EFFICACY OF DIFFERENT ECOFRIENDLY MANAGEMENT PRACTICES IN CONTROLLING CUCURBIT FRUIT FLY ON BITTER GOURD

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JUNE, 2018

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BY

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REGISTRATION NO. : 11-04412

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

MASTER OF SCIENCE (MS)

IN

ENTOMOLOGY

SEMESTER: JANUARY-JUNE, 2018

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CERTIFICATE

This is to certify that the thesis entitled **'EFFICACY OF DIFFERENT ECOFRIENDLY MANAGEMENT PRACTICES IN CONTROLLING CUCURBIT FRUIT FLY ON BITTER GOURD'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Entomology,** embodies the result of a piece of bonafide research work carried out by **Md. Asif Iqbal, Registration number: 11-04412** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2018
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ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, the great, the gracious, merciful and supreme ruler of the universe to complete the research work and thesis successfully for the degree of Master of Science (MS) in Entomology.

The author expresses the deepest sense of gratitude, sincere appreciation and heartfelt indebtedness to his reverend research supervisor **Prof**. **Dr. Md. Mizanur Rahman**, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, innovative suggestions, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.

Special thanks to his co-supervisor **Prof. Dr. Mohammed Sakhawat Hossain**, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his assistance and help during works and continued encouragement.

The author expresses his sincere respect to **Prof**. **Dr. S.M. Mizanur Rahman,** Chairman, Examination Committee, Department of Entomology and all the teachers of the Sher-e-Bangla Agricultural University, Dhaka who provided the facilities to conduct the experiment.

Cordial thanks to all the staff of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, for their sincere help and co-operation during the whole study period.

Mere diction is not enough to express my profound gratitude and deepest appreciation to my younger brother Tousif and friends Hera, Jony for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate me to this level.

The Author

June, 2018

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ABSTRACT

The present study was conducted in the experimental field of Sher-e-Bangla Agricultural University to find out the efficient as well as risk free management practice(s) of cucurbit fruit fly infesting bitter gourd cultivated during Kharif I season (March 2017 to June 2017). There were five treatments. These were as follows T_1 = Spinosad, T_2 = Neem oil, T_3 = Poison bait trap, T_4 = Black seed oil, T_5 = Untreated control. The treatments :T_1 comprised of Spraying of spinosad @ .08 ml liter^{-1} of water at 7 days interval , T_2 comprised of Spraying of neem oil @ 3ml and 10 ml Trix mixed with 1 liter of water 7 days interval, T_3 comprised of setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses and replaced at 4 days interval, T_4 comprised of black seed oil @ 5 ml with 10 ml Trix mixed with 1 liter of water applied at 7 days interval, T_5 comprised of Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Poison bait trap (T_3) produced the highest number of fruit at early (27.23 fruit/plot), mid (38.89 fruit/plot) and late (28.00 fruit/plot) fruiting stages; and reduced the maximum fruit infestation over control at early (93.66%), mid (91.63%) and late (85.44%) fruiting stage. Percent fruit infestation by weight at early (10.95%), mid (9.04%) and late (18.76%) and reduced maximum fruit infestation over control at early (83.79%), mid (81.27%) and late (78.65%) was also obtained in T_3 treated plot. The highest yield (24.03 t/ha) was recorded in T_3 which provided the highest yield (163%) over control. The highest benefit cost ratio (43.20) was also found from T_3 treated plot and the lowest BCR (14.91) obtained from T_5 treated plot. Considering the social acceptance and environmental safely point of view, T_3 poison bait trap was the most effective management practices in reducing the fruit fly infestation and thereby increasing the yield of bitter gourd.

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CHAPTER I

INTRODUCTION

Cucurbits are the popular name of the family Cucurbitaceae, commonly known as the gourd family. Cucurbits are the major groups among vegetables grown in Bangladesh (Nasiruddin *et al.*, 2004).Vegetables are cultivated in 885127 acre of land and annual production of vegetables is only 2726723 metric tons (MT). Among those, cucurbitaceous vegetables occupy about 66% of the lands under vegetables cultivation and contribute15.25% of total vegetables production (BBS, 2013). In 2012-2013 cropping year, 52020 metric tons bitter gourd was produced in Bangladesh (BBS, 2013).Bitter gourd (*Momordica charantia*) is a young, tender, cooked husk of climbing vines. In many Asian countries including Bangladesh, it is one of the popular edible vegetable. It contains just 17 calories per 100 g. The plant has medicinal properties and a compound known as 'Charantin' present in the bitter gourd is used to reduce blood sugar of diabetic patient (Dhillon et al., 2005a). Bitter gourd is also enriched with Carbohydrates. It is also rich in Iron, Vitamin A, Vitamin B, and Vitamin C (Gopalan *et al.,* 1982). It can be cultivated round the year but mainly cultivated in the Kharif season. Bangladesh Agricultural Research Institute (BARI) has released "BARI Karala -1" which is high yielding. Bangladesh Agricultural Development Corporation (BADC) has released bitter gourd variety "Gaj Karala". Besides these, Lal Teer Seed Company has released bitter gourd variety Tia, Parrot and Taj. The agro-ecological condition of Bangladesh is mostly favorable for the cultivation of cucurbit vegetables. The constraints to sustainable increased of production of cucurbit vegetables are many. High incidence of insect pests, and poor management practices are one of the main causes. The extent of damage varies from year to year, season to season and locality to locality depending on the seasonal abundance of the pests affected by the influence of prevailing abiotic and biotic factors and impact of control measures adopted (Anon., 2001). Fruit fly is one of the most serious pests of cucurbits in Bangladesh (Alam, 1969; Akhtaruzzaman *et al*., 1999; 2000).

Fruit fly, *Bactrocera cucurbitae* Coquillet, is a major pest causing yield loss in bitter gourd grown in Bangladesh. Fruit flies reduce yield as well as the quality of fruit (IPM CRSP, 2004). Yield losses vary from 19.19 to 69.96 percent in different fruits and vegetables due to fruit fly infestation (Kabir *et al.*1991). Particularly small farmers suffer a lot, as they are unable to afford enough protection measures. Losses without control have been estimated as 21% of fruits and 24% of cucurbits in Pakistan (Stonehouse *et al.*, 1998). The female fly drums on the skins of young fruits by her oviposit or and sometimes on the young leaves or stems of the host plants and makes punctures for laying eggs. Afterward, fruit juice oozes out which transforms in to resinous brown deposit. After hatching in the fruit, the larvae feed into pulpy tissue and make tunnels in fruits and cause direct damage. Traditionally farmers use chemical insecticides. But most of the cases, it is not possible to control because the larvae live inside there. Farmers use toxic chemicals without considering economic injury level (EIL) of the pest. Therefore, the judicious use of pesticides along with bio-pesticides is important in the management of pest resistance to pesticides, conservation of beneficial insects, minimizing the environmental hazards, improving the safety condition of workers in the field, and overall reducing the farm input costs. In view of the above analysis, the present research was conducted by using some eco-friendly management practices along with a bio pesticide for suppressing cucurbit fruit fly infesting bitter gourd.

The objectives are:

i. To assess the level of infestation of cucurbit fruit fly on bitter gourd

ii. To evaluate the different management practices along with a bio-pesticide and find out the most efficient eco-friendly management practices for suppressing cucurbit fruit fly on bitter gourd and calculate cost benefit ratio (BCR)

CHAPTER II

REVIEW OF LITERATURE

Cucurbit fruit fly *Bactrocera cucurbitae* (Coquillett), is one of the most important pests of cucurbits, particularly bitter gourd (*Momordica charantia*) is highly prone to damage by this pest in Bangladesh. Because of the difficulties associated with the control of this pest by chemical insecticides, farmers had to face a great losses in cucurbits. The literatures on the ecofriendly management utilizing several non-hazardous components to combat this pest are very sporadic. For the purpose of this study, the most relevant information's are given below under the following sub-headings:

2.1Systemic position of cucurbit fruit fly (Plate 1&2)

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 cucurbita*

Plate 1. Adult Male Cucurbit Fruit Fly

Plate 2. Adult Female Cucurbit Fruit Fly

2.3 Origin and distribution

Anon (1987) reviewed that fruit fly is considered to be the native of oriental, probably India and South East Asia and it was first discovered in the Yacyama Island of Japan in 1919. However, the fruit fly is widely distributed in India, Bangladesh, Pakistan, Myanmar, Nepal, Malaysia, China, Philippines, Formosa (Taiwan), Japan, Indonesia, East Africa, Australia and Hawaiian Island (Atwal, 1993; Alam, 1965). It is also a solemn pest in Mediterranean region (Andrewartha and Birch, 1960). Although, this pest is widely distributed, but it does not occur in the UK, central Europe and continental USA (McKinlay *et al.*,1992). Fruit fly was mainly reported from Hawaii and now widely distributed throughout the oriental region including China, Japan, much of the pacific including New Guinea, Soloman and Bismark Islands, Australia, Mauritius, East Africa, Kenya and Tanzania. Fruit flies are distributed almost everywhere in the world and infest a large number of host plants (Kapoor, 1993). The distribution of an individual species is limited perhaps due to physical, climatic and gross vegetation factors, but mostly for host specificity. Such species may become widely distributed when their host plants are widespread, either naturally or cultivation by man (Kapoor, 1993). Gapud (1993) has cited references of five species of fruit fly in Bangladesh e.g., *B. brevistylus* (melon fruit fly), *Bactrocera caudatus* (fruit fly) (strumeta), *B. cucurbitae* (melon fly), *B. dorsalis* Hendel (mango fruit fly) and *B. zonatus* (zonata fruit fly). Akhtaruzzaman (1999) reviwed that *Bactrocera cucurbitae, Bactrocera tau* and *ciliates* have been currently identified in Bangladesh of which *Bactrocera ciliatus* is a new record. *Bactrocera cucurbitae* is dominant in all the locations of Bangladesh followed by *Bactrocera tau* and *Bactrocera cilialus.*

