SHOOT FEEDERS OF MANGO AND THEIR MANAGEMENT

PREETHA. L

(2009-11-147)

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Department of Agricultural Entomology

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KERALA, INDIA

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DECLARATION

I hereby declare that this thesis entitled "**Shoot feeders of mango and their management**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Shoot feeders of mango and their management**" is a record of research work done independently by Mrs. Preetha.L (2009-11-147) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Dedicated to
My loving parents and
family members

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LIST OF ABBREVIATIONS

%	Per cent
/m^2	Per square metre
@	At the rate of
a.i	Active ingredient
CD	Critical difference
DAS	Days after sowing
DAT	Days after treatment
et al.	And others
Fig.	Figure
g	Gram
h	Hour
ha^{-1}	Per hectare
Kg	Kilogram
m	Metre
ml	Millilitre
SC	suspension concentrate
SP	Soluble powder
sp.	Species
viz.	Namely
WP	Wettable powder

Introduction

1. INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most popular fruits widely grown in tropical and subtropical parts of the world. It is indigenous to India and Southeast Asia. India is having an area of 2,312 thousand ha and the production is around 15.03 million tons, contributing 40.48 per cent of the total world production of mango (FAO, 2010).

High incidence of pests and diseases is reported as one of the major constraints for the low productivity of mango in India. The perennial nature of the crop results in the persistence of many economically important pests. More than 500 pests including insects, mites, nematodes, birds and mammals have been reported to infest mango (Tandon and Verghese, 1985). Of the 260 species of insects and mites that have been reported as pests of mango, 127 are foliage feeders (Pena *et al*., 2002). Shoot or leaf feeders are one of the largest group of injurious insects of mango. They cause damage by reducing the photosynthetic area of the plant and thereby decrease the quantity of photosynthates. Foliage feeders attain major pest status when they attack the newly emerging leaves. Young plants showed poor establishment due to continuous damage on new shoots. The poor establishment of the grafts and seedlings of mango limits the area expansion of the crop.

The leaf cutting weevil, *Deporaus marginatus* Pasc. cause significant loss to mango by damaging the newly emerging leaves. The weevil inflicts two kinds of damage on new leaves. Feeding damage is caused by both male and female weevils. Serious damage is caused by the female weevil by cutting the leaf blade near the petiole after laying eggs in the mid rib. Infested shoots become almost leafless. The leafless shoots may be more than 80 per cent, if control measures are not taken (Zhang and Wei, 1991).

The biology of the leaf cutting weevil has been studied in other parts of India. As far as Kerala is concerned, the information on biology, susceptible stage

of infestation of the plant and the susceptibility of varieties to the weevil are lacking at present. These information are vital in evolving strategies for the management of the pest.

Over use and misuse of highly toxic, persistent and broad spectrum insecticides are common practice among farmers. This may cause pest flare up due to the development of insecticide resistance, resurgence and secondary pest outbreak. Recently, neonicotinoids like imidacloprid and synthetic pyrethroids like lambdacyhalothrin were found effective for the management of leaf hoppers of mango (Verghese, 2000). Botanicals like neem and annona products have been found successful in managing chewing as well as sucking pests of crops (Lenin, 2011). Effective chemicals and botanicals have to be identified and the time of application has to be standardised for formulating management strategy for the leaf cutting weevil of mango.

Kerala, a humid tropical part of India is known for many traditional varieties of mango. Both seedlings and grafts are commonly seen in many homesteads. Considering the importance of foliage feeders in mango, the present study was undertaken with the objectives of documenting shoot feeders of mango, assessing the intensity of damage and identifying effective pesticides for the management of major shoot feeder, *D. marginatus*.

Review of literature

2. REVIEW OF LITERATURE

The literature related to shoot feeders of mango, extent of damage caused by leaf cutting weevil and its management is briefly reviewed.

Mango (*Mangifera indica* L.) is one of the major fruit crops of India, known as the king of fruits for its sweetness, excellent flavour, delicious taste and high nutritive value (Singh, 1968). Mango had been reported to be infested by 551 pests in different parts of the world which include 492 species of insects, 17 species of mites, 26 species of nematodes, 9 species of birds and 7 species of mammals (Tandon and Verghese, 1985). They also reported 250 insects and mite pests on mango from Indian subcontinent, of which 30 pests were serious, capable of causing loss to crop growth and yield. The insect pests of mango were mango hoppers, mealy bugs, scale insects, stem and shoot borers, leaf feeders, fruit flies, flower feeders and gall formers (Veeresh, 1989; Pena *et al*., 2002).

2.1 SHOOT AND LEAF FEEDERS OF MANGO

Mango suffers regularly a collosal loss due to ravages of pests in nursery as well as in field conditions in Gujarat. Studies on the insect pests infesting mango root stocks in nursery revealed that shoot borer (*Chlumetia transversa* Walker), mango hopper (*Amritodus atkinsoni* Lethierry), gall midge (*Procontarinia matteiana* Kiefer and Cecconi), leaf eating caterpillars (*Penicillaria jocosatrix* Guenee), leaf cutting weevil (*Deporaus marginatus* Pasc.), leaf miner (*Acrocercops syngramma* Meyrick), leaf mining weevil (*Rhynchaenus mangiferae* Marshall) and mealy bug (*Drosicha mangifera* Green) were identified as major pests (Patel, *et al*. 1997).

Kannan and Rao (2006) conducted a field study to document incidence of various coleopteran pests of mango in Andhra Pradesh. The incidence of new flush, fruit and stem damaging coleopterans *viz*., flea weevil, *Rhynchaenus*

mangiferae, leaf twisting weevil, *Apoderus transquebaricus* Fabricius, leaf cutting weevil, *Deporaus marginatus* Pascal, ash weevil, *Myllocerus discolor* Boheman, stone weevil, *Sternochaetus mangiferae* Fabricius and stem borer, *Batocera rufomaculata* Dagear were prevailed in the mango ecosystem. The study also revealed that *R. mangiferae*, *A. transquebaricus*, *D. marginatus* and *M. discolor* had negative correlation with minimum and maximum temperature and positive correlation with rainfall and relative humidity. While stone weevil, *S. mangiferae* and stem borer, *B. rufomaculata* were positively correlated with maximum and minimum temperature and negatively correlated with relative humidity and rainfall.

The incidence of lepidopteran pest complex in mango cv. Neelum in Andhra Pradesh was studied by Kannan and Rao (2007). Twelve species of lepidopteran pests were found infesting mango trees at different growth stages. Shoot borer (*Penicillaria jocosatrix*), leaf miner (*Acrocercops syngramma*), leaf-eating caterpillars (*Euthalia garuda garuda* Moore, *Porthesia scintillans*, Wlk, *Lymantria marginata,* Wlk, *Latoia lepida*, Cramer, *Orgyia postica* Wlk and *Thalassodes quadraria*, Guenee), flower-feeding caterpillar (*Euproctis fraterna* Moore) and leaf folder (*Homona permutata* Meyrick) damaged the new vegetative flush and flowers of mango. The leaf webber (*Orthaga exvinacea* Hbn.) and fruit borer (*Conogethes punctiferalis* Guenee) infested mainly the old foliage or matured leaves and ripened fruits.

The occurrence of pests during the new flush, twig expansion, matured leaf and fruit maturity stages of 0 to 5, 5 to 15 and ≥15 year old mango cv. Neelum in Andhra Pradesh was studied by Kannan and Rao (2007). Trees that are 0-5 year old were preferred by new flush pests such as *R. mangiferae, A. transquebaricus, D. marginatus, M. discolor, A. syngramma, P. jocosatrix, O. postica, E. garuda garuda, P. scientillans, P. lepida* and *L. marginata* whereas trees that are 5-15 years old were preferred by aphids such as *Toxoptera odinae*

Van der Goot and *T. quadraria*. Trees of 15 year old and above were preferred by the pests *Amradiplosis ecinogalliperda* Kieffer, *O. exvinacea, A. atkinsoni, Idioscopus niveosparsus* Leth., *D. mangiferae G, S. mangiferae, Bactrocera dorsalis* Henden, *C. punctiferalis G* and *B. rufomaculata*.

Chaturvedi *et al*. (1981) reported *P. lepida, O. exvinacea, P. jocosatrix,* and *C. transversa* as common lepidopteran pests of mango in West Bengal. Bhole *et al*. (1987) studied the seasonal incidence of the geometrid *T. dissita,* the noctuids *P. jocosatrix.* and *C. transversa,* the lymantriid *Laelia* sp., the gracillariid *A. syngramma,* the attelatid *D. marginatus,* the scarabaeid *Popillia* sp. and the pseudococcid *D. mangiferae* in Maharashtra. The pests appeared in June-July and their incidence was high in July-October after which it declined.

Zaman and Maiti (1994) reported the geometrid *Thalassodes veraria* Wlk, the lymantriid *D. mendosa*, the chrysomelids *Aspidolopha melanophthalma* Lacordaire, *Diapromorpha pallens* Fabricius and *Monolepta* sp., the curculionids *D. marginellus* and *Myllocerus* sp., in mango seedlings in West Bengal. *D. marginatus* was the major pest, defoliating new growth. Shaw *et al*. (1997) and Verghese (1998) recorded the prevalence of *O. exvinacea* in Madhya Pradesh and Andhra Pradesh.

Reddy *et al*. (2001) recorded the seasonal occurrence and distribution pattern of mango leaf webber (*O. exvinacea*) on mango cv. Bangalora in Andhra Pradesh. The incidence of mango leaf webber was first observed during second fortnight of June. The peak incidence (78.0 webs/tree) was recorded during the second fortnight of October. Thereafter, the incidence declined and reached negligible level in January. No incidence was recorded from February to May. More number of leaf webs was observed in the lower region of the tree followed by the middle and upper regions. The highest number of leaf webs was recorded in the southern direction of the tree followed by East and West, and the lowest number of webs was observed in northern direction. *O. exvinacea* was considered

as one of the minor pests of mango but, since last few years, this pest attained the status of a major pest of mango in Kerala (Mohammed and Renjith, 2011).

Barkade, *et al*. (2010) recorded *T. dissita* was very common on both the mango and cashew and this was considered as a minor pest in the past. However, in recent days, it became regular pest causing considerable damage to the tender foliage of nursery seedlings and grafts. The infestation was also severe in bud wood orchards and young plantations on tender vegetative flush during rainy season.

Hoppers were reported as major pests of mango from Phillipines, Pakistan, Thaiwan, Burma, Bangladesh, Srilanka and India (Baker, 1915; Kato, 1926; Jepson, 1935; Palo, 1935; Alam, 1962; Ghauri 1967). Verghese (1998) opined that among the hoppers damaging mango in India, *A. atkinsoni*, *A. brevistylus*, *Idioscopus niveosparsus*, *I. clypealis*, *I. nagpurensis* and *Amrasca splendens* Ghauri were caused serious damage.

Among the mango hoppers, *I. clypealis* was severe in Punjab, Haryana, Utter Pradesh, Tamil Nadu, Bihar, West Bangal, Karnadaka and Andhra Pradesh (Tandon and Lal, 1976). The wide spread attack of three species of hopper, *I. clypealis*, *I. niveosparsus* and *A. atkinsoni* were reported from Southern India (Prashad and Bagle 1979; Soomro *et al.* 1987).

Das *et al.* (1969) observed the incidence of *A. splendens* as serious pest in Kerala. The hoppers clustered on the lower side of tender leaves and suck the sap from mid rib and side veins. Later, the leaf veins turned brown and the leaves became curled distorted and stunted.

D. mangiferae, a serious pest of mango had been reported from China, Bangladesh, Pakistan and India (Pruthi and Batra, 1960; Alam 1962; Rafiq and Ghani, 1972). Tandon and Lal (1976) reported that *D. mangiferae* was found in

all states except Karnataka and Kerala and infestation was serious in Punjab, Utter Pradesh, Bihar and Delhi. While moderate infestation was recorded from West Bangal and low in Orissa, Tamil Nadu, Gujarat, Himachal Pradesh, Maharashtra, Madhya Pradesh and Andhra Pradesh.

Infestation of many species of scales and mealy bugs were observed on leaves, shoot, flowers and fruits of mango from Kerala. The major species reported were *Chionaspis vitis* Gr., *Chloropulvinaria psidii* Gr., *Phenacoccus mangiferae* and *P. iceryoides* Gr. (Nair, 1989).

2.2 MANGO LEAF CUTTING WEEVIL

The mango leaf cutting weevil, *D. marginatus* had been recorded as a pest of mango in India, Burma, Sri Lanka, Malaysia, China and Bangladesh (Fletcher, 1917, 1918; Hutson and Alwis, 1934; Ahmad and Ho, 1970; Butani, 1979; Zou 1982; Hill, 1983) reported that among the pests mango leaf cutting weevil was major pest, which caused extensive damage to the foliage in Assam.

2.2.1 Biology

Hutson and Alwis (1934) studied biology of leaf cutting weevil and reported that eggs were laid in the fleshy part of the mid-rib of the leaf, usually on the upper side, about 0.5 inch apart. The female then cuts the leaf right across about 3 inches from the stalk, so that the part containing the eggs falls to the ground. The eggs hatch in 2 to 2.5 days, and the larval and prepupal periods total 10 to 12 days. The larvae completed their development in shrivelled leaves, provided that there was sufficient moisture to prevent them from drying too quickly. The pupal stage, in cells just below the surface of the soil, occupied 11 to 12 days. Beesan (1941) reported that the adult live for about 12 weeks. Khanna (1952) reported the larval period of 7 to 9 days and the pupal period of 9 to 15 days. Butani (1993) reported the larval life between 6 and 8 days.

