EVALUATION OF SOME MANAGEMENT PRACTICES FOR THE SUPPRESSION OF CUCURBIT FRUIT FLY IN BITTER GOURD

BY

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This is to certify that thesis entitled, **"Evaluation of Management Practices for the Suppression of Cucurbit Fruit Fly in 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 bona fide research work carried out by **Md. Wasim Akram, Roll No. 0123, Registration No. 01000** 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, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: December, 2007
Place: Dhaka, Bangladesh

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Dedicated TO
MY
Nephew who Suffering from Blood Cancer

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ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from March to June 2007 to evaluate some pest management practices for the suppression of cucurbit fruit fly in bitter gourd. There were seven treatments viz; T_1: Hand picking of infested fruits of bitter gourd at 7 days interval; T_2: Neem seed kernel at 5 gm/l of water at 5 days interval $+T_1$; T_3: Spray of shobicron 425EC @ 2ml/l of water at 7 days interval + T_1; T_4: Micronutrient-Zn @ 6.72kg/ha; T_5: Micronutrient-B @ 1.96kg/ha; T_6: Micronutrient Zn + B and T_7: Untreated control. The lowest fruit infestation (15.91% and 13.78% respectively) by number and by weight was recorded from the treatment T_2, while the highest (56.01% and 46.09% respectively) fruit infestation by number and by weight was recorded from T_7 untreated control. The lowest (4.22) number of flower per 0.25 m^2 was recorded for the treatment T_7 as untreated control condition, while the maximum (6.15) number of flower per 0.25 m^2 was recorded for T_2 treated plots. The highest (85.00) number of fruits per plot was recorded for T_2 treated plots while the lowest (61.00) number of fruits per plot was recorded from the untreated control T_7. The highest (7.73 kg) yield per plot was recorded from the treatment T_2 and the lowest (6.01 kg) yield per plot was recorded for T_7 treatment. The application of neem seed kernel at 5 days interval + hand picking of infested fruit in T_2 treated plots gave the highest yield (12.88 t/ha) while it was lowest (10.02 t/ha) in T_7 untreated control plots. The combined application of micronutrients was more effective in T_6 than the sole application of micronutrients in T_4

and T_5 respectively. The results of economic analysis of bitter gourd showed that the highest benefit cost ratio (9.44) was estimated for T_6 treatment and the lowest (1.06) benefit cost ration for T_3 treatment. Among the different treatment Neem seed kernel at 5 days interval + Hand picking of infested fruits in T_2 treated plots was more effective than the insecticide Shobicron 425 EC at 7 days interval + Hand picking of infested fruits followed by the T_6 treated plots in combination of micronutrients Zn +B.

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CHAPTER 1

INTRODUCTION

The soil and climatic condition of Bangladesh are suitable for growing numerous kinds of vegetables. Among them cucurbits (squashes, gourds and pumpkins etc.) is one of the major group. Total production of vegetables in Bangladesh in 2003 was 1.74 million ton (Weinberger and Genova, 2005). Cucurbitaceous vegetables occupy about 66% of the lands under vegetable cultivation and contribute 11% of total vegetable production. As many as 15 kinds of cucurbitaceous vegetables are grown in the country; some of them are cultivated in more than one season and even throughout the year. Cucurbits meet the demand to a large extent in summer season when the supplies of other vegetables are scanty.

Bitter gourd is an important vegetable among different cucurbitaceous vegetable in Bangladesh and it is a fast growing warm seasonal climbing crop. Bitter gourd covered an area of 5,502 hectare with a total production of 20,470 tons in Bangladesh (Anon., 2004). It is considered one of the most nutritious gourd and the plant has medicinal properties and a compound known as 'Charantin' present in the bitter gourd is used to reduce blood sugar for diabetic patient (Dhillon *et al*, 2005). Bitter gourd is also rich in vitamins and carbohydrates.

The production of bitter gourd is hindered due to several factors such as short of knowledge on production technology, many disease and insect pests. Among these factors insect pests are the most destructive one. Many insects viz., Red pumpkin beetles, Epilachna beetle, and melon fruit fly *Bactrocera cucurbitae (Coquillett)* are the major constraints to the successful production of bitter gourd.

For cucurbits, especially for bitter gourd the melon fruit fly damage is the major limiting factor in obtaining high yield (Rabindranath and Pillai, 1986). The first report on melon fruit flies was published by Bezzi (1913), who listed 39 species from India. The melon fruit fly, *Bactrocera cucurbitae* (*Coquillett*) (Diptera: Tephritidae) is distributed widely in temperate, tropical, and sub-tropical regions of the world. Two species of cucurbit fruit fly viz. *Bactrocera* (Dacus) *cucurbitae* and *Bactrocera* (Dacus) *caudtus* are commonly found in Bangladesh (Alam *et al.*, 1964). Other species of fruit fly like *Bactrocera cucurbitae*, *Bactrocera tau* and *Dacus ciliatus* have been recently identified in Bangladesh of which *Dacus ciliatus* is a new record. *Bactrocera cucurbitae* is dominant in all the locations of Bangladesh followed by *Bactrocera tau* and *Dacus ciliatus* (Akhtaruzzaman, 1999).

The pest has been reported to damage 81 host plants and as a major pest of cucurbitaceous vegetables, especially the bitter gourd *(Momordica charantia)*, muskmelon *(Cucumis melo)*, snap melon (*C. melo var. momordica*), and snake gourd (*Trichosanthes anguina*). Among 15 Cucurbits, fruit fly prefer bitter gourd, the extent of losses varies between 30 to 100%, depending on the cucurbit species and the season (Anon., 2004). It prefers to infest young, green, soft-skinned fruits. It inserts the eggs 2 to 4 mm deep in the fruit tissues, and the maggots feed inside the fruit. Pupation occurs in the soil at 0.5 to 15 cm below the soil surface depending on the nature and type of soil (Dhillon *et al.*, 2005).

Now a day's farmers in Bangladesh solely rely on the use of toxic insecticides to control the pest in bitter gourd. In some areas, farmers spend about 25% of the cultivation cost in bitter gourd production only to buy toxic pesticides (Anon., 2004). In a research, the residues of pesticide in bitter gourd were found next to brinjal, which was the cause of export reduction of vegetables because of serious concern of the importing countries (Quasem, 2003). Moreover, repeated use of toxic insecticides has created a hazardous situation for the environment as well as health of the farmers and consumers. Since, the maggots damage the fruits internally; it is difficult to control this pest with chemicals. Therefore, it is desirable to explore alternative methods of control, and develop a control strategy for effective, cheap and environment friendly management of fruit fry.

Use of plant extract against pest control is however a recent approach and it has drawn the special attention of the researchers all over the world (Suratuzzaman *et al.*, 1994). Cultural methods such as crop fertilization can affect susceptibility of plants to insect pests by altering plant tissue nutrient levels. The ability of a crop plant to resist or tolerate insect pests and diseases is tied to optimal physical, chemical and biological properties of soils. Micronutrients are essential plant mineral nutrients taken up and utilized by crops in very small quantities. They include copper (Cu), zinc (Zn), boron (B), iron (Fe), manganese (Mn), Molybdenum (Mo) and Chlorine (Cl). Micronutrients are naturally occurring elements and use of these elements is environmentally safe and highly desirable. The deficiency of Zn and B are severe in soil of Bangladesh especially in low land and water logging condition, Zn deficiency is acute. Boron deficiencies were found in well drained, sandy and soils with low water holding capacity (Farid *et al.*, 2003).

Zinc affects enzyme systems that regulate various metabolic activities like protein synthesis, formation of chlorophyll, transformation of carbohydrates and regulation of the consumption of sugar in the plant. More over they played role in seed and grain formation, maturation date, height of plant, if present in sufficient quantities in the leaf, acts like anti freeze in citrus, tomatoes and other crops (Horn and Wimmer, 2006).

Boron acted in protein synthesis, formation of plant hormones, promotes plant maturity by increasing cellular activity, increases set of flowers and fruit and yield and quality. A common result of boron deficiency in all crops as an interruption in flowering and fruiting; Yields are poor, and the fruit or grain is deformed or discolored on the surface (Ho, 1999).

Cruz (1996) evaluate different insecticide along or in mixture with micronutrients (Boron, Zinc and Molybdenum) as seed treatments for the control of maize pests and he found that the average maize yield from treated plot varied from 818 to 1414 Kg/ha, greater than the yield obtained from the control plots.

Considering the above mentioned factors, a research program was undertaken with the following objectives-

- To know the extent of damage caused by cucurbit fruit fly in bitter gourd;
- To evaluate the effectiveness of management practices against bitter gourd fruit fly
- To determine the role of micronutrients in controlling the fruit fly in bitter gourd to the farmers
- To estimate the benefit cost ratio for bitter gourd production

CHAPTER 2

REVIEW OF LITERATURE

Fruit fly is the most damaging pests of cucurbits and considered as an important constrains for successful production of the crops. Works have been done globally on this pest about its origin, distribution, biology, seasonal abundance, influences of color, host range, nature of damage and control measures. However, some literatures about this pest are reviewed below which essential for the justifications of the present research work.

2.1 Origin and distribution of fruit fly

Fruit fly is considered to be the native of oriental origin, probably India and South East Asia and it was first discovered in the Yaeyama Island in 1919 (Anon., 1987). Two of the world's most damaging tephritids, *Bactrocera* (Dacus) *drosalis* and *Bactrocera* (Dacus) *cucurbitae*, are widely distributed in Malaysia and other South East Asian countries of the (Vijaysegaran, 1987). However, fruit fly is widely distributed in India, Bangladesh, Pakistan, Myanmer, Nepal, Malaysia, China, Philippines, Formosa, Japan, Indonesia, East Africa, Australia and Hawaiian Island (Atwal, 1993).

The melon fruit fly is distributed all over the world, but India is considered as its country of origin. They infest a wide variety 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 due to cultivation by man (Kapoor, 1993).

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

2.2 Host range of fruit fly

In the Hawaiian Islands, melon fruit fly has been observed feeding on the flowers of the sunflower, Chinease bananas and the juice exuding from sweet corn. Under induced oviposition, McBride and Tanda (1949) reported 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*.

Doharey (1983) reported that it infests over 70 host plants, amongst which, fruits of bitter gourd (*Momordica charantia*), muskmelon (*Cucumis melo*), snap melon (*Cucumis melo* var. *momordica*) and snake gourd (*Trichosanthes anguina* and *T. cucumeria*) are the most preferred hosts. Melon fruit fly damages over 81 plant species. In Bangladesh, Kabir *et al.* (1991) obtained 16 species of cucurbit plants as the host of fruit fly.