2.4 Biology and life cycle

The melon fruit fly remains operative all the year round on one or the other host. They hide and huddle all together under dried leaves of bushes and trees during winter, in the time of hot and dry season, the flies take shelter under humid and bowery places and feed on honeydew of aphids infesting the fruit trees. They 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. Fruit flies have to go four development stages; eggs, larvae (three larval instars), pupae and adults. The life cycle from egg to adult takes between 14 and 27 days. The duration of each stage and degree of survival depends on species host plant and environmental conditions (Shaw *et al*., 1967). Adult fruit flies have to go through a diet based on secretion of plants from leaves, fruits and rotting fruits but also nectar, pollen, bird feces, and honeydew secreted by other insects (Christenson and Foote, 1960).

Eggs:

The eggs of the melon fly are slender, white and measure 1/12 inch in length. Eggs are compacted into fruit in bunches of 1 to 37. They hatch in 2 to 4 days. 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). Favorable condition is when the temperature falls below 32.2° C and the relative humidity ranges between 60 to 70%. The egg incubation period on pumpkin, bitter gourd, and squash gourd has been reported to be 4.0 to 4.2 days at 27 ± 1° C (Doharey, 1983), 1.1 to 1.8 days on bitter gourd, cucumber and sponge gourd (Gupta and Verma, 1995), and 1.0 to 5.1 days on bitter gourd (Koul and Bhagat, 1994; Hollingsworth *et al*., 1997).

Larvae:

The larval period lasts from 6 to 11 days and every stage lasting 2 or more days. Duration of larval development is sharply affected by host. The larval period lasts for 3 to 21 days (Renjhan, 1949; Narayanan and Batra, 1960; Hollingsworth *et al*., 1997), depending on temperature and the host. On different cucurbit species, the larval period varies from 3 to 6 days (Gupta and Verma, 1995; Koul and Bhagat, 1994; Doharey, 1983; Chelliah, 1970; Chawla, 1966).

Larval feeding damage in fruits is the most damaging (Wadud *et al.*, 2005). Mature assault fruits develop a water soaked appearance (Calcagno *et al*., 2002). Young fruits become perverted and usually exude. 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. 53 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).

Pupa:

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

Adults:

The adults survive for 27.5, 30.71 and 30.66 days at 27 ± 1° C on pumpkin, squash gourd and bitter gourd, respectively (Doharey, 1983). Khan *et al.*, (1993) reported that the males and females survived for 65 to 249 days and 27.5 to 133.5 days respectively. The 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. *B. 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 Seasonal abundance of fruit fly

Sujit (2005) cited that 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 noticed to be active in the field almost throughout the year where the weather is proportionate (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 slothful below 10°C. Cucurbit fruit flies normally increases when the temperature goes below 15°C and relative humidity varies from 60-70 % (Alam, 1966). The peak population of fruit fly in India is acquired during July and August in rainy months and January and

February in cold months (Nair, 1986). The adults of melon fly, *B. 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.

2.6 Host Range

Many fruit fly species causes serious damage to vegetables, oil-seeds, fruits and ornamental plants. More than 100 plant species have been recorded as hosts of melon fly worldwide, it commonly infests the cucurbitaceous (melon, squash and gourds) and Solanaceous (tomatoes and peppers) crops (Pandey *et al.,* 2008). Allwood *et al*., 1999 cited that Melon fruit fly damages over 81 plant species. Based on the extensive surveys carried out in Asia and Hawaii, plants belonging to the family Cucurbitaceae are preferred most (Batra,1953) listed as many as 70 hosts of fruit fly species, whereas, Christenson and Foote (1960) reported more than 80 kinds of vegetables and fruits as the hosts. Lawrence (1950) recorded that cucurbit vegetables are the most suitable host of *B. cucurbitae.* Batra (1968) observed that the male flowers and flowers bud of sweet gourd were found as usual host with anthers being the special food for the larvae and only occasionally small sweet gourd fruits attacking through the female flower. Kapoor (1993) reported that more than one hundred vegetables and fruits are attacked by *Bactrocera sp.* Atwal (1993) and McKinlay *et al.* (1992) reported that cucurbits as well as 70-100 non-cucurbitaceous vegetables and fruits are the host of fruit fly. Ten cucurbit vegetables as the host of fruit fly (Alam, 1962).Tomato, green pepper, papaya, cauliflower, mango, guava, citrus, pear, fig and peaches are also infested by fruit fly (Atwal, 1993 and Anon., 1987). Sixteen species of plants act as the host of fruit flies among which sweet gourd was the most preferred host for both *B. cucurbitae* and *B.tau.* Among flowers, the rate of infestation was greater in sweet gourd but the intensity was higher in bottle gourd (Kabir *et al*., 1991). The males pollinate the flowers and acquire the floral essence and store it in the pheromone glands to attractnon-specific females (Hong and Nishida, 2000). Doharey (1983) reported that it infests over 70 host plants, among which fruit of bittergourd (*Momordica charantia*), musk melon (*Cucumis melo*), snap melon (*Cucumismelo* var. *momordica*) and snake gourd (*Trichosanthes anguina* and *T. cucumeria*) are the most preferred hosts. Many species of fruit fly attack a wide variety of fruit and vegetables such as mango, guava, plum, peach, pear, fig, apple, quince, persimmon, banana, pomegranate, jujube, sweet lime, orange, chilies, jack fruit, carambola, papaya, avocado, bread fruit, coffee, berries, passion fruit, star apple, Spanish pepper, cucurbits etc (Narayanan and Batra, 1960). White and Elson-Harris (1994) reviewed that many of the host records might be emerged on casual observations of adults resting on plants or caught in traps set in non-host plant species. In the Hawaiian Islands, melon fruit fly has been observed feeding on the flowers of the sunflower, Chinese bananas and the juice exuding from sweet corn. Under induced oviposition, McBride and Tanda (1949) cited that broccoli (*Brassica oleracea* var. *capitata*), dry onion (*Allium cepa*), blue field banana (*Musa paradisiaca* sp. *sapientum*), .tangerine (*Citrus reticulata*) and longan (*Euphoria longan*) are doubtful hosts of *B.cucurbitae*. The melon fly has a mutually beneficial association with the orchid, *Bulbophyllum paten, which* produces zingerone. Thirteen cucurbit crops were overcast for their resistance to the fruit fly (*B.cucurbitae*) during the summer and rainy seasons of 2001 and 2002, in Varanasi, Uttar Pradesh, India. None of the cucurbits were found free from pest attack during both seasons. However, great differences were recorded in the degree of infestation among cucurbits. Healthy bitter gourd (Plate 3) Damage during the summer season of 2001 and 2002 was maximum in bitter gourd (26.11 and 31.96%) (Plate 4) and minimum in pumpkin (2.78and 1.39%). Similarly, damage during the rainy season of 2001 and 2002 was maximum in bitter gourd (46.8 and 45.3%) (Plate 4,5,6) and minimum in pumpkin (7.4 and11.1%). Bitter gourd, followed by bottle gourd, was the most preferred host of *B.cucurbitae* (Nath and Bhushan, 2006).

2.7 Nature of damage of fruit fly

Nature of infestation of fruit fly varies with the kinds of fruits (Janjua 1948). Shah *et al.* (1948) and York (1992) reviewed that the formation of brown resinous deposits on fruits as the symptom of infestation. Fruit flies damage fruits by puncturing and laying eggs inside 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 eradicated (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 (Plate 7) emerge from the injured fruit and drop to the ground and pupate in a burrow (4-8 cm) prepared by the pre pupa. Infested fruits often drop to the ground prematurely. According to Praveen *et al*., 2012 reviewed inside the damage fruits small white color larvae are present. The larvae hatches and feed into pulp tissue and make tunnels in fruits that is direct damage. Indirect damage is that the fruits by contaminating with grass and accelerate rotting of fruit by pathogenic infection. If it is not rotten, become deformed and hardy which make it improper for human consumption. The infested flower becomes juicier and drops from the stalk at a slight jerk (Kabir *et al*., 1991). Some flies make mines and a few form galls on different parts of the plants (Kapoor, 1993). Singh (1985) cited 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. Weems and Heppner, 2001 cited that the egg laid into unopened flowers, and the larvae successfully enter in the tap roots, stems, and leaf stalks The vinegar fly, *Drosophillam lanogaster* has also been observed to lay eggs on the fruits infested by melon fly, and acts as a scavenger (Dhillon *et al.*, 2005c).

