EFFECTIVENESS OF SOME IPM COMPONENTS FOR THE MANAGEMENT OF FRUIT FLY ON BITTER GOURD

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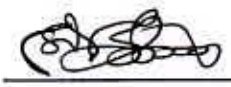

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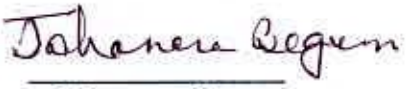

Jahanara Begum
Chairman
Department of Entomology

Dedicated to

My

Beloved Parents

THESIS ABSTRACT

Effectiveness of some IPM components for the management of fruit fly on bitter gourd

A field experiment was carried out at research field of Sher-e-Bangla Agricultural University, Dhaka, to study the effectiveness of different IPM components for the management of fruit fly infestation on bitter gourd in kharip season; 2006.The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications of each treatment. Seven components were used in the experiment. The treatment components used were T_1: Neem Leaves Extract 10%, T_2: Hand picking of infested fruits, T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water, T_4: Garlic extract 5%, T_5: Neem leaves Extract 10% + Hand picking of infested fruits, T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days., T_7: Untreated (control).The results indicated that higher production of fruits per plant (by number and weight), and higher healthy fruits (by number and weight) was obtained in the treatment T_5 showing lowest percent of infested fruit (by number and weight). Accordingly the highest total numbers of fruits per plant (by number and weight) were also recorded in plants treated with T_5 compared to other components. The overall highest percent fruit infestation (by number and weight) was obtained in treatment T_7. The highest fruit yield (t ha^{-1}) was recorded in T_5 component and the lowest yield (t/ha) in control treatment (T_7). The yields due to different treatment components ranked in the order of T_5>T_1> T_6> T_4> T_3> T_2> T_7.In reproductive stages, the highest percent weight of edible portion of single infested fruit was recorded in plants treated with T_5 compared to other treatments. The economic analysis demonstrated that the highest net benefit of Tk. 315300 ha^{-1} was obtained from treatment component T_5, probably it was the effect of combined application of neem leaves extract 10% + hand picking of infested fruits, resulting lower fruit infestation, increase total yield and healthy yield. On the other hand, BCR analysis indicated that the use of neem leaves extract (10%) in the treatment component T_1 gave the higher BCR value than the other components, this may be due to minimum management cost involve in this treatment.

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Amena Sultana

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CHAPTER I

INTRODUCTION

Vegetables are cheaper sources of vitamin and minerals which is essential for maintaining sound health. But in our country the vegetables are not equally produced quantitatively through out the year. Of the total vegetables production, less than 25% is produced during kharif season and more than 75% is produced in rabi season (Anon., 1993). Cucurbits are more important in the summer season, when supplies of other vegetables are scanty. Cucurbit crops occupy about 66% of the vegetable lands producing only 11% of total vegetables (Nasiruddin *et al.*, 2004).

Among different cucurbit, bitter gourd is a fast growing warm seasonal climbing vegetable crop. The crop was originated in India (Indo-Burma center of origin). The region of Eastern India and southern china are suggested as possible center of domestication (Sands, 1928). Area covered by Bitter gourd was 5502 hectare with a total production of 20,470 tons (BBS, 2004). There are several varieties available, having fruits 3-4 inches to even 12 inches in length. It is considered one of the most nutritious gourds and the plant has medicinal properties as well. A compound known as "Charantin" present in the bitter gourd is used to reduce blood sugar for diabetic patients (Dhillon *et al.*, 2005a). Bitter gourd is also rich in vitamins and carbohydrates. The production of bitter gourd is hindered due to several factors. High infestation of *Bactrocera cucurbitae* (Coquillett), fruit fly, commonly known as melon fruit fly is the major constrain for satisfactory production. Fruit fly reduces the yield as well as quality of the cucurbit fruits. The melon fruit fly *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) is distributed widely in temperate, tropical and sub-tropical regions of the world. Two species of cucurbits fruit fly viz, *Bactrocera cucurbitae*, *Dacus caudatus* are commonly found in Bangladesh (Alam *et*

al., 1964). Other species like *Bactrocera tau* and *Dacus ciliatus* have been currently identified in Bangladesh of which *Dacus ciliatus* is a new record. *Bactrocera cucurbitae* is dominant in all the locations of Bangladesh followed by *Bactrocera tau* and *Dacus ciliatus (*Akhtaruzzaman, 1999).

Especially for bitter gourd, (*Momordica charantia*) the melon fruit fly (*Bactrocera cucurbitae)* damage is the major limiting factor in obtaining good quality fruits and high yield (Srinivasan,1959; Lall and Singh,1969; Rabindranath and pillai, 1986). Fruit infestation by fruit fly in bitter gourd has been reported to vary from 41 to 89% (Lall and Singh, 1969; Narayanan and Batra, 1960; Kushwasha *et al.*, 1973; Gupta and Verma, 1978; Rabindranath and Pillai, 1986). Bitter gourd was the most preferred host in terms of infestation rates (39-60%), followed by sweet gourd (35-58%), Cucumber (30-54%) and ash gourd (28-49%) (Nasiruddin *et al.*, 2004).

In Bangladesh, the production of vegetables is already much below from the requirement; so the damage due to these flies is undesirable. On the other hand presently, farmers in Bangladesh rely solely on the use of toxic insecticides to control the pest; it has positive and negative effects. Several management practices have been reported to combat this pest. Mechanical, Physical and cultural controls consisting of field sanitation, infested fruit picking, bagging of fruits, ploughing of soils are very effective control measure against cucurbit fruit fly (Agarwal *et al.*, 1987; Smith, 1992; Kapoor, 1993; Akhteruzzaman, 1999). Unfortunately no single method has so far been proved to be effective and reliable against fruit fly (Butani and Jotwani, 1984; Kapoor, 1993).

Bangladesh Agricultural Research Institute (BARI) has developed an effective poison bait trap prepared by taking 100g paste of sweet gourd placed in an earthen container (small in size having diameter 15 cm) and mixed with 0.25g Mipcin 75wp or Sevin 85wp or Dipterex 80wp and 100ml of water. It attracts and kills the adult fruit flies which showed 61.92-78.38% reduction of fruit fly infestation in cucurbits (Nasiruddin and karim, 1992).

So far, a little work has been done on the use of botanical pesticide against *Bactrocera cucurbitae*. Different plant extracts and oil may have repelling and anti feeding action.

Integrated pest management (IPM) bears a lot of advantages but truly it got no global diffusion. As a result, information on IPM of fruit fly is scanty. Only Shaha (1992), Uddin (1996) and Akhteruzzaman (1999) tried to develop IPM package using two or three components. Therefore, the effective control of fruit fly in cucurbit demands some new approaches which do not rely only on chemicals, reduce the use of chemicals, safe gourd the environment and ensure economical and social acceptance. This might lead to develop the IPM package(s) against this fruit fly. Uses of some of the IPM components are selected from the result of the previous trials of Akhteruzzaman, 1999 and were utilized to suppress this pest.

Thus the present study has been undertaken with the following objectives:

1. To measure the extent of damage of bitter gourd caused by the cucurbit fruit fly at different fruiting stages
2. To find out the effectiveness of different botanicals in combination with other different IPM components.
3. To assess the economics of infestation free bitter gourd cultivation.

CHAPTER II

REVIEW OF LITERATURE

Fruit fly is the most damaging pest of cucurbits and considered as an important constraint for economic production of the crops. Therefore, substantial works have been done globally on this pest about its origin, distribution, biology, and seasonal abundance, and host range, nature of damage and control measures. However, some literatures are reviewed below which will help discussion for supporting the results of the present research work.

Origin and distribution of fruit fly

The fruit flies are distributed all over the world. They infest a large number of host plants. The distribution of a particular species is limited perhaps due to physical, climatic and gross vegetation factors, but most likely due to host specificity. Such species may become widely distribution when their host plants are widespread, either naturally or cultivation by man (Kapoor, 1993). Two of the world's most damaging Tephritids, *Bactrocera* (*Dacus*) *dorsalis* and *Bactrocera (Dacus*) *cucurbitae*, are widely distributed in Malaysia and other South East Asian countries (Vijiaysegaran, 1987).

Fruit fly is considered to be the native of oriental origin, probably India and South East Asia and it was first discovered in the Yaeyama Island in 1919 (Anon.,1987). However, fruit fly is widely distributed in India, Bangladesh, Pakistan, Myanmer, Nepal, Malaysia, China, Philippines, Formosa, Japan, Indonesia, East Africa, Australia and Hawaiian Island (Alam, 1965; Atwal, 1993). The fruit fly is also a serious pest in Mediterranean

region (Andrewartha and Birch, 1960) but not yet been recorded in UK, Central Europe and Continental USA (Mckinlay *et al.,* 1992).

Gapud (1993) has reviewed five species of fruit fly in Bangladesh e.g., *Bactrocera brevistylus* (melon fruit fly), *Dacus (Zeugodacus) caudatus* (fruit fly) D. *(Strumeta) cucurbitae* (malon fly) *D. (Bactrocera) dorsalis Hendel* (mango fruit fly) and *Dacus (Chactodacus)* zonatus (zonata fruit fly).

Batra (1953) reported as many as 70 hosts of fruit fly and later Christenson and Foote (1960) reported more than 80 kinds of fruit and vegetables as the host of the fruit fly. Kapoor (1993) reported that more than one hundred vegetables and fruits are attacked by *Bactrocera* sp. Atwal (1993) and Mckinlay *et al.*,(1992) found that cucurbits as well as 70-100 noncucurbitaceous vegetables and fruits are the host of the cucurbit fruit fly. In Bangladesh, Alam (1962) recorded 10 cucurbit vegetables as the host of fruit fly. Kabir *et. al.*, (1991) obtained 16 species of plants as the host of fruit flies among which sweet gourd was the most preferred host of both *Bactrocera cucurbitae* and *Bactrocera tau.*

Nature of damage

The adult female lays eggs just below the epidermis or sometimes a little deeper in the pulp, and /or young leaves or stems of the host plants. Piercing by the ovipositor causes wounds on the fruit or vegetable in the form of punctures, which appear like dark spots on the surface. In freshly punctured specimens, the fluid that exudes accumulates in the form of a droplet which later dries up and appears like brown resinous deposit (Shah *et al.*, 1948; Narayanan and Batra, 1960; York, 1992). After hatching the larvae fed into

pulp tissue and make tunnels in fruits causing direct damage. They also indirectly damage the fruits by contaminating with frass and accelerate rotting of fruit by pathogenic infection. In infested fruits if not rotten become deformed and hardy which make it unfit for consumption. The infested flower often become juicier and drops from the stalk at a slight jerk (Kabir *et al.*, 1991).

Seasonal abundance

The population of fly fluctuates throughout the year. Tanaka *et al.*, (1978) reported that population of melon fly was increased in autumn and decreased in winter in Kikai Islands, Japan. Yao and Lee (1978) observed that populations of oriental fruit fly were higher in the ripening season of any fruit in Taiwan. Nasiruddin (1991) observed that the incidence of fruit flies was the highest in February and the lowest in September. On the contrary, Kapoor (1993) pointed out that the fruit fly *Bactrocera cucurbitae* Coquillett and *Bactrocera zonata* Saunders are active throughout the year except for a short period from December to mid February due to excessive cold when they hide under leaves of guava, citrus fruits mangoes etc. Most of the fruit fly species are more or less active at temperature ranging between 12^0 C and become inactive below 10^0 C (Narayanan and Batra, 1960). The peak population of fruit fly in India is attained during July and August in rainy season and January and February in cold months (Nair, 1986). The adult of melon fruit fly *B. cucurbitae* over winter in November to December and the fly is the most active during July to August (Agarwal *et al.*, 1987). In 1995, Amin also observed the highest population incidence in the ripening stage of cucumber in Bangladesh.

Life history of fruit fly

Kaul and Bhagat (1994) studied the biology of *Bactrocera cucurbitae* on bitter gourd under laboratory conditions in Jammu and Kashmir, India. The insect laid 7-21 eggs/clutch and a total of 169 eggs in a span of 27 days averaging 6.3 per day. The preoviposition and oviposition period ranged between 10.0-16.3 days and 5-15 days, respectively. The female lived longer (21.7-32.7 days) than the male (15-28.5 days). The total life span was 27.8-69.8 days in male and 30.7-76.0 days in female.

Hsu *et al.*, (1985) reported that adults of the Tephritid, *Dacus dorsalis* mated out doors when the temperature and light intensity decreased with peak mating at 15 minutes before sunset. Chu and Chen (1985) obsered in Taiwan that the mature larvae of *Dacus dorsalis* dropped from the infested citrus fruits by jumping to search for available pupation sites. The maximum jumping distance was 70 cm and maximum mining depth was 5 cm. Larvae moved horizontally in the soil up to 10cm after entering and the pupae tended to orient towards surface to facilitate successful emergence of the adult. Newly emerged adult moved upward through the soil to escape if the pupae were oriented upside down.