Tigvattnanont (1988) reported that the female *D. marginatus* excavate small cavities on either side of the midrib on leaves and deposit one egg in each cavity. Two to 14 eggs were laid in one leaf which was then cut near the base and droped to the ground. The larvae fed the tissue of fallen leaves and mature larvae pupate in the soil. The average duration of the egg, larval and pupal stages in the laboratory was 1.99, 11.13 and 7.71 days, respectively. The average duration of one generation was 20.83 days, and the longevity of males and females were 63.40 and 71.80 days, respectively and, on average, 614.47 eggs were laid per female.

Bhole and Dumbre (1990) recorded the biology of the mango leaf cutting weevil *D. marginatus* in laboratory. Before the oviposition, the female excavated small cavities on either side of the midribs on upper surfaces of leaves. Only one egg was laid in each cavity. About 2 to 14 eggs laid in one young leaf which was found cut later by the female weevil, near the base of the leaf from one edge through the midrib to the other edge. Larvae mine in the tissues of the fallen leaves, and full grown larvae came out of leaves to pupate in moist soil, within earthen cells. It was found that the average duration of incubation, larval and pupal stages were 2.12, 10.53 and 6.89 days, respectively. The average life cycle from egg to adult was 21.79 days and life spans of male and female averaged 56.46 and 67.43 days, respectively. The mating started in the morning (approx.7.00 a.m.) on 5 to 7^{th} day after the emergence. The copulation time was 50 to 65 minutes and the average number of eggs oviposited thoughout female life was 512.32.

Rafiquzzaman and Maiti (1998 a) opined that two to three days after emergence, the weevil mated freely, which lasted for 15 to 40 min. A female laid 1 to 21 eggs on the leaf, usually on the dorsal side of the midrib. Larvae developed on fallen cut leaves by passing through three larval instars. The mean egg, larval, prepupal and pupal period were 1.93, 7.26, 4.64 and 7.06 days,

respectively. Pupation took place in an earthen shell at a depth ranging from 3 to 5 cm. The adults were shiny dark brown with a light brown abdomen. The mean developmental period from egg to adult was completed in 20.89 days.

Sahoo and Jha (2006) studied the biology of the mango leaf cutting weevil, *D. marginatus*, under laboratory conditions. The study revealed that incubation period and fecundity of the weevil was approximately 24 h and 234 to 390 eggs per female, respectively. Larval, pre-pupal and pupal period varied from 94 to 145 h, 110 to 180 h and 6 to 30 days, respectively. In laboratory condition, adult weevil survived for 15-25 days. The total life cycle of the leaf cutting weevil was completed within 17.18 to 49.67 days. Female weevil was slightly bigger than the male and possessed light brownish sclerotized distinctly curved genitalia, while in the case of male, it was tubular in nature.

2.2.2 Bioecology

Rafiquzzaman and Maiti (1997) reported the population fluctuations of *D. marginellus* in relation to major abiotic factors in West Bengal. It was found that leaf damage on mango was at a peak during July-August and least during the 2nd fortnight of November, followed by no activity during December-February. Temperature, relative humidity and rainfall influenced the development of the population. Kannan and Rao (2006) conducted a study and concluded that *D. marginatus* had negative correlation with minimum and maximum temperature, positive correlation with rainfall and relative humidity.

Rafiquzzaman and Maiti (1999) investigated induction and termination of larval hibernation of the mango leaf cutting weevil, *D. marginatus*, under laboratory condition. The peak incidence of dormancy in the larval stage was induced at the onset of winter, i.e. during November in West Bengal, when the temperature falls below 26°C. Dormancy was terminated by an increase in

temperature above 26°C during February. Dormancy in the larval stage was indicated by the loss of body weight of up to 26.69 per cent from November onwards, while the weight was regained from February onwards.

Two forecasting methods (Field monitoring) were proposed by Zhang *et al.* (1993). One was the phenology method, which was based on the synchronization between the development of young shoots and that of *D. marginatus* larvae inhabiting the soil. Another was the duration method; pupation occured after rain and pupal duration can be used to forecast the peak of oviposition.

2.2.3 Nature of damage

Hutson and Alwis (1934) reported that the larvae mined in the leaves, causing brown blotches, and the adults fed on the epidermis and leaf tissues of young foliage, and the injured leaves turned brown and curled up. Soh and Khoo (1983) reported that two kinds of damage were inflicted on new flushes of leaves by the adult insect. Feeding damage was caused by both male and female adults. More serious damage was caused by the female when she neatly cut the leaf blade near the petiole after laying one or more eggs on the leaf lamina which then found falling to the ground. Tigvattnanont (1988) studied the feeding behavior of adults and reported that they fed on the epidermis of young leaves causing browning and death of leaves.

Bhole and Dumbre (1990) opined that the adult weevils fed on the epidermis of young leaves, the affected areas turned brown, and finally, the young leaves curled and crumpled, while their larvae acted as leaf miner. Uddin *et al.* (2003) reported mango leaf cutting weevil attacked the new flushes of leaf and destroyed them completely leaving only the stems. Young trees suffered more than the older ones. The females were excavated small cavities on either side of the midribs on lower surfaces of tender pinkish leaves which were found cut by the weevils near the base. The leaf was droped on the ground.

2.2.4 Alternate hosts

Beesan (1941) reported that *D. marginatus* was a pest of mango, this pest defoliating *Butea frondosa* Palash also. Gupta and Singh (1986) recorded the *D. marginatus* as a pest of *Litchi chinensis* L. in Uttar Pradesh. The insects attack new flushes of *L. chinensis* and mango plants at the end of June. Damage to mango was more severe than to *L. chinensis.*

Tigvattnanont (1988) studied the host range and distribution of *D. marginatus* in Thailand. *Mangifera caloneura* Kurz, *M. foetida* Lour and *Bouea burmanica* Griff were recorded as host plants. Bhole and Dumbre (1990) conducted an extensive survey on the host range and local distribution of *D. marginatus* and revealed that *M. indica, Mangifera caloneura, M. foetida* and *Bouea burmanica* were the host plants of *D. marginatus*.

2.2.5 Varietal reaction

Rafiquzzaman *et al.* (1999) studied susceptibility of *D. marginatus* to 10 mango cultivars in West Bengal. The incidence of the weevil was estimated from the number of leaves damaged, at monthly intervals. All the cultivars studied were susceptible to attack by the weevil, the most susceptible cultivar was Amrapali which had 53.9 and 57.4 per cent leaf infestation in 1995 and 1996 respectively. Sorikhus was the least susceptible cultivar, with 33.17 and 39.8 per cent leaf infestation in 1995 and 1996 respectively. Damage was moderate in June and then increased exponentially until August. Damage was lowest in October.

Chakraborti *et al*. (2007) conducted a screening study in West Bengal. Ten mango hybrids were evaluated for resistance to leaf cutting weevil (*D. marginatus*). The lowest mean infestation levels were recorded for Prabha Sankar and Mahmud Babar. Neeluddin registered the highest mean infestation levels.

Uddin *et al.* (2003) studied the reaction of 12 mango graft varieties on the incidence of mango leaf cutting weevil (*D. marginatus*). The highest infestation

of 52.55 per cent was recorded in Amrapali. The lowest infestation of 13.78 and 18.55 per cent was found in Langra and Gopalbhog.

Sahoo and Jha (2008) evaluated mango cultivars for resistance to *D. marginatus* under nursery conditions. Himasagar was most susceptible to the pest. Bangalora was the least affected by the leaf cutting weevil. Among the other cultivars, the weevil also significantly damaged Langra, Ratna, Sorikhas and Subarna Rekha.

A survey was conducted by Chakraborti *et al.* (2009) to determine leaf cutting weevil, *D. marginatus* infestation to 20 mango cultivars in West Bengal. Weevil infestation was significantly more in Alphonso (65.1 per cent), while Suvarnarekha (9.8 per cent) was least. Suvarnarekha and Bangalora exhibited the highest resistance to *D. marginatus*.

2.2.6 Management

Singh and Pandey (1972) conducted control tests in Uttar Pradesh with six insecticides in sprays and dusts. The results showed that all treatments were significantly better in protecting the leaves. A wettable-powder spray of DDT at 0.25% and an emulsion spray of dichlorvos (Nuvan) at 0.05% were the most consistently effective.

Siddiqi and Mathur (1980) reported that nursery plants infested with *D. marginatus* were sprayed with DDT (0.25%), methyl demeton (0.05%), endosulfan (0.05%) or fenitrothion (0.05%) and the number of healthy or damaged leaves assessed 72 h after spraying. They found that all insecticidal treatments provided significant control of the pest, endosulfan was the most effective chemical. After treatment, the control had only 23.97 per cent leaves undamaged by the pest compared with 76.72 to 89.00 per cent for the treated plants.

Soh and Khoo (1983) conducted a field test with four insecticides for the control of *D. marginatus* on mango in West Malaysia. Deltamethrin applied at 0.0022 per cent was the most effective of the compounds tested, reducing the number of cut shoots from 44.9 (for no treatment) to 4.9% and retaining its toxicity only up to 2 weeks. Deltamethrin was followed, by etrimfos at 0.075%, acephate at 0.082% and dicrotophos at 0.053%.

Bhole and Dumbre (1990) reported that the mango pest *D. marginatus* was susceptible to BHC, carbaryl and quinalphos. It was found that only 0.2 and 10% HCH were effective against the pest, causing 83.33 and 86.66 per cent adult mortality respectively 48 h after treatment. Rafiquzzaman and Maiti (1998 c) reported the relative contact toxicity of four insecticides to adult mango leaf cutting weevil, *D. marginatus*, under laboratory conditions. Based on the LC50, the rank order of efficacy was cypermethrin > quinalphos > carbaryl > dichlorvos.

Insecticides such as trichlorphon, deltamelthrin and fenvalerate were effective for the control of *D. marginatus* (Huang and Fei, 1987; Zhang and Wei, 1991). Rafiquzzaman and Maiti (1998 b) conducted studies with two soil insecticides, chlorpyriphos (0.06 and 0.08%) and aldrin (0.03 and 0.05%), under laboratory conditions against prepupa and pupa of the mango leaf cutting weevil, *D. marginatus*. Both insecticides gave an excellent level of control with a contact period of one hour. Chlorpyrifos at 0.08% and aldrin at 0.05% produced rapid kill of prepupa and pupa within 120 and 96 hours, respectively. Aldrin at 0.03% gave a poor level of control.

Verghese (1998) reported that imidacloprid was effective at all doses tested including the lowest dose of 0.2 ml/lt. Lambdacyhalothrin was also effective and was comparable with the standard monocrotophos. Efficacy of the azadirachtin (3000 and 1000 ppm) seemed to depend on the level of hopper density. At lower densities (<4 per panicle), they were as effective as the synthetic chemicals.

Materials and methods

3. MATERIALS AND METHODS

The study on shoot feeders of mango and their management was conducted at College of Agriculture, Vellayani during the period 2010-2011. The objectives of the study were to document the shoot feeders of mango, to assess the intensity of damage and to identify the effective pesticides for their management. The research includes survey, laboratory experiments and a field experiment.

3.1 SURVEY

Survey was conducted in Thiruvananthapuram district to document the shoot and leaf feeders of mango and to assess the intensity of damage to crop. Six panchayats, (two each from each taluk) were selected from three taluks of Thiruvananthapurm district *viz.* Neyyattinkara, Nedumangadu and Thiruvananthapuram. The locations of survey were selected panchayats. They were Vilavoorkal and Venganoor from Neyyattinkara taluk, Manickal and Vembayam from Nedumangad taluk and Kalliyoor and Thiruvallam from Thiruvananthapuram taluk. From each location 10 young plants were selected randomly. The plants were observed during flushing stage. The occurrence of the pests on the leaf buds, leaves and shoots were recorded, collected, identified and documented. The intensity of damage was scored 0-3 scale as detailed below.

Score	Damage percentage using
0	No damage
1	1 – 25% damage
2	26 – 50% damage
3	more than 50% damage

3.1.1 DOCUMENTATION

From the survey, pests were categorized in to leaf eating caterpillars, leaf eating beetles and sucking pests and their different stages of pests were documented.

3.2 BIOLOGY OF MANGO LEAF CUTING WEEVIL, *Deporaus marginatus* Pasc.

3.2.1 Maintenance of Stock Culture of the Insect

Infested leaves were collected from the field. A trough (15-20 cm diameter) containing moist soil was used for rearing the weevil. Two infested leaves were kept in one trough and maintained at the required moisture level. Emerged adults were allowed to lay eggs on tender mango leaves. After egg laying, fresh leaves were kept in troughs. Insects from this stock culture were used for further studies.

3.2.2 Determination of Life Stages

Newly emerged adults were collected from the stock culture. Five pairs of adults were released to tender mango twigs in the trough. The twigs were replaced every day. The leaves with oviposition scars were collected and examined carefully. Morphological characteristics of eggs were observed. Eggs were examined every day for the emergence of larvae. Newly emerged grubs were examined and characters were recorded. Feeding behaviour of larvae and the larval period were observed. Characters of pupae, site of pupation and pupal period were recorded. Newly emerged adults were examined for their morphological characters, longevity and fecundity.

3.3 DETERMINATION OF SUSCEPTIBLE STAGE OF INFESTATION

New shoots of mango were tagged at the bud bursting stage for collecting leaves of different age of maturity. Newly emerged adult weevils collected from the stock culture were used for the study. Shoots of different age of maturity from one day to 15 days of bud bursting were collected from the tagged shoots. Five pairs of adults were released on each shoot. Feeding behavior (scraping and cutting of leaf) and egg laying behaviour of adult weevils were recorded.