Plate 3. Healthy bitter gourd

Plate 4. Fruit fly infested bitter gourd

Plate 5. Inside condition of fruit fly infested bitter gourd

Plate 6. Fruit fly larvae inside the bitter gourd

Plate 7. Fruit fly larvae

2.8 Rate of infestation and yield loss by fruit fly

The loss of cucurbits caused by fruit fly in South East Asia might be up to 50% (York, 1992). Kabir *et al*. (1991) reviewed that yield losses due to fly infestation varies in fruits and vegetables and it is minimum in cucumber (19.19%) and maximum in sweet gourd (69.96%). The damage caused by cucurbit fruit fly is the most serious in melon after the first shower in monsoon when it often reaches up to 100%. Other cucurbit might also be infested and the infestation might be gone up to 50% (Atwal, 1993). Shah *et al.* (1948) reported that the damage done by fruit flies in North West Frontier Province (Pakistan) cost an annual loss of over $ 655738. (Gupta, 1992) investigated the rate of infestation of *B. cucurbitae* and *B. tau* on cucurbit in India during 1986-87 and recorded that 80% infestation on cucumber and bottle gourd in July-August and 50% infestation on bitter gourd, 50% infestation on sponge gourd in August-September. Lee (1972) observed that the rate of infestation in bottle gourd and sweet gourd flowers were 42.2 ± 8.6% and 77.1 ± 3.5%, respectively. The highest occurring in sweet gourd (32.5±3.9) and the lowest in sponge gourd (14.7 4.0).

Borah and Dutta (1997) studied the infestation of tephritids on the cucurbits in Assam, India and obtained the highest fruit fly infestation rate in snake gourd (62.02%). Larger proportion of marketable fruits was obtained from ash gourd in and bottle gourd in summer season. Snake gourd and pumpkin yielded the lowest proportion of marketable fruits. According to the reports of Bangladesh Agricultural Research Institute, fruit infestations were 22.48, 41.88 and 67.01% for snake gourd, bitter gourd, and musk melon, respectively (Anon, 1988). Kabir *et al*. (1991) cited that yield losses due to fruit infestation varies in different fruits and vegetables and it is minimum in cucumber (19.19%) and maximum in sweet gourd (69.96%). In cucumber, Amin (1995) observed 42.08 % fruit infestation while, Uddin (1996) reported 45.14% infestation. The infested fruits become rotten, dry up and finally shed up prematurely (Gupta and Verma, 1992). Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89% (Rabindranath and Pillai, 1986; Gupta and Verma, 1978). Borah and Dutta (1997) studied the infestation of Tephritids on the cucurbits in Assam, India and obtained the highest fruit fly infestation rate in snake gourd (62.02%). Larger proportion of marketable fruits was obtained from ash gourd in Kharif and bottle gourd in summer season. Snake gourd and pumpkin yielded the lowest proportion of marketable fruits. The field experiment on assessment of yield losses caused by cucurbit fruit fly in different cucurbits have been reported as 28.7-59.2, 24.7-40.0, 27.3-49.3, 19.4-22.1 and 0-26.2% in pumpkin, bitter gourd, bottle gourd, cucumber and sponge gourd, respectively, in Nepal (Pradhan, 1976).

2.9 Fruit fly infestation

Agarwal *et al*. (1987) reported that 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. The ovipositor is drawn out of the fruit for oviposition and they 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. (Narayanan and Batra, 1960).

2.10 Management of fruit fly

Cucurbit fruit fly is the major pest causes considerable economic damage of bitter 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 inside 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 Spinosad

Sparks *et al.* (2001) cited that Spinosad is a natural compound with insecticidal activity that has many properties considered to be highly desirable for insect control programs. This compound has been shown to be highly efficient on a wide range of pest species, yet at the same time appear to have limited impact on non-target organisms, including mammals, that may be exposed to it. Moreover, spinosad is readily degradable by exposure to sunlight, thus minimizing any environmental hazard that may occur as a result of widespread use. BCPC (2006) expressed that Spinosad acts as a stomach poison, although spinosad is activated by both contact and ingestion. Spinosad was originally collected from a Caribbean island in 1985 (Sparks *et al.,* 2001), and the formulation is currently the most widely used as an insecticide consists primarily of A and D forms of this compound, both of which are naturally produced by the bacterial species *Saccharopolyspora spinosa*. Insecticide compounds founded on spinosad have been extensively used as agents for control of insect pest species of the Diptera, Lepidoptera, Coleoptera, and Hymenoptera orders (Hertlein *et al*., 2010) among others. Sparks *et. al.* 2001) cited that within the Diptera, spinosad has been shown to be operative for controling Tephritid species within the *Ceratitis, Bactrocera, Rhagoletis*, and *Dacus* genera. As with any compound used in control programs, however, one concern over such widespread use is the potential for resistance to this compound to arise either in laboratory and/or natural populations. Indeed, the history of both natural and artificial compounds used for insect control is replete with examples of resistance development even where much more highly toxic compounds such as DDT or malathion have been used (C. Magana *et al.,* 2007; Georghiou, 1986). For most of the past forty years, organophosphate-(OP) compounds were the sole insecticides used to suppress this pest. Recently, due to growing environmental concerns raised over the use of OPs, alternatives such as spinosad have also been used (Vargas, 2008; Barry *et al.*, 2006). As part of a formulation known as GF-120 (Dow AgroSciences, Indianapolis, IN, USA), spinosad has been employed as part of an area-wide fruit fly pest management program (HAW-FLYPM) to control melon flies in Hawaii since 2002 (Mau, 2006; Mau, 2007), and in central Taiwan since 2007. These values were also higher than those received from similar studies looking for possible delays in response to spinosad for other species such as *B. dorsalis* (Hsu and Feng. 2006). E. G. Kakani, (2010) expressed that in terms of field applications, spinosad has been used since 2004 for control of *B. oleae* in California and in Hawaii in control of both *B. cucurbitae* and *B. dorsalis* since 2000.

2.10.2 Management with Neem oil solution spray

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*). Neem is the most important and easily available for safe fleshly farming and medicinal use. To control pests and diseases, it has been used for hundreds of years

Neem oil is a mixture of different 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). Alcohol extract of neem oil, *Azadirachta indica* (5%) reduced oviposition of *B. cucurbitae* (Singh and Srivastava, 1985) on bittergourd completely and its 20% concentration was highly effective to inhibit oviposition of *B. zonata* on guava. Azadirachtin is the most effective component for repelling and killing pests and can be extracted from neem oil. It curtail 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.The effect of Azadirachtinon on metamorphosis, longevity and reproduction of *Ceratitis capitata, B. cucurbitae and B. dorsalis*. (Stark *et al.*, 1990). Khalid (2009) found that in laboratory test that both neem oil and neem seed water extract at 10,000 ppm adversely affected the settling of cucurbit fruit fly.

2.10.3 Management with poison bait

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 as 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. 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 different. (Uddin, 2002) 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 (Samalo *et al.*, 1995). 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 suited 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 plot, and was significantly lower than 36.55% in control plot of bitter gourd. A lower rate of infestation in snake gourd (6.47%) when treated with bait spray (Dipterex + molasses) compared to control (22.48%), (Nasiruddin and Karim,1992). 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 encompassed 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 infestation on 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).

2.10.4 Management with blackseed oil

Black seed oil mixed with trix and after water was added on it. Then it was used for fruit fly control by spraying on the plant.

2.10.5 Management with untreated control

No botanicals were used here.

CHAPTER III

MATERIALS AND METHODS

The present study was conducted to evaluate the ecofriendly management of cucurbits fruit fly on bitter gourd at the experimental field of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during March, 2017 to June, 2017.

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 Characteristics of soil:

The soil of the experimental field was silty loam belonging to the Non-Calcareous Dark grey Flood plain soils under the Agro Ecological Zone 12. The selected site was a well-drained medium high land.

3.3 Season of the study:

The study was conducted during Kharif I season (March2017-June 2017).

3.4 Materials used:

The bitter gourd BARI Korola-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 three replications. Total 20 plots were made for conducting the experiments. The whole experimental plot was divided into 4 equal blocks. Each of the 5 equal blocks had 5 plots assigned for 5 treatments. The size of a unit plot was 4 m x 2 m broad. Distance of 0.75 m between blocks and 1.0 m between the plots was maintained to facilitate different intercultural operations.

3.6 Replication:

Each treatment of the experiment was replicated 4 times in the field of bitter gourd.

3.7 Treatments

Treatments	Item	Dose/Rate
T_1	Spinosad	Spraying of spinosad @.08 ml per liter of water applied at 7 days interval
T_2	Neem oil	Neem oil prepared @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water sprayed @ 7 days interval
T_3	Poison bait trap	Setting up of poison bait trap consisted of 2 gm Sevin 85 SP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval
T_4	Black seed oil	Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water applied @ 7 days interval
T_5	Untreated	No botanicals were used

3.8 Land preparation:

The land was cultivated 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 repeated 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, were applied as recommended by Rashid, 2006, during land preparation. The experimental field was divided into three blocks maintaining 1m block to block distance and each block were subdivided into 5 plots for treatment and the field was divided into 20 plots. There was 2 pits per plot. Pit to pit distance was 1.25 m.