The eggs laid by *Bactrocera cucurbitae* are creamy white, oblong banana shaped and are about 1.3 mm in length (Anon., 1987). Eggs are normally inserted under the skin of the fruits vegetables, fleshy parts of plants, stems or flowers where they are protected from sun (Feron *et. al.,* 1958). The puparium is 4.8 to 6.0 mm in lenth. At 23-25^0 C the pupal stage lasts for 8-12 days. At 27^0 C the mean pupal period for *B. dorsalis* and *ceratitis capatita* is 10 days and that for *B. cucurbitae* is 9 days (Mithell *et al.,* 1985). Adult flies

begin to copulate 9-12 days after emergence. They mate in the evening and continue to copulate until dawn. Female flies found to lay eggs about 7-10 days after emergence from pupae in the soil as long as they feed on protein hydrolysis. Eggs are laid @ 7-10 per female pr day. A mated female melon fly can lay a total of 800-900 eggs during her life with approximately 50% fertility (Vargas *et al.*, 1984). Under optimum condition, the length of one generation is around one month (Anon., 1987)(Plate 1 ABC).

Control of fruit fly

Although there are various methods to reduce the damage of fruit flies, there is not a single such method which has so far successfully reduced the damage to an economically low level. This is mainly due to the polyphagous nature of these flies, which helps them to continue increasing their number throughout the year. The available literature on the measures for the control and management of these flies are discussed under the following subheadings.

Hand picking of infested fruits:

It is one of the most effective Mechanical controls. Systemic picking and burning of infested fruits in proper manner to keep down the population is resorted to reduce the damage caused by fruit flies infesting cucurbits, Mango, Guava, peach, etc and many tissue borers of plants (Mitchell and Saul, 1990; Chattopudhyay, 1991). Nasiruddin and Karim (1992) recommended Collection and destruction of infested fruits with larva inside for reducing fruit fly population on snake gourd. Mitchell and Saul (1990) reported that this practice is widely used in USA for suppressing Mediterranean fruit fly; *Ceratitis capitata*. Atwal (1993) suggested such mechanical control measures in farmer's fields at

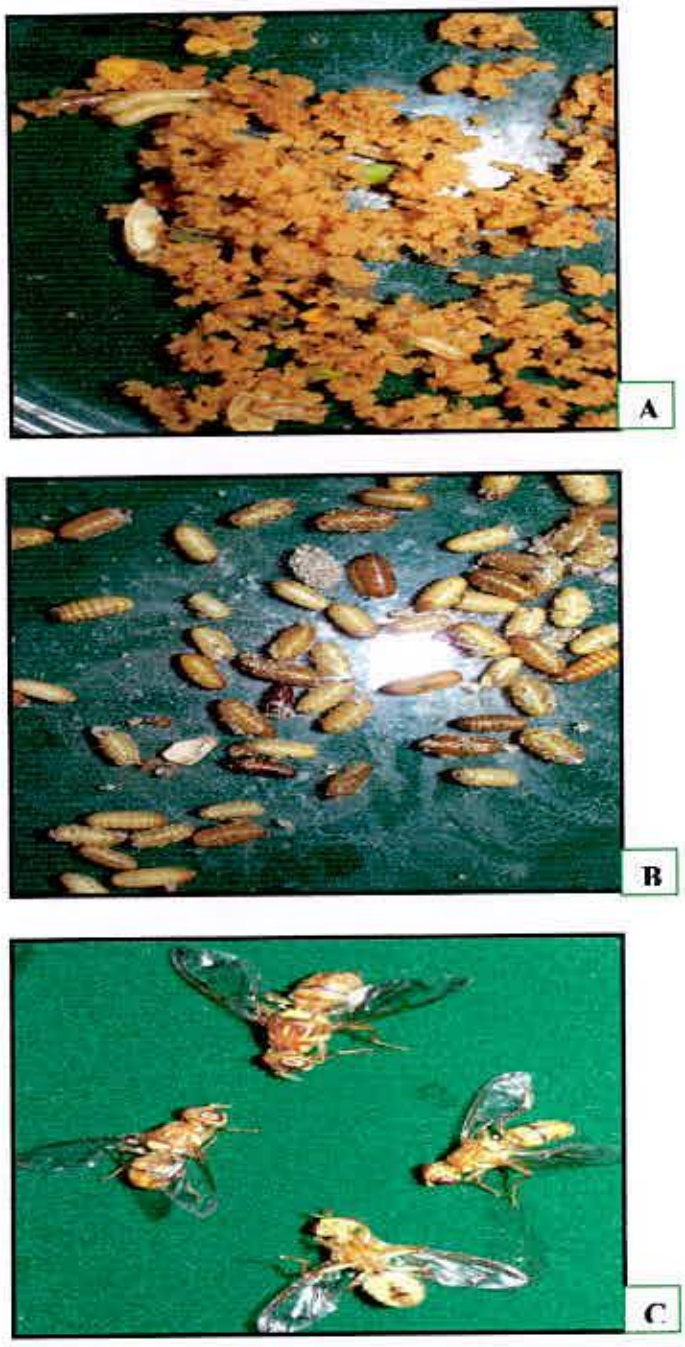

Plate 1. Larvae (A) pupae (B) and adult (C) of fruit fly in the laboratory

normal practice for effective control against this pest in India the treatment hand picking and burning had considerably lowered infestation (average 34.08%) when compared with untreated plot (average 58.39%).

Bagging of fruits

Bagging of fruits showed significantly lowest fruit infestation (average 10.77%). The highest infestation (average 58.39%) was observed in control condition (Biswas, 2005).

Amin (1995) obtained significantly lowest fruit infestation (4.61%) in bagged cucumber compared to other chemical and botanical control measures. Covering of teasel gourd by polythene bag reduced the fruit infestation reduced substantially (Anon.,1988). Sometimes each and every fruits is covered by a paper or cloth bag or mosquito net to block the contact of flies with the fruit there by protecting from oviposition by the fruit fly. This is quite useful for small area. But this is a tedious task for big commercial orchards (Kapoor, 1993).

Bagging bitter gourd in Taiwan at the stage of 3.4 cm fruit lest and sponge gourd at 5-6 cm length with two layers of paper bags every after 2-3 days against *B. cucurbitae* increased yield by 40-48 percent compared to control (Fang, 1989).

Neem leaves extract

Aqueous extact of neem seed kernel (NSKE) was tested for its effect on the fecundity and post-embryonic development of *Bactrocera cucurbitae* and *Bactrocera dorsalis*. The effects on fecundity, fertility and adult emergence were confirmed with pure azadirachtin. But significant effects on adult emergence and behavior were recorded. And the post-

embryonic effects of neem seed karnel extracts on the two species of fruit flies were confirmed. (Shivendra, 2003)

Neem derivaties have been demonstrated as repellents, antifeedants, growth inhibitors and chemosterilant (Butterworth and Morgan, 1968). Singh and Srivastava (1985) found that alcohol extract of neem oil *Azadirachta indica* (5%) reduced oviposition of *B. cucurbitae* on bitter gourd completely and its 20 percent concentration was highly effective to inhibit oviposition of *B. zonata* on guava. Stark *et al.*, (1990) studied the effect of Azadiraction on metamorphosis, longivity and reproduction of *Ceratitis capitata* (Wiedemann), *B. cucurbitae* and *dorsalis.*

Ranganath *et al.*, (1997) tested a number of botanical and chemical insecticides against *Bactrocera cucurbitae* on cucumber (*Cucumis sativus*) and ribbed gourd (*Luffa acutangula*) and found that neem oil at 1.2% was the most effective treatment in reducing damage to cucumber (mean percentage damage 6.2%, as compared with 39.0% in the control), while neem cake at 4.0% and DDVP (Dichlorovos) at 0.2% were the most effective against the pest on ribbed gourd, reducing damage to 9.1-9.5% as compared with 32.9% in the control.

Singh and Singh (1998) evaluated neem (*Azadirachta indica)* seed kernel extract at 1.25-20% and pure azadirachtin at 1.25-10 ppm as oviposition deterrents to *Bactrocera cucurbitae* on pumpkin. They reported that neem seed kernal extract deterred oviposition by *B. ccurbitae* at all the concertration and azadirachtin failed to deter oviposition in *B. cucurbitae*. Biswas (2005) reported that Neem oil 5% and Karanja oil 5% showed significantly lower infestation of fruit fly in bitter gourd.

Bait trap

A field trial in Bangladesh showed that poison bait traps containing Dipterex were more effective in trapping females than males of *B. cucurbitae*, a pest of bitter gourd (Chowdhury *et al.*, 1993). The average number of flies caught per trap per day ranged form 2.36 to 4.57.

A bait (100g sweet gourd mashes mixed with 0.5 g Dipterex 80 SP and insecticidal spray (0.1% Dipterex 80 SP) and a bait spray (1.0g Dipterex + 100 g molasses per liter of water) gave a statistically similar fruit infestation by *B. cucurbitae* in snake gourd with an infestation range of 4.9-8.6% as compared to 22.5% in the untreated control in the farmer's field during the Kharif season in Bangladesh. Capture of fruit flies in bait traps showed 1.6 times more females than males (Nasiruddin and karim, 1992).

The fruit fly traps with methyl eugenol @ 3 ml/trap baited with 0.05% Dichlorvos (DDVP) was found the most effective and economical treatment against fruit flies *(Dacus* sp.) in Maharashtra, India. The lowest percentage of fruit infestation, maximum yield and net returns\ha and greatest cost benefit ratio (1:47.5) were obtained in this study (Deshmukh and Patil, 1996). Populations of *D. cucurbitae (B. cucurbitae)* were monitored in bitter gourd crops in India using traps baited with the sex attractant cue-lure or food attractant tephritlure and found that cue-lure was more effective attractant than tephritlure (Power *et al.*, 1991).

Yield loss

The fruit fly infestations in cucurbit were 22.48%, 41.88% and 67.01% for snake gourd, bitter gourd and muskmelon, respectively (Anon., 1988). York (1992) indicated that the yield loss of cucurbits in South East Asian might be up to 50%. Kabir *et al.*, (1991) reported that yield losses due to fruit fly infestation varies in different fruits and vegetables and it is minimum in cucumber (19.19%) and maximum in sweet gourd (69.96%). Borah (1997) studied the infestation of Tephritids on the cucurbits in Asam, India and obtained the highest fruit infestation in snake gourd (62.02%). Gupta (1992) investigated the level of infestation of *Dacus cucurbitae* (*Bactrocera cucurbitae*) and *Dacus tau* on cucurbits in India during 1986-87 and found the population peaked in July-August on cucumber and bottle gourd (80% infestation) and August- September on bitter gourd (60% infestation) and Sponge gourd (50%infestation). Rahman (2001) indicated that the treatment comprising hand picking of infested fruits plus bait spray showed significantly lower overall infestation (31.83%) compared with other treatments. Higher yield (9.14t/ha) and yield increase over control (27.30%) were also obtained from hand picking of infested fruits plus bait spray treated plot. Fruit fly populations were in general positively correlated with temperature and with relative humidity.

Climatic factors and fruit fly infestation

Dhillon *et al.*,(2005) reported that the melon fruit fly, *Bactrocera cucurbitae* is distributed widely in temperate, tropical, and sub-tropical regions of the world. Its extent of losses very between 30 to 100%, depending on the cucurbit species and the season. Its abundance increases when the temperatures fall below 32^0 C, and the relative humidity ranges between 60 to 70%.

Brevault and Quilici (2000) studied the development and survival of *Neoceratitis cyanescens* (Bezzi) (Diptera: Tephritidae) from egg to complete ovarian maturation were studied in the laboratory at five different constant temperatures: 15, 20, 25, 30, and 35^0 C. They suggested that the developmental rate of the different life stages increased linearly with increasing temperatures up to 30^0 C.

Hui and Jianhon (2007) indicated that the fruit fly was present all year round in Xishungbanna. Its population remained at a lower level from November to February and increased from March until it reached a peak in June or July, depending on the rainfall that year. Afterward, the fly population declined remarkable until October. Temperature, rainfall, and host fruits were major factors comprehensively influencing the population fluctuation. The monthly mean temperature was in a range of temperatures suitable for development and reproduction of the fly. But the monthly mean minimum temperature from December to February was lower than the suitable temperature range, which was suggested a possible reason for the lower populations in winter months. Rainfall was another essential factor influencing the population fluctuations. The population was depressed when the monthly mean rainfall amount was lower than 50 mm but increased when rainfall ranged from 100 to 200 mm and when the monthly rainfall amount was higher than 250 mm, the fruit fly population was reduced remarkably.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the experimental field of Sher-e- Bangla Agricultural University (SAU) Farm during March 2006 to June 2006. In order to evaluate the effectiveness of different management components and combination of components to suppress the infestation level of cucurbit fruit fly on bitter gourd *(Momordica charantia* Linn*)*. The treatments, their application procedures and other relevant methodologies followed in this study are described below:

Treatment details:

T_1 : Ten percent neem leaves extract applied at 7 days intervals @ 250 L/ha

T_2 : Hand picking of infested fruits at 7 days intervals

T_3 : Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash mixed with 100ml water

T_4 : Five percent garlic extract applied at the 7 days intervals @ 2.50 L/ha

T_5 : Ten percent neem leaves extract applied at the 7 days intervals @ 250 L/ha + hand picking of infested fruits applied at 7 days intervals

T_6 : Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7 : Untreated (control)

Location

The experimental field was located at 24.09 N latitude and 90.26 E longitudes with an elevation of 8.4 meter from sea level (Figure 1).

