INTEGRATED MANAGEMENT OF CUCURBIT FRUIT FLY ON ASH GOURD

MD. GOLAM ZILANI

DEPARTMENT OF ENTOMOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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INTEGRATED MANAGEMENT OF CUCURBIT FRUIT FLY ON ASH GOURD

BY

MD. GOLAM ZILANI
REGISTRATION NO. 17-08206

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Approved by:

....
Prof. Dr. Md. Mizanur Rahman
Supervisor
Department of Entomology
SAU, Dhaka

....
Dr. Mst. Nur Mohal Akther Banu
Co-supervisor
Associate Professor
Department of Entomology
SAU, Dhaka

....
Prof. Dr. S.M. Mizanur Rahman
Chairman
Examination Committee
Department of Entomology
SAU, Dhaka

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

CERTIFICATE

This is to certify that thesis entitled **"INTEGRATED MANAGEMENT OF CUCURBIT FRUIT FLY ON ASH GOURD"** submitted to the **Faculty of Agriculture,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. GOLAM ZILANI, Registration no. 17-08206** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:JUNE,2018

Place: Dhaka, Bangladesh

Prof. Dr. Md Mizanur Rahman
Supervisor
Department of Entomology
SAU, Dhaka

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Author
SAU, Dhaka

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ABSTRACT

A field experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University to find out the effective as well as hazards free management practice(s) of cucurbit fruit fly infesting ash gourd cultivated during Kharif I season from February 2018 to June 2018. There were six treatment including untreated control. The treatments were as follows T_1 (comprised of setting up of pheromone trap replaced at 1 month interval), T_2 (comprised of setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval), T_3 (comprised of setting up of banana pulp trap @1 ml malathion 57EC with 100gm mashed banana pulp @ 4days interval), T_4 (comprised of spraying of Neem oil @ 3 ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval), T_5 (comprised of covering fruit with polythene bag at 1 poly bag per fruit @ 4 days interval); T_6 (comprised of untreated control). The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications.Covering fruit with polythene (T_5) contributed to produce the highest number of healthy fruit (14.50 fruit/plot); total weight of healthy fruit (103613gm/plot) and reduced the maximum fruit infestation over control (93.75%). The maximum single fruit weight over control (49.46%) was recorded in $T_{5.}$ The higher temperature (34.5^{o}C) negatively affected the capturing of adult fruit fly for poison bait trap because of drying up of bait materials, but not affected on the adult capturing capacity of pheromone trap. The highest benefit cost ratio (42.24) was also found for T_5 and the lowest BCR (19.23) for T_3. Considering the social acceptance and environmental safely point of view, T_5 comprising of covering fruit with polythene bag was the most effective management practices in reducing the fruit fly infestation. Thereby increasing the yield of ash gourd.

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INTRODUCTION

The growth in vegetable production in Bangladesh has been the third fastest in the world. This nation now grows 3.7 million tonnes of vegetables a year from less than a tenth of Bangladesh's available cultivable land (FAOSTAT 2017). Vegetable in general is popular for additional income generation in farmers backyards or small portion of their scare landholdings, comparatively well-endowed in terms of soil and irrigation. According to the Ministry of Agriculture and Department of Agricultural Extension, some 156 types of local and exotic vegetables were grown in Bangladesh with the output hitting 3.73 million metric tonnes from 0.8 million hectares of land in the last fiscal year. The national demand for vegetables is 13.25 million metric tonnes (BBS 2017).

Cucurbits are vegetable crops belonging to family Cucurbitaceae which are consumed as food worldwide. The family consists of about 118 genera and 825 species. In Bangladesh, number of cucurbits viz., ridge gourd (*Luffa acutangula* L. Roxb.), snake gourd (*Trichosanthes anguina* L.), cucumber (*Cucumis sativus* L.), bitter gourd (*Momordica charantia* L.), bottle gourd (*Lagenaria siceraria* Malina Stand L.), watermelon (*Citrullus lanatus* Thunb), sponge gourd (*Luffa cylindrical* Roem), pumpkin (*Cucurbita moschata* Ducherne), winter squash (*Cucurbita maxima* Duchesne), ash gourd (*Benincasa hispida* Thunb), sweet gourd (*Momordica cochinchinensis*) etc have been cultivated for years (Pessarakli, M. (2016). Ash gourd (*Benincasa hispida* Thunb.) belongs to the family Cucurbitaceae with chromosome number 2n=24. The only cultivated species is *Benincasa hispida*, commonly known as ash gourd, tallow gourd, chinese preserving melon, chinese water melon, white gourd, wax gourd and 'chaal kumra' in Bengali (Bisen, M. S. (2015). It is indigenous to Asian subtropics. It is widely cultivated in Bangladesh, India, China, Malaysia, Indonesia, Philippines, Taiwan and the Caribbean Islands. In 2016-17, ash gourd has been cultivated in 24742 acres of land and yielded 74052 mt in Bangladesh (BBS 2017). Green immature fruits and young twigs of ash gourd are used as vegetables, and mature fruits are used for preparing candy, sweets, sun dried delicacy called 'kumra bari' and also for cooking as a vegetable. World famous confectionery known as Petha is prepared using ripe flesh in sugar syrup. It is an excellent source of vitamin B1 (thiamine), a good source of vitamin B3 (niacin) and vitamin C and also rich in many minerals like calcium. Its high potassium content makes this a good vegetable for maintaining healthy blood pressure (Tamilnayagan *et al.* 2017).

Ash gourd is attacked by a wide range of cucurbitacious and noncucurbitacious insect pests including fruit fly, red pumpkin beetle, striped cucurbit beetle, twelve spotted cucumber beetles, spider mites, melon aphids, squash borer, squash bug and leaf minors etc. are important insects (Dhillon *et al*. 2005).

Fruit fly *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae) is most destructive which causes damage to all the cucurbitaceous vegetables and its infestation level ranges from 20 to 100% depending on the cucurbitaceous species, climatic region and cultivation season (Sapkota *et al.* 2010). In Bangladesh, *B. Cucurbitae* caused 71.5% and 21.0% fruit infestation on sweet gourd and ridge gourd, respectively (Amin *et al.* 2011).

Chemical pesticides are effective for the control of these pests, but their indiscriminate use has resulted in insecticide resistance in pests, resurgence of minor pests and high level of residual toxicity in direct consumables besides other environmental hazards.

The most alarming situation is the environmental pollution due to contamination of air, soil and water by these chemical pesticides which results in health hazards and appearance of new disease in human beings (Carson 2007), harmful effect upon human life, wild life and other flora and fauna. Growing public awareness and concern about the adverse effects of pesticides on human health, soil and water resources and development of resistance and resurgence among the insect-pests have necessitated the need to look for eco-friendly, safer and effective methods of pest control.

The process which is used to control the pests by minimizing the risks to the people and the environment is called as integrated pest management. Management is attained by the perfect monitoring like checking the fields, crops and houses for the presence of pests. Once we get an idea about the biology and environmental factors of the pests we can decide for the management.

Keeping above facts in mind, the present study has been undertaken to-

i. To know the nature and extent of damage of cucurbit fruit fly on ash gourd and
ii. To develop an integrated management approach to suppress of cucurbit fruit fly on ash gourd.

CHAPTER II

REVIEW OF LITERATURE

Ash gourd (*Benincasa hispida*) is an important vegetable crop in Bangladesh. Fruit fly is most damaging insect pest of Ash gourd and other cucurbit fruits and vegetables. It causes great yield reduction, which is considered as an important obstacle for economic production of these crops. The last several decades Cucurbit fruit fly, *Bactrocera cucurbitae (*Coquillett) has been reported the most prominent pest of cucurbitaceous vegetables (Manjunathan, 1997). The difficulties associated with the control of this pest by chemical insecticides, farmers experienced great losses in cucurbits. Therefore, the judicious use of pesticides along with bio-pesticides is important. The literatures on the ecofriendly management utilizing several non-hazardous components to combat this pest are very sporadic. The relevant information pertaining to origin, distribution, biology and seasonal abundance, host range, host preference, nature of damage of these pest and yield loss due to their attack and management of fruit fly have been discussed in this section.

