STUDY ON INSECTICIDES AND OTHER MEASURES USED BY THE FARMERS AGAINST FRUIT FLY IN BITTER GOURD

A THESIS
BY

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Registration No. 00829
Session: July- December, 2006

A THESIS

Submitted to
Sher-e-Bangla Agricultural University, Dhaka
In the partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)
IN
ENTOMOLOGY

Approved by

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CERTIFICATE

This is to certify that the Thesis entitled, "**STUDY ON INSECTICIDES AND OTHER MEASURES USED BY THE FARMERS AGAINST FRUIT FLY IN BITTER GOURD**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MOHAMMAD FORHAD ALAM** bearing **Registration No. 00829** under my supervision and guidance. No part of the Thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

(**Dr. Md. Mizanur Rahman**)

Research Supervisor

Advisory Committee

DEDICATED TO MY
BELOVED MOTHER
&
HEAVENLY FATHER

ACKNOWLEDGEMENTS

All the praises, gratitude and thanks are due to the omnipresent, omnipotent, and omniscient Allah who enabled me to complete this Thesis work successfully.

The author expresses his deepest sense of gratitude sincere appreciation to his venerable research supervisor Dr. Md. Mizanur Rahman, Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his continued guidance, support, encouragement, invaluable suggestions and scholastic supervision throughout the study period and successfully completing the research work and in the preparation of this manuscript.

The author wishes to express his sincere thanks, earnest obligation and profound gratitude to honorable co-supervisor Professor Jahanara Begum, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for planning painstaking and scholastic guidance, inestimable help, valuable suggestions and gratuitous labor in conducting and successfully completing the research work and in the preparation of the Thesis.

The author also wishes to express his grateful appreciation and thanks to Dr. Md. Abdul Latif, Associate Professor and Chairman, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh.

The author humbly desires to acknowledge his heartfelt gratitude to Professor Dr. Md. Serajul Islam Bhuiyan, Professor Dr. Mohammed Ali, and Dr. Md.

Razzab Ali, Associate Professor, Department of Entomology, SAU for all kinds of assistance and scholastic guidance to conduct the experiment and the well wishers who prayed for his success.

The author is highly grateful to other teachers and classmates under the Department of Entomology, SAU for their kind co-operation and help during the study period of MS programme. The author is also especially grateful to M. Asaduzzaman Munna for his sincere co-operation in the preparation of the Thesis.

The author also desires to acknowledge his profound respect and indebtedness to his parents, elders, younger and other members of his family and relatives for their sacrifices and blessings which can never be forgotten.

Finally, the author expresses his cordial appreciation to all his well wishers and close friends for their encouragements and inspirations during his study, research work and preparation of this thesis.

July, 2008 The author

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STUDY ON INSECTICIDES AND OTHER MEASURES USED BY THE FARMERS AGAINST FRUIT FLY IN BITTER GOURD

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ABSTRACT

Two intensive bitter gourd cultivated area, Dhaka and Norshingdi districts were selected for conducting the study. The data obtained for different characters were statistically analyzed to find out the significance of the different farmers practices and chemical used by the respondents' farmers on yield contributing characters, yield, economics return and arthropod diversity in bitter gourd. In Dhaka district, the highest sample farmers (33.00%) practiced FP_1 and the lowest sample farmers (6.67%) practicing FP_5. On the other hand in Norshingdi district, the highest sample farmers (40.00%) practiced FP_1 and the lowest sample farmers (6.67%) practiced FP_4. Fruit infestation by number and by weight varied for different FPs. In Dhaka district, the lowest fruit infestation by number and by weight was observed in FP_5 (8.46% and 7.94% respectively) while it was the highest by number and by weight (10.25% and 11.08% respectively) in FP_1. In Norshingdi district, the lowest fruit infestation by number and by weight was observed in FP_5 (8.06% and 8.13% respectively) while it was the highest by number and by weight (11.08% and 10.49% respectively) in FP_1. Considering the BCR for different farmers practices in Dhaka district, it was maximum in FP_5 (2.28) while it was minimum (2.06) in FP_1. On the other hand in Norshingdi district, the BCR was maximum in FP_5 (2.10), while it was minimum (1.85) in FP_1. Similarly chemical used by respondent farmers in Dhaka district, the highest sample farmers (33.33%) used IC_2, while the lowest sample farmers (6.67%) used IC_4. On the other hand, in Norshingdi district, the highest sample

farmers (40.00%) used IC_3 and the lowest sample farmers (6.67%) used IC_4. Again, fruit infestation by number and by weight varied for different insecticide combinations. In Dhaka district, the lowest fruit infestation by number and by weight was observed in IC_5 (8.04% and 7.39% respectively) while it was the highest by number and by weight (10.08% and 9.82% respectively) in IC_1. In Norshingdi district, the lowest fruit infestation by number and by weight was observed in IC_5 (9.11% and 8.00% respectively) while it was the highest by number and by weight (10.88% and 10.02% respectively) in IC_1. In terms of total fruit yield in Dhaka district, it was the highest in IC_5 (23.92 t/ha), while it was the lowest (21.25 t/ha) in IC_1. In Dhaka district, the BCR for the combined use of different chemical was maximum in IC_5 (2.04), while it was minimum (1.86) in IC_1. On the other hand in Norshingdi district, the BCR was maximum in IC_5 (2.06), while it was minimum (1.83) in IC_1.

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Bangladesh is predominantly an agriculture based country. The soil and climatic conditions of Bangladesh are suitable for growing numerous kinds of vegetables, cucurbits being major groups of them. Vegetables are the most important sources of vitamins and minerals. The optimum daily requirement of vegetable for a full grown person is 285g (Hossain *et al.* 1990 and Ramphall and Gill, 1990).

Vegetables are not equally produced throughout the year in the country. Most of the important vegetables are produced in winter but its production in summer is tremendously low (Anon., 1993). In summer the major vegetables grown are cucurbits. As a result, cucurbitaceous vegetables play an important role to supplement this shortage during the lag period (Rashid, 1993).

In Bangladesh, in 2003 the total production of vegetables 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 the year round. Cucurbits meet the demand to a large extent in summer season when the supplies of other vegetables are scanty. But as a part of whole vegetables, the production of cucurbits does not fulfill our total demand.

A large number of cucurbit vegetables, viz., bottle gourd, bitter gourd, sweet gourd, snake gourd, white gourd, ribbed gourd, sponge gourd, kakrol, cucumber etc. are grown in Bangladesh. Among different cucurbits, bitter gourd is one of the most important of them and it is infested by several insect pests which are considered to be the significant obstacles for the successful production. Among them, cucurbit fruit fly is the most serious pest responsible for considerable damage of cucurbits (Butani and Jotwai, 1984; Alam *et al.*, 1969). The cucurbit fruit fly *Bactrocera cucurbitae* can attack about 16 different types of cucurbit crops. Although the rate of attack varies among the crop, infestation reduced both the yield and quality of the cucurbit fruits. Other cucurbitaceous fruits may also be infested up to 50 percent (Atwal, 1993). Yield losses due to fruit infestation vary from 19 to 70 percent in different cucurbits (Kabir *et al.*, 1991).

Fruit fly is of the most serious pest of cucurbits in Bangladesh (Alam *et al.*, 1969, Akhtaruzzaman *et al.*, 2000). This pest is also known as melon fly and sometimes as cucurbit fruit fly. It was reported that *Bactrocera (Daucus) cucurbitae* and *Bactrocera (Daucus) cudata* are two species of cucurbit fruit fly which are commonly found in Bangladesh (Alam *et al.*, 1969). *Bactrocera tau* and *Dacus ciliates* have been currently identified in Bangladesh of which *Dacus ciliates* is a newly recorded one. *Bactrocera cucurbitae* is dominant in all the locations of Banladesh followed by *Bactrocera tau* and *Dacus ciliates* (Akhtaruzzaman *et al.*, 2000). The quantitative and qualitative damages due to this pest cause great economic loss to cucurbit vegetables growers almost all over the world.

The control of this menacing pest is quite difficult for its internal feeding behavior. There are various methods available to suppress the fruit fly but there is no a single such method or package to IPM which has so far been successfully utilized to suppress them for reducing its damage at an economically lower level. A cluster of methods were suggested by Kapoor (1993) to control this pest using various cultural, physical, chemical, biological and legal methods components. These methods are not always feasible and all these are not used by the growers. Each and every method has its positive and negative effects. Several authors and scientists have described and evaluated these methods in different ways with partial success (Narayanan and Batra, 1960, Mitchell and Saul, 1990, Kapoor, 1993).

It was found that 61.92% reduction of fruit fly infestation over control by spraying Dipterex 80 SP in snake gourd, but Dipterex 80 SP is banned for farmer use (Nasiruddinn and Karim, 1992). Protein hydrolysate insecticide formulations and other insecticides (Malathion, Fenitrothion and Diazinon) with molasses as attractant are being widely used for the control of fruit fly (Nasiruddin and Karim, 1992, Smith 1992, Kapoor, 1993). Some insecticides e.g. 0.05% Fenthion has been used satisfactorily in minimizing the damage to fruits and vegetables against fruit fly (Hameed *et al.*, 1980, Nair, 1986, York, 1992 and Kapoor, 1993).

Inappropriate pesticides, incorrect timing of application, and improper dosages all have resulted in high pesticide costs with little or no appreciable reduction in target pest populations. Furthermore, non-optimal and non-judicious use of pesticides may result in a series of problems related to both loss of their effectiveness in the long run and certain externalities such as pollution and health hazards. Since pesticides impart undesirable effects on the environment and human health, several countries including Bangladesh are introducing the combination of management practices approaches that are based on the natural balance between pests and natural enemies in ecological systems.

The present study was undertaken to know the bitter gourd pest problems, farmers' management practices, patterns of input use, and economic returns in order to develop a baseline to understanding socio-economic condition that influence farmers pest management practices in bitter gourd cultivation. Considering the importance of bitter gourd and the necessity to explore the above aspects, this study was undertaken with the following objectives:

Objectives:

- To investigate the effectiveness of different components of farmers' practices in managing cucurbit fruit fly in bitter gourd.
- To study in details the usage and effectiveness of the combinations of insecticides in combating cucurbit fruit fly and their impact on arthropod diversity in bitter gourd.
- To know economics of the farmers' practices and chemicals used by the respondent farmers in the study areas.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Cucurbit fruit fly is the most damaging pest of cucurbit fruits and vegetables and hence, it is considered as an important obstacle for economic production of these crops. It causes great yield reduction. Substantial works have been done globally on this pest regarding their origin, distribution, biology, seasonal abundance, host range, nature of damage, yield loss, talc of infestation and control measures. The information related to the studies reviewed is given below under the following sub-headings.

2.1. Origin and distribution of cucurbit fruit fly

Fruit flies are distributed all over the world and infest a large number of host plants. The distribution of a particular species is limited perhaps due to physical, climatic and gross vegetational factors, but most likely due to host specificity. Such species may become widely distributed when their host plants are widespread, either naturally or cultivation by man (Kapoor 1993). Two of the world's most damaging tephritids *Bactrocera (Dacus) dorsalis* and *Bactrocera (Dacus) cucurbitae*, are widely distributed in Malaysia and other South East Asian countries (Vijaysegaran 1987). Gupud (1993) has cited references of five species of fruit fly in Bangladesh e.g., *Bactrocera brevistylus* (melon fruit fly), *Dacus* (Zeugo *Dacus*) caudatus (fruit fly) *D.* (*strumeta*) *cucurbitae* (melon fly), D. (Bractrocera) *dorsalis Hendel* (mango fruit fly) and D. (*Chacto Dacus*) zonatus (zonata fruit fly).

According to Akhtaruzzaman *et al.* (2000) *Bactrocera cucurbitae* . *Bactrocera tau* and *Dacus ciliatus* have been currently identified in Bangladesh of which *Ducus ciliutus* is a new record. *Bactrocera cucurbitae* is dominant in all the locations of Bangladesh followed by *Bactrocera tau* and *Dacus cilialus*.