3.9 Collection of seed and seedling raising (Plate 8):

The seeds of bitter gourd (BARI Korola-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 8. Seedling raising in poly bag

3.10 Transplanting of seedling:

The 25 days old seedlings grown in the polybags were transplanted in the sub plots of the main field (Plate 9).

Plate 9. 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 in the main field. The first application of the treatment was started just one week after the transplanting of the seedlings (14 days) in the main field and continued up to one week before the harvest of the fruits.

3.13 Management Practices

3.13.1 Management with Spinosad

Spinosad was sprayed @ 0.08 ml per liter of water. It was sprayed at the foliage of the plant at 7 days interval.

3.13.2 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. Neem oil prepared @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water sprayed @ 7 days interval .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 anti feeding actions against fruit fly. The mixture was sprayed at 7 day intervals in the selected plots

3.13.3 Management with poison bait trap

The poison bait trap was composed of 1g Sevin 85 SP (carbaryl), mixed with l00 g of mashed sweet gourd and 10 ml molasses. The bait was kept in a small earthen pot placed within a four splited bamboo sticks, 50 cm above the ground. An earthen cover plate was placed 20 cm above the bait container to protect the bait material from sun and rain (Plate 10). The number of adult fruit flies (male and female) trapped in those bait traps were recorded at each four days interval in the morning (Plate 11). The old bait materials werereplaced by fresh bait at 4 days intervals.

Plate 10. Poison bait trap set in the field

Plate 11. Trapped fruit fly in poison bait trap

3.13.4 Spraying of black seed oil

Five ml black seed oil with 10 ml Trix mixed with 1 liter of water applied 7 days interval

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 day intervals on the following parameters.

3.14.1 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.

3.14.2 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.

3.14.3 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.

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

3.14.5 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.

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

3.14.7 Weight of fruits: For the estimation of weight of 10 randomly selected fruits plot^{-1} were recorded and weight was recorded, from each plot at each time of data collection.

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

3.14.9 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:

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

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

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 labors and inputs for each management treatment including untreated control during the entire cropping season. The plot yield (kgplot^{-1}) of each treatment was converted into tonha^{-1} 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 bitter gourd (Tk 40/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

$$\text{Benefit cost ratio} = \frac{Adjust\ net\ return}{Total\ management\ cost}$$

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 Duncan's Multiple Range Test (DMRT).

CHAPTER IV

RESULT AND DISCUSSION

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

4.1 Fruit infestation by number at early fruiting stage

The effect of management practices on fruit infestation by number at early fruiting stage has been shown in Table 1. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The highest number of fruit per plot (27.23 fruits/plots) was recorded in T_3 (Poison bait trap), which statistically different from others and followed by T_2 (23.67 fruitsplot^{-1}) (Neem oil), T_1 (19.33 fruitplot^{-1}) (Spinosad) and T_4 (16.11 fruitsplot^{-1}) (Black seed oil). On the other hand, the lowest number of fruit per plot (12.00) was recorded in T_5 (Untreated control), which was statistically different from all other treatments. Accordingly, the lowest number of infested fruit per plot (1.66) was recorded in T_3, which is statistically different from others and followed by T_2 (4.39), T_1 (6.67) and T_4 (11.63) (Black seed oil). Considering the rate of infestation, the lowest fruit infestation (6.09%) by number was recorded in T_3 (Poison bait trap), which was statistically different and followed by T_2 (18.94%), T_1 (34.50%) and T_4 (53.94%). On the other hand, the highest fruit infestation by number was recorded in T_5 (96.22%).Considering the reduction of fruit infestation, the highest reduction of fruit infestation over control was observed 93.66% in T_3, followed by T_2 (80.17%), T_1 (64.10%) and T_4 (88%). Considering the reduction over control of fruit infestation, the highest reduction of fruit infestation over control was observed 93.66% in T_3 (Poison bait trap), followed by T_2 (80.17%) (Neem oil), T_1 (64.10%)(Spinosad) and T_4 (43.88%) (Black seed oil). Black seed oil)

Table 1:- Effect of management practices on fruit infestation by number at early fruiting stage

Treatment	% fruit infestation by number at early fruiting stage			
	Total no. of fruit per plot	No. of infested fruit per plot	% fruit infestation	% reduction of fruit infestation over control
T_1 (Spinosad)	19.33 c	6.67 c	34.50 c	64.10
T_2 (Neem oil)	23.67 b	4.39 d	18.54 d	80.17
T_3 (Poison bait trap)	27.23 a	1.66 e	6.09 e	93.66
T_4 (Black seed oil)	16.11 d	8.69 b	53.94 b	43.88
T_5 (Untreated control plot)	12.00 e	11.63 a	96.22 a	--
LSD(0.05)	2.93	1.63	9.93	--
CV (%)	6.58	15.02	18.62	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

From the above findings it was revealed that the lowest fruit infestation (6.09%) by number was recorded in T_3 using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 93.66%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction over control was T_3>T_2>T_1>T_4>T_5.

4.2 Fruit infestation by number at mid fruiting stage

The effect of management practices on fruit infestation by number at mid fruiting stage has been shown in Table 2. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The highest number of fruit per plot (38.89 fruits/plots) was recorded in T_3 (Poison bait trap), which statistically different from others and followed by T_2 (34.67 fruits/plot)(Neem oil),T_1 (30.63 fruits/plot)(Spinosad) and T_4 (24.87 fruits/plot) (Black seed oil). On the other hand, the lowest number of fruit per plot (20.00) was recorded in T_5, which was statistically different from all other treatments. Accordingly, the lowest number of infested fruit per plot (2.93) was recorded in T_3, which is statistically different from others and followed by T_2 (7.30), T_1 (10.85) and T_4 (14.46).Considering the level of infestation, the lowest fruit infestation (7.53 %) by number was recorded in T_3 (Poison bait trap), which was statistically different and followed by T_2 (21.05%), T_1 (35.42%) and T_4(58.14%). On the other hand, the highest fruit infestation by number was recorded in T_5 (90.05%).Considering the reduction of fruit infestation over control, the highest reduction of fruit infestation over control was observed (91.63%) in T_3, followed by T_2 (76.62%), T_1 (60.63%) and T_4 (35.43%).Whereas the lowest reduction of fruit infestation over control was observed in T_4 (43.88%).

Table 2:- Effect of management practices on fruit infestation by number at mid fruiting stage

Treatments	% fruit infestation by number at mid fruiting stage			
	Total no. of fruit per plot	No. of infested fruit per plot	% fruit infestation	% reduction of fruit infestation over control
T_1	30.63 c	10.85 c	35.42 c	60.63
T_2	34.67 b	7.30 d	21.05 d	76.62
T_3	38.89 a	2.93 e	7.53 e	91.63
T_4	24.87 d	14.46 b	58.14 b	35.43
T_5	20.00 e	18.01 a	90.05 a	--
LSD(0.05)	3.01	3.42	10.12	--
CV (%)	5.56	14.90	14.01	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

From the above findings it was revealed that the lowest fruit infestation (7.53%) by number was recorded in T3 using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 91.63%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction over control was T_3>T_2>T_1>T_4>T_5.

4.3 Fruit infestation by number at late fruiting stage

The effect of management practices on fruit infestation by number at mid fruiting stage has been shown in Table 2. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The highest number of fruit per plot (28.00 fruits/plots) was recorded in T_3 (Poison bait trap), which statistically different from others and followed by T_2 (24.52 fruits/plot) (Neem oil), T_1 (20.94 fruits/plot) (Spinosad) and T_4 (17.01 fruits/plot) (Black seed oil). On the other hand, the lowest number of fruit per plot (12.24) was recorded in T_5 (Untreated control plot), which was statistically different from all other treatments. Accordingly, the lowest number of infested fruit per plot (3.37) was recorded in T_3, which is statistically different from others and followed by T_2 (5.56), T_1 (7.89) and T_4 (7.89). T_1 and T_4 were statistically similar.

Considering the level of infestation, the lowest fruit infestation (12.03 %) by number was recorded in T_3, which was statistically different and followed by T_2 (22.55), T_1 (37.68%) and T_4 (46.38%). On the other hand, the highest fruit infestation by number was recorded in T_5 (82.67%).Considering the reduction of fruit infestation over control, the highest reduction of fruit infestation over control was observed (85.44%) in T_3, followed by T_2 (72.43%), T_1 (54.42%) and T_4 (43.9%).Whereas the lowest reduction of fruit infestation over control was observed in T_4 (43.9%). Considering the reduction of fruit infestation, the highest reduction of fruit infestation over control was observed (85.44%) in T_3, followed by T_2 (72.43%), T_1 (54.42%) and T_4 (43.9%).

Table 3: Effect of management practices on fruit infestation by number at late fruiting stage

Treatments	% fruit infestation by number at late fruiting stage			
	Total no. of fruit per plot	No. of infested fruit per plot	% fruit infestation	% reduction of fruit infestation over control
T_1	20.94 c	7.89 b	37.68 b	54.42
T_2	24.52 b	5.56 c	22.55 c	72.43
T_3	28.00 a	3.37 d	12.03 d	85.44
T_4	17.01 d	7.89 b	46.38 b	43.9
T_5	12.24 e	10.12 a	82.67 a	--
LSD(0.05)	3.42	2.12	10.49	--
CV (%)	7.65	12.46	14.56	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

From the above findings it was revealed that the lowest fruit infestation (12.03%) by number was recorded in T_3 using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 85.44%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction was $T_3>T_2>T_1>T_4>T_5$.