2.1 Systemic position of cucurbit fruit fly

Phylum: Arthropoda
Class: Insecta
Sub-class: Pterygota
Division: Endopterygota
Order: Diptera
Sub-order: Cyclorrhapa
Family: Tephritidae
Genus: *Bactrocera*
Species: *Bactrocera cucurbitae*

2.2 Synonyms

Bactrocera cucurbitae (Coquillett) has also been known as*:*

i)Chaetodacus cucurbitae

ii) Dacus cucurbitae

iii) Strumeta cucurbitae

iv) Zeugodacus cucurbitae

Plate 1: Cucurbit fruit fly

2.3 Origin and distribution of fruit fly

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

Fruit flies are distributed almost everywhere in the world and infest a large number of host plants. The distribution of a particular species is limited perhaps due to physical, climatic and gross vegetational factors, but most likely due to host specificity. Such species may become widely distributed when their host plants are widespread, either naturally or cultivation by man (Kapoor, 1993). Two of the world's most damaging tephritids, *B. dorsalis* and *B. cucurbitae* are widely distributed in Malaysia and other South East Asian countries (Vijaysegaran, 1987). Five species of fruit fly in Bangladesh, e.g., *B. brevistylus* (melon fruit fly), *Dacus (Zeugodacus) caudatus* (fruit fly), *D. (Strumeta) cucurbitae* (melon fly), *D. (Bactrocera*) *dorsalis* Hendel (mango fruit fly) and *D. (Chactlodacus) zonatus* (zonata fruit fly). According to Akhtaruzzaman (1999) *B. cucurbitae, B. tau* and *D. ciliatus* have been currently identified in Bangladesh of which *D. ciliatus* is a new record. *B. cucurbitae* is dominant in all the locations of Bangladesh followed by *B. tau*and *D. ciliatus.* Aktheruzzaman (1999) *Bactrocera cucurbitae, Bactrocera tau and Bactrocera ciliates* have been currently identified in Bangladesh of which *Bactrocera ciliates* is a new record. *B. cucurbitae* is dominant in all the locations of Bangladesh followed by *B. tau* and *B. ciliates.*

2.4 Life history of fruit fly

The melon fruit fly remains active throughout the year on one or the other host. During the severe winter months, they hide and huddle together under dried leaves of bushes and trees. During the hot and dry season, the flies take shelter under humid and shady places and feed on honeydew of aphids infesting the fruit trees. Fruit flies breed in fruits but also in other living plant tissues as leaves, buds, stems and flowers. The host ranges of fruit flies can vary from monophagous (e.g. Mediterranean fruit flies) to highly polyphagous (e.g. Melon flies and Oriental fruit flies). The life cycle from egg to adult requires 14-27 days.

Insects are able to grow and develop on a variety of host species which effect on their growth, reproduction and development . The life history of *B. cucurbitae* on sweet gourd and reported pre-oviposition, oviposition, incubation, larval and pupal periods, and adult male and female longevity 11.25, 9.75, 0.81, 12.25, 7.75, 18.25, and 23.50 days, respectively. They also reported that the mean fecundity of fruit fly on this crop was 52.75 female^{-1} (Islam, M. 2013)

2.4.1 Eggs

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

2.4.2 Larvae

Heppner (1989) cited detailed description of larvae. The larval period lasts from 6 to 11 days, with each stage lasting 2 or more days. Duration of larval development is strongly affected by host. The larval period lasts for 3 to 21 days (Renjhan, 1949; Narayanan and Batra, 1960; Hollingsworth *et al.,* 1997), depending on temperature and the host. On different cucurbit species, the larval period varies from 3 to 6 days (Gupta and Verma, 1995; Doharey, 1983). Larval feeding damage in fruits is the most damaging (Wadud *et al.,* 2005). Mature attacked fruits develop a water soaked appearance (Calcagno *et al.,* 2002). Young fruits become distorted and usually drop. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot (Collins *et al.,* 2009). These maggots also attack young seedlings, succulent tap roots, stems and buds of host plants such as mango, guava, cucumber, custard apple and others (Weldon *et al.,* 2008). Egg viability and larval and pupal survival on cucumber have been reported to be 91.7, 86.3, and 81.4%, respectively; while on pumpkin these were 85.4, 80.9, and 73.0%, respectively, at 27 ± 1° C. The full-grown larvae come out of the fruit by making one or two exit holes for pupation in the soil. The larvae pupate in the soil at a depth of 0.5 to 15 cm. The depth up to which the larvae move in the soil for pupation, and survival depend on soil texture and moisture (Jackson *et al.*, 1998).

2.4.3 Pupae

Doharey (1983) observed that the pupal period lasts for 7 days on bitter gourd and 7.2 days on pumpkin and squash gourd at 27 ± 1° C. In general, the pupal period lasts for 6 to 9 days during the rainy season, and 15 days during the winter 13 (Narayanan and Batra, 1960). Depending on temperature and the host, the

pupal period may vary from 7 to 13 days (Hollingsworth *et al.*, 1997). On different hosts, the pupal period varies from 7.7 to 9.4 days on bitter gourd, cucumber, and sponge gourd (Gupta and Verma, 1995), and 6.5 to 21.8 days on bottle gourd (Koul and Bhagat, 1994; Khan *et al.*, 1993).

2.4.4 Adults

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

2.5 Host range of fruit fly

Many fruit fly species do serious damage to vegetables, oil-seeds, fruits and ornamental plants. In Bangladesh, Alam *et al.,* (1969) recorded ten cucurbit vegetables as the host of fruit fly. Tomato, green, pepper, papaya, cauliflower, 7
mango, guava, citrus, pear, fig and peaches are also infested by fruit fly (Anon, 1987 and Atwal,1993). Sixteen species of plants act as the host of fruit flies among which sweet gourd was the most preferred host of the *Bactrocera cucurbitae* and *Bactrocera tau*. Among flowers the rate of infestation was greater in sweet gourd but the intensity was higher in bottle gourd (Kabir *et al*., 1991) Batra (1968) listed as many as 70 hosts of fruit fly species, whereas. Christenson and Foote (1960) reported more than 80 kinds of vegetables and fruits as hosts. Batra (1968) observed that the male flowers and flowers bud of sweet gourd were found to serve as usual host with anthers being the special food for the larvae and only occasionally small sweet gourd fruits attacking perhaps through the female flower.

Kapoor (1993) reported that more than one hundred vegetables and fruits are attacked by *Bactrocera sp*. Atwal (1993) and McKinlay *et al*., (1992) reported that cucurbit as well as 70-100 non-cucurbitaceous vegetables and fruits are the host of fruit fly.

According to Narayanan and Batra (1960),different species of fruit fly attack a wide variety of fruits and vegetables such as mango, guava, loquat, plum, peach, apple, quince, persimmon, banana, pomegranate, jujube, sweet lime, orange, chilies, jack fruit, carambola, papaya, avocado, bread fruit, coffees, berries, passion fruit, star apple, Spanish pepper, cucurbit fruit, cherries, black berry , grapes etc.

2.6 Seasonal abundance of fruit fly

The population of fruit fly fluctuates throughout the year and the abundance of fruit fly population varies from month to month, season to season, even year to year depending upon various environmental factors. The fly has been observed to be active in the field almost throughout the year where the weather is equable (Narayan and Batra 1960). Tanaka *et al*., (1978) reported that population of melon fly was increased in autumn and decreased in winter in Kikai islands Japan. Narayan and Batra (1960) reported that most of the fruit fly species are more or less active at temperatures ranging between 12ºC-15ºC and become inactive below 10°C. Cucurbit fruit flies normally increases their multiplication when the temperature goes below 15°C and relative humidity varies from 60-70 % (Alam 1966). The fruit fly population is generally low during dry weather and increases with adequate rainfall (Butani and Jotwani 1984). The peak population of fruit fly in India is attained during July and August in rainy months and January and February in cold months (Nair 1986). The adults of melon fly *Bactrocera cucurbitae* over winter November to December and the fly is the most active during July to August (Agarwal *et al*., 1987). Fruit fly populations were in general positively correlated with temperature and relative humidity. Amin (1995) observed the highest population incidence at ripening stage of cucumber in Bangladesh.

2.7 Nature of damage of fruit fly

According to Janjua (1948), the nature of infestation of fruit fly varies with the kinds of fruits. Shah *et al.* (1948) and York (1992) observed the formation of brown resinous deposits on fruits as the symptom of infestation. Fruit flies damage fruits by puncturing and laying eggs under the soft skin in both mature and green fruits (Hollingsworth and Allwood, 2000). The eggs hatch and feed inside the fruit causing the fruits to rot

(Dhillon, 2005b) resulting in unmarketable fruits. Due to the larva's three instars the fruits can be totally destroyed (Ye and Liu, 2005).

Furthermore, injuries caused by the larvae may be used as gateways by secondary organisms (e.g. bacteria and fungi) and contribute to further destruction of the fruit. At maturity, larvae emerge from the damaged fruit and drop to the ground and pupate in a burrow (4-8 cm) prepared by the prepupa. Infested fruits often drop to the ground prematurely.

Plate 2: Healthy fruit of ash gourd

Plate 3: Fruit fly infested ash gourd

Piercing by the ovipositor causes wounds on the fruit or vegetables 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 (York, 1992; Narayanan and Batra, 1960; Shah *et al.,* 1948). Inside the damage fruits small white color larvae are present (Praveen *et al*., 2012). After hatching the larvae feed into pulp tissue and make tunnels in fruits causing direct damage. They also indirectly damage the fruits by contaminating with grass and accelerate rotting of fruit by pathogenic infection. In infested fruits if not rotten become deformed and hardy which make it unfit for human consumption. The infested flower often becomes juicier and drops from the stalk at a slight jerk (Kabir *et al*., 1991).

According to Kapoor (1993), some flies make mines and a few form galls on different parts of the plants. Singh (1985) reviewed that the maggots bore and feed inside the fruits causing sunken discolored patches, distortion and open cracks.

In Hawaii, pumpkin and squash are heavily damaged even before fruit set. The eggs are laid into unopened flowers, and the larvae successfully develop in the taproots, stems, and leaf stalks (Weems and Heppner, 2001). The vinegar fly, *Drosophilla melanogaster* has also been observed to lay eggs on the fruits infested by melon fly, and acts as a scavenger (Dhillon *et al.*, 2005c).

