5	3.57 b	2.20 cd	38.13 e	39.19
T_6	6.00 a	2.50 c	29.41 f	53.09
T_7	6.00 a	2.02 d	25.19 f	59.82
T_8	3.00 bc	4.89 a	62.70 a	--
Level of significance	**	**	**	--
CV (%)	17.05	8.55	3.91	--

In a column, numeric data represents the mean value of 3 replications

** Significant at 0.01 level of probability.

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval
T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval
T_3 = Bait trap+Hand picking (Infested fruit) at 7 days interval
T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval
T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene agging
T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene agging
T_7 = Polythene bagging+ Hand picking (Infested fruit) at 7 days interval
T_8 = Untreated control

At late fruiting stage, the highest amount of healthy fruit weight (6.00kg) was observed from T_7 treated plot, which was statistically identical the T_6 (6.00 kg) treated plot.

The second highest amount of healthy fruit weight (4.16 kg) was observed from the treatment T_1. Which was statistically identical the T_4 (4.00 kg), T_3 (3.76 kg) and T_2 (3.16 kg) treated plots. The lowest amount of healthy fruit weight (3.00 kg) was observed the T_8 (untreated control).

The mean percentages of fruit infestation (by weight) among the treatments varied significantly (Table 6) the lowest fruit infestation (by weight) was observed from treatment T_7 (25.19 %), which was statistically identical the T_6 (29.41%) treated plot. The control plots had the highest fruit infestation (62.07 %), which differed significantly from all other treatments. The second highest fruit infestation (49.12 %) was recorded from the T_3 treated plot. The lowest amount of fruit infestation by weight (25.19%) was observed the T_7 treated plot.

The weight of infested fruit (4.89kg) differed significantly higher in control plots (T_8) compared to other treatments the lowest quantity of infested fruit weight was obtained from T_7 treated (2.02 kg) plots followed by (2.05 kg) and (2.20 kg) in T_2 and T_5 respectively. The highest amount of infested fruit weight (4.89 kg) was observed in the T_8 untreated control plots. The highest fruit infestation Reduction over control (by weight) was obtained from the treatment T_7 (59.82 %) followed by the treatment T_6 (53.09 %), T_4 (37.61 %), T_2 (37.26 %), T_5 (39.19 %), T_1 (26. 57 %), T_3 (21.66 %), respectively.

Covering of fruits by polythene bag was found to be an effective method to control fruit fly and the lowest fruit fly incidence in teasel gourd occurred in bagging fruits (4.2%) while the highest (39.38%) was recorded in the fruits of control plot (Anon 1988). However, in the present study, some infestation was observed in bagged fruits (Table 1), this was might be due to the presence of some unnoticed eggs that was already laid by the female flies before bagging. The second possible reason might be the oviposition in bagged fruit by the smart female, pushing her ovipositor through the minute hole of the bag made for aeration.

According to Kapoor (1993) bagging technique was tried in India and achieved appreciable results in controlling fruit fly infestation on cucurbit vegetables in small area.

Amin (1995) also obtained significantly lowest fruit fly infestation (4.61%) in bagged cucumber. They opined that bagging method is quite effective when the fruits are less in number especially in small scale production of cucurbits. Hand picking of infested fruit might reduce the fruit fly population as it removes the infested fruit from plot before pupation. But other adult insect coming from another plot and causes infestation that might be increase the infestation level.

Rabindranath and Pillai (1986) reported that synthetic pyrethroids, Permethrin, Fenvelerate cypermethrin (all at 100 g a.i/ha) and Deltamethrin (at 15 g a.i/ha) were very useful in controlling *Bectrocera cucurbitae* in bitter gourd in south India.

Amin (1995) and Uddin *et al.* (1998) observed reduced rate of fruit infestation when the fruits were bagged at the initial stage. In the study of IPM package bagging of fruits was one IPM component and it was precisely made at 3 days after anthesis (DDA) and left for five days. Another IPM component of this study such as, cypermethrin applied at 10 days intervals which might gave the additional help in controlling fruit fly infestation. Cypermethrin not only reduced fruit fly infestation in cucurbit vegetables but it also has the capacity to reduce drastically the infestation rate of another internal feeder (Mohn and Mohn 1985, Pawar et al. 1987, Chowdhury *et al.* 1993).