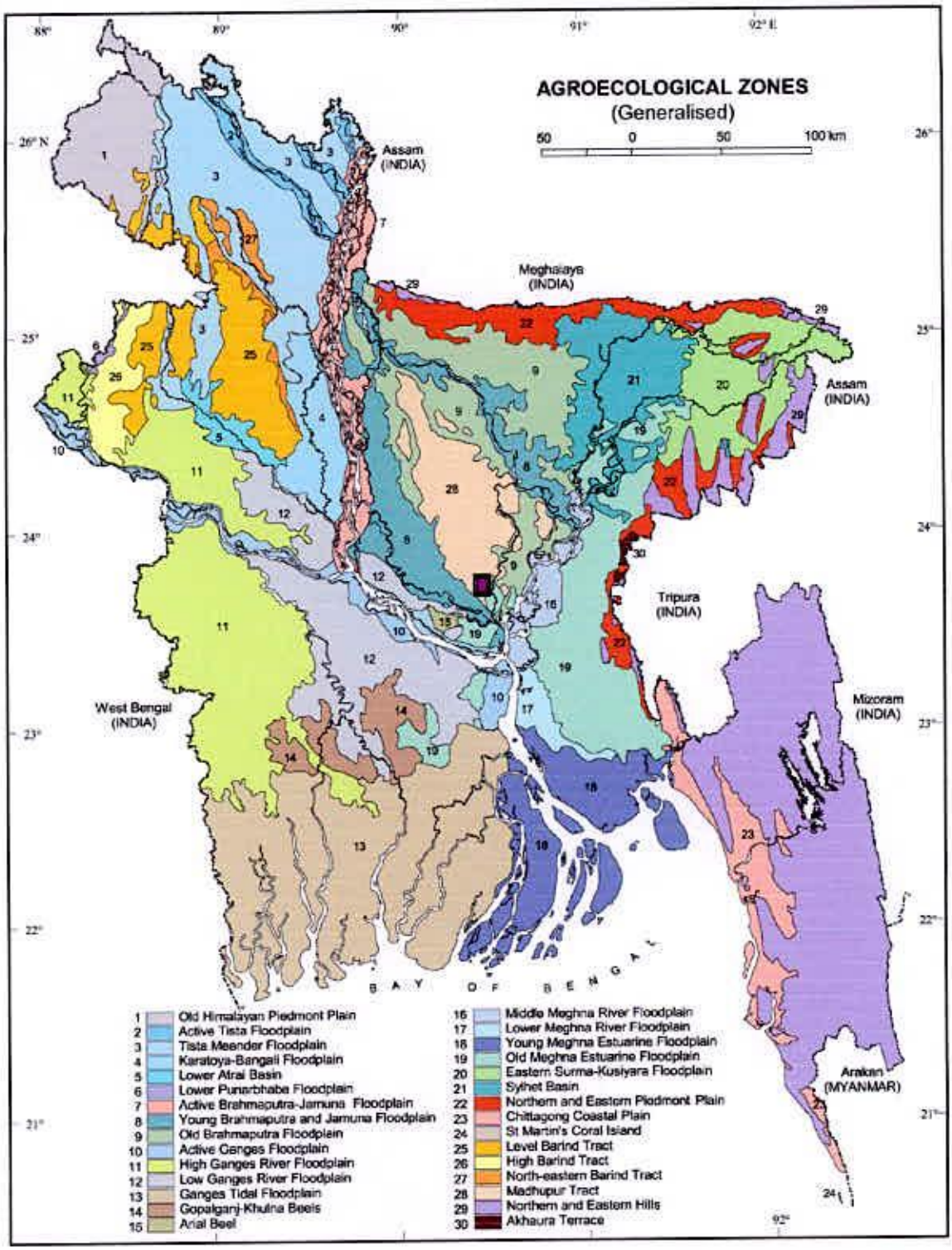

Fig. 1. Map showing the experimental site of study ■

Soil and climate

The experimental site was situated in the sub-tropical climatic zone characterized by heavy rainfall during the month of May to September and scanty rainfall during rest of the year. The soil of the experimental land was silty clay loam texture, soil type grey terrace and belongs to the agro ecological zone, Madhupur tract (AEZ-28) with p^H 5.8 to 6.5 and C:N ratio 0.30:1 (Begum, 2002).

Design of the experiment

The experiment was conducted with the six treatments and untreated control laid out in a Randomized Complete Block design (RCBD) with 4 replications in the experimental field of Sher- e- Bangla Agricultural University farm, Dhaka.

Raising seedling

Seeds of High Yielding variety named "Gaje corolla" were collected from the Gazipur Beez Vandar, Gazipur. Seeds were soaked for 24 hours and then 2 seeds were sown in each polythene bag (10 cm × 10 cm) containing 50% well decomposed cow dung and 50% sandy loam soil. After seven days of germination weaker seedlings was removed leaving healthy one per bag.

Land preparation and fertilization

The land was prepared thoroughly by 3 to 4 ploughing followed by laddering to attain a good tithe. Weeds and stubbles were removed and the land was finally prepared by addition of basal doses of fertilizers and well decomposed cow dung. The size of each experimental plot was 2m × 2m with an inter plot distance of 1 m. Two pits of 30cm ×30cm × 20cm were dug in each plot at a distance of 1m between pits. The whole experimental field was divided into 28 plots to accommodate 4 replications having 28 plants per replication. Therefore, there were 112 plants in the whole experiment. No chemical fertilizers were used as basal dose only Cow dung and Oil cake (Organic

fertilizers) were applied as basal dose. Cow dung and Oil cake were applied @ 10,000 kg and 500 kg per hectare respectively. The total cow dung was applied as basal dose during land preparation and half of the oil cake was applied during pit preparation. The rest half of the oil cake was applied in the pits fifteen days after transplanting (DAT) of seedling.

Cultural Operations

After transplanting, the seedlings were provided with a light irrigation. Propping of each plant using bamboo stick (2 m length) was done to facilitate creeping of plant and to avoid lodging. All the bamboo sticks were tightened strongly with long wire and rope to make macha for individual plots. Irrigation and weeding were done as per requirement for proper development.

Treatment application

Hand picking of infested fruits (T_2)

Regular visual observation of infested fruits of each plant from each plot under the treatment T_2 where have picking of infested fruits was done at 7 days interval and the number of infested fruits were recorded. Then collected infested fruits were cut to separate out the edible portion and non edible portion of the fruit and weighed separately to find the percent edible portion of the infested fruits. This procedure was continued from early to late fruiting stages.

Bagging of fruits at 3 days after anthesis (DAA) and left for 5 days (T_6)

The bagging of fruits was down by using transparent polythene bags provided with holes made by an ordinary pin. These tiny holes were provided for aeration. The size of the perforated polythene bags was large (30cm×20cm) enough for normal fruit growth and provides sufficient aeration. The bitter gourd is a cross-pollinated crop

and both male and female flowers are generally open in the morning and fertilized naturally by cross- pollination. All the full-bloomed female flowers of the plant under the treatment T_6 were visually checked everyday and tagged. In the morning (8:00 to 9.30am) before the beginning of frequent visit of fruit fly, the female flowers were bagged individually with perforated polythene bags at 3days after anthesis (DAA) and left for five days. The open mouth of the bag was wrapped and closed by jams clip the peduncle of the fruit. After 5 days the polythene bags were removed. Regular observation was done to cheek the fruit fly infestation on these bagged fruits and the operations are continued till the late fruiting stage.

Preparation of bait trap and fruit fly catches (T_3)

The trap consisted of 0.5g Dipterex 80sp with 100g sweet gourd smash mixed with 100ml water (Plate 2 A, B). The bait was kept in a small earthen pot placed within a three split bamboo sticks, 100 cm above the ground. An earthen cover plate was placed avertedly 20cm above the bait container like an umbrella to protect the bait materials from sunlight and rainfall. The old bait materials were replaced by fresh ones at an interval of 3 days. Each set of bait trap was placed in the middle of the randomly selected for plots (T_3).

Bait traps were checked regularly and counted the number of fruit flies caught. Adult were sorted into male and female flies. The traps were maintained in the field from the flower initiation stage to last harvest covering the entire reproductive stage of bitter gourd. Males and females so collected were accumulated fortnightly and counted for their sex ratio.

A

B

Plate 2. Showing bait trap (A) and fruit caught by the trap (B)

Collection of plant materials

Plant materials were collected from different places. Neem leaves was collected from Sher-e-Banga Agricultural University campus and Garlic was collected from Agargaon Bazar.

Preparation of plant extracts

Neem leaves extracts 10 %(T_1):

One Kilogram (kg) of neem leaves was boiled with two kg of water, It was strained out and made 1 kg of neem leaves extract. Neem leaves extract 10% were made by mixing the ratio of 1 kg Neem leaves extract with 10 liter of water.

Garlic extract 5 %(T_4):

One piece of garlic was cut into small pieces and past was made and then mixed with one liter of water followed by sieving of the solution. Then the sieved solution was diluted by five times and 20 g of soap powder was added and mixed with the solution and then finally sieved the solution and the garlic extract solution was found.

Data collection

Data on fruit infestation were taken at early, mid and late fruiting stages (Amin, 1995 and Uddin, 1996). During this stages a total of 7 harvests were carried out. Fruits were harvested at an interval of after 7days starting from 3rd May 2006 to 15th June 2006. The impact of each treatment was evaluated. The data were taken on number and weight of healthy fruits, number and weight of infested fruits, weight of partial infested fruit and over all yields in comparison to control.

Data analysis

The recorded data were analyzed by using MSTAT-C program for ANOVA by contrast and mean separation was done by using DMRT after necessary transformation of data.

Percent fruit infestation by number

After harvesting the healthy fruit (HF) and the infested fruits (IF) were separated by visual observation. The number of healthy fruits and infested fruits were counted and the percent fruit infestation for each treatment was calculated by using the following formula:

$$\% \text{ Fruit infestation by no.} = \frac{\text{no. of infested fruits}}{\text{no. of healthy fruits} + \text{no. of infested fruit}} \times 100$$

Percent fruit infestation by weight

During all successive stages, the total fruits were sorted into healthy and infested for each treatment. On the basis of weight of healthy fruit (HF) and infested fruit (IF) the percent fruit infestation was calculated with the following formula:

$$\% \text{ Fruit infestation by wt.} = \frac{\text{wt. of infested fruits}}{\text{wt. of healthy fruits} + \text{wt. of infested fruit}} \times 100$$

Weight of edible portion and non-edible portion of single infested fruit

After harvest all collected fruits were sorted into healthy and infested ones. The infested ones fruits were cut and the edible and non-edible portion of the fruits were

separated. Individual portion was weighed for each treatment. Finally the percent edible portion of single infested fruit was calculated by the following formula:

Weight of edible portion of single

$$\text{infested fruit (\%)} = \frac{\text{Weight of edible portion of infested fruits}}{\text{Total weight of infested fruit}} \times 100$$

Fruit Yield

Yield of control plot

During the yield data calculation, the weight of healthy fruits and infested fruits were separately recorded. The total yield under each treatment was finally converted to determine the yield (t ha^{-1}). The percent increase and decrease of yield over control was computed by using the following formula:

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

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

Economic analysis of IPM packages:

The economic analysis or Benefit cost Ratio (BCR) was analyzed on the basis of total expenditure of the respective treatment along with the total return from that particular treatment. In this study BCR was analyzed for a hectare of land. For this analysis following parameters were considered.

Treatment wise management cost:

This was calculated by adding the costs incurred for labours and inputs for each treatment including untreated control during the entire cropping season.

Yield of Bitter Gourd:

The total yield after every harvest was calculated separately for each treatment and accumulated at the end of the final harvest. The total yield of each treatment was converted for determining yield (t ha^{-1}). This yield was utilized to calculate the gross return.

Gross return:

This was measured by multiplying the total yield by the unit price of bitter gourd at the cultivation period.

Net return:

Net return was calculated by subtracting management cost from gross return.

Adjusted net return:

A separate formula was used for determining adjusted net return. The adjusted net return was determined by subtracting the net return with particular treatment from the net return with untreated control plot.

Finally the benefit cost ratio (BCR) was calculated by utilizing the formula:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Adjusted net return}}{\text{Total management cost}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University (SAU) farm, during kharif season, 2006. The results obtained from the study are discussed under the following sub- headings:

4.1 Effect of different IPM component on the number of healthy fruits, infested fruits, percent infestation and percent reduction over control at different stages of bitter gourd

The results on the number of healthy and infested fruit, percent infestation and percent reduction over control at early, mid and late stages during bitter gourd growing season are presented in the tables (1, 2 and 3) and figures (2, 3 and 4) respectively. Experimental plot of bitter gourd at reproductive stage during kharip season (plate 3), same at untreated control plot, T_7 (Plate 4) plots treated with 10% neem leaf extract+ hand picking T_5 (plate 5), healthy and infested fruits of bitter gourd (plate 6,plate 7), are shown.

4.1.1 Early fruiting stage

The effect of different treatments on the number of healthy fruits per plant, number of infested fruits per plant, percent infestation (by number) and their percent reduction over control of bitter gourd at early stage are presented in Table 1. At early fruiting stage, plots having treatment component T_5 gave the lowest percent fruit infestation by number (5.81%), which was statistically similar with treatment component T_1 (9.53%) and treatment component T_6 (12.83%) and the highest percent fruit infestation by number (30.57%) was found in untreated control plot T_7 which was statistically similar with treatment component T_2 (24.38%). On the other hand the lowest number of healthy fruits was obtained in untreated control plots T_7 (1.50) and

the highest number of healthy fruits was obtained in treatment component T_5 (3.20) which was significantly differ with the other treatments (Figure 2). Significantly the highest infested fruits were harvested from treatment T_7 (0.65), which was statistically similar with treatment component T_2 (0.60) and treatment component T_3 (0.55) and the lowest number of infested fruits were harvested from treatment component T_5 (0.20), which was statistical identical with treatment component T_1 (0.30), treatment component T_4 (0.40) and treatment component T_6 (0.35) respectively (Table 1). The highest percent reduction of fruit infestation over control (by number) was obtained in treatment component T_5 (80.99%), and the lowest percent was obtained in treatment component T_2 (20.24%).

