MANAGEMENT PRACTICES FOR FRUIT FLY AND FRUIT WEEVIL OF MANGO AT BANDARBAN, RANGAMATI AND KHAGRACHARI DISTRICTS

MD. GOLAM MUKTADIR

DEPARTMENT OF ENTOMOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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BY

MD. GOLAM MUKTADIR

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Approved By:

Professor Dr. Md. Abdul Latif
Supervisor

Professor Dr. Mohammed Ali
Co-Supervisor

Dr. Mohammed Sakhawat Hossain
Chairman
Examination Committee

DEPARTMENT OF ENTOMOLOGY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that thesis entitled, "**MANAGEMENT PRACTICES FOR FRUIT FLY AND FRUIT WEEVIL OF MANGO AT BANDARBAN, RANGAMATI AND KHAGRACHARI DISTRICTS**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **Md. Golam Muktadir**, **Registration No. 10-03924** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2015
Dhaka, Bangladesh

Prof. Dr. Md. Abdul Latif
Supervisor
Department of Entomology
Sher-e-Bangla Agricultural University
Dhaka-1207

Dedicated

To My

Beloved Parents

&

Teachers

LIST OF ACRONYMS

AEZ	:	Agro-Ecological Zone
BARI	:	Bangladesh Agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
cm	:	Centimeter
CV%	:	Percentage of coefficient of variance
EC	:	Emulsifiable Concentrate
et al.	:	And others
etc	:	Etcetera
g	:	Gram
h	:	Hour
ha	:	Hectare
IPM	:	Integrated Pest Management
j.	:	Journal
kcal	:	Kilocalorie
kg	:	Kilogram
L	:	Liter
m	:	Meter
ml	:	Milliliter
mm	:	Millimeter
MP	:	Muriate of Potash
no.	:	Number
RCBD	:	Randomized Complete Block Design
SP	:	Soluble Powder
t	:	Ton
TSP	:	Triple Super Phosphate
Vit-C	:	Vitamin-C
%	:	Percent
^{0}C	:	Degree Celsius
a.i	:	Active Ingredient
@	:	At the rate of

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Dated: December, 2015 **The Author**

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ABSTRACT

The present study was conducted at the farmer's orchard in Bandarban, Rangamati and Khagrachari districts, during the period from January to July, 2016 to develop management options against mango fruit fly and fruit weevil. The treatments of the experiment were T_1 = application of Ripcord 10EC 4 times, T_2 = application of Ripcord 10EC 5 times, T_3 = application of Ripcord 10EC 4 times + pheromone trap, T_4= 5 times application of Ripcord 10EC + pheromone trap, T_5= 4 times application of Ripcord 10EC + pheromone trap + bait trap, T_6 = 5 times application of Ripcord 10EC + pheromone trap + bait trap and T_7 = untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The lowest percent of fruit infestation (6.88%, 6.99% and 5.72% at Bandarban, Rangamati and Khagrachari, respectively) was observed in T_4 as against the highest percent fruit infestation (83.68%, 88.58% and 86.12% at Bandarban, Rangamati and Khagrachari, respectively) was found in T_7. Treatment T_4 gave maximum protection of fruit infestation (91.77%, 92.10% and 93.36% at Bandarban, Rangamati and Khagrachari, respectively) over control and produced higher amount of healthy mango fruits/tree. Treatment T_6 consisting spraying Ripcord 10EC @ 1.0 ml/L water 5 times + pheromone trap + bait trap and T_5 spraying Ripcord 10EC @ 1.0 ml/L water 4 times + pheromone trap + bait trap also showed the similar performance for the management of mango insect pests. Among seven treatments T_4 comprising spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap was the most effective management practice and may used for the management of mango fruit fly and fruit weevil.

CHAPTER I

INTRODUCTION

Mango (*Mangifera indica* L.), a tropical and sub-tropical fruit, belongs to the family Anacardiaceae, which was originated in South Asia and has been in cultivation for more than 4000 years (Bose 1985, Candole 1984, Mukherjee 1949). It is an important and popular fruit in the world for its excellent flavors, attractive color, delicious taste, and high nutritive value. In nutritional aspects, both ripe and unripe mango is rich in several vitamins as well as minerals (Paramanik 1995). Besides, mango contains appreciable quantity of iron, vit-C, carotene and soluble sugar. Moreover, it provides a lot of energy (as much as 74 kcal/100g edible portion) which is nearly equals the energy values of boiled rice of similar quantity by weight (Hossain 1989). In Bangladesh, it occupies an area of 32011 hectares of land with an annual production of 1047849 metric tons (BBS 2011).

Although it grows well in all parts of Bangladesh, the grafted mango trees are concentrated in a few places in the north western region and seedling mangoes are grown in the southern and other parts of Bangladesh (Bhuyan 1995). But in recent years, some elite farmers have taken keen interest to establish commercial orchard for mango with grafted mango trees in southern region, especially in the hilly areas and Chittagong Hill Tracts. Bangladesh Agricultural Research Institute (BARI) has already released 10 (ten) mango varieties with variable quality. In general, the cultivars are location specific and the commercial varieties of one region may not do so well when grown in other areas (Majumder *et al*. 2001).

Fruit flies are recognized worldwide as the most important insect pests to fruits, especially mangos (Ekesi *et al.* 2009, Vayssieres *et al*. 2008, Drew *et al*. 2005). The fruit flies belong to the order Diptera, family Tephritidae and the attacking genera are *Anastrepha* (8 species), *Bactrocera* (30 species), *Ceratitis* (7 species), *Dirioxa* (2 species) and *Toxotrypana* (one species). Female fruit flies lay eggs under the skin of the fruit, which hatch into larvae that feed in the decaying flesh of the crop. Infested fruits quickly rot and become inedible or drop off from the tree causing direct loss to the farmer. Besides the direct damage to the fruit, presence of fruit fly and fruit weevil is associated with quarantine restrictions that are imposed by fruits and vegetable importing countries. Without control, direct damage has been reported from 30 to 100% depending on the fruit maturity stage, variety, location and season (Vayssieres *et al.* 2008, 2009, De Meyer *et al.* 2007, Mwatawala *et al.* 2006).

Over 175 species of insects have been reported damaging mango trees (Nayar *et al*. 1976 and Fletcher 1970). Mango hopper, fruit fly and fruit weevils are the major insect pests of mango in Bangladesh. Rahman (2005) reported 37.5% infestation in mango due to fruit fly. The mango fruit weevil, *Sternochetus frigidus* (Fabr.), is considered as a major pest which causes significant damage to the mango fruit by contaminating the edible portion and destroys both value and marketability of the product. No outward signs of attack are evident until the adult weevil bores out of the fruit. *Sternochetus frigidus* is spread mainly by infested fruits because the weevil develops within the mango seed (Griesbach 2003). Lefroy (1906) first reported another fruit weevil, *Sternochetus frigidu*s the pest of mango from Bangladesh first time which is quite serious in north eastern part of Bangladesh.

Many mango orchards have been developed by farmers at Bandarban, Rangamati and Khagrachari hill districts. Mango hopper, fruit fly and fruit weevil are the three major pests of mango at this hill region. Some farmers use only chemical insecticides many times for the management of these obnoxious pests of mango and others do not take proper control measure against them. Moreover, they don’t know the application time of insecticides. The major portion of mango is damaged by these pests every year which reduce total production as well as market price of mango. Besides, most of the farmers are not aware of the harmful effect of these chemical insecticides. Indiscriminate use and improper dose of pesticides create several problems such as development of pest resistance to pesticide, outbreak of secondary pests, destruction of beneficial organisms, hazards to the human health and pollution of the environment. To reduce the use of pesticide, environmentally sound and safe methods of pest management is of prime importance.

Integrated pest management is the successful way to control several important insect pests of mango. Sex pheromone trap and bait trap are two traps, which used to catch fruit fly. According to Mohyuddin and Mahmood (1993), 75% fruit fly can be controlled through methyl eugenol (sex pheromone traps). Many reserach works have been done on biology and control of these pests by different workers like (Seshagiri *et al.* 1971, Balock and Kozuma 1964, Subramanyam 1925) in different parts of the world but in Bangladesh research report on damage severity and management of fruit fly and fruit weevil attacking mango at three hill districts is scanty. Thus, the research work on management of mango fruit fly and fruit weevil in hilly regions of Bangladesh was undertaken to fulfill the following objectives.

- To determine damage severity of mango fruit fly and fruit weevil at Bandarban, Rangamati and Khagrachari districts.
- To evaluate some management tactics against mango fruit fly and fruit weevil at three hill districts.

CHAPTER II

REVIEW OF LITERATURE

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae. Mango is indigenous to India. Cultivated in many tropical and subtropical regions and distributed widely in the world, mango is one of the most extensively exploited fruit for food, juice, flavor, fragrance and color. In several cultures, its fruit and leaves are ritually used as floral decorations at weddings, public celebrations and religious ceremonies (McGovern and LaWarre, 2001). Literatures cited below under the following headings and sub-headings reveal some information about the present study.

2.1 General overview of Fruit fly

2.1.1 Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Family: Tephritidae

Genus: *Bactrocera*

Species: *Bactrocera dorsalis*

2.1.2 Biology of fruit fly

Fruit fly eggs average about 1.17 mm long and 0.21 mm wide, which is slightly smaller than melon fly. The female may puncture fruit and deposit her eggs, or she may take advantage of cracks or other wounds, including the ovipositor punctures of other flies. Eggs may be deposited at a depth of 5-6 mm in soft fruit, whereas they may be very near the surface in hard fruit. The upper and lower-developmental thresholds for eggs are estimated at 38^0C and 12^0C, respectively. The average time for egg hatching is 1.6 days (Vargas *et al*. 1984) but hatching may be extended up to 20 days in cold weather.

Fruit fly larvae are typical in form of tephritid fruit flies, cylindrical and broad posteriorly and tapering to point at the anterior end. There are three instars; all are whitish in color. The first instar ranges in size from about 1.2 -2.3 mm, whereas the second ranges from 2.5-5.7 mm and third instar ranges from 7.0-11.0 mm. The upper and lower-developmental thresholds for larvae are estimated at 34^0C and 11^0C, respectively (Calkins *et al*. 1987). Larval development generally requires about 7.8 days, though its development time can range from 6 to 35 days.