If the level of infestation due to fruit fly was higher then the percent weight reduction per fruit was found higher. Plants with bagging of fruits at 3 days DAA and left for five days gave the lowest percent weight reduction per fruit. At this stage of anthesis, the size and qualities of fruits were most favourable for oviposition by the female fruit fly (Narayanan and Battra 1960).

Bagging of fruits with performed polythene bags at immature stage significantly reduced the fruit fly infestation (Uddin *et al.* 1998). Bagging of fruits at this stage of fruit therefore decreased the infestation.

Table 7. Effect of different treatments applied against cucurbit fruit fly on the increase/decrease of yield over control of sweet gourd

Treat-ments	Healthy fruit (t/ha)	Increase over control (%)	Infested fruit(ton/ha)	Decrease over control %	Total yield (t/ha)	Increase over control %
T_1	19.55ef (.20)	41.15	1.49 b (.15)	30.69	21.04e (.21)	31.50
T_2	22.87d (.23)	65.13	1.12 c (.11)	47.91	23.99d (.24)	49.94
T_3	18.32f (.18)	36.60	1.51 b (.15)	29.77	20.43e (.20)	27.69
T_4	26.04c (.26)	88.01	1.03 c (.10)	52.09	27.07c (.27)	69.19
T_5	21.81de (.22)	57.47	1.11 c (.11)	48.37	22.92d (.23)	43.25
T_6	32.39b (.32)	133.86	1.05 c (.10)	51.17	33.44b (.33)	109.00
T_7	36.02a (.36)	160.07	1.00 c (.10)	53.48	37.02a (.37)	131.37
T_8	13.85g (.14)	--	2.15 a (.21)	--	16.00f (.16)	--

In a column, numeric data represents the mean value of 3 replication s

** Significant at 0.01 level of probability.

T_1 = Marshal 20 EC @ 2 ml/L at 10 days interval

T_2 = Sumialpha 5 EC @ 1 ml/L at 10 days interval

T_3 = Bait trap+Hand picking (Infested fruit) at 7 days interval

T_4 = Pheromone trap+ Hand picking (Infested fruit) at 7 days interval

T_5 = Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene bagging

T_6 = Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene bagging

T_7 = Polythene bagging+ Hand picking (Infested fruit) at 7 days interval

T_8 = Untreated control

Effect on fruit yield

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 (37.02 t/ha) was obtained from the plots treated with the treatment (T_7) comprising of Polythene bagging of fruits at 3 days after anthesis and left for five days + hand picking (Infested fruit) at 7 days interval. The total fruit yield of T_6 comprising of Sumialpha 5EC @1ml/L at 10 days interval + bagging of fruits at 3 days after anthesis and left for five days was second highest (33.44 t/ha) which was statistically different from that of treatment T_7 (Table7).
The total fruit yield increase over control was the highest (131.37%) in the plots of treatment T_7, which was significantly higher from that of treatment (T_6) (109 %), The total fruit yield in the plots treated with the components of treatment (T_4) was 27.07 t / ha followed by 23.99 t/ha and 22.92 ton/ha in T_2 and T_5 treated plots respectively. The total fruit yields in the plots treated with the components of T_1 and T_3 were 21.04 t/ ha and (20.43 t/ ha) respectively and there was no significant difference among them (Table 7). Significantly the lowest total fruit yield (16.00 t/ha) was obtained from the untreated control plots (T_8) and this was statistically different from all other

treatments. Under this experiment, significantly the highest (36.02 t/ha) healthy fruit was obtained from the plots treated with the treatment (T_7) comprising of Polythene bagging of fruits at 3 days after anthesis and left for five days + Hand picking (infested fruits) at 7 days interval but this yield was statistically different from that of the yield of healthy fruits obtained from the plots exposed to the T_6 (32.39 t/ha).

The maximum (160.07%) healthy fruits yield increase over control was obtained from the plots where the Treatment (T_7) was applied. The healthy fruits yield (26.04 t/ha) recorded from the T_4 treated plot followed by 22.87 t/ ha and 21.81t/ha in T_2 and T_5 treated plots respectively.