4.4 Fruit infestation by weight at early fruiting stage

The effect of management practices on fruit infestation by weight at early fruiting stage has been shown in Table 4. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The highest weight of fruit per (1938.7 g/ plot) plot was recorded in T_3 (Poison bait trap), that is statistically different with others and followed by T_2 (1675.00 g /plot) (Neem oil), T_1 (1525.00g/plot) (Spinosad) and T_4 (1264.00g/plot) (Black seed oil). On the other hand, the lowest weight of fruit per plot (765.00g/plot) was recorded in T_5 (Untreated control plot), which is statistically different from all other treatments. Accordingly, the lowest weight of infested fruit per plot (212.30g) was recorded in T_3, which is statistically different with others. Considering the level of infestation, the lowest fruit infestation (10.95%) by weight was recorded in T_3, which is statistically different with others followed by T_2 (17.11%), T_1 (23.11%) and T_4 (32.68%). On the other hand, the highest fruit infestation by weight was recorded inT_5 (67.58%), which was statistically different from all other treatments. Considering the reduction of fruit infestation, by weight the highest reduction of fruit infestation over control was observed 83.79% in T_3, followed by T_2 (74.38), T_1 (65.71%) and T_4 (51.64 %).

Table 4:- Effect of management practices on fruit infestation by weight at early fruiting stage

Treatments	% fruit infestation by weight at early fruiting stage			
	Total weight of fruit per plot (gm)	Total weight of infested fruit per plot (gm)	% fruit infestation	% reduction of fruit infestation over control
T_1	1525.0 c	352.5 c	23.11 c	65.71
T_2	1675.2 b	290.13 d	17.31 d	74.38
T_3	1938.7 a	212.3 e	10.95 e	83.79
T_4	1264.0 d	413.13 b	32.68 b	51.64
T_5	765.0 e	517.00 a	67.58 a	--
LSD(0.05)	191.62	55.27	5.89	--
CV (%)	5.89	11.93	8.01	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

From the above findings it was revealed that the lowest fruit infestation (10.95%) by weight was recorded in T_3, using the poison bait trap in the field, where the highest reduction of fruit infestation by weight over control was 83.79 %. As a result, the order of efficacy of management practices in terms of fruit infestation reduction over control was $T_3>T_2>T_1>T_4>T_5$

4.5 Fruit infestation by weight at mid fruiting stage

The effect of management practices on fruit infestation by weight at early fruiting stage has been shown in Table 5. Significant variations were observed among the treatments in respect of fruit fly infestation on bitter gourd. The highest weight of fruit per (1938.7 g/ plot) plot was recorded in T_3 (Poison bait trap), that is statistically different with others and followed by T_2 (1675.00 g /plot) (Neem oil), T_1 (1525.00g/plot) (Spinosad) and T_4 (1264.00g/plot) (Black seed oil). On the other hand, the lowest weight of fruit per plot (765.00g/plot) was recorded in T_5 (Untreated control plot), which is statistically different from all other treatments. Accordingly, the lowest weight of infested fruit per plot (212.30g) was recorded in T_3, which was statistically different from others. Considering the level of infestation, the lowest fruit infestation (10.95%) by weight was recorded in T_3, which is statistically different from others followed by T_2 (17.11%), T_1 (23.11%) and T_4 (32.68%). On the other hand, the highest fruit infestation over control by weight was recorded inT_5 (67.58%), which was statistically different from all other treatments. Considering the reduction of fruit infestation, the highest reduction of fruit infestation over control was observed 83.79% in T_3, followed by T_2 (74.38), T_1 (65.71%) andT_4 (51.64 %).

Table 5:- Effect of management practices on fruit infestation by weight at mid fruiting stage

Treatments	% fruit infestation by weight at mid fruiting stage			
	Total weight of fruit per plot (gm)	Total weight of infested fruit per plot (gm)	% fruit infestation	% reduction of fruit infestation over control
T_1	3338.0 c	757.70 c	22.75 c	71.77
T_2	3772.0 b	569.17 d	15.08 d	81.27
T_3	4136.0 a	374.00 e	9.04 e	88.78
T_4	2891.0 d	943.41 b	32.63 b	59.51
T_5	1460.0 e	1176.0 a	80.60 a	--
LSD (0.05)	377.12	175.70	4.83	--
CV (%)	5.93	12.11	7.45	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

From the above findings it was revealed that the lowest fruit infestation (9.04%) by weight was recorded in T_3, using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 88.78 %. As a result, the order of efficacy of management practices in terms of fruit infestation reduction over control was $T_3 > T_2 > T_1 > T_4 > T_5$.

4.6 Fruit infestation by weight at late fruiting stage

The effect of management practices on fruit infestation by weight at late fruiting stage has been shown in Table 6. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The highest weight of fruit per (2335.10 g/ plot) plot was recorded in T_3 (Poison bait trap), that is statistically different with others and followed by T_2 (1982.00 g /plot), T_1 (1583.89g/plot) (Spinosad) and T_4 (1326.13 g/plot) (Black seed oil). On the other hand, the lowest weight of fruit per plot (1076.00 g/plot) was recorded in T_5 (Untreated control plot), which is statistically different from all other treatments. Accordingly, the lowest weight of infested fruit per plot (438.10 g) was recorded in T_3 (Poison bait trap), which is statistically different with others. Considering the level of infestation, the lowest fruit infestation (18.76%) by weight was recorded in T_3 (Poison bait trap), which is statistically different with others followed by T_2 (27.41%), T_1 (41.51%) and T_4 (59.67%). On the other hand, the highest fruit infestation by weight was recorded in T_5 (87.90%), which was statistically different from all other treatments. Considering the reduction of fruit infestation, the highest reduction of fruit infestation over control was observed 78.65% in T_3, followed by T_2 (68.81), T_1 (52.77%) and T_4 (32.11 %).

Table 6. Effect of management practices on fruit infestation by weight at late fruiting stage

Treatments	% fruit infestation by weight at mid fruiting stage			
	Total weight of fruit per plot (gm)	Total weight of infested fruit per plot (gm)	% fruit infestation	% reduction of fruit infestation over control
T_1	1583.89 c	657.62 c	41.51 c	52.77
T_2	1982.00 b	543.36 d	27.41 d	68.81
T_3	2335.10 a	438.10 e	18.76 e	78.65
T_4	1326.13 d	791.30 b	59.67 b	32.11
T_5	1076.00 e	945.70 a	87.90 a	--
LSD(0.05)	196.76	97.26	4.79	--
CV (%)	4.87	6.18	4.93	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

From the above findings it was revealed that the lowest fruit infestation (18.76%) by weight was recorded in T3, using the poison bait trap inthe field, where the highest reduction of fruit infestation over control was (78.65%). Asa result, the order of efficacy of management practices in terms of fruit infestation reduction over control was $T_3>T_2>T_1>T_4>T_5$.

4.7 Infestation of edible portion of fruit at different fruiting stage

4.7.1 Early fruiting stage

The effect of management practices on the infestation of edible portion of fruit at early fruiting stage has been shown in Table 7. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The lowest infested edible portion of bitter gourd was recorded in T_3 (3.94) (Poison bait trap) that is statistically different with T_2 (9.01%) (Neem oil) , T_1 (16.91%)(Spinosad) , T_4 (23.80%)(Black seed oil) andT_5(69.37%).Considering the reduction of infestation on edible portion of bitter gourd, the highest reduction of edible portion infestation over control was observed 94.32% in T_3 (Poison bait trap),followed by T_2(87.01%)(Neem oil),T_1 (75.62%)(Spinosad) and T_4 (65.69%)(Black seed oil).From the above findings it was revealed that the lowest edible portion infestation of bitter gourd (3.94%) was recorded in T_3 poison bait trap in the field, where the highest reduction of edible portion infestation over control was 94.32%. As a result, the order of efficacy in terms of reducing the infestation of edible portion of fruit at early fruiting stage is $T_3>T_2>T_1>T_4$.

4.7.2 Mid fruiting stage

The effect of management practices on the infestation of edible portion of fruit at early fruiting stage has been shown in Table 7. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The lowest infested edible portion of bitter gourd was recorded in T_3 (3.96%)(Poison bait trap) that is statistically different with T_2 (10.92%)(Neem oil), T_1 (18.26%)(Spinosad), T_4 (26.2%)(Black seed oil) and T_5 (72.93%).Considering the reduction of infestation on edible portion of bitter gourd, the highest reduction of edible portion infestation over control was observed (94.57%) in T_3 (Poison bait trap),followed by T_2(85.01%)(Neem oil),T_1 (74.96%)(Spinosad) and T_4 (64.07%)(Black seed oil).From the above findings it was revealed that the lowest edible portion infestation of bitter gourd (3.96%) was recorded in T_3 poison bait trap in the field, where the highest reduction of edible portion infestation over control was 94.57%. As a result, the order of efficacy in terms of reducing the infestation of edible portion of fruit at early fruiting stage is $T_3>T_2>T_1>T_4$

4.7.3 Late fruiting stage

The effect of management practices on the infestation of edible portion of fruit at late fruiting stage has been shown in Table 7. Significant variations were observed among the treatments in terms of fruit fly infestation on bitter gourd. The lowest infested edible portion of bitter gourd was recorded in T_3 (12.36%) (Poison bait trap) that is statistically different with T_2 (17.55%) (Neem oil), T_1 (29.52%)(Spinosad), T_4 (35.60%)(Black seed oil) and T_5 (78.83%).Considering the reduction of infestation on edible portion of bitter gourd, the highest reduction of edible portion infestation over control was observed (84.32%) in T_3 (Poison bait trap) ,followed by T_2(77.83%)(Neem oil),T_1 (62.55%)(Spinosad) and T_4 (54.83%)(Black seed oil). From the above findings it was revealed that the lowest edible portion infestation of bitter gourd (123.6%) was recorded in T_3 poison bait trap in the field, where the highest reduction of edible portion infestation over control was (84.32%). As a result, the order of efficacy in terms of reducing the infestation of edible portion of fruit at early fruiting stage is$T_3>T_2>T_1>T_4$.