3.4 REACTION OF MANGO VARIETIES TO LEAF CUTTING WEEVIL

Varieties planted in the newly established orchard of Instructional Farm Vellayani were observed in the flushing season for the occurrence of leaf cutting weevil. The varieties observed were Alphonso, Amrith, Banganapalli, Bangalora, Imampasand, Jehangir, Jnattukuzhiyan, Kalapadi, Kottukonam, Langra, Malgoa, Mundappa, Neelam, Pairi, Perakka Varikka, Prior, Pulichi, Rose Pichi, Savitha, Suvarnarekha and Vellari Varikka. Six plants were selected from each variety for the study. From each plant three new shoots were selected and total number of young leaves was counted. Observations were recorded on the feeding damage (scraping) by adult weevils on leaves and leaf cutting by the female weevils. Percentage infestation was also worked out.

3.5 LABORATORY EVALUATION OF BOTANICALS

Insects maintained in the stock culture were used for the study.

The experimental laid out in CRD with six treatments replicated four times.

Treatments

T1 - Neem seed kernel extract 5%

T2 - Annona seed extract 5%

T3 - Neem oil 2%

T4 - Neem oil garlic emulsion 2%

T5 - Econeem plus 1%

T6 - Treated control (water)

3.5.1 Preparation of Spray Solutions

Neem Seed Kernel Extract (NSKE) 5%

Neem seeds were dried and 50 g of kernel was weighed out after removing the seed coat. The kernels were crushed well, tied in a piece of cloth and immersed in one litre of water for 12 hours to get five per cent neem seed kernel extract.

Annona Seed Extract (ASE) 5%

Fifty g of annona seed was weighed and ground into a coarse powder and immersed in one litre of water and kept as such for two days for fermentation. After that the extract was filtered to get five per cent annona seed extract (Lenin, 2011).

Neem Oil (NO) 2%

Five g of bar soap shavings were dissolved in 100 ml of warm water and made up to one litre soap solution. To this soap solution, 20 ml neem oil was added and stirred to obtain two per cent neem oil.

Neem Oil Garlic Emulsion (NOGE) 2%

NOGE (2%) was prepared by mixing 20 ml neem oil, 20 g garlic and 5 g ordinary bar soap were required. Sliced the bar soap and dissolved in 50 ml warm water. Grind 20 g of garlic and take the extract in 30 ml water. Poured 50 ml soap solution in 20 ml neem oil slowly and stirred vigorously to get a good emulsion. Mixed the garlic extract in the neem oil soap emulsion. The stock solution (100 ml) was diluted by adding 900 ml of water to get one litre of 2 per cent neem oil garlic emulsion.

Econeem plus 1%

One litre water was mixed with 2 ml of econeem plus 1 % EC to get a solution containing Econeem plus one per cent.

3.5.2 Effect of Botanicals on Scraping and Cutting of Leaves by *D. marginatus*

Three days old mango shoots were collected from the field and sprayed with the above mentioned botanicals in given doses in para 3.5. Water was sprayed as check (untreated control). The treated twigs were kept for 10 minutes. Five pairs of leaf cutting weevils were released to the treated twigs. Observations were taken at one and two days after treatment. Leaf damage was recorded as leaves scraped by the adults and leaves cut by the adults after oviposition.

3.5.3 Effect of Botanicals on Adults of *D. marginatus*

Three days old mango shoots were collected from the field and sprayed with the above mentioned botanicals in given doses in para 3.5. Water was sprayed as check. The treated shoots were kept for 10 minutes. Five pairs of leaf cutting weevils were released to the treated shoots. Mortality of adults were recorded at one day and two days after treatment.

3.5.4 Effect of Botanicals on Grubs of *D. marginatus*

The soil (100 g) was treated with 50 ml of the above mentioned botanicals in given doses in para 3.5. Infested mango leaves having 10 larvae were placed in each trough. Number of adults emerged from each trough were counted the percentage of mortality was worked out. The adults emergence from the untreated trough, was taken as the standard time of emergence of adults. The number of adults emergence treated trough was also recorded to calculate the effect on grubs.

3.6 LABORATORY EVALUATION OF CHEMICAL INSECTICIDES

The experiments were laid out in CRD with six treatments and each treatment was replicated four times.

The treatments were as follows

T1	-	Imidacloprid (Confidor)	0.003%
T2	-	Deltamethrin 1% + Triazophos 35% (Spark)	0.05%
T3	-	Triazophos (Hostathion)	0.05%
T4	-	Lambdacyhalothrin (Karate)	0.005%
T5	-	Dimethoate (Standard chemical, Rogor)	0. 05%
T6	-	Treated control (water)	

3.6.1 Effect of Chemical Insecticides on Adults

Three days old mango shoots were collected from the field and sprayed with insecticides as mentioned in para 3.6. The treated shoots were kept for 10 minutes. Five pairs of adult leaf cutting weevils were released to the treated shoots. Observations were taken at 2, 4, 6, 24 and 48 hours after release of the weevils.

3.6.2 Effect of Chemical Insecticides on Grubs

The soil (100 g) was taken in a trough and treated with 50 ml of the above mentioned chemical insecticides. Infested mango leaves having 10 larvae were placed in each trough. Number of adults emerged from each trough were counted and percentage of mortality was worked out in each treatment.

3.7 ASSESSMENT OF PERSISTENT TOXICITY OF PESTICIDES

One hundred and fifty shoot buds were tagged in the field for testing the persistence of three insecticides and a botanical under field condition. On the 3rd day of bud bursting, shoots were sprayed with chemicals such as lambdacyhalotbrin 0.005%, deltamethrin 1% + triazophos 35%, dimethoate 0.05% and annona seed extract 5%. Shoots were collected from the field first day to 15th days after spraying. Five pairs of adult leaf cutting weevils were released on the treated shoots in the trough. Mortality of adults were recorded on 3rd, 5th, 7th, 9th and 11th day of treatment.

3.8 FIELD EVALUATION OF PESTICIDES

The field experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani. Based on the results of the laboratory studies, three chemicals and a botanical mentioned below were selected for the field study. Treatments were applied on 3rd day of bud bursting.

The experimental laid out in RBD with five treatments replicated four times.

T1	-	Lambdacyhalothrin (Karate)	0.005%
T2	-	Deltamethrin 1% + Triazophos 35% (Spark)	0.05%
T3	-	Annona seed extract	5%

T4 - Dimethoate (Standard chemical, Rogor) 0. 05%

T5 - Treated control (water)

Observation on the incidence of pests were recorded at three, five, seven and nine days after treatment.

3.9 STATISTICAL ANALYSIS.

Data obtained from the experiments were subjected to analysis of variance (Panse and Sukhatme, 1985).

Results

4. RESULTS

Shoot or leaf feeders of mango were collected, identified and documented by a survey conducted in Thiruvananthapuram district and the results are presented in Table 1 to 3. Botanicals and chemical insecticides were tested for the management of leaf cutting weevil of mango and the results are presented in Table 4 to 11.

4.1 SURVEY

4.1.1 Occurrence of Shoot and Leaf Feeders of Mango

Survey was conducted in Thiruvananthapuram district to document the shoot and leaf feeders associated with mango. Six panchayats were selected from Thiruvananthapuram district *viz*. Neyyattinkara, Nedumangad and Thiruvananthapuram. From each panchayat (location) 10 young plants were selected randomly. The plants were observed during the flushing stage of the plant. Shoot and leaf feeders of mango were collected, identified and documented. The details of pests collected from the survey are presented in Table 1.

The insect pests collected from the new shoots and leaves of mango were grouped as leaf eating caterpillars, leaf eating beetles, sucking pests and midges. The leaf eating caterpillars observed were shoot webber (*Orthaga exvinacea*), butterfly caterpillar (*Euthalia garuda*), looper caterpillar (*Thalassodes quadraria*), flush caterpillar (*Bombotelia jocostrix*), hairy caterpillar (*Dasychira mendosa*), lymantrid caterpillar (*Lymantria* sp.), slug caterpillar (*Latoia lepida*), mango lycaenid (*Rothinda amor*) and mango blue (*Arhopala* sp.).

The leaf eating beetles observed during the survey were leaf cutting weevil (*Deporaus marginatus*), leaf twisting weevil (*Apoderus tranquebaricus*), leaf

Table 1. List of shoot and leaf feeders of mango in Neyyattinkara, Nedumangadu and Thiruvananthapuram taluks of Thiruvananthapuram district

Sl. No.	Pests	Scientific name	Family	Order
	Leaf eating caterpillars			
1	Shoot webber	*Orthaga exvinacea* Hbn.	Noctuidae	Lepidoptera
2	Butterfly caterpillar	*Euthalia garuda* Moore	Nymphalidae	Lepidoptera
3	Looper caterpillar	*Thalassodes quadraria* Gu.	Geometridae	Lepidoptera
4	Flush caterpillar	*Bombotelia jocosatrix* Gu.	Noctuidae	Lepidoptera
5	Hairy caterpillar	*Dasychira mendosa* Hbn.	Lymantridae	Lepidoptera
6	Lymantrid caterpillar	*Lymantria* sp.	Lymantridae	Lepidoptera
7	Slug caterpillar	*Latoia lepida* Cram.	Cochlidiidae	Lepidoptera
8	Mango lycaenid	*Rothinda amor* Fab.	Lycaenidae	Lepidoptera
9	Mango blue	*Arhopala* sp.	Lycaenidae	Lepidoptera
	Leaf eating beetles			
10	Leaf cutting weevil	*Deporaus marginatus* (Pas.)	Curculionidae	Coleoptera
11	Leaf twisting weevil	*Apoderus tranquebaricus* F.	Curculionidae	Coleoptera
12	Leaf mining weevil	*Rhynchaenus mangiferae* Ms.	Curculionidae	Coleoptera
13	Grey weevil	*Myllocerus* spp.	Curculionidae	Coleoptera
	Sucking pests			
14	Scales	*Aspidiotus* spp. *Ceroplastes* spp. *Coccus* spp. *Chionaspis* spp.	Diaspididae	Hemiptera
15	Mealy bugs	*Ferrisia* spp. *Phenacoccus* spp.	Pseudococcidae	Hemiptera
16	Mango hoppers	*Amritodus* spp. *Idioscopus* spp..	Cicadellidae	Hemiptera
17	Shoot midge	*Erosomyia indica* Grover	Cecidomyidae	Diptera
18	Leaf midge	*Proscontarinia* spp. Kieffer	Cecidomyidae	Diptera

miner (*Rhynchaenus mangiferae*) and grey weevil (*Myllocerus* spp.). Scales, mealy bugs and mango hoppers were the sucking pests observed during the survey. Shoot midge and leaf midges were also observed on mango plants. The natural enemies observed during the survey were red ants and spiders.

4.1.2 Documentation of Shoot and Leaf Feeders of Mango

The insect count and damage score are presented in Table 2. The shoot webber or leaf webber, *O. exvinacea* was a grey moth with dark patches on wings. The caterpillar was slender, pale green with dark bands (Plate 1). Early instar caterpillar fed by scraping the leaf surface, later webbed the leaves and fed from within. Several caterpillars were found in a single webbed up cluster.

The butterfly caterpillar, *E. garuda* was a brown butterfly with black and white markings on wings. The caterpillar had a series of branched process on either side of the segments (Plate 2). They preferred 2 to 3 weeks old leaves and consumed the entire lamina.

T. quadraria, the looper caterpillar was a green moth with geometric shape and the catepillar was green looper feeding on tender leaves (Plate 3).

The occurrence of flush caterpillar *B. jocostrix* was observed only in Thiruvananthapuram taluk. It was a stout moth and the caterpillar pinkish green, damaged newly emerged leaves of mango. The slug caterpillar, *L. lepida* was also observed on mango leaves (Plate 3).

The hairy caterpillar *D. mendosa* a polyphagous pest was also observed on flushes of mango. The adult moth was brown and caterpillar was hairy (Plate 4). Another lymantrid, *Lymantria* sp. was recorded from Thiruvallam and Kalliyoor panchayats of Thiruvananthapuram taluk. The female was sluggish and with rudimentary wings whereas males had well developed wings and bipectinate antennae (Plate 5). The caterpillar was hairy and preferred 2 to 3 week old leaves.