Significantly the lowest healthy fruits yield (13.85 t/ha) was obtained from the untreated control plots (T_8) and this was statistically different from all other treatments. In this study significantly the lowest infested fruits yield was (1.00 t/ha) obtained from the plots treated with (T_7) plots. There was no significant difference among the infested fruit yield of T_2 (1.12 t/ha), T_4 (1.03 t/ha), T_5 (1.11 t/ha), T_6 (1.05 t/ha) but significantly different from that of T_1 (1.49 t/ha), T_3 (1.51 t/ha) and T_8 (2.15 t/ha).

The maximum infested fruits yield decrease over control (53.48 %) was obtained from the plots where the treatment (T_7) was applied followed by T_6 (51.16 %), T_4 (52.09 %), T_5 (48.37 %), T_2 (47.91%) treated plots respectively (Table 7). 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.

CHAPTER V

SUMMARY AND CONCLUSION

The comparative effectiveness of different control methods to suppress fruit fly, *Bactrocera cucurbitae* Coq. on sweet gourd was evaluated in replicated field trials at the experiment field of Sher-e Bangla Agricultural University, Dhaka. Eight treatments viz, T_1 comprising of Marshal 20 EC @ 2 ml/L at 10 days interval, T_2 comprising of Sumialpha 5 EC @ 1 ml/L at 10 days interval, T_3 comprising of Bait trap+ hand picking (Infested fruit) at 7 days interval, T_4 comprising of Pheromone trap+ hand picking (Infested fruit) at 7 days interval, T_5 comprising of Marshal 20 EC @ 2 ml/L at 10 days interval + Polythene bagging , T_6 comprising of Sumialpha 5 EC @ 1 ml/L at 10 days interval+ Polythene bagging, T_7 comprising of Polythene bagging+ hand picking (Infested fruit) at 7 days interval and T_8 comprising of untreated control ..

The plants of the plots under treatment T_6 showed significantly the lowest overall infestation by number (17.25%) and also by weight (18.45 %) compared to control (75.00% and 62.70 %) respectively. At the early, mid and late fruiting stages the rate of infestation by number was significantly lower in the fruits harvested from T_7 and T_6 treated plots compared to those from other treatments including control.

The rate of infestation by number at the early, mid and late fruiting stages were ranged from 17.25 - 74.20, 23.11- 73.17 and 20.50 - 75.00 %, respectively. The rate of infestation by weight at early, mid and late fruiting stages was significantly lower in the fruits harvested from T_7 treated plots compared to those from other treatments including control.

The rate of infestation by weight at the early, mid and late fruiting stages were ranged from 18.65 - 58.73, 18.45- 61.69 and 25.19 - 62.7 %, respectively.

The percent reduction over control by number at the early, mid and late fruiting stages were ranged from 28.68 - 76.69, 15.47- 68.42 and 16.51 - 72.66 %, respectively.

On the other hand, the percent reduction over control by weight at the early, mid and late fruiting stages were ranged from 22.79 - 68.24, 34.80- 70.09 and 21.66 - 59.82 %, respectively.

The plants of the plots treated with T_7 gave significantly the highest healthy fruit yield (36.02 t/ha) compared to control and increased 160.07 % healthy fruit yield over control. The T_6 treated plots gave significantly the second highest (32.09 t/ha) healthy fruit yield compared to control and increased 133.86 % healthy fruit yield over control.

The treatments T_4, T_2, and T_5 gave an average yield of 26.04, 22.87, and 21.81 t/ha respectively with an yield increase of 88.01%, 65.13% and 57.47%, respectively. The T_7 treated plots gave significantly the lowest (1.00 t/ha) infested fruit yield compared to control.

Statistically similar infested fruit yield obtained from T_6 (1.05 ton/ha), T_5 (1.11 t/ha), T_4 (1.03 t/ha), T_2 (1.12 ton /ha) and decreased 51.16, 48.37, 52.09 and 47.91% infested fruit yield over control, respectively. The T_1 and T_3 treated plots gave 1.49 t/ha and 1.51 t/ha infested fruit yield and decrease 30.69 % and 29.77% yield over control respectively which were statistically similar. The highest infested fruit yield (2.15 t/ha) was obtained from untreated control plot.

Significantly the highest total fruit yield (37.02 t/ha) obtained from T_7 plots compared to control and increased 131.37 % total fruit yield over control. The second highest total fruit yield gave the T_6 treated plot (33. 44 t/ha) and increased 109 % yield over control. The lowest total fruit yield (16.00 t/ha) was obtained from T_8 (control plot). The T_2 and T_5 treated plots gave 23.99 ton/ha and 22.92 t/ha total fruit yield and increased 49.94% and 43.25% yield over control, respectively, which were statistically similar.