Fruit fly is considered to be the native of oriental, probably India and South East Asia and it was first discovered in the Yaeyama Island of Japan in 1919 (Anon., 1987). However, the fruit fly is widely distributed in India, Bangladesh, Pakistan, Myanmar, Nepal, Malaysia, Chin, Philippines, Formosa (Taiwan), Japan, Indonesia, East Africa, Australia and Hawaiian Island (Atwal 1993).

Although, this pest is widely distributed, it does not occur in the UK, central Europe and continental USA (McKinlay *et al.* 1992). Kapoor (1993) reviewed that fruit fly was originally reported from Hawaii and now widely distributed throughout the oriental region including China, Japan, much of the pacific region including New Guinea, Soloman and Bismark islands, Australia, Mauritius, East Africa, Kenya and Tanzania.

2.2. Host range of fruit fly

Many fruit fly species do serious damage to vegetables, oil-seeds, fruits and ornamental plants. In Bangladesh, Alam *et al* (1969) recorded ten cucurbit vegetables as the host of fruit fly. Tomato, green pepper, papaya, cauliflower, mango, guava, citrus, pear, fig and peaches are also infested by fruit fly (Anon., 1987 and Atwal, 1993).

Sixteen species of plants act as the host of fruit flies among which sweet gourd was the most preferred host of both *Bactrocera cucurbitae* and *Bactrocera tau*. Among flowers the rate of infestation was greater in sweet gourd but the intensity was higher in bottle gourd (Kabir *et al.*, 1991).

Batra (1968) listed as many as 70 hosts of fruit fly species, whereas. Christenson and Foote (1960) reported more than 80 kinds of vegetables and fruits as the hosts. Batra (1968) observed that the male flowers and flowers bud of sweet gourd were found to serve as usual host with anthers being the special food for the larvae and only occasionally small sweet gourd fruits attacking perhaps through the female flower.

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

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

2.3. Seasonal abundance of fruit fly

The population of fruit fly fluctuates throughout the year and the abundance of fruit fly population varies from month to month, season to season, even year to year depending upon various environmental factors. The fly has been observed to be active in the field almost throughout the year where the weather is equable (Narayan and Batra, 1960). Tansaka *et al.* (1978) reported that population of melon fly was increased in autumn and decreased in winter in Kikai islands, Japan.

Narayan and Batra (1960) reported that most of the fruit fly species are more or less active at temperatures ranging between 12°C-15°C and become inactive below 10°C. Cucurbit fruit fly normally increases their multiplication when the temperature goes below 15°C and relative humidity varies from 60-70 % (Alam *et al.*, 1969). Nasiruddin (1991) observed that the incidence of fruit flies was the highest in February and the lowest in September.

The fruit fly population is generally low during dry weather and increases with adequate rainfall (Butani and Jotwani, 1984). The peak population of fruit fly in India is attained during July and August in rainy months and January and February in clod months (Nair, 1986). The adults of melon fly *Bactrocera cucurbitae* over winter November to December and the fly is the most active during July to August (Agarwal *et al.*, 1987). Fruit fly populations were in general positively correlated with temperature and relative humidity. In 1995, Amin observed the highest population incidence at ripening stage of cucumber in Bangladesh.

2.4. *Life history of fruit fly*

The adult fly (*Bactrocera cucurbitae*) is about 8 mm in body length; reddish brown with yellow stripes on its dorsal thorax and has brown spots along the veins otherwise clear wings (Plate-1). In late ours of the day, the female flies lay eggs on the tender fruits. The eggs lay by *Bactrocera cucurbitae* inside the fruit, which are creamy, white in color; oblong; banana shaped and is about 1.3 mm in length (Anon., 1987). Eggs are normally inserted under the skin of the fruits, vegetables, nuts or fleshy parts of plants, stems or flowers where they are protected from sun (Feron *et al.* 1958). The maggots feed inside List after hatching from the eggs. The creamy white maggot gradually becomes darker as it matures. The length of the mature larvae is about 12 mm. the full grown larvae come out of the bores and make a loop holding the last abdominal segment by mouth hook and drop forcely on the soil by releasing their mouth hook for pupation. This phenomenon takes place usually in the early morning between 6:00 am to 9:00 am. The most of the full grown larvae penetrate the soil rapidly and pupate -under the soil surface. The larval period is 4-7 days, varying with temperature, nutritional condition, larval rearing density etc. (Anon., 1987). Puparium formation may require as little as one hour and complete pupal formation within the puparium by less than 48 hours (Christenson and Foote, 1960). The larvae spend 4th instars in the puparium formed by the exuviae's of the 3rd instar and subsequently become pupae. The puparium is 4.8 to 6.0 mm in length. At 23-25°C the pupal stage lasts for 8-12 days. At 27 °C the mean pupal period for *Bactrocera* dorsalis and Ceratitis capitata (Wiedemann) is 10 days and that for *Bactrocera cucurbitae* is 9 days (Mitchell *et al.*, 1965).

Plate 1. An Adult cucurbit fruit fly of bitter gourd

Mating between the adult melon fruit flies generally takes place at about dusk and last for about an hour or more (Narayan and Batra, 1960). Mating starts in the evening and continues till dawn. Melon Flies may mate every 4-5 days. Females found to lay eggs up to 7-10 days. Eggs are laid @ 7-10 per female per day. A female melon fly can lay a total of 800-9000 eggs during her life span with approximately 50% fertility (Vargas *et al.*, 1984). The pre-oviposition period of *Dacus* (Strumeta) ferrugeneus is two to five days but it may range from ten to fifteen days or longer in varying conditions of climate and diet. In another report of Butani and Jotwani (1984) indicates that the pre-oviposition period of melon fly lasts for 9-12 days.

A single life cycle is completed in 10 to 18 days but it takes 12 to 13 weeks in winter. Adult longevity is 2 to 5 months; females live longer than males. Generally, males die soon after fertilizing the females, whereas, females die after Nair (1986) reported that the flies, which emerge in the morning hours, oviposit for four days in autumn and nine to thirty days in winter. Adults begin to copulate 9-12 days after emergence and the longevity of adult fly is one to five months in the laboratory and under the optimum condition, the length of one generation is around one month (Anon., 1987).

2.5. Nature of damage of fruit fly

According to Janjua (1948) the nature of infestation of fruit fly varies with the Kinds of fruits. Shah *et al.* (1948) and York (1992) observed the formation of brown resinous deposits on fruits as the symptom of infestation. The insertion of the ovipositor causes wounds on the fruits or vegetables in the form of puncture. The adult female lays eggs just below the epidermis or sometimes a little deeper in the pulp, and/or sometimes on young leaves or stems of the host plants. After that fluid substance oozes out which transform into a brown resinous deposits. After hatching, the larva feed into pulpy tissues and make tunnels in fruits causing direct damage.

They also indirectly damage the fruits by contaminating it with frass and accelerate rotting of fruits by pathogenic infection. Infested fruits if not rotten, become deformed and hardy, which make it unfit for consumption. The fly also attacks flowers and the infested flowers often become juicier and drop from the stalk at slight jerk Kabir *et al.* (1991).

According to Kapoor (1993), some flies make mines and a few form galls on different Darts of the plants. Singh (1983) reviewed that the maggots bore and feed inside the fruits causing sunken discolored patches, distortion and open cracks. Affected fruits prematurely ripe and drop from the plants. The cracks on fruits serve as the predisposing factor to cause pathogenic infection resulting in decomposition of fruits.

2.6. Infestation & yield loss by fruit fly

According to the reports of Bangladesh Agricultural Research Institute (BARI), rate of fruit fly infestation were 22.45, 41.88 and 67.01 % for snake gourd, Bitter gourd and musk melon, respectively (Anon., 1988). Experiment revealed that fruit flies attack melon and teasel gourd within 1 to 11 and 3 to 11 days after fruit setting when the average fruit size ranged from 1.38 x 0.78 cm to 3.53 x 2.07 cm and 2.13x1.18 cm to 4.98 × 3.1 cm respectively (Anon., 1988). Maximum infestation (26.67%) in melon occurred in the 4th day after fruit setting when average fruit size was 2.03 ×1.08 cm. In teasel gourd, it was 19.28% on 8th day after fruit setting when average fruit size was 4.57 x 2.91 cm (Anon., 1988). Amin (1995) and Uddin (1996) observed 42.08 and 45.14% fruit fly infestation in cucumber, respectively.

Borah and Dutta (1997) studied the infestation of tephritids on the cucurbits in Assam, India and obtained the highest hest fruit fly infestation rate in snake gourd (62.02%). Larger proportion of marketable fruits was obtained from ash gourd in and bottle gourd in summer season. Snake gourd and pumpkin yielded the lowest proportion of marketable fruits. Gupta (1992) investigated the rate of infestation of *Dacus cucurbitae* (*Bactrocera cucurbitae*) and *Dacus tau* on cucurbit in India during 1986-87 and recorded that 80% infestation on cucumber and bottle gourd in July-August and 50% infestation on bitter gourd, 501o infestation on sponge gourd in August-September. Lee (1972) observed that the rate of infestation in bottle gourd and sweet gourd flowers were 42.2 ± 8.6% and 77.1 ± 3.5%, respectively the highest in sweet gourd (32.5±3.9) and the lowest in sponge gourd (14.7± 4.0).

York (1992) reviewed that the loss of cucurbits caused by fruit fly in South East Asia might be up to 50%. Kabir *et al.* (1991) reported that yield losses due to fly infestation varies in different fruits and vegetables and it is minimum in cucumber (19.19%) and maximum in sweet gourd (69.96%). The damage caused by fruit fly is the most serious in melon after the first shower in monsoon when the often reaches up to 100%. Other cucurbit might also be infected and the infestation might be gone up to 50% (Atwal, 1993). Shah *et al.* (1948) reported that the damage done by fruit flies in North West Frontier Province (Pakistan) cost an annual loss of over $ 655738.

2.7. Management of fruit fly

Fruit fly is the most damaging factor of cucurbits almost all over the world. Although there are various methods are available to combat this cost, there is not a single such method which has so far been successfully reduced the damage of fruit fly. This perhaps, is mainly due to the polyphagous nature of these pests that helps their year round population build up. The available literatures on the measures for the controlling of these flies are discussed under the following sub-headings:

2.7.1. Cultural Control

Cultural methods of the pest control aim at reducing, insect population encouraging a healthy growth of plants or circumventing the attack by changing various agronomic practices (Chattopadhyay, 1991). The cultural practices used for controlling fruit flies were described by the following headings.

2.7.2. *Ploughing of soil*

In the pupal stage of fruit fly, it pupates in soil and also over winter in the soil. In the winter period, the soil n the field s turned over or given a light ploughing; the pupae underneath are exposed to direct sunlight and killed. They also become a prey to the predators and parasitoids. A huge number of pupae are died due to mechanical injury during ploughing (Agarwal *et al.*, 1987; Chattopadhyay, 1991; Nasiruddin and Karim, 1992; Kapoor, 1993).

2.7.3. Field sanitation

The female fruit fly lay eggs and the larvae hatch inside the fruit, it becomes essential to look for the available measures to reduce their damage on fruit. One of the Safety measures is the field sanitation (Nasiruddin and Karim, 1992)

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).

According to Kapoor (1993), in this method of field sanitation, the infested fruits on the plant or fallen on the ground should be collected and buried deep into the soil or Cooked and fed to animals. Systematic picking and destruction of infested fruits in Proper manner to keep down the population is resorted to reduce the damages caused by fruit files infesting cucurbits, Guava, mango, peach etc. and many borers of plants (Chattopadhyay, 1991).

2.7.4 Mechanical control

Mechanical destruction of non-economic and non-cultivated alternate wild host plants reduced the fruit fly populations, which survive at times of the year when their cultivated hosts are absent (Kapoor, 1993). Collection and destruction of infested fruits with the larvae inside helped population reduction of fruit flies (Nasiruddin and Karim, 1992).