Mature larvae leave infested fruit and enter the soil, usually at the base of affected trees, to pupate. The puparia are 3.8-5.2 mm long and vary in color from tan to brownish-yellow. Pupal development requires about 10.3 days.

The adult fruit fly has a yellow to orange abdomen marked with a black "T". The thorax is predominantly black but bears two yellow stripes laterally. Oriental fruit fly lacks cross bands on its wings, and therefore is easily differentiated from melon fly. The adult of *B. dorsalis*, which is noticeably larger than a house fly, has a body length of about 8.0 mm; the wing is about 7.3 mm in length and is mostly hyaline. After adults emerge, a period of 6-12 days normally elapses before oviposition can occur. Copulation persists for 2-12 h. Males expel pheromone in a visible form resembling smoke (Anwar *et al.* 1982), similar to pheromone production by melon fly. Mating occurs at dusk in aggregations called "leks". Mating normally occurs at 4-5 day intervals. The adults continue to produce eggs for about two months. The female oriental fruit fly is more fecund than the related tephritids melon fly and Mediterranean fruit fly, and she produces an average of over 1400 eggs per female during a life span of about 80 days (Vargas *et al*. 1984). The oviposition rate is reported to be about 130 eggs per day.

The ovipositor is very slender and sharply pointed. Keys for distinguishing all life stages of these species were provided (Bustos *et al*. 2004, Follett and Armstrong 2004, White and Elson-Harris 1992). Oriental fruit fly can complete a generation in about 30 days. In tropical climates, many overlapping generations per year are reported. Fruit fly abundance typically coincides with availability of ripening fruit, though they tend to be most common in summer and autumn (Vargas *et al*. 1996).

2.1.3 Economic importance of fruit fly

The damage to crops caused by fruit flies result from oviposition in fruit and soft tissues of vegetative parts of hosts, feeding by the larvae and decomposition of tree tissue by invading secondary microorganisms.

These flies remain active throughout the year on one or the other hosts. During the severe winter months, they conceal and crowd together under dried leaves of bushes and trees. In the hot and dry season, the flies take shelter under humid and shady places and feed on honeydew of aphids infesting the fruit trees (Dhillon *et al.* 2005). Generally, the females of this fly prefer to lay the eggs in soft tender fruit tissues by piercing them with their ovipositor. A watery fluid oozes from the puncture, which becomes slightly concave with leaching of fluid, and transforms into a brown resinous deposit (Gupta and Verma 1978). After egg hatching, the larvae bore into the pulp tissue and make the feeding galleries. The fruit subsequently rotten or becomes distorted. Young larvae present at the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition (Arthur *et al*. 1989). Sometimes pseudo-punctures (punctures without eggs) have also been observed on the fruit skin (Bhatti 1970). This reduces the market value of the produce. The full-grown larvae come out of the fruit by making one or two exit holes for pupation in the soil. The larvae pupate in the soil at a depth of 0.5 to 15 cm. The depth up to which the larvae move in the soil for pupation, and survival depend on soil texture and moisture (Pandey and Misra 1999, Jackson *et al.* 1998). Larval feeding damage in fruits is the most damaging (Wadud *et al.* 2005). Mature attacked fruits develop a water soaked appearance (Calcagno *et al*. 2002). Young fruits become distorted and usually drop. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot (Collins *et al*. 2009). These maggots also attack young seedlings, succulent tap roots, stems and buds of host trees such as mango, guava, cucumber, custard apple and others (Weldon *et al*. 2008).

2.1.4 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:

Cultural methods of the pest control aim at reducing, insect population encouraging a healthy growth of trees or circumventing the attack by changing various agronomic practices (Chattopadhyay 1991). In the pupal stage of fruit fly, it pupates in soil and also over winter in the soil. In the winter period, the soil in the fields 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 (Kapoor 1993, Nasiruddin and Karim 1992, Chattopadhyay 1991, Agarwal *et al.* 1987). The female fruit fly lays 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 pre requisite 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 tree 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 flies infesting cucurbits, guava, mango, peach etc. and many borers of trees (Chattopadhyay 1991).

Thirty-two species and varieties of natural enemies to fruit flies were introduced to Hawaii between 1947 and 1952 to control the fruit flies. These parasites lay their eggs in the eggs or maggots and emerge in the pupal stage. Only three, *Opius longicaudatus* var. *malaiaensis* (Fullaway), *O. vandenboschi* (Fullaway) and *O. oophilus* (Fullaway) have become abundantly established. These parasites are primarily effective on the oriental and Mediterranean fruit flies in cultivated crops. The most efficacious parasite of the melon fly is *O. fletcheri* (Silvestri). It was introduced in 1916 from India. This parasite attacks the melon fly during the larval stage. Bess *et al.* (1961) reported that this parasite killed 20-40 per cent of fruit fly larvae. It is more effective in reducing populations in wild areas than in cultivated crops.

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

A wide range of organophosphoras, carbamate and synthetic pyrethroids of various formulations have been used from time to time against fruit fly (Kapoor 1993, Nayar *et al.* 1989, Gruzdyev *et al.* 1983, Canamas and Mendoza 1972). 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. Fenthion, Dichlorovos, Phosphamidon 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 *Bactrocera cucurbitae* on pumpkin in Assam during 1997. The most effective treatment in terms of lowest pest incidence and highest yield was carbofuran at 1.5 kg a.i/ha (Borah 1998).

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 and Deltamethrin (at 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 tree hosts tried during 1968-1990.

Protein hydrolysate insecticide formulations are now used against various dacine fruit fly species (Kapoor 1993). Now a day, different poison baits are used against various *Bactrocera* 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 water) or spraying trees with 500 g molasses plus 50 g Malathion in 50 liters of water or 0.025% Fenitrothion plus 0.5% molasses. This is repeated at weekly intervals where the fruit fly infestation is serious (Kapoor 1993).

Nasiruddin and Karim (1992) 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. Agarwal *et al.* (1987) achieved very good results for fruit fly (*Bactrocera cucurbitae*) management by spraying the trees with 500 g molasses and 50 liters 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.

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 (Qureshi *et al.* 1981). *Bactrocera dorsalis* was eradicated from the island of Rota by male annihilation using Methyl eugenol as attractant (Steiner *et al.* 1965). The attractant may be effective to kill the captured flies in the traps as reported several authors, one per cent Methyl eugenol plus 0.5 per cent Malathion (Lakshmann *et al.* 1973) or 0.1 per cent Methyl eugenol plus 0.25 per cent Malathion (Bagle and Prasad 1983) have been used for the trapping the oriental fruit fly, *Bactrocera dorsalis* and *Bactrocera zonata*. Neem derivatives have been demonstrated as repellents, antifeedants, growth inhibitors and chemosterilant (Steets 1976, Leuschner 1972, Butterworth and Morgan 1968). Singh and Srivastava (1985) found that alcohol extract of neem oil *Azadirachta indica* reduced oviposition per centage 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*.

Males of numerous *Bactrocera* and *Dacus* species are known to be highly attracted to either methyl eugenol or cuelure (Metcalf and Metcalf 1992). In fact, at least 90 per cent species are strongly attracted to either of these attractants (Hardy 1979).

Pheromone traps are important sampling means for early detection and monitoring of the fruit flies that have become an integrated component of integrated pest management.

2.2 General overview of Mango fruit weevil

2.2.1 Nomenclature

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Curculionidae

Genus: *Sternochetus*

Species: *Sternochetus frigidus*

2.2.2 Biology and ecology of mango weevil

The Mango stone weevil is an insidious pest that spends most of its life cycle inside the mango seeds (Pena *et al*. 1998). Adult female weevils oviposit into boat-shaped cavities on the fruit (Follet 2002, Smith 1996).

The larvae burrow through the pulp to the developing seed on hatching. The tunnel made by the larvae becomes undetectable after a short time (Woodruff and Fasulo 2006, Joubert 1998). The subsequent larval and pupal stages occur in the seed (Follet and Gabbard 2000). The larvae feed on the seed and makes extensive tunnels on the seed surface. A copious amount of frass is deposited in these feeding tunnels. The strategy of feeding inside the seed capsule makes it difficult to control the pest by use of such conventional methods as a foliar application of chemical pesticides. Newly emerged grubs bore through the pulp, feed on seed coat and later cause damage to cotyledons. Pupation takes place inside the seed. Pulp is discoloured around the affected portion.

The adult weevils become reproductively active when mango flowers begin to bloom (Hansen *et al.* 1989). Small or marble-size fruits are preferred, but nearly full-grown fruit may also be attacked. The female makes a boat shaped cavity in the skin (epicarp) in which an egg is deposited. She then covers each egg with a brown exudate and cuts a crescent-shaped area 0.25 - 0.50 mm in the fruit, near the posterior end of the egg. The wound creates a sap flow, which solidifies and covers the egg with a protective opaque coating (Hansen 1993). One female may lay 15 eggs per day, with a maximum of almost 300 over a three-month period (Balock and Kozuma 1964). The oviposition data suggested that the female weevils randomly select fruit for egg-laying and, hence, do not mark the oviposition site (Hansen *et al.* 1989). Hansen *et al.* (1989) concluded that the mango seed itself must be a nutritious resource, considering that five or more individuals can successfully complete development within one seed. After hatching, the small larva burrows through the pulp to the young developing seed. Generally, only one larva develops into a seed, but as many as five have been found. Larval development usually occurs within the seed and only very rarely in the pulp (Hansen *et al.* 1989). Hansen *et al.* (1989) believed that the larvae excavate cavities within the seed and pupate. Balock and Kozuma, (1964) calculated the larval period at 22 days. However, larval developmental period may be influenced by climate, location, host cultivar, and non-biotic site characteristics, for example, soil chemistry and humidity (Hansen *et al.* 1989). The pupal stadium lasts for about a week (Balock and Kozuma 1964).

Adults generally emerge from the seed about one or two months after the fruit has dropped and the fruit pulp has been consumed by various organisms (Balock and Kozuma 1964). Upon maturation, the adults rapidly move out of the seed and find hiding places. The weevils hide under loose tree barks, in the crotches of trees, under loose material beneath the trees and are able to hibernate inside the seed of the mangoes. Schoeman (1987) found weevils in crotches of trees after harvest, whereas soil samples and samples of loose material under the trees produced no weevils. According to Griesbach (2003) once the mango stone weevils have left the fruit, they search for a hiding place such as beneath loose bark of trees or in waste material under the trees where they spend the time of the year that is unfavorable for them. According to Balock and Kozuma (1964) the weevils remain in the sheltered locations until the fruiting season of the following year.