The results of this study indicated that the treatment T_7 comprising of Polythene bagging of fruits at 3 days after anthesis and left for five days + hand picking (Infested fruit) at 7 days interval, might be considered as a superior treatment. On the basis of the effectiveness in suppressing the fruit fly infestation and increasing the healthy fruits yield. This method might be quite useful for economic sweet gourd cultivation in Bangladesh.

CHAPTER VI

REFERENCES

Agarwal, M.I., Sharma D. D. and Rahman O. (1987). Melon fruit fly and its control. *Indian Hort*. **32**(ii): 10-11.

Akhtaruzzaman, M., Alam M. Z. and Sardar M. A. (1999). Suppressing fruit fly infestation by bagging cucumber at different days after anthesis. *Bangladesh J. of Entomol.* **9**: 1-2, 103p.

Akhtaruzzaman, M., Alam M. Z. and Sardar M. A. (2000). Efficacy of different bait sprays for suppressing fruit fly on cucumber. Bulletin of the Institute of Tropical Agriculture, Kyushu University. **23**: 15-26.

Alam, M. Z. (1962). A list of insects and mites of East Pakistan Agril. Res. Inst., Tejgaon, Dacca. 104 p.

Alam, M. Z. (1965). Insect pests of vegetables and their control. East Pakistan Agril. Res. Inst. and Agri. Infor. Serv., Dacca. 146 p.

Alam, M. Z. (1966). Shasha Kumrar Machipoka (In Bangla). East Pakistan Agril. Res. Inst. and Agril. Infor. Serv., Dacca. 7 p.

Alam, M. Z. (1969). Insect pests of vegetables and their control. East Pakistan Agric. Res. Inst. and Agric. Infor. Serv. Dacca, 145p.

Amin, M. R. (1995). Effect of some indigenous materials and pesticides in controlling fruit fly Bactrocera cncurbitae Coquillet on cucumber. M. S. Thesis. Department of Entomology, Institute of Postgraduate Studies in Agriculture, Gazipur, Bangladesh. 56p.

Andrewartha, H. G. and Birch L. C. (1960). Distribution and abundance of insects. Annual Review of Entomology. **5**: 219-242.

Anonymous. (1983). Comparative efficacy of bagging and trapping in controlling fruit fly, Bractrocera cucrcrbitae Coq. attacking kakrol (Momordica diocia Roxb.). Research Report on Fruit fly in Cucurbits (1987-1988). Paper presented at the International Review Workshop held on August 28-30, 1988. Division of Entomology, BARI, Gazipur, Bangladesh. 17p.

Anonymous. (1987). Comparative efficacy of bagging and trapping in controlling fruit fly, *Bactrocera cucurbitae* Coq. Attacking kakrol research report on fruit fly in cucurbits (1987-1988). Paper prresnnted at the International Review Workshop held on August 28-30, 1988. Division of Entomology, BARI, Gazipur, Bangladesh. 17p.

Anonymous. (1988). Melon Fly Eradication Project in Okinawa Prefecture. Akatsuki Pruning Ltd, Japan. 28p.

Anonymous. (1993). Research and development of vegetable crops. Paper presented in the workshop on research and development of vegetable crops; held on March 9-10, 1993 at IPSA, Gazipur, Bangladesh. pp1-7.

Atwal, A. S. (1993). Agricultural Pests of India and South East Asia. Kalyani Puhl., New Delhi, Ludhiana. 189p.

Batra, H. N. (1953). Danger of Dacus (Leptoxyda) longistylus Wied becoming a pest of cucurbitaccous plants in India. *Indian J. Entomol*. **17**(ii): 278-279.

Batra, H. N. (1968). Biology and bionomics of Dacus (Zeugodacus) hageni Meijer (Dacus caudatus Fabr.). *Indian J. Agric. Sci*. **38**: 1015-1020.

BBS. (2004). Statistical Year Book of Bangladesh 2002. Bangladesh Bureau of Statistics (BBS). Planning Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka. 144p.