Table 2. Pests count and damage score of shoot and leaf feeders of mango in Neyyattinkara, Nedumangadu and Thiruvananthapuram taluks

	Pests	Locations											
		Neyyattinkara				Nedumangadu				Thiruvananthapuram			
		Vilavoorkkal		Venganoor		Manickal		Vembayam		Kalliyoor		Thiruvallam	
		No.	Score	No.	Score	No.	Score	No.	Score	No.	Score	No.	Score
1	Shoot webber	8	1	9	1	23	1	12	1	21	1	19	1
2	Butterfly caterpillar	9	1	7	1	1	1	6	1	6	1	6	1
3	Looper caterpillar	3	1	2	1	2	1	2	1	3	1	4	1
4	Flush caterpillar	0	0	0	0	0	0	0	0	2	1	2	1
5	Hairy caterpillar	3	1	4	1	2	1	2	1	5	1	4	1
6	Lymantrid caterpillar	0	0	0	0	0	0	0	0	1	1	10	1
7	Slug caterpillar	2	1	1	1	1	1	1	1	1	1	2	1
8	Mango lycaenid	0	0	0	0	0	0	0	0	7	1	5	1
9	Mango blue	0	0	0	0	0	0	0	0	0	1	4	1
10	Leaf cutting weevil	65	3	63	3	67	3	56	3	74	3	72	3
11	Leaf twisting weevil	3	1	2	1	2	1	2	1	3	1	3	1
12	Leaf miner	4	1	5	1	4	1	4	1	6	1	7	1
13	Grey weevil	4	1	6	1	5	1	4	1	6	1	5	1
14	Scales	5	1	3	1	4	1	5	1	3	1	3	1
15	Mealy bugs	4	1	7	1	5	1	4	1	6	1	6	1
16	Mango hoppers	2	1	3	1	2	1	2	1	2	1	2	1
17	Shoot midge	1	1	0	0	1	1	0	0	3	1	4	1
18	Leaf midge	1	1	0	1	1	1	0	1	2	1	1	1

* Mean of ten plants

Early instar larva

Late instar larva

Pupa

Adult

Larvae with webbed up leaves

Leaf web

Plate 1. Leaf eating caterpillar of mango – leaf webber, *Orthaga exvinacea*

Egg

Larva

Pupa

Adult

Adult

Plate 2. Leaf eating caterpillar of mango - Butterfly caterpillar *Euthalia garuda*

Looper caterpillar *Thalassodes quadraria*

Flush caterpillar *Bombotelia jacosatrix*

Slug caterpillar *Latoia lepida*

Plate 3. Leaf eating caterpillars of mango

Plate 4. Leaf eating caterpillar of mango - Hairy caterpillar *Dasychira mendosa*

Eggs and Female moth

Early instar larvae

Late instar larva

Pupa

Symptom

Male and female

Plate 5. Leaf eating caterpillar of mango - *Lymantria* sp.

Two lycaenids found feeding on mango leaves of Thiruvananthapuram taluk were the mango lycaenid or monkey puzzle, *Rothinda amor* and the mango blue, *Arhopala* sp. *R. amor* was a beautiful butterfly with the upper side of wings dark brown with white spots. Underside of the wing was dark yellowish brown with white spots. The hind wings had a silvery margin with many irregular black lines, spots and three tails. The caterpillar was pale green with a long line of protrusions along the back. Pupa was green coloured (Plate 6). *Arhopala* was a blue lycaenid and the caterpillar was green in early stages while later instar reddish brown (Plate 7). They fed on both leaves and inflorescence.

Among the leaf eating beetles the leaf cutting weevil, *D. marginatus* was observed in three taluks. The damage score was three in all locations. *D. marginatus* was a small greyish brown weevil causing two types of damage on flushes. They fed on the leaves by scraping the mesophyll and the females after laying the eggs cut the leaves from the base (Plate 8).

Other beetles such as *A. tranquebaricus, R. mangiferae* and *Myllocerus* spp. were observed only in very low numbers. The leaf twisting weevil cut and twisted mango leaves in to rolls which remain attached to the parent leaf. The leaf miner grubs damaged the leaves by feeding the chorophyll (Plate 9).

The incidence of sucking pests was very low in all locations with a damage score of one (Table 2). Several species of *Aspidiotus*, *Coccus*, *Ceroplastes* and *Chionaspis* were observed from leaves as well as shoots of mango (Plate 10). The psecudococcids, *Ferrisia* sp. and *Phenacoccus* spp. were also observed from leaves and shoots of mango (Plate 10). The incidence of mango hopper, shoot midge and leaf midge were very low (Table 2, Plate 11). The natural enemies observed during the survey were red ants and spiders.

4.1.3 Intensity of Damage Caused by Shoot and Leaf Feeders of Mango

Larva

Pupa

Adult

Plate 6. Leaf eating caterpillar - Mango lycaenid *Rothinda amor*

Larva

Adult

Plate 7. Leaf eating caterpillar - Mango blue *Arhopala* sp.

Adults

Plate 8. Leaf cutting weevil *Deporaus marginatus* in mango

Leaf twisting weevil

Apoderus tranqubaricus

Leaf miner

Rhynchaenus mangiferae

Plate 9. Leaf eating beetles of mango

Mealy bugs

Scales

Plate 10. Mealy bugs and scales of mango

Shoot midge *Erosomyia indica*

Leaf midge *Procontarinia* sp.

Plate 11. Midges of mango

Shoot webber was observed from Neyyattinkara, Nedumangadu and Thiruvananthapuram taluks with a damage score of one (Table 2). Number of caterpillars observed ranging from 1 - 23. Mean number of butterfly caterpillar was 8, 3.5, and 6 caterpillars were observed from Neyyattinkara, Nedumangadu and Thiruvananthapuram taluks with a damage score of one. The pest count of looper caterpillar was low (2 to 3.5) with damage score of one. The pest count was low and the damage score of flush caterpillar and slug caterpillar was one.

Among the leaf eating beetles the leaf cutting weevil, *D. marginatus* was observed in three taluks. The damage score was three in all locations. Other beetles such as *A. tranquebaricus, R. mangiferae* and *Myllocerus* spp. were observed only in very low numbers.

The incidence of sucking pests was very low in all locations with a damage score of one (Table 2).

4.2 BIOLOGY OF MANGO LEAF CUTTING WEEVIL, *D. marginatus*

4.2.1 Egg

The female laid eggs singly by thrusting the eggs in to the midrib of young leaves (Plate 12). Eggs were small, whitish, cylindrical and rounded at both ends. An adult female laid 74 to 85 eggs. Eggs laid in a single leaf ranged from 1 to 19. Egg period lasted for 2.5 days on an average.

4.2.2 Larva

There were three distinct larval instars (Plate 12). The larva mined the leaf tissues in between the two epidermal layers of the leaf and fed on the mesophyll. Larval period was 6.5 days. The full grown larva was yellow.

4.2.3 Pupa

Oviposition site

Egg

1st instar larva

2nd instar larva

3rd instar larva

Pupa

Plate 12. Biology of leaf cutting weevil *D. marginatus* in mango

The full grown larva came out of the leaves and entered in to the moist soil for pupation. They construct earthen chamber for pupation (Plate 12). The pre-pupa was shining white. The pupal period was 13.5 days.

4.2.4 Adult

The adult male was greyish brown in colour and female reddish brown with a black border around the elytra (Plate 13). Female was slightly bigger than male. The longevity of adult male and female were 53 and 63 days, respectively. The total life cycle completed in 20 to 25 days.

4.2.5 Nature of Damage

The leaf cutting weevil produced two types of symptoms on leaves, the feeding symptom and the leaf cutting symptom. Male and female weevils feed on the leaf lamina by scraping the epidermis of leaf tissues. As a result the affected portions became brown and later dried up. The female weevil cut the leaves from the base after laying the eggs on the midrib of young leaves (Plate 14). Sometimes both symptoms were seen on the same leaf. The larva mined the leaf tissues in between the two epidermal layers of the leaf and feed on the mesophyll (Plate 15).

4.2.6 Alternate Host

Cashew (*Anacardium occidentale* L.) was found as an alternate host of leaf cutting weevil. Adult weevil fed the young leaves of cashew. Only feeding symptoms were observed on cashew. Egg laying or leaf cutting symptom was not observed in cashew (Plate 16).

4.3 DETERMINATION OF SUSCEPTIBLE STAGE OF INFESTATION

Adult weevils were released on shoots of different age. Feeding as well as egg laying behaviour was studied and the results are presented in Table 3.

No scraping damage on leaf was observed on first and second day of bud bursting. On third day of bud bursting, 57.10 per cent leaves were scraped by the

Male weevil

Female weevil

Mating of adults

Plate 13. Biology of leaf cutting weevil *D. marginatus* in mango

Scraping of leaves

Cutting of leaves

Plate 14. Symptoms of damage caused by leaf cutting weevil *D. marginatus* in mango

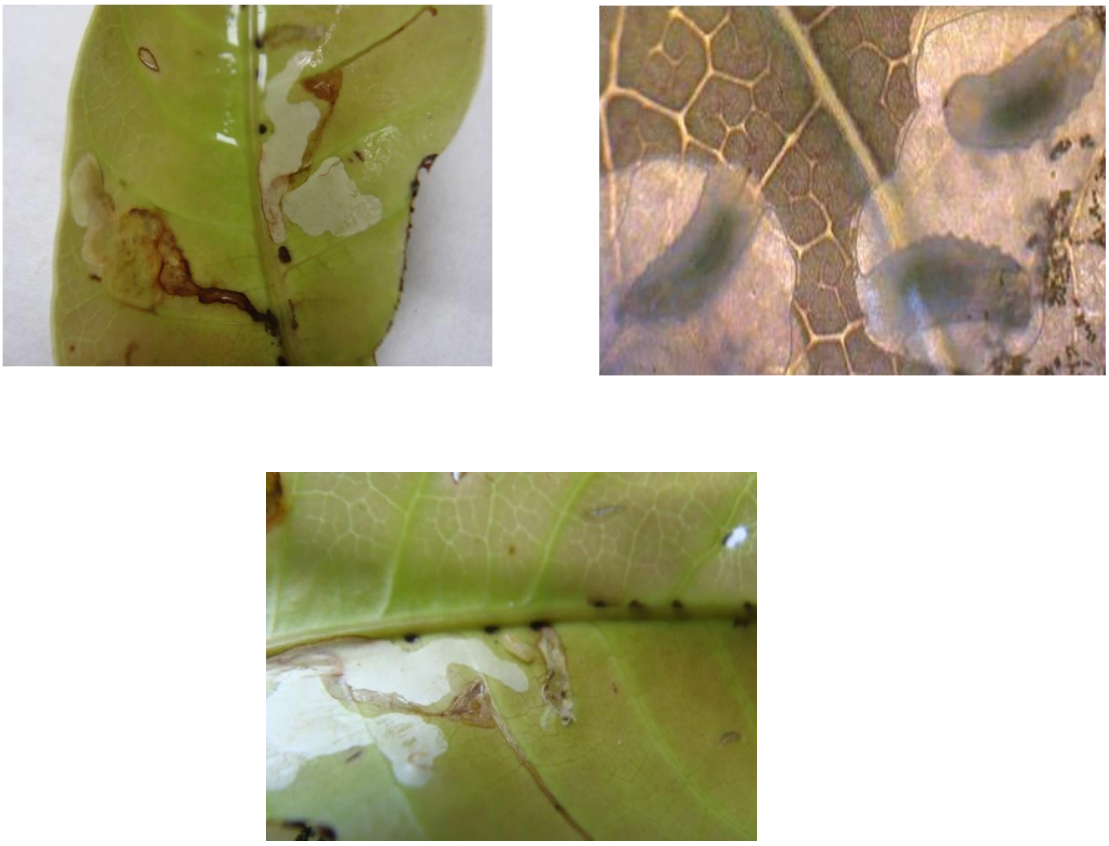

Plate 15. Damage caused by grubs of leaf cutting weevil *D. marginatus* in mango

Weevils feeding on cashew leaves

Leaf scraping symptom on cashew leaves

Plate 16. Cashew - Alternate host of leaf cutting weevil *D. marginatus*

Table 3. Leaf damage caused by the leaf cutting weevil on leaves of different age

Age of leaf (DABB)	Leaf damage / plant		Total leaf damage (%)
	Scraping (%)	Cutting (%)	
1	0.00	00.00	00.00
2	0.00	00.00	00.00
3	57.10	40.00	97.10
4	58.00	42.00	100
5	62.00	38.00	100
6	69.20	25.10	94.30
7	55.50	30.70	86.20
8	44.40	22.20	66.60
9	30.00	20.00	50.00
10	21.40	14.30	35.70
11	14.30	14.30	28.60
12	00.00	00.00	00.00
13	00.00	00.00	00.00
14	00.00	00.00	00.00
15	00.00	00.00	00.00

* Mean of ten plants

DABB: days after bud bursting

weevil. The scraping damage increased to 58.00 per cent, 62.50 per cent and 69.20 per cent on 4th, 5th and 6th day of bud bursting, respectively. Leaf scraping damage of 55.50 per cent was observed on 7th day of bud bursting. Feeding damage decreased gradually to 44.40 per cent, 30.00 per cent, 21.40 per cent and 14.30 per cent on 8th, 9th, 10th and 11th day of bud bursting. No scraping damage was recorded from 12th day of bud bursting to 15th day of bud bursting.

No leaf cutting damage was recorded on first and second day of bud bursting. On third day of bud bursting, 40.00 per cent leaves were cut by the weevil. On the 4th day, 42.80 per cent of leaf cutting damage was observed. The leaf cutting damage decreased gradually to 33.30 per cent, 31.30 per cent, 30.70 percent, 22.20 per cent, 20.00 per cent, 14.30 per cent, and 14.30 per cent respectively on 5th, 6th, 7th, 8th, 9th, 10th and 11th day of bud bursting. No leaf cutting damage was observed from 12th day of bud bursting to 15th day of bud bursting.

The total leaf damage was 100 per cent on 4th and 5th day of bud bursting and this was the critical stage of infestation by the weevil (Plate 17). The leaf damage decreased as the age of the flush increased. The lowest leaf damage of 28.60 per cent was observed on 11th day of bud bursting. Third day to 11th day old flush were susceptible to the weevil attack.

4.4 REACTION OF MANGO VARIETIES TO LEAF CUTTING WEEVIL

Mango varieties planted in the Instructional Farm, Vellayani were observed in the flushing season for the occurrence of leaf cutting weevil. Leaf damage (scraping and leaf cutting) by the adult weevil was observed and the results are presented in Table 4.