The factors which break diapause and motivate the weevils to seek oviposition sites are unknown (Hansen *et al.* 1989). Balock and Kozuma (1964) suggested that the onset of diapause seems to be associated with long-day photoperiod, and the break with short-day photoperiod. Mango weevils possess well-developed wings, but are poor fliers and fly only 50 to 90 cm at a time (De Villiers 1983, Kok 1979). However, Schoeman (1987) observed the weevils fly from tree to tree with ease and quickly disappear into the foliage. In India the adult weevils were found to feed on the leaves and tender shoots of mango trees during March and April. They are nocturnal, fly readily and usually feed, mate and oviposit at dusk. After emergence, adults enter a diapause, which varies in duration according to the geographic area (Shukla and Tandon 1985).

In a similar study in Ghana it was argued that the adult weevils fed on both honey and cotyledons of the mango seed in the laboratory and the adult weevils were attracted to mango flowers and appeared to feed on nectar and pollen. The attraction of mango stone weevils to flowers probably explains how it moves out of its hideout into flowering and fruiting mango trees and odours of flowers provide cues that direct the weevils to the host tree (Braimah *et al*. 2009).

2.2.3 Economic importance of mango weevil

Mango weevil is considered an important pest of mango fruit worldwide (Pena *et al.* 1998). It is considered as a serious pest because its development in the fruit causes damage to the pulp rendering it unmarketable, reduces the germination of seeds and causes premature fruit drop. Contrasting reports are found in literature regarding pulp feeding by the mango seed weevil; however, pulp feeding is considered to be rare (Follet and Gabbart 2000, Hansen *et al.* 1989). Pulp feeding was observed in South Africa, but the incidence was considered to be low in the cultivar "Kent" but not in the early maturing cultivar "Tommy Atkins". Pulp feeding might have resulted from eggs laid late in the season when seed husks had already hardened and thus prevented penetration by larvae (Louw 2006). Pulp damage is also caused when adult weevils emerge from the fruit on the trees in late season cultivars (Kok 1979, Milne *et al.* 1977).

Louw (2006) found emergence holes on the cultivar "Kent" but the incidence was low. Exit holes were not present on the early maturing cultivar "Tommy Atkins". Studies conducted in Hawaii to assess the effect of mango weevil infestation on seed viability showed that mango seed can withstand substantial damage and still germinate successfully (Follett and Gabbard 2000). Follett (2002) studied the effect of mango seed weevil infestation on premature fruit drop and reported that mango weevil infestation can increase fruit drop during early fruit development. When infestation by mango seed weevil was reduced by chemical sprays, fruit drop also decreased (Verghese 2005).

2.2.4 Management of mango weevil

Recommended practices for management of the mango stone weevil include orchard hygiene, application of pesticides (such as Lebaycid, Azinphos, Endolsulfan, Malathion and Carbosulfan) adherence to quarantine regulations and treeing resistant cultivars (Pinese and Holmes 2005, Griesbach 2003, Hill 1975, Joubert 1998, Smith 1996). Pesticides are applied either as foliar sprays or as trunk paint bands (Griesbach 2003). The reduction in infestation levels that results after using the recommended practices varies from one region to the other. Griesbach (2003) argued that most of these insecticides have been uneconomical and ineffective. He argued that the combination of sanitation of the orchard, treatment of the trunk and branches with insecticides and fruit treatment with pesticides usually reduces the weevil population in the orchard better than the application of single insecticides.

Habitat disruption of the mango pulp weevil population (MPW) by the removal of 25% of the canopy diameter of MPW-infested mango trees, or open centre pruning, an improved component of integrated pest management (IPM). The IPM mango trees yielded an average of 175 kg fruit/tree and a net income of 1,729.50 pesos/tree in contrast to traditionally (farmers) managed trees, which yielded only 4 kg or an income of only 20.00 pesos/tree (Lorenzana 2013).

Verghese (2005) found that intervention with a single spray of monocrotophos 0.05% or fenthion 0.08% at pea to marble size (middle of March) showed 13 to 15%

infestation as compared to 34% in the control in 1997. Two sprays of monocrotophos 0.05% at a 10 day interval, in 1998, and destruction of fallen fruits (at and just before harvest of the previous year) resulted in 97.5% and 100% control in Banganpalli and Alphonso. In the farmers field in Andhra Pradesh, South India, two experiments with three sprays of monocrotophos 0.05% or fenthion 0.08% at pre-flowering, at pea size and at marble size gave 100% control, thus ensuring pest-free fruits for export and processing.

It was found that four synthetic insecticides - deltamethrin, acephate, carbaryl and ethofenprox - obtained levels of infestation of between 3.3% and 14.8% at harvest, in contrast with a level without control of 33.0%. Two biological-origin insecticides - azadirachtin (of tree origin) and fish oil rosin soap (of animal origin) - obtained intermediate levels of control, of 27.4 and 23.0% respectively, which were not significantly superior to no-treatment (Verghese 2005).

According to Ntow (2008), worldwide pesticide usage has increased tremendously since the 1960s. It has largely been responsible for the “green revolution”, when there was massive increase in food production obtained from the same surface of the land with the help of mineral fertilizers (nitrogen, phosphorus and potassium), more efficient machinery and intensive irrigation. The use of pesticides helped to significantly reduce crop losses and to improve the yield of crops such as corn, maize, vegetables, potatoes and cotton. Notwithstanding the beneficial effects of pesticides, their adverse effects on environmental quality and human health have been well documented worldwide and constitute a major issue that gives rise to concerns at local, regional, national and global scales (Cerejeira *et al*. 2003, Huber *et al*. 2000, Kidd *et al*. 2001, Ntow 2001, Planas *et al*. 1997). Residues of pesticides contaminate soils and water, persist in the crops, enter the food chain, and finally are ingested by humans with foodstuffs and water. Furthermore, pesticides can be held responsible for contributing to biodiversity losses and deterioration of natural habitats (Sattler *et al.* 2007). There have been reported instances of pest resurgence, development of resistance to pesticides, secondary pest outbreaks and destruction of non-target species. Despite the fact that pesticides are also applied in other sectors, agriculture can undoubtedly be seen as the most important source of adverse effects (Sattler *et al.* 2007).

2.3 Management of mango hopper

Synthetic pyrethroids, viz. permethrin, fenvalerate (at 20, 30 and 40 ppm) or cypermethrin (at 10, 20 and 30 ppm) when sprayed after flowering were found effective in minimizing the hopper population (Shah *et al.* 1985). It can be controlled by spraying with malathion (0.15%), diazinon (0.02%), endrin (0.04%), carbaryl (0.15%), phosphamidon (0.05%) or nuvacron (0.04%) once at the time of panicle emergence and then again at the fruit set stage. Spraying of methyl parathion (0.025%), monocrotophos (0.025%), fenitrothion (0.25%) or carbaryl (0.1%) with high volume sprayer at the rate of 10 l/tree significantly reduced the hopper population in mango (Khangura and Malhi 1985). Spraying of carbaryl (0.1%), permethrin (0.01%) and dimethoate (0.03%) controlled both species, while carbaryl was the most effective against *A. atkinsoni* and permethrin against *I. neveosparsus* (Pingali and Patil 1988). Monocrotophos (0.03%), endosulfan (0.05%) and carbaryl (0.2%) are recommended for the control of *A. atkinsoni* (Mishra and Choudhuary 1996).

Godase *et al*. (2004) was conducted a field experiment in Maharashtra, India during 1998, 1999 and 2001 to evaluate the yield loss in mango cv. Alfonso caused by the mango hopper (Idioscopus niveosparsus). Monocrotophos was applied at 1, 2 and 3 sprays as individual treatments, during panicle emergence stage and at subsequent 15-day intervals. The hopper population was 6.71 and 8.5/panicle in 2 and 3 sprays, respectively, which was significantly less than the untreated control. Approximately 46.30 and 41.09% increase in yield was observed over the control, with 2 and 3 sprays, respectively. Two sprays applied first at panicle emergence and second at 15 days after the first spray were effective.

Indumathi and Savithri (2003) found the efficacy of endosulfan, malathion, carbaryl, cypermethrin, azadirachtin and imidacloprid at 1, 2 or 3 sprayings, in controlling the mango hoppers Amritodus atkinsoni and Idioscopus spp. was determined in a field experiment conducted in Andhra Pradesh, India from November 2001 to May 2002. 1, 2 and 3 sprayings of imidacloprid resulted in the highest, whereas sprayings with malathion resulted in the lowest reduction in the number of the mango hoppers.

Samanta *et al*. (2013), field experiment was conducted at Horticultural Research Farm, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal during 2007-08 and 2008-09 to evaluate the effectiveness of different spray treatments viz., T_1: Spraying of imidacloprid (0.005%) at panicle emergence, T_2: T_1+Spraying of endosulfan (0.07%) at 21 days after spraying of imidacloprid (0.005%) spray and T_3: T_2+Spraying of endosulfan (0.07%) at 15 days after first spraying of endosulfan (0.07%) along with untreated check against mango hopper. All insecticidal treatments were found to be significantly superior in reducing the hopper population as well as increase in fruit yield over untreated check. Among these treatments, the triple spray (T_3) was found to be most effective, which recorded lowest hopper population (5.48 hoppers/panicle) as well as highest fruit yield both at marble stage (197.62 fruits/100 panicles) and mature stage (96.4 kg/tree) and avoidable fruit loss (82.9%) followed by T_2 (double spray) and T_1 (single spray), respectively.

Ray *et al*. (2014) found the result on efficacy of module 4 (first spray at panicle emergence with spinosad 0.004%, second spray of thiamethoxam 0.008% after 21 days of 1st spray and third spray (need based) of neem azal 1000 ppm when fruits were at pea size) was found to be most effective in reducing (5.13 hoppers/panicle/week, 63%) mango hopper population in Zone III of Bihar. Next best was module 3 (first spray of thiamethoxam 0.008% at panicle emergence, second spray of profenophos 0.05% after 21 days of 1st spray and third spray (need based) of carbaryl 0.15% when fruits were at pea size) (5.84 hoppers/panicle/week, 58%). While maximum (113.68/100 panicle) fruit set/100 panicle at marble stage was recorded in module 4. Considering yield and cost-benefit ratio against management of mango hopper over the period of investigation, module 4 (88.20 kg/tree, 49%) was found most economical and it was followed by module 3 (80.38 kg/tree, 45%).