Table 7:- Effect of management practices on infestation of edible portion of fruit at different fruiting stage

Treatments	% fruit infestation					
	Early fruiting stage		Mid fruiting stage		Late fruiting stage	
	% infested edible portion	% reduction over control	% infested edible portion	% reduction over control	% infested edible portion	% reduction over control
T_1	16.91 c	75.62	18.26 c	74.96	29.52 c	62.55
T_2	9.01 d	87.01	10.92 b	85.01	17.55 d	77.83
T_3	3.94 e	94.32	3.96 e	94.57	12.36 e	84.32
T_4	23.80 b	65.69	26.2 d	64.07	35.60 b	54.83
T_5	69.37 a	--	72.93 a	--	78.83 a	--
LSD (0.05)	5.36	--	6.71	--	4.06	--
CV (%)	14.03	--	17.01	--	6.76	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

4.8 Effect of management practices on the yield attributes of bitter gourd

4.8.1 Single fruit weight

The effect of management practices on single fruit weight has been shown in Table 8.Significant variations were observed among the treatments in terms of single fruit weight of bitter gourd. The highest single fruit weight (106.3g) was recorded in T_3 (Poison bait trap), which is statistically different from all other treatments. That is followed by T_2 (93.67g) (Neem oil), T_1 (82.67g) (Spinosad) and T_4 (74.63 g) (Black seed oil). On the other hand, the lowest single fruit weight was recorded in (63.37g) in T_5. Considering the increase of single fruit weight, the maximum increase of single fruit weight over control (66.95%) was observed in T_3 (Poison bait trap), which was followed by T_2 (47.11%)(Neem oil) , T_1 (30.35%)(Spinosad) and T_4 (14.65%)(Black seed oil). From the above findings it was revealed that the highest single fruit weight (106.30g)was recorded in T_3 using poison bait trap in the field, where the highest increase of single fruit weight over control was 66.95%.As a result, the order of efficacy in increasing single fruit weight of bitter gourd is $T_3>T_2>T_1>T_4>T_5$.

.4.8.2 Number of fruit per plant

The effect of management practices on number of fruit per plant has been shown in Table 8. Significant variations were observed among the treatments in terms of number of fruit per plant of bitter gourd. The highest number of fruit per plant (2.41) was recorded in T_3 (Poison bait trap), that is statistically different with others followed by T_2 (2.05(Neem oil), T_1 (1.84) (Spinosad) and T_4 (1.39) (Black seed oil). On the other hand, the lowest number of fruit per plant (1.00) was found in T_5, that is statistically different from all other treatments. Considering the increase of number of fruit per plant, the maximum increase of number of fruit per plant over control (141.70%) was observed in T_3, followed by T_2 (105.00%)(Neem oil), T_1 (84.30%)(Spinosad) and T_4 (39.00%)(Black seed oil).From the above findings it was revealed that the highest number of fruit per plant(2.41) was recorded in T_3 poison bait trap in the field, where the highest increase of number of fruit per plant over control was 141.70%As a result, the order of efficacy in increasing number of fruit per plant of bitter gourd is $T_3>T_2>T_1>T_4>T_5$.

Table 8:- Effect of management practices on the yield attributes of bitter gourd

Treatments	Single fruit weight per plot (gm)	% increased over control	No. of fruit per plant	% increase d over control
T_1	82.67 c	30.35	1.84 c	84.30
T_2	93.67 b	47.11	2.05 b	105.00
T_3	106.3 a	66.95	2.41 a	141.70
T_4	74.63 d	14.65	1.39 d	39.00
T_5	63.37 e	--	1.00 e	--
LSD(0.05)	7.22	--	0.37	--
CV (%)	3.62	--	9.11	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

4.8.3 Length and girth of single healthy fruit

Length of fruit: The effect of management practices on length of healthy fruit of bitter gourd has been shown in Table 9. Significant variations were observed among the treatments in terms of length of healthy fruits. The highest length (19.99 cm) of bitter gourd was recorded in T_3 (Poison bait trap) that is statistically different with others .On the other hand the lowest length of healthy bitter gourd was recorded in T_5 (12.77cm) (Untreated control plot) .Considering the increase of fruit length, the maximum increase of bitter gourd length over control (54.54%) was observed in T_3 (Poison bait trap), which was followed by T_2 (42.68%) (Neem oil) , T_1(25.60%)(Spinosad) and T_4 (11.35) (Black seed oil)

.From the above findings it was revealed that the highest healthy bitter gourd length (19.99 cm) was recorded in T_3 using bait trap in the field, where the maximum increase of fruit length over control was 56.54%. As a result, the order of efficacy in increasing healthy bitter gourd length is $T_3 > T_2 > T_1 > T_4 > T_5$.

Girth of fruit: The effect of management practices on girth of healthy fruit of bitter gourd has been shown in Table 9. Significant variations were observed among the treatments in terms of girth of healthy fruits. The highest girth (16.87 cm) of bitter gourd was recorded in T_3 (Poison bait trap), that is followed by T_2 (14.94 cm) (Neem oil). On the other hand the lowest girth of healthy bitter gourd was recorded in T_5 (8.86 cm) (Untreated control plot), which is statistically different from all other treatments.

Table 9:- Effect of management practices on the yield attributes of bitter gourd

Treatment	Length of single healthy fruit per plot (cm)	% increase over control	Girth of single healthy fruit per plot (cm)	% increase over control
T_1	16.04 c	25.60	13.02 c	46.95
T_2	18.22 b	42.68	14.94 b	68.62
T_3	19.99 a	56.54	16.87 a	90.40
T_4	14.22 d	11.35	11.17 d	26.07
T_5	12.77 e	--	8.86 e	--
LSD(0.05)	1.71	--	1.83	--
CV (%)	3.93	--	5.91	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

Considering the increase of fruit length, the maximum increase of fruit girth over control (90.40%) was recorded in T_3, which was followed by T_2 (68.62%), T_1(46.95%) and T_4 (26.07%).From the above findings it was revealed that the highest healthy bitter gourd girth(19.99 cm) was recorded in T_3 using the poison bait trap in the field, where the maximum increase of fruit girth over control was 86.97%. As a result, the order of efficacy in increasing the girth of healthy bitter gourd is$T_3 > T_2 > T_1 > T_4 > T_5$

4.8.4 Effect on yield of bitter gourd

The effect of management practices on yield of bitter gourd has been shown in Table 10. Significant variations were observed among the treatments in terms of yield of bitter gourd. The highest yield (9.01 kg/plot) was recorded in T_3 (Poison bait trap), which was statistically different with others followed by T_2 (7.68 kg/plot) (Neem oil) andT_1 (6.38kg/plot) (Spinosad) and (5.28 kg/plot) T_4 (Black seed oil). On the other hand, the lowest yield (3.42 kg/plot) was recorded in T_5, which was statistically different from all other treatments. Considering the yield of bitter gourd in ton/ha, the highest yield (24.03 ton/ha) was recorded in T_3 (Poison bait trap), which was statistically different with others followed by T_2 (20.50 ton/ha) (Neem oil) and T_1 (17.02 ton/ha) (Spinosad) and (14.08 ton/ha) in T_4 (Black seed oil). On the other hand, the lowest yield (9.13 ton/ha) was recorded in T_5, which was statistically different from all other treatments.

Table 10: Effect of management practices on yield of bitter gourd

Treatment	**Yield (Kg/plot)**	**Yield (ton/ha)**	**% increase over Control**
T_1	6.38 c	17.02 c	86.41
T_2	7.66 b	20.45 b	123.98
T_3	9.01 a	24.03 a	163.13
T_4	5.28 d	14.08 d	54.21
T_5	3.42 e	9.13 e	--
LSD(0.05)	0.81	2.16	--
CV (%)	5.11	5.11	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control]

Considering the yield increase over control, the maximum increase of yield of bitter gourd over control (163.19%) was recorded in T_3, which was followed by T_2 (123.98%) ,T_1 (124.53%) and T_4 (54.21%). From the above findings it was revealed that the highest yield (24.03 ton/ha) was produced in T_3 treated plot using the poison bait trap in the field, where the highest increase of yield over control was 163.19%. As a result, the order of efficacy of management practices in terms of increasing the yield isT_3>T_2>T_1>T_4.