All varieties were infested by the weevil. The leaf scraping was lowest in Jehangir (56.00 per cent) and highest in Malgoa (83.33 per cent). The leaf cutting damage was lowest in Kalapadi (16.44 Per cent) and highest in Banganampalli

Four day- old shoot

Five day- old shoot

Plate 17. Critical stage of infestation of leaf cutting weevil *D. marginatus* in mango

Table 4. Intensity of damage caused by leaf cutting weevil in different varieties of mango

Sl. No.	Variety	Leaf damage / plant		Total leaf damage (%)
		Scraping (%)	Cutting (%)	
1	Alphonso	76.92	22.58	99.50
2	Amrith	70.00	20.00	90.00
3	Banganapalli	66.67	29.17	95.84
4	Bangalora	69.23	23.08	92.31
5	Imampasand	61.29	19.35	80.64
6	Jehangir	56.00	24.00	80.00
7	Kalapadi	72.41	16.64	89.65
8	Kottukonam	65.22	26.09	91.31
9	Langra	67.86	21.43	89.29
10	Malgoa	83.33	16.67	100.00
11	Mundappa	67.27	27.28	94.55
12	Neelam	70.83	25.00	95.83
13	Njattukuzhiyan	72.73	18.18	90.91
14	Pairi	69.69	21.21	90.90
15	Perakka Varikka	81.48	18.52	100.00
16	Prior	70.83	29.17	100.00
17	Pulichi	69.23	23.08	92.31
18	Rose Pichi	59.09	27.27	86.36
19	Savitha	65.22	21.74	86.96
20	Suvarnarekha	76.92	19.23	96.15
21	Vellari Varikka	73.08	23.08	96.16

Figures are mean of six plants

and Prior. More than 80 per cent leaf scraping damage was recorded in Malgoa and Perakka Varikka. Seventy to seventy nine per cent leaf scraping damage was observed in Amrith, Alphonso, Kalapadi, Neelam, Njattukuzhiyan, Prior, Suvarnarekha and Vellari Varikka. The leaf scraping damage by adult leaf cutting weevil ranged from 60 to 69 per cent in Imampasand, Banganapalli, Bangalora, Kottukonam, Langra, Mundappa, Pulichi, Savitha and Pairi. The lowest leaf damage of 50 to 59 per cent was recorded Rose Pichi and Jehangir.

The leaf cutting damage by the weevil ranged from 16.44 to 29.17 per cent. In Kalapadi, Malgoa, Njattukuzhiyan, Perakka Varikka, Suvarnarekha, Imampasand and Amrith, the leaf cutting damage ranged from 16.44 to 20.00 per cent. The leaf cutting damage was 21.00 to 25.00 per cent in varieties Pairi, Pulichi, Savitha, Vellari Varikka, Alphonso, Bangalora, Jehangir, Langra and Neelam. Leaf cutting damage was 26.00 to 30.00 per cent in varieties Banganapalli, Kottukonam, Mundappa, Prior and Rose Pichi.

The leaf damage was 100 per cent in varieties Malgoa, Perakka Varikka, Prior and Alphonso.

4.5 LABORATORY EVALUATION OF BOTANICALS

Effects of botanicals on the leaf damage caused by *D. marginatus* on mango shoots are presented in Table 5 and 6.

4.5.1 Effect of Botanicals on Scraping of Leaves

Three day old shoots of mango were sprayed with neem seed kernel extract 5%, annona seed extract 5%, neem oil 2%, neem oil garlic emulsion 2% and Econeem plus 1%. The effect on scraping of leaves is presented in Table 5.

One day after treatment, leaves treated with annona seed extract 5% showed leaf scraping damage of 25.81 per cent which was significantly superior to all other treatments. Leaf damage of 34.11 per cent and 37.71 per cent were

Table 5. Effect of botanicals on leaf damage due to scraping by *D. marginatus* under laboratory condition

Treatments	Leaves scraped (%)	
	1 DAT	2 DAT
Neem seed kernel extract 5%	52.32 (62.67)	65.81 (83.25)
Annona seed extract 5%	25.81 (18.97)	25.81 (18.97)
Neem oil 2%	34.11 (31.47)	56.24 (69.15)
Neem oil garlic emulsion 2%	46.42 (52.52)	65.44 (82.76)
Econeem plus 1%	37.71 (37.44)	65.44 (82.76)
Treated control (water)	56.77 (70.00)	90.00 (99.99)
C D (0.05)	(11.35)	(15.62)

Figures in parentheses are angular transformed values

DAT: days after treatment

recorded in treatments with neem oil 2% and Econeem plus 1%, respectively and on par with each other. Percentage leaf damage was higher in treatments with neem oil garlic emulsion 2% (46.42 per cent) and neem seed kernel extract 5% (52.32 per cent) and on par with untreated control.

On the second day of treatment, further leaf scraping damage was not observed in treatment with annona seed extract 5% (25.81 per cent). All other treatments were statistically on par. Neem oil garlic emulsion 2% recorded a leaf damage of 65.44 per cent and Econeem plus 1% recorded a damage of 65.44 per cent. When leaves treated with neem oil 2% scraping damage of 56.24 per cent was observed and 65.81 per cent damage was observed when leaves treated with neem seed kernel extract 5%.

4.5.2 Effect of Botanicals on Cutting of Leaves

The effect of botanicals on cutting of leaves by *D. marginatus* is presented in Table 6.

One day after treatment, all treatments significantly reduced the leaf cutting damage in mango. The leaves treated with Econeem plus 1% showed the lowest leaf cutting damage of 24.52 per cent. This was statistically on par with neem seed kernel extract 5% (26.43 per cent), neem oil 2% (27.28 per cent) and annona seed extract 5% (27.73 per cent). The treatment with neem oil garlic emulsion 2% recorded leaf cutting damage of 32.18 per cent.

A significantly lower leaf cutting percentage (26.99) was observed in treatment with Econeem plus1% on second day of treatment. All other treatments were statistically on par. The damage was 31.19 per cent and 32.61 per cent in treatment with neem seed kernel extract 5% and neem oil 2% respectively. Treatment with annona seed extract 5% and neem oil garlic emulsion 2% recorded a leaf cutting percentage of 34.38 per cent and 36.10 per cent respectively. In control 51.19 per cent leaves were damaged by the weevils.

Table 6. Effect of botanicals on leaf damage due to cutting of leaves by *D. marginatus* under laboratory condition

Treatments	Leaves cut (%)	
	1 DAT	2 DAT
Neem seed kernel extract 5%	26.43 (19.82)	31.19 (26.84)
Annona seed extract 5%	27.73 (21.67)	34.38 (31.90)
Neem oil 2%	27.28 (21.03)	32.61 (29.06)
Neem oil garlic emulsion 2%	32.18 (28.39)	36.10 (34.75)
Econeem plus 1%	24.52 (17.23)	26.99 (20.62)
Treated control (water)	39.98 (41.31)	51.19 (60.76)
C D (0.05)	(9.55)	(9.51)

Figures in parentheses are angular transformed values

DAT: days after treatment

4.5.3 Effect of Botanicals on Adults and Grubs of *D. marginatus*

Effect of neem seed kernel extract 5%, annona seed extract 5%, neem oil 2%, neem oil garlic emulsion 2% and Econeem plus 1% on adults and grubs of D. *marginatus* are presented in Table 7.

When adult weevils were released on new shoots treated with annona seed extract 5%, a mortality level of 32.89 per cent and 43.48 per cent was recorded on first and second day of treatment respectively. In all other treatments, no mortality was recorded.

Percentage mortality of grubs were worked out by counting the number of adults emerged from the treated soil. Hundred per cent emergence of adults were recorded in control. Annona seed extract 5% recorded 83.35 per cent mortality which was on par with Econeem plus 1% (76.70 per cent). The mortality of grubs were 57.08 per cent, 53.91 per cent and 51.03 per cent in treatment with neem seed kernal extract 5%, neem oil 2% and neem oil garlic emulsion 2% respectivly, which was statistically on par.

4.6 EFFECT OF INSECTICIDES ON LEAF CUTTING WEEVIL

Three day old shoots of mango were treated with imidacloprid 0.003%, deltamethrin + triazophos 0.05%, triazophos 0.05%, lambdacyhalothrin 0.005% and dimethoate 0.05%. Weevils were released on treated shoots and the mortality was noted at different intervals and the result is presented in Table 8.

Two hours after treatment, lambdacyhalothrin 0.005% showed a significantly higher mortality of 37.71 per cent. Treatments with deltamethrin + triazophos 0.05% recorded 20.46 per cent mortality. Shoots treated with imidacloprid 0.003% and dimethoate 0.05% recorded a mortality of 9.21 per cent.

Table 7. Effect of botanicals on the mortality of adults and grubs of *D. marginatus* under laboratory condition

Treatments	Percentage mortality		
	Adults		Grubs (indicated as the adult emergence)
	1DAT	2DAT	
Neem seed kernel extract 5%	0.00	0.00	57.08 (70.49)
Annona seed extract 5%	32.89	43.48	83.35 (98.67)
Neem oil 2%	0.00	0.00	53.91 (65.34)
Neem oil garlic emulsion 2%	0.00	0.00	51.03 (60.48)
Econeem plus 1%	0.00	0.00	76.70 (94.74)
Treated control (water)	0.00	0.00	0.00 (0.00)
C D (0.05)			(14.90)

Figures in parentheses are angular transformed values

DAT: days after treatment

Table 8. Effect of insecticides on the mortality of adults and grubs of *D. marginatus* under laboratory condition

Treatments	Percentage mortality					
	Adults (hours after treatment)					Grubs (indicated as the adult emergence)
	2	4	6	24	48	
Imidacloprid 0.003%	9.21 (2.57)	9.21 (2.57)	9.21 (2.57)	40.38 (41.99)	50.87 (60.22)	70.06 (88.39)
Deltamethrin + Triazophos 0.05%	20.46 (12.23)	31.54 (27.38)	37.71 (37.44)	65.81 (83.25)	85.38 (99.36)	76.70 (94.74)
Triazophos 0.05%	0.00	4.61 (0.65)	4.61 (0.65)	60.09 (75.17)	80.77 (97.44)	53.91 (65.34)
Lambdacyhalothrin 0.005%	37.71 (37.44)	47.86 (55.03)	49.31 (57.52)	85.38 (99.36)	90.00 (99.99)	90.00 (99.99)
Dimethoate 0.05% (Check)	9.21 (2.57)	13.28 (5.28)	26.18 (19.48)	80.77 (97.44)	90.00 (99.99)	70.06 (88.39)
Treated control (water)	0.00	0.00	0.00	0.00	0.00	
C D (0.05)	(9.63)	(12.94)	(9.63)	(12.75)	(11.15)	(15.21)

Figures in parentheses are angular transformed values

Lambdacyhalothrin 0.005% resulted a significantly high mortality of 47.86 per cent at four hours after treatment. Treatments with deltamethrin + triazophos 0.05% showed a mortality of 31.54 per cent. Dimethoate 0.05% registered a mortality of 13.28 per cent and was on par with imidacloprid 0.003% (9.21 per cent).

Shoots treated with lambdacyhalothrin 0.005% recorded 49.31 per cent mortality of adults at six hours after treatment, which was significantly superior to all other treatments. Deltamethrin + triazophos 0.05% registered a mortality of 37.71 per cent, followed by dimethoate 0.05% (26.18 per cent). Shoots sprayed with imidacloprid 0.003% resulted a mortality of 9.21 per cent and was on par with triazophos 0.05% (4.61 per cent). In the control treatment no mortality was observed.

When the adults were released on three day old shoots sprayed with insecticides, at 24 hours after treatment, lambdacyhalothrin 0.005% showed a mortality of 85.38 per cent, which was on par with dimethoate 0.05% (80.77 per cent). The treatment with deltamethrin + triazophos 0.05% registered a mortality of 65.81 per cent which was on par with triazophos 0.05% (60.09 per cent). Imidacloprid 0.003% showed a mortality of 40.38 per cent. No mortality was observed in control treatment.

Two days after treatment, lambdacyhalothrin 0.005% and dimethoate 0.05% resulted 90.00 per cent mortality of weevils. These treatments were onpar with deltamethrin + triazophos 0.05% (85.38 per cent) and triazophos 0.05% (80.77 per cent). The treatment with imidacloprid 0.003% registered a mortality of 50.87 per cent.

When the soil was treated with lambdacyhalothrin 0.005%, 90.00 per cent grub mortality was noticed, which was on par with deltamethrin + triazophos 0.05% (76.70 per cent), dimethoate 0.05% (70.06 per cent) and imidacloprid 0.003% (70.06 per cent). No mortality was observed in control treatment.

4.7 PERSISTENT TOXICITY OF INSECTICIDES AGAINST *D. marginatus*

Persistence of insecticides in the field was assessed by testing the mortality of adults. The results are presented in Table 9.

Leaves treated with lambdacyhalothrin 0.005% gave the highest mortality of 83.35 per cent on third day of treatment, which was significantly superior to all other treatments. Treatment with deltamethrin + triazophos 0.05% registered 57.08 per cent mortality and annona seed extract 5% registered a mortality of 45.26 per cent followed by dimethoate 0.05% (32.89 per cent), which were statistically on par.

Five days after treatment, the highest mortality was observed in lambdacyhalothrin 0.005% (83.35 per cent). Leaves treated with deltamethrin + triazophos 0.05% registered a mortality of 70.06 per cent which was significantly superior from treatment with annona seed extract 5% (36.05 per cent) and dimethoate 0.05% (32.89 per cent).