However, White and Elson-Harris (1994) stated that many of the host recorded might be based on casual observations of adults resting on plants or caught in traps set in non-host plant species. Based on the extensive surveys carried out in Asia and Hawaii, plants belonging to the family Cucurbitaceae are preferred most (Allwood *et al*, 1999). The males pollinate the flowers and acquire the floral essence and store it in the pheromone glands to attract con-specific females (Hong and Nishida, 2000).

2.3 Life history of fruit fly

The melon fruit fly remains active throughout the year on one or the several hosts. During the severe winter, 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 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).

Bhatia and Mahto (1969) reported that the life cycle is completed in 36.3, 23.6, 11.2, and 12.5 days at 15, 20, 27.5, and 30°C, respectively. The eggs laid by *Bactrocera cucurbitae* are creamy white, oblong banana shaped and are about 1.3 mm in length (Anon., 1987). 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 (Samalo *et al.*, 1991). High temperatures, long period of sunshine and plantation activates influence the *B. cucurbitae* abundance in the Northeastern Taiwan (Lee *et al.*, 1992). Development from egg to adult stage takes 13 days at 29° C in Solomon Islands (Hollingsworth *et al.*, 1997). The eggs 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 (Hollingsworth *et al.*, 1997). The larval period lasts for 3 to 21 days (Narayanan and Batra, 1960), depending on temperature and the host. On different cucurbit species, the larval period varies from 3 to 6 days (Koul and Bhagat, 1994; Gupta and Verma, 1995).

The puparium is 4.8 to 6.0 mm in length. At 23-25°C the pupal stage last for 8-12 days. At 27°C the mean pupal period for *B. dorsalis* and *Ceratities capatita* is 10 days and that of *B. cucurbitae* is 9 days (Mithell *et al.*, 1985).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). 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 (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 (Khan *et al.*, 1993).

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

The males of the *B. cucurbitae*mate with females for 10 or more hours, and sperm transfer increases with the increase in copulation time. Egg hatchability is not influenced by mating duration (Tsubaki and Sokei, 1988). Yamagishi and Tsubaki (1990) observed that no sperms were transferred during the first 0.5 h of copulation. Sperm transfer increased to nearly 6400 until 4 h, and thereafter, the number of sperms remained almost unchanged up to 8 h of copulation. The pre-oviposition period of flies fed on cucumbers ranged between 11 to 12 days (Hollingsworth *et al.*, 1997). Pre-oviposition and oviposition periods range between 10.0 to 16.3, and 5 to 15 days, respectively, and the females live longer (21.7 to 32.7 days) than the males (15.0 to 28.5 days) (Koul and

Bhagat, 1994). 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 pre-mating 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 (Vargas *et al.*, 1992). Yang *et al.* (1994) reported the net reproductive rate to be 72.9 births per female.

2.4 Nature and extent of damage

Miyatake *et al.* (1993) reported < 1% damage by pseudo-punctures by the sterile females in cucumber, sponge gourd and bitter gourd. After egg hatching, the maggots bore into the pulp and make the feeding galleries. The fruit subsequently rots or becomes distorted. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition. The infested fruits if not rotten become deformed and hardy which make it unfit for consumption.

Maggots feed inside the fruits, but some times, also feed on flowers, and stems. Generally, the females prefer to lay the eggs in soft tender fruit tissues by piercing them with the ovipositor. A watery fluid oozes from the puncture, which becomes slightly concave with seepage of fluid, and transforms into a brown resinous deposit. Sometimes pseudo-punctures (punctures without eggs) have also been observed on the fruit skin. This reduces the market value of the fruit. 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.*, 2005).

2.5 Yield loss

Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89% (Gupta and Verma, 1978; Rabindranath and Pillai, 1986). The melon fruit fly has been reported to infest 95% of bitter gourd fruits in Papua (New Guinea), and 90% snake gourd and 60 to 87% pumpkin fruits in Solomon Islands (Hollingsworth *et al.*, 1997). Singh *et al.* (2000) reported 31.27% damage on bitter gourd and 28.55% on watermelon in India.

2.6 Seasonal abundance

Most of the fruit fly species are more or less active at temperature ranging between 12° C to 15°C and become inactive below 10°C (Narayanan and Batra, 1960). The adult of melon fruit fly *B. cucurbitae* over winter in November to December and the fly is most active during July to August (Agarwal *et al.*, 1987).

The population of fly fluctuates throughout the year. Kapoor (1993) pointed out that the fruit fly *Bactrocera cucurbitae* Coquillett and *Bactrocera zonata* Saunders are active throughout the year except for a short period from December to mid February due to excessive cold when they hide under leaves of guava, citrus fruits, mangoes etc. Amin (1995) also observed the highest population incidence in the ripening stage of cucumber in Bangladesh. The peak population of fruit fly in India is attained during July and August in rainy season and January and February in cold months (Nair and Thomson, 1999).

2.7 Management of cucurbit fruit fly

The present practice of frequent insecticide sprays by the farmers to protect their cucurbit crops from fruit fly damage has proven to be largely ineffective, create potential problems for the environment as well as for the health of the farmers and consumers. Various measures have been reported for controlling this pests, but there is not a single such method that can successfully be adopted to combat the incidence and damage caused by this pest. This perhaps, is mainly due to the polyphagous nature of these pests that helps there year round population build up. The available literatures on the measures for the controlling of these flies are discussed under the following sub-headings:

A. Mechanical control

Hand picking followed by field sanitation is an essential prerequisite to reduce the insect population or defer the possibilities of the appearances of epiphytotics or epizootics (Reddy and Joshi, 1992). The female fruit fly lay eggs and the larvae hatch inside the fruit, it become essential to look for the available measures in the field sanitation (Nasiruddin and Karim, 1992).

The most effective method in melon fruit fly management uses primary component- field sanitation. To break the reproduction cycle and population increase, growers need to remove all unharvested fruits or stubles from a field by completely burning them deep into the soil. Burying damaged fruits 0.46 m deep in the soil prevents adult fly eclosion and reduces population increase (Klungness *et al.*, 2005).

B. Botanical extract

Botanical pesticides are becoming popular day by day. Now a day these are using against many insects. It was found that Lepidopteran insect is possible to control by botanical substances.

Khan and Khan (1984) stated that the toxicity of the vegetable oils 1% taramira (seed oil of *Eruca sativa*) and 1% Aartemisia (oil from the distilation of leaves and shoots alone and in combination with 0.5% DDT and 0.5% lindane against *Dacus dorsalis*, *D. zonatus* were assessed in the laboratory. Direct and indirect spray techniques were used. The vegetables oils alone and in combination with the DDT and lindane were effective against the tephritids.

Weekly spray application of the extract of neem seed kernel has been found to be effective against *Helicoverpa armigera* (Karim, 1994). Ranganath *et al.* (1997) tested a number of botanical against *Bactrocera cucurbitae* on cucumber (*Cucumis sativus*) and ribbed gourd (*Luffa acutangula*) and found that neem oil at 1.2% was the most effective treatment in reducing damage to cucumber (mean percentage damage 6.2%, as compared with 39.0% in the control), while neem cake at 4.0% and DDVP (dichlorovs) at 0.2% were the most effective against the pest on ribbed gourd, reducing damage to 9.1 to 9.5% as compared with 32.9% in control.

Lopez *et al.* (1999) assayed short-term choice and no-choice feeding used to assess the antifeedant activity of *T. havanensis* fruit extracts (at 5000 ppm) against 5th-instar *H. armigera* larvae. The acetonic extract gave the highest activity and was further fractionated by silica gel column chromatography. Of the 7 fractions isolated, 5 were identified as the limonoids azadirone, trichilinone acetate, 14,15-deoxyhavanensin-1,7-diacetate, 14,15-deoxyhavanensine-3,7-diacetate and a mixture of havanensin-1,7-diacetate and havanensin-3,7-diacetate. Choice and no-choice feeding assays of each fraction at 1000 ppm, showed that the mixture of havanensin-1,7-diacetate and havanensin-3,7-diacetate had the highest antifeedant activity against *H. armigera* larvae. Azadirone and trichilinone acetate were also antifeedants. No antifeedant activity was found in the remaining fractions. It is suggested that all of the limonoids with antifeedant activity have a similar mode of action, which is probably toxic.

Ju *et al.* (2000) tested six desert plants chosen to study their toxicity and effects on the growth and metamorphosis of the insect pest, *Heliothis armigera* [*Helicoverpa armigera*]. An artificial diet containing 5% aqueous extracts of *Cynanchum auriculatum* or *Peganum harmala* var. multisecta showed strong toxicity to the larvae and caused mortality of 100% and 55%, respectively. These two extracts at the same dosage also significantly affected metamorphosis of the insect. An artificial diet containing 1% aqueous extracts of *C. auriculatum* or 5% aqueous extracts of *P. harmala* resulted in mortality of 85% and 55%, respectively, and a zero emergence rate. Tests of extracts of *C. auriculatum* made at different pHs showed that the pH 3 and pH 10 portions of the extracts affected the larvae growth significantly. The other plant species tested were *Euphorbia helioscopia, Sophora alopecuroides, Peganum nigellastrum and Thermopsis lanceolata*; extracts of these species caused either much lower mortality of *H. armigera* or zero mortality (*E. helioscopia*).

Sundarajan & Kumuthakalavalli (2000) tested Petroleum ether extracts of the leaves of *Gnidia glauca* Gilg., *Leucas aspera* Link., and *Toddalia asiatica* Lam. against sixth instar larvae of *Helicoverpa armigera* (Hubner.) at 0.2, 0.4, 0.6, 0.8 and 1.0% by applying to bhendi (okra) slices. After 24 hr, percentage mortality, EC50 and EC90 were calculated. Total mortality was recorded in the treatment with 0.8% of the extract of *G. glauca*. Of the three leaf extracts used, *G. glauca* showed an EC50 of 0.31%.

Kulat *et al.* (2001) conducted an experiment on extracts of some indigenous plant materials, which are claimed important as pest control like seed kernels of neem, *Azadiracta indica*, *Pongamia glabra* [*P. pinnata*], leaves of tobacco, *Nicotiana tabacum* and indiara, a neem based herbal product, against *H. armigera* on chickpea cv. I.C.C.V.5 for its management in Rabi seasons of 1993-96 at College of Agriculture, Nagpur, Maharashtra, India. The results revealed that the crop treated with the leaf extract of *N. tabacum* and seed extract of *P. glabra* (5%) and indiara (1%) and neem seed kernel extract (5%) exhibited low level of population built up compared to control.