4.9 Relationship between fruit infestation and yield of bitter gourd

4.9.1 Percent fruit infestation and yield at early fruiting stage

Here percent lowest fruit infestation in early fruiting stage (6.09%), in mid fruiting stage (7.53%) and late fruiting stage (12.03%) in T_3. And highest yield (24.03 ton/ha) produced here

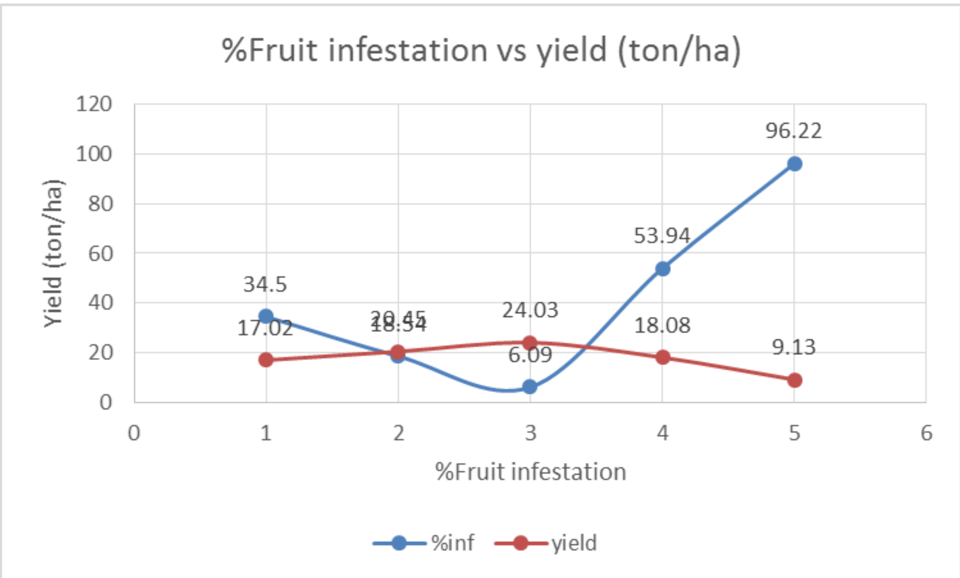

Fig1: Percent Fruit Infestation in early fruiting stage vs Yield ($tonha^{-1}$)

4.9.2 Percent fruit infestation and yield at mid fruiting stage

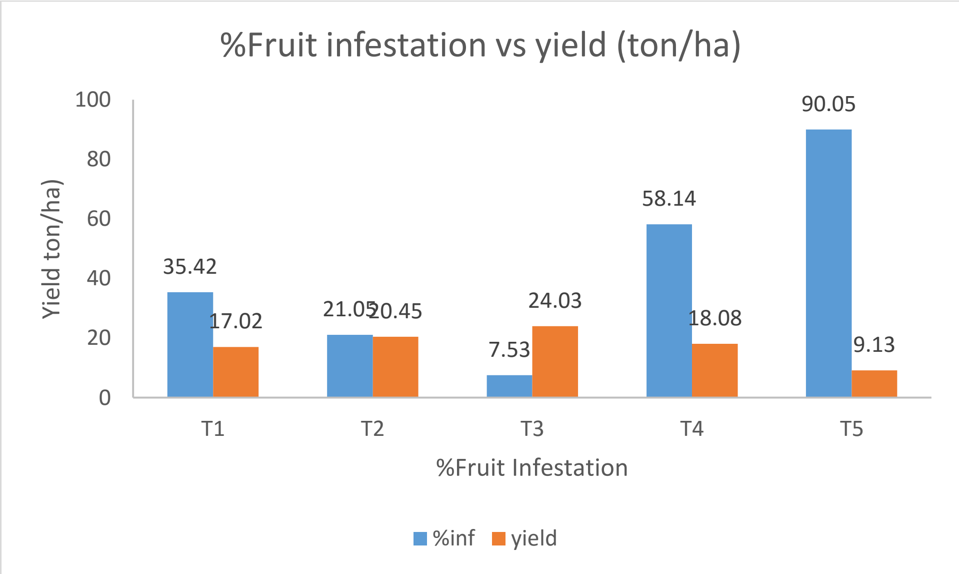

Fig 2: Percent Fruit Infestation in mid fruiting stage vs Yield (tonha^{-1})

4.9.3 Percent fruit infestation and yield at late fruiting stage

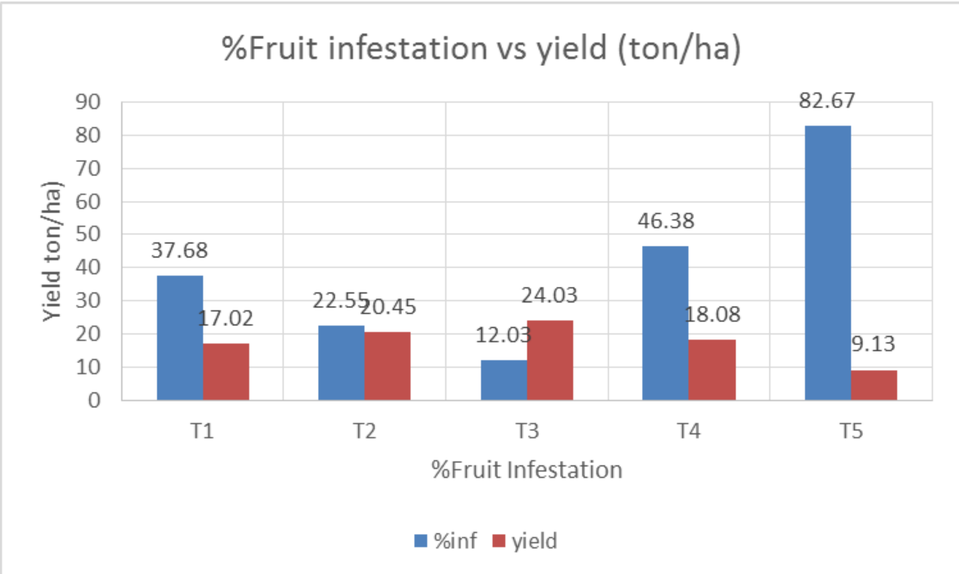

Fig 3: Percent Fruit Infestation in late fruiting stage vs yield (tonha^{-1})

4.10 Economic analysis

Economic analysis of different management practices applied against cucurbit fruit fly infestation on bitter gourd presented in Table 11. The untreated control (T_5) did not incur any pest management cost. The labor costs were involved in T_1, T_2, T_3, T_4, for applying treatments in the experimental plots. From the economic analysis, it was revealed that the highest benefit cost ratio (BCR)(43.20) was calculated in T_3(poison bait trap), where the total adjusted net return was counted as benefit. This was followed (42.27) by T_2, T_1 **(**134.83), T_4 (17.90).

Table 11: Economic analysis of different management practices applied against cucurbit fruit fly in bitter gourd during Kharif I, 2017 at Dhaka.

Treatments	Cost of management (Tk)	Yield (kg/ha)	Gross Return(Tk)	Net Return (Tk)	Adjucent Net Return (Tk)	BCR
T_1	6346.80	20500	410000	403654	221054	34.83
T_2	6485.33	23160	463200	456715	274115	42.27
T_3	6742.00	24030	480600	473858	291258	43.20
T_4	5111.00	13960	279200	274089	91489	17.90
T_5	0.00	9130	182600	182600	0	--

[In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water @ 7 days interval, T_5=Untreated control] Wholesale price of bitter gourd at that time, 1 Kg = 20 Tk

CHAPTER V

SUMMARY AND CONCLUSION

Ecofriendly management of cucurbit fruit fly on bitter gourd was investigated at the field laboratory of the Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from March 2017 to June, 2017. Here, T_1= Spraying of spinosad @.08 ml per liter of water at 7 days interval , T_2= Spraying of neem oil @ 3ml neem oil and 10 ml Trix mixed with 1 liter of water at 7 days interval, T_3= Setting up of poison bait trap @ 2 gm Sevin 85 WP mixed with 100 g mashed sweet gourd and 10 ml molasses replaced at 4 days interval, T_4= Black seed oil 5 ml with 10 ml Trix mixed with 1 liter of water at 7 days interval, T_5=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 bitter gourd. Considering the effect of different management practices in reducing the level of infestation by fruit fly on bitter gourd, at early fruiting stage of bitter gourd, the lowest fruit infestation (6.09%) by number was recorded in T_3 using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 93.66%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction over control was $T_3>T_2>T_1>T_4$. At mid harvesting stage of bitter gourd, the lowest fruit infestation (7.53%) by number was recorded in T_5 using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 91.63%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction is $T_3>T_2>T_1>T_4$. .At late fruiting stage of bitter gourd, the lowest fruit infestation (12.03%) by number was recorded in T_3 using the setting up of poison bait trap in the field, where the highest reduction of fruit infestation over control was 85.44%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction over control was $T_3>T_2>T_1>T_4$.