Leaves treated with lambdacyhalothrin 0.005% registered the highest mortality of 76.70 per cent at seven days after treatment statistically superior to other. The treatment with deltamethrin + triazophos 0.05% resulted in a mortality level of 63.41 per cent, dimethoate 0.05% showed a mortality of 36.05 per cent and treatment with annona seed extract 5% gave a mortality of 29.72 per cent, which were statistically on par.

Nine days after treatment, highest mortality was recorded in lambdacyhalothrin 0.005% (70.06 per cent) which was statistically superior. Treatment with deltamethrin + triazophos 0.05% resulted a mortality of 53.91 per cent, which was significantly superior. Annona seed extract 5% registered a mortality of 32.89 per cent, which was on par with dimethoate 0.05% (26.55 per cent).

Table 9. Persistent toxicity of pesticides against *D. marginatus*

Treatments	Percentage mortality of adult				
	3 DAT	5 DAT	7 DAT	9DAT	11DAT
Lambdacyhalothrin 0.005%	83.35 (98.67)	83.35 (98.67)	76.70 (94.74)	70.06 (88.39)	70.06 (88.39)
Deltamethrin + Triazophos 0.05%	57.08 (70.49)	70.06 (88.39)	63.41 (80.00)	53.91 (65.34)	53.91 (65.34)
Annona seed extract 5%	45.26 (50.49)	36.05 (34.66)	29.72 (24.59)	32.89 (29.50)	13.28 (5.28)
Dimethoate 0.05% (Check)	32.89 (29.50)	32.89 (29.50)	36.05 (34.66)	26.55 (20.00)	19.92 (11.61)
Treated control (water)	0.00	0.00	0.00	0.00	0.00
C D (0.05)	(13.97)	(14.25)	(11.98)	(11.08)	(16.89)

Figures in parentheses are angular transformed values

DAT: days after treatment

On the eleventh day, the highest mortality was recorded in lambdacyhalothrin 0.005% (70.06 per cent). Treatments with deltamethrin + triazophos 0.05% registered a mortality of 53.91 per cent followed by treatment with dimethoate 0.05% (19.92 per cent). Leaves treated with annona seed extract 5% showed a mortality of 13.28 per cent.

4.8 FIELD EVALUATION OF PESTICIDES

4.8.1 Effect of Pesticides on Scraping of Leaves by D. *marginatus*

Three day old shoots of mango were sprayed with lambdacyhalothrin 0.005%, deltamethrin + triazophos 0.05%, dimethoate 0.05% and annona seed extract 5% to assess the effect on scraping of leaves by *D. marginatus.* The results are presented in Table 10.

Third day after treatment, leaves treated with lambdacyhalothrin 0.005% recorded the lowest leaf damage of 6.71 per cent, which was statistically superior. Treatment with deltamethrin + triazophos 0.05% showed 19.01 per cent of leaf damage which was on par with dimethoate 0.05% (22.53 per cent) and annona seed extract 5% (20.81 per cent). In control leaf damage was 35.82 per cent.

Leaves treated with lambdacyhalothrin 0.005%, showed the same leaf damage (6.71 per cent) on the fifth day also. Treatment with annona seed extract 5% recorded a leaf damage of 26.31 per cent, which was statistically on par with deltamethrin + triazophos 0.05% (28.30 per cent). 36.23 per cent damage was observed when leaves treated with dimethoate 0.05%. The control treatment showed a leaf damage of 42.89 per cent.

On the seventh day, leaves treated with lambdacyhalothrin 0.005% recorded a significantly low leaf damage of 6.71 per cent. Deltamethrin + triazophos 0.05% showed 36.49 per cent leaf damage followed by dimethoate

Table 10. Effect of pesticides on the leaf scraping by *D. marginatus* under field condition

Treatments	Leaves scraped (%)			
	3 DAT	5 DAT	7 DAT	9 DAT
Lambdacyhalothrin 0.005%	6.71 (1.37)	6.71 (1.37)	6.71 (1.37)	6.71 (1.37)
Deltamethrin + triazophos 0.05%	19.01 (10.61)	28.30 (22.49)	36.49 (35.28)	37.95 (37.85)
Annona seed extract 5%	20.81 (12.63)	26.31 (19.66)	52.69 (63.31)	62.41 (78.59)
Dimethoate 0.05% (Check)	22.53 (14.69)	36.23 (34.96)	44.21 (48.66)	60.41 (75.65)
Treated control (water)	35.82 (34.28)	42.89 (46.36)	60.31 (75.49)	67.30 (85.14)
C D (0.05)	(7.71)	(8.91)	(10.17)	(9.03)

Figures in parentheses are angular transformed values

DAT: days after treatment

0.05% (44.21 per cent). Leaves treated with annona seed extract 5% recorded a leaf damage of 52.69 per cent, which was on par with control (60.31 per cent).

Nine days of treatment, leaves treated with lambdacyhalothrin 0.005% showed the same leaf damage of 6.71 per cent. Deltamethrin + triazophos 0.05% resulted a leaf damage of 37.95 per cent followed by dimethoate 0.05% (60.41 per cent), annona seed extract 5% (62.41 per cent).

4.8.2 Effect of Pesticides on Cutting of Leaves by *D. marginatus*

Three day old shoots were treated with lambdacyhalothrin 0.005%, deltamethrin + triazophos 0.05%, dimethoate 0.05% and annona seed extract 5%. The effect on the cutting of leaves by *D. marginatus* are presented in Table 11.

No leaf cutting damage was recorded when leaves were treated with lambdacyhalothrin 0.005% third day after treatment. Leaves treated with deltamethrin + triazophos 0.05% and dimethoate 0.05% resulted leaf damage of 10.13 per cent. Percentage leaf damage in treatment with annona seed extract 5% was 27.63 per cent and control recorded a leaf damage of 34.80 per cent.

Fifth day after treatment with lambdacyhalothrin 0.005%, recorded no leaf damage. 14.95 per cent of leaf cutting damage was recorded in dimethoate 0.05% which was on par with deltamethrin + triazophos 0.05% (14.95 per cent). Treatment with annona seed extract 5% showed a leaf damage of 43.67 per cent.

Seven days after treatment, lambdacyhalothrin 0.005% registered no leaf damage, which was significantly superior to all other treatments. Percentage leaf cutting damage of deltamethrin + triazophos 0.05% was 31.33 and dimethoate 0.05% resulted a leaf damage of 42.54 per cent. Treatment with annona seed extract 5%, recorded a leaf damage of 56.54 per cent and control treatment showed a leaf damage of 60.92 per cent.

Table 11. Effect of pesticides on the leaf cutting by *D. marginatus*

Treatments	Leaves cut (%)			
	3 DAT	5 DAT	7 DAT	9 DAT
Lambdacyhalothrin 0.005%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Deltamethrin + Triazophos 0.05%	10.13 (3.09)	14.95 (6.66)	31.33 (27.05)	34.36 (31.87)
Annona seed extract 5%	27.63 (21.52)	43.67 (47.72)	56.54 (69.63)	69.06 (87.26)
Dimethoate 0.05% (Check)	10.13 (3.09)	14.95 (6.66)	42.54 (45.73)	51.37 (61.07)
Treated control (water)	34.80 (32.60)	53.95 (65.40)	60.92 (76.41)	80.35 (97.21)
C D (0.05)	(13.12)	(12.57)	(6.70)	(10.71)

Figures in parentheses are angular transformed values

DAT: days after treatment

On the ninth day of treatment, leaves treated with lambdacyhalothrin 0.005% showed no leaf damage and treatment with deltamethrin + triazophos 0.05% recorded a leaf damage of 34.36 per cent. This was followed by treatment with dimethoate 0.05% (51.37 per cent). Tender shoots treated with annona seed extract 5% showed a leaf damage of 69.06 per cent and in control treatment leaf damage was 80.35 per cent.

Discussion

5. DISCUSSION

Mango is one of the seasonal fruits, widely cultivated in tropical and subtropical parts of the world. One of the major constraints for low productivity in mango is high incidence of insect pests and diseases. Shoot feeders or leaf feeders damaged the plant by reducing the photosynthetic area and thereby reducing the quantity of photosynthates. Young plants especially the grafts showed poor establishment due to the continuous damage on new shoots. To document the shoot or leaf feeders of mango and to assess the intensity of damage caused by these pests, a survey was conducted in Neyyattinkara, Nedumangad and Thiruvananthapuram taluks of Thiruvananthapuram district during 2010-2011. The major shoot feeder identified from the survey was subjected to further studies. Management of the pest using chemicals as well as botanicals was carried out in the Instructional Farm, Vellyani during the flushing season of mango and the results obtained are discussed hereunder.

5.1 DAMAGE CAUSED BY SHOOT FEEDERS OF MANGO

Eighteen shoot or leaf feeders of mango were observed during the survey. There were nine leaf eating caterpillars, four leaf eating beetles, three sucking pests and midges. The leaf eating caterpillars or lepidopteran pests observed were shoot webber, butterfly caterpillar, looper caterpillar, flush caterpillar, hairy caterpillar, lymantrid caterpillar, slug caterpillar, mango lycaenid and mango blue. Among the leaf eating caterpillars, the shoot webber, *O. exvinacea* was observed from Neyyattinkara, Nedumangad and Thiruvananthapuram taluks. They caused damage to the plant by webbing the leaves along with shoot and converted them to a dried mass. The mean numbers of caterpillar observed were 8.5, 17.5 and 20 (Fig.1). Heavy infestation of leaf webber adversely affected the panicle emergence and made the mango tree, unproductive with a burnt look. (Varghese, 1998). Reddy *et al.*, 2001 reported heavy incidence of *O. exvinacea* on mango cv. Banglora in Andra Pradesh. The leaf webber was considered as the minor pest of

mango, attained the status of a major pest now in Kerala (Mohammad and Renjith, 2011). The present study revealed that the looper caterpillar, *T. quadraria*, flush caterpillar, *B. jocosatrix* and the hairy caterpillar, *D. mendosa* damaged the mango plant by feeding on the new leaves whereas the larvae of slug caterpillar *L. lepida*, butterfly caterpillar *E. garuda* and the lymantrid, *Lymantria* sp. were found feeding on 2-3 week old leaves.

The lycaenid, *Rothinda amor*, commonly known as monkey puzzle and the mango blue *Arhopala* sp. observed in the present study are first report from Kerala as pests of mango. The caterpillars were found feeding on leaves as well as inflorescences of mango.

The leaf eating beetles observed during the survey were leaf cutting weevil, leaf twisting weevil, leaf miner and grey weevil. Among the leaf eating beetles, leaf cutting weevil, *D. marginatus* caused severe damage to new flushes of mango. The incidence of this pest was very high in all locations surveyed with a damage score of 3 (Table 4). Number of weevils observed in Neyyattinkara, Nedumangad and Thiruvananthapuram taluks was 64, 61.5 and 75 respectively (Fig. 2). The leaf cutting weevil was reported from India, Burma, Sri Lanka, Malaysia, China and Bangladesh as major pest of mango (Fletcher 1917, Hutson and Alwis 1934, Ahamad and Ho, 1970, Butani 1979). Other minor leaf eating weevils observed were leaf twisting weevil, *A. tranquebaricus* and leaf miner, *R. mangiferae* and the polyphagous pest, *Myllocerus* spp.

Scales, mealy bugs and mango hoppers were the sucking pests observed on new shoots of mango. The shoot midge and leaf midges were also observed during the survey. However, the incidence of sucking pests was found very low in all three taluks (Fig. 3).

The present study revealed that the leaf cutting weevil, *D. marginatus* was the major pest associated with new shoots of mango in southern parts of Kerala.

5.2 BIOLOGY OF LEAF CUTTING WEEVIL

The female weevil laid small whitish cylindrical eggs singly by thrusting into the mid rib of young leaves. Several workers reported similar egg laying behaviour of leaf cutting weevil (Tigvattnanont, 1988; Bhole and Dumbre, 1990; Rafiquzzaman and Maiti, 1998 a; Sahoo and Jha, 2006)

One to nineteen eggs were laid in a single leaf and a female laid 74 to 85 eggs in her life time. A fecundity of 74 to 614.47 was reported by several scientists (Tigvattnanont, 1988; Rafiquzzaman and Maiti, 1998 a; Sahoo and Jha, 2006). The incubation period was 2.5 days. The larval period observed in the present study (6 to 7 days) was found relatively short compared to reports from other parts of India (7 to 11.3 days). The short larval period may be due to the high soil temperature as reported by Rafiquzzaman and Maiti (1999). After attaining the larval maturity they entered into the soil for pupation and the pupal period was 13.5 days. Females were slightly bigger than males with a black border around the elytra. The longevity of male and female were 53 and 63 days respectively.

The leaf cutting weevil produced two types of symptoms on infested plants, the scraping and the leaf cutting symptom. Male and female weevils fed on the leaf lamina by scraping the epidermis of leaf tissues. As a result the affected portions became brown and later dried. The female weevil cut the leaves from the base after laying the eggs on the midrib of young leaves. Occasionally both symptoms were seen on the same leaf.

Cashew (*Anacardium occidentale* L.) was found as an alternate host of leaf cutting weevil. Adult weevils caused damage to the young leaves of cashew. However, only feeding symptom was noticed on cashew and no egg laying or leaf cutting symptom was observed. Being the member in the family Anacardiaceae it is obvious that cashew can be considered as the alternate host. Similar reports on the presence of common pests *viz. O. exvinacea, T. quadraria, Lymantria* sp. etc. are there in India (Nair, 1989).