Sundarajan (2002) screened methanol extracts of selected plants namely *Anisomeles malabarica, Ocimum canum [O. americana], O. basilicum, Euphorbia hirta, E. heterophylla, Vitex negundo, Tagetes indica and Parthenium hysterophorus* for their insecticidal activity against the fourth instar larvae of *H. armigera* by applying dipping method of the leaf extracts at various concentrations (0.25, 0.5, 1.0, 1.5 and 20) on young tomato leaves. The larval mortality of more than 50% has been recorded for all the plant extracts in 2 per cent test concentration (48 h) except *E. heterophylla* which recorded 47.3 per cent mortality in 2 per cent concentration. Among the plant extracts tested *V. negundo* is found to show higher rate of mortality (82.5%) at 2 per cent concentration.

C. Chemical Control

Chemical control of the melon fruit fly is relatively ineffective. However, insecticides such as malathion, dichlorvos, phosphamidon, and endosulfan are moderately effective against the melon fly (Agarwal *et al.*, 1987). Bhatnagar and Yadava (1992) reported malathion (0.5%) to be more effective than carbaryl (0.2%) and quinalphos (0.2%) on bottle gourd, sponge gourd, and ridge gourd. The application of molasses + malathion (Limithion 50 EC) and water in the ratio of 1: 0.1: 100 provides good control of melon fly (Akhtaruzzaman *et al.*, 2000).

Gupta and Verma (1982) reported that fenitrothion (0.025%) in combination with protein hydrolysate (0.25%) reduced fruit fly damage to 8.7 % as compared to 43.3 % damage in untreated control. Application of carbofuran granules at 1.5 kg a.i./ha at the time of sowing, vining, and flowering gave 83.35% protection to bitter gourd against *B. cucurbitae* (Thomas and Jacob, 1990). Application of either 0.05% fenthion or 0.1% carbaryl at 50% appearance of male flowers, and again at 3 days after fertilization is helpful in reducing the melon fly damage (Srinivasan, 1991). Dicrotophos (at 600g a.i.) and trichlorfon (at 1920g a.i./ ha) has been found to give good control of *B. cucurbitae* in muskmelon (Chughtai and Baloch, 1988). Formathion is more effective than trichlorfon (Talpur *et al.*, 1994). Diflubenzuron has also been reported to be effective in controlling the melon fly (Mishra and Singh, 1999).

Reddy (1997) reported triazophos to be the most effective insecticide against this pest on bitter gourd. Neem oil (1.2 %) and neem cake (4.0 %) have also been reported to be as effective as dichlorvos (0.2 %) (Ranganath *et al.*, 1997). Highest yield and lowest damage were observed in pumpkin when treated with carbofuran at 1.5 kg a.i./ ha at 15 days after germination (Borah, 1998). An extract of *Acorus calamus* (0.15%) reduced the adult longevity from 119.2 days to 26.6 days when fed continuously with sugar mixed with extract (at 1 ml/g sugar) (Nair and Thomas, 1999).

D. Role of nutrients and minerals in insect resistance in crop plants

Nutrients have an ambivalent effect on plant resistance. In some instances, high levels of nutrients increase the level of insect resistance, and in other they increase the susceptibility. Unfertilized plots of sorghum suffer high shoot fly damage compared to those treated with normal dosage of fertilizers (Sharma, 1995). Application of nitrogenous fertilizers reduced the damage of shoot fly and spotted stem borer (*C. partellus*) in sorghum (Chand *et al.*, 1979).

Any compound at high concentration can become a toxin. This is also true with the every minerals that provide essential role in the biochemical processes of life, both in plants and / or insects. For example, while cadmium, arsenic, and mercury chlorides were most toxic to *Drosophila*, so do were nickel, silver, copper, cobalt, chromium, and zinc (Williams *et al.*, 1982). The physiological mechanisms of these toxicities and many other insect examples are reviewed by Heliobvaara and Vaisanen (1993).

Leaf water and minerals are often forgotten or omitted when the chemical ecology of insect-plant interactions are discussed (Raubengeimer and Simpson, 1999). However, there are many other intrinsic and extrinsic factors that affect host plant resistance and the effectiveness of specific traits or resistance mechanisms including the interaction of allelochemicals and nutrients (Slansky, 1992) with different abiotic and biotic variables (Schoonhoven *et al.*, 1998)

Antixenotic resistance consists of plant morphology or chemical factors that reduce the attractiveness of a plant as a host, resulting in the selection of an alternative host (Smith, 1989). The mechanisms of plant resistance are antixenosis, antibiosis and tolerance (Smith, 1989). Antixenosis operates by disrupting normal arthropod behaviour (non-preferance), where as antibiosis adversely affects a pest physiological process, there by impairing arthropods survival, growth, development and behavior. Tolerance is a plant response to injury where acceptable plant yield is achieved in spite of a injury by a pest (Fundarburk *et al.*, 1993). Minerals and primary metabolites that are involved in basic processes are rarely considered as determents of plant resistance to insects despite the major effect they have on insect behavior, physiology and ecology (Zangerl and Berenbaum, 1998, Scriber, 2001).

Numerous studies have shown that the growth, reproduction and survival of phytophagous insects are positively correlated with the nitrogen content in their food (Mattson, 1980; Scriber and Slansky, 1981). And when read pumpkin beetle destroy new leaves the hormone balance of the plant is disrupted. This causes a major change in the older leaves. Proteins hydrolyze to amines and amino acids and become available to the sucking insects as food. Nitrogen also causes higher amines and amino acid levels in the plant. The more the nitrogen used the greater the threat. Zinc will lower the level of amines and amino acids in the new leaves.

Mineral elements, which are not necessarily essential but which are beneficial for certain plants or insect species under certain conditions, include: Silicon, Selenium, Cobult, Sodium and nickel. For example, boron, cobalt and molybdenum improve growth of pea aphids in synthetic diet (Auclair and Srivastava, 1972).While many mineral elements are essential for the healthy growth of animals, the minimal needs and balance of any on relative to others basically remains unknown for insect (Matson and Scriber, 1987). Nutrient deficiency between herbs and trees and between deciduous and evergreen trees show seasons trends and varies with a number of other factors (Matson and Scriber, 1987; Clancy *et al.*, 1995).

Nematode feeding interferes with absorption in plants (Ritter, 1976). While certain plants have a direct nematicidal effect, the particular sensitivity of insect and host will give variable results (Ritter, 1976). Manipulation of soil nutrients, to benefit plants and adversely affect nematodes, has been suggested as a tool in IPM (Melakeberahan, 1997).

It is important to realize that numerous factors in addition to artificial fertilization will determine the mineral and nutrient levels in plants including: water stress (Kozlowski *et al.*, 1991), air pollution including acid rain (Clancy *et al.*, 1995), plant tissue age (stand age or density) (Vulzquez *et al.*, 1992) as well as the plant species and genotypes (Clancy *et al.*, 1993). The interaction of nutrients and allochemicals in plants under different environmental condition complicates the research for simple stable mechanism of resistance or cause of susceptibility to insects (Hammerschmidt and Schultz, 1996).

Tin and bismath are trace elements (micronutrients) that are reported to increase the quantity of Tannin production in *Acacia catuchu*, but iron does not (Karunanithy and Kepel 1985). The improvement in growth and development of some insects with the right balance of copper, iron, manganese, zinc, boron, cobalt and molybdenum may actually be due to direct benefits to the symbionts rather than the insect (Reinecke, 1985). However, insects have been shown to benefit from the proper balance of minerals and nutrients, which may be the most important factor in the nutritional ecology of insect herbivores (Slansky, 1993) which can be understood as a response surface design of the "nutritional niche" (Clancy and King 1993) and the insect integration (Raubengeimer and Simpson, 1999).

When several levels of nitrogen were tasted, both with and without mineral supplements, over three generations of spruce budworms, regression analysis estimated that the ratio of Zn to N was the best prediction of fitness, not the amount of nitrogen itself in the diet (Clancy, 1992). Not only is the zinc-nitrogen interaction important, but the high fiber levels in plant tissue may also reduce bio-diversity of zinc and iron and alter the effect of this mineral concentrations (Reinhold 1982; Kies *et al.*, 1983).

Another observation that hints at the critical importance of conversing zinc for some insects is that male *Heliothis virescens* transfer zinc (but not manganese, copper, or other metal ions) in there copulation with females (Engebretson and Mason, 1980).The difference in corn borer oviposition in corn were in part mediated by the plant minerals balance, which involved both the absolute levels and ratios of minerals with borers preferring higher Zn, Al and N (Phelan *et al.*, 1996).

The metal ions Cu, Fe, K, Mg, Mn, Co, and Mb are all important in catalyzing a diversity of enzyme reactions and other such as Na, Ca, K and Mg are involved in physiological control mechanism and maintaining the structure of cell walls. It has been proposed that the minimal mineral needs and their optimal balance for growth of insects may determine the intensity of herbivory on plants with variable levels of nutrients (Matson *et al.*, 1982).

In another study by Cruz (1996) evaluate different insecticide along or in mixture with micronutrients (Boron, Zinc and Molybdenum) as seed treatments for the control of maize pests and he found that the average maize yield from treated plot varied from 818 to 1414 Kg/ha, greater than the yield obtained from the control plots.

Sachdev *et al.* (1992) found that, seed yield, harvest index, protein content and amino acid composition of chickpea was affected by sulphur and micronutrients. Application of S, Cu and Zn increased seed protein content of chickpea. Abro (2004) studied the effect of hormone and micronutrients on plant growth and insect infestation of cotton crop under field conditions and he observed that there was no significant effect of application of hormone and micronutrients on multiplication of Thrip, *Scirtothrips dorsalis*, Jassid, *Amrasca devastans*, Whitefly, *Bemisia tabaci* and percent infestation of bollworms. However, application of plant growth regulator and micronutrients significantly delayed the maturity of cotton.

Zinc affects enzyme systems that regulate various metabolic activities like protein synthesis, formation of chlorophyll, transformation of carbohydrates and regulation of the consumption of sugar in the plant. More over they played role in seed and grain formation, maturation date, height of plant, if present in sufficient quantities in the leaf, acts like anti freeze in citrus, tomatoes and other crops (Horn and Wimmer, 2006).