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4.1.2 Mid fruiting stage

At mid fruiting stage the percent of fruit infestation by number varied significantly among the treatments (Table 2). The highest fruit infestation by number (28.53%) was found in treatment component T_7, which was statistical identical with treatment component T_2 (25.25%) and the lowest fruit infestation by number (6.95%) was obtained in the treatment component T_5, which was statistical identical with treatment component T_1 (10.25%). The lowest number of healthy fruits from control plots in treatment component T_7 (1.75) were obtained and the highest number of healthy fruits from the treatment component T_5 (3.35) were obtained, which was statistical identical with treatment component T_1 (3.1) (Figure 3). The highest number of infested fruits were harvested from treatment component T_7 (0.70) which was statistically similar with treatment component T_2 (0.65) and treatment component T_3 (0.65) and the lowest number of infested fruits were harvested from

Table 1. Effect of different treatment components on the number of healthy fruits, infested fruits, percent infestation and their percent reduction over control of bitter gourd at early fruiting stage

Treatments	Number of fruits / plant	% Infestation	% reduction over control
T_1	0.30 d	9.53 de	68.82
T_2	0.60 ab	24.38 ab	20.24
T_3	0.55 abc	21.51 bc	29.66
T_4	0.40 bcd	14.69 cd	51.94
T_5	0.20 d	5.81 e	80.99
T_6	0.35 cd	12.83 de	58.03
T_7	0.65 a	30.57 a	-
Level of Significance	*	**	-
CV (%)	15.65	10.24	-

* = Significant at 5% level of significance
** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1 : Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2 : Hand picking of infested fruits applied at 7 days intervals

T_3 : Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4 : Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5 : Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha+ Hand picking of infested fruits applied at 7 days intervals

T_6 : Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7 : Untreated control

Table 2. Effect of different treatment components on the number of healthy fruits, infested fruits, percent infestation and their percent reduction over control of bitter gourd at mid fruiting stage

Treatments	Number of fruits / plant	% Infestation	% reduction over control
T_1	0.35 b	10.25 cd	64.07
T_2	0.65 a	25.25 ab	11.49
T_3	0.65 a	21.29 b	25.37
T_4	0.45 b	15.03 c	47.31
T_5	0.25 b	6.95 d	75.65
T_6	0.45 b	14.49 c	49.21
T_7	0.70 a	28.53 a	-
Level of Significance	**	**	-
CV (%)	15.07	12.21	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

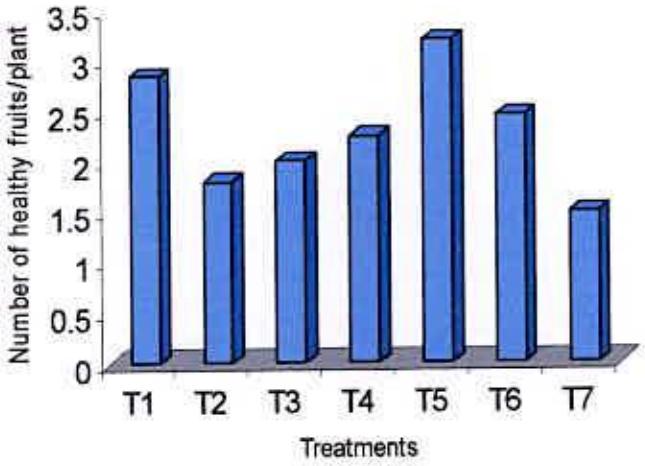

Figure 2: Total number of healthy fruits per plant treated with different IPM components at early stage

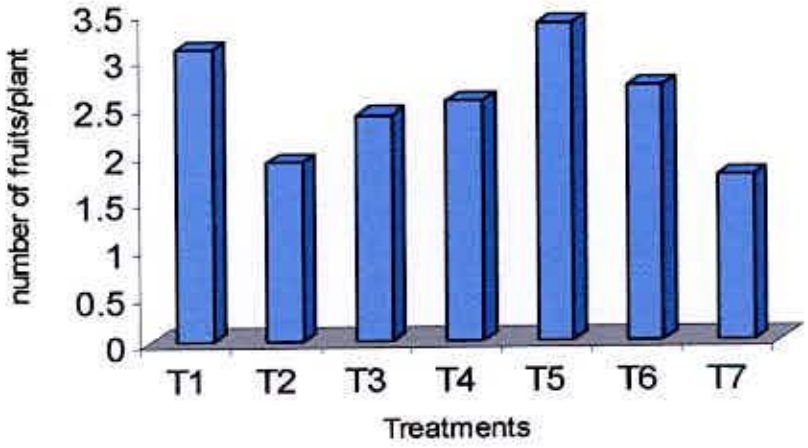

Figure 3: Total number of healthy fruits per plant treated with different IPM components at mid stage

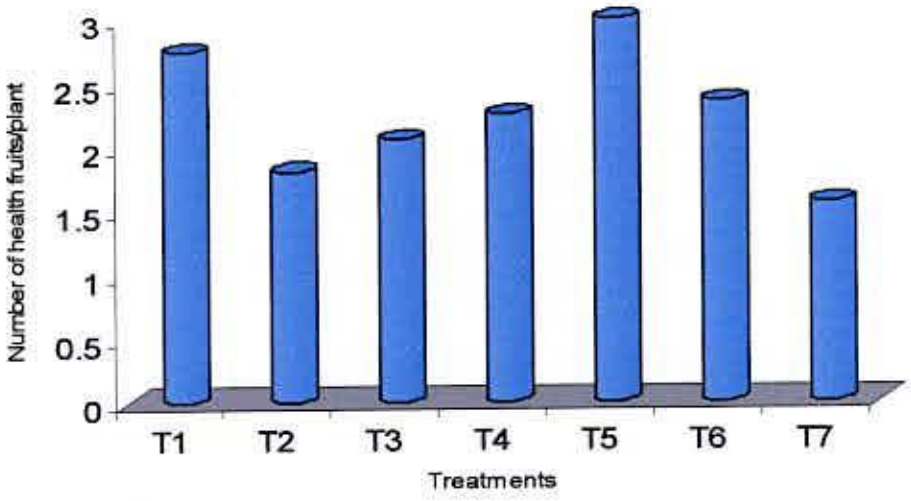

Figure 4: Total number of healthy fruits per plant treated with different IPM components at late stage

treatment component T_5 (0.25), which was statistical identical with treatment T_1 (0.35), treatment T_4 (0.45) and Treatment T_6 (0.45). The highest percent reduction over control in fruit infestation by number was obtained from treatment T_5 (75.62%) followed by treatments T_1 (64.07%), T_6 (49.21%) and T_4 (47.31%).

4.1.3 Late fruiting stage

At late fruiting stage significantly highest fruit infestation by number was observed in untreated control T_7 (31.25%) which was statistical identical with treatment T_2 (26.44%).The lowest infestation was recorded in treatment componentT_5 (8.97%) which was statistical identical with treatment T_1 (14.07%) (Table 3).

In case of healthy fruits, the lowest number of healthy fruits (1.55) was obtained from untreated control T_7, which was statistical identical with treatment T_2 (1.80) and the highest number of healthy fruits was obtained from the treatment T_5 (3.00), which was statistical identical with treatment T_1 (2.75) (Figure 4). The highest number of infested fruits were harvested from treatment T_7 (0.70), which was statistically similar with treatment componentT_2 (0.65), treatment T_3 (0.65), treatment componentT_4 (0.50) and treatment T_6 (0.50) respectively and the lowest infested fruits was found in the treatment T_5 (0.30), which was statistical identical with treatment componentT_1 (0.45), treatment T_4 (0.50) and treatment T_6 (0.50). The highest percent reduction over control in fruit infestation by number was obtained from treatment componentT_5 (71.28%) and the second highest percent reduction over control was found in the treatment T_4 (61.56%).

Table 3. Effect of different IPM components on the number of healthy fruits, infested fruits, percent infestation and their percent reduction over control of bitter gourd at late fruiting stage

Treatments	Number of fruits / plant	% Infestation	% reduction over control
T_1	0.45 bc	14.07 de	54.96
T_2	0.65 ab	26.44 ab	15.39
T_3	0.65 ab	24.04 bc	23.07
T_4	0.50 abc	18.01 cd	61.56
T_5	0.30 c	8.98 e	71.28
T_6	0.50 abc	17.63 cd	43.58
T_7	0.70 a	31.25 a	-
Level of Significance	**	**	-
CV (%)	13.28	12.57	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

Plate 3. Experimental plot of bitter gourd at reproductive stage in the experimental field during kharif-2006

Plate 4. Experimental plot of bitter gourd at reproductive stage in a untreated control plot, T_7

Plate 5. Experimental plot of bitter gourd at reproductive stage treated with neem leaf extract (10%) and hand picking of infested fruits, T_5

Plate 6. Healthy fruits of bitter gourd

Plate 7. Infested fruit of bitter gourd

4.2 Effect of different IPM component on the weight of healthy fruits, infested fruits, percent infestation and their percent reduction over control at different stages of bitter gourd

The effect of various treatment components by weight on healthy and infested fruits, percent fruit infestation at early, mid and late fruiting stages during bitter gourd cultivation period and their percent reduction over control is presented in Table 4- 6.

4.2.1 Early fruiting stage

The effect of different treatment components on the weight of healthy fruits, infested fruits, percent infestation and their percent reduction over control of bitter gourd at early stage was found statistically significant at variable level(Table 4).

At early fruiting stage plots having treatment component T_5 gave the lowest percent fruit infestation by weight (4.86%), which was statistically similar with treatment component T_1 (7.46%) and the highest percent fruit infestation by weight was found in treatment T_7 (25.16%), which was statistically similar with treatment component T_2 (21.72%). The lowest weight of healthy fruits was obtained from control plots treatment T_7 (295.3 g/plant), which was statistically similar with untreated control treatment T_2 (351.7 g/plant) and the highest weight of healthy fruits was obtained from the treatment T_5 (628.2 g/plant) which was significantly differ with all other treatments. Significantly the highest infested fruits by weight was harvested from treatment T_7 (98.52 g/plant), which was statistically similar with treatment component T_2 (97.92 g/plant) and treatment component T_3 (81.10 g/plant) and the lowest infested fruits was harvested from treatment component T_5 (32.64 g/plant), which was statistically identical with treatment component T_1 (46.26 g/plant), and treatment component T_6 (58.37 g/plant) respectively (Table 4). The highest percent reduction over control in fruit infestation by weight was obtained from treatment component T_5

(80.66%) and the second highest percent reduction over control was found in treatment component T_1 (70.36%).

4.2.2 Mid fruiting stage

At mid stage of fruiting, the percent of fruit infestation by weight varied significantly among the treatments (Table 5). The highest fruit infestation by weight was found in untreated control treatment T_7 (23.15%), which was statistical identical with treatment component T_2 (20.93%) and the lowest fruit percent infestation by weight was obtained in the treated plots treatment component T_5 (6.44%), which was statistically identical with treatment component T_1 (8.84%) and treatment component T_3 (17.22%). The lowest weight of healthy fruits was obtained from the control plots treatment component T_7 (333.5 g/plant), which was statistically identical with treatment component T_2 (355.8 g/plant) and the highest weight of healthy fruits was obtained from the treatment component T_5 (620.0 g/plant), which was statistically identical with treatment component T_1 (584.0 g/plant). The highest infested fruits weight was harvested from treatment component T_7 (100.3 g/plant) which was statistically similar with treatment component T_2 (94.79 g/plant) and treatment component T_3 (94.30 g/plant) and the lowest weight of infested fruits was harvested from treatment component T_5 (42.80 g/plant), which was statistically identical with treatment component T_1 (56.51 g/plant) and treatment component T_4 (64.87 g/plant). The highest percent reduction over control in fruit infestation by weight was obtained from treatment component T_5 (72.81%) and the lowest percent reduction over control was found from treatment component T_2 (9.58%).

4.2.3 Late fruiting stage

The effect of different treatments on healthy and infested fruit (by weight), percent fruit infestation by weight at late fruiting stages of bitter gourd and their percent reduction over control are presented in Table 5. At late fruiting stage significantly highest fruit infestation by weight was observed in untreated control plots treatment T_7 (27.05%) which was statistically identical with treatment component T_2 (22.77%) and the lowest infestation was recorded in treatment component T_5 (7.76%) which was statistically identical with treatment component T_1 (12.17%). In case of healthy fruits, the lowest weight of healthy fruits was obtained from control plots treatment T_7 (254.3 g/plant), which was statistically identical with treatment component T_2 (292.1 g/plant) and the highest weight of healthy fruits was obtained from the treatment component T_5 (489.4 g/plant), which was statistically identical with treatment component T_1 (445.9 g/plant). The highest infested fruits weight was harvested from untreated control T_7 (93.31 g/plant) which was statistically similar with treatment component T_2 (86.63 g/plant), treatment component T_3 (88.13 g/plant), treatment component T_4 (68.75 g/plant) and treatment component T_6 (64.11 g/plant) respectively and the lowest infested fruits weight was harvested from treatment component T_5 (41.64 g/plant), which was statistical identical with treatment component T_1 (61.81 g/plant). The highest percent reduction over control in fruit infestation by weight was obtained from treatment component T_5 (71.29%) and the lowest percent reduction over control in fruit infestation by weight was recorded in treatment component T_2 (15.82%).