5.3 SUSCEPTIBLE STAGE OF INFESTATION

The detailed study on the susceptibility of the plant to the leaf cutting weevil proved that 3 to 11 day old shoots were susceptible to the weevil attack. The first and second day of bud bursting, the new shoots were free from the attack of the weevil. Neither scraping nor egg laying were noticed. The leaf damage was 100 per cent on 4 and 5 day old shoots. The highest scraping damage of 69.20 per cent was noticed on 6 day old flush whereas the leaf cutting damage was highest on 4 day old flush. As the age of the flush increased the leaf damage by the weevil found decreased and reached minimum on 11 day old flush (Fig. 4). Twelve day onwards no weevil infestation was noticed. The susceptible stage was confirmed as 3 to 11 day old shoots. The tenderness of the leaf might played a vital role in the preference of the weevil for feeding as well as egg laying.

5.4 REACTION OF MANGO VARIETIES TO LEAF CUTTING WEEVIL

Information on reaction of a plant towards the incidence of pest is always helpful in formulating precautionary measures. With this view twenty one varieties of mango were observed for natural infestation of leaf cutting weevil and observations were taken during the emergence of new flushes. All 21 varieties of mango observed in the present study were infested by the leaf cutting weevil. The weevil caused two types of damages *viz* scraping and leaf cutting damage during flushing. Leaf scraping damage ranged from 56.00 per cent to 83.33 per cent. More than 80 per cent leaf feeding damage was recorded in Malgoa and Perakka Varikka (Fig. 5). 70 to 79 per cent leaf feeding damage was recorded in Amrith, Alphonso, Kalapadi, Neelam, Njattukuzhiyan, Prior, Suvarnarekha and Vellari Varikka. The least leaf damage of 50 to 59 per cent was recorded Rose Pitchi and Jehangir. The leaf cutting damage by the weevil was ranging from 16.44 to 29.17 per cent. Leaf cutting damage was 26.00 to 30.00 per cent in varieties Banganapalli, Kottukonam, Mundappa, Prior and Rose Pitchi (Fig. 6). The leaf

cutting damage ranged from 21.00 to 25.00 per cent in varieties Pairi, Pulichi, Saviha, Vellari Varikka, Alphonso, Banglora, Jahangir, Langra and Neelam. In Malgoa, Njattukuzhiyan, Perakka Varikka, Suvarnarekha, Kalapadi, Imampasand and Amrith, the leaf cutting damage was below 20.00 per cent. Based on the present study, Malgoa, Perakka Varikka and Prior were most susceptible varieties with 100 per cent leaf damage on new shoots.

Rafiquzzaman *et al.* (1999) reported the reaction of ten mango varieties to leaf cutting weevil from West Bengal. They reported that all varieties listed were susceptible to the weevil attack. Amrapali had the highest infestation of 57.4 per cent and Sorikhus with lower infestation of 39.8 per cent. Uddin *et al.* (2003) also reported the susceptibility of the variety Amrapali (52.55 per cent infestation). Among the ten hybrids evaluated for resistance to leaf cutting weevil, Prabha Sankar and Mahamad Babar were showed lowest mean infestation (Chakraborti *et al.* 2007).

5.5 LABORATORY EVALUATION OF BOTANICAL INSECTICIDES

Use of botanicals as alternate strategy in controlling the pests is getting prospects in many crop plants. In place like Kerala, where homestead agriculture prevails, it is having prime importance. Among the botanicals *viz*. neem seed kernal extract 5%, annona seed extract 5%, neem oil 2%, neem oil garlic emulsion 2% and Econeem plus 1%, were tested. Among the treatments tested, annona seed extract 5%, showed 71.32 per cent reduction in the scraping of leaves (Fig. 7). The leaf cutting damage was lowest in treatment with Econeem plus 1% and percentage reduction of leaf cutting was 38.67 per cent (Fig. 8). Mortality of weevils was observed only in treatment with neem seed kernel extract 5%. Soil drenching with botanicals registered more than 50 per cent mortality of grubs under laboratory conditions. Results of this study indicated that soil drenching with botanical insecticides can be included as one of the methods to manage the leaf cutting weevil.

Efficiency of annona seed extract 5 %, neem oil garlic emulsion 2%, neem seed kernel extract 5% in managing pumpkin caterpillar under laboratory condition has already been reported (Lenin, 2011).

5.6 EFFECT OF INSECTICIDES ON LEAF CUTTING WEEVIL

The efficiency of chemical insecticides *viz*. imidacloprid 0.003%, deltamethrin 1% + triazoiphos 35%, triazophos 0.05%, lambdacyhalothrin 0.005% and dimethoate 0.05% were tested in the laboratory. The results of the study revealed that lambdacyhalothrin 0.005% was the best chemical insecticide which gave 90.00 per cent mortality of leaf cutting weevil within two days. Soil drenching with the above insecticide registered more than 70 per cent mortality of weevils.

In the persistence study, all the chemicals tested registered mortality of weevils' up to nine days after treatment. However lambdacyhalothirin 0.005% registered more than 70 per cent mortality of weevils, which indicated the superiority of the chemical.

5.7 FIELD EVALUATION

The results of the laboratory studies were tested under field conditions. Lambdacyhalothrin 0.005% was found to be the superior treatment with a leaf scraping damage of 6.71 per cent. The Percentage reduction of leaf scraping over control was 81.26 (Fig. 9). No leaf cutting damage was observed with this treatment. The leaf cutting damage was 10.13 per cent in one day after treatment and increased to 34.36 per cent seven days after treatment with deltamethrin + triazophos 0.05%. The percentage reduction over control was 70.89 percent (fig. 10). Annona seed extract 5% and dimethoate 0.05% registered more than 50 per cent leaf cutting damage with a percentage reduction of only 20.60 percent and 70.89 percent respectively.

Several workers reported the efficacy of chemicals such as methyl demeton (0.05%), endosulfan (0.05%), fenitrothion (0.05%), chlorpyriphos (0.08%) against mango leaf cutting weevil (Siddiqi and Mathur, 1980; Bhole and Dumbre, 1990; Rafiquzzaman and Maiti, 1998 c)

Based on the results of the present study it was proved that the infestation of mango leaf cutting weevil can be managed by applying lambdacyhalothrin 0.005% on the second day of bud bursting, and the chemical gave protection to the flush during the susceptible period.

Summary

6. SUMMARY

The salient findings of the investigation on "Shoot feeders of mango and their management" are summarized below.

Shoot feeders are one of the largest groups of injurious insects of mango. They attain major pest status when they attack the newly emerging flushes. Young plants showed poor establishment due to the continuous damage on new shoots. A survey was conducted in three taluks of Thiruvananthapuram district to document shoot feeders of mango and to assess the intensity of damage. One of the major shoot feeders of mango identified from the survey was subjected to further studies. Botanical and chemical insecticides were tested for the management of the pest

Eighteen leaf and shoot feeders recorded from mango were grouped as leaf eating caterpillars, leaf eating beetles and sucking pests. The shoot webber Orthaga exvinacea webbed the leaves along with the shoot and converted the entire shoot in to a webbed mass. Among the leaf eating caterpillars, looper caterpillar, Thalassodes quadraria flush caterpillar, Bombotelia jocosatrix, hairy caterpillar, Dasychira mendosa and the lycaenid Rothinda amor caused damage to the plant by feeding the just emerged leaves. The butterfly caterpillar, Euthalia garuda, Slug caterpillar, Latoia lepida and the lymantrid Lymantria sp. preferred 2-3 weeks old leaves. The two lycaenids Rothinda amor and Arhopala sp. were new report from Kerala. They damage the newly emerged leaves as well as the inflorescence. The pest count was very low (0-23) and the damage score was one.

Among the leaf eating beetles, the leaf cutting weevil *Deporaus marginatus* Pas. was the serious pest. Adult weevils damaged the new flushes by feeding

(scraping) on the leaf lamina, later the infested leaves dried up. The female weevil laid the eggs in the mid rib of young leaves and then cut the leaves from the base. The count was 56 to 74 with a damage score of three. In all locations where the survey conducted leaf cutting weevil, *D. marginatus* was the serious pest associated with new leaves of mango.

Female weevil laid eggs singly by thrusting the egg in to the midrib of young leaves. Eggs laid in a single leaf ranged from 1 to 19. The fecundity of the female weevil was 74 to 85 eggs. The egg period, larval period and pupal period were 2.5, 6 .5 and 13.5 days, respectively. Total life cycle was completed in 20 to 25 days. The longevity of adult male and female were 53 and 63 days, respectively.

The susceptible stage of the plant was assessed by releasing the adult weevils on shoots of different age, starting from one day to 15 days after bud bursting. Leaf feeding was not observed on one and two day old flush. Feeding damage was 57.10 per cent on third day of bud bursting and damage increased to 69.50 per cent on five day old leaves. There after the feeding percentage decreased gradually to 14.30 on 11 day old leaves. Twelfth day onwards no feeding was noticed on leaves. Leaf cutting was 42.80 percentage on fourth day old leaves. Then the damage decreased gradually to 14.30 percent on 11 day old leaves. Twelfth day onwards there was no leaf cutting damage. The susceptible stage of mango to the leaf cutting weevil was third day to 11 day of bud bursting.

Twenty one mango varieties planted in the Instructional Farm, Vellayani were observed in the flushing season for the occurrence of leaf cutting weevil *D. marginatus*. All varieties were infested by the weevil. Feeding damage (scraping on

leaves) was 56.00 per cent in Jehangir and 83.33 per cent in Malgoa. The leaf cutting damage was 16.64 per cent in Kalapadi and 29.17 per cent in Prior and Banganapalli.

Three day old shoots were when treated with neem seed kernel extract 5%, annona seed extract 5%, neem oil garlic emulsion 2% and Econeem plus 1%, the treatment with annona seed extract recorded the lowest leaf damage (scraping) of 25.81 per cent. The botanicals treated shoots were observed for the leaf cutting damage by weevils, the lowest damage (26.99 per cent) was recorded in the treatment with Econeem plus 1%.

When the adult weevils were released on new shoots treated with neem seed kernel extract 5%, neem oil 2%, neem oil garlic emulsion 2%, Econeem plus 1%, 43.48 per cent mortality of adults were registered in treatment with annona seed extract 5%. Soil drenching with botanicals registered more than 50 per cent mortality of grubs in all treatments. Annona seed extract 5% recorded a grub mortality of 83.35

New shoots of mango treated with imidacloprid 0.003%, deltamethrin + triazophos 0.05%, triazophos 0.05%, lambdacyhalothrin 0.005% and dimethoate 0.05%, when exposed to the weevils, 2 h after treatment, lambdacyhalothrin 0.005% registered a mortality of 37.71 per cent. Four hours after treatment 47.86 per cent of adult mortality was observed in lambdacyhalothrin 0.005%. Adult mortality was below 10 per cent in treatment with imidacloprid 0.003% and triazophos 0.05% same traced was noticed six hours after treatment also.

All other treatment registered more than 60 per cent mortality of adults, one day after treatment except imidacloprid 0.003%. Lambdacyhalothrin 0.005% recorded 85.38 per cent mortality of adults. Within two days, more than 80 per cent mortality was recorded in all treatments except imidacloprid 0.003%. 90 per cent mortality of adult weevil was recorded in treatment with lambdacyhalothrin 0.005% and dimethoate 0.05%. Soil drenching with insecticides recorded 90.00 per cent mortality of grubs in treatment with lambdacyhalothrin 0.005%.

Field trails with lambdacyhalothrin 0.005%, deltamethrin + triazophos 0.05%, dimethoate 0.05% and annona seed extract 5% were conducted and lambdacyhalothrin 0.005% was effective with leaf feeding damage of 6.71 per cent from one day after treatment to seven day treatment. Deltamethrin + triazophos 0.05% registered an initial leaf feeding damage of 37.95 per cent on seven days after treatment. Treatment with annona seed extract 5% and dimethoate 0.05% recorded more than sixty per cent leaf feeding damage. No leaf cutting damage was noted in treatment with lambdacyhalothrin 0.05%. Deltamethrin + triazophos 0.05% registered a gradual increase in leaf cutting damage of 10.13 per cent to 34.36 per cent on seven days after treatment.

Persistence of insecticides was assessed by testing the mortality of adults recorded from treated shoots. Lambdacyhalothrin 0.005% recorded a mortality of 83.35 per cent on third day and fifth day after treatment, 76.70 per cent on sixth and seventh day and 70.06 per cent on eighth and nineth day after treatment. On third day deltamethrin + triazophos 0.05% registered 57.08 per cent mortality and it increased to 70.06 per cent on fifth day. The mortality reduced gradually and on ninth day it was 53.91 per cent. Annona seed extract 5% recorded only 45.26 per cent mortality on third day and decreased to 13.28 per cent on ninth day after treatment.

Based on the study it was proved that the infestation of mango leaf cutting weevil can be managed by applying lambdacyhalothrin 0.005% on second day of bud bursting. The chemical gave protection to the flushes during the susceptible period (3 – 11th day of bud bursting).

References

7. REFERENCES

Alam, 1962. *Insect and mite pests of fruits and fruit trees in East Pakistan and their control*. Department of Agriculture, East Pakistan, Dacca. 115p.

Ahmad, Y. and Ho, T. H. 1970. *Host- pest list (1920 – 1970).* Part II. Ministry of Agriculture and Co-operatives Malaysia. 690 p.

Barkade, D. P., Landge, S. A., Kadu, R. V. and Godase, S. K. 2010. Study on evaluation of different insecticides against leaf eating caterpillar *(Thalassodes dissita* Walker) on mango and cashew. *Int. J. Pl. Prot.* 3 (2): 170-173.

Baker, C. F. 1915. Studies of Philippines Jassoidea. *Philippine J. Sci.* 10 (6) : 3: 342.