At early fruiting stage of bitter gourd, the lowest fruit infestation (10.95 %) by weight was recorded in T_3, using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 83.79 %. As a result, the order of efficacy of management practices in terms of fruit infestation reduction over control was $T_3>T_2>T_1>T_4$. At mid fruiting stage of bitter gourd, the lowest fruit infestation (9.04%) by weight was recorded in T_3 using poison bait trap in the field, where the highest reduction of fruit infestation over control was 88.78%.As a result, the order of efficacy of management practices in terms of fruit infestation reduction is $T_3>T_2>T_1>T_4$. At late fruiting stage of bitter gourd, the lowest fruit infestation (18.76%) by weight was recorded in T_3 using the poison bait trap in the field, where the highest reduction of fruit infestation over control was 78.65%. As a result, the order of efficacy of management practices in terms of fruit infestation reduction is $T_3>T_2>T_1>T_4$.

At early harvesting stage of bitter gourd, that the lowest edible portion infestation of bitter gourd (3.94%) was recorded in T_3 using the poison bait trap in the field, where the highest reduction of edible portion infestation over control was94.32%. As a result, the order of efficacy in terms of reducing the infestation of edible portion of fruit at early fruiting stage is $T_3>T_2>T_1>T_4$. At mid harvesting stage of bitter gourd, the lowest edible portion infestation of bitter gourd (3.96%) was recorded in T_3 using poison bait trap in the field, where the highest reduction of edible portion infestation over control was 94.57%. As a result, the order of efficacy in terms of reducing the infestation of edible portion of fruit at mid fruiting stage is $T_3>T_2>T_1>T_4$. At late fruiting stage of bitter gourd, the lowest edible portion infestation of bitter gourd (12.36%) was recorded in T_3 using the poison bait trap in the field, where the highest reduction of edible portion infestation over control was 84.32%. As a result, the order of efficacy in terms of reducing the infestation of edible portion of fruit at mid fruiting stage is $T_3>T_2>T_1>T_4$.

The highest single fruit weight (106.30g) was recorded in T_3 using the poison bait trap in the field, where the highest increase of single fruit weight over control was 66.95%.As a result, the order of efficacy in increasing single fruit weight of bitter gourd is $T_3>T_2>T_1>T_4$.

The highest number of fruit per plant (2.41) was recorded in T_3 using the poison bait trap in the field, where the highest increase of number of fruit per plant over control was141.70%. As a result, the order of efficacy in increasing number of fruit per plant of bitter gourd is $T_3>T_2>T_1>T_4$.

The highest healthy bitter gourd length (19.99 cm) was recorded in T_3 using the poison bait trap in the field, where the maximum increase of fruit length over control was 56.54%. As a result, the order of efficacy in increasing healthy bitter gourd length is $T_3>T_2>T_1>T_4$.

The highest healthy bitter gourd girth (16.87 cm) was recorded in T_3 using the poison bait trap in the field, where the maximum increase of fruit girth over control was 90.40%. As a result, the order of efficacy in increasing the girth of healthy bitter gourd is $T_3>T_2>T_1>T_4$.

Considering the yield of bitter gourd, the highest yield (24.03 ton/ha) was recorded in T_3. On the other hand, the lowest yield (9.13 ton/ha) was recorded in T_5, which was statistically different from all other treatments. The highest benefit cost ratio (BCR) (43.20) was calculated in T_3 (poison bait trap), where the total adjusted net return was counted as benefit. This was followed (42.27) by T_2 (Neem seed oil solution spray).

CONCLUSION

From the present study, it may be concluded that incidence of cucurbit fruit fly and its infestation on bitter gourd was significantly varied among the treatments. The overall study revealed that the highest performance was achieved from the Poison bait trap (T_3). Highest reduction (88%) of fruit infestation over control was achieved by poison bait trap (T_3). Highest yield increase (163.19%) over control was achieved by Poison bait trap (T_3).. Highest yield (24.03 ton/ha) was achieved from Poison bait trap (T_3). Highest BCR (43.20) was also achieved by the Poison bait trap (T_3). Considering the results of the present study, it can be concluded that Poison bait trap (T_3) may be used for the management of fruit fly attacking cucurbitaceous vegetables.

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

1. To minimize the use of chemical insecticides in cucurbit fruit fly control programs, Poison bait trap can play a significant role. It should be adopted in large scale production of chemical free cucurbitaceous vegetables.

2. Further study of this study is needed in different locations of Bangladesh to compare of the results obtained from the present study.

CHAPTER VI

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CHAPTER VII

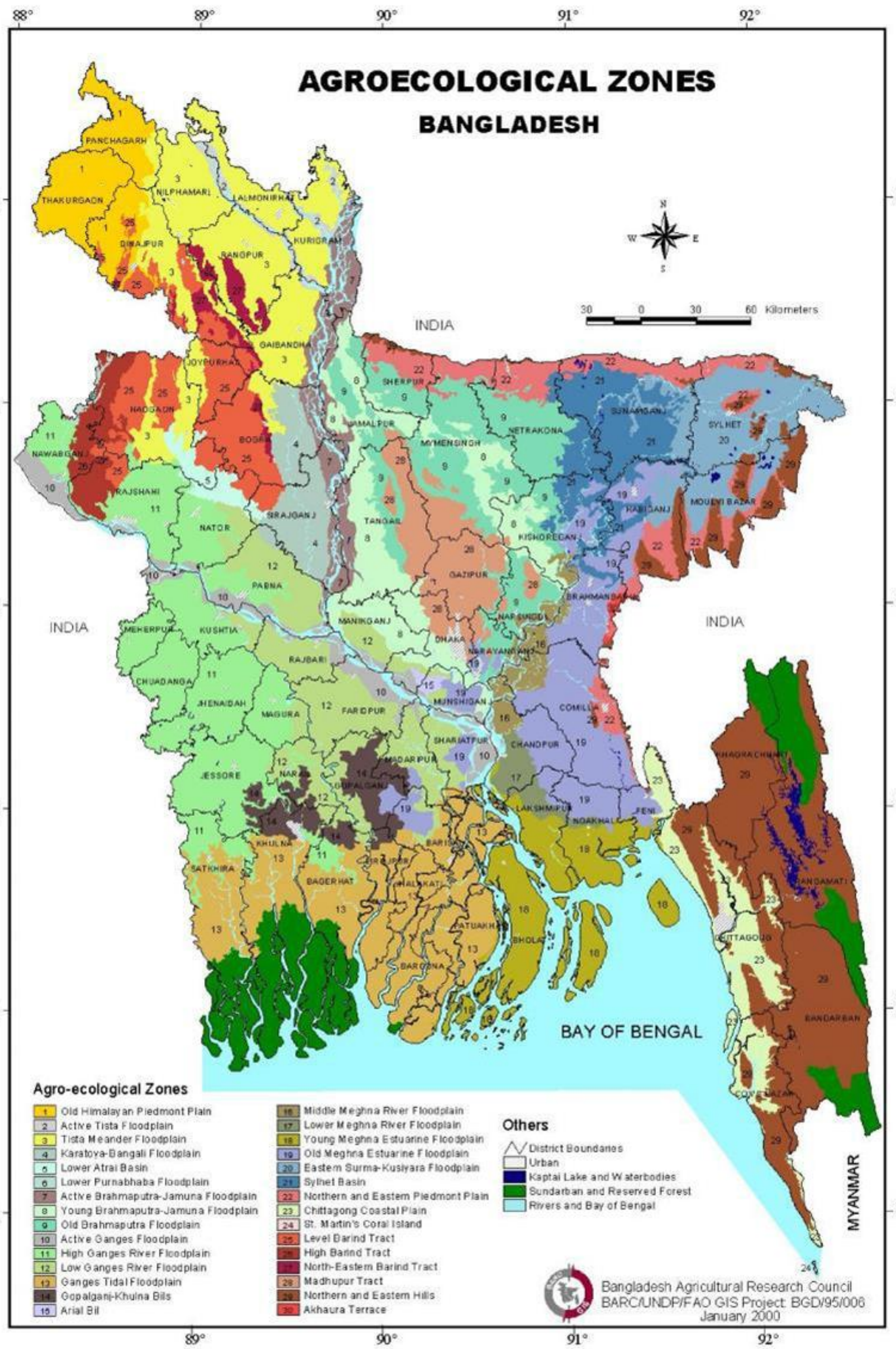
APPENDICES

Appendix I. Experimental locations environmental factor on the map of Agro-ecological Zones of Bangladesh

Date/Week	**Temperature** $°c$		**Relative humidity (%)**	**Rainfall (mm)**
February	31	24	64	28.9
March	28	36	62	65.8
April	27	36	71	156.3
May	39	27	76	339.4
June	31	36	82	340.4

Source: Bangladesh Agricultural Research Council, Khamarbari, Dhaka

Appendix II: Experimental location on the map of Agro-ecological Zones of Bangladesh



LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
BADC	Bangladesh Agriculture Development Corporation
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCPC	British Crop Production Council
BCR	Benefit Cost Ratio
CV	Coefficient of variation
$_oC$	Degree Celsius
DAT	Days After transplanting
d.f.	Degrees of freedom
et al.	And others
EC	Emulsifiable Concentrate
FAO	Food and Agriculture Organization
Fig.	Figure
G	Gram
Ha	Hectare
IPMCRSP	Integrated Pest Management Collaborative Research Support
J.	Journal
Kg	Kilogram
LSD	Least Significant Difference
MoP	Muriate of Potash
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University