Table 4. Effect of different treatment components on the weight of healthy fruits, infested fruits and their percent infestation and their reduction over control of bitter gourd at early fruiting stage

Treatments	Weight of fruits gm/plant		% Infestation	% reduction over control
	Healthy	Infested		
T_1	562.3 b	46.26 cd	7.46 de	70.36
T_2	351.7 ef	97.92 a	21.72 a	13.67
T_3	389.6 de	81.10 ab	17.31 b	31.20
T_4	436.3 cd	60.24 bc	12.04 c	52.14
T_5	628.2 a	32.64 d	4.86 e	80.66
T_6	479.3 c	58.37 bcd	10.89 cd	56.71
T_7	295.3 f	98.52 a	25.16 a	-
Level of Significance	**	**	**	-
CV (%)	8.53	14.55	11.58	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

Table 5. Effect of different treatment components on the weight of healthy fruits, infested fruits and their percent infestation and their reduction over control of bitter gourd at mid fruiting stage

Treatments	Weight of fruits gm/plant		% Infestation	% reduction over control
	Healthy	Infested		
T_1	584.0 a	56.51 bc	8.84 cd	61.81
T_2	355.8c	94.79 a	20.93 ab	9.58
T_3	453.1 b	94.00 a	17.22 d	25.61
T_4	474.1 b	64.87 bc	12.08 c	47.81
T_5	620.0 a	42.80 c	6.44 d	72.81
T_6	508.5 b	66.86 d	11.63 c	49.76
T_7	333.5 c	100.3 a	23.15 a	-
Level of Significance	**	**	**	-
CV (%)	9.44	13.84	15.82	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

Table 6. Effect of different treatment components on the weight of healthy fruits, infested fruits and their percent infestation and their reduction over control of bitter gourd at late fruiting stage

Treatments	Weight of fruits gm/plant		% Infestation	% reduction over control
	Healthy	Infested		
T_1	445.9 a	61.81 bc	12.17 de	55.00
T_2	292.1 cd	86.63 ab	22.77 ab	15.82
T_3	333.9 bc	88.13 a	20.83 bc	22.99
T_4	364.7 b	68.75 ab	15.77 cd	41.77
T_5	489.4 a	41.64 c	7.76 e	71.29
T_6	382.7 b	64.11 ab	15.10 cd	44.17
T_7	254.3 d	93.31 a	27.05 a	-
Level of Significance	**	**	**	-
CV (%)	10.10	11.96	13.53	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

4.3 Overall total fruits number per plant

From the Table 7, it is found that the highest number of fruit was harvested from treatment component T_5 (13.45). The plots treated with treatment component T_5 (neem leaves extract 10% + hand picking of infested fruit, applied at 7 days intervals), was statistically similar with treatment component T_1 (12.60) and the lowest number of fruit was found in untreated control T_7 (8.65) which was statistically similar with treatment component T_2 (9.55). The results from the present study reveals that treatment component T_5 (neem leaves extract 10%+ hand picking of infested fruit, applied at 7 days intervals,) showed the highest total number of fruit per plant, it may be due to the combined effect of neem leaves extract 10% and hand picking of infested fruits. Collection and destruction of infested fruits with larva inside for reducing fruit fly population on snake gourd (Nasiruddin and Karim 1992). The highest percent increased over control was recorded from the treatment component T_5 (55.49%) and lowest percent increased over control was recorded from the treatment component T_2 (10.40%).

4.4. Overall total fruit weight per plant

It is found From the Table 8, the highest weight of fruit (2.43 kg/plant), was harvested from the plots treated with treatment T_5 which was statistically similar with treatment T_1 (2.27 kg/plant) and the lowest of fruit (1.48 kg/plant) was found in treatment T_7 which was statistically similar (1.65 kg/plant)with treatment T_2. From the present study result reveals that treatment T_5 (neem leaves extract 10% + hand picking of infested fruit applied at 7 days intervals) increased the weight of fruit per plant this may be due to increased number of fruits per plant. The highest percent increase over control (by weight) was recorded (64.18%) from the treatment component T_5 and the

lowest percent increase over control (by weight) was recorded (11.48%) from the treatment component T_2.

Table 7. Effect of different treatment components on total number of fruits per plant of bitter gourd

Treatments	Total no. of fruits/ plant	% increase over control
T_1	12.60 a	45.66
T_2	9.55 cd	10.40
T_3	10.60 bc	22.54
T_4	10.70 bc	23.69
T_5	13.45 a	55.49
T_6	11.30 b	30.63
T_7	8.65 d	-
Level of Significance	**	-
CV (%)	6.83	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

Table 8. Effect of IPM components on total fruits weight (kg/plant) of bitter gourd

Treatments	Total weight of fruits (kg/ plant)	% Increase over control
T_1	2.27 a	53.39
T_2	1.65 c	11.48
T_3	1.84 b	24.34
T_4	1.88 b	27.02
T_5	2.43 a	64.18
T_6	2.00 b	35.13
T_7	1.48 c	-
Level of Significance	**	-
CV (%)	6.05	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

4.5. Effect of different IPM components on the overall rate of fruit fly infestation by number and weight in bitter gourd

The overall rate of fruit fly infestation in fruit (by number) of six treated and untreated plots are presented in Table 9. The fruits under treatment component T_5 resulted significantly the lowest level of infestation (6.58%) as compared to other treatments (Table 9), which was statistically similar with the treatment component T_1 (10.34%). The highest level of infestation was obtained from the fruit of untreated control T_7 (30.63%) which was also statistically similar with the treatment component T_2 (25.33%).

Singh and Srivastava (1985) found that alcohol extract of neem oil, *Azadirachta indica* (5%) reduced oviposition of *Bactrocera cucurbitae* on bitter gourd completely and its 20% concentration was highly effective to inhibit oviposition of *Bactrocera zonata* on guava. Another treatment, such as hand picking of infested fruit gave the additional support for suppressing the fruit fly infestation. Nasiruddin and Karim (1992) observed that collection and destruction of infested fruits with the larvae inside helped population reduction of fruit fly infestation.

On the other hand the overall rates of fruit fly infestation by weight in six treated and an untreated plot are presented in Table 9. After the application of different IPM component, the fruits under treatment T_5 gave the lowest percent infestation by weight (5.58%) compared to other treatments and the highest percent infestation by weight in the treatment T_7 (23.23%).

Table 9. Effect of different IPM components on the overall rate of fruit fly infestation by number and weight in bitter gourd

Treatments	% Fruit infestation	
	By number	By weight
T_1	10.34 cd	8.46 ef
T_2	25.33 ab	21.36 b
T_3	22.18 b	17.81 c
T_4	15.35 c	12.38 d
T_5	6.58 d	5.58 f
T_6	14.20 c	11.49 de
T_7	30.63 a	25.23 a
Level of Significance	**	**
CV (%)	10.15	14.99

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

4.6 Effect of IPM components on the fruit yield of bitter gourd

The effect of various treatments on the yield of healthy fruits, infested fruits and total number of fruits were obtained during the reproductive stage of the crop and the percent increases and decreases of yield over control were presented in Table 10. Significantly the highest total fruit yield (12.15 t/ha) was obtained from the plots treated with the IPM component T_5 (Neem leaves extract 10% + hand picking and burning of infested fruits) and the total fruits yield of the treatment component T_1 (11.31 t/ha) was the second highest and statistically similar to each other. Significantly the lowest total yield (7.40 t ha^{-1}) was obtained in plots of untreated control and it was statistically identical with their of treatment component T_2 (8.26 t ha^{-1}). The highest percent of the total fruit yield increase over control (64.19%) was found in the IPM component T_5 and the lowest percent of the total fruit yield increase over control (11.62 %) was found in the IPM component T_2 (Table 10).

The present study significantly the highest (11.47 t ha^{-1}) healthy fruits yield was obtained from the plots treated with the IPM component of T_5 consisting of Neem leaves extract (10%) + hand picking of infested fruits applied at 7 days intervals and the lowest (5.54 t ha^{-1}) healthy fruits yield was found in untreated control plots (T_7) (Table 10). The maximum percent (107.3%) of healthy fruit yield increase over control was obtained in plots of T_5 IPM component.

Significantly the lowest infested fruit yield was 0.68 t ha^{-1} and it was obtained from the plots treated with the IPM components T_5 and it was statistically similar

Table 10. Effect of IPM components on the increase/ decrease of yield (t ha^{-1}) over control by the infestation of fruit fly on bitter gourd

IPM components	Healthy yield (Ton/ha)	Increase over control (%)	Infested yield (Ton/ha)	Decrease over control (%)	Total yield (Ton/ha)	Increase over control (%)
T_1	10.39 b	87.55	0.96 bc	48.66	11.31 a	53.51
T_2	6.49 e	17.14	1.77 a	5.35	8.26 c	11.62
T_3	7.57 d	36.64	1.64 a	12.29	9.20 b	24.32
T_4	8.24 cd	48.74	1.16 a	37.96	9.40 b	27.03
T_5	11.47 a	107.03	0.68 c	63.63	12.15 a	64.19
T_6	8.88 c	60.28	1.16 b	37.96	10.00 b	35.14
T_7	5.54	-	1.87 a	-	7.40 c	-
Level of Significance	**	-	**	-	**	-
CV (%)	5.60	-	11.32	-	6.05	-

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

to those of T_1 (0.96 t ha^{-1}). But it was significantly differ from that of untreated control. The highest infested fruit yield was obtained in the treatment T_7 (1.87 t ha^{-1}). The percent decrease of infested fruit yield over control was evident being the highest (63.63%) in the plots of IPM component T_5 and was followed by 48.66%, 37.96%, 37.96%, 12.29% and 5.35% in IPM component plots of T_1, T_4, T_6, T_3 and T_2, respectively. Rahman (2001) indicated that the treatment comprising hand picking of infested fruits plus bait spray showed significantly lower infestation compared to other IPM components. He also reported that the higher yield and yield increase over control were also obtained from hand picking of infested fruits plus bait spray treated plot.

The infestation of fruit fly on bitter 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.*, 1991; Mckinlay *et al.*, 1992).

4.7. Effect of IPM components on the quality of infested fruits

The quantity of infested fruits is presented in Table 11 in terms of percent edible portion of single infested fruit by weight. At the early fruiting stage significantly the highest (93.75%) edible portion of single infested fruit was obtained from the plots of IPM component T_5 as compared to control and other components. And significantly the lowest (26.25%) edible portion of single infested fruit was obtained from the plot of untreated control as compared to those of the treatments (Table11). The qualities of infested fruit directly depend on the intensity of infestation. Just a simple infestation

might not affect the quality or quantity of fruits. Infestation of severe nature i.e., the multiple infestation or feeding of a fruit by multiple number of larvae affect the quality and quantity of infested fruit and reduced its weight tremendously (Kabir *et al.*, 1991).

At the mid fruiting stage significantly the highest (88.50%) edible portion of single infested fruit was obtained from the IPM component T_5 as compared to untreated control and other treatments. And significantly the lowest (24.25%) edible portion of single infested fruit was obtained from the plot of untreated control as compared to those of the other treatments (Table11). According to Uddin (1996) regular hand picking of infested fruits might prevent the maggot to feed intensively for long time to reduce the edible portion of the fruit and this might lead to the existence of slightly infested and deformed fruits of which considerable portion remained edible.

At the late fruiting stage significantly the highest (92.75%) edible portion of single infested fruit was obtained from the plots of IPM components T_5 as compared to control and other treatments. And significantly the lowest (20.25%) edible portion of single infested fruit was obtained from the plot of untreated control as compared to those of the other treatments (Table11). Edible portion will be higher when the fecundity and post-embryonic development of fruit fly might be hampered by the application of neem leaves extract (10%) and hand picking of infested fruits. According to Shivendra Singh (2003) aqueous extract of neem seed kernal (NSKE) was tested and found its negative effect on the fecundity and post-embryonic development of *Bactrocera cucurbitae.*

The mean weight of edible portion of single infested fruit (%) was significantly higher in the fruits from the plots treated with IPM component T_5 (90.68%). And

significantly the lowest (23.31%) mean edible portion of single infested fruit was obtained from the plot of untreated control as compared to the other IPM component treated plots (Table11). The reason for this might be the prevalence of hindrance free activities of the fruit fly in untreated plots. As a result, the damage in majority of infested fruits incurred by larval activity inside the fruit might reach the extreme level leading to rotting of the fruits (Uddin, 1996).

This study indicated that the IPM component T_5 comprising neem leaves extract 10%+ hand picking of infested fruits applied at 7 days intervals might be considered as a best component on the basis of its effectiveness in reducing the fruit infestation, increasing total yield and healthy yield.