2.8 Fruit fly behavior :

Melon flies are most often found on low, leafy, succulent vegetation near cultivated areas. In hot weather they rest on the undersides of leaves and in shady areas. They are strong fliers and usually fly in the mornings and afternoons. They feed on the juices of decaying fruit, nectar, bird feces, and plant sap (Agarwal *et al*., 1987). Narayanan and Batra (1960) observed that as soon as the ovipositor is drawn out of the fruit for oviposition the fruit fly walks a short distance and pauses for a while to clean the fully extended ovipositor by movement of the hind pair of legs.

2.9 Yield Loss

Cucurbits are infested by several insects which are considered to be the significant obstacle for its economic production. Amont them, fruit fly is the serious pest responsible for considerable damage of cucurbits (Alam, 1969; Butani and Jatwai, 1984). In reality, this is very difficult to correctly appraise the extent of damage by the pest except in a generalize term (Narayanan and Batra, 1960). This is not only due to the complexity of the problem but also to interplay of other factors like the variety of the fruits grown, the resistance offered by 14 these varieties to the attack by flies, the influence of environmental factors particularly climatic conditions and lastly the fluctuating market value. All these make it difficult to asses the damage caused and average loss to the farmers from year to year (Narayanan and Batra, 1960). Yet, information of this aspect of the problem is necessary if only to prove the effectiveness of the control methods adopted. According to the reports of Bangladesh Agricultural Research Institute (BARI), fruit fly infestations were 39-69, 35-58, 30-54 percent for sweet gourd, cucumber and ash gourd, respectively (Anon., 1988). 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 ash gourd (69.96%). Karim (2005) observed 52.08 percent fruit fly infestation in ash gourd and this value was 49.14 percent as reported by Ahmed (1996). The damage caused by fruit fly is the most serious in melon after the shower in monsoon when the infestation often Reaches up to 100 percent. Other cucurbit may also be infested and infestation may go up to 50 percent. In any case, it can be safely stated that the damage caused by these flies to fruits as well as vegetables in India is alarming (Narayanan and Batra, 1960) and this is also true for Bangladesh. Almost every vegetable and fruit growers must have experienced every year that it is almost impossible to get infestation free fruits and vegetables. It can, however, be stated without any contradiction that the horticultural industry suffers most from the depredations of the pests.

2.10 Management of fruit fly

Cucurbit fruit fly is the major pest causes considerable economic damage of ash gourd. It is important to manage or control the pest before its outbreak. Usually farmers try to control this pest using chemical insecticides but they failed because the larvae live in the internal portion of fruits. And they do not consider economic injury level that is hazardous to the environment. So, the judicious use of pesticide with bio- pesticide is important in the management of cucurbit fruit fly and it will be helpful in minimizing environmental hazard. Fruit fly infestation was reduced by 53 to 73 percent and yields were raised 1.4 to 2.3 times using the traps (IPM CRSP Annual Highlights, 2002-2003). Bait spray (Steiner *et al.,* 1988), trapping with chemical attractant (Qureshi *et al.,* 1981) were undertaken to control fruit fly on various crops. Different types of attractants (Tanaka *et al.,* 1978), cucurbit fruit fly traps (Nasiruddin and Karim, 1992) and repellants of plant extracts (Sing and Srivastava, 1985) were utilized against this pest with variable success.

2.10.1 Management with Poison bait trap

Niranjana and Raveendranath (2002) carried out a study in Maha (October 2000-January 2001) to evaluate the efficacy of trapinol trap and sugar baited trap on fruit flies of cucurbits. It was followed by another study in Yala (April 2001- July 2001) was carried out to find out the efficacy of petroleum spirit extract of cloves trapping agent of cucurbit fruit flies and found that, the number of fruit flies caught in trapinol trap and trap with extract of clove was significantly higher than the control and sugar baited trap.

There was no significant (P> 0.05) difference between control and sugar baited trap. However, the number of fruit flies caught in the trapinol was significantly higher than the clove extraction.

Uddin (2002) reported that the number of flies were higher at early fruiting stage and the ratio of male and female flies in bait traps at different reproductive stages of plants does not showed significantly difference.

Samalo *et al.* (1995) reported that baiting with dichlorvos, monocrotophos or quinalphos at a concentration of 0.025% killed 100% of adults within 6 h, as compared with 6.6% mortality in a 10% sugar solution. Contact toxicity tests showed that chlorpyrifos, endosulfan and dichlorvos caused 100% mortality of adults in 18 h as compared with 3.3% mortality of untreated adults. Chowdhury *et al.* (1993) captured 115.16 to 167.48 flies/ trap/ season in poison bait traps containing trichlorfon in bitter gourd.

Bangladesh Agricultural Research Institute has developed a simple and cheap method of poison bait trap which showed 31.18-95.07% reduction of fruit infestation in cucurbit fruit as compared to those in untreated plots (Nasiruddin, 1991).

In a study (Anon., 1990) the rate of fruit infestation was 15.34% and 15.36% respectively in baited and bait sprayed, and was significantly lower than 36.55% in control plot of bitter gourd. Nasiruddin and Karim (1992) reported a lower rate of infestation in snake gourd (6.47%) when treated with bait spray (Dipterex + molasses) compared to control (22.48%). Steiner *et al*. (1988) reported that poison bait containing malathion and protein hydrolysate gave good result in controlling fruit flies on squash and melon.

In Hawaii, squash and melon fields were often surrounded by a few rows of corn as trap crop. Corn plant which were treated with poison bait containing malathion and protein hydrolysate attracted a large number of fruit flies to the trap plants leaving a very few for infesting squash or melon (Van den Boech and Messenger, 1973). Lall and Singh (1969), in tests of bait traps, the catches of flies were highest with mixtures of either citronella oil, dried mango juice, palm juice and diazinon or sugar, palm juice and diazinon. The increase in yield of melon using poison bait technique has also been reported by Stonehouse *et al.,* (2002).

2.10.2 Management of pheromone trap

Pheromones are a class of semio-chemicals that insects and other animals release to communicate with other individuals of the same species. The key to these entire behavioral chemical is that they leave from the body of the first organism, pass through the air (or water) and reach the second organism, where they are detected by the receiver. In insects, these pheromones are detected by the antennae. Since pheromone is naturally occurring biological products, they are environmentally safe, non target organisms are not affected, insect are less likely to develop resistance and moreover they are effective at incredibly low concentrations. Sex pheromones have been utilized in the insect pest control program through population monitoring survey, mass-trapping, mating disruption and killing the target pest in the trap (Bottrell, 1979).

Cuelure, named after the formidable melon fly *Bactrocera cucurbitae*, is a synthetic chemical compound that mimics female melon fly sex pheromones. With cuelure, damage caused by fruit flies went down 70%, and farmers have been making a profit. In Bangladesh the adoption of sex pheromone traps by Syngenta Bangladesh Ltd. has been paralled by the govt. of Bangladesh's adoption of the concept of IPM (Integrated Pest management) whereby the more toxic pesticides are replaced by sustainable and environmentally benign mean of pest and disease control.

Research Support Program (IPM CRSP) conducted field experiments which indicate that bait trapping for fruit fly control in cucurbits with a synthetic pheromone called Cuelure and mashed sweet gourd (MSG) is highly effective. Fruit fly infestation was reduced by 53 to 73 percent and yields were raised 1.4 to 2.3 times using the traps (IPM CRSP Annual Highlights, 2002-2003).

The sex attractant cue-lure traps are more effective than the food attractant tephritlure traps for monitoring the *B. cucurbitae* in bitter gourd (Pawar *et al.,* 1991). Methyl eugenol and cue-lure traps have been reported to attract *B. cucurbitae* males from mid-July to mid-November (Zaman, 1995; Liu and Lin, 1993; Ramsamy *et al.,* 1987). A leaf extract of *Ocimum sanctum*, which contain eugenol (53.4%), beta- caryophyllene (31.7%) and beta-elemene (6.2%) as the major volatiles, when placed on cotton pads (0.3 mg) attract flies from a distance of 0.8 km (Roomi *et al*., 1993). Cue-lure traps have been used for monitoring and mass trapping of the melon fruit flies in bitter gourd (Permalloo *et al*., 1998; Seewooruthun *et al*., 1998; Pawar *et al*.**,** 1991). A number of commercially produced attractants (Flycide® with 85% cue-lure content; Eugelure® 20%; Eugelure® 8%; Cue-lure® 85% + naled; Cue-lure® 85% +diazinon; Cue-lure® 95% + naled) are available on the market, and have been found to be effective in controlling this pest (Iwaizumi *et al*., 1991). Chowdhury *et al*. (1993) captured 2.36 to 4.57 flies/ trap/ day in poison bait traps containing trichlorfon in bitter gourd. The use of male lure cearlure B1® (Ethylcis-5-Iodo-trans-2- methylcyclohexane-1-carboxylate) have been found to be 4-9 times more potent than trimedlure® for attracting medfly, *Ceratitis capitata* males (Mau *et al*., 2003), and thus could be tried for male annihilation strategies of melon fruit fly area wide control programs. Jaiswal *et al.* (1997) reported that in Nepal integrated control with pheromone traps, field sanitation and bagging of individual fruits proved very effective against *Bactrocera cucurbitae*.