Borah, R. K. (1998). Evaluation of an insecticide schedule for the control of red pumpkin beetle and fruit fly of red pumpkin in the hills zone of Assam. *Indian J. of Entomol.* **50**(iv): 417-419.

Borah, R.K. and Datta K. (1997). infestation of fruit fly in some cucurbitaceous vegetables. *Journal of Agricultural Science Society of North East India.* **10**(i): 128-131.

Butani, D. K and Jotwani M. G. (1984). Insects in Vegetables. Periodical Expert Book Agency. Vivek-vihar, Delhi, India. 69p.

Butterworth, J.H. and Morgan. E.D. (1968). Isolation of substance that suppress feeding in locusts Chem. Commun. pp.23-24.

Canamas, M. R. and Mendoza M. R. (1972). Development of treatments against Ceratitis capitata in the province of Valencia. Beletin Informative de Plagas, Valencia, Spain. **92**: 23-31.

Chattopadhyay, S. B. (1991). Principles and Procedures of Plant Protection. Third Edition Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India. 584p.

Cheng, H. H. and Struble, D. L. (1982). Field evaluation of black light and sex attractants traps for monitoring seasonal distribution of the dark sided cutworm (Lepidoptera: Noctuidae) in Ontario. *Candian Entomologist.* **114**: 1121-1125.

Chiristenson, L.D. and Foote, R.H. (1960). Biology of fruit flies. Annual Review of Entomology. **5**:171-192.

Chowdhury, M. K., Malaker, J. C. and Hossain M. N. (1993). Efficiency of poison bait traps in controlling fruit fly, *Bactrocera cucurbitae* in bitter gourd. *Bangladesh J. of Entomol.* **3**(ii): 91-92.

Cork. A. and Basu, S. K. (1992). Control of the yellow stem borer, Scirpophaga incertulus by mating disruption with a PVC resin formulation of the sex pheromone of Chilo suppressalis (Lepidoptera: Pyralidae) in India. Bull. Entomol.Res.**86** p:1-9.

Fang, M. N. (1989). A non-pesticide method for the control of melon fly. Special publication. Taichung District Agricultural Improvement Station, Taiwan. **16**:193-205.

Feron, M. P. Delanoue and Soria, F. (1958). Clevage massif artificial de Ceratilis capitata Wied. *Entomophaga*. **3**: 45-53.

Gapud, V. P. (1993). Insect and mite pests of plant crops in Bangladesh and their natural enemies. A consultancy report financed by USAID. Organized by BARC, Dhaka, Bangladesh. 265p.

Gruzdyev, G. S., Zinchenko V. A., Kalinin V. A. and Slovtsov R. L. (1983). The Chemical; Protection of Plants. Mir publishers, Moscow. 471p.

Gupta, D. (1992). Population fluctuations of the maggots of fruit flies infesting cucurbitaceous crops. Advances in Plant Science. **5**(ii): 518-523.

Hameed, S. F., Suri, S. M. and Kashyap, N. P. (1980). Toxicity and persistence of residues of some organophosphorous insecticides applied for the control of Bactrocera cucurbitae Coq. on fruits of cucumber. *Indian J. Agri. Sci.* **50**(i):73-77.

Islam. M.N. (1994). Trapping of the male pulse beetle, *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae), in the laboratory using crude extract of female sex pheromone. *Bangladesh. J. Entomol*. **4** (i&ii): 1-8.

Janjua, M.A. (1948). The biology of *Dacus (strumeta) ferrugeneus* (Tryptidae: Diptera) in Baluchistan. *Indian Journal of Entomology*. **10**:55-59.

Jiaiswal, J. D., Gurung, T. B. and Pandey, R. R. (1997). Findings of melon fruit fly control survey and its integrated management, 1996/97. Working Paper Lumle Agricultural Research Centre.No. 97-53. 12 p.

Kabir, S. M. Rahman, H., R. and Molla, M. A. S. (1995). Host plants of Dacinae fruit flies (Diptera: Tephritidae) of Bangladesh. *Bangladesh Journal of Entomology*. **1**:60-75.

Kapoor, V. C. (1993). Indian Fruit Flies. Oxford & IBH Publishing Co. Ltd. New Delhi, India. 228 p.