2.7.5 Bagging of fruits

Sometimes each and every fruit is covered by a paper or cloth bag to block the contact of flies with the fruit thereby protecting from oviposition by the fruit fly and it is quite useful when the flies are within the reach and the number of fruits to be covered are less and it is a tedious task for big commercial orchards Kapoor (1993). Bagging of the fruits against *Dacus* (*Bactrocera*) *cucurbitae* greatly promoted fruit quality and the yields (net income increased by 45 and 58% respectively in bitter gourd and 40 and 45% in sponge gourd (Fang, 1989). Covering of fruits by polythene bag is an effective method to control fruit fly in teasel gourd and the lowest fruit fly incidence in teasel gourd occurred in bagging. Fruits (4.2%) while the highest (39.35) was recorded in the fruits of control plot (Anon., 1988). Amin (1995) obtained significantly lowest fruit fly infestation (4.61%) in bagged cucumber compared to other chemical and botanical control measures.

2.7.6 Fruit picking

Systematic picking and destruction of infested fruits in proper manner to keep down the population is resorted to reduce the damages caused by fruit flies infesting cucurbits, guava, mango, peach etc. and many borers of plants (Chattopadhyay, 1991).

2.7.7 Wire netting

Kapoor (1993) reviewed that fine wire netting may sometimes be used to cover small orchards. Though it is a costly method, but it can effectively reduce the fruit fly infestation and protect the fruit from injury and deform, and also protects fruit crops against vertebrate pest.

2.7.8 Chemical control

The method of insecticide application is still popular among the farmers because of its quick and visible results but insecticide spraying alone is not yet becomes a potential method in controlling fruit flies. There are number of studies on the application of chemical insecticide in the form of cover sprays, bait sprays, attractants and repellents have been undertaken globally. Available information relevant these are given below:

2.7.9 Cover spray of insecticide

A wide range of organophosphoras, carbamate and synthetic pyrethroids of various formulations have been used from time to time against fruit fly (Kapoor, 1993). Spraying of conventional insecticide is preferred in destroying adults before sexual maturity and oviposition (Williamson, 1989). Kapoor (1993) reported that 0.05% Fenitrothion, 0.05% Malathion, 0.03% Dimethoate and 0.05% Fenthion have been used successfully in minimizing the damage to fruit and vegetables against fruit fly but the use of DDT or BHC is being discouraged now. Sprays with 0.03% Dimethoate and 0.035% Phesalone were very effective against the fruit fly (Pareek and Kavadia, 1988). Fenthion, Dichlorovos, Phosnhamidon and Endosulfan are effectively used for the control of melon fly (Agarlwal *et al.*, 1987). In field trials in Pakistan in 1985-86, the application of Cypermethrin 10 EC and Malathion 57 EC at 10 days intervals (4 sprays in total) significantly reduced the infestation of *Bactrocera cucurbitae* on Melon (4.8-7.9) compared with untreated control. Malathion was the most effective insecticide (Khan *et al.*, 1992).

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

Nasiruddin and Karim (1992) reviewed that comparatively less fruit fly infestation (8.56%) was recorded in snake gourd sprayed with Dipterex 80SP compared to those in untreated plot (22.48%). Pawer et *al.* (1984) reported that 0.05% Monocrotophos was very effective in controlling *Bactrocera cucurbitae* in muskmelon. Rabindranath and Pillai (1986) reported that Synthetic pyrethroids, Permethrin, Fenvelerate, Cypermethrin (@ 100g a.i./ha) and Deltamethrin (@ 15g a.i/ha) were very useful in controlling *Bactrocera cucurbitae*, in bitter gourd in South India. Kapoor (1993) listed about 22 references showing various insecticidal spray schedules for controlling for fruit flies on different plant hosts tried during 1968-1990.

2.7.10 Bait spray

Protein hydrolysate insecticide formulations are now used against various dacine fruit fly species (Kapoor, 1993). New a day, different poison baits are used against various *Dacus* species which are 20 g Malathion 50% Or 50 ml of Diazinon plus 200 g of molasses in 2 liters of water kept in flat containers or applying the bait Spray containing Malathion 0.05% plus 1% sugar/molasses or 0.025% of protein hydrolysate (20m lof malathion 50Ec and 200g of sugar /molasses in 50 litres of water)or spraying plants with 500 g molasses plus 50 g Malathion in 50 liters of water or 0.025% Fenitrothion plus 0.5% percent molasses.

This is repeated at weekly intervals where the fruit fly infestation is serious (Kapoor, 1993). Nasiruddin (1991) reported that bait spray (1.0 g Dipterex 80SP and 100 g of molasses per liter of water) on snake gourd against fruit fly (*Bactrocera cucurbitae*) showed 8.50% infestation compared to 22.48% in control.

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

Agarwal *et al.* (1987) achieved very good results for fruit fly (*Dacus cucurbitae*) management by spraying the plants with 500 g molasses and 50 litres of water at 7 days intervals. According to Steiner *et al.* (1988) poisoned bait containing Malathion and protein hydrolysate gave better results in fruit fly management program in Hawaii.

2.7.11 Attractants and others

The fruit flies have long been recognized to be susceptible to attractants. A successful suppression program has been reported from Pakistan where mass trapping with Methyl eugenol, from 1977 to 1979, reduced the infestation of *Bactrocera* zonata below economic injury levels. *Bactrocera* dorsalis was eradicated from the island of Rota by male annihilation using Methyl eugenol as attractant (Steiner *et al.*, 1988).

The attractant may be effective to kill the captured flies in the traps as reported several authors, one percent Methyl eugenol plus 0.5 percent Malathion or 0.1 percent Methyl eugenol plus 0.25 percent Malathion have been used for the trapping the oriental fruit fly, *Bactrocera dorsalis* and *Bactrocera zonata*.

Neem beriatives have been demonstrated as repelients, antifeeedants, growth inhibitors and chemosterilant (Butterworth and Morgan, 1968). Singh and Srivastava (1985) found that alcohol extract of neem oil Azadirachta indica (%) reduced oviposition of *Bactrocera cucurbitae* on bitter gourd completely and its 20% concentration was highly effective to inhibit ovipositon of *Bactrocera* zonata on guava. Stark *et al.* (1990) studied the effect of Azadiractin on metamorphosis, longevity and reproduction of *Ceratilis capitala* (Wiedemann), *Bactrocera cucurbitae* and *Bactrocera dorsalis.*

2.7.12 Use of Sex pheromone in management of fruit fly

Results of an experiment on monitoring the sweet potato weevil in the farmers' field by sex pheromones at the river belt of Jamalpur revealed that sweet potato weevils were a problem in this area. The idea on the weevil population density in the field can guide the farmers to schedule their proper management Anon, Cheng, and Struble, (1982) conducted an experiment on field evaluation of black light, Incl sex attractant traps for monitoring seasonal distribution of the dark sided cutworm (Lepidoptera : Noctuidae) in Ontario. Of these, the dark sided cutworm, *Euxoa messoria*, as expected, was the most numerous over the 5- year study. These results proved, further, that the sex attractant trap is highly specific.

The effect of the height of sex attractant traps on catches of *male E. messoria* moths in the field was consistent among the years. In general, all baited traps, regardless of the height, caught significantly more moths as compared with the unbaited traps. Although there were no significant differences between the catches of traps set at 1.0 m and 0.5 m above the ground level, traps set at 0.5 m tented to capture more moths than the traps at 1.0 m above the ground level. The unbaited traps occasionally captured a moth by chance.

Results of initial test comparing sex attractant with black light traps are presented. In the 5-year test, all sex attractant trap catches, regardless of the height, were much greater than blacklight trap catches. During the study period, the sex attractant traps captured 3155 male *E. messoria* moths, while the black light traps captured 205 *E. messoria* moths. The data clearly indicate that the sex attractant traps were more effective than the black light traps for trapping moths of *E. messoria* in an open field. This make them superior to black light traps for monitoring population of this species especially considering their species specificity, low cost and convenience Cheng and Struble (1982). The sex attractant traps provide more exact information about the activity of the *E. messoria* populations than the black light traps and they should be valuable aid in predicting outbreaks of this pest. In addition this technique can easily be fitted into a system of integrated pest management program the monitoring station or farm level.

Kehat *et al*. (1998) observed that suppression of mating of *H. armigera* females was high throughout the entire test (49 days), even at high population levels, particularly with the two-component blend (mixture of two pheromone component) and it was significantly better than that obtained with the five-component (mixture of five pheromone component) blend. When percentage mating was determined by using six to eight mating tables per plot each containing one female, the two-component blend was, again, very effective but on two occasions (days 26, 34) there was a low percentage of mating. The five component blend was, in this case, clearly inferior to the two-component blend and low percentages of mating (15-30%) were observed more often. Statistical analysis indicated that the use of six to eight mating table each containing one female per table, was significantly more sensitive in detecting percent mating than the use of two mating tables, each containing five to seven females. Each of the two methods showed that the binary blend was significantly better in disrupting mating of *H. armigera* than the five-component blend. On test 2 mating of *P. gossypiella* females in the HPROPE treated plot were completely suppressed throughout the entire test (161 days). Mating percentages of sentient females in the control were low in this test. On test 3, this mating disruption test was conducted only against *P. gossypiella*, using "PBW rope L" pheromone. It was sufficient to achieve complete suppression of male captures and of mating during the 75 days of the field experiment.

Mating disruption of Yellow Stem Borer (YSB) by pheromone was tested by Cork *et al.* (1992) and they observed the tiller and particle assessments and the effects of mating on final yield. In order to compare damage estimates for the treatment plot for DH (Dead heart), and WH (White heads), data from 21 to 41 DAT and 69 to DAT respectively, were used. The results show that the level of DH damage in the farmers' practice plot was lower than that in either the untreated control pheromone treated plots, but the differences were not statistically significant. However, the levels of WH damage recorded in the farmers' practice and the untreated control plots were significantly higher than that observed in the pheromone treated plot.

Islam (1994) conducted an experiment on trapping of the male pulse beetle, *Callosobruchus chinensis (L.)* (Coleoptera: Bruchidae), in the laboratory using crude extract of female sex pheromone and observed the trapping efficiency of a new plastic trap developed for *Callosobruchus chinensis* On the result of male response to pheromone baited traps Containing crude female extract or live females he observed that there was no significant difference between the number of males caught with crude female extract or live females.

Tamaki *et al.* (1983) conducted an experiment on impact of removal of males with sex pheromone baited traps on suppression of the peach twig borer, *Anarsia lineatella* (Zeller). Male removal sex pheromone - baited traps has been successful in reducing damage caused by the red banded leafroller, *Agrotaenia velutinana* (Walker), the grapeberry moth, *Endopiza viteana* Clemens. However, in few of these cases has the amount of damage observed been at or below corn commercially acceptable levels.

In Bangladesh the adoption of sex pheromone traps by Syngenta Bangladesh Ltd. has been paralled by the govt. of Bangladesh's adoption of the concept of IPM (Integrated Pest management) whereby the more toxic pesticides are replaced by sustainable and environmentally benign mean of pest and disease control. IPM provides a role for alternative approaches such as cultural methods, use of predators, viruses and use of sex pheromone etc. Syngenta in Bangladesh in collaboration with UK's Department for International Development (DFID) and BRRI (Bangladesh Rice Research Institute) made program on mass trapping by sex pheromone to control Yellow Stem Borer (YSB) of rice in Comilla and Mymensingh districts for 2001-2003. The traps used in their program are inexpensive, easy to maintain and catch only male YSB. Farmers involved in the trials were so enthusiastic that they wanted pheromone for use on their other crops.

To make the pheromone component, E-11 hexadacenyle acetate and E-11-hexadacene-1.ol were used from 10: 1 to 100:1 ratio. A tube filled with 2-3 mg of mixture was used in a trap for 6 weeks and it proved a significant result to reduce the population bellow the economic injury level.

2.7.13 Integrated management of fruit fly

An attempt for developing IPM program or packages(s) related experiments are very few almost everywhere in the world. Uddin (1996) studied the comparative effectiveness of three IPM packages vix., the IPM package 1 consisting of barrier + yellow pan trap + bagging of fruits. IPM package 2 comprising Malathion spray (Hilthion 57EC @ 2ml/liter fo water) plus mechanical control and IPM package 3 containing bait spray (@ 25g of molasses, 2.5 ml of Hilthion 57EC and 2.5 liter of water). Plus treating soil with Diazinon 14G (@ 2g/plot) in reducing the infestation level of fruit fly, red pumpkin beetle and aphids on cucumber. To investigate *Bactrocera cucurbitae* control at different places of Nepal during 1996-97, a survey among 32 farmers indicated the great loss in the productivity of cucurbit vegetables. Use of pheromone traps (cue-lure) and field sanitation proved very effective. Integrated control (pheromone traps, field sanitation and bagging of individual fruits) in marrows showed varietal difference (Jaiswal *et al.*, 1997).