Males of numerous *Bactrocera* and *Dacus* species are known to be highly attracted to either methyl eugenol or cuelure (Metcalf and Metcalf, 1992). In fact, at least 90 per cent species are strongly attracted to either of these attractants (Hardy, 1979). Pheromone traps are important sampling means for early detection and monitoring of the fruit flies that have become an integrated component of integrated pest management. According to Metcalf *et al.* (1983), *B. cucurbitae* was extremely responsive to cuelure, but nonresponsive to methyl eugenol, A study carried out by Wong *et al.* (1991) on age related response of laboratory and wild adults of melon fly, *B. cucurbitae* to cuelure revealed that response of males increased with increase in age and corresponded with sexual maturity for each strain.

According to Vargas *et al.* (2000) methyl eugenol and cuelure were highly attractive kairomone lures to oriental fruit fly, *B. dorsalis* and melon fly, *B. cucurbitae,* respectively.

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

The most predominant fruit fly species was *B. dorsalis* (48%) followed by *B. cucurbitae* (21%), *B. correcta* (16%) and *B. zonata* (15%). Thomas *et al.* (2005) evaluated two parapheromones viz., cuelure and methyl eugenol for their attraction to *B. cucurbitae* in a bitter gourd field and revealed that melon flies were attracted to only cuelure traps. Singh *et al.* (2007) tested sex attractant methyl eugenol, cuelure and food attractant protein hydrolysate for attraction to fruit flies and reported that five fly species viz., *B. zonata, B. affinis* (Hardy), *B. dorsalis, B. correcta and B. diversa* (Coquillett) were attracted to methyl eugenol traps and two species viz., *B. cucurbitae* and *B. nigrotibialis* (Perkins) to cuelure traps and two species namely, *B. cucurbitae* and *B. zonata* to protein hydrolysate traps.

Vargas *et al.* (2009) evaluated various traps with methyl eugenol and cuelure for capturing fruit flies and observed that *B. dorsalis* was captured in methyl eugenol traps and *B. cucurbitae* in cuelure traps. Rakshit *et al.* (2011) assessed the economic benefits of managing fruit flies infecting sweet gourd using pheromones. In this study, a pheromone called Cuelure imported by the Bangladesh Agricultural Research Council (BARC) was used for suppressing fruit fly infesting sweet gourd. Analysis of the potential benefits of farmers adopting the Cuelure technology projects

benefits over 15 years range from 187 million Taka or $2.7 million to 428 million Taka or $6.3 million, depending on assumptions. The projected rate of return on the BARI investment in pheromone research ranges from to 140 to 165 per cent. The size of these returns implies that pheromone research at BARI has a high economic return and that Bangladesh benefits significantly as Cuelure becomes more widely available to farmers.

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

Hossen (2012) reported that the highest performance was achieved from Pheromone trap with funnel + Bait trap where Pheromone trap with funnel showed the second highest performance in terms of healthy, infested and total fruit yield by controlling cucurbit fruit fly and control treatment showed the lowest performance along with the treatment of T1 (Only pheromone trap).

2.10.3 Management of neem oil

Botanical insecticides are plant derivatives which have insecticidal properties against pest. Neem oil is used as botanical in the experiment. Neem oil is a naturally occurring pesticide found in seeds from the neem tree (*Azadirachta indica*). It is the most important of the commercially available products of neem for organic farming and medicines. It has been used for hundreds of years to control pests and diseases. Neem oil is a mixture of components. It is composed mainly of triglycerides and contains many triterpenoid compounds, which are responsible for the bitter taste. It is hydrophobic in nature and in order to emulsify it in water for application purposes, it must be formulated with appropriate surfactants. Neembecidine is such an insecticide derived from seed kernel mixed with other preservatives. Besides this fresh neem seed kernel could be used for this purpose. Neem derivatives have been demonstrated as repellents, antifeedants, growth inhibitors and chemosterilant (Butterworth and Morgan, 1968; Leuschner, 1972; Steets, 1976). Singh and Srivastava (1985) found that alcohol extract of neem oil, *Azadirachta indica* (5%) reduced oviposition of *B. cucurbitae* on bittergourd completely and its 20% concentration was highly effective to inhibit oviposition of *B. zonata* on guava.

Azadirachtin is the most active component for repelling and killing pests and can be extracted from neem oil. It reduces insect feeding and acts as a repellent. It also interferes with insect hormone systems, making it harder for insects to grow and lay eggs. Azadirachtin can also repel and reduce the feeding of nematodes. Stark *et al.* (1990) studied the effect of Azadirachtinon metamorphosis, longevity and reproduction of *Ceratitis capitata, B. cucurbitae and B. dorsalis*. Khalid (2009) found that in laboratory test, both neem oil and neem seed water extract at 10,000 ppm adversely affected the settling of cucurbit fruit fly.

2.10.4 Management of covering fruits with polythene bag

Sometimes each and every fruit is covered by polythene bag bag to block the contact of flies with the fruit thereby protecting from oviposition by the fruit fly and it is quite useful when the flies are within the reach and the number of fruits to be covered and less and it is a tedious taskfor big commercial orchards Kapoor (1993).Bagging of the fruits against *Bactrocera cucurbitac* greatly promoted fruit quality and the yields and net income increased by *45* and 56% respectively in ash gourd and 40 and 45% in sponge gourd (Nathan 2006). Amin (1995) obtained significantly lowest fruit fly infestation (4.61%) in bagged cucumber compared to other chemical and botanical control measures. Covering of fruits by polythene bag is an effective method to control fruit fly in teasel gourd and the lowest fruit fly incidence in teasel gourd occurred in bagging. Fruits (4.2%) while the highest (39.35) was recorded in the fruits of control plot

CHAPTER III

MATERIALS AND METHODS

The present study was conducted to evaluate the integrated management of cucubit fruit fly on ash gourd at the experimental field of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during February, 2018 to June, 2018.

3.1 Location of the study: The experiments were conducted in the experimental field under the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka.

3.2 Season of the study: The study was conducted during Kharif I season (February 2018-June 2018).

3.3 Characteristics of soil: The soil of the experimental area was silty loam belonging to the Non-Calcareous Dark grey Floodplain soils under the Agro Ecological Zone 12. The selected site was a well drained medium high land.

3.4 Materials used: The Ash gourd BARI ChalKumra-1 was cultivated in the field during Kharif-I for combating cucurbit fruit fly using different management practices.

3.5 Design of experiment: The experiment was laid out in Randomized Completely Block Design (RCBD) with Four replications. Total 24 plots were made for conducting the experiments. The whole experimental plot was 20 m long and 15 m broad, which was divided into 4 equal blocks. Each of the 4 equal blocks has 6 plots assigned for 6 treatments. The size of a unit plot was 2.5 m long and 1.5 m broad. Distance of 0.75 m between blocks and 0.5 m between the plots was kept to facilitate different intercultural operations.

3.6 Replication: Each treatment of the experiment was replicated with Four times in the field of ash gourd.

3.7 Land Preparation : The land was ploughed with a power tiller and kept open to sunlight. The land was then cross-ploughed several times with a power tiller to obtain good tilth. All ploughing operations were followed by laddering for breaking up the clods and leveling the surface of soil. The weeds and stubbles were removed from the field during land preparation. Finally, the unit plots were prepared as 10 cm raised beds along with basal doses of Urea 1 kg, TSP 1 kg, MoP 1 kg, Cowdung 5 kg, Potash, other micronutrients were applied as recommended by Rashid, 2006, during land preparation. The experimental field was divided into four blocks maintaining 1m block to block distance and each block were subdivided into 6 plots for treatment and the field was divided into 24 plots. There was 6 pits per plot. Pit to pit distance was 1.25 m.

3.8 Treatments : The cucurbit fruit fly will be controlled using following management practices:

Treatment	Items	Dose/Rate
T_1	Pheromone trap	1 pheromone trap per plot replaced at 1 month interval
T_2	Poison bait trap	2 g Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval
T_3	Banana pulp trap	1 ml malathion 57EC + 100gm mashed banana pulp; @ 4days interval
T_4	Neem oil	3 ml neem oil + 10 ml trix + 1L Water @ 7days interval
T_5	Covering fruit with polythene bag	1 poly bag per fruit @4 days interval
T_6	Untreated control	No treatment was used

3.9 Collection of seed and seedling raising: The seeds of ash gourd (BARI Chal Kumra-1) was collected from Horticulture Research Centre (HRC) of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The seeds were sown in the organic matter containing polybags.

Plate 4: Seedling raising in polybag

3.10 Transplanting of seedling: The one month old seedlings grown in the polybags were transplanted in the sub plots of the main field.

Plate 5. Seedling transplanting

3.11 Intercultural operation: The watering and other intercultural operations were done for each of the seedlings transplanted in the field and a bamboo stick was used for each of the seedlings for supporting the seedlings.

3.12 Treatment application: Various treatments as mentioned earlier were applied to the respective sub-plot of the ash gourd in the main field. The first application of the treatment was started just one week after the transplanting of the seedlings in the main field and continued up to one week before the harvest of the fruits.

3.13 Management with trap

3.13.1 Management with pheromone trap

Sex pheromone trap designed by BARI with cue-lure and soapy water, were used to conduct this experiment. The traps were hung up under bamboo scaffold, 50 cm above the ground. The soap water was replaced by new soap water at an interval of 4 days each. At each four days interval the number of insects trapped was recorded. In case of trapping, number of trapped fruit flies was counted. Total fruit and infested fruits were recorded and percentage of infested fruit was calculated.