Heavy applications of phosphate fertilizer (200 mg P_2O_5/kg soil) combined with 10 mg Zn/kg soil (in the form of zinc sulfate or ZnEDTA) increased grain and straw yield of rice on sandy loam soils. They also reduced the percentage of unfilled grains. In Taiwan, 30 to 50 kg/ha of zinc oxide is recommended for rice production on soils with low available zinc status. For sugarcane in Taiwan, 25 kg/ha of zinc oxide is recommended, and increases the cane yield by 14% and sugar yield by 8%, compared to fields which did not recieve zinc oxide applications. (Nammuang *et al*, 1984).

Muralidharan and Jose (1994) observed that N uptake was increased by the application of B, Cu and Mo, in rice particularly in the Kharif season. Zn and Mg applications reduced N and K uptakes, respectively. Muralidharan, and Jose (1995) stated that Zn application increased the availability of Zn while B decreased it and Zn application increased the uptake of Cu.

Monga and Josan, (2000) observed that, application of zinc, alone and in combination with Fe and Mn (as zinc sulfate, manganous sulfate, and ferrous sulfate, respectively) increased the fruit yield, juice content, and total soluble solids of *Kinnow mandarin*. These were maximum under zinc sulfate (0.3%) treatment.

Boron acted in protein synthesis, formation of plant hormones, promotes plant maturity by increasing cellular activity, increases set of flowers and fruit and yield and quality. A common result of boron deficiency in all crops as an interruption in flowering and fruiting; Yields are poor, and the fruit or grain is deformed or discolored on the surface (Ho, 1999). Lack of Borons reduces the production of phenolic allochemicals by oil palm seedlings, which may make them more susceptable to spider mite damage (Rajaranan and Hook, 1975).

Ghanta *et al.*, (1994) found that foliar applications of B (0.1%) increased femaleness and decreased maleness. Treatment with micronutrients increased the yield of papain and when all 3 B, Cu and Mn were given together, papain yield was 5.20 g/plant, vs. 3.40 g in the untreated control.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period of March to June 2007 to evaluate of pest management practices for the suppression of cucurbit fruit fly in bitter gourd. The treatments, their application procedures and other relevant methodologies followed in this study are described below.

3.1 Location

The study was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^0 74'$N latitude and $90^0 35'$E longitude and an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil testing Laboratory, SRDI Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix I.

3.3 Weather condition of the experimental site

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the metrological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka and presented in Appendix II.

3.4 Raising seedling

Seeds of hybrid variety "Shapla-1" were collected from Siddiques Seeds, Mirpur, Dhaka. Seeds were soaked for 24 hours and then 2 seeds were sown in each polythene bag (10 cm × 10 cm) containing 50% well decomposed cow dung and 50% sandy loam soil. After seven days of germination weaker seedlings were removed leaving healthy one per bag. The single seedling of 25 days old were transplanted in the well preparedfield on 23^{th} April 2007.

3.5 Land preparation and fertilization

The land was prepared thoroughly by 4 ploughing followed by laddering to attain a good tilth. Weeds and stubbles were removed and the land was finally prepared by addition of basal doses of fertilizers and well decomposed cowdung. The size of each experimental plot was 2m × 2m with an inter plot distance of 0.5 m. Two pits of 30cm ×30cm × 20cm size each was dug in each plot at a distance of 1m between pits. The whole experimental field was divided into 30 plots to accommodate 3 replications having 40 plants per replication. Therefore, there were 120 plants in the whole experiment. Cowdung and other chemical fertilizers were applied as recommended by Rashid (1993) for bitter gourd. Cowdung, urea, TSP and MP were applied @ 10 t/ha, 150 kg, 125 kg and 100 kg per hectare respectively. The total cowdung, two third of TSP and one third of urea were applied as basal dose during land preparation. The rest of the TSP and half of MP were applied in the pits seven days before transplanting of seedling. The remaining portions of urea and MP were top dressed after each three flush of flowering and fruiting in two equal splits.

3.6 Treatment of the experiment

The experiment consists of seven treatments. The details of the treatments were presented below:

- T_1: Hand picking of infested fruits and flowers at 7 days interval
- T_2: Neem seed kernel @ 5g/litre of water at 5 days interval + T_1
- T_3: Shobicron 425 EC 2 ml/litre of water at 7 days interval +T_1
- T_4: Micronutrient-Zn (6.72 kg/litre of water)
- T_5: Micronutrient-B (1.96 kg/litre of water)
- T_6: Micronutrient Zn + B
- T_7: Untreated control

3.7 Design and layout of the Experiment

The experiment was laid out at Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatment combinations in each plot of each block. There were 21 unit plots altogether in the experiment. The distance between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.8 Cultural Operations

After transplanting, the seedlings were provided with a light irrigation. Propping of each plant using bamboo stick (2 m length) was done to facilitate creeping of plant and to avoid lodging. All the bamboo sticks were tightened strongly with long wire and rope to make scaffold for individual plots. Irrigation, top dressing of urea (@ 10g/plot/application) and weeding were done as and when necessary for proper development.

3.9 Treatment application

a. Hand picking of infested fruits (T_1)

Regular visual observation of infested fruits of each plant from each plot under the treatment (T_1) where have picking of infested fruits was done at 7 days interval and the number of infested fruits were recorded. This procedure was continued from early to late fruiting stages.

b. Application of micronutrients

The micronutrients were applied subsequently in two splits. First application of micronutrients was done as top dress on April 24, 2007 after one day of transplanting and second application of the treatment was done on 23 May 2007 after second harvest following the top cress method. The plots of the untreated control were left without any application of micronutrients.

c. Preparation of Neem seed kernel extracts

d. Insecticide application

The insecticide Shobicron 425 EC @ 2ml/litre of water tested for the management of cucurbit fruit fly. Spraying was done at 11.00 am to avoid moisture on leaves. First application was done after observation of infested fruits of bitter gourd. Treatments were applied at 7 days interval for controlling the pest. To get complete coverage of plants spraying was done uniformly on the entire plant with special care. All the time the mixture of insecticides in the sprayer was shaken well and sprayed by a Knapsack sprayer. Before spraying, volume was calibrated to find out the required quantity of spray materials for the same replicated plots. The required quantity was measured as 6 litres.

3.10 Data collection

Data on fruit infestation was taken at fruit initiation, early, mid and late fruiting stages according to Amin (1995) and Uddin (1996). During these stages a total of 7 harvests were done. At very beginning of the fruiting stage one harvest is done and other stage consists of 2 harvests. Fruits were harvested at an interval of 7 days starting from 6 April 2006. The effect of each treatment was valuated on the basis of the tag along parameters. The data was taken on the flower initiation date, number of flowers per 0.25 m^2, number of infested fruit, percent of number and weight of infested fruit and yield (t/ha) in comparison to untreated control.

3.10.1 Fruit infestation

a. Percent fruit infestation by number

After harvesting, the healthy and the infested fruits were separated by visual observation. The numbers of healthy and infested fruits were counted and the percent fruit initiation for each treatment was calculated by using the following formula:

$$\textbf{\% Fruit infestation by number} = \frac{\text{Number of infested fruit}}{\text{No. of Healthy fruit + No. of Infested fruit}} \times 100$$

b. Percent fruit infestation by weight

After harvest at each fruiting (initial, early, mid and late) stage, the total fruits were sorted into healthy and infested for each treatment. On the basis of weight of healthy fruit and infested fruit the percent fruit infestation was calculated.

$$\text{\% Fruit infestation by weight} = \frac{\text{Weight of infested fruit}}{\text{Wt. of healthy fruit + Wt. of infested fruit}} \times 100$$

3.10.2 Yield contributing characters and yield of bitter gourd

a. Days to flowering

Days to flowering was calculated from seed sowing to first start of flowering and expressed in days.

b. Number of flower per 0.25 m^2

During the study period after first flowering date, the number of flowers was counted at an interval of 0.25 m^2 from which mean number of flower is calculated by using the following formula

$$\textbf{Mean number of flower} = \frac{\text{Total number of flower}}{\text{Total number of observation}}$$

c. Number of fruits per plant

Number of total fruits for individual plant was counted and total number was made by adding the number of all harvest.

d. Weight of individual fruit

After harvest at each reproductive stage 10 selected fruits were weighted for each treatment. Weighing the mean weight of fruit was calculated from the weight of 10 fruits.

e. Fruit yield

Fruit yield was measured by adding the total harvest attaining from all harvest in individual plot and converted into per hectare yield.

f. Increase or decrease of yield over control:

Increase or decrease of yield over control was calculated using the following formula:

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

$$\text{Percent decrease of yield over control} = \frac{\text{Yield of untreated control plot} - \text{Yield of treated plot}}{\text{Yield of untreated control plot}} \times 100$$

Economic analysis of treatments or BCR

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

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

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

3.11 Statistically analysis

The data obtained for different characters were statistically analyzed to find out the significant difference among the treatments. The analysis of variance was performed by using MSTAT Program. The significance of the difference among the treatment combinations means was estimated by DMRT (Duncan's Multiple Range Test) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The study was conducted to evaluate some pest management practices for the suppression of cucurbit fruit fly in bitter gourd. Data on fruit infestation in number and weight, on days to flower, and the effect of management practices on yield contributing characters and their yield were recorded. The results have been presented and discussed, and possible interpretations have been given under the following headings:

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

The results on the number of infested fruit, percent infestation by number and by weight, percent infestation reduction over control at early, mid and late stages and the weather components i.e., temperature, rainfall and humidity on fruit infestation of bitter gourd at different harvesting time during bitter gourd growing season are presented in Tables (1 and 2) and in figures (1 and 2) respectively. Healthy plants and fruits treated with Neem seed kernel + T_1 and Shobicron 425 EC @ 2ml/litre of water + T_1 are shown in the plate 1A, 1B, 2A and 2B.

4.2 Fruit infestation by number

Fruit infestation in bitter gourd by number of fruit per plot for the attack of fruit fly showed significant differences for different management components at different fruiting stage under the present trial (Appendix III).

In terms of fruit infestation by number and weight the treatment T_2 was the most effective compared with other treatments and the T_7 was less effective. Insecticide and micronutrients had significant effect on bitter gourd production (Table 1). At initial stage of fruit setting minimum fruit infestation (12.82%) by number was recorded for the treatment T_2 i.e., application of Neem seed kernel @ 5 gm/ liter of water at 5 days interval + T_1 which was statistically identical with T_3 application of Shobicron 425 EC at

7 days interval + hand picking (13.33%) and T_6 treatment application of Zn + B (13.85%), respectively. On the other hand, the highest fruit infestation (51.24%) by number was recorded for T_7 as untreated control condition which was closely followed (28.75%) by T_1 treatment as hand picking were done for controlling fruit fly. The treatment T_4 and T_5 performed intermediate level of fruit infestation by number which was 18.00% and 21.38% respectively (Table 1).