Chapter III

Methodology

CHAPTER III

METHODOLOGY

The experiment was conducted in two intensive bitter gourd cultivated areas of Dhaka and Norshindi districts. These two areas have a long history of growing vegetables, especially bitter gourd. A total of 30 farmers were interviewed during May to November, 2007.

3.1 Selection of survey locations and their characteristics

Two locations from each district and 15 farmers from each location were selected randomly for questionnaire survey. For the purpose of determine the recent insecticide use pattern; farmers who did not grow bitter gourd over the last five years were not selected. Objective-oriented, structured questionnaires were used to identify socio-economic status of the bitter gourd growers, different pest problems, pest management practices, chemicals used by the farmers and economic returns associated with cucurbit cultivation. All the villages under Dhaka and Norshingdi district belong to AEZ 28. The prevailing temperatures, relative humidity and annual rainfall in the survey sites of Savar were 18.2-33.0^{0}C, 83.5% and 1,405 mm respectively while those in the survey site of Norshingdi were 17.3-33.4^{0}C, 85.2% and 1,485 mm, respectively.

3.2 Selection of farmers and their characteristics

The study was conducted staying close contact of the bitter gourd growers for the entire harvesting period and a pre-tested survey instrument was used for the collection of data during growth stage of bitter gourd. Several factors were hypothesized to affect pesticide misuses during the cropping seasons, including producer characteristics, farm structure and management and pesticide and pest management perceptions. Among producer characteristics, the specific variables included in the model are: area, land holding status, training receiving status, age of the growers, education level of the growers, how long they have been engaged in bitter gourd cultivation, variety used by the respondents, information on insects and pests, insect diversity, application of insecticides, nature, interval, methods etc.

All the collected information's were tabulated, checked and analyzed by using descriptive statistical methods, including the computer based statistical package SPSS (Statistical Package for Social Sciences).

3.3 Data processing and analysis

For impact assessment, different farmers' practices and chemical used were identified and their impacts on cucurbits growing were assessed. For district level information it was analyzed by considering three villages from each district in three replications.

The data obtained for different characters were statistically analyzed to find out the significance of the different farmers practices and chemical used by the respondents' field on yield contributing characters, yield, economical return and arthropod diversity in cucurbits. Data were analyzed by ANOVA-2 in RCBD for each set of test separately and the means were separated by DMRT (Duncan's Multiple Range Test) at 5% level of probability.

3.4 Economic analysis of IPM tools

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

Treatment wise management cost

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

Yield of yard long bean

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

Gross return

This was measured by multiplying the total yield by the unit price of yard long bean at the cultivation period.

Adjusted net return

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

Benefit cost ratio (BCR)

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

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

Chapter IV

Results and discussion

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Farmers' Practices for managing cucurbit fruit fly in bitter gourd

The farmer's practices (FPs) for bitter gourd pest management as reported by all of the 30 sample farmers from the study areas of the two districts together were primarily divided into different group. Accordingly, the study reveals a total of 5 farmer's practices (FPs) for cucurbits fruit fly management in bitter gourd, which may be designated as follows:

FP_1 : Chemical (Insecticides)

FP_2 : Chemical, Mechanical (Removal of infested shoots and fruits)

FP_3 : Chemical, Mechanical, Cultural (Earthing up, irrigation, weeding and manuring)

FP_4 : Chemical, Mechanical, Field sanitation (Clean old and fallen leaves) and

FP_5 : Chemical, Mechanical, Cultural, Field sanitation

The sample farmers altogether from two sample districts and those from each sample districts practicing the FPs have been shown in Table 1. In Dhaka district, the highest sample farmers (33.00%) practicing FP_1 followed by FP_3 (26.67%) and FP_2 (20.00%) whereas the lowest sample farmers (6.67%) practicing FP_5 followed by FP_4 (13.33%). On the other hand, in Norshingdi district, the highest sample farmers (40.00%) practicing FP_1 followed by FP_3 (26.67%) and FP_2 and FP_5 (13.33%) whereas the lowest sample farmers (6.67%) practicing FP_4. The above findings indicate that the use of chemicals still highly dominate in the farmers' practice for the management of fruit fly of cucurbits in all the districts. However, a slight change has occurred in the sole reliance on insecticide with some inclusion of some other options like cultural practice, mechanical control and field sanitation. But surprisingly, the options like mechanical control, cultural practices and field

Table 1. Farmers' practices for fruit infestation management and their effects on farmers' practice and fruits infestation of bitter gourd in the study areas during May to November, 2007.

Farmer practices	Practicing farmers (%)		Fruits infestation by number (%)		Fruits infestation by weight (%)	
	Dhaka	Norshingdi	Dhaka	Norshingdi	Dhaka	Norshingdi
FP_1	33.00 a	40.00 a	10.25 a	11.08 a	10.02 a	10.49 a
FP_2	20.00 c	13.33 c	10.02 a	10.84 a	9.45 b	10.32 a
FP_3	26.67 b	26.67 b	9.56 b	10.31 b	8.69 c	9.06 b
FP_4	13.33 d	6.67 d	9.82 b	10.54 b	8.78 c	9.29 b
FP_5	6.67 e	13.33 c	8.46 c	8.06 c	7.94 d	8.13 c
$LSD_{(0.05)}$	2.365	4.891	0.324	0.836	0.489	0.368
CV(%)	8.84	9.05	12.15	7.55	6.91	11.06

In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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*

FP_1: Chemical
FP_2: Chemical, Mechanical
FP_3: Chemical, Mechanical, Cultural
FP_4: Chemical, Cultural, Field sanitation
FP_5: Chemical, Mechanical, Cultural, Field sanitation

sanitation altogether were not used alone without any chemicals. Many of the farmers were found to solely depend on chemicals. The dominance of insecticide use for the management of bitter gourd as observed in the present study is in conformity with the general phenomenon as reported in case of crops including vegetables (1.12 kg/ha) and rice (0.2 kg/ha). But at the same time, the inclusion of IPM in the FPs is an indication of the farmers' motivation towards reducing sole dependence on chemicals. Such motivation of farmers might have been the outcome of the training, demonstration and other interventions through Farmers Field Schools (FFSs) and CRSP (Anon., 1999).

4.2 *Effectiveness of the FPs for managing fruit infestation*

The effectiveness of FPs in managing bitter gourd insect pest was measured in terms of some important parameters such as fruit infestation by number and by weight, yield per hectare, total healthy and infested fruits per hectare, production cost, net return and benefit cost ratio (BCR), number of pests and natural enemies. The detailed analyses of all these parameters have been shown in Table 1, 2, 3 and 4.

4.2.1 Fruit infestation by number

As depicted in table 1, the recorded rate of fruit infestation by number in Dhaka district was the lowest in FP_5 (8.46%) which was closely followed by FP_3 (9.56%) and FP_4 (9.82%). On the other hand it was the highest (10.25%) in FP_1 which was statistically similar with FP_2 (10.02%).

In Norshingdi districts the lowest fruit infestation in number was recorded in FP_5 (8.06%) which was closely followed by FP_3 (10.31%) and FP_4 (10.54%). Again, it was the highest (11.08%) in FP_1 which was statistically identical with FP_2 (10.84%).

Maximum infestation (26.67%) in melon occurred in the 4th day after fruit setting when average fruit size was 2.03 ×1.08 cm. In teasel gourd, it was 19.28% on 8th day after fruit setting when average fruit size was 4.57 x 2.91 cm (Anon., 1988). Amin (1995) and Uddin (1996) observed 42.08 and 45.14% fruit fly infestation in cucumber, respectively.

4.2.2 Fruit infestation by weight

As shown in Table 1, the recorded rate of fruit infestation by weight in Dhaka *district* was the lowest in FP_5 (7.94%) followed by FP_3 (8.69%) and FP_4 (8.78%). On the other hand it was the highest (10.02%) in FP_1 followed by FP_2 (9.45%).

In Norshingdi upazilla the lowest fruit infestation in weight was recorded in FP_5 (8.13%) followed by FP_3 (9.06%) and FP_4 (9.29%). Again, it was the highest (10.49%) in FP_1 which was statistically similar with FP_2 (10.32%). Borah and Dutta (1997) studied the infestation of tephritids on the cucurbits in Assam, India and obtained the highest hest fruit fly infestation rate in snake gourd (62.02%). Larger proportion of marketable fruits was obtained from ash gourd in and bottle gourd in summer season. Snake gourd and pumpkin yielded the lowest proportion of marketable fruits. Gupta (1992) investigated the rate of infestation of *Dacus cucurbitae* (*Bactrocera cucurbitae*) and *Dacus tau* on cucurbit in India during 1986-87 and recorded that 80% infestation on cucumber and bottle gourd in July-August and 50% infestation on bitter gourd, 501o infestation on sponge gourd in August-September.

4.2.3 Fruit yield (t/ha)

As shown in Table 2, the recorded rate of total fruit yield in Dhaka district was the highest in FP_5 (23.85 t/ha) which was followed by FP_3 (22.82 t/ha), while it was the lowest (20.68 t/ha) in FP_1 which was closely followed by FP_2 (21.95 t/ha) and FP_4 (22.18 t/ha). In consideration of healthy fruit the highest was recorded in FP_5 (21.50 t/ha) which was

Table 2. Farmers' practices for fruit infestation management and their effects on yield of bitter gourd in the study areas during May to November, 2007.

Farmer practices	Fruit yield (t/ha)					
	Dhaka			Norshingdi		
	Total	Healthy	Infested	Total	Healthy	Infested
FP_1	20.68 d	19.47 c	1.21 d	19.58 d	18.23 c	1.35 c
FP_2	21.95 c	20.70 b	1.25 d	20.45 c	19.00 b	1.45 bc
FP_3	22.82 b	21.32 a	1.50 c	21.82 b	20.03 a	1.79 b
FP_4	22.18 c	20.43 b	1.75 b	21.65 b	19.65 b	2.00 b
FP_5	23.85 a	21.50 a	2.35 a	22.92 a	20.07 a	2.85 a
$LSD_{(0.05)}$	0.842	0.55	0.210	0.384	0.301	0.421
CV (%)	8.45	8.65	10.33	5.97	8.50	10.53

In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

FP_1: Chemical
FP_2: Chemical, Mechanical
FP_3: Chemical, Mechanical, Cultural
FP_4: Chemical, Cultural, Field sanitation
FP_5: Chemical, Mechanical, Cultural, Field sanitation

statistically identical with FP_3 (21.32 t/ha), while it was the lowest (19.47 t/ha) in FP_1 which was followed by FP_4 (20.43 t/ha) and FP_2 (20.70 t/ha). The highest infested fruit was recorded in FP_5 (2.35 t/ha) which was followed by FP_4 (1.75 t/ha), while it was the lowest (1.21 t/ha) in FP_1 which was statistically identical with FP_2 (1.25 t/ha) and followed by FP_3 (1.50 t/ha).

In Norshingdi, the highest total fruit yield was recorded in FP_5 (22.92 t/ha) which was closely followed by FP_3 (21.82 t/ha) and FP_4 (21.65 t/ha). Again, it was the lowest (19.58 t/ha) in FP_1 which was closely followed by FP_2 (20.45 t/ha). In case of healthy fruit, the highest yield was recorded in FP_5 (20.07 t/ha) which was statistically identical with FP_3 (20.03 t/ha), while it was the lowest (18.23 t/ha) in FP_1 which was closely followed by FP_4 (19.65 t/ha) and FP_2 (19.00 t/ha). The highest infested fruit was recorded in FP_5 (2.85 t/ha) which was closely followed by FP_4 (2.00 t/ha) and FP_3 (1.79%), while it was the lowest (1.35 t/ha) in FP_1 which was statistically identical with FP_2 (1.45 t/ha).