Kehat, M. (1998). Evaluation of Shin-Etsu twist-tie rope dispensers by the mating table technique for disrupting mating of the cotton bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae), and the pink bollworm, *Pectinophora gossypiella* (Lepidoptera: Gelechiidae). Bull. Entomol. Res. **88**. pp: 141-148.

Khan, L., Inayatullah, C. and Haq, M. (1992). Control of melon fly, *Dacus cucurbitae* (Diptera: Tephritidae) on melon in Pakistan. *Tropical Pest Management*. **38**(3): 261-264.

Lakshmann, P.L., Balanubramaniam, G.B. and Subramanian, T. R. (1973). Effect of methyl eugenol in the control of fruit fly, *Dacus dorsalis* Hend. On mango. *Madras Agr. J.* **69**(vii):628-629.

Lawrence, T. C. (1950). US mission in South India to gather materials for the biological control of fruit flies (Diptera: Tephritidae) in Hawaii. *Indian J. Entomol*. **12**, 233-236.

Lee, H. S. (1972). A study on the ecology of melon flies. Plant Prot. Bull., Taiwan. **14:**175-182.

Leuschner, K. (1972). Effect of an unknown plant substance on shield bug. Nourwissenschafter. **59**: 217-218.

Mckinlay, R. G., Spavll, A. M. and Straub, R. W. (1992). Pests of solanaccous crops. In: Vegetable Crop Pests. Mckinlay, R. G. (ed.). Mckinlay Press. Houndmilis, Basingstok Hampshire and London. pp 263-326.

Mitchell, S., N. Tarana and Steiner, L. F. (1965), Methods for mass culturing of Oriental, Melon and Mediterranean fruit flies. U.S. Dept. Agri. ARS. **33-**104.pp.1-22.

Mohan, N. J. and Mohan, N. (1985). Control of epilachna beetle and fruit borer of brinjal. *Pesticides* **19**(vii): 32-33.

Nair, M.R.G. (1986). Insects and Mites of Crops in India. Publication and Information Division, Indian Council of Agricultural Research, New Delhi. pp.162-169.

Narayanan, E.S. and Batra, H. N. (1960). Fruit flies and Their Control Indian Council of Agricultural Research, New Delhi. 68p.

Nasiruddin, M. (1991). Seasonal abundance of fruit fly, *Bactrocera cucurbitae* Coq. by bait trap. Ann. Res. Report (1990-91), Div. Entomol., BARI, Gazipur. 51p.

Nasiruddin, M. and Karim, M. A. (1992). Evaluation of potential control measures for fruit fly, *Bactrocera (Dacus) cucurbitae* in snake gourd. *Bangladesh J. Entomol.* **2**(i&ii):31:34.

Nayar, K. K., Ananthakrishnan, T. N. and David, B. V. (1989). General and Applied Entomology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi. 203p.

Pawar, D. B., Jony, M. B. and Sonone, H. N. (1987). Chemical control of red pumpkin beetle and fruit fly of muskmelon by modern insecticides. *South Indian Hort.* **32**: 317-318.

Qureshi, Z. A., Bughio, A. R. and Siddiqui, Q. H. (1981). Population suppression of fruit fly, *Dacus zonatus (Saund.)* (Diptera: Tephritidae) by male annihilation technique and its impact on fruit fly infestation. *Z. Ang. Ent.* **91**: 521-524.

Ramphall and Gill, H. S. (1990). Demand and supply of vegetables and pulses in South Asia. In: Vegetable Research and Development in South Asia. S. Shanmugasundaram (ed). Proc. Workshop held at Islambad, Pakistan on 24-29 September, 1990. AVRDC Publication No. 90. 331, AVRDC, Tainan, Taiwan.

Rashid, M. (1993). Vegetables Science (Sabji Bighan) (in Bengali), Bangla Academy, Dhaka. 33-254 p.

Ravindranath, K. and Pillai, K. S. (1986). Control of fruit fly of bitter gourd using synthetic pyrethroids. *Entomol.* **11**(iv): 269-272.

Reddy, D. B. and Joshi, N. C. (1992). Plant Protection in India. Second edition. Allieed Publishers Limited, New Delhi. 550p.

Rekhi, S. S. (1997). Vegetable improvement and seed production. Key note paper presented in the National Seminar on March 3-4, at BARI, Joydebpur, Gazipur, Bangladesh.