2.4 Use of Cypermethrin 10EC

Among the different traditional and synthetic pyrethriods evaluated for control of mango-hoppers for three years during 2004-06, synthetic pyrethriods, cypermethrin and fenvalerate proved better in reducing the pest population more than 89% for upto 10 days followed by quinalphos, carbaryl, endosulfan, monocrotophos and dimethoate with pest reduction ranging between 78.3 to 60.6% (Handa 2008).

Sathianandan (1972) reported carbaryl to be effective against mango hopper. Butani (1979) recommended phosphamidon and monocrotophos. Endosulfan and monocrotophos were reported to be effective against mango hoppers by many earlier workers (Khangura *et al*. 1993, Nachiappan and Baskaran 1986, Kumar *et al.* 1985, Dakshinamurthi 1984, Yazdani and Mehto 1980, Tandon and Lal 1979). In the present study, however, synthetic pyrethriods, *viz.* cypermethrin and fenvalerate were found more effective resulting in 92.7 and 89.8% reduction in pest population respectively. Quinalphos, carbaryl endosulfan and monocrotophos were also quite effective but significantly lower than synthetic pyrethriods. Dimethoate was the least effective. All the insecticides remained effective for upto 7 days.

Research compiled in five treatments and each test was repeated on five trees. Those five treatments were: T_1 = Actara 2 gram/5 liter water/tree, T_2 = Cypermetrin 5 ml/5 liter water/tree, T_3 = Amistar Top 5 ml/5 liter water/tree, T_4 = Combination of T_1+T_2+T_3 and T_5 = no treatment (control). The result showed that controlling major pest and disease of mangoes by combination of some alternative pesticides could effectively controlling pests and diseases of mango such as mango leafhopper, red banded mango caterpillar, and anthracnose. By combination of all treatments (T_4), production of mangoes increase into 161.20 kg/tree compared to control which only 122.40 kg/tree (Hidayah *et al*. 2013).

2.5 Use of Sex Pheromone

Sixty compounds related to methyl eugenol were evaluated for their attractiveness against oriental fruit fly, *B. dorsalis* and melon fruit fly, *B. cucurbitae* by Lee and Chen (1977) who reported that methyl isoeugenol, veratric acid, methyl eugenol and eugenol to be most effective attractants against *B. dorsalis* among the tested compounds. However, none of the tested chemicals was found to be significantly attractive against *B. cucurbitae.* According to Metcalf *et al.* (1983), *B. cucurbitae* was extreamly responsive to cuelure, but nonresponsive to methyl eugenol, whereas, *B. dorsalis* extremely responsive to methyl eugenol, but non-responsive to cuelure. In an experiment in melon field, commercially produced attractants Flycide C (80% cuelure content), Eugelure 20 (20%), Eugleure DB (8%), cuelure (80%) + naled cuelure (80%) + diazinon and cuelure (90%) + naled were tested against *B. cucurbitae* showed no significant difference in captured flies (Iwaizumi *et al.* 1991).

A study carried out by Wong *et al.* (1991) on age related response of laboratory and wild adults of melon fly, *B. cucurbitae* to cuelure revealed that response of males increased with increase in age and corresponded with sexual maturity for each strain. They failed to eradicate the pest with male annihilation programmes against *B. cucurbitae*, which might be because of the fact that only older males, which may have already mated with gravid females, responded to cuelure. Pawar *et al.* (1991) used cuelure (sex attractant) and tephritlure (food attractant) for the monitoring of *B. cucurbitae* and found cuelure traps more efficient in trapping fruit flies as compared to tephritlure. Gazit *et al.* (1998) studied the four trap types viz., IP-McPhail trap, Frutect trap, Cylinderical trap and Ga' aton trap with three female attractant baits viz., naziman, a proprietary liquid protein and a three component based synthetic attractant compound of ammonium acetate, putrescine and trimethylamine for Mediterranean fruit fly, Ceratitis capitata (Wiedemann). Their results ranked the trap and attractant performance as IP-McPhail trap baited with synthetic attractant > Frutect trap baited with proprietary lure > Cylinderical trap baited with synthetic attractant > IP-McPhail trap baited with naziman and Ga' aton trap baited either with synthetic attractant or naziman.

Vargas *et al.* (2009) evaluated various traps with methyl eugenol and cuelure for capturing fruit flies and observed that *B. dorsalis* was captured in methyl eugenol traps and *B. cucurbitae* in cuelure traps. Sapkota *et al.* (2010) reported that a participatory field experiment was conducted under farmer field conditions to assess losses and to measure the efficacy of different local and recommended management options to address the problem of it in squash var. Bulam House (F1). The experiment consisted of six different treatments including untreated control, and there were four replications. All the treatments were applied 40 days after transtreeing. Cucurbit fruit fly preferred young and immature fruits and resulted in a loss of 9.7% female flowers. Out of total fruits set, more than one-fourth (26%) fruits were dropped or damaged just after set and 14.04% fruits were damaged during harvesting stage, giving only 38.8% fruits of marketable quality.

CHAPTER III

MATERIALS AND METHODS

Experiment was conducted at the farmer's orchard of Bandarban, Rangamati and Khagrachari districts during the period from January to July 2016. The detail materials and methods adopted for this study are discussed under the following sub-headings:

3.1 Location of the experiment

The experiment was conducted at the farmer's orchard of three hill districts of Bangladesh. Experimental site at Bandarban (Plate 1), Rangamati (Plate 2) and Khagrachari (Plate 3) districts and farmer's information are given below:

Sl.	Farmer's Name	Location
1	Chingpat Murang	Kramadipara, Tongabati, Bandarban
2	Hemokumar Chakma	Shukurchari, Manikchari, Rangamati
3	Bayes Mia	Borobil, Manikchari, Khagrachari

Plate 1. Experimental orchard at Kramadipara, Tongabati in Bandarban district

Plate 2. Experimental orchard at Shukurchari, Manikchari in Rangamati district

Plate 3. Experimental orchard at Borobil, Manikchari in Khagrachari district

3.2 Characteristics of soil

The soils of the experimental sites are high land belonging to the Chittagong Hill tracts under the Agro Ecological Zone (AEZ) 29 (Northern and Eastern hills). The experimental sites were high hill (Appendix I).

3.3 Climate

The climate of the experimental site is sub-tropical characterized by heavy rainfall during April to September and sporadic during the rest of the year.

3.4 Variety of the mango

Amrapali or BARI Mango 3 was the cultivated variety for the experiment. Each of the orchards contained at least 21 mango trees which were considered as experimental unit and one mango tree was considered as one replication.

3.5 Treatments

Seven treatments were used in this study, which were same at Bandarban, Rangamati and Khagrachari districts. Details of treatments used in this study are shown in Table 1.

Table 1. Treatments for the management of mango fruit fly and fruit weevil and their application time

Sl. No.	Description
01	**T_1=** Spraying Ripcord 10 EC @ 1.0 ml/Liter water 4 times (30 January, 30 March, 28 April and 28 May)
02	**T_2=** Spraying Ripcord 10 EC @ 1.0 ml/Liter water 5 times (30 January, 24 February, 30 March, 28 April and 28 May)
03	**T_3=** Spraying Ripcord 10 EC @ 1.0 ml/Liter water 4 times (30 January, 30 March, 28 April and 28 May) + Sex pheromone trap
04	**T_4=** Spraying Ripcord 10 EC @ 1.0 ml/Liter water 5 times (30 January, 24 February, 30 March, 28 April and 28 May) + Sex pheromone trap
05	**T_5=** Spraying Ripcord 10 EC @ 1.0 ml/Liter 4 times (30 January, 30 March, 28 April and 28 May) + Sex pheromone trap + Bait trap
06	**T_6=** Spraying Ripcord 10 EC @ 1.0 ml/Liter water 5 times (30 January, 24 February, 30 March, 28 April and 28 May) + Sex pheromone trap + Bait trap
07	**T_7=** Untreated control

3.6 Design and layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each mango tree was considered as one experimental unit. Thus seven trees were considered as one block. Treatments were allocated randomly within the block and randomization was done separately for each block. Same treatments were used for each of three hill districts. As the experiment was conducted in the hilly regions, tree to tree distance was varied according to the slope of the hill.

Plate 4. Experimental orchard with the farmer

3.7 Intercultural operations

The experimental orchards were prepared by removing of bushes and weeds followed by cleaning and weeding during December to January’ 2016. Then, weeding was done as it grew higher through the period of experiment. Removing of dead twig and leaves was done during the preparation of experiment field.

3.8 Manure and fertilizer application

Age of all the mango trees using as a block in this experiment were within 4 (Four) to 10 (Ten) years. So, manures and fertilizers with their doses and their methods of application followed in the study were recommended in Hand Book on Agro-technology by BARI (Mondal *et al.* 2014) and are shown in Table 2.

Table 2. Doses of manures and fertilizers and their methods of application used for this experiment

Chemical and compost fertilizer	Age of Tree (Year)		
	2-4	5-7	8-10
Compost (kg)	10-15	16-20	21-25
Urea (g)	250	500	750
TSP (g)	250	250	500
MOP (g)	100	200	250
Gypsum (g)	100	200	250
Zinc Sulphate (g)	10	10	15
Boric acid (g)	20	20	30

3.9 Treatment application

3.9.1 Insecticide

For chemical insecticide spray, 10.0 ml of Ripcord 10EC was mixed with 10.0 litre water to make the spray solution. Spray mixture was applied with the help of foot pump sprayer for each treatment and Fungicide Tilt 250EC @ 0.5 ml/L was applied with each insecticidal spray as cover spray for the management of fungal disease. No insecticide was applied in untreated control trees.

3.9.2 Pheromone Trap (Plastic pot)

The pheromone, ‘methyl eugenol’ or ‘cuelure’, which mimics the scent of female flies, attracts the male flies and traps them in large numbers resulting in mating disruption. Simple plastic containers developed by BARI scientists known as 'BARI trap' or popularly known as 'Magic trap' (Plate 5) were used for deployment of the pheromones.