4.2.4 Benefit cost ratio (BCR)

As depicted in Table 3 for Dhaka district, the BCR bitter gourd cultivation was maximum in FP_5 (2.28) followed by FP_3 (2.19), FP_2 and FP_4 (2.16) while it was minimum (2.06) in FP_1. On the other hand in Norshingdi district the BCR was maximum in FP_5 (2.10) followed by FP_4 and FP_3 (2.01), while it was minimum (1.85) in FP_1.

The BCR was the maximum in FP_5 since the net return in it was the maximum (Tk. 274,275/ha and 275,040/ha) for Dhaka and Norshingdi district, respectively because of the higher healthy fruit yield. Moreover the cost of production was the highest (Tk 120,510/ha and 130,850/ha) in this FP_5 among all other FPs.

Table 3. Economic analysis of farmer's practices for fruit infestation management of bitter gourd in the study areas during May to November, 2007.

Farmer practices	Production cost		Net return		BCR	
	Dhaka	Norshingdi	Dhaka	Norshingdi	Dhaka	Norshingdi
FP_1	115650e	126850 e	237820 e	234960 e	2.06 c	1.85 d
FP_2	116840 d	128420 d	252425 d	245400 d	2.16 b	1.91 c
FP_3	119620 b	129975 b	262430 b	261840 b	2.19 b	2.01 b
FP_4	118080 c	128970 c	255070 c	259800 c	2.16 b	2.01 b
FP_5	120510 a	130850 a	274275 a	275040 a	2.28 a	2.10 a
$LSD_{(0.05)}$	112.45	101.25	98.45	63.84	0.106	0.082
CV(%)	9.05	10.52	7.22	12.45	9.11	6.45

In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

FP_1: Chemical
FP_2: Chemical, Mechanical
FP_3: Chemical, Mechanical, Cultural
FP_4: Chemical, Cultural, Field sanitation
FP_5: Chemical, Mechanical, Cultural, Field sanitation

The above results indicated that among the different FPs, the FP_5 that included combination of all the control options including chemical, mechanical, cultural and field sanitation were more effective than other FPs. Thus the effect of chemicals, mechanical, cultural and field sanitation was positively demonstrated in significantly reducing the fruit infestation. The chemicals used in the FPs most significantly reduced the bitter gourd pests like Fruit fly, Semi lopper and Epilachna beetle population to a minimum and consequently reduced the infestation. All these ultimately contributed to the increased number of fruits set, higher number and quantity of healthy fruits harvest, higher healthy fruits yield and higher gross return and ultimately the higher BCR. Such effectiveness of different combinations of farmers' practices in reducing the fruit infestation and consequently in increasing the healthy fruits, total fruit yield and BCR as observed in the present study is comparable with the results of different components of IPM studied individually by many other researchers. Hand picking of infested shoots and fruits was used as a component of IPM and it reduced the damaged fruits per plot and greater yield in plots with single picking than those with frequent picking in India (Verma 1986). IPM involved in pest control were suited to current production practices, and the objectives of IPM programs are to maintain farmers' income while minimizing the use of chemical pesticides through substitution of information and farmers' management skills. Removal of infested fruits compensated the loss of yield by producing more flowers, fruits or producing larger size fruits (FAO, 2003). Weekly removal of damaged fruits and a net barrier gave the highest number and weight of undamaged fruits; in contrast control plots had the lowest marketable yield (Arida *et al.*, 2000). Total yield varied significantly and significant yield increase was obtained due to hand picking + spray of Cymbush over untreated control treatment. The high production cost indicates misuse of chemicals and or other components in the FP and the high amount of infested fruits indicate the inability of even the best FP (FP_5) to minimize the infestation up to the desired level. Gahukar (2000) reported that IPM is compatible and has the potential to be adopted on a broad scale, together with other measures, to provide a low cost management strategy. Kabir *et al.* (1991) reported that yield losses due to fly infestation varies in different fruits and vegetables and it is minimum in cucumber (19.19%) and maximum in sweet gourd (69.96%).

According to such data (Appendix I-XI), 16.67% farmers were up to 30 years *old,* 43.33% farmers were 31-40 years old and 40.00% farmers were above 41 years old. Among them, 10.00% were illiterate, 56.67% completed primary level of education and 33.33% had SSC level of education. On an average 60.00% of the sample farmers received training whereas 40.00% did not receive any type of training. Among the trained farmers, 83.33% received training on IPM and 16.67% received training on pest control. The training duration was about 5 days for 76.67% while it was above 5 days for 23.33% farmers. Among the sample farmers, 30.00% cultivated cucurbits during 1-3 years, 56.67% cultivated during last 3-6 years, and only 13.33% cultivated during more than 7 years. Among the respondents 46.67% cultivated local variety, 43.33% cultivated high yielding variety and 10.00% cultivated local variety of cucurbits.

4.3 Number of pests ('000)

The common insect pests such as Fruit fly, Semi lopper and Epilachna beetle were recorded in the sample farmers' fields. The incidence was much higher in case of Fruit fly than Semi lopper and Epilachna beetle as shown in Table 4. The FPs had significant effect on the incidence of the insect pests. In Dhaka, the lowest number of fruit fly was recorded from FP_5 (Chemical, Mechanical, cultural and field sanitation) (5.15), which was followed by FP_4 (Chemical, Mechanical and Field sanitation) (7.29) while the highest number was recorded from FP_1 (Chemical) (12.22) and followed by FP_2 (Chemical, Mechanical) (10.48). In Narshingdi, the lowest number of fruit fly was found in FP_5 (8.78) while it was highest in FP_1 (14.25).

In Dhaka, the lowest number of semi-lopper was recorded from FP_5 (2.09), which statistically differed from all other FPs. The similar trend of this pest abundance found in Norshingdi. Epilachna beetle was lowest in FP_5 (1.2 and 1.5) and highest in FP_1 (3.5 and 5.63) both in Dhaka and Norshingdi respectively.

In Dhaka, the lowest number of total pests (8.44) was recorded from FP_5 (Chemical, mechanical, cultural, field sanitation) and FP_4 (11.97) while it was the highest (21.07) in FP_1 (Chemical). The incidence was moderate in FP_2 (17.96) and FP_3 (14.67) (Figure 1).

In Norshingdi, the lowest number of total pests (13.33) was recorded from FP_5 (Chemical, mechanical, cultural, field sanitation) and FP_4 (15.77) while it was the highest (27.79) in FP_1 (Mechanical, cultural, field sanitation). The incidence was moderate in FP_2 (20.47 thousand) and FP_3 (18.67) (Figure 2).

Table 4. Farmers' practices for fruit infestation management and their effects on pest of bitter gourd in the study areas during May to November, 2007

Farmer practices	Number of pest ('000)					
	Dhaka			**Norshingdi**		
	Fruit fly	Semi-lopper	Epilachna beetle	Fruit fly	Semi-lopper	Epilachna beetle
FP_1	12.22 a	5.35 a	3.5 a	14.25	7.58 a	5.63 a
FP_2	10.48 b	4.68 b	2.8 b	11.65	5.22 b	3.6 b
FP_3	8.15 c	4.02 c	2.5 b	10.17	5.00 b	3.5 b
FP_4	7.29 d	3.18 d	1.5 c	9.22	4.45 c	2.1 c
FP_5	5.15 e	2.09 e	1.2 c	8.78	3.05 d	1.5 d
$LSD_{(0.05)}$	1.058	0.256	0.310	0.489	0.369	0.510
CV(%)	3.89	8.44	8.33	7.12	5.01	7.65

In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

FP_1: Chemical
FP_2: Chemical, Mechanical
FP_3: Chemical, Mechanical, Cultural
FP_4: Chemical, Cultural, Field sanitation
FP_5: Chemical, Mechanical, Cultural, Field sanitation

4.4 Number of natural enemies ('000)

The common beneficial insects like Honey bee, Lady bird beetle, Bumble bee and Wasp were recorded from the sample farmers' fields while the abundance of Honey bee, Lady bird beetle and Bumble bee were much higher as shown in Table 5.

In Dhaka, Honey bee was recorded highest from FP1 (Chemical) (15.24), which was followed by FP_2 (13.15) while it was lowest in FP_5 (Chemical, mechanical, cultural, field sanitation) (7.19). Lady bird beetle was abundant secondly and the trend was similar with Honey bee.

In Norshingdi, Honey bee was more abundant than another two natural enemies in all FPs. The highest number of honey bee was recorded from FP_1 (Chemical) (18.25) while it was lowest in FP_5 (Chemical, mechanical, cultural, field sanitation) (9.05), which was statistically differed from all other FPs. The prevalence of lady bird beetle and bumble bee maintained the similar trend in FPs like Honey bee.

In Dhaka, the lowest number of total natural enemy (14.02) was recorded from FP_5 (Chemical, mechanical, cultural, field sanitation) and FP_4 (18.55), while it was the highest (31.69) in FP_1 (Chemical). The moderate number of natural enemy was recorded in FP_2 (26.79) and FP_3 (22.47) (Figure 1).

In Norshingdi, the lowest total number of natural enemy (17.46) was recorded from FP_5 (Chemical, mechanical, cultural, field sanitation) and FP_4 (22.7), while it was the highest (38.39) in FP_1 (Chemical). The incidence was moderate in FP_2 (30.05) and FP_3 (27.01) (Figure 2). Although the effect of the FPs could not be compared with any literature, the recorded incidence of the natural enemies in cucurbits in the present study was comparable with other findings. FAO (2003) reported that among a number of predators, lady bird beetles, spider and carabid beetles were the most frequently occurring predators.

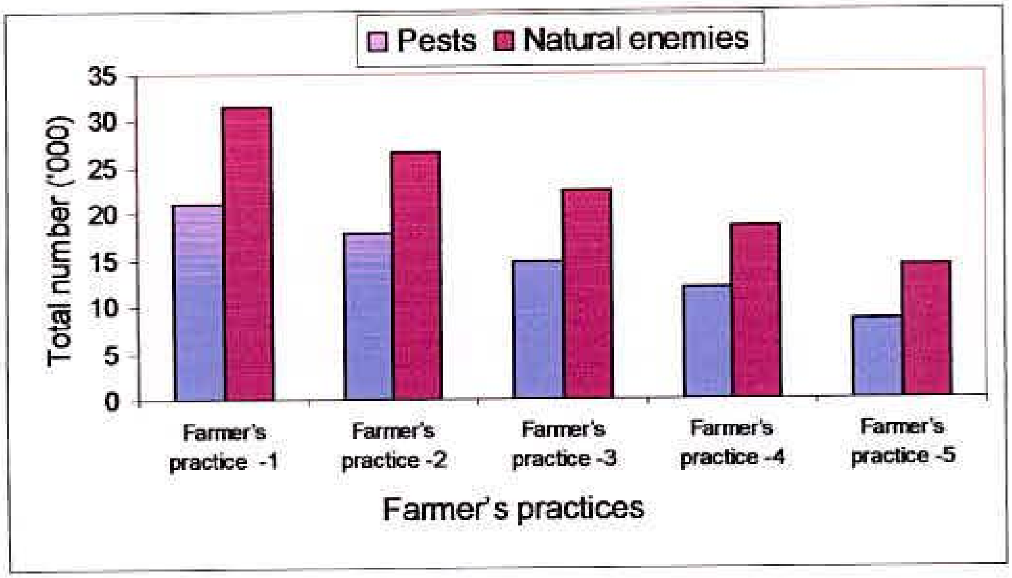

Fig 1. Total number of pests and natural enemies for different farmers practices in the study area Dhaka

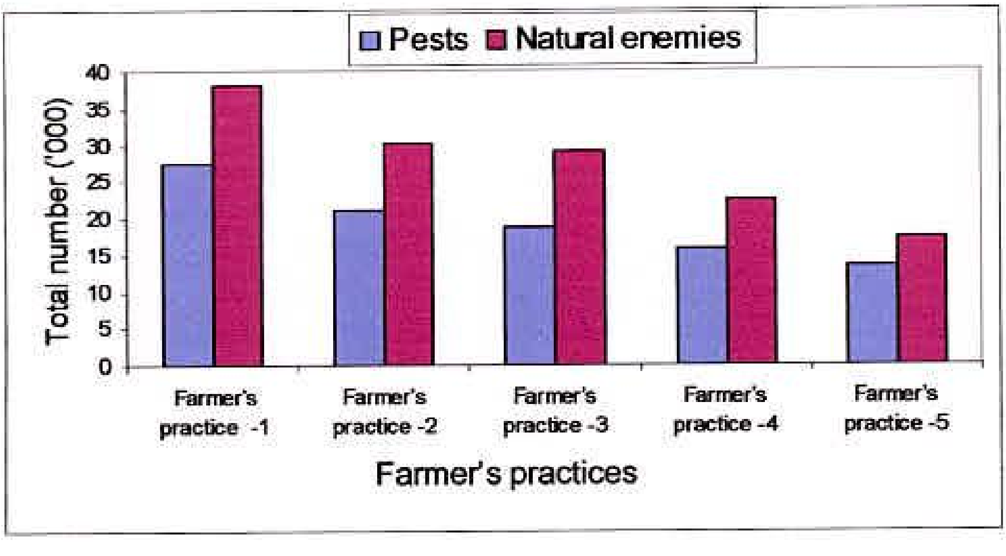

Fig 2. Total number of pests and natural enemies for different farmers practices in the study area Norshingdi.