Table 11. Effect of IPM component on the weight of edible portion of single infested fruit at various reproductive stages of bitter gourd

Treatments	Weight of edible portion of single infested fruit (%)			
	Early	Mid	Late	Mean
T_1	77.50 b	73.00 b	82.50 b	78.87 b
T_2	63.75 c	62.75 c	73.50 c	66.81 b
T_3	55.00 d	73.00 b	56.25 e	. 47.58 c
T_4	55.75 d	52.50 d	59.50 d	55.25 c
T_5	93.75 a	88.50 a	92.75 a	90.68 a
T_6	55.00 d	55.00 d	49.50 e	55.50 c
T_7	26.25 e	24.25 e	20.25 f	23.31d
Level of Significance	**	**	*	**
CV (%)	5.98	2.74	2.52	4.77

* = Significant at 5% level of significance
** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

4.8 Relationship between Percent fruit infestation by number at early fruiting stage and yield

There was a negative correlation between percent fruit infestation (by number) at early fruiting stage and yield. This indicated that higher fruit infestation conversely lower the fruit yield. A linear regression line was fitted between fruit infestation (by number) at early fruiting stage and total yield shown in (Figure 5). The correlation coefficient (r) was 0.9622 and the contribution of R2 =0.9258 indicated that 92.58% variation of total yield could be caused by the fruit infestation (by number) at early stage.

4.9. Relationship between Percent fruit infestation by number at mid fruiting stage and yield

The results revealed that there was a negative correlation between percent fruit infestation (by number) at mid fruiting stage and yield. This indicated that higher fruit infestation conversely lower the fruit yield. A linear regression line was fitted between fruit infestation (by number) at early fruiting stage and total yield shown in (Figure 6). The correlation coefficient (r) was 0.9625 and the contribution of R2 =0.9264 indicated that 92.64 variation of total yield could be caused by the fruit infestation at mid stage.

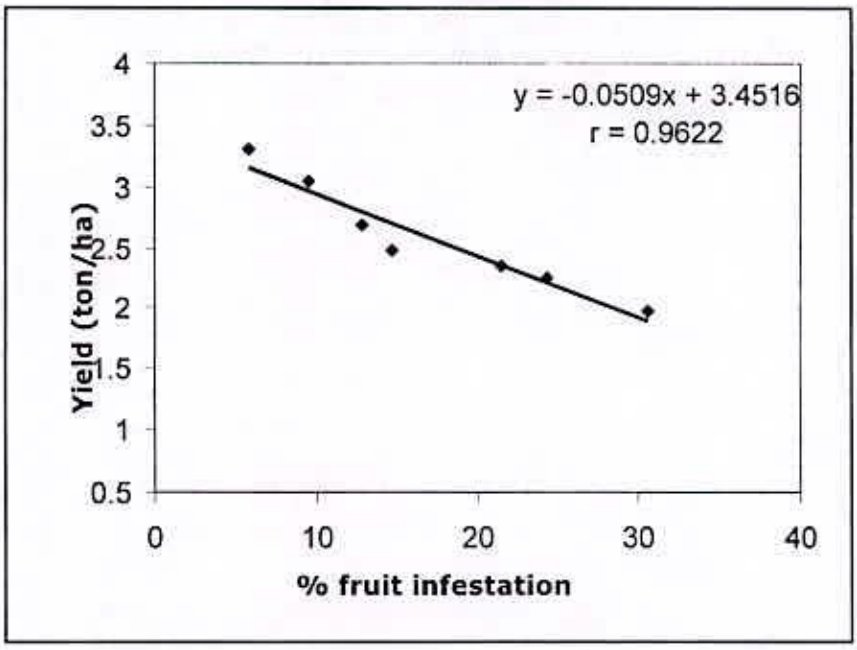

Figure 5. Relationship between % fruit infestation and yield of bitter gourd obtained from different treatments at early fruiting stage

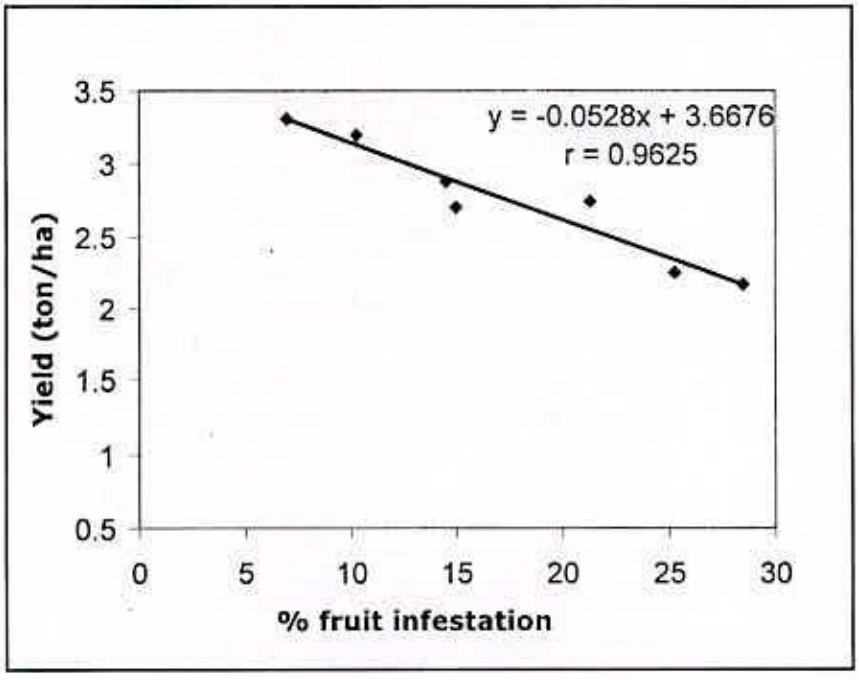

Figure 6. Relationship between % fruit infestation and yield of bitter gourd obtained from different treatments at mid fruiting stage

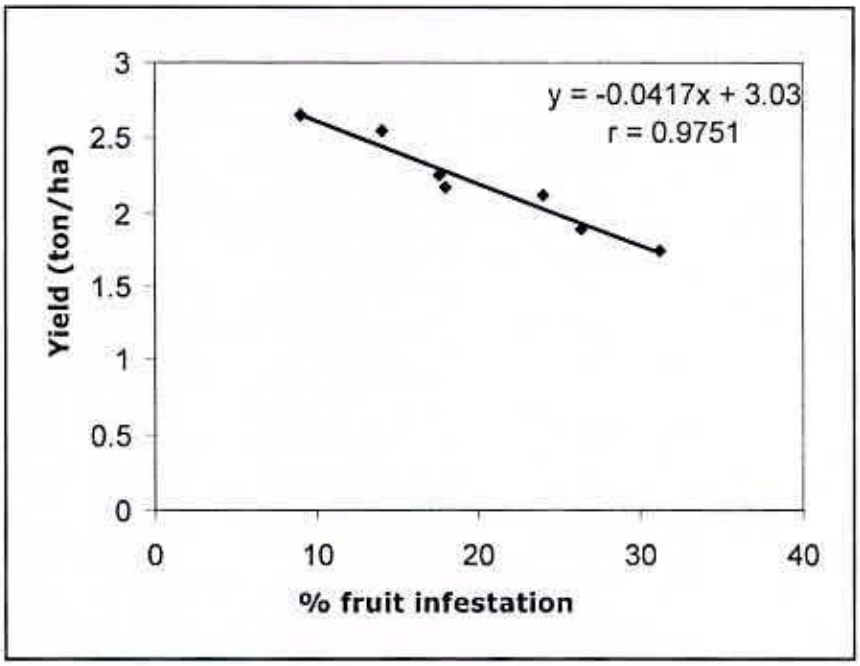

Figure 7. Relationship between % fruit infestation and yield of bitter gourd obtained from different treatments at late fruiting stage

4.10. Relationship between Percent fruit infestation by number at late fruiting stage and yield

A highly significant negative correlation between percent fruit infestation (by number)at mid fruiting stage and yield was found for different treatments (Figure 7) which indicated that with the increase of fruit infestation there was a progressive fall in the yield. The correlation coefficient (r) was 0.9751 and the contribution of the regression (R2 =0.9508) indicated that 95.08 % of total yield could be affected by the variation in fruit infestation at late fruiting stage.

The fruit infestation on bitter gourd is not the exception. Its infestation on bitter gourd invariably causes deformation and retardation of growth of fruit. It finally reduces the size and weight of the fruit compared to healthy ones. The heavy infestation by

multiple larvae causes decomposition of fruit accompanied by liquefaction of pulp with foul odor (Kabir *et al.*, 1991; Mckinlay, *et al.*, 1992).

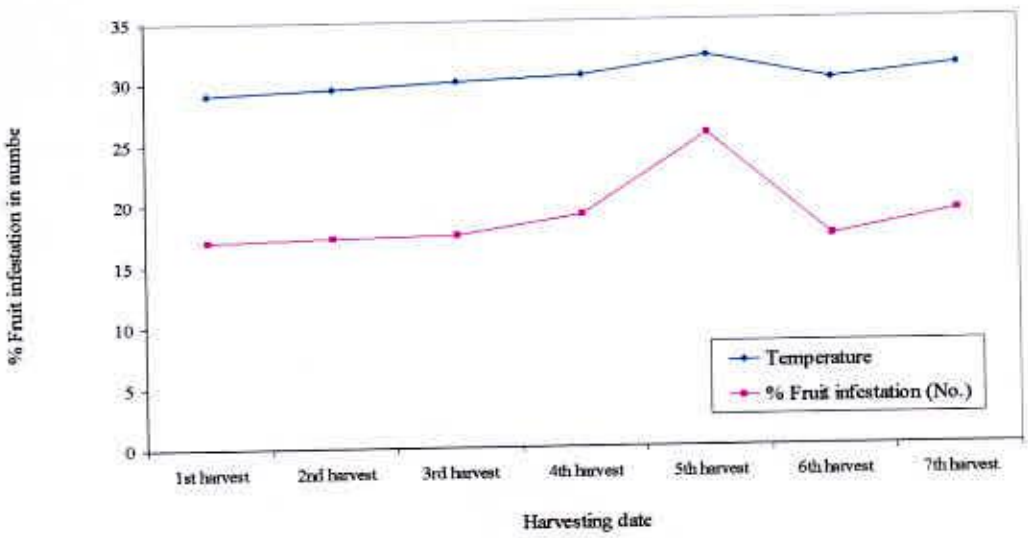

Figure 8. Effect of temperature on fruit infestation of bitter gourd at different harvesting time

4.11. Effect of temperature on fruit infestation of bitter gourd at different harvesting time

With increasing of temperature at different harvesting time, percent fruit infestation increasing and with decreasing the temperature percent fruit infestation also decreasing trend was found (Figure 8). And it was clearly seen at 5^{th} harvesting time, when the highest mean temperature was raised at 32.02^0 C. Similar result was found Dhillon *et al.*, (2005), they expressed that the extent of losses vary 30 to 100% depending on the species and season and the abundance of fruit fly increases when the temperature fall bellow 32^0C Brevault *et al.*, (2000) also reported that the developmental rate of the different life stages increased linearly with increasing temperature unto 30^0 C.

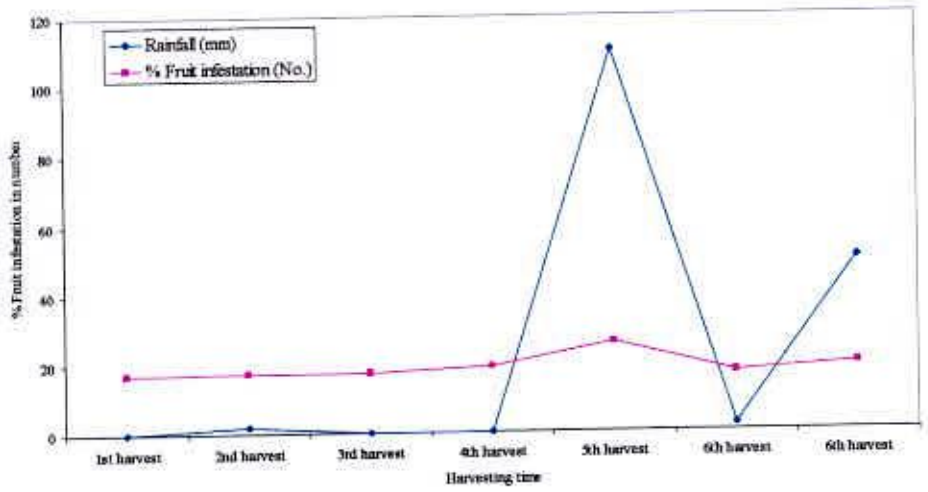

Figure 9. Effect of rainfall on fruit infestation of bitter gourd at different harvesting time

4.12. Effect of rainfall on fruit infestation of bitter gourd at different harvesting time

Percent fruit infestation trend was found more or less similar when the mean rainfall was bellow 40 mm and the trend was increasing when the mean rainfall was more than 100 mm (Figure 9). Result also supported with the report of Hui *et al.*, (2007) they concluded that the population was depressed when the monthly mean rainfall amount was lower than 50 mm but increased when rainfall ranged from 100 to 200 mm and when the monthly rainfall amount was higher than 250 mm; the fruit fly population was reduced remarkably.