Beesan, C. F. C. 1941. *The ecology and control of the forest insects of India and the neighbouring countries*. Forest Research Institute and College, Dehradun. 232 p.

Bhole, S. D., Jadhav, V. S., Dumbre, R. B. and Dalvi, C. S. 1987. Seasonal incidence and chemical control of mango nursery pests in the Konkan region. *J. Maharashtra Agric. Univ.* 12 (3): 387-388.

Bhole, S. D. and Dumbre, R. B. 1990. Bionomics and chemical control of mango leaf cutting weevil, *Deporaus marginatus* Pasc. (Coleoptera: Curculionidae). *Indian J. Ent*. 51 (3): 234-237.

Butani, D. K. 1979. *Insects and Fruits*, periodical expert book agency, New Delhi. 415p.

Butani, D. K. 1993. *Mango pest problems*. Periodical expert book Agency, New Delhi. 290p.

Chakraborti, K., Tuhinsri S., Samanta, S. K. and Choudhury, J. P. 2007. Screening of mango hybrids for tolerance against leaf cutting weevil in new alluvial zone of West Bengal. *J. Interacademicia*. **11** (4): 409-411.

Chakraborti, K., Tuhinsri, S., Samanta, S. K. and Samanta, A. 2009. Screening of mango varieties against *Deporaus marginatus* in Gangetic West Bengal. *Ann. of Pl. Prot. Sci.* **17** (1): 237-238.

Chaturvedi, N., Satheesan, S. M. and Hornbill. 1981. *Butterflies of Bombay*. Bombay Natural History Society, Mumbai, India. 336p.

Das, N. M., Ramamony, K. S. and Nair, M. R. G. K. 1969. Biology of a new jassid of mango *Amrasca splendens* Ghauri. *Indian J. Ent*. **31** (3): 288-290.

Fletcher, T. B. 1917. Report of the Imperial Entomologist. *Scient. Repts. Agric. Research Inst*. Pusa, 1916-17. 71-90.

Fletcher, T. B. 1918. Report of the Imperial Entomologist. *Scient. Repts. Agric. Research Inst*. Pusa, 1917-18. 84-116.

FAO. 2010. Food and Agricultural Organisation, FAO stat. http : // www. fao. org.

Ghauri, M. S. K. 1967. Mango leaf hoppers from Oriental and austro-oriental regions (Hemiptera : Cicadellidae). *Proc. R. Ent. Soc*. **36** (11): 159-166.

Gupta, B. P. and Singh, Y. P. 1986. New record of *Deporaus marginatus* (Pasc.) as a pest of *Litchi chinensis* L. *Prog. Hort.* 18 (3-4): 295-296.

Hill, D.S. 1983. *Agricultural insect pests of the tropics and their control*. 2nd ed. Cambridge University press, London. 746 p.

Hutson, J. C. and De Alwis, E. 1934. Two weevil pests of mango leaves. *Trop. Agricst.* **83** (2): 128-135.

Huang, P. S. and Fei, N. 1987. Mango leaf cutting weevil, *Deporaus marginatus*. *Ann. of Pl. Prot. Sci.* **2**(3): 141-145.

Jepson, F. P. 1935. Report on the work of Entomological Division. *Adm. Rep. Dir. Agri. Ceylon*: 132-147.

Kato, M. C. 1926. On the homopterous insects infesting mango. *Formosan Agri. Rev.* **22**: 47-52.

Khanna S. S. 1952. Biology of *Deporaus marginatus* Pasc. (Curculionidae : Coleoptera). *Proc. Natl. Acad. Sci. India.* **22**, 72-80.

Kannan, M. and Rao, N. V. 2006. Influence of age and stage of the host plant on insect pests of mango (*Mangifera indica* L.) *Int. J. Agric. Sci.* **2** (2): 351-353.

Kannan, M. and Rao, N. V. 2007. Seasonal incidence of lepidopteran pests in relation to weather parameters in mango (*Mangifera indica*). *Crop Res.* **33** (3): 198-203.

Kannan, M. and Rao, V. 2006. Ecological studies on mango leaf webber *Orthaga exvinacea* Hampson in Andhra Pradesh as a basis for IPM. *Int. J. Agric. Sci*. **2** (2): 308-311.

Mohammedrafeequ, A. P. M. and Renjith, K. R. 2011. Life tables of the mango leaf webber pest, *Orthaga exvinacea* Hampson (Lepidoptera: Pyralidae), on different host plant leaves. *J. Exp. Z ool. India*. **14** (2): 425-429.

Nair, M. R. G. K. 1989. *A monograph on crop pest of Kerala and their control.* Directorate of Extension, Kerala Agricultural University, Thrissur. 189p.

Lenin, N. 2011. Infestation of the pumpkin caterpillar, *Diaphania indica* Saunders in cucurbits and its management. M. Sc. (Ag) thesis, Kerala Agricultural University, Thrissur. 80p.

Palo, M. A. 1935. Anthracnose and important insect pests of the mango in the Philippines with a report on blossom spraying experiments. *Phil. J. Sci.* **48**: 209-235.

Panse, V. G. and Sukhatme, P. V. 1985. *Statistical method for Agricultural workers.* Indian council of Agricultural Research, New Delhi, 381p.

Prashad, V.G. and Bagle, B.G. 1979. Control of mango hopper. *Idioscopus clypealis* Leth by new insecticides. *Pestology*. **3**(3): 11-14.

Pena, J. F., Mohyuddin, A. I. and Wysoki, M. 2002. A review of the pest management situation in mango agroecosystems. *Phytoparasitica.* **26** (2): 129-148.

Patel, J. R., Patel, M. B., Radadia, G. C., Shah, A. A. and Pandya, H. V. 1997. Insect pest management in mango nursery. *J. Applied Hort.* **3** (1/2): 125-128.

Pruthi, H. S. and Batra, H. N. 1960. *Important fruit pests of North West India*. Indian Council of Agricultural Research, New Delhi. 113p.

Rafiq, A. and Ghani, M. A. 1972. Coccoidea and their natural enemy complexes in Pakistan. *Tech. Bull. Commonwealth. Inst. Biological Control, Rawalpindi.* 59-104.

Rafiquzzaman, M. D. and Maiti, B. 1997. Population fluctuation of mango leaf cutting weevil, *Eugnamptus marginellus* Faust (Coleoptera: Curculionidae) in relation to major abiotic factors. *Crop Res.* **14** (1): 143-150.

Rafiquzzaman, M. D. and Maiti, B. 1998 a. Biology of mango leaf cutting weevil, *Eugnamptus marginellus* Faust. (Coleoptera: Curculionidae). *Hort. J.* **11** (2): 33-43.

Rafiquzzaman, M. D. and Maiti, B. 1998 b. Efficacy of two soil insecticides against prepupa and pupa of mango leaf cutting weevil, *Eugnamptus marginellus* Faust (Coleoptera: Curculionidae). *J. Interacademicia* **2** (4): 335-338.

Rafiquzzaman. M. D. and Maiti, B. 1998 c. Laboratory evaluation of few insecticides against adults of mango leaf cutting weevil, *Eugnamptus marginellus* Faust. (Coleoptera: Curculionidae). *J. Interacademicia* **2** (3): 230-232.

Rafiquzzaman, M. D. and Maiti, B. 1999. Dormancy of mango leaf cutting weevil, *Eugnamptus marginellus* Faust. (Coleoptera : Curculionidae). *Crop Res.* **18** (2): 283-286.

Rafiquzzaman, M D., Mitra, S. and Chattopadhyay, A. 1999. Varietal susceptibility to the mango leaf cutting weevil, *Eugnamptus marginellus* Faust. (Coleoptera: Curculionidae). *Hort. J.* **12** (2): 91-95.

Reddy, C. H. P., Prasad, P. R. and Umamaheswari, T. 2001. Screening of mango cultivars against the leaf webber, *Orthaga exvinacea* Hampson (Lepidoptera: pyralidae). *Indian J. Pl. Prot.* 29 (1/2): 118-120.

Sahoo, S. K. and Jha, S. 2006. Behaviour and development of mango leaf cutting weevil, *Deporaus marginatus* (Pasc.) (Attelabidae: Coleoptera). *J. Pl. Prot. and Environ.* **3** (1): 68-75.

Sahoo, S. K. and Jha, S. 2008. Screening of mango varieties against leaf cutting weevil, *Deporaus marginatus* Pasc. (Attelabidae: Coleoptera) in the nursery. *Crop Res*. **35** (3): 226-232.

Shaw, S. S., Mukherjee, S. C., Mahajan, V., Choudhary, S. K., Tripathi, A. K. and Sharma, R.B. 1997. Incidence of mango leaf webber *Orthaga exvinacea* Hampson in different varieties/ hybrids of mango in Madhya Pradesh. *Proceedings of the first National Symposiym on Pests Management in Horticultural Crops*. pp 22-25.

Siddiqi, M. S. and Mathur, K. P. 1980. A note on the chemical control of mango leaf cutting weevil, *Deporaus marginatus* Pasc. *Prog. Hort.* **11** (4): 53-55.

Singh, L. B. 1968. *The Mango: Botany, Cultivation and Utilization*. World Crop Series Books, Leonard Hill, London. 438p.

Singh, R. K. and Pandey, V. 1972. Studies on the control of mango leaf cutting weevil, *Deporaus marginatus* Pasc. (Coleoptera: Curculionidae). *J. Sci. and Technol.* **10** (3/4): 173-174.

Soh, P. G. and Khoo, K. C. 1983. Field evaluation of four insecticides for the control of the mango leaf cutting weevil, *Deporaus marginatus* Pasc. *Pertanika*. **6** (1): 67-70.

Soomro, A., Khuhro, R. and Ansari, H. 1987. Status of insects associated with mango blossom. *Proc. V Pakistan Congr. Zool*. **5**: 123-125.

Srivastava, R. P. 1997. *Mango insect pest management.* International Book Distributing Co, Lucknow, India. 272p.

Tandon, P. L . and Lal, B. 1976. New record of predatory mite on mango mealy bug, *Drosicha mangiferae* Green (Margarodidae; Hemiptera) *Curr. Sci*. **45**(15): 566-567.

Tandon, P. L and Verghese, A. 1985. World list of insect, mite and other pests of mango. *Tech. Doc. Indian. Inst. Hortic. Res.* 5. Banglore, 376p.

Tigvattnanont, S. 1988. Biological and autecological studies of the mango leaf cutting weevil, *Deporaus marginatus* Pasc. (Coleoptera: Attelabidae). *Khon Kaen Agric. J.* **16** (1): 51-62.

Uddin, M. A., Islam, M. S., Rahman, M. A., Begum, M. M. and Hasanuzzaman. 2003. Susceptibility of different varieties of mango to leaf cutting weevil, *Deporaus marginatus* Pasc. and its control. *Pakistan J. Biol. Sci.* **6** (7): 712-714.

Veeresh, G. K. 1989. Pest problems in mango world solution. *Acta. Horti.* **231**: 551-565.

Verghese, A. 1998. Effect of imidacloprid on mango hoppers, *Idioscopus* spp. (Homoptera: Cicadellidae). *Pest. Manag. Hort. Ecosyst*. **4**: 70-74.

Verghese, A. 2000. Effect of imidacloprid, lambdacyhalothrin and azadirachtin on the mango hopper, *Idioscopus niveosparsus* Leth. (Homoptera : Cicadellidae). *Pest. Manag. Hort. Ecosyst.* 2 (3): 67-69.

Zaman, Z. and Maiti, B. 1994. Insects and mites infesting seedlings of mango in West Bengal. *Environ.* and *Eco.* **12** (3): 734-735.

Zhang, S. K. and Wei, K. C. 1991. Report on incidence of *Deporaus* (*Eugnamptus*) *marginatus* (Pasc.). *Chinese J. Eco*. **4** (3): 72.

Zhang, C., Pu, T. S. and Dan, J. G. 1993. Host suitability for mango funnel-rolling leaf weevil (*Deporaus marginatus* Pasc.). *Chinese J. Eco*. **11** (2): 25-26.

Zou, H. 1982. Three new curculionid pests of mango in Xishuangbanna. *Entomotaxonomia.* **4** (3): 231-232.

Abstract

SHOOT FEEDERS OF MANGO AND THEIR MANAGEMENT

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Abstract of the

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ABSTRACT

A study was carried out at College of Agriculture, Vellayani during 2010-2011 with the objectives of documenting shoot feeders of mango, assessing the intensity of damage and identifying effective pesticides for their management.

Survey conducted in three taluks of Thiruvananthapuram district revealed the occurrence of eighteen shoot and leaf feeders (nine leaf eating caterpillars, four leaf eating beetles, three sucking pests and two midges) on mango. Among the leaf eating caterpillars, two lycaenids, *Rothinda amor* and *Arhopala* sp. are new reports from Kerala. The leaf cutting weevil, *Deporaus marginatus* was found to be the major leaf feeder of mango with a damage intensity of more than 50 per cent under field condition.

Biology of the weevil was worked out in the laboratory and the egg, larval and pupal periods were 2.5, 6.5 and 13.5 days, respectively. In a single leaf, 1 to 19 eggs were observed and the fecundity of the weevil was 74 to 85 eggs. Based on the feeding as well as the oviposition behaviour of the adults, third to eleventh day of bud bursting was found to be the critical stage of susceptiblilty.

The reaction of twenty one mango varieties against leaf cutting weevil in the flushing season of the plants were observed. All the varieties were found susceptible to weevil infestation with the minimum leaf feeding damage (scraping on leaves) of 56.00 per cent in Jehangir and 83.33 per cent (maximum damage) in