4.5 Chemicals used for managing cucurbit fruit fly in bitter gourd

The insecticides combination (ICs) for cucurbit fruit fly management as reported by the entire 30 sample farmers from all the two districts together were primarily into different group. Accordingly, the study reveals a total of 5 ICs for cucurbits fruit fly management, which may be designated as follows:

IC_1 : Corolux, Helix, Cartap

IC_2 : Corolux, Darsban, Cargon, Rigen

IC_3 : Altap, Basathrin, Cargon,, Miliborn

IC_4 : Corolux, Diathinon, Basudin, Cargon, Rigen

IC_5 : Corolux, Altap, Helix, Darsban, Cargon, Rigen

The above insecticides (with their group) in different doses used by the sample farmers are shown in Appendix Table XII, which were higher or much higher than the recommended dose. They did not follow any basis for timing the application of the insecticides. The doses and frequencies of insecticides application were more or less the same in two districts. The sample farmers altogether from two sample districts and those from each sample districts practicing the ICs have been shown in Table 6. In Dhaka district, the highest sample farmers (33.33%) practicing IC_2 followed by IC_1 (26.67%), while the lowest sample farmers (6.67%) practicing IC_4 followed by IC_3 (13.33%) and IC_5 (20.00%). On the other hand, in Norshingdi district, the highest sample farmers (40.00%) practicing IC_3 followed by IC_2 (26.67%) and the lowest sample farmers (6.67%) practicing IC_4 which was closely followed by IC_1 and IC_5 (13.33%).

As a general practice the bitter gourd growers used different combinations of insecticides instead of single insecticide. They do this practice for one or more reasons like unavailability of an insecticide at the time when it is required, advice of the pesticide dealers or extension personnel and to substitute the poorly performed earlier insecticide. In India George *et al.* (2002) revealed that majority of the farmers (63.3%) controlled the pest by blanket spraying of one or more insecticides. Sabur and Mollah (2000) observed an increase in use of pesticides by farmers in combating pests throughout Bangladesh. Meanwhile, inappropriate pesticides, incorrect timing of application, and improper dosages all have resulted in high pesticide costs with little or no appreciable reduction in target pest populations.

4.6 Effectiveness of insecticides under different ICs for managing fruit infestation

The effectiveness of ICs in managing cucurbits fruit fly was measured in terms of some important parameters such as fruit infestation by number and weight, yield per hectare, total, healthy and infested fruits per hectare, production cost, net return and benefit cost ratio (BCR), number of pests and natural enemy of the pests. The detailed analyses of all these parameters have been shown in Table 6, 7, 8, 9 and 10.

4.6.1 Fruit infestation by number

As shown in Table 6 the recorded rate of fruit infestation in number in Dhaka district the lowest in IC_5 (8.04%) which was followed by IC_4 (9.15%). On the other hand it was the highest (10.08%) in IC_1 which was followed by IC_2 (9.92%). In Norshingdi district, the lowest fruit infestation in number was recorded in IC_5 (9.11%) which was closely followed by IC_3 (10.03%), while it was the highest (10.88%) in IC_1 which was closely followed by IC_2 (10.61%).

Table 6. Chemicals used by the farmers' for fruit infestation management and their effects on insecticides combination and fruit infestation of bitter gourd in the study areas during May to November, 2007

Insecticides Combination	Practicing farmers (%)		Fruits infestation by number (%)		Fruits infestation by weight (%)		Yield	
	Dhaka	Norshingdi	Dhaka	Norshingdi	Dhaka	Norshingdi	Dhaka	Norshingdi
IC_1	26.67 b	13.33 c	10.08 a	10.88 a	9.82 a	10.02 a	1041 b	1047 c
IC_2	33.33 a	26.67 b	9.92 b	10.61 b	9.30 b	9.86 b	1043 b	1049 c
IC_3	*13.33 d*	*40.00 a*	*9.36 c*	*10.03 d*	*8.52 c*	*9.32 c*	*1044 b*	1056 b
IC_4	6.67 e	6.67 d	9.15 d	10.18 c	8.51 c	9.15 d	1043 b	1050 c
IC_5	20.00 c	13.33 c	8.04 e	9.11 e	7.39 d	8.00 e	1098 a	1102 a
$LSD_{(0.05)}$	5.971	3.842	0.108	0.094	0.184	0.127	6.745	4.058
CV (%)	14.22	9.48	7.88	10.55	8.02	10.69	6.84	9.55

In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

IC_1: Corolux, Helix, Cartap
IC_2: Corolux, Darsban, Cargon, Rigen
IC_3: Altap, Basathrin, Cargon,, Miliborn
IC_4: Corolux, Diathinon, Basudin, Cargon, Rigen
IC_5: Corolux, Altap, Helix, Darsban, Cargon, Rigen

4.6.2 Fruit infestation by weight

As shown in Table 6, the recorded rate of fruit infestation in weight in Dhaka district the lowest in IC_5 (7.39%) which was followed by IC_4 (8.51%) and IC_3 (8.52%). On the other hand it was the highest (9.82%) in IC_1 which was closely followed by IC_2 (9.30%). In Norshingdi district, the lowest fruit infestation in weight was recorded in IC_5 (8.00%) which was followed by IC_4 (9.15%) and IC_3 (9.32%). Again, it was the highest (10.02%) in IC_1 which was closely followed by IC_2 (9.86%).

4.6.3 Fruit yield (t/ha)

As depicted in Table 7, the recorded rate of total fruit yield in Dhaka district the highest in IC_5 (23.92 t/ha) which was closely followed by IC_4 (23.08 t/ha) and IC_3 (23.02 t/ha), while it was the lowest (21.25 t/ha) in IC_1 which was closely followed by IC_2 (21.99 t/ha). In consideration of healthy fruit yield the highest was recorded in IC_5 (21.57 t/ha) which was closely followed by IC_3 (21.22 t/ha) and IC_4 (20.93 t/ha), while it was the lowest (19.64 t/ha) in IC_1 which was closely followed by IC_2 (20.43 t/ha). The highest infested fruit yield was recorded in IC_5 (2.35 t/ha) which was closely followed by IC_4 (2.15 t/ha), while it was the lowest (1.61 t/ha) in IC_1 which was statistically identical with IC_2 (1.65 t/ha) and closely followed by IC_3 (1.80 t/ha).

In Norshingdi district, the highest total fruit yield was recorded in IC_5 (23.06 t/ha) which was closely followed by IC_3 (21.91 t/ha) and IC_4 (21.78 t/ha). Again, it was the lowest (19.95 t/ha) in IC_1 which was closely followed by IC_2 (20.63 t/ha). In case of healthy fruit yield, the highest was recorded in IC_5 (20.11 t/ha) which was statistically identical with IC_3 (19.92 t/ha) and IC_4 (19.48), while it was the lowest (18.30 t/ha) in IC_1 which was similar with IC_2 (18.78 t/ha). The highest infested fruit yield was recorded in IC_5 (2.95 t/ha) which

Table 7. Chemicals used by the farmers' and their effects on yield of bitter gourd in the study areas during May to November, 2007.

Insecticides Combination	Fruit yield (t/ha)					
	Dhaka			Norshingdi		
	Total	Healthy	Infested	Total	Healthy	Infested
IC_1	21.25 d	19.64 d	1.61 c	19.95 d	18.30 b	1.65 c
IC_2	21.99 c	20.34 c	1.65 c	20.63 c	18.78 b	1.85 b
IC_3	23.02 b	21.22 b	1.80 b	21.91 b	19.92 a	1.99 b
IC_4	23.08 b	20.93 b	2.15 a	21.78 b	19.48 a	2.30 a
IC_5	23.92 a	21.57 a	2.35 a	23.06 a	20.11 a	2.95 a
$LSD_{(0.05)}$	0.684	0.325	0.250	0.241	0.652	0.321
CV (%)	10.05	3.59	10.10	6.45	5.81	10.42

Price of cucurbits: @ 11.5 Tk/kg for Dhaka and 12.0 Tk/kg for Norshingdi;
In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

IC_1: Corolux, Helix, Cartap
IC_2: Corolux, Darsban, Cargon, Rigen
IC_3: Altap, Basathrin, Cargon,, Miliborn
IC_4: Corolux, Diathinon, Basudin, Cargon, Rigen
IC_5: Corolux, Altap, Helix, Darsban, Cargon, Rigen

was followed by IC_4 (2.30 t/ha), while it was the lowest (1.65 t/ha) in IC_1 which was closely followed by IC_2 (1.85 t/ha) and IC_3 (1.99 t/ha).

4.6.4 Benefit cost ratio (BCR)

As shown in Table 8 for Dhaka district, the BCR was maximum in IC_5 (2.04) which was statistically similar with IC_3 (1.99) and IC_4 (1.98), while it was minimum (1.86) in IC_1 which was also statistically similar with IC_2 (1.91). On the other hand, in Norshingdi district, the BCR was maximum in IC_5 (2.06) which was followed by IC_3 (1.98) and IC_4 (1.95), while it was minimum (1.83) in IC_1 which was statistically similar with IC_2 (1.87).

The BCR was the maximum in IC_5 since the net return in it was the maximum (Tk. 275,080/ha and 276,720/ha) for Dhaka and Norshingdi district, respectively because of higher healthy fruit yield although the cost of production was the highest (Tk 134520/ha) in this IC_5, respectively among all the ICs.

The above results indicates that among the different ICs, the IC_5 that included combination of all the control options including Corolux, Altap, Helix, Darsban, Cargon, Rigen were more effective than other ICs. Thus the effect of Corolux, Altap, Helix, Darsban, Cargon, Rigen was positively demonstrated in significantly reducing the fruit infestation. The chemicals used in the ICs most significantly reduced the bitter gourd pests like fruit fly, semi lopper, epilachna beetle population to a minimum and consequently reduced the infestation. All these ultimately contributed to the increased number of fruits set, higher number and quantity of healthy fruits harvest, higher healthy fruits yield and higher gross return and ultimately the higher BCR.

Table. 8 Economic analysis of the chemicals used by the farmers' for fruit infestation management of bitter gourd in the study areas during May to November, 2007.