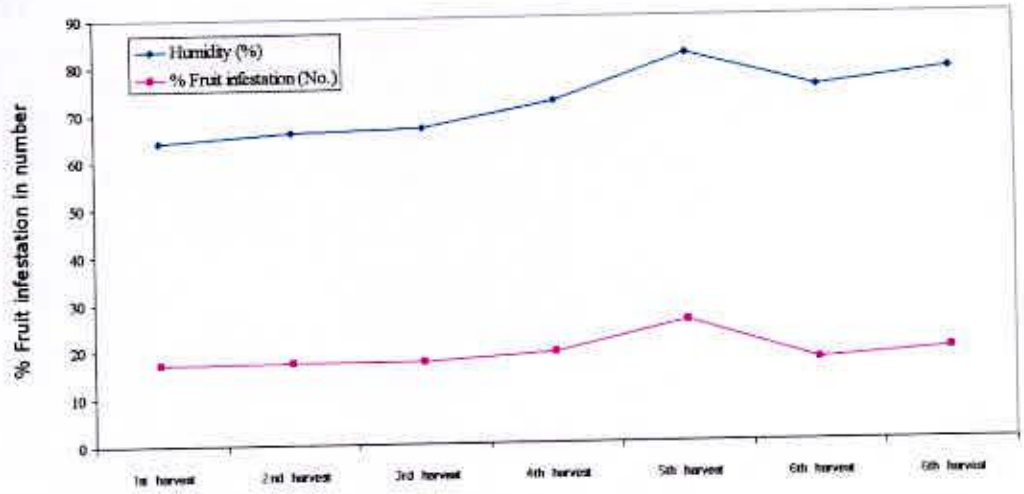

Figure 10. Effect of rainfall on fruit infestation of bitter gourd at different harvesting time

4.13. Effect of relative humidity on fruit infestation of bitter gourd at different harvesting time

Like temperature positive effect was also found in case of relative humidity. With increasing relative humidity, percent fruit infestation increased and with the decreasing relative humidity, percent fruit infestation decreased. It was clearer at 5th harvesting time when the highest relative humidity was 82% (Figure 10). Dhillon *et al.*, (2005) also stated that the abundance of fruit fly increased when the relative humidity ranges between 60 to 70%.

4.14. Economic Analysis of IPM component

In the study the untreated control did not have pest management cost, but rest of the components needed variable pest management costs. All these costs were calculated per hectare basis. The component (T_1) neem leaves extract (10%) applied at 7 days intervals involved labors cost for sprays, cost of neem leaves and preparing the neem leaves extract (10%); treatment (T_2), hand picking at 7 days intervals include the labors cost for hand picking component (T_3) bait trap, 50 ml Dipterex (80 SP) and 1.5 kg of sweet gourd. This treatment also includes the cost of bamboo, earthen pot for bait trap and also considered the cost of labors for preparing and installing bait traps; treatment (T_4), garlic extracts (5%) included garlic 1.50 kg/ha and soap powder 0.50 kg/ha and the cost of labors for preparing and spraying of garlic extracts (5%) ; component (T_5), involved hand picking of infested fruits + Neem leaves extract (10%) applied at 7 days interval, needed the cost of labour for preparing and spraying of neem leaves extract and also included labor cost for hand picking.

T_6, polythene bagging of fruits, at 3 DAA for 5days, involved labor cost for bagging and costs of tag, bags and clips.

The analysis was done in order to find out the most profitable IPM component based on cost and benefit of various components. The results of economic analysis of bitter gourd showed that the highest net benefit of Tk. 3,15,300 ha^{-1} was obtained in T_5 treatment component and the second highest net benefit was found Tk. 3,09,950 ha^{-1} in T_1, followed by Tk. 2,67,100 ha^{-1}, Tk. 2,54,900 ha^{-1}, Tk. 2,41,250 ha^{-1}, Tk. 2,29,500 ha^{-1} and Tk. 2,22,000 ha^{-1} in T_6, T_4, T_3 and T_2 treatment components respectively (Table 12). Highest net benefit return was found in the T_5 treatment component combined application of neem leaves extract 10% and hand picking of infested fruits from the experimental plots. After application of neem leaves extract 10% there are

Table 12. Cost returns analysis of various IPM components for the management of fruit fly in bitter gourd

Treatments	Cost of management (Tk/ ha)	Total yield (t/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Adjusted net return (Tk/ha)	Benefit cost ratio (BSR)
T_1	30850	11.36	340800	309950	87950	+2.85
T_2	18300	8.26	247800	229500	7500	+0.41
T_3	34750	9.2	276000	241250	19250	+0.55
T_4	27100	9.4	282000	254900	32900	+1.21
T_5	49200	12.15	364500	315300	93300	+1.90
T_6	32900	10	300000	267100	45100	+1.37
T_7	00	7.4	222000	222000	--	--

Market price bitter gourd @ Tk 30.00/ kg
Labour cost 120.00 Tk/day
Neem leaves 10.00 Tk /kg
Cost of single tag 5.00 Tk
Cost of jams clip Tk 20.00/packet
Cost of single polythene bag 2.00 Tk
Cost of single bait trap 100.00 Tk
Insecticide Dipterex (80 SP) 50 ml= 75.00Tk
Sweet gourd 20.00Tk/kg
Garlic 100 Tk/kg
Fuel (kerosine) 50 Tk/L
Wheel powder 40 Tk/kg

T_1: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha

T_2: Hand picking of infested fruits applied at 7 days intervals

T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash and 100ml water

T_4: Garlic extract 5% applied at 7 days intervals @ 2.50 L/ha

T_5: Neem Leaves Extract 10% applied at 7 days intervals @ 250 L/ha +Hand picking of infested fruits applied at 7 days intervals

T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days.

T_7: Untreated control

some insects may attack that's come from newly developed fruit fly in the infested fruits.Singh and Srivastava (1985) found that alcohol extract of neem oil *Azadirachta indica* (5%) reduced oviposition of *B. cucurbitae* on bitter gourd completely. Singh and Singh (1998) evaluated neem (*Azadirachta indica)* seed kernel extract at 1.25-20% and pure azadirachtin at 1.25-10 ppm as oviposition deterrents to *Bactrocera cucurbitae* on pumpkin and they reported that neem seed kernal extract deterred oviposition by *B. cucurbitae* at all the concertration. Atwal (1993) suggested mechanical control measures in farmer's fields as normal practice for effective control against this pest in India and the treatment hand picking and burning had considerably lowered the infestation (average 34.08% when compared with untreated plot (average 58.39%). The benefit cost ratio (BCR) calculated for each of the treatment component revealed that the BCR of the treatment T_1 was the highest (2.85) and the second highest BCR was found in the treatment component T_5 (1.90) and was followed by the treatment T_6 (1.37), treatment T_4 (1.21), treatment T_3 (0.55) and treatment T_2 (0.41), respectively (Table 12). Highest BCR was found in the treatment T_1 may be due to the less management cost compared to the other treatment components.

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Sher-e-Bangla Agricultural University (SAU) experimental farm, Dhaka, during kharif season of 2006 to evaluate the efficacy of some IPM components management practices to suppress the infestation level of cucurbit fruit fly attacking bitter gourd (*Momordica charantia* Linn).

Seven treatment components were utilized in the experiment. The trail was laid out in Randomized Complete Block Design (RCBD) with four replications. The treatments used were T_1: Neem Leaves Extract (10%), T_2: Hand picking of infested fruits, T_3: Bait trap with 0.5g of Dipterex 80sp with 100g sweet gourd smash mixed with 100ml water, T_4: Garlic extract (5%), T_5: Neem Leaves Extract (10%) +hand picking of infested fruits, T_6: Bagging of fruits at 3 days after anthesis (DAA) and left for five days., T_7: Untreated control.

At early fruiting stage significantly the highest fruit infestation by number (30.57%) and by weight (26.16%) was obtained from untreated control plots, which was statistically similar to those treatment components T_2 by number and weight. The lowest fruit infestation was found from the plots having the treatment component T_5 by number (5.81%) and by weight (4.86%), which were statistically identical with treatment component T_6 (by number) and treatment component T_1 (by weight). The highest healthy fruits by number (3.20) and weight (628.2 g/plant) were recorded from treatment component T_5 which was significantly different from those of other treatment components. The lowest healthy fruits per plant by number (1.50 g/plant) and weight (2.95 g/plant) was recorded from untreated control plot which was significantly different

from those of other treatment components (by no.) but statistically similar with treatment component T_2 by weight.The highest infested fruit by number and weight was counted from untreated control plots (0.65 and 98.52 g/plant), which was statistically similar to those of treatment component T_2 and T_3 (by number and weight). The lowest infested fruit was counted from component T_5 treated plot (0.20) by number which was statistically similar to that of treatment component T_1, T_4, and T_6 and the lowest infested fruits was counted from treatment T_5 by weight (32.64g/plant), which was statistically similar to that of treatment component T_1 and T_6.

At mid fruiting stage the highest fruit infestation by number(28.53%) and weight (23.15%) was counted from control plots, which was statistically similar to those of treatment component T_2, the lowest fruit infestation by number(6.95%) and by weight (6.44%) was counted from treatment component T_5, which was statistically similar with treatment component T_1. The highest healthy fruits by number and weight was recorded from T_5 treated plots (3.35 and 620.0 g/plant), which was statistically similar to those of treatment component T_1. The lowest healthy fruit by number and weight was recorded from untreated plots (1.75 and 333.5 g/plant), which was statistically different from that of other treatments by number but statistically similar from that of treatment component T_2 by weight. The highest infested fruit by number and weight was obtained from untreated control plot (0.70 and 100.3g/plant) which was statistically similar to those of treatment components T_2 and T_3 (by both number and weight). The lowest infested fruit was recorded from treatment component T_5 by number(0.25) which was statistically similar with treatment component T_1, T_4, and T_6 and the lowest infested fruit was recored

from treatment component T_5 treated plots by weight (42.80g/plant), which was statistically similar to that of treatment component T_1 and T_4.

At late fruiting stage significantly the highest fruit infestation by number (31.25%) and by weight (27.05%) were obtained from untreated control plots which was statistically similar to those of treatment component T_2. The lowest fruit infestations by number (8.98%) and by weight (7.76%) were found in the treatment component T_5 plots, which was statistically similar to those of treatment component T_1. The highest healthy fruits by number and weight was recorded from treatment component T_5 treated plots (3.00 and 489.4 g/plant), which was significantly identical to that of treatment component T_1. The lowest healthy fruit by number and weight was recorded from untreated control plots (1.55 and 254.3 g/plant), which was statistically similar to those of treatment component T_2. The highest infested fruit by number and weight was counted from untreated control plots (0.70 and 93.31 g/plant), which was statistically similar to those treatment components T_2, T_3, T_4 and T_6. The lowest infested fruit was counted from treatment component T_5 by number (0.30) which was statistically similar with treatment components T_1, T_4, and T_6 and the lowest infested fruit was counted from treatment component T_5 by weight (41.64 g/plant), which was statistically similar with treatment T_1. The highest total fruit by number and weight was recorded from treatment component T_5 (13.45 and 2.43 g/plant), which was statistically similar with treatment component T_1. The lowest total fruit by number and weight was recorded from untreated control plot T_7 (8.65 and 1.48 g/plant), which was statistically similar with those of treatment component T_2. At early fruiting stage, neem leaves extract (10%) + hand picking of infested fruits applied at 7days intervals, exceeded the standard level of 80% reduction of fruit

infestation over control both by number and weight but at mid and late fruiting stage treatment component T_5 exceeded the standard level of 70% reduction of fruit infestation over control both by number and weight. The standard level of 80% increase of total fruit over control both by number and weight.

The plants of the plots under treatment component T_5 showed significantly the lowest overall infestation by number (60.58%) and also by weight (5.58%), which was statistically similar to those of treatment component T_1. The highest overall infestation by number (30.63%) and also by weight (25.23%), which was statistically identical to that of treatment T_2 (by number) and statistically different with other treatment (by weight).The plants of the plots treated with treatment component T_5 gave significantly the highest healthy fruit yield (11.47 t ha^{-1}) compared to control plots and increase 107.03% healthy fruit yield over control, which was statistically different with all other treatments. The lowest healthy fruit yield (5.54 t ha^{-1}) was obtained from untreated control plot, which was statistically different with that of other treatments. The treatment component T_5 gave significantly the lowest infested fruit yield (0.68 t ha^{-1}) compared to control and decrease infested fruit yield (63.63%) over control. Statistically similar infested fruit yield (0.96 t ha^{-1}) obtained from treatment component T_1 and decrease infested yield of 48.66% over control. The highest infested fruit yield (1.87 t ha^{-1}) was obtained from treatment T_7, which was statistically similar with treatment components T_2 (1.77 t ha^{-1}), T_3 (1.64 t ha^{-1}) and T_4 (1.16 t ha^{-1}) and decrease 5.35%, 12.29% and 37.96% infested yield over control, respectively. Significantly the highest total fruit yield (12.15 t ha^{-1}) obtained from treatment component T_5 compared to control plot and increase total fruit yield 64.19% over control plot. The treatment component T_1 gave statistically similar yield (11.31 t ha

^{1}) and increase 53.51% yield over control. The lowest total fruit yield (7.40 t ha^{-1}) was obtained from untreated control plot. The treatment component T_2 gave total fruit yield 8.26 t/ha and increase 11.62% yield over control. The lowest edible portion of single infested fruit was obtained from control plot at all fruiting stages. Significantly the higher level of edible portion of single infested fruit was obtained from the fruits harvested from treatment component T_5 plots at all fruiting stage. The edible portion of single infested fruit at early, mid and late fruiting stages was ranged from 26.25-93.75%, 24.25-88.50% and 20.25-92.75%, respectively. Percent fruit infestation at all stages was negatively correlated with the total yield. Highest BCR was found in the treatment component T_1 (+2.84) and the lowest BCR was found in the treatment component T_2 (+0.36).