Plate 6. Pheromone trap hanging in the field

Plate 7. Trapped fruit flies in pheromone trap

3.13.2 Management with poison bait trap

The poison bait trap was consisted of 2g Sevin 85 SP (carbaryl), mixed with l00 g of mashed sweet gourd and 10 ml molasses. The bait was kept in a small plastic pot placed

Plate 8: Poison bait trap hanging in the field

within a two splitted bamboo sticks, 60 cm above the ground. The number of adult fruit flies (male and female) trapped in those bait traps were recorded at each four days interval in the morning. The old bait materials were changed at the interval of 4 days each and fresh ones were placed there for further use.

3.13.3 Management with Banana pulp trap

The banana pulp trap was consisted of 1ml malathion 57 EC, mixed with l00 g of mashed banana pulp. The bait was kept in a small plastic pot placed within a two splitted bamboo sticks, 60 cm above the ground.

Plate 9: Banana pulp trap hanging in the field

The number of adult fruit flies (male and female) trapped in those bait traps were recorded at each four days interval in the morning. The old bait materials were changed at the interval of 4 days each and fresh ones were placed there for further use.

3.13.4 Management with botanical insecticide Spraying of neem oil

Neem oil (*Azadirachta indica*) was used as botanical insecticide in fruit fly management experiment. Neem oil was collected from the local market Siddique Bazar, Dhaka. The required spray volume was prepared by mixing 75 ml neem oil (3%), 1 ml Trix (liquid detergent as mixing agent) with 2 litres of water. The detergent was used to break the surface tension of water and to help the solubility of neem oil in water. This preparation might have repelling and antifeeding actions against fruit fly. The mixture was sprayed at each 7 days interval in the selected plots.

3.13.5 Untreated control

The randomly selected 4 plots were kept untreated, where no treatment was applied.

3.14 Data collection: The collection of data was started at flower initiation of the cucurbit and collected from the fields at 7 days interval on following parameters:

Total number of fruits: For the estimation of total number of fruits per plot, fruits were randomly selected and counted from each plot, at each time of data collection.

Number of infested fruits: For the estimation of number of infested fruits per plot, fruits were randomly selected and counted from each plot, at each time of data collection.

Weight of infested fruits: For the estimation of weight of infested fruits per plot, fruits were randomly selected and weight recorded, from each plot, at each time of data collection.

Total weight of fruits: For the estimation of total weight of fruits per plot, fruits were randomly selected and weight was recorded, from each plot, at each time of data collection.

Weight of edible portion of the infested fruits: For the estimation of weight of edible portion of the infested fruits per plot, the infested fruits were collected and weight of edible portion were recorded.

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

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

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

Yield of fruits: For the estimation of yield per plot total fruits were collected and weight recorded, from each plot, at each time of data collection.

Data on economic analysis: The data were also recorded on cost of cultivation, cost of management practices and market price of fruit (Tk/kg).

3.15 Calculation of data: Percent of fruit infestation by number and weight will be calculated using the following formula:

$$\% \text{ Fruit infestation} = \frac{\text{Number of the infested fruit}}{\text{Total number of fruit}} \times 100$$

$$\% \text{ Reduction over control} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, X_1 = the mean value of the treated plot X_2 = the mean value of the untreated plot

3.16 Economic analysis of the treatment: Economic analysis in terms of benefit cost ratio (BCR) was analyzed on the basis of total expenditure of the respective management practices along with the total return from that particular treatment. In this study BCR was calculated for a hectare of land.

3.16.1 Treatment wise management cost/variable cost: This cost was calculated by adding all costs incurred for labours and inputs for each management treatment including untreated control during the entire cropping season. The plot yield (kg/plot) of each treatment was converted into ton/ha yield.

3.16.2 Gross Return (GR): The yield in terms of money that was measured by multiplying the total yield by the unit price of ash gourd (Tk 20/kg).

3.16.3 Net Return (NR) = The Net Return was calculated by subtracting treatment wise management cost from gross return.

3.16.4 Adjusted Net Return (ANR): The ANR was determined by subtracting the net return for a particular management treatment from the net return with control plot. Finally, BCR for each management treatment was calculated by using the following formula:

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

3.17 Data analysis: All the collected data was analyzed following the analysis of variance (ANOVA) technique with the help of MSTAT-C Computer Package and the mean differences was adjusted by Tukey's HSD Test technique.

CHAPTER IV
RESULTS AND DISCUSSION

This chapter comprises the presentation and explanation of the results obtained from the experiment on the incidence of cucurbit fruit fly in ash gourd and their management. The data have been presented and discussed and possible interpretations are made under the following sub-headings:

4.1 Effect of different integrated pest management practices on the number of healthy fruit

The effect of management practices on the number of healthy fruit has been shown in Table 1. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest number of healthy fruit per plot (14.50) was recorded in T_5 followed by T_1 (12.75 fruits/plot), T_2 (11.00 fruits/Plot), T_4 (9.75 fruits/ plot), T_3 (8.oo fruits/Plot). On the other hand, the lowest number of healthy fruit per plot (6.00) was recorded in T_6, which was statistically different from all other treatments.

Considering the number of healthy fruit, the highest percent increase of number of healthy fruit over control was observed 141.66% in T_5 followed by T_1 (112.5%), T_2 (83.33%), T_4 (62.50%).Whereas the lowest percent increase of number of healthy fruit over control was observed in T_3 (33.33%).

Table 1. Effect of different integrated pest management practices on the number of healthy fruit

Treatment	Number of healthy fruit per plot (kg)	% increase over control
T_1	12.750 b	112.5
T_2	11.000 c	83.33
T_3	8.000 e	33.33
T_4	9.750 d	62.50
T_5	14.500 a	141.66
T_6	6.000 f	-
$LSD_{0.05}$	0.99	
CV (%)	4.21	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at 4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

From the above findings it was revealed that the highest number of healthy fruit (14.50) was recorded in T_5 using covering with polythene in the field, where the highest number of healthy fruit increasing over control was 141.66%. As a result, the order of efficacy of management practices in terms of number of healthy fruit increasing is

$T_5 > T_1 > T_2 > T_4 > T_3$.

4.2 Effect of different integrated pest management practices on the number of infested fruit

The effect of management practices on the number of infested fruit has been shown in Table 2. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest number of infested fruit per plot (8.0) was recorded in T_6 followed by T_3 (6.50 fruits/plot), T_4 (5.25 fruits/Plot), T_2 (4.50 fruits/ plot), T_1 (3.50 fruits/Plot). On the other hand, the lowest number of healthy fruit per plot (0.50) was recorded in T_5, which was statistically different from all other treatments.

Considering the number of infested fruit, the highest percent decrease of number of infested fruit over control was observed 93.75% in T_5 followed by T_1 (56.25%), T2 (43.75%), T_4 (34.38%).Whereas the lowest percent decrease of number of healthy fruit over control was observed in T_3 (18.75%).

Table 2. Effect of different integrated pest management practices on the number of infested fruit

Treatment	Number of Infested fruit per plot	% Reduction over control
T_1	3.5000 b	56.25
T_2	4.5000 c	43.75
T_3	6.5000 e	18.75
T_4	5.2500 d	34.38
T_5	0.5000 a	93.75
T_6	8.0000 f	-
$LSD_{0.05}$	1.08	
CV (%)	9.95	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at

4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit @ 4 days interval , T_6=Untreated control]

From the above findings it was revealed that the lowest number of infested fruit (0.50) was recorded in T_5 using covering with polythene in the field, where the highest reduction of fruit infestation over control was 93.75%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction is $T_5>T_1>T_2>T_4>T_3$.

4.3 Effect of different integrated pest management practices on the total healthy fruit weight per plot

The effect of management practices on the total healthy fruit weight per plot has been shown in Table 3. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest number of healthy fruit weight per plot (24.40) was recorded in T_5 followed by T_1 (21.25fruits/plot), T_2 (18.30fruits/Plot), T_4 (16.02fruits/ plot), T_3 (12.79fruits/Plot). On the other hand, the lowest number of healthy fruit per plot (10.65) was recorded in T_6, which was statistically different from all other treatments.

Considering the number of healthy fruit, the highest percent increase of number of healthy fruit weight over control was observed 129.17% in T_5 followed by T_1 (101.49%), T_2 (71.88%), T_4 (50.46%).Whereas the lowest percent increase of number of healthy fruit over control was observed in T_3 (20.16%).

Table 3 . Effect of different integrated pest management practices on the total healthy fruit weight per plot

Treatment	Total healthy fruit weight per plot (kg)	% increase over control
T_1	21.453 b	101.49
T_2	18.300 c	71.88
T_3	12.793 d	20.16
T_4	16.020 c	50.46
T_5	24.400 a	129.17
T_6	10.647 d	-
$LSD_{0.05}$	2.43	
CV (%)	6.13	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at 4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

From the above findings it was revealed that the highest number of the total healthy fruit weight (24.40) was recorded in T_5 using covering with polythene in the field, where the highest increase of healthy fruit weight over control was 129.17%. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_5>T_1>T_2>T_4>T_3$.