At early fruiting stage, the lowest (15.26%) fruit infestation by number was recorded from the treatment T_2 (Neem seed kernel extracts + hand picking of infested fruits at 5 days interval) which was statistically similar (18.52% and 19.05%) with the treatment T_3 (18.52%) i.e., application of insecticide Shobicron 425 EC @ and combined application of micronutrients Zn and B in the T_6 treated plots respectively. Sole application of micronutrients Zn and B for the treatment T_4 and T_5 comparing with the untreated control performed intermediate level of fruit infestation by number 26.74% and 31.02%, respectively. On the other hand, the highest (53.38%) fruit infestation by number was recorded from untreated control T_7 which was followed (35.45%) by T_1 treatment.

At mid fruiting stage, the lowest (16.05%) fruit infestation by number was found in the treatment T_2 which was followed by T_6 i.e., the combined application of micronutrients Zn and B (20.33%) and T_3 treatment in which insecticide Shobicron 425 EC @ was sprayed (21.28%). On the other hand, the highest (58.02%) fruit infestation by number was found in untreated control plots T_7 which was followed (41.35%) by hand picking of infested in T_1 treatment. Sole application of micronutrient-Zn and B for the treatment T_4 (30.64%) and T_5 (35.78%) had intermediate level of fruit infestation by number. Hand picking was less effective but it was necessary that the female fruit fly lay eggs and the larvae hatch inside the fruit, it become essential to look for the available measures in the field sanitation (Nasiruddin and Karim, 1992).

Table 1. Effect of different pest management practices on fruit infestation (%) by number at different fruiting stages and reduction over control in bitter gourd

Treatment	Fruit infestation (%) by number at					Reduction over Control (%)
	Initial stage	Early stage	Mid stage	Late stage	Average	
T_1	28.75 b	35.45 b	41.35 b	47.85 b	38.35 b	31.53
T_2	12.82 d	15.26 e	16.05 f	19.50 e	15.91 f	71.59
T_3	13.33 d	18.52 e	21.28 e	23.62 e	19.19 e	65.74
T_4	18.00 c	26.74 d	30.64 d	34.55 d	27.48 d	50.94
T_5	21.38 c	31.02 c	35.78 c	40.23 c	32.10 c	42.69
T_6	13.85 d	19.05 e	20.33 e	24.14 e	19.34 e	65.47
T_7	51.24 a	53.38 a	58.05 a	61.39 a	56.01 a	--
$LSD_{(0.05)}$	3.537	4.108	3.839	4.439	1.585	--
CV(%)	8.73	8.10	6.76	9.95	12.99	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: Hand picking of infested fruits of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/liter of water at 5 days interval + T_1

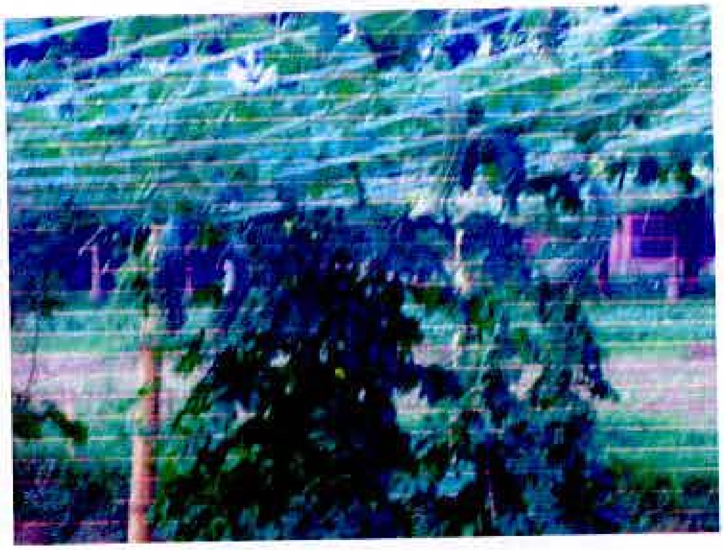
T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @6.72 kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control



A

B

Plate 1.

A. Healthy plant and fruit in neem seed kernel treated plot

B. Healthy fruit in neem seed kernel treated plot

A

B

Plate 2.

A. Healthy plant and fruit in Shobicron 425 EC treated plot

B. Healthy fruit in Shobicron 425 EC treated plot

At late fruiting stage the lowest (19.50%) fruit infestation by number was recorded for the treatment T_2 which was statistically similar (23.62% and 24.14%) with T_3 and T_6 treatment, respectively. On the other hand, the highest (61.39%) fruit infestation by number was found in T_7 treatment which was followed (47.85%) by T_1 treatment. Comparing with the untreated control and treatment T_2 and T_3 sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 and T_5 performed intermediate level of fruit infestation by number and the value was 34.55% and 40.23%, respectively. Singh and Srivastava (1985) found that alcohol extract of neem oil *Azadirachta indica* (5%) reduced oviposition of *B. cucurbitae* on bitter gourd completely. Singh and Singh (1998) evaluated neem (*Azadirachta indica)* seed kernel extract at 1.25-20% and pure azadirachtin at 1.25-10.0 ppm as oviposition deterrents to *Bactrocera cucurbitae* on pumpkin and they reported that neem seed kernal extract deterred oviposition by *B. cucurbitae* at all the concentration. Atwal (1993) suggested mechanical control measures in farmer's fields as normal practice for effective control against this pest in India and the treatment hand picking and burning had considerably lowered the infestation (average 34.08% when compared with untreated plot (average 58.39%).

In an average, fruit infestation for entire fruiting stage the lowest (15.91%) fruit infestation by number was recorded from the treatment T_2 which was followed (19.19% and 19.34%) by T_3 and T_6 treatment, respectively. On the other hand, the highest (56.01%) fruit infestation by number was recorded from T_7 treatment which was followed (38.35%) by T_1 treatment. Sole application of micronutrient Zn and B for the treatment T_4 and T_5 comparing with the untreated control had intermediate level of fruit infestation by number (27.48% and 32.10%) respectively. The application of molasses + malathion (Limithion 50 EC) and water in the ratio of 1: 0.1: 100 provides good control of melon fly (Akhtaruzzaman *et al.*, 2000). Fruit infestations by number reduction of over control for different treatments were calculated and recorded different value for different treatment. Maximum (71.59%) reduction over control was recorded from the treatment T_2 and the minimum (31.53%) reduction over control was recorded from T_1 treatment. Published literature on the possible reasons of variation of percent fruit infestation by number in different micronutrients fertilizer level is not available. Many physiological, morphological and genetically response might be responsible for this variation. Climatic factor might also play significant role in this regard. However highest number of fruit on a particular treatment may probably attract more fruit flies for infestation.

4.2 Fruit infestation by weight

Different IPM components at different fruiting stage showed significant differences for fruit infestation in bitter gourd by weight of fruit per plot for the attack of fruit fly under the present trial (Appendix III).

As shown in Table 2, at fruit initial stage lowest (10.05%) fruit infestation by weight was recorded for the treatment T_2 (application of neem seed kernel @ 5g/litre of water at 5 days interval + hand picking) which was statistically similar with T_3 (Spraying of Shobicron 425 EC @ 2ml/litre of water and hand picking of infested fruits at 7 days interval)(11.64%) and T_6 (Combined application of micronutrients Zn + B)(12.05%) treated plots. On the other hand, the highest (39.68%) fruit infestation by weight was recorded from untreated control plots T_7 which was followed (24.32%) by T_1 treatment (hand picking of infested fruits)y. Sole application of micronutrient Zn + B for the treatment T_4 (15.85%) and T_5 (19.33%) had intermediate level of fruit infestation by weight. Tin and bismath are trace elements (micronutrients) that are reported to increase the quantity of Tannin production in *Acacia catuchu*, but iron does not (Karunanithy and Kepel 1985). The improvement in growth and development of some insects with the right balance of copper, iron, manganese, zinc, boron, cobalt and molybdenum may actually be due to direct benefits to the symbionts rather than the insect (Reinecke, 1985).

At early fruiting stage, the lowest (12.85%) fruit infestation by weight was recorded from the treatment T_2 which was statistically similar (13.26% and 13.74%) with T_6 and T_3 treatment, respectively. On the other hand the highest (43.68%) fruit infestation by weight was recorded from T_7 untreated control plots which were followed (30.08%) by T_1 treatment. Sole application of micronutrient Zn + B for the treatment T_4 and T_5 comparing with the untreated control and treatment T_2 and T_3 performed intermediate level of fruit infestation by weight and the value was 19.85% and 25.22%, respectively. Hand picking was less effective but it was necessary that the female fruit fly lay eggs and the larvae hatch inside the fruit, it become essential to look for the available measures in the field sanitation (Nasiruddin and Karim, 1992).

At mid fruiting stage, the lowest (15.02%) fruit infestation by weight was recorded from the treatment T_2 which was statistically similar (16.85% and 17.11%) with T_3 and T_6 treatment, respectively. On the other hand, the highest (48.36%) fruit infestation by weight was recorded from T_7 treatment which was followed (34.77%) by T_1 treatment. Application of carbofuran granules at 1.5 kg a.i./ha at the time of sowing, veining, and flowering gave 83.35% protection to bitter gourd against *B. cucurbitae* (Thomas and Jacob, 1990). Application of either 0.05% fenthion or 0.1% carbaryl at 50% appearance of male flowers, and again at 3 days after fertilization is helpful in reducing the melon fly damage (Srinivasan, 1991). Formathion is more effective than trichlorfon (Talpur *et al.*, 1994). Diflubenzuron has also been reported to be effective in controlling the melon fly (Mishra and Singh, 1999).