(A) **(B)**

Plate 5. Sex pheromone traps with captured fruit flies

The cylindrical plastic container having 3 liter capacity and 20-22 cm tall was used for this experiment. A triangular hole measuring 10-12 cm height and 10-12 cm base was cut in two opposite sides of the container. The base of the hole should be 3 cm above the bottom. Water containing two-three drops of detergent should be maintained inside the trap throughout the season. Pheromone soaked cotton or lure was tied inside the trap with thin wire. Fruit fly adults entered the trap and fall into the water and died. Water level was regularly checked to avoid dryness of trap. Pheromone dispenser was continued throughout the cropping season. One pheromone traps was hanged from the branch of the selected mango tree starting from 15 April before coming full maturity and was continued up to last harvest.

3.9.3 Bait trap

Bait trap was prepared using 100 g mashed sweet gourd mixed with 10.0 ml water and Sevin 50WP 2.0 g. Freshly prepared bait were taken in earthen pots and hanged from the branch of the tree. Bait trap was set 1st week of May and continued upto harvest. Used baits were changed by freshly prepared baits after one week to attract more fruit flies.

3.10 Harvesting

Harvesting of mango fruit was done during 20th June to 20th July, 2016. That time period was suitable for harvesting because the mangoes were matured and ready to sell in the local market. It was taken three to four days, to harvest all of the mangoes in a plot. Mangoes were harvested according to the treatments though each tree was treated as a treatment. After harvesting of one treatment, harvesting of another treatment was started. During the time of harvesting, mangoes were counted and mangoes were looked and tested thoroughly as it was infested or not. Then the mangoes were kept in a specific site.

Plate 6. Mangoes were gathered together after harvesting

3.11 Data collection

After harvest healthy and infested fruits/tree were sorted out visually and recorded separately for each treated and untreated tree in each district. Total number of fruits/tree was calculated by addition of healthy and infested fruits/tree.

3.11.1 Percent total fruit infestation

Percent total fruit infestation for each tree was calculated by using the following formula:

$$\%\text{ total fruit infestation} = \frac{\text{No. of infested fruits/tree}}{\text{Total no. of fruits /tree}} \times 100$$

3.11.2 Fruit infestation by fruit fly and fruit weevil

Twenty fruits were selected randomly from each tree and dissected longitudinally by knives. Number of healthy fruits, fruit fly infested fruits (Plate 8) and weevil infested fruits (Plate 13) out of 20 fruits from each tree were recorded separately. Percent fruit infestation by fruit fly and fruit weevil was calculated separately for each treatment in each district:

$$\%\text{ fruit infestation by fruit fly} = \frac{\text{No. of fruit fly infested fruits}}{20} \times 100$$

$$\%\text{ fruit infestation by weevil} = \frac{\text{No. of fruit weevil infested fruits}}{20} \times 100$$

3.11.3 Percent increase of healthy fruits/tree

The percent increase of healthy fruits/tree in treated tree over untreated control tree was computed by using the following formula:

% increase of healthy fruits/tree over control

$$= \frac{\%\text{ healthy fruits in treatements} - \%\text{ healthy fruits in control}}{\%\text{ healthy fruits in control}} \times 100$$

Plate 7. Adult mango fruit fly is laying eggs on fruit

(A)

(B)

Plate 8. External (A) and Internal (B) symptoms of fruit fly infested fruit

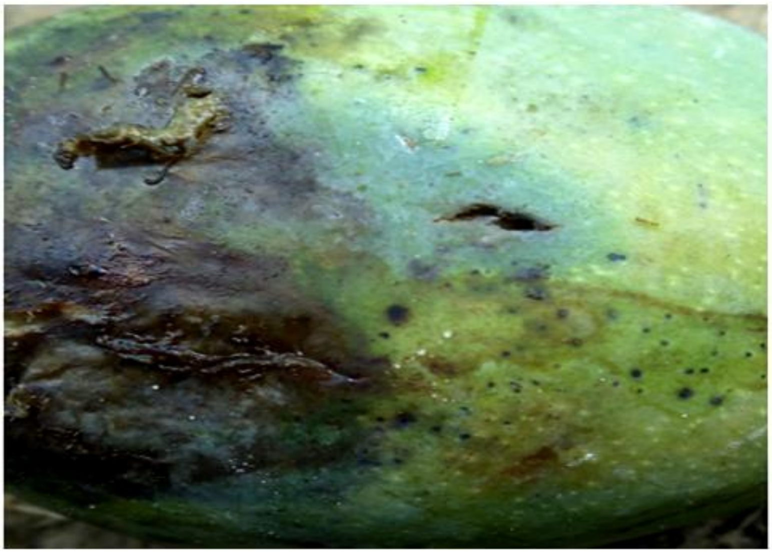

Plate 9. Fruit rot due to fruit fly infestation

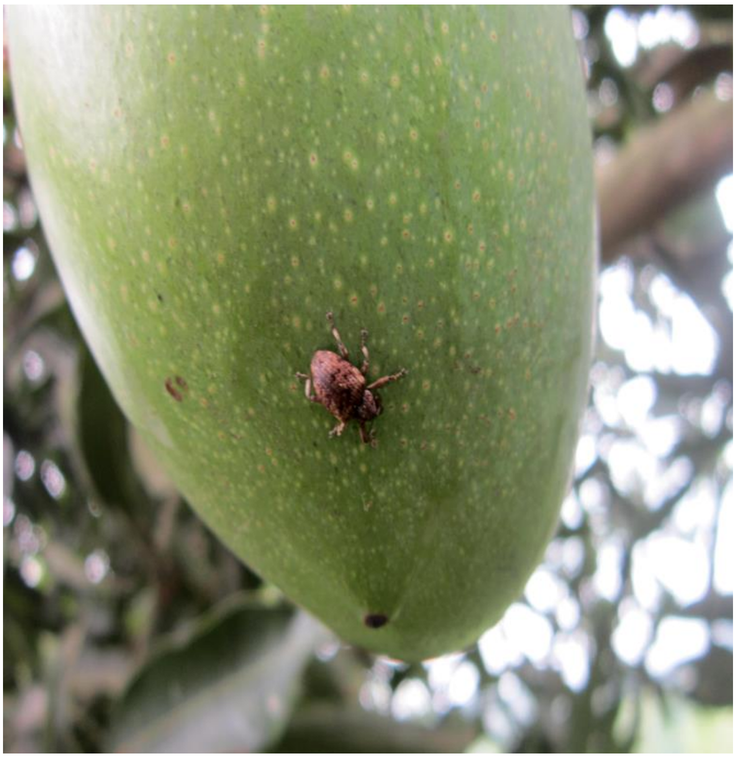

Plate 10. Adult mango fruit weevil (*Sternochetus frigidus*) on fruit

Plate 11. Exit hole by mango fruit weevil after emergence

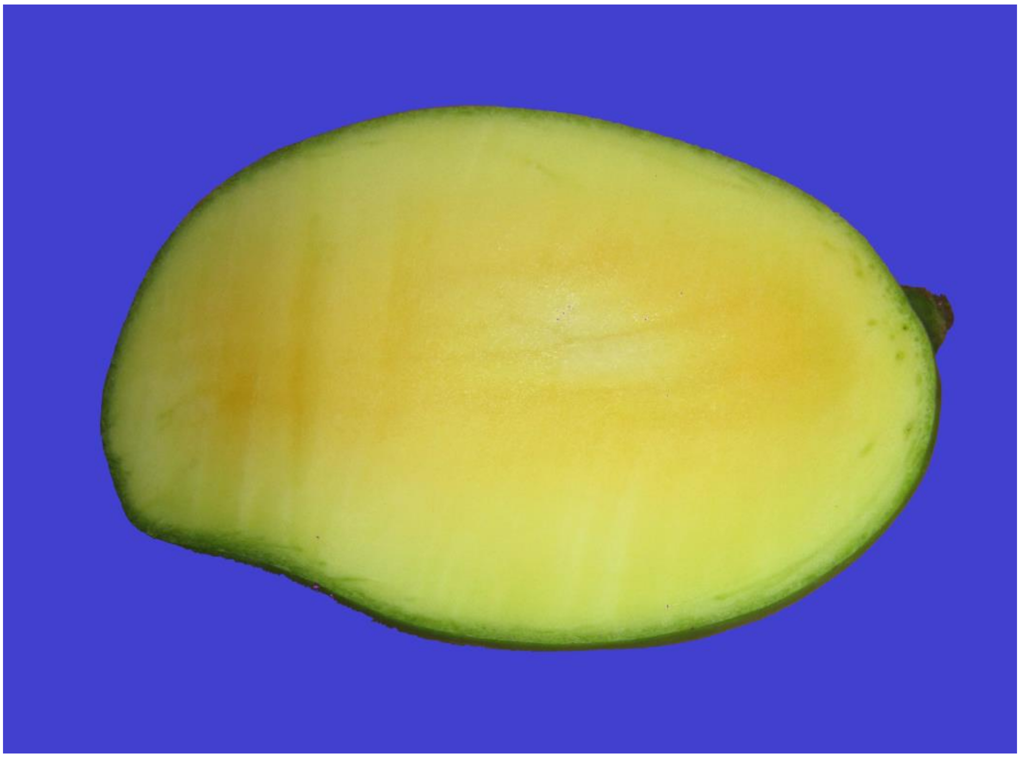

Plate 12. Fresh mango fruit showing no symptoms of infestation

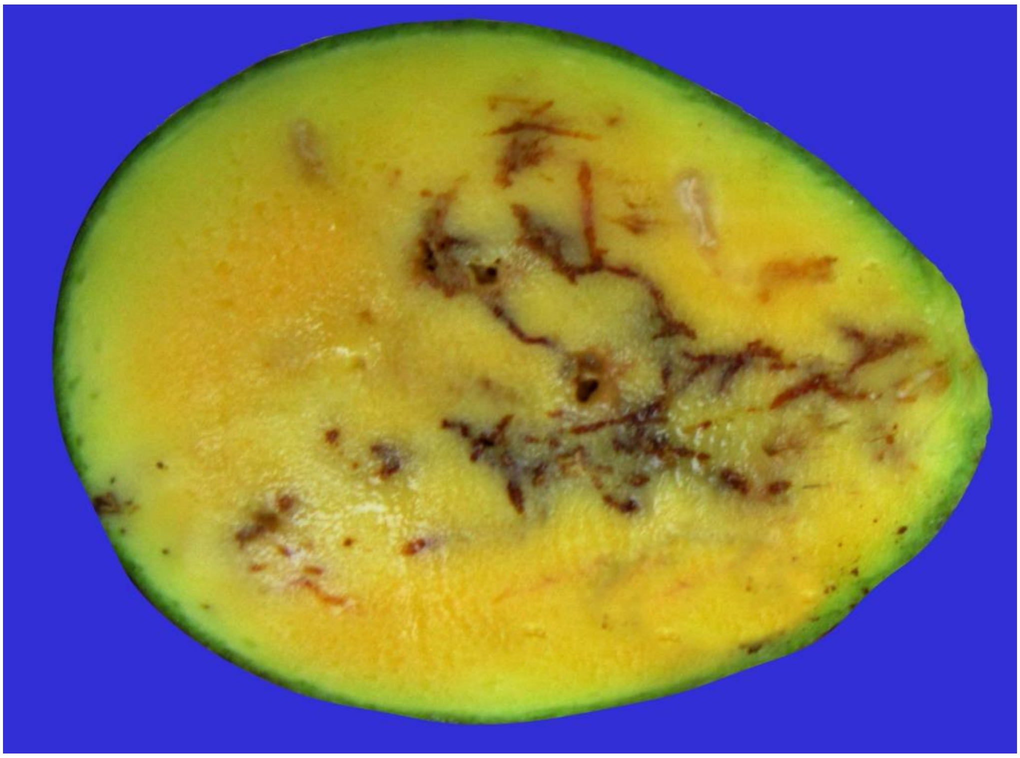

Plate 13. Mango fruit weevil infested fruit

Plate 14. Data collection after harvesting

3.11.4 Percent decrease of infested fruits/tree

The percent decrease of infested fruits/tree in treated tree over untreated control tree was computed by using the following formula:

% decrease of infested fruits over control

$$= \frac{\text{\% infested fruits in control} - \text{\% infested fruits in treatments}}{\text{\% infested fruits in control}} \times 100$$

% decrease of fruit infestation

$$= \frac{\text{\% fruit infestation in control} - \text{\% fruit infestation in treatemetns}}{\text{\% fruit infestation in control}} \times 100$$

3.12 Statistical analysis of data

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT program (Gomez and Gomez, 1976). The treatment means were separated by Duncan's Multiple Range Test (DMRT).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted at farmer's orchard in Kramadipara, Bandarban; Sukurchari, Rangamati and Borobil, Khagrachari districts during January 2016 to July 2016 to develop pest management tactics against mango fruit fly and fruit weevil which were major insect pests of mango. The results of the present study have been presented and discussed under the following sub-headings:

4.1 Effect of different treatments on production of mango fruits

Total number of mango fruits/tree varied significantly in different treatments at Bandarban, Rangamati and Khagrachari districts. Data in Table 3 indicate that the highest number of total fruits/tree (447.33/tree) was recorded from T_4 treatments at Kramadipara (Bandarban) followed by T_6 (438.33/tree) and T_5 (430.00/tree) having no significance difference among them but significantly higher than other treatments. In contrast the lowest number of total fruits/tree (362.00) was observed in T_7 (control) which was significantly different from other treatments. No significant difference was observed among T_3 (422.67 fruits/tree), T_5 (430.00 fruits/tree) and T_6 (438.33 fruits/tree) for production of total number of mango fruits/tree. Moreover, treatments T_1 and T_2 gave statistically similar number of mango fruits/tree (399.33 fruits/tree and 400.67 fruits/tree respectively). Similar trend of total number of mango production was found at Sukurchari (Rangamati) and Borobil (Khagrachari) for all treatments. However, the number of fruits/tree was recorded higher at Bandarban than Khagrachari and Rangamati for all treatments.

Results indicate that spraying chemical insecticide during production of mango increased number of fruits/tree at Bandarban, Rangamati Khagrachari districts.

Application of ripcord 10EC during flowering and fruit setting period (30 January and 28 February) reduced the population of mango hoppers and increased number of fruits/tree. The result agrees with the findings of several researchers (Hidayah *et al*. 2013, Handa 2008, Shah *et al.* 1985) who reported that spraying Cypermethrin reduced hopper population and increased mango fruit production. However, variation in number of fruits/tree in different treatments might be the variation of canopy size, effect of pheromone trap and bait trap. Pheromone bait trap reduced population of fruit fly and might decrease fruit dropping. Further, variation in number of fruits/tree at Bandarban, Rangamati and Khagrachari districts might be the variation of canopy size of the mango tree at three districts.

Table 3. Number of fruits/tree under different treatments at Bandarban, Rangamati and Khagrachari districts in 2016

Treatments	Number of fruits/tree		
	Bandarban	Rangamati	Khagrachari
T_1	399.33 c	165.67 d	234.00 bc
T_2	400.67 c	195.33 c	248.00 b
T_3	422.67 b	200.67 bc	281.67 a
T_4	447.33 a	223.67 a	300.67 a
T_5	430.00 ab	202.33 bc	288.67 a
T_6	438.33 ab	208.67 b	291.33 a
T_7 (Control)	362.00 d	163.33 d	211.33 c
$S_{\bar{x}}$	**6.35**	**3.01**	**7.83**
CV (%)	**8.65**	**8.68**	**10.82**

In a column, means having same letter(s) are statistically similar at 5% level of significance by DMRT.

[T_1= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times, T_2= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times, T_3= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap, T_4= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap, T_5= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap + bait trap, T_6= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap + bait trap]

4.2 Effect of different treatments on mango fruits infestation

Data express that the lowest number of infested fruits/tree (30.00) was recorded from T_4 at Bandarban district having no significant difference with T_6 (30.33 infested fruits/tree) and T_5 (31.00 infested fruits/tree but significantly different from other treatments (Table 4). On the other hand the highest number of infested fruits/tree (302.67) was recorded from T_7 (control) which was significantly higher than all other treatments. Further no significant variation was observed between T_2 (49.00 infested fruits/tree and T_3 (41.67 infested fruits/tree).

Table 4. Number of infested fruits/tree and percent decrease of infested fruits/tree over control by treatment application at Bandarban, Rangamati and Khagrachari in 2016

Treatments	Bandarban		Rangamati		Khagrachari	
	No. of infested fruits/tree	Percent decrease of infested fruits/tree over control	No. of infested fruits/tree	Percent decrease of infested fruits/tree over control	No. of infested fruits/tree	Percent decrease of infested fruits/tree over control
T_1	53.33 b	82.36 d	24.67 b	82.92 d	27.00 b	85.16 c
T_2	49.00 bc	83.80 c	19.67 c	86.41 c	21.33 c	88.27 b
T_3	41.67 c	86.22 b	19.67 c	86.42 c	20.00 cd	89.02 b
T_4	30.00 d	90.07 a	13.67 d	90.53 a	16.33 d	91.02 a
T_5	31.00 d	89.74 a	17.33 cd	88.01 b	17.67 cd	90.30 a
T_6	30.33 d	89.95 a	17.33 cd	88.00 b	16.67 d	90.83 a
T_7 (Control)	302.67 a	--	144.67 a	--	182.00 a	--
$S_{\bar{x}}$	**2.87**	**0.29**	**1.50**	**0.45**	**1.22**	**0.34**
CV (%)	**11.47**	**5.57**	**12.07**	**5.89**	**9.90**	**5.67**

In a column, means having same letter(s) are statistically similar at 5% level of significance by DMRT.

[T_1= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times, T_2= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times, T_3= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap, T_4= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap, T_5= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap + bait trap, T_6= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap + bait trap]

All the treatments gave more than 80.0% decrease of infested fruits/tree over untreated control (T_7). However the best result was found for T_4 which offered 90.07% decrease of infested fruits/tree over T_7 (control) having no significant difference with T_6 (89.95%) and T_5 (89.74%). Similar results on number of infested fruits/tree and percent decrease of infested fruits/tree were found at Rangamati and Bandarban districts for all treatments.

Significant variation was also observed for percent mango fruit infestation by fruit fly and weevil at three hill districts (Table 5). At Bandarban, the lowest percent of fruit infestation (6.88%) was observed in T_4 treatment which was statistically similar with T_6 (7.17%) and T_5 (7.49%) but significantly different from other treatments. In contrast the highest percent fruit infestation (83.68%) was recorded from T_7 (control) which was significantly higher than other treatments (Table 5). Data also indicate that all the treatments showed effectiveness by providing more than 80.0% decrease of fruit infestation over untreated control (T_7). However treatments T_4, T_5 and T_6 gave more than 90.0% protection of fruit infestation over untreated control (T_7) having no significant variation among them but significant difference with other treatments. Similar results were observed at Rangamati and Khagrachari districts for all treatments tested in this study.

Results indicate that all the treatments significantly reduced mango fruit infestation over untreated control (T_7) but T_4 performed best. Treatments T_5 and T_6 also gave same results as T_4 in case of percent decrease of fruit infestation over untreated control. The order of effectiveness of six treatments in terms of percent decrease of mango fruit infestation over untreated control (T_7) at three hill districts is $T_4 > T_6 > T_5 > T_3\ T_2 > T_1$. The result agrees with the findings of several authors (Vargas *et al*. 2009, Metcalf and Metcalf 1992, Nasiruddin and Karim, Quershi 1981) who reported that pheromone trap (Methyl eugenol) reduced infestation of oriental fruit fly, *Bactrocera dorsalis*. Moreover, Verghese (2005) reported that synthetic pyrithroid, deltamethrin reduced weevil infestation.

Table 5. Percent fruit infestation and reduction of infestation over control by treatment application at Bandarban, Rangamati and Khagrachari in 2016

Treatments	Bandarban		Rangamati		Khagrachari	
	Percent fruit infestation	Percent decrease of infestation over control	Percent fruit infestation	Percent decrease of infestation over control	Percent fruit infestation	Percent decrease of infestation over control
T_1	12.16 b	85.47 d	11.86 b	86.61 d	9.47 b	89.01 e
T_2	11.39 c	86.39 c	11.82 b	86.66 d	8.54 c	90.09 d
T_3	10.29 d	87.71 b	9.79 c	88.94 c	7.55 d	91.24 c
T_4	6.88 e	91.77 a	6.99 e	92.10 a	5.72 f	93.36 a
T_5	7.49 e	91.05 a	8.57 d	90.33 b	6.64 e	92.29 b
T_6	7.17 e	91.43 a	7.75 de	91.25 ab	5.81 f	93.25 a
T_7 (Control)	83.68 a	--	88.58 a	--	86.12 a	--
$S_{\bar{x}}$	0.25	0.27	0.27	0.30	0.14	0.17
CV (%)	11.16	9.52	11.27	9.58	10.29	8.31

In a column, means having same letter(s) are statistically similar at 5% level of significance by DMRT.