4.4 Effect of different integrated pest management practices on infested fruit weight per plot

The effect of management practices on infested fruit weight per plot has been shown in Table 4. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest number of infested fruit weight per plot (7.69) was recorded in T_6 which is statistically similar with T_3(6.53 fruit/ plot), followed by T_4 (5.36 fruits/plot), T_2 (4.52 fruits/Plot), T_1 (3.66 fruits/ plot). On the other hand, the lowest number of infested fruit weight per plot (0.40) was recorded in T_5, which was statistically different from all other treatments.

Considering the number of infested fruit weight, the highest percent decrease of number of healthy fruit over control was observed 94.80% in T_5 followed by T_1 (52.36%), T2 (41.27%), T_4 (30.26%).Whereas the lowest percent decrease of number of healthy fruit over control was observed in T_3 (15.08%).

Table 4 . Effect of different integrated pest management practices on Infested fruit weight per plot

Treatment	Infested fruit weight per plot (kg)	% decrease over control
T_1	3.6650 d	52.36
T_2	4.5175 cd	41.27
T_3	6.5325 ab	15.08
T_4	5.3650 bc	30.26
T_5	0.4000 e	94.80
T_6	7.6925 a	-
$LSD_{0.05}$	1.47	
CV (%)	13.65	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at 4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

From the above findings it was revealed that the lowest number of the infested fruit weight (0.40) was recorded in T_5 using covering with polythene in the field, where the highest increase of infested fruit weight over control was 94.80%. As a result, the order of efficacy of management practices in terms of infested fruit weight per plot is $T_5 > T_1 > T_2 > T_4 > T_3$.

4.5 Effect of different integrated pest management practices on the single fruit weight

The effect of management practices on the single fruit weight per plot has been shown in Table 5. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest single fruit weight per plot (1.75) was recorded in T_5 which is statistically similar with T_1(1.70 kg/ fruit), T_2(1.66 kg/fruit), T_3(1.52kg/fruit), T_4(1.62kg/fruit). On the other hand, the lowest number of healthy fruit per plot (1.17kg/fruit) was recorded in T_6, which was statistically different from all other treatments.

Considering the number of healthy fruit, the highest percent increase of single fruit weight over control was observed 49.46% in T_5 followed by T_1 (45.61%), T2 (42.18%), T4 (38.76%).Whereas the lowest percent increase of single fruit weight over control was observed in T_3 (30.62%).

Table 5 . Effect of different integrated pest management practices on the single fruit weight

Treatment	single fruit weight (kg)	% increase over control
T_1	1.7000 ab	45.61
T_2	1.6600 ab	42.18
T_3	1.5250 b	30.62
T_4	1.6200 ab	38.76
T_5	1.7450 a	49.46
T_6	1.1675 c	-
$LSD_{0.05}$	0.21	
CV (%)	5.87	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at 4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

From the above findings it was revealed that the highest weight of single fruit (1.74) was recorded in T_5 using covering with polythene in the field, where the highest weight of single fruit over control was 49.46%. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_5 > T_1 > T_2 > T_4 > T_3$.

4.6 Effect of different integrated pest management practices on length of single fruit

The effect of management practices on length of single fruit per plot has been shown in Table 6. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest length of single fruit (31.82cm/fruit) was recorded in T_5 followed by T_1 (29.87cm/fruit), T_3 (28.47cm/fruit), T_4 (28.05cm/fruit), T_2 (27.95cm/fruit). On the other hand, the lowest length of single fruit (18.22cm/fruit) was recorded in T_6, which was statistically different from all other treatments.

Considering the lenth of single fruit, the highest percent increase of length of single fruit over control was observed 74.62% in T5 followed by T1 (63.92%), T3 (56.24%), T4 (53.90%).Whereas the lowest percent increase of length of single fruit over control was observed in T2 (53.36%).

Table 6 . Effect of different integrated pest management practices on length of single fruit

Treatment	Length of single fruit (cm)	% increase over control
T_1	29.875 b	63.92
T_2	27.950 c	53.36
T_3	28.475 bc	56.24
T_4	28.050 c	53.90
T_5	31.825 a	74.62
T_6	18.225 d	-
$LSD_{0.05}$	1.76	
CV (%)	2.79	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at

4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

From the above findings it was revealed that the highest length of single fruit (31.82) was recorded in T_5 using covering with polythene in the field, where the highest length of single fruit over control was 74.62%. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_5 > T_1 > T_3 > T_4 > T_2$.

4.7 Effect of different integrated pest management practices on girth of single fruit

The effect of management practices on girth of single fruit per plot has been shown in Table 7. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest girth of single fruit (35.87cm/fruit) was recorded in T_5 which is statistically similar with T_1(35.27cm/fruit) followed by T_2 (34.67cm/fruit), T_4 (34.25cm/fruit), T_3 (33.82cm/fruit). On the other hand, the lowest girth of single fruit (32.52cm/fruit) was recorded in T_6, which was statistically different from all other treatments.

Considering the girth of single fruit, the highest percent increase of girth of single fruit over control was observed 10.30% in T_5 followed by T_1 (8.46%), T_2 (6.61%), T_4 (5.30%).Whereas the lowest percent increase of girth of single fruit over control was observed in T_2 (6.61%).

Table 7 . Effect of different integrated pest management practices on girth of single fruit

Treatment	Girth of single fruit (cm)	% increase over control
T_1	35.275 ab	8.46
T_2	34.675 bc	6.61
T_3	33.825 d	3.99
T_4	34.250 cd	5.30
T_5	35.875 a	10.30
T_6	32.525 e	-
$LSD_{0.05}$	0.81	
CV (%)	1.02	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at 4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

From the above findings it was revealed that the highest girth of single fruit (35.87cm/fruit) was recorded in T_5 using covering with polythene in the field, where the highest girth of single fruit over control was 10.30%. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is

$T_5 > T_1 > T_2 > T_4 > T_3$.

4.8 Effect of different integrated pest management practices on the number of fruit per plant

The effect of management practices on the number of fruit per pant has been shown in Table 8. Significant variations were observed among the treatments in terms of fruit fly on ash gourd. The highest number of fruit per plant (7.75fruit/plant) was recorded in T_5 which is statistically similar with T_1(7.50fruit/plant), T_4(7.50fruit/plant), T_3(7.25fruit/plant), T_5(7.25fruit/plant), T_6(7.25fruit/plant).

Considering the number of fruit per plant , the highest percent increase of fruit per plant over control was observed 6.90% in T_5 followed by T_1 (3.45%), T_4 (3.45%).Whereas the lowest percent increase of fruit per plant over control was observed in T_3 (0%).

Table 8. Effect of different integrated pest management practices on the number of fruit per plant

Treatment	**Number of fruit per plant**	**% increase over control**
T_1	7.5000 a	3.45
T_2	7.7500 a	6.90
T_3	7.2500 a	0
T_4	7.5000 a	3.45
T_5	7.2500 a	0
T_6	7.2500 a	-
$LSD_{0.05}$	1.21	
CV (%)	7.11	

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Tukey's HSD Test]

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at 4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

From the above findings it was revealed that the highest number of fruit per plant (7.75 fruit/plant) was recorded in T_2 using poison bait trap in the field, where the highest number of fruit per plant over control was 6.90%. As a result, the order
of efficacy of management practices in terms of the total healthy fruit weight is $T_2>T_1=T_4>T_3=T_5$.

4.9 Adult fruit fly captured in pheromone traps, poison baits & banana pulp traps

The efficacy of pheromone trap as compared with poison bait & banana pulp trap in terms of capturing number of adult fruit flies had been assessed in this study. The data as depicted in the Figure 1 represented that more or less higher number of adult fruit flies had been captured in poison bait trap among pheromone trap & banana pulp trap throughout the cropping season of ash gourd. From the comparative study it was observed that the average number of adult fruit flies captured in poison bait trap ranged from 24.5 to 42.65 fruit flies/trap, whereas the average number of adult fruit flies captured in pheromone traps ranged from 18.45 to 34.65 fruit flies/trap and the average number of adult fruit flies captured in banana pulp trap ranged from 6.36 to 16.87 fruit flies/trap. Considering the overall average fruit fly captured, the number of adult fruit flies captured was much higher (34.46 fruit flies/trap) in poison bait trap among that of pheromone trap (26.05 fruit flies/trap) & banana pulp trap (10.87 fruit flies/trap).