From the present study, the comparative evaluation of some IPM components against fruit fly infestation of bitter gourd indicated that the neem leaves extract (10%) sprayed at reproductive stages would be the best practices for reducing fruit fly infestation and damage of bitter gourd. The treatment component T_5 comprising of neem leaves extract 10% + hand picking of infested fruits applied at 7 days intervals might be better treatment for suppressing fruit fly infestation of bitter gourd. As there was an increasing tendency of fruit fly infestation beginning from early to late fruiting stages control measure should be taken at early and mid fruiting stages for effective and profitable bitter gourd cultivation. But control action at flower initiation and late fruiting stages would not be economically sound because of the lower number of fruits in the plant. Neem leaves extract 10% spray might be selected as non hazardous component of IPM against fruit fly for economic bitter gourd cultivation in Bangladesh.

CHAPTER VI

REFERENCES

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

Akhtaruzzaman, M. (1999). Integrated management of fruit fly in cucumber. Ph. D. Dissertation, Department of Entomology, Institute of Postgraduate Studies in Agriculture, Gazipur, Bangladesh. p. 193.

Alam, M. Z.; Ahmed, A.; Alam, S. and Islam, M. A. (1964). A Review of Research, Div. Ent., Agri. Infor. Serv. in collaboration with EPARI, Dept. Agri., East Pakistan, Dacca, p. 272.

Alam, M. Z. (1962). A list of Insect and Mite of East Pakistan, Agri. Res. Inst.Tejgaon, Dacca. P. 104.

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

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

Andrawaetha, H. G. and L. G. Birch, (1960). Distribution and abundance of insects. Ann. Rev. Ent. **5**:219-242.

Anonymous (1987). Melon Fly Eradication Project in Okinawa Prefecture. Akatsuki Printing Ltd. Japan, p. 28.

Anonymous, (1988). Comparative efficacy of bagging and trapping in controlling fruit fly, *Bsctrocera cucurbitae* Coq.attacking kakrol (*Momordoca diocia* Roxb.). Res. Report on fruit fly in cucurbits (1987-88). Paper presented at the International Review Workshop held on Aug. 28-30, 1988. Div. Ent., BARI, Gazipur, p.17.

Anonymous, (1993). Research and development of vegetable crops. Paper presented in the workshop on March 9-10, 1993 at IPSA. Gazipur.pp. 1-7.

Atwal, A.S.(1993). Agricultural Pests of India and South East Asia. Kalyani publ. New Delhi, Ludhiana, pp. 189-190.

Batra, H. N. (1953). *Dacus* (Leptoxyda) longistylus Wied becomeing a pest of cucurbitaceous plants in India. *Indian J. Ent.* **17(2)**: 278-179.

BBS(Bangladesh Bureau of Statistics). (2004). Statistical Year Book of Bangladesh, Statistics Division, Ministry of Planning, Government of the people's Republic of Bangladesh. p. 141.

Begum, L. A. (2002). Host preference of fruit fly and red pumpkin beetle to different cucurbit vegetables grown in summer. M.S. Thesis. Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. p. 17.

Biswas, S. K. (2005). Studies on the bionomics and management approaches of cucurbit fruit fly, *B. cucurbitae* on bitter gourd. M. S. Thesis. Department of Entomology, Bangladesh Agricultural University. Mymensingh. p 48.

Borah, S. R. and S. K. Datta, (1997). Infestation of fruit fly in some cucurbitaceous vegetables. *Journal of the Agricultural Science Society of North East India*, **10(1):** 128-131.

Brevault, T. and Quilici, S. (2000). Relationships between temperature, development and survival of different life stages of the tomato fruit fly, *Neoceratitis cyanescens* .Entomologia Experimentalis et Applicata. Springer Netherlands. **94**(1): pp 25-30.

Butani, D. K. and M. G. Jotwani. (1984). Insects in vegetables. Periodical Expert Book Agency. Vivek-Vihar, Delhi, India. pp. 69-79.

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

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

Chiristenson, L. D. and R. H. Foote, (1960). Biology of fruit flies. Ann. Rev. Ent. **5**:171-192.

Chowdhury, M.K.; J.C. Malapert and M.N. Hosanna, (1993). Efficiency of poison bait trap in controlling fruit fly, *Dacus cucurbitae* in bitter gourd. *Bangladesh Journal of Entomology* **3:** 91-92.

Chu, Y. I.; G. J. Chen, (1985). Behavior of pupation and emergence in oriental fruit fly *Dacus dorsalis* Hendel. Plant Protectoin Bullatin, Taiwan. **27(2):** 135-143.

Deshmukh, R. P. and R. S. Patil. (1996). Comparative efficacy of baited and non baited sprays of insecticides and chemical attractant against fruit flies infesting ridge gourd. Journal of Maharastra Agricultural Universitt. **21** (2): 346-349

Dhillon M. K.; J. S. Naresh, R. Singh and N. K. Sharma (2005). The melon fruit fly, *Bactrocera cucurbitae*: A review of its biology and management. Journal of Insect Science . 5 PP. 1-16

Dhillon M. K.; J. S. Naresh, R. Singh and N. K. Sharma (2005a). Evaluation of bitter gourd (Momordica charantia L.) genotypes to melon fruit fly, *Bactrocera cucurbitae* (*Coquillett*). *Indian Journal of Plant Protection*. **33**: 55-59

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

Feron, M.; P. Delanous and F. Soria. (1958). L'clvage massif artificial de *Ceratitis 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, p. 265.

Gupta J.N. and A.N. Verma, (1978). Screening of different cucurbit crops for the attack of the melon fruit fly, *Dacus cucurbitae Coq.* (Diptera: Tephritidae). *Haryana Journal of Horticulture Science.* **7**: 78-82.

Gupta, D. (1992). Population fluctuations of the maggots of fruit flies infesting cucurbitaceous crops. Advances in plant Science. **5** (2): 518-523.

Hsu, E. L. and N. M. Doog. (1985). Biological studies of oriental fruit flies (*Dacus dorsalis* Hendel). The effects of photoperiod and temperature on the mating behavior of *Dacus dorsalis* Hendel. Memoirs of the College of Agriculture, National Taiwan University. **25(1)**: 121-141.

Hui, Y. and Jianhong, L. (2007). Population dynamics of oriental fruits fly Bactrocera dorsalis (Diptera: Tephritidae) in Xishuangbanna, Yunnan Province, China. Frontiers of Agriculture in China. Higher Education press, co-published with Springer-Verlag Gmbh. (1): pp. 76-80.

Kabir, S. M. H.; R. Rahman and M. A. S. Molla. (1991). Host plant of Dacinae fruit flies (Diptera: Tephtitidae) of Bangladesh. *Bangladesh j. Ent.* **1**: 60-75.

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

Koul, V.K.; and K.C. Bhagat. (1994). Biology of melon fruit fly, *Bactrocera* (*Dacus*) *cucurbitae Coquillett* (Diptera: Tephritidae) on bottle gourd. Pest Management and Economic Zoology **2**: 123-125.

Kushwaha K. S.; B. L. Pareek and A. Noor. (1973). Fruit fly damage in cucurbits at Udaipur. *Udaipur University Research Journal.* **11**: 22-23.

Lall, B.S.; S.N. Sinha. (1959). On the biology of the melon fly, *Dacus cucurbitae* (*Coq.*) (Diptera7B: 148-153.: Tephritidae). Science & Culture **25**: 159-161.

Mckinlay, R. G.;A. M. Spavll and R. W. Straub.(1992). Pests of solanaceous crops. In: Vegetable crop pests. Mckinlay. R.G. (ed.). Mckinlay Press. Houndmills, Basingstok. Hampshire and London. pp. 263-326.

Mitchell, S. N.; N. Tanaka and L. F. Steiner. (1985). Method of mass culturing Oriental, Melon and Mediterranean fruit flies. U.S. Dept. Agri. ARS. pp.1-22.

Mitchell, W. C. and S. H. Saul. (1990). Current control methods for the Mediterranean fruit fly, *Ceratitis capitata* and their application in the U.S.A. Rev. Agril. Entomology. **78**(9): 923-930.

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

Narayanan E. S.; H. N. Batra. (1960). Fruit Flies and Their Control. Indian Council of Agricultural Research, New Delhi, India. pp.1-68.

Nasiruddin, M. (1991). Seasonal abundance of fruit fly, *Bactrocera cucurbitae* Coq. by bait trap. Ann. Res. Report. (1990-91), Div. Entomol., BARI, Gazipur. pp. 51-54.

Nasiruddin, M. and M. A. Karim. (1992). Evaluation of potential control measures for fruit fly, B. (*Dacus*) *cucurbitae* in snake gourd. *Bangladesh J. Entomol.* **2(1&2):** 31-34.

Nasiruddin, M., Alam, S. N., Khorsheduzzaman, A. K. M., Rahman, A. K. M. Ziaur, Karim, A. N.M. Rezaul, Jasmine, H. S. and Rajotte, Edwin G.(2004). Integrated management of cucurbitae fruit fly, Bactrocera cucurbitae Coquillett in Bangladesh. IPM CRSP Bangladesh site Technical Bulletin no.1. p. 16.

Powar, D. B., M. B. Jot and H. N. Sonone. (1984). Chemical control of red pumpkin beetle and fruit fly of muskmelon by modern insecticides. South India Hort. **32**: 317-318.

Rabindranath, K. and K.S. Pillai. (1986). Control of fruit fly of *bitter* gourd using synthetic pyrethroids. *Indian J. Ent* . **11:** 269-272.

Rahman, A.K.M. Z. (2001). Use of visual color ribbons and some other management pproches against the cucurbit fruit fly (*Bactrocera cucurbitae* coquillett) in bitter gourd.M. S. Thesis. Depatment of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural Univercity. Gajipur. Bangladesh.

Ranganath H. R, Suryanarayana MA, Veenakumari K. (1997). Management of melon fly (*Bactrocera* (*Zeugodacus*) *cucurbitae* in cucurbits in South Andaman. Insect Environment. **3:** 32-33.

Sands, W. N.(1928). The bitter cucumber or perea. *Malayan Agricultural Journal.* **16:** 32-9.

Shah, M. I.; H. N. Batra and P.G. Renjhen. (1948). Notes on biology of Dacus (Streumeta) ferrugeneus and other fruit flies in the North West Frontier Province. *Indian J. Ent.* **10:** 240-166.

Shaha, L. R. (1992). Hand Book of Plant Protection. Kalyani Publications. Ludhina, New Delhi, Nodia (U. P), Hyderabad, Madras, Calcutta. pp. 650-653.

Shivendra, S. (2003). Effects of aqueous extract of neem seed kernels and azadiractin on the fecundity, fertility of the cucurbit fruit fly *B. cucurbitae* (Diptera: Tephritidae). *Indian. J. Ent.* **127** (9/10): 540-547.

Singh, R. R. and B. G. Srivastava. (1985). Alcohol extract of neem (*Azadirachta indica* A. Juss.) seed oil as oviposition deterrent for *Dacus cucurbitae* Coq. Indian Journal Entomol. **45** (4): 497-498.

Singh, S. and R. P. singh. (1998). Neem seed kernel extracts and azadirachtin as oviposition deterrents against the melon fly (*Bactricera cucurbitae*) and the oriental fruit fly. Div. of Ent. Indian Agri. Res. Ins.(IARI) New Delhi.

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

Srinivasan, P. M. (1959). Guard your bitter gourd against the fruit fly. Indian farming. **9:** 8.

Stark, J. D., R. I. Vargas and R. K. Thalman. (1990). Azadirachtin effect on metamorphosis, longevity and reproduction of three tephritid fly species (Diptera: Tephritidae). J. Econ. Entomol. **83** (6): 2168-2174.

Tansaka, A.; H. Shimada and N. Shimada. (1978). Fluctuation in number of the melon fly males, *Dacus cucurbitae* Coquillelt (Diptera: Tephritidae) caught in traps at different habitats on kikai Islands. Proceedings of the Association for Plant Protection of Kyushu, Japan, **24:** 122-124.

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

Vargas, R. I.; D. Miyashita and T. Nishida. (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. Pant quarantine and Phytosanitary Barrier to Tread in the ASEAN, Selangor, Malaysia, ASEAN Plant Quarentine Center and Training Institute. OE Review of Applied Entomology, 9-12 December 1986-1987. pp. 209-216.

Yao, A. L. and W. Y. Lee. (1978). A population study of the Oriental Fruit fly, *B. dorsalis* in guava, citrus fruits and wax apple fruit in Northern Taiwan. Bull. Inst. Zool. Academia Sinica, **19(2):** 103-108.

York, A. (1992). Pest of cucurbit crops: Marrow, pumpkin squash, melon and cucumber. *In*: Vegetable Crop pests Mckinlay, R. G. (ed). Mcmillan Press. Houndmills,Basingstoke, Hampshire and London. pp.139-161.

List of appendices

Appendix I. Monthly average of Temperature, Relative humidity and Total Rainfall of the experiment site during the period from April to July, 2006

Year	Months	Air temperature (^{0}C)			Relative humidity (%)	Total Rainfall (mm)
		Maximum	Minimum	Mean		
2006	April	33.74	23.81	28.77	68.92	179
	May	33.66	24.95	29.39	72.74	184
	June	32.39	26.08	29.23	79.82	562
	July	32.38	26.68	29.53	80.43	331

Source: Bangladesh Metrological Department (Climate division), Agargaon, Dhaka - 1212