[T_1= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times, T_2= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times, T_3= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap, T_4= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap, T_5= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap + bait trap, T_6= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap + bait trap]

4.3 Effect of different treatments on healthy mango fruits production

Significant variation was observed for total number of mango fruits/tree at three districts. Data (Table 6) indicate that the highest number of healthy fruits/tree (19.67) was recorded from T_4 treatments at Kramadipara (Bandarban) having significant variation with all other treatments. On the other hand, the lowest number of healthy fruits/tree (59.00) was observed in T_7 (control) which was significantly lower than other treatments. No significant variation was observed among T_6 (392.33 fruits/tree), T_5 (385.33 fruits/tree) and T_3 (381.00 fruits/tree) and T_2 (370.67 fruits/tree) for production of healthy mango fruits/tree. Similar trend of healthy mango fruits/tree production was found at Sukurchari (Rangamati) and Borobil (Khagrachari) for all treatments. All the treatments increased more than 80.00% healthy fruits/tree over control at Bandarban and Rangamati districts but T_4 gave the best result (increased 85.93% healthy fruits/tree) which was similar to T_6 (increased 84.95% healthy fruits/tree) having no significant difference between them. At Khagrachari district, treatment T_4 increased 70.48% healthy fruits/tree followed by T_6 (70.32%) and T_5 (69.05%) having no significant difference among them but significantly different from others.

Results demonstrate that application of chemical insecticide with pheromone and bait trap during production of mango increased number of healthy fruits/tree at three hill districts. The best result was found for T_4 (spraying of Ripcord 10EC @ 1ml/L of water 5 times + pheromone trap). The order of effectiveness of six treatments in terms of percent increase of healthy fruits/tree over untreated control (T_7) at three hill districts is $T_4 > T_6 > T_5 > T_3\ T_2 > T_1$. Different treatments increased healthy fruits/tree by reducing population of mango hopper, fruit fly and fruit weevil infestation. The result agrees with the findings of Hidayah *et al.* (2013) who reported that spraying

Cypermethrin reduced hopper population and increased mango production. However, variation in number of fruits/tree in different treatments might be variation of canopy size, effect of pheromone trap and bait trap. Pheromone and bait trap reduced population of fruit fly and may be decreased fruit dropping. Further, variation in number of healthy fruits/tree at Bandarban, Rangamati and Khagrachari districts might be the variation of canopy size of the mango tree at three districts.

Table 6. Number of healthy mango fruits/tree and percent increase of healthy fruits/tree over control by treatment application at Bandarban, Rangamati and Khagrachari in 2016

Treatments	Bandarban		Rangamati		Khagrachari	
	No. of healthy fruits/tree	**Percent increase of healthy fruits/tree**	**No. of healthy fruits/tree**	**Percent increase of healthy fruits/tree**	**No. of healthy fruits/tree**	**Percent increase of healthy fruits/tree**
T_1	364.00 c	83.76 c	146.00 c	87.23 c	216.33 c	63.89 c
T_2	370.67 bc	84.08 bc	181.67 b	89.69 b	229.00 c	66.67 b
T_3	381.00 bc	84.51 bc	181.00 b	89.72 b	258.33 b	66.67 b
T_4	419.67 a	85.93 a	206.33 a	90.95 a	280.67 a	70.48 a
T_5	385.33 bc	84.68 bc	184.00 b	89.84 b	265.33 ab	69.05 a
T_6	392.33 b	84.95 ab	185.00 b	89.90 b	274.67 ab	70.32 a
T_7 (Control)	59.00 d	--	18.67 d	--	29.33 c	--
$S_{\bar{x}}$	**7.22**	**0.32**	**2.12**	**0.12**	**6.90**	**0.35**
CV (%)	**10.69**	**7.65**	**7.33**	**7.22**	**12.39**	**7.70**

In a column, means having same letter(s) are statistically similar at 5% level of significance by DMRT.

[T_1= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times, T_2= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times, T_3= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap, T_4= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap, T_5= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap + bait trap, T_6= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap + bait trap]

4.4 Effect of different treatments on fruit fly infestation

Percent fruit infestation by fruit fly significantly varied under different treatments at three hill districts. Data in Table 7 indicate that the lowest percent fruit infestation by fruit fly (5.00%) was recorded from T_4 treatment at Bandarban district having no significant difference with T_6 (6.67%) and T_5 (8.33%) but significantly different from other treatments. On the contrary the highest percent of fruit infestation (86.67%) was recorded from control (T_7). No significant variation was observed among T_1 (13.33%), T_2 (11.67%) and T_3 (10.00%) in terms of percent mango fruit infestation by fruit fly. In case of percent reduction of fruit fly infestation over control (T_7) T_4 treatment showed the best performance by providing 94.23% reduction of infestation. Treatments T_6 (92.27%) and T_5 (90.41%) also gave statistically similar result of T_1. Other treatments T_1, T_2 and T_3 gave more than 80.00% reduction of fruit infestation over untreated control. Similar trend of mango fruit infestation by fruit fly under different treatments was observed at Rangamati and Khagrachari districts.

Result reveals that T_4 treatment (spraying of Ripcord 10EC @ 1ml/L of water 5 times + pheromone trap) showed best performance for protection of fruit fly infestation over control. Treatments T_6 (spraying of Ripcord 10EC @ 1ml/L of water 5 times + pheromone trap + bait trap) and T_5 (spraying of Ripcord 10EC @ 1ml/L of water 4 times + pheromone trap + bait trap) also gave similar result against fruit fly attacking mango fruit. The order of effectiveness of six treatments in terms of percent reduction of fruit infestation by fruit fly over untreated control (T_7) at three hill districts is $T_4 > T_6 > T_5 > T_3\ T_2 > T_1$. The result supports the report of Qureshi *et al*. (1981) who reported that mass trapping with methyl eugenol reduced infestation of *Bactrocera zonata* below economic injury level. Rabindranath and Pillai (1980) also reported that Cypermethrin spraying was very useful in controlling *Bactrocera cucurbitae* in bitter gourd which also supports this result.

Table 7. Percent of fruit infestation by fruit fly under different treatments and percent decrease of fruit infestation over control at Bandarban, Rangamati and Khagrachari in 2016

Treatments	Bandarban		Rangamati		Khagrachari	
	Percent of fruit infestation	Percent decrease of fruit infestation over control	Percent of fruit infestation	Percent decrease of fruit infestation over control	Percent of fruit infestation	Percent decrease of fruit infestation over control
T_1	13.33 b	84.64 c	13.33 b	84.86 b	11.67 b	86.36 d
T_2	11.67 bc	86.49 bc	13.33 b	84.97 b	10.00 bc	88.21 cd
T_3	10.00 bcd	88.45 abc	11.67 bc	86.82 ab	8.33 bcd	90.29 bcd
T_4	5.00 e	94.23 a	6.67 c	92.48 a	3.33 e	96.19 a
T_5	8.33 cde	90.41 abc	10.00 bc	88.67 ab	6.67 cde	92.25 abc
T_6	6.67 de	92.27 ab	6.67 c	92.37 a	5.00 de	94.10 ab
T_7 (Control)	86.67 a	--	88.33 a	--	85.00 a	--
$S_{\bar{x}}$	**1.50**	**1.73**	**1.61**	**1.84**	**1.21**	**1.25**
CV (%)	**12.83**	**3.35**	**12.98**	**3.61**	**11.25**	**2.38**

In a column, means having same letter(s) are statistically similar at 5% level of significance by DMRT.

[T_1= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times, T_2= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times, T_3= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap, T_4= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap, T_5= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap + bait trap, T_6= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap + bait trap]

4.5 Effect of different treatments on mango fruit weevil infestation

Percent fruit infestation by fruit weevil significantly varied under different treatments at three hill districts. Data in Table 8 indicate that the lowest percent fruit infestation by fruit weevil (6.67.00%) was recorded from T_4 treatment at Bandarban district having no significant difference with T_6 (8.33%) and T_5 (10.00%) but significantly different from other treatments. On the contrary the highest percent of fruit infestation (83.33%) was recorded from control (T_7). No significant variation was observed among T_1 (15.00%), T_2 (13.33%) and T_3 (11.67%) in terms of percent mango fruit infestation by fruit weevil. In case of percent reduction of fruit weevil infestation over control (T_7), T_4 treatment showed the best performance by providing 91.91% reduction of infestation. Treatments T_6 (89.95%), T_5 (87.99%) and T_3 (86.03%) also gave statistically similar result of T_4. Other treatments T_1 and T_2 gave more than 80.00% reduction of fruit infestation over untreated control. Similar trend of mango fruit infestation by fruit weevil under different treatments was observed at Rangamati and Khagrachari districts.

Result reveals that T_4 treatment (spraying of Ripcord 10EC @ 1ml/L of water 5 times + pheromone trap) showed best performance for protection of fruit weevil infestation over control. Treatments T_6 (spraying of Ripcord 10EC @ 1ml/L of water 5 times + pheromone trap + bait trap) and T_5 (spraying of Ripcord 10EC @ 1ml/L of water 4 times + pheromone trap + bait trap) also gave similar result against fruit weevil attacking mango fruit. The order of effectiveness of six treatments in terms of percent reduction of fruit infestation by fruit weevil over untreated control (T_7) at three hill districts is $T_4 > T_6 > T_5 > T_3\ T_2 > T_1$.

Pheromone and bait trap has no effect on fruit weevil but spraying Ripcord 10EC may reduce the weevil infestation. Schoeman (1987) reported that weevils flew from tree to tree during March to April and fed on leaves and deposited eggs at dusk. Moreover Braimah *et al*. (2009) observed that odours of mango flower provided cues which attracted weevils to the host tree. Thus schedule spraying Ripcord 10EC may cause mortality of adult weevil that might reduce fruit infestation.