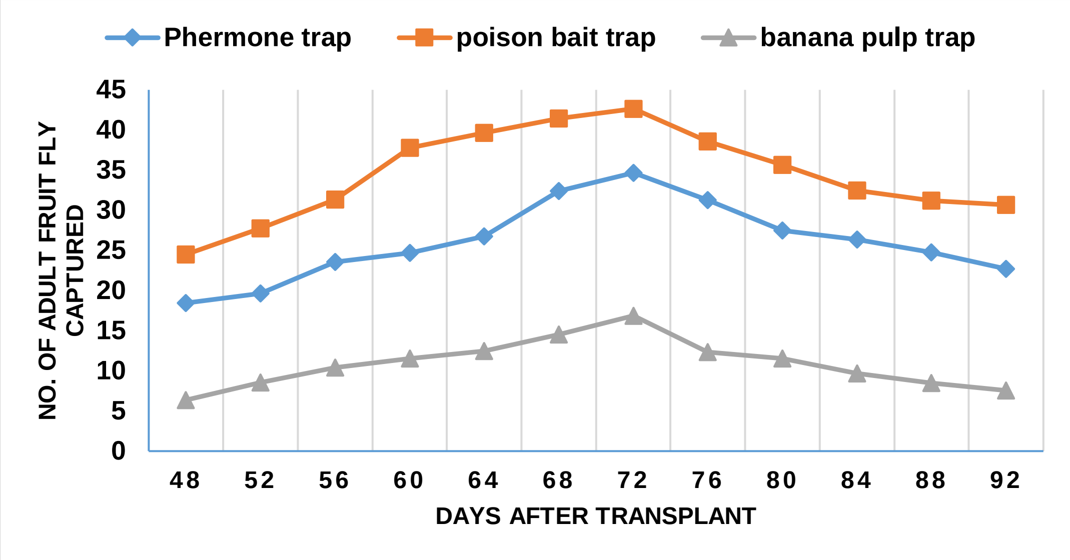

Figure 1 Number of adult fruit fly captured in pheromone trap, poison bait trap and banana pulp trap

4.10 Reasons for variations of number of fruit fly captured in poison bait trap

In case of poison bait trap, the less number (24..5) of adult fruit fly captured per trap was observed at 48 DAT and from 52 DAT to onward data recording time, but higher number of fruit fly captured at 72 DAT. Now the question arises what were the reasons for lower number of adult fruit flies captured in those data recording times as compared with other data recording times In depth analysis was done to find out the above mentioned reasons for variations of adult fruit fly capture in poison bait traps. On the other hand, the temperature variation throughout the data recording time was ranged from 26ºC to 34.5ºC, of which the highest temperature (34.5ºC) was recorded at 48 DAT and lowest temperature (26ºC) was recorded at 72 DAT (Figure 2). This highest temperature might be responsible for drying up of the materials kept in poison bait traps. That's why the less number of adult fruit flies was captured in poison bait trap at 48 DAT, but this highest temperature did not affect the number of fruit fly captured in pheromone trap. On the other hand, the lower temperature at 72 DAT might be responsible for higher number of adult fruit flies per trap due to presence of more suitable temperature for fruit flies.

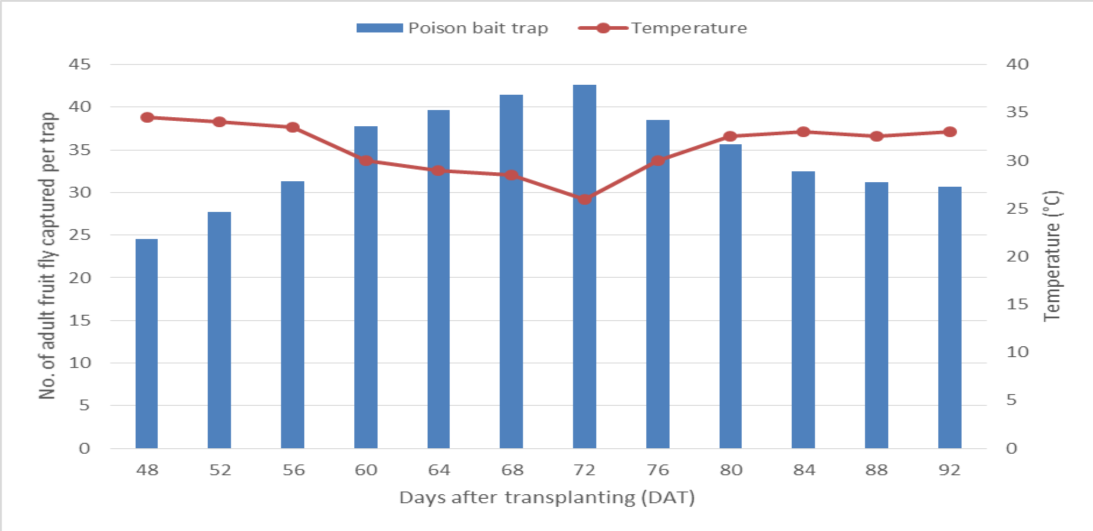

Figure 2 Relationship between number of adult fruit fly captured in poison bait trap & temperature

From the above findings it was revealed that poison bait trap was more effective than pheromone trap & banana pulp trap in terms of capturing adult fruit fly throughout the cropping season, where in case of poison bait trap the average number of adult fruit flies captured per trap was 34.47 and in case of pheromone Trap this number was 26.0 fruit flies per trap. The higher temperature (34.5°C) negatively affected the capturing of adult fruit fly for poison bait trap because of drying up of bait materials, but not affected on the adult capturing capacity of pheromone trap.

4.11 Economic analysis of different management practices applied against cucurbit fruit fly infesting ash gourd

Economic analysis of different management practices applied against cucurbit fruit fly infestation on ash gourd presented in Table 9. The untreated control (T_6) did not incur any pest management cost. The labor costs were involved in T_1, T_2, T_3, T_4, T_5 for applying treatments in the experimental plots (Appendix III). From the economic analysis, it was revealed that the highest benefit cost ratio (BCR) (42.24) was calculated in T_5 (covering fruit with polythene), where the total adjusted net return was counted as benefit. This was followed (34.62) by T_2 (Poison bait trap) and 32.19 in T_1 (Pheromone trap). The minimum BCR (19.23) was calculated in T_3 (Banana pulp trap @1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval)

Table-9: Economic analysis of different integrated management practices applied against cucurbit fruit fly in ash gourd during Kharif I, 2018 at Dhaka

Treatmens	Cost of Management (Tk.)	Yield (kg/ha)	Gross return (Tk.)	Net Return (Tk.)	Adjusted net return (Tk.)	BCR
T_1	6640.00	20350	407000	400360	213760	32.19
T_2	6328.00	20600	412000	405672	219072	34.62
T_3	4380.00	13760	275200	270820	84220	19.23
T_4	6250.00	17120	342400	336150	149550	23.93
T_5	6845.00	24130	482600	475755	289155	42.24
T_6	0.00	9330	186600	186600	0	-

Here, T_1= Setting up of pheromone trap replaced at 1 month interval, T_2= Setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd replaced at 4 days interval, T_3= Setting up of Banana pulp trap@1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval, T_4= Spraying of neem oil @ 3 ml neem oil mixed with 1 liter of water @ 7 days interval, T_5=Covering fruit with polythene @ 1polythene bag per fruit, T_6=Untreated control]

Wholesale price of ash gourd at that time, 1 Kg = 20 Tk.

CHAPTER V
SUMMARY AND CONCLUSIONS

Integrated management of cucurbit fruit fly on ash gourd was investigated at the field laboratory of the Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from February, 2018 to June, 2018. The treatments were T_1 comprised of setting up of pheromone trap replaced at 1 month interval, T_2 comprised of setting up of poison bait trap @ 2 g Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_3 comprised of banana pulp trap@1 ml malathion 57EC with 100gm mashed banana pulp at 4days interval, T_4 comprised of spraying of neem oil @ 3 ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5 comprised of covering fruit with polythene bag @ 1 poly bag per fruit at 4 days interval, T_6 comprised of untreated control. Data on fruit infestation by number and weight and yield contributing characters and yield were recorded including benefit cost ratio (BCR) of different management practices applied against fruit fly on ash gourd.

Considering the effect of different management practices in reducing the level of infestation by fruit fly on ash gourd. Considering the number of healthy fruit, the lowest percent increase of number of healthy fruit (33.33%)by number was recorded in T_3 using the banana pulp trap in the field, Whereas the highest percent increase of number of healthy fruit over control (141.66%) by number was recorded in T5 using covering fruit with polythene bag. As a result, the order of efficacy of management practices in terms of number of healthy fruit increasing is $T_5>T_1>T_2>T_4>T_3$. Considering the number of infested fruit, the highest percent decrease of number of infested fruit (93.75%)by number was recorded in T5 using covering fruit with polythene bag. Whereas the lowest percent decrease of number of infested fruit (18.75%) by number was recorded in T_3 using banana pulp trap. As a result, the order of efficacy of management practices in terms of fruit infestation reduction is $T_5>T_1>T_2>T_4>T_3$. Considering the number of healthy fruit of ash gourd, the highest percent increase of number of healthy fruit weight over control was observed 129.17% in T_5 using covering fruit with polythene bag.Whereas the lowest percent increase of number of healthy fruit over control was observed in T_3 (20.16%) using banana pulp trap. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_5>T_1>T_2>T_4>T_3$. Considering the number of infested fruit weight of ash gourd, the highest percent decrease of number of healthy fruit (94.80%) by number was recoreded in T5 using covering fruit with polythene bag.Whereas the lowest percent decrease of number of healthy fruit over control (15.08%) in T_3 using banana pulp trap. As a result, the order of efficacy of management practices in terms of infested fruit weight per plot is $T_5>T_1>T_2>T_4>T_3$.

Considering the number of healthy fruit, the highest percent increase of single fruit weight over control (49.46%) in T_5 using covering fruit with polythene bag. Whereas the lowest percent increase of single fruit weight over control was observed (30.62%) in T_3 using banana pulp trap. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_5>T_1>T_2>T_4>T_3$.

Considering the length of single fruit, the highest percent increase of length of single fruit over control was observed 74.62% in T_5 using covering fruit with polythene bag. Whereas the lowest percent increase of length of single fruit over control was observed (53.36%) in T_3 using banana pulp trap. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_5>T_1>T_2>T_4>T_3$.