Insecticides Combination	Production cost		Net return		BCR	
	Dhaka	Norshingdi	Dhaka	Norshingdi	Dhaka	Norshingdi
IC_1	131100 e	131100 e	244375 e	239400 e	1.86 b	1.83 c
IC_2	132540 d	132540 d	252885 d	247560 d	1.91 b	1.87 c
IC_3	133025 c	133025 c	264730 c	262920 c	1.99 a	1.98 b
IC_4	133950 b	133950 b	265420 b	261360 b	1.98 a	1.95 b
IC_5	134520 a	134520 a	275080 a	276720 a	2.04 a	2.06 a
$LSD_{(0.05)}$	84.16	63.84	112.41	124.12	0.072	0.045
CV (%)	9.94	6.78	12.11	7.81	9.05	8.22

Price of cucurbits: @ 11.5 Tk/kg for Dhaka and 12.0 Tk/kg for Norshingdi;
In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

IC_1: Corolux, Helix, Cartap
IC_2: Corolux, Darsban, Cargon, Rigen
IC_3: Altap, Basathrin, Cargon,, Miliborn
IC_4: Corolux, Diathinon, Basudin, Cargon, Rigen
IC_5: Corolux, Altap, Helix, Darsban, Cargon, Rigen

4.7 Number of pests ('000)

The common insect pests like Fruit fly, Semilopper and Epilachna beetle were in the sample farmers' fields while the incidence was much higher in case of fruit fly, Semilopper and Epilachna beetle as shown in Table 7. The ICs had significant effect on the incidence of the insect pests.

In Dhaka, fruit fly was highest in number and recorded from IC_1 (11.45), which was statistically differed from all other ICs. It was lowest in IC_5-IC_2 (5.08-10.02). Semi-lopper was second pest and they were highest in IC_1 and lowest in IC_5-IC_2 (2.86-5.29).

In Norshingdi district, fruit fly was highest in IC_1 (14.25) while it was lowest in IC_5. Intermediate level of number of fruit fly was abundant in IC_4-IC_2 (9.22-11.65) by number. Similar trend was found in all ICs with semi-lopper and epilachna beetle.

In Dhaka district, the lowest number of total pests (9.47) was recorded from IC_5 and IC_4 (11.75) while it was the highest (21.37) in IC_1. The incidence was moderate in IC_2 (17.63) and IC_3 (15.42). In Norshingdi, the lowest number of total pests (13.43) was recorded in IC_5 and IC_4 (16.17) while it was the highest (27.33) in IC_1. The incidence was moderate in IC_2 (20.67) and IC_3 (19.67) (Figure 3).

Table 9. Chemicals used by the farmers' and their effects on pest of bitter gourd in the study areas during May to November, 2007.

Insecticides Combination	Number of pest ('000)					
	Dhaka			Norshingdi		
	Fruit fly	Semi-lopper	Epilachna beetle	Fruit fly	Semi-lopper	Epilachna beetle
IC_1	11.45 a	5.29 a	4.63 a	14.25 a	7.58 a	5.50 a
IC_2	10.02 b	4.01 b	3.60 b	11.65 b	5.22 b	3.80 c
IC_3	8.47 c	3.45 c	3.50 b	10.17 c	5.00 b	4.50 b
IC_4	6.33 d	3.32 c	2.10 c	9.22 d	4.45 c	2.50 d
IC_5	5.08 e	2.89 d	1.50 d	8.78 e	3.05 d	1.60 e
$LSD_{(0.05)}$	0.781	0.164	0.410	0.442	0.245	0.543
CV (%)	3.48	7.88	7.65	4.96	5.81	8.23

In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

IC_1: Corolux, Helix, Cartap
IC_2: Corolux, Darsban, Cargon, Rigen
IC_3: Altap, Basathrin, Cargon., Miliborn
IC_4: Corolux, Diathinon, Basudin, Cargon, Rigen
IC_5: Corolux, Altap, Helix, Darsban, Cargon, Rigen

4.8 Number of natural enemies ('000)

The common beneficial insects like Honey bee, lady bird beetle and bumble bee were recorded from the sample farmers' fields as shown in Table 8.

In Dhaka, Honey bee was highest in number in IC_1 (15.84) while it was lowest in IC_5 (7.15). The next highest number of natural enemy, lady bird beetle was also highest in IC_1 (10.12) while it minimum in IC_5 (4.15).

In Norshingdi, Honey bee was more prevalent than any other natural enemy. It was recorded highest in number from IC_1 and minimum in number from the IC_5 (9.05). The abundance of other two natural enemies were in similar manner like honey bee.

In Dhaka district, the lowest number of natural enemy (13.82) was recorded from IC_5 followed by IC_4 (17.07), while it was the highest (32.06) in IC_1. The moderate number of natural enemy was recorded in IC_2 (24.48) and IC_3 (22.02) (Figure 3).

In Norshingdi area, the lowest number of total natural enemy (17.52) was recorded from IC_5 and IC_4 (22.75), while it was the highest (37.89) in IC_1. The incidence was moderate in IC_2 (29.14) and IC_3 (27.03) (Figure 4).

Table 10. Chemicals used by the farmers' and their effects on natural enemy's bitter gourd in the study areas during May to November, 2007.

Insecticide combinations	Number of natural enemy ('000)					
	Dhaka			Norshingdi		
	Honey bee	Lady bird beetle	Bumble bee	Honey bee	Lady bird beetle	Bumble bee
IC_1	15.84 a	10.12 a	6.10 a	18.25 a	12.84 a	6.80 a
IC_2	11.25 b	8.33 b	4.90 b	13.21 b	10.68 b	5.25 b
IC_3	10.02 c	7.65 c	4.35 b	12.46 c	9.05 c	5.52 b
IC_4	8.44 d	5.38 d	3.25 c	11.24 c	7.36 d	4.15 c
IC_5	7.15 e	4.15 e	2.52 d	9.05 d	5.21 e	3.26 d
$LSD_{(0.05)}$	0.814	0.642	0.668	0.915	1.025	0.328
CV (%)	8.05	6.96	5.22	14.58	7.22	10.13

In a column, numeric data represent the mean value of 3 villages of Dhaka and Norshingdi; data of each village are derived from the field of 3 respondents

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

IC_1: Corolux, Helix, Cartap
IC_2: Corolux, Darsban, Cargon, Rigen
IC_3: Altap, Basathrin, Cargon,, Miliborn
IC_4: Corolux, Diathinon, Basudin, Cargon, Rigen
IC_5: Corolux, Altap, Helix, Darsban, Cargon, Rigen

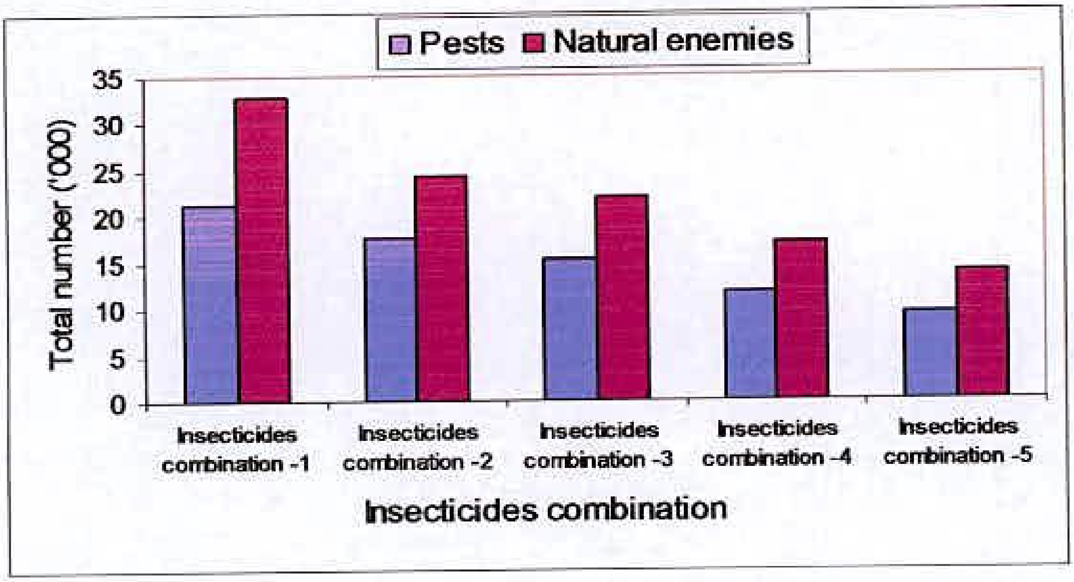

Fig 3. Total number of pests and natural enemies for different insecticide combinations in the study area Dhaka

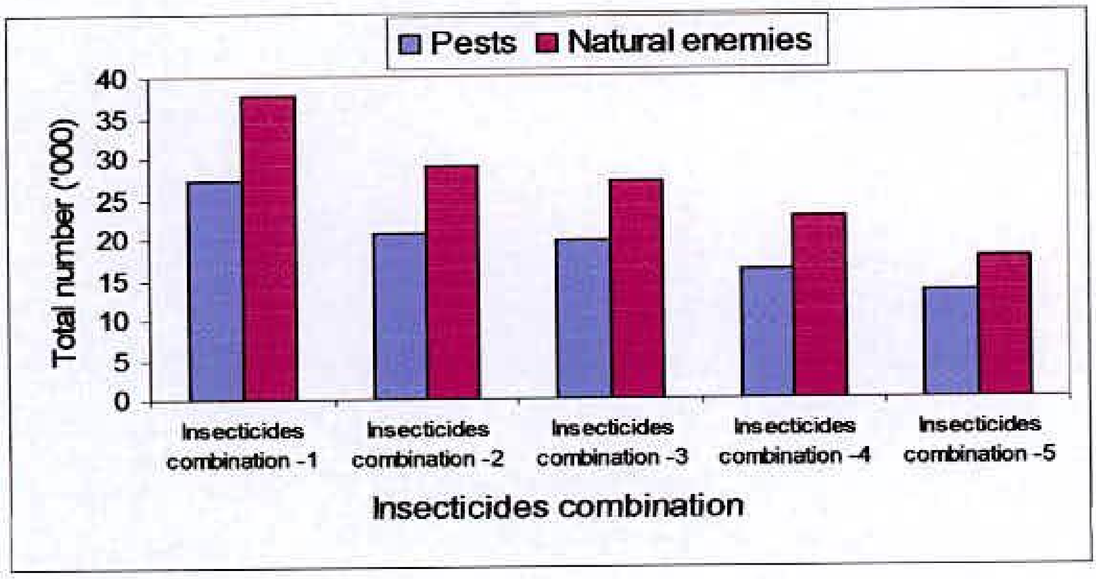

Fig 4. Total number of pests and natural enemies for different insecticide combinations in the study area Norshingdi

A comparison of the total number of pests and natural enemies presented in Figure 3 and 4 and shows a higher number of pests than natural enemies in all the insecticides combination. Both pests and natural enemies lower in all insecticides combination than IC_1 and the lowest in IC_5. The above results indicate that the chemicals used in IC_1 in combination with different insecticides considerably suppressed the pest and natural enemies and the maximum pest and natural enemies were suppressed by the combined effect of all options in IC_5. This suggests that the insecticides used in IC_1 & $IC_5$and other insecticides combinations were non-selective and they might have destroyed the non-target natural enemies along with the target pests.

The analysis of the effectiveness of the combinations of different insecticide and the most commonly used insecticides of a particular combination as presented above reveals different scenarios and inconsistencies in the results in respect of any single parameter. However, based on the results of the majority of parameters considered together, the following generalizations can be made in respect of their performance and the most commonly used insecticide (s) in the combinations:

(i) all of the insecticides used in different combinations were non-selective, however, having different levels of toxicity both to the pests and the natural enemies;

(ii) the production cost was relatively higher in combinations that used insecticides belonging to different class but the healthy fruit yield and net return in those combinations were higher, which consequently resulted in higher BCR;

(iii) Majority of the farmers used the insecticide combinations or insecticides that did not provide any satisfactory level of pest control.

A wide range of organophosphoras, carbamate and synthetic pyrethroids of various formulations have been used from time to time against fruit fly (Kapoor, 1993). Spraying of conventional insecticide is preferred in destroying adults before sexual maturity and oviposition (Williamson, 1989).

Alam *et al.* (2003) reported that the farmers of Bangladesh as well as in Asia mostly depend on pesticides to combat this obnoxious pest. They use variety of insecticides belonging to different chemical groups. The most popular chemicals were quinalphos, an organophosphate; and carbosulfan and cartap, both carbamate. Other insecticides used by farmers were cypermethrin, monocrotophos, esfenvalerate, lambda-cyhalothrin, chloropyriphos etc.