Table 8. Percent of fruit infestation by fruit weevil under different treatments and percent decrease of fruit infestation over control at Bandarban, Rangamati and Khagrachari in 2016

Treatments	Bandarban		Rangamati		Khagrachari	
	Percent of fruit infestation	Percent decrease of fruit infestation over control	Percent of fruit infestation	Percent decrease of fruit infestation over control	Percent of fruit infestation	Percent decrease of fruit infestation over control
T_1	15.00 b	81.99 c	13.33 b	84.64 b	11.67 b	85.91 b
T_2	13.33 bc	84.07 bc	13.33 b	84.53 b	10.00 bc	87.99 ab
T_3	11.67 bcd	86.03 abc	11.67 bc	86.49 ab	8.33 bc	89.95 ab
T_4	6.67 e	91.91 a	6.67 c	92.37 a	5.00 c	94.00 a
T_5	10.00 cde	87.99 ab	10.00 bc	88.45 ab	6.67 c	92.03 a
T_6	8.33 de	89.95 ab	8.33 bc	90.31 ab	6.67 bc	92.03 a
T_7 (Control)	83.33 a	--	86.67 a	--	83.33 a	--
$S_{\bar{x}}$	**1.50**	**1.75**	**1.67**	**1.89**	**1.50**	**1.78**
CV (%)	**12.26**	**3.49**	**13.47**	**3.74**	**13.81**	**3.41**

In a column, means having same letter(s) are statistically similar at 5% level of significance by DMRT.

[T_1= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times, T_2= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times, T_3= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap, T_4= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap, T_5= Spraying of Ripcord 10EC @ 1.0 ml/L of water 4 times + pheromone trap + bait trap, T_6= Spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap + bait trap]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the farmer's orchard in Bandarban, Rangamati and Khagrachari districts during January 2016 to July 2016 to develop management tactics against mango fruit fly and mango weevil. The treatments of the experiment were T_1= Spraying Ripcord 10EC @ 1.0 ml/L water 4 times, T_2= spraying Ripcord 10EC @ 1.0 ml/L water 5 times, T_3= spraying Ripcord 10EC@ 1.0 ml/L water with pheromone trap 4 times + pheromone trap, T_4= spraying Ripcord 10EC @ 1.0 ml/L water 5 times + pheromone trap, T_5 = spraying Ripcord 10EC @ 1.0 ml/L water 4 times + pheromone trap + bait trap, T_6 = application of ripcord 10EC @ 1.0 ml/L water 5 times + pheromone trap + bait trap. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each mango tree was considered as one experimental unit.

The highest number of fruits/tree was recorded from T_4 treatments at Bandarban (447.33/tree), Rangamati (223.67/tree) and Khagrachari (300.67/tree) districts as against the lowest from T_7 (362.00/tree, 163.33/tree and 211.33/tree from Bandarban, Rangamati and Khagrachari, respectively).

Number of infested fruits/tree was found the lowest in T_4 treatments (30.00/tree, 13.67/tree and 16.33/tree at Bandarban, Rangamati and Khagrachari districts, respectively as against the highest (302.67/tree, 144.67/tree and 182.0/tree at Bandarban, Rangamati and Khagrachari, respectively). Treatments T_5 and T_6 gave similar results. All the treatments reduced more than 80.0% fruit infestation over control treatment (T_7).

In terms of percent fruit infestation by insect pests, the lowest infestation (6.88%, 6.99% and 5.72% from Bandarban, Rangamati and Khagrachari districts, respectively) was observed from T_4 treatment. Treatments T_4, T_5, and T_6 provided more than 90.0% reduction of fruit infestation over control (T_7). Other treatments (T_1, T_2, and T_3) reduced more than 80.0% fruit infestation over untreated control (T_7) at three hill districts.

Number of healthy fruits/tree was found highest (419.67/tree, 206.33/tree and 280.67/tree at Bandarban, Rangamati and Khagrachari districts respectively) from T_4 treatment. All the treatments increased more than 80.0% healthy fruits/tree over untreated control (T_7) at Bandarban and Rangamati districts. Only T_4 and T_6 increased more than 70.0% healthy fruits/tree over untreated control (T_7) at Khagrachari district. Number of healthy fruits/tree was very poor in control treatment (59.0/tree, 18.67/tree and 29.33/tree at Bandarban, Khagrachari and Rangamati respectively).

Fruit fly infestation varied significantly in different treatments and lowest percent fruit infestation (5.00%, 6.67% and 3.33% at Bandarban, Rangamati and Khagrachari respectively) was recorded in T_4 treatment as against the highest fruit infestation in control (86.67%, 88.33% and 85.00% at Bandarban, Rangamati and Khagrachari respectively). This treatment gave maximum protection against fruit fly by reducing more than 90.0% fruit infestation over control (T_7) at three hill districts. Treatments T_6 and T_5 also gave similar result against mango fruit fly by reducing about 90.0% fruit infestation over control (T_7). Other treatments (T_1, T_2 and T_3) gave more than 80.0% reduction of fruit fly infestation over control (T_7) at three hill districts.

Fruit weevil infestation also significantly varied in different treatments and lowest percent fruit infestation (6.67%, 6.67% and 5.00% at Bandarban, Rangamati and Khagrachari respectively) was recorded in T_4 treatment as against the highest fruit infestation in control (83.33%, 86.67% and 83.33% at Bandarban, Rangamati and Khagrachari respectively). This treatment gave maximum protection against fruit weevil by reducing more than 90.0% fruit infestation over control (T_7) at three hill districts. Treatments T_6 and T_5 also gave similar result against mango fruit weevil by reducing about 90.0% fruit infestation over control (T_7). Other treatments (T_1, T_2 and T_3) gave more than 80.0% reduction of fruit weevil infestation over control (T_7) at three hill districts.

The result of the study revealed that treatment T_4 (spraying Ripcord 10EC @ 1.0 ml/L of water 5 times + pheromone trap) showed the best performance against mango fruit fly and fruit weevil, gave lower amount of infested fruits/tree and produced higher number of healthy fruits/tree compared to control. Treatment T_6 (spraying Ripcord 10EC @ 1.0 ml/L water 5 times + pheromone trap + bait trap) and T_5 (spraying Ripcord 10EC @ 1.0 ml/L water 4 times + pheromone trap + bait trap) showed the similar performance.

Considering the result of the present study it may by concluded that treatment T_4 comprising spraying of Ripcord 10EC @ 1.0 ml/L of water 5 times with pheromone trap was the most effective management practices against mango fruit fly and fruit weevil. Treatment T_6 consisting spraying Ripcord 10EC @ 1.0 ml/L water 5 times + pheromone trap + bait trap and T_5 spraying Ripcord 10EC @ 1.0 ml/L water 4 times + pheromone trap + bait trap also showed the similar performance against these pest. These treatments may be used for the overall management of mango insect pests but needs further trial for validation in large area.

CHAPTER VI

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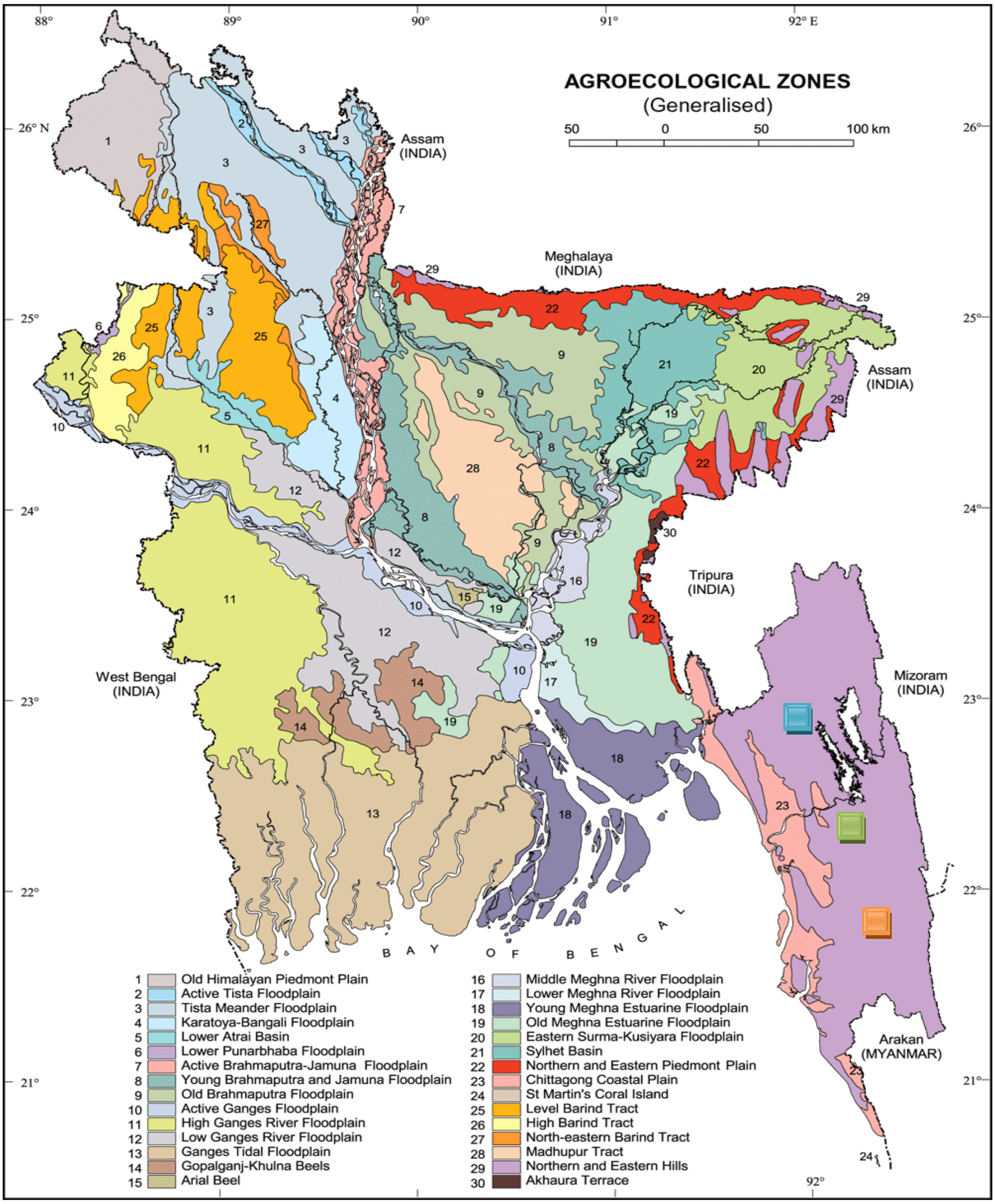
APPENDIX

Appendix I. Map showing the Location of farmer's orchard under the study



Kramadipara, Tongabati, Bandarban

Shukurchari, Manikchari, Rangamati

Borobil, Manikchari, Khagrachari