Considering the girth of single fruit, the highest percent increase of girth of single fruit over control was observed 10.30% in T_5 using covering fruit with polythene bag. Whereas the lowest percent increase of girth of single fruit over control was observed (6.61%) in T_2 using poison bait trap. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_5>T_1>T_3>T_4>T_2$.

Considering the number of fruit per plant of ash gourd, the highest percent increase of fruit per plant over control 6.90% in T5 using covering fruit with polythene bag. Whereas the lowest percent increase of fruit per plant over control was observed (0%) in T_3 using banana pulp trap. As a result, the order of efficacy of management practices in terms of the total healthy fruit weight is $T_2>T_1=T_4>T_3=T_5$.

Considering the overall average fruit fly captured, the highest number of adult fruit flies captured was (34.46 fruit flies/trap) in poison bait trap. Whereas the lowest number of fruit flies captured was (10.87 fruit flies/trap) in banana pulp trap. The higher temperature (34.5^{o}C) negatively affected the capturing of adult fruit fly for poison bait trap because of drying up of bait materials, but not affected on the adult capturing capacity of pheromone trap.

The highest benefit cost ratio (BCR) (42.24) was calculated in T_5 (Covering with polythene bag), where the total adjusted net return was counted as benefit. This was followed (34.62) by T_2 (Poison bait). The minimum BCR (19.23) was calculated in T_3 (Banana pulp trap @1 ml malathion 57EC mixed with 100 g mashed Banana pulp at 4days interval).

CONCLUSIONS

From the present study, it may be concluded that incidence of cucurbit fruit fly and infestation of ash gourd by cucurbit fruit fly was significantly varied among the treatments. The overall study expressed that the highest performance was achieved from covering fruit with polythene bag (T_5). Highest production (141.66%) of healthy fruit over control was achieved by covering fruit with polythene bag (T_5). Highest infestation (93.75%) reduction of fruit over control was achieved by covering fruit with polythene bag (T_5). Highest total healthy fruit weight per plot (129.17), highest decrease of infested fruit weight per plot(94.80), increase of single fruit weight (49.46%), length (74.62%) & girth(10.30%) over control was achieved by covering fruit with polythene bag (T_5). Poison bait trap is more effective for capturing adult fruit fly (34.46 adults/trap/4 days) than Pheromone trap (26.05 adults/ trap/4 days). Highest BCR (42.24) was also achieved by Covering fruit with polythene bag (T_5). Pheromone trap (T_1) and poison bait trap (T_2) also showed similar performance in terms of number of fruit per plant, weight of single fruit, edible portion of infested fruit, length of fruit, girth of fruit and yield. It also reduced fruit infestation. Considering the results of the present study, it can be concluded that covering fruit with polythene bag (T_5) and Pheromone trap (T_1) may be used for the management of fruit fly attacking cucurbitaceous vegetables.

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

i) To minimize the use of chemical insecticides in cucurbit fruit fly control programmes, Covering fruit with polythene bag play a significant role. It should be adopted in large scale production of chemical free cucurbitaceous vegetables.

ii) Further study of this experiment is needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI
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Appendix I

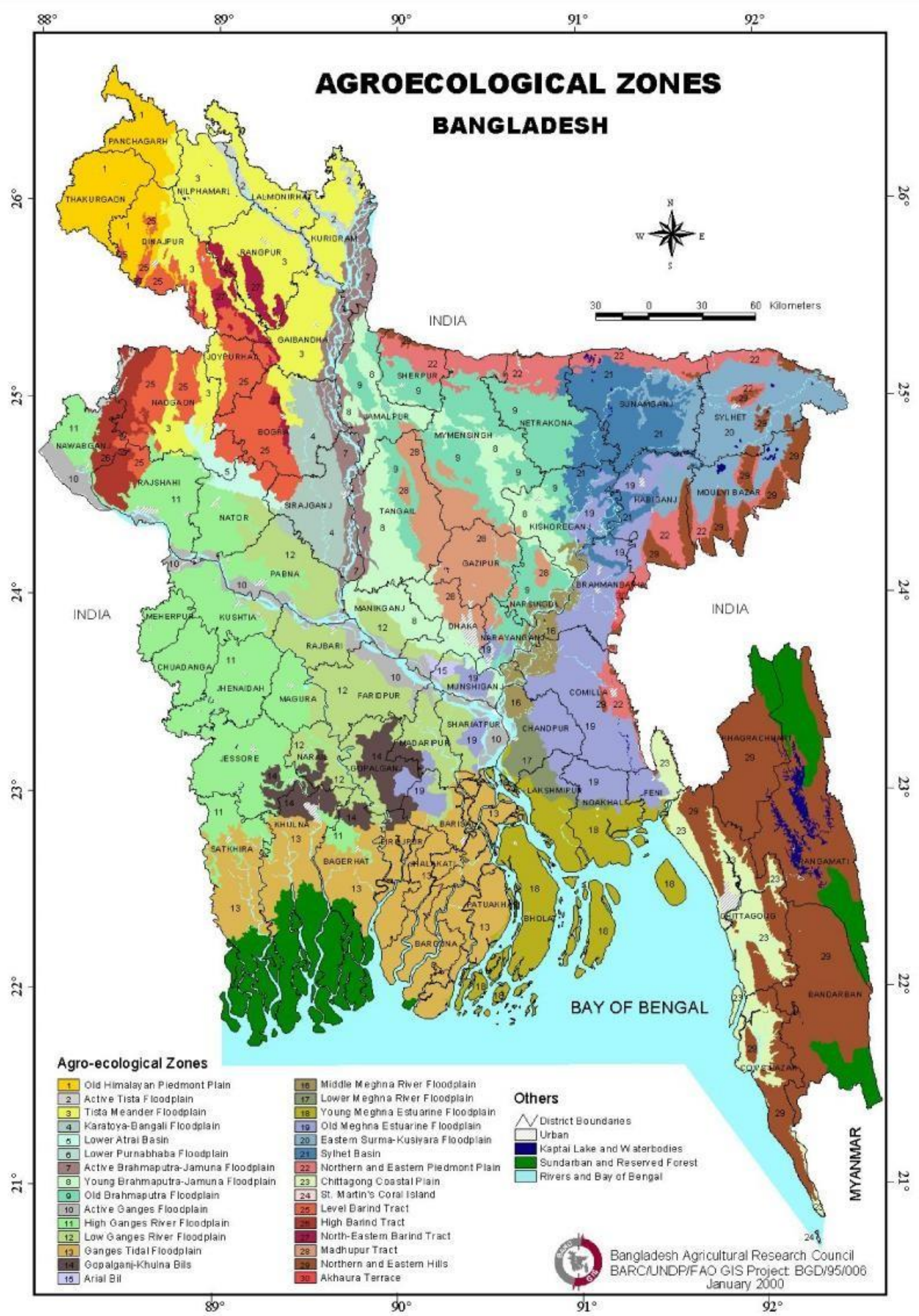
Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from February 2018 to June 2018.

Date/Week	**Temperature (°C)**		**Relative humidity (%)**	**Rainfall (mm) (Total)**
	Maximum	**Minimum**		
February	32	25	64	28.8
March	36	27	63	64.8
April	34	26	70	154.3
May	37	27	75	337.4
June	36	29	80	338.4

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207.

Appendix II

Experimental location on the map of Agro-ecological Zones of Bangladesh.



Source: Bangladesh Agricultural Research Council, Khamarbari, Dhaka.

Appendix III

Cost incurred per hectare in different control measures applied against cucurbit fruit fly on ash gourd during Kharif I, 2018 at SAU Dhaka

[a] = Labor cost 500.00 Tk/day; [b] = Pheromone trap set 40.00 Tk/set; [c] = Lure 25 Tk/lure; [d] = Sevin (85 SP) 100 gm = 120 Tk.; [e] = Banana=200 Tk.; [f] =

Treatment	Items of expenditure	Cost (Tk)
T_1=Pheromone trap(Cue-lure + soap; @ 4 days interval	Total no. of labors for giving treatment 1x500[a] Pheromone trap set (for 4 replications) x 40[b] Lure (for 4 replications) x 25[c] Wheel powder **Total cost**	6000.00 320.00 200.00 120.00 **6640.00**
T_2=Poison bait trap(2 gm Sevin 85 WP + 100 gm Mashed Sweet Gourd + 8 ml Molasses; @ 4 days interval	Total no. of labors for giving treatment 1x500[a] Earthen pot Sweet gourd Molasses Sevin 85 SP (for 4 replications) x1[d] **Total cost**	6000.00 180.00 110.00 30.00 8.00 **6328.00**
T_3=Banana pulp trap (1 ml malathion 57EC + 100gm mashed banana pulp;@ 4days interval)	Total no. of labors for giving treatment 1x500[a] Earthen pot Banana Malathion 57 Ec (for 4 replications) x1[f] **Total cost**	4000.00 180.00 200.00 8 **4380.00**
T_4=Neem oil (3 ml + 1 L Water @ 7 days interval	Total no. of labors for spraying insecticide 1x500[a] Neem oil Trix **Total cost**	4000.00 450.00 1800.00 6250.00
T_5= Covering with polythene bag (1 poly bag per fruit @4 days interval)	Total no. of labors for giving treatment 1x500[a] Polythene bag **Total cost**	4000.00 70.00 **4070.00**
T_6 (Untreated control)	No management cost at all	00.00

Malathion (57 EC) 100 ml = 90 Tk.