Shah, M. I., Batra, H. N. and Renjhen, P. G. (1948). Notes on biology of *Dacus (Streumeta) ferrugeneus* and other fruit flies in the North West Frontier Province. *Indian J. Entomol*. **10:** 240-266.

Singh, J. P. (1983). Crop Protection in the Tropics. Vikas Publishing House Pvt. Ltd., New Delhi. 213p.

Singh, R. R. and Srivastava, B. G. (1985). Alcohol extract of neem (*Azadiraclrta indica A. Juss.*) seed oil as oviposition deterrent for *Dacus cucurbitae* Coq. *Indian J. Entomol.* **45**(iv): 497-498.

Smith, E. S. C. (1992). Fruit flies in Home Garden. Agnote-Darwin, 425 p.

Stark, J. D., Vargas, R. I. and Thalman, R. K. (1990). Azadirachtin: effect on metamorphosis, longevity and reproduction of three tephritid fly species (Diptera: Tephritidae). *J. Econ. Entomol.* **83**(vi): 2168-2174.

Steets, R. (1976). Zur wirking eines gereinigten extracktes aus fruchten von *Azadiracta indica* A. auf Leptinotarsa decemlineata Say (*Coleoptera: Chrysomelidac*). *Z. Angew Er.* **82**: 167-176.

Steiner, L. F., Mitchell, W. C. and Ohinata, K. (1988). Fruit fly control with poisoned bait sprays in Hawaii. USDA Agri. Res. Serv. pp 1-5.

Steiner, L. F., Mitchell, W. C., Harris, E. J., Kozuma, T. T. and Fujimoto, M. S. (1965). Oriental fruit fly eradication by male annihilation. *J. Econ. Entomol.* **58**(v): 1961-1964.

Tanaka, A., Shimada, H. (1978). Fluctuation in number of the melon fly males, *Dacus cucurbitae* Coquillelt (Diptera: Tephritidae) caught in traps at different habitats on Kikai lands Proceedings of the Association for Plant Protect ion of Kyushu, Japan. **24**: 122-124.

Taschenberg, E.F., and Roelofs, W.L. (1974). Sex pheromone mass trapping and mating disruption for control of redbanded leafroller and grape berry moths in vineyards. Environ. Ent. **3**: pp. 239-242

Uddin, M. J. (1996). Development of suitable package(s) of IPM components for the management of selected insect pests of cucumber. M. S. Thesis, Institute of Postgraduate Studies in Agriculture, Gazipur, Bangladesh. 72 p.

Uddin, M. J., Alam, M. Z., Haq, M. and Rahman, M. M. (1998). Evaluation of some management practices against fruit fly on cucumber. *Bangladesh J. Agril.* Res. **23**(iii): 531-538.

Vargas, R.I., Miyashita, D. and Nishida, T. (1984) Life history and demographic parameters of three laboratory reared Tephritids. *Ann. Ent. Soc.* Amer. **77**: 651-656.

Vijaysegaran, S. (1987). Combating fruit fly problem in Malaysia. The current situation and strategies to overcome the existing problems. Plant Quarantine and Phytosanitary Barriers to Trade in the ASEAN, Selangor, Malaysia. ASEAN Plant Quarantine Center and Training Institute OE Review of Applied Entomology, 9-12 December, 1986, pp.209-216.

Williamson, D. D. (1989). Oogenesis and Spermatogenesis. In: Fruit flies. Robinson and Hoppers. 141p.

York, A. (1992). Pest of cucurbit crops: Marrow, pumpkin, squash, melon and cucumber. M: Vegetable Crop Pests. Mckinlay, R. G. (ed.). McMillan Press. Houndmills, Basingstoke, Hampshire and London. 139p.

LIST OF APPENDIX

Appendix 1. Monthly average of Temperature, Relative humidity and Total Rainfall of the experiment site during the period from October, 2006 to March 2007.

year	Months	Air temperature (0^C)			Relative humidity (%)	Total Rainfall (mm)
		Maximum	Minimum	Mean		
2006	October	32.3	24.7	28.5	72	88
2006	November	29.7	20.1	24.9	65	5
2006	December	26.9	15.8	21.35	68	0
2007	January	24.6	12.5	18.55	66	0
2007	February	27.1	16.8	21.95	64	0
2007	March	18.5	19.6	19.05	47	16

Source : Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka-1212.