Table 2. Effect of different pest management practices on fruit infestation (%) by weight at different fruiting stages during cultivation period 2006-2007

Treatment	Fruit infestation (%) by weight at					Reduction over control (%)
	Initial stage	Early stage	Mid stage	Late stage	Average	
T_1	24.32 b	30.08 b	34.77 b	38.58 b	31.94 b	30.70
T_2	10.05 d	12.85 e	15.02 e	17.22 e	13.78 e	70.10
T_3	11.64 d	13.74 e	16.85 e	19.55 e	15.44 e	66.50
T_4	15.85 c	19.85 d	22.85 d	26.93 d	21.37 d	53.63
T_5	19.33 c	25.22 c	29.94 c	31.74 c	26.56 c	42.37
T_6	12.05 d	13.26 e	17.11 e	19.08 e	15.38 e	66.63
T_7	39.68 a	43.68 a	48.36 a	52.63 a	46.09 a	--
$LSD_{(0.05)}$	3.558	4.633	3.769	2.671	1.987	--
CV(%)	10.53	11.49	8.02	5.11	4.58	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

At late fruiting stage, the lowest (17.22%) fruit infestation by weight was recorded for the treatment T_2 which was statistically identical (19.08% and 19.55%) with T_6 and T_3 treatment, respectively. On the other hand, the highest (52.63%) fruit infestation by weight was recorded from T_7 treatment which was followed (38.58%) by T_1 treatment. Application of micronutrient Zn and B alone for the treatment T_4 (26.93%) and T_5 (31.74%) had moderate level of fruit infestation by weight. Cruz (1996) evaluate different insecticide along or in mixture with micronutrients (Boron, Zinc and Molybdenum) as seed treatments for the control of maize pests and he found that the average maize yield from treated plot varied from 818 to 1414 Kg/ha, greater than the yield obtained from the control plots.

In an average fruiting infestation for entire fruiting stage minimum (13.78%) fruit infestation by weight was recorded for the treatment T_2 which was closely followed (15.38% and 15.44%) by T_6 and T_3 treatment, respectively. On the other hand the maximum (46.09%) fruit infestation by weight was recorded for T_7 treatment which was closely followed (31.94%) by T_1 treatment. Application of micronutrient-Zn and micronutrient-B solely for the treatment T_4 and T_5 comparing with the untreated control and treatment T_2 and T_3 performed intermediate level of fruit infestation by number and the value was 21.37% and 26.56%, respectively. The reason for this might be the prevalence of hindrance free activities of the fruit fly in untreated plots. As a result, the damage in majority of infested fruits incurred by larval activity inside the fruit might reach the extreme level leading to rotting of the fruits (Uddin, 1996).

Fruit infestations by weight reduction of over control for different treatments were calculated and recorded different value for different treatment. Maximum (70.10%) reduction over control was recorded from the treatment T_2 and the minimum (30.70%)

reduction over control was recorded from T_1 treatment. Treatment T_4 and T_5 gave reduction over control 53.63% and 42.37% by weight under the present trial. Fruit infestation in number was always higher than the infestation in weight (Figure 1).

4.3 Effect of temperature, rainfall and humidity on fruit infestation of bitter gourd at different harvesting time

With increasing of temperature at different harvesting time, percent fruit infestation increasing and with decreasing the temperature percent fruit infestation also followed decreasing trend (Figure 2). And it was highest in 7^{th} harvesting, when the highest mean temperature was raised at 30.35^0C. Dhillon *et al.*, (2005) found that the extents of losses vary 30 to 100% depending on the species and season and the abundance of fruit fly increases when the temperature fall bellow 32^0C. Brevault *et al.*, (2000) also reported that the developmental rate of the different life stages increased linearly with increasing temperature unto 30^0C.

Percent fruit infestation trend was found more or less similar when the mean rainfall was bellow 185 mm and the trend was increasing when the mean rainfall was more than 265 mm (Figure 2). Result also supported with the report of Hui *et al.*, (2007) they concluded that the population was depressed when the monthly mean rainfall amount was lower than 50 mm but increased when rainfall ranged from 200 to 1000 mm and when the monthly rainfall amount was higher than 628 mm; the fruit fly population was reduced remarkably. Like temperature positive effect was also found in case of relative humidity. With increasing relative humidity, percent fruit infestation increased and with the decreasing relative humidity, percent fruit infestation decreased. It was highest in 7^{th} harvesting time when the highest relative humidity was 85% (Figure 2). Dhillon *et al.*, (2005) also stated that the abundance of fruit fly increased when the relative humidity ranges between 60 to 70%.

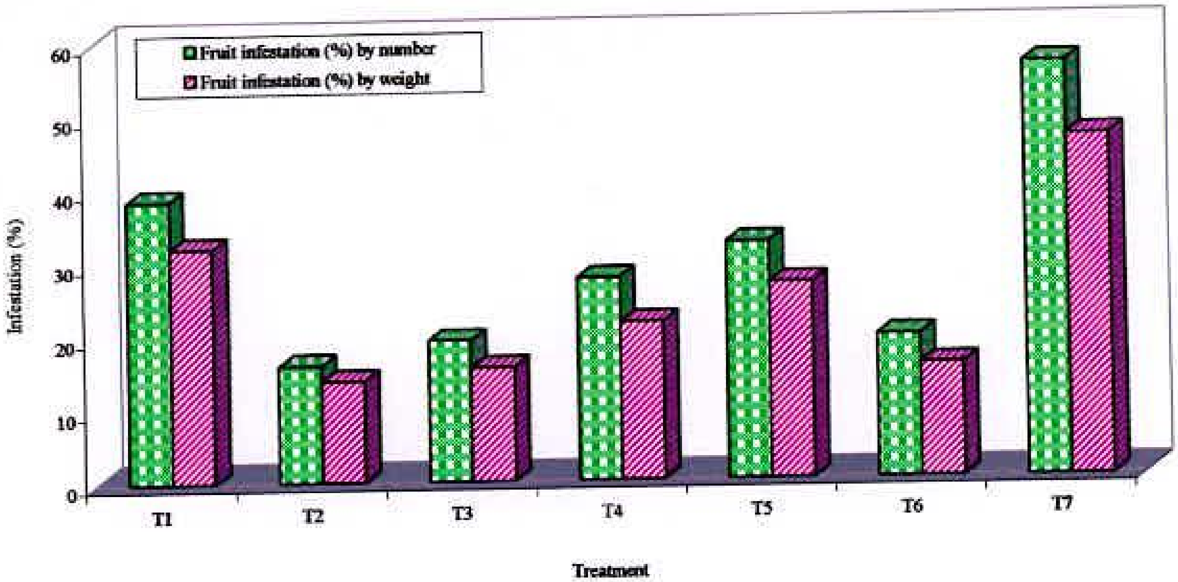


Figure 1. Fruit infestation by number and weight due to different treatment in bitter gourd

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

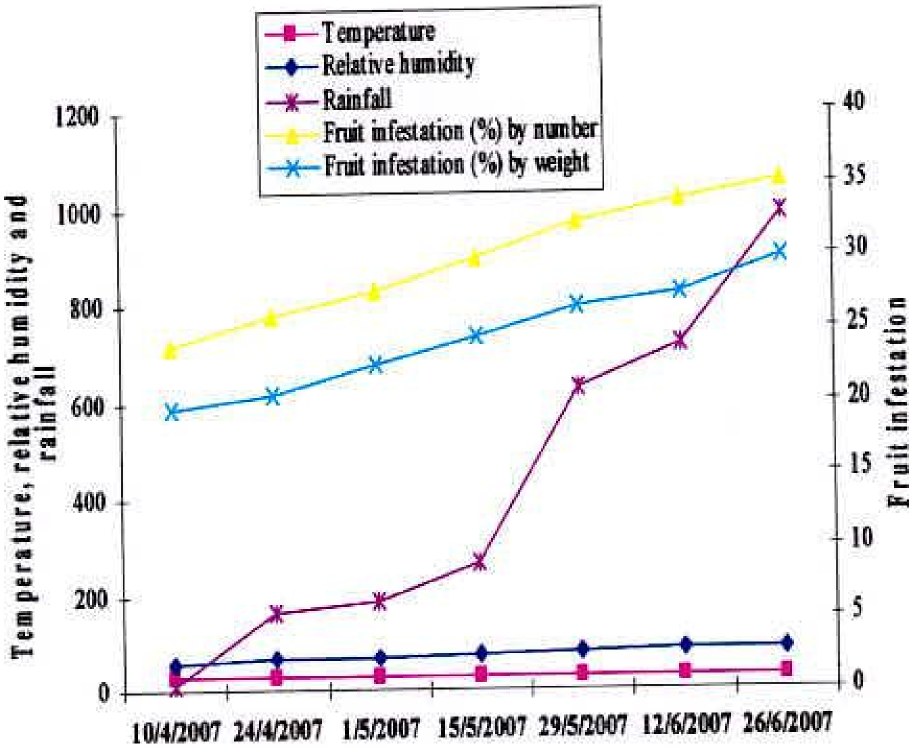


Figure 2. Relationship between fruit infestation in number and weight with average temperature, relative humidity and rainfall

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

4.3 Yield contributing characters

4.3.1 Days to flowering

The minimum (27.33) days to flowering was recorded for the treatment T_2 as application of neem seed kernel at 5 days interval + hand picking which was statistically identical (28.67 days) with T_3 and T_6 treatment as spray of shobicron at 7 days interval + hand picking and micronutrient Zn+B application. On the other hand the maximum (35.00) days to flowering was recorded for T_7 as untreated control condition which was closely followed (33.33 days) by T_1 treatment as hand picking were done for controlling fruit fly. Comparing with the untreated control and treatment T_2 and T_3 sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 and T_5 performed intermediate level of days to flowering and it was 30.33 days and 31.67 days, respectively (Table 3). Zinc affects enzyme systems that regulate various metabolic activities like protein synthesis, formation of chlorophyll, transformation of carbohydrates and regulation of the consumption of sugar in the plant. More over they played role in days to flowering, height of plant, if present in sufficient quantities in the leaf, acts like anti freeze in citrus, tomatoes and other crops (Horn and Wimmer, 2006). Days to flowering reduction over control for different treatments were calculated and recorded different value for different treatment. Maximum (21.91%) reduction over control was recorded from the treatment T_2 and the minimum (4.77%) reduction over control was recorded from T_1 treatment.

4.3.2 Number of flower per 0.25 m2

The minimum (4.22) number of flower per 0.25 m^2 was recorded for the treatment T_7 as untreated control condition which was closely followed (5.13 and 5.38) with T_1 and T_5 treatment as hand picking and micronutrient Boron application.

Table 3. Effect of different pest management practices on days to flowering & reduction over control, number of flower in 0.25 m^2 area and increase over control in bitter gourd

Treatment	Days to flowering	Reduction over control	Number of flower per $0.25m^2$	Increase over control
T_1	33.33 ab	4.77	5.13 d	21.56
T_2	27.33 d	21.91	6.15 a	45.73
T_3	28.67 cd	18.09	6.03 a	42.89
T_4	30.33 bcd	13.34	5.62 bc	33.18
T_5	31.67 abc	9.51	5.38 cd	27.49
T_6	28.67 cd	18.09	5.95 ab	41.00
T_7	35.00 a	--	4.22 e	--
$LSD_{(0.05)}$	3.31	--	0.365	--
CV(%)	6.65	--	9.73	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

On the other hand the maximum (6.15) number of flower per 0.25 m^2 was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking which was statistically identical (6.03) by T_3 treatment as spray of shobicron at 7 days interval + hand picking were done for controlling fruit fly. Sole application of T_4 and T_5 comparing with the untreated control performed next to the treatment T_2, T_6 and T_3 for flower per 0.25 m^2 and the number was 5.62 and 5.38, respectively (Table 3). Number of flower per 0.25 m^2 increase over control for different treatments was calculated and recorded different value for different treatment. Maximum (45.73%) increase over control was recorded from the treatment T_2 and the minimum (21.56%) increase over control was recorded from T_1 treatment.