There are many natural enemies that parasitize BSFB eggs, larvae etc. *Trathala flavor-orbonalis, Trichogramma sp.* etc. are good example of hymenopteran parasites (Alam *et al.*, 2002). But its population was very much correlated with insecticides spraying frequently. The higher the spray frequency the lower was the abundance of *Trathala flavor-orbonalis*. Probably this is the reason for lower infestation of shoot and fruit infestation in the pheromone treated plots than the insecticides treated plots (Alam *et a*l., 2002). Maleque *et al.* (1999) reported that lady bird beetles and spiders were seriously affected in the field where Cymbush 10 EC was applied at weekly intervals compared with fields where mechanical control and few sprays were applied and unsprayed fields.

Chapter V

Summary & conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Two intensive bitter gourd cultivated area in the districts of Dhaka and Norshingdi were selected for conducting the study. In these two areas have a long history of growing vegetables, especially bitter gourd. The study were conducted with staying close contact of the cucurbits growers for the entire growing period and a pre-tested survey instruments were used for the collection of data. Among grower characteristics, the specific variables included in the model are: area, land holding status, training receiving status, age of the growers, education level of the growers, how long they have been engaged in bitter gourd cultivation, variety used by the respondents, information on insects and pests, other insecticides, insect diversity, application time, interval, methods etc. The data obtained for different characters were statistically analyzed to find out the significance of the different farmers practices and chemicals used by the respondents' field on yield contributing characters, yield, economical return and arthropod diversity in bitter gourd.

- In Dhaka district, the highest sample farmers (33.00%) practiced FP_1 and the lowest sample farmers (6.67%) practiced FP_5. On the other hand in Norshingdi district, the highest sample farmers (40.00%) practiced FP_1 and the lowest sample farmers (6.67%) practiced FP_4.

- Fruit infestation by number and by weight varied for different FPs. In Dhaka district, the lowest fruit infestation by number and by weight was observed in FP_5 (8.46% and 7.94% respectively) while it was the highest by number and by weight (10.25% and 11.08% respectively) in FP_1. In Norshingdi district, the lowest fruit infestation by number and by weight was observed in FP_5 (8.06% and 8.13% respectively) while it was the highest by number and by weight (11.08% and 10.49% respectively) in FP_1.

- Fruit infestation by weight also varied for different FPs. Fruit infestation by weight in Dhaka districts was the lowest in FP_5 (7.94%). On the other hand it was the highest (10.02%) in FP_1. In Norshingdi districts the lowest fruit infestation by weight was recorded in FP_5 (8.13%) while it was the highest (10.49%) in FP_1.

- In terms of total fruit yield, the highest was in FP_5 (23.85 t/ha and 22.92 t/ha respectively) while it was the lowest in FP_1 (20.68 t/ha and 19.58 t/ha respectively) both in Dhaka and Norshingdi district respectively. Considering the healthy fruit yield, the highest was recorded in FP_5 (21.50 t/ha and 20.07 t/ha respectively), while it was the lowest (19.47 t/ha and 18.23 t/ha respectively) in FP_1 both in Dhaka and Norshingdi district respectively.

- In Dhaka district, the BCR was maximum in FP_5 (2.28) while it was minimum (2.06) in FP_1. In Norshingdi district, the BCR was maximum in FP_5 (2.10), while it was minimum (1.85) in FP_1. The trend is similar in both the districts.

- In Dhaka, the lowest number of total pests was recorded from FP_5 while it was the highest in FP_1 and the lowest number of natural enemies was recorded from FP_5 and FP_4, while it was the highest in FP_1.

- In Norshingdi, the lowest number of total pests was recorded from FP_5 and it was the highest in FP_1 and the lowest number of natural enemies was recorded from FP_5 and FP_4, while it was the highest in FP_1.

- In case of chemical insecticides used in combination, the highest sample farmers (33.33%) used IC_2 in Dhaka district, while the lowest sample farmers (6.67%) used IC_4. On the other hand, in Norshingdi districts, the highest sample farmers (40.00%) used IC_3 and the lowest sample farmers (6.67%) used IC_4.

- Fruit infestation by number and by weight varied for different insecticides combinations. In Dhaka district, the lowest fruit infestation by number and by weight was observed in IC_5 (8.04% and 7.39% respectively) while it was the highest by number and by weight (10.08% and 9.82% respectively) in IC_1. In Norshingdi district, the lowest fruit infestation by number and by weight was observed in IC_5 (9.11% and 8.00% respectively) while it was the highest by number and by weight (10.88% and 10.02% respectively) in IC_1.

- Fruit infestation in weight also varied for different FPs. Fruit infestation in weight in Dhaka districts was the lowest in FP_5 (7.94%). On the other hand it was the highest (10.02%) in FP_1. In Norshingdi districts the lowest fruit infestation in weight was recorded in FP_5 (8.13%) while it was the highest (10.49%) in FP_1.

- In terms of total fruit yield, the highest was in IC_5 (23.92 t/ha and 23.06 t/ha respectively) while it was the lowest in IC_1 (21.25 t/ha and 19.95 t/ha respectively) both in Dhaka and Norshingdi district respectively. Considering the healthy fruit yield, the highest was recorded in IC_5 (21.57 t/ha and 20.11 t/ha respectively), while it was the lowest (19.64 t/ha and 18.30 t/ha respectively) in $IC_{1\ both}$ in Dhaka and Norshingdi district respectively. Again, considering the infested fruit yield, the highest was recorded in IC_5 (2.35 t/ha and 2.95 t/ha respectively), while it was the lowest (1.61 t/ha and 1.65 t/ha respectively) in IC_1 both in Dhaka and Norshingdi district respectively.

Chapter VI

Recommendations

- In Dhaka districts the BCR was maximum in IC_5 (2.04), while it was minimum (1.86) in IC_1. On the other hand in Norshingdi districts the BCR was maximum in IC_5 (2.06), while it was minimum (1.83) in IC_1.
- The ICs had significant effect on the incidence of the insect pests. In Dhaka, the lowest number of total pests was recorded from IC_5 and it was the highest in IC_1. The lowest number of natural enemy was recorded from IC_5, while it was the highest in IC_1.
- In Norshingdi, the lowest number of total pests was recorded from IC_5 while it was the highest in IC_1. In Norshingdi the lowest number of natural enemy was recorded from IC_5, while it was the highest in IC_1.

RECOMMENDATIONS

Based on the findings and inadequacies of the study, the following recommendations are made:

- The integrated management practice (Chemical + Mechanical + Cultural + Field sanitation) found most effective. Further studies may be required on a large scale under farmer's field conditions.
- The integrated practice comprising the application of Corolux, Altap, Helix, Darsban, Cargon and Rigen may be designed for further study.
- Use of sex pheromone may be included with new generation insecticides in judicious manner.

Chapter VII

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Chapter VIII

Appendices

APPENDICES

Appendix I

Geographical status (location) of surveyed different cucurbit cultivated area from the place data were collected

District	Village	No. of surveyed farmers
Dhaka	Comlapur	5
	Mastapara	5
	Barulia	5
Norshingdi	Balabo	5
	Dainarchar	5
	Amtali	5

Appendix II

Data represents the age, education level of the respondents of cucurbits cultivated farmers in Dhaka and Norshingdi

Location	Age (years)			Education level		
	Up to 30	31-40	above 41	Illiterate	Up to primary	Up to SSC
Dhaka	20.00	46.67	33.33	13.33	60.00	26.67
Norshingdi	13.33	40.00	46.67	6.67	53.33	40.00
Average	16.67	43.33	40.00	10.00	56.67	33.33

Appendix III

Data represents the land holding status of the respondents of Dhaka and Norshingdi

Location	Vegetable cultivated			Land holding status (%)		
	Summer	Winter	Year round	Own land	Leased in	Leased out
Dhaka	26.67	60.00	13.33	40.00	13.33	46.67
Norshingdi	20.00	53.33	26.67	53.33	26.67	20.00
Average	23.33	56.67	20.00	46.67	20.00	33.33

Appendix IV

Data represents the training status of the respondents in different villages of Dhaka and Norshingdi

Location	Training receiving status (%)		Training on (%)		Duration of training	
	Yes	No	IPM	Pest Control	05 days	Above 05 days
Dhaka	53.33	46.67	80.00	20.00	73.33	26.67
Norshingdi	66.67	33.33	86.67	13.33	80.00	20.00
Average	60.00	40.00	83.33	16.67	76.67	23.33

Appendix V

Data represents the duration of cucurbit cultivation and variety used by the respondents in different villages of Dhaka and Norshingdi

Location	Duration of cucurbit cultivation (Years)			Variety used by respondents		
	1-3	3-6	above 7	Local	HYV	Hybrid
Dhaka	26.67	53.33	20.00	40.00	46.67	13.33
Norshingdi	33.33	60.00	6.67	53.33	40.00	6.67
Average	30.00	56.67	13.33	46.67	43.33	10.00

Appendix VI

Data represents the plot size and age of seedlings that were generally used of the respondents in different villages of Dhaka and Norshingdi

Location	Plot size (acre/farmer)				Cropping pattern		
	<.50	0.51-1.0	1.1-1.5	>1.6	Vegetable	Rice	Vegetable
Dhaka	26.67	40.00	20.00	13.33	53.33	33.33	13.33
Norshingdi	13.33	60.00	13.33	13.33	40.00	20.00	40.00
Average	20.00	50.00	16.67	13.33	46.67	26.67	26.67

Appendix VII

Data represents the information on fruit fly by the respondents in different villages of Dhaka and Norshingdi

Location	Infestation					
	Low (1-2%)	Mild (3-6%)	Moderate (7-10%)	Medium (10-15%)	High (16-20%	Severe (>21%)
Dhaka	26.67	33.33	13.33	13.33	13.33	26.67
Norshingdi	33.33	33.33	6.67	13.33	6.67	33.33
Average	30.00	33.33	10.00	13.33	10.00	30.00

Appendix VIII

Data represents the information on interval of insecticide spray by the respondents in different villages of Dhaka and Norshingdi

Location	*Interval of insecticide spray (days)*				
	1	2-4	5-7	8-10	above 11
Dhaka	6.67	33.33	33.33	20.00	6.67
Norshingdi	6.67	20.00	26.67	33.33	13.33
Average	6.67	26.67	30.00	26.67	10.00

Appendix IX

Data represents the information on month wise frequency of insecticide application by the respondents in different villages of Dhaka and Norshingdi

Location	*Month*					
	April	May	June	July	August	September
Dhaka	2	4	6	5	2	3
Norshingdi	4	4	7	5	3	3

Appendix X

Data represents the information on month wise interval of insecticide application by the respondents in different villages of Dhaka and Norshingdi

Location	Month					
	April	May	June	July	August	September
Dhaka	15	7	5	6	15	10
Norshingdi	7	7	4	6	10	10

Appendix XI

Data represents the information on healthy and infested fruit/plant and price by the respondents in different villages of Dhaka and Norshingdi

Location	Average healthy fruit/plant		Average infested fruit/plant		Price (Tk./kg)
	Number	Wight (kg)	Number	weight (kg)	
Dhaka	48.00	4.25	4.50	0.72	11.5
Norshingdi	45.00	4.03	6.00	0.86	12.0
Average	*46.50*	*4.14*	*5.25*	*0.78*	*11.75*

Appendix XII

Chemicals used (with their group) in different doses used by the farmers in the study areas

Group	Chemical combination used	Dose (ml/L of water)
Organophosphate	Corolux, Helix, Cartap	2 ml/L of water
Organophosphate Pyrethroid	Corolux, Darsban, Cargon, Rigen	2 ml/L of water 4 ml/L of water
Pyrethroid	Altap, Basathrin, Cargon,, Miliborn	4 ml/L of water
Organophosphate Pyrethroid	Corolux, Diathinon, Basudin, Cargon, Rigen	2 ml/L of water 4 ml/L of water
Organophosphate Pyrethroid Organocarbamate	Corolux, Altap, Helix, Darsban, Cargon, Rigen	2 ml/L of water 4 ml/L of water 4 ml/L of water

Recommended dose 2 ml/L of water