4.3.3 Number of fruits per plot

Different IPM components for number of fruits per plot showed significant differences under the present trial (Appendix IV). The minimum (61.00) number of fruits per plot was recorded for the treatment T_7 as untreated control condition which was closely followed (68.00) by T_1 treatment as hand picking. On the other hand the maximum (85.00) number of fruits per plot was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking which was statistically identical (81.00) by T_3 treatment as spray of shobicron at 7 days interval + hand picking were done for controlling fruit fly. Sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 (75.00/plot) and T_5 (71.00/plot) gave medium number of fruits (Table 4). Number of fruits per plot increase over control for different treatments was calculated and recorded different value for different treatments. Maximum (39.34%) increase over control was recorded from the treatment T_2 and the minimum (11.48%) increase over control was recorded from T_1 treatment.

Table 4. Effect of different pest management practices on number of fruits per plot, weight of individual fruit and increase over control in bitter gourd

Treatment	Number of fruits per plot	Increase over control	Weight of individual fruit (g)	Increase over control
T_1	68.00 c	11.48	141.88 bc	10.53
T_2	85.00 a	39.34	172.35 a	34.27
T_3	81.00 a	32.79	168.30 a	31.12
T_4	75.00 b	22.95	151.21 b	17.80
T_5	71.00 bc	16.39	147.22 b	14.69
T_6	82.00 a	34.43	166.62 a	29.81
T_7	61.00 d	--	128.36 c	--
$LSD_{(0.05)}$	5.337	--	13.77	--
CV(%)	4.02	--	7.04	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

4.3.4 Weight of individual fruit

Different management components for weight of individual fruit showed significant differences under the present trial (Appendix IV). The minimum (128.36 g) weight of individual fruit was recorded for the treatment T_7 as untreated control condition which was closely followed (141.88 g) by T_1 treatment as hand picking. On the other hand the maximum (172.35 g) weight of individual fruit was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking which was statistically identical (168.30 g) by T_3 treatment as spray of shobicron at 7 days interval + hand picking were done for controlling fruit fly. Sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 and T_5 comparing with the untreated control and treatment T_2 and T_3 gave intermediate level of weight of individual fruit weight and the weight was 151.21 g and 147.22 g, respectively (Table 4). Weight of individual fruit increase over control for different treatments was calculated and recorded different value for different treatment. Maximum (34.27%) increase over control was recorded from the treatment T_2 and the minimum (10.53%) was recorded from T_1 treatment.

4.3.5 Yield per plot

Different pest management practices at different fruiting stage showed significant differences for yield per plot under the present trial (Appendix V).

At initial fruiting stage maximum (1430.72 g) yield per plot was recorded for the treatment T_2 as application of neem seed kernel at 5 days interval + hand picking which was statistically identical (1405.84 g, 1400.00 g and 1362.50 g) with T_3, T_6 and T_4 treatment where spraying of shobicron 250 EC @ at 7 days interval + hand picking, application of Zn + B , Zn respectively. On the other hand, the minimum (1069.48 g) yield per plot was recorded for T_7 as untreated control condition which was closely followed (1201.10 g) by T_1

treatment as hand picking were done for controlling fruit fly. Application of micronutrient-Zn and micronutrient-B for the treatment T_4 and T_5 comparing with the untreated control gave intermediate level of fruit yield per plot and the yield was 1362.50 g/plot and 1276.56 g/plot, respectively (Table 5).

At early fruiting stage, the highest (2030.93 g) yield per plot was recorded from the treatment T_2 which was statistically similar (2007.00 g and 2000.00 g) with T_3 and T_6 treatment, respectively. On the other hand, the lowest (1676.00 g) yield per plot was recorded from T_7 treatment which was statistically similar (1804.90 g) with T_1 treatment. Comparing with the untreated control, sole application of micronutrient Zn and B for the treatment T_4 and T_5 had intermediate level of fruit yield per plot and the yield was 1944.90 g and 1871.37 g, respectively.

At mid fruiting stage, the highest (2245.32 g) yield per plot was recorded from the treatment T_2 which was statistically identical (2215.48 g and 2214.00 g) with T_6 and T_3 treatment, respectively. On the other hand, the lowest (1810.56 g) yield per plot was recorded from T_7 treatment which was followed (1944.90 g) by T_1 treatment. Sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 (2108.66 g/plot) and T_5 (2003.68 g/plot) had intermediate level of fruit yield per plot.

At late fruiting stage, the lowest (2022.72 g) yield per plot was recorded for the treatment T_2 which was statistically similar (1969.36 g and 1953.88 g) with T_3 and T_6 treatment, respectively. On the other hand, the lowest (1456.50 g) yield per plot was recorded from T_7 treatment which was followed (1601.48 g) by T_1 treatment. Sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 and T_5 comparing with the untreated control and treatment T_2 and T_3 performed intermediate level of fruit yield per plot at late fruiting stage and the yield was 1843.10 g/plot and 1705.38 g/plot, respectively.

Table 5. Effect of different pest management practices on fruit yield per plot at different fruiting stage and increase over control in bitter gourd

Treatment	Fruit yield (g/plot) at the stage of				Yield (kg/plot)	Increase over control (%)
	Initiation	Early	Mid	Late		
T_1	1201.10 b	1804.90 bc	1944.90 cd	1601.48 de	6.55 d	8.99
T_2	1430.72 a	2030.93 a	2245.32 a	2022.72 a	7.73 a	28.62
T_3	1405.84 a	2000.00 a	2214.00 a	1969.36 ab	7.59 a	26.29
T_4	1362.50 a	1944.90 ab	2108.66 ab	1843.10 bc	7.26 b	20.80
T_5	1276.56 b	1871.37 ab	2003.68 bc	1705.38 cd	6.86 c	14.14
T_6	1400.00 a	2007.00 a	2215.48 a	1953.88 ab	7.58 a	26.12
T_7	1069.48 c	1676.00 c	1810.56 d	1456.50 e	6.01 e	--
$LSD_{(0.05)}$	80.98	158.5	141.1	146.6	0.239	--
CV(%)	9.48	4.68	7.82	8.58	11.91	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

Yield per plot was calculated by adding different harvest and the maximum (7.73 kg) yield per plot was recorded for the treatment T_2 which was statistically similar (7.59 kg and 7.58 kg) by T_3 and T_6 treatment, respectively. On the other hand, the minimum (6.01 kg) yield per plot was recorded for T_7 treatment which was closely followed (6.55 kg) by T_1 treatment. Sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 (7.26 kg/plot) and T_5 (6.86 kg/plot) performed intermediate level of fruit yield per plot. Fruit yield per plot increase over control for different treatments were calculated and recorded different value for different treatments. Maximum (28.62%) increase over control was recorded from the treatment T_2 and the minimum (8.99%) increase over control was recorded from T_1 treatment. Treatment T_4 and T_5 gave reduction over control 20.80% and 14.14% yield per plot under the present trial.

From the above findings it was observed that including the management practice hand picking of infested fruits with neem seed kernel or spraying of insecticide shobicron was more effective in controlling fruit fly. Cruz (1996) evaluate different insecticide along or in mixture with micronutrients (Boron, Zinc and Molybdenum) as seed treatments for the control of maize pests and he found that the average maize yield from treated plot varied from 818 to 1414 Kg/ha, greater than the yield obtained from the control plots.

4.3.6 Yield per hectare

Different IPM components for yield per hectare showed significant differences under the present trial (Appendix V). The the maximum (12.88 t/ha) yield was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking which was statistically identical (12.65 t/ha) with T_3 treatment as Shobicron at 7 days interval + hand picking were done for controlling fruit fly and the minimum (10.02 t/ha) yield was recorded for the treatment T_7 as untreated control condition which was closely followed (10.92 t/ha) by T_1 treatment as hand picking. On the other hand, Comparing with the untreated control and treatment T_2 and T_3 sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 and T_5 performed intermediate level of yield per hectare and it was 12.10 t/ha and 11.43 t/ha, respectively (Figure 3). Zinc affects enzyme systems that regulate various metabolic activities like protein synthesis, formation of chlorophyll, transformation of carbohydrates and regulation of the consumption of sugar in the plant. More over them played role in days to flowering maturation date, height of plant, if present in sufficient quantities in the leaf, acts like anti freeze in citrus, tomatoes and other crops and ultimate results was highest yield (Horn and Wimmer, 2006).

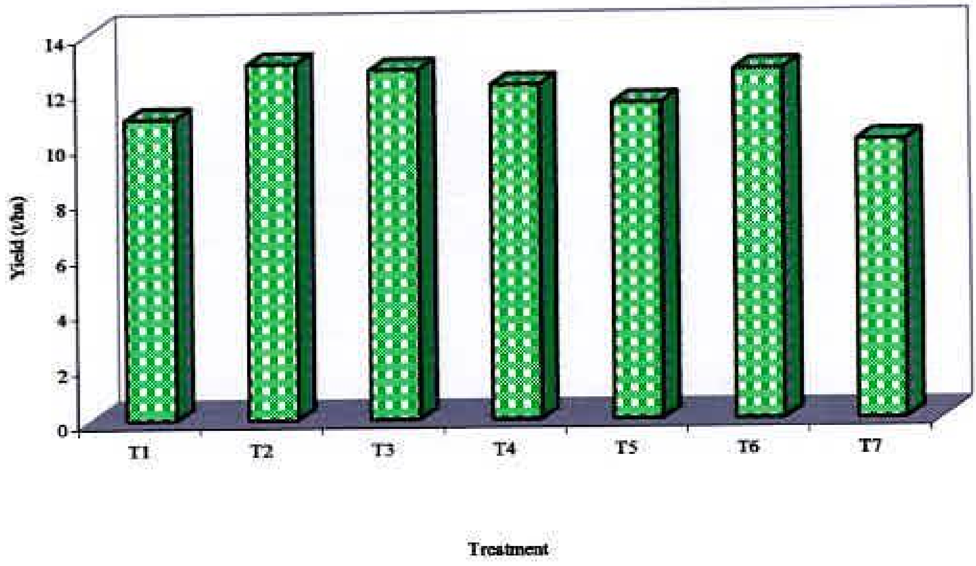


Figure 3. Effect of different treatment on yield per hectare of bitter gourd.

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

4.4. Economic Analysis of IPM component

In the study the untreated control did not have pest management cost, but rest of the components needed variable pest management costs. All these costs were calculated per hectare basis. The component (T_1) hand picking was done only involved labors cost; treatment (T_2), neem seed kernel at 5 days intervals + hand picking include neem kernel cost and mixture preparation; Component (T_3) Spray of shobicron 7 days interval + hand picking this treatment also includes the cost pesticides and other treatment include the cost of Zn and B.

The analysis was done in order to find out the most profitable management practices based on cost and benefit of various components. The results of economic analysis of bitter gourd showed that the highest net benefit of Tk. 247,600 ha^{-1} was obtained in T_6 treatment component and the second highest net benefit was found Tk. 237,000 ha^{-1} in T_4 (Table 6). The highest benefit cost ratio (9.44) was estimated for T_6 treatment and the lowest (1.06) benefit cost ration for T_3 treatment under the trial. Singh and Srivastava (1985) found that alcohol extract of neem oil *Azadirachta indica* (5%) reduced oviposition of *B. cucurbitae* on bitter gourd completely. Singh and Singh (1998) evaluated neem (*Azadirachta indica)* seed kernel extract at 1.25-20% and pure azadirachtin at 1.25-10 ppm as oviposition deterrents to *Bactrocera cucurbitae* on pumpkin and they reported that neem seed kernal extract deterred oviposition by *B. cucurbitae* at all the concentration. Atwal (1993) suggested mechanical control measures in farmer's fields as normal practice for effective control against this pest in India and the treatment hand picking and burning had considerably lowered the infestation (average 34.08% when compared with untreated control plot (average 58.39%).

Table 6. Cost of production of bitter gourd for of different IPM components in bitter gourd

Treatments	Cost of pest Management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net Return (Tk.)	Adjusted net return (Tk.)	Benefit cost ratio
T_1	8000	10.92	218400	210400	10000	1.25
T_2	22000	12.88	257600	235600	35200	1.60
T_3	25500	12.65	253000	227500	27100	1.06
T_4	5000	12.10	242000	237000	36600	7.32
T_5	5000	11.43	228600	223600	23200	4.64
T_6	5000	12.63	252600	247600	47200	9.44
T_7	0	10.02	200400	200400	--	--

T_1: Hand picking of infested fruit of bitter gourd at 7 days interval

T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + T_1

T_3: Shobicron 425 EC @ 2ml/l of water at 7 days interval + T_1

T_4: Micronutrient-Zn @ 6.72kg/ha

T_5: Micronutrient-B @ 1.96kg/ha

T_6: Micronutrient Zn + B

T_7: Untreated control

The benefit cost ratio (BCR) calculated for each of the treatment component revealed that the BCR of the treatment T_4 was (7.32) and the in the treatment component T_5 (4.64) and was followed by the treatment T_2 (1.60) and treatment T_1 (1.25), respectively (Table 6). Highest BCR was found in the treatment T_6 may be due to the less management cost compared to the other treatment components and highest yield.

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to June 2007 to utilization of pest management practices for the suppression of cucurbit fruit fly in bitter gourd. The experiment considered seven treatments and the details of the experiments were T_1: Hand picking of infested fruits of bitter gourd at 7 days interval; T_2: Neem seed kernel @ 5gm/l of water at 5 days interval + Hand picking; T_3: Spray of shobicron 425 EC @ 2ml/l of water at 7 days interval + Hand picking; T_4: Micronutrient-Zn @ 6.72 kg/ha; T_5: Micronutrient-B @ 1.96kg/ha ; T_6: Micronutrient Zn + B and T_7: Untreated control. The experiment was laid out at Randomized Complete Block Design (RCBD) with three replications. Data on fruit infestation in number and weight basis for different stage and yield contributing characters and yield were recorded.

In an average, the lowest (15.91%) fruit infestation by number was recorded from the treatment T_2, while the highest (56.01%) fruit infestation by number was recorded in T_7 treatment. Sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 and T_5 comparing with the untreated control performed intermediate level of fruit infestation by number and the value was 27.48% and 32.10%, respectively. In an average fruiting infestation for entire fruiting stage minimum (13.78%) fruit infestation by weight was recorded for the treatment T_2 and the maximum (46.09%) fruit infestation by weight was recorded for T_7 treatment and treatment T_4 and T_5 comparing with the untreated control and treatment T_2 and T_3 performed intermediate level of fruit infestation by number and the value was 21.37% and 26.56%, respectively. Fruit infestation in number was always higher than the infestation in weight

The minimum (27.33) days to flowering was recorded for the treatment T_2 as application of neem seed kernel at 5 days interval + hand picking and the maximum (35.00) days to flowering was recorded for T_7 as untreated control condition. For days to flowering the maximum (21.91%) reduction over control was recorded from the treatment T_2 and the minimum (4.77%) reduction over control was recorded from T_1 treatment. The minimum (4.22) number of flower per 0.25 m^2 was recorded for the treatment T_7 as untreated control condition, while the maximum (6.15) number of flower per 0.25 m^2 was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking. Number of flower per 0.25 m^2 the maximum (45.73%) increase over control was recorded from the treatment T_2 and the minimum (21.56%) increase over control was recorded from T_1 treatment.

The minimum (61.00) number of fruits per plot was recorded for the treatment T_7 as untreated control condition and the maximum (85.00) number of fruits per plot was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking. Number of fruits per plot the maximum (39.34%) increase over control was recorded from the treatment T_2 and the minimum (11.48%) was recorded from T_1 treatment. The minimum (128.36 g) weight of individual fruit was recorded for the treatment T_7 as untreated control condition, while the maximum (172.35 g) weight of individual fruit was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking. Maximum (34.27%) increase over control of individual fruit weight was recorded from the treatment T_2 and the minimum (10.53%) was recorded from T_1 treatment. The maximum (7.73 kg) yield per plot was recorded for the treatment T_2 and the minimum (6.01 kg) yield per plot was recorded for T_7 treatment. Sole application of micronutrient-Zn and micronutrient-B for the treatment T_4 (7.26 kg/plot) and T_5 (6.86 kg/plot) performed intermediate level of fruit yield per plot. For fruit yield per plot the maximum

(28.62%) increase over control was recorded from the treatment T_2 and the minimum (8.99%) was recorded from T_1 treatment. Treatment T_4 and T_5 gave reduction over control 20.80% and 14.14% yield per plot under the present trial. The minimum (10.02 t/ha) yield was recorded for the treatment T_7 as untreated control condition and the maximum (12.88 t/ha) yield was recorded for T_2 as application of neem seed kernel at 5 days interval + hand picking. The results of economic analysis of bitter gourd showed that the highest net benefit of Tk. 247,600 ha^{-1} was obtained in T_6 treatment component and the highest benefit cost ratio (9.44) was estimated for T_6 treatment and the lowest (1.06) benefit cost ration for T_3 treatment. Application of neem seed kernel along with hand picking of infested fruits was most effective in relation to yield and BCR while spraying of insecticide shobicron and combined application of micronutrients were comparatively better than other treatments. Thus it might be concluded that judicious use of insecticides in combination with micronutrients as well as hand picking of infested fruits would be best for bitter gourd cultivation at farmers' level.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

I. Alternative plant extract may be used for further study;
II. The use of Copper, Zinc and Boron to increase the yield and higher doses of zinc may further studied as an economic and safe IPM tool for reducing fruit fly infestation on bitter gourd;
III. Similar experiment in combination of different micronutrients and variable doses may be carried-out further to conclude about the combined effect of micronutrients on insect pests;
IV. Chemical analysis of fruits should be made out to know the amount of residues of micronutrients in plants and fruits after harvest.

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APPENDICES

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from March to July, 2007

Year	Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	Soil temperature			*Sunshine (hr)
		Maximum	Minimum			5 cm depth	10 cm depth	20 cm depth	
2007	March	31.4	19.6	54	11	24.8	26.9	26.9	8.2
	April	33.6	23.6	69	163	28.9	30.1	30.1	6.4
	May	34.7	25.9	70	185	30.5	31.4	31.5	7.8
	June	32.4	25.5	81	628	30.0	30.8	30.7	5.7
	July	33.9	26.8	85	985	31.7	32.2	31.5	5.8

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate and weather division) Agargoan, Dhaka - 1212

Appendix II. Characteristics of Experimental Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Winter Vegetable – Summer Vegetable

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis	
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

* Source: SRDI

Appendix III. Analysis of variance of the data on different pest management practices on fruit infestation (%) by number at different fruiting stages and reduction over control in bitter gourd

Source of variation	Degrees of freedom	Mean square				
		Fruit infestation (%) by number at the stage of				
		Initiation	Early	Mid	Late	Average
Replication	2	3.643	4.259	21.473	7.324	7.998
Treatment	6	569.334**	520.482**	643.817**	685.585**	592.990**
Error	12	3.953	5.331	4.657	6.227	0.794

** Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on different pest management practices on fruit infestation (%) by weight at different fruiting stages during cultivation period

Source of variation	Degrees of freedom	Mean square				
		Fruit infestation (%) by weight at the stage of				
		Initiation	Early	Mid	Late	Average
Replication	2	1.509	0.106	3.196	0.098	0.835
Treatment	6	324.285**	387.754**	442.221**	493.679**	407.655**
Error	12	4.000	6.781	4.488	2.255	1.248

** Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on different pest management practices on yield contributing characters in bitter gourd

Source of variation	Degrees of freedom	Mean square			
		Days to flowering	Flower No. /0.25m2	Fruit No./plot	Weight/Fruit
Replication	2	1.000	0.057	7.00	66.286
Treatment	6	23.048**	1.354**	222.714**	778.964**
Error	12	4.167	0.042	9.000	59.945

** Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on different pest management practices on yield in bitter gourd

Source of variation	Degrees of freedom	Yield-Initiation	Yield-Early	Yield-Mid	Yield-Late	Yield(kg/plot)	Yield (t/ha)
Replication	2	1439.448	5783.097	6476.421	125.673	0.003	0.008
Treatment	6	52680.63**	50235.988**	80547.157**	134927.82**	1.214**	3.371**
Error	12	2072.092	7935.492	6287.989	6754.188	0.018	0.051

** Significant at 0.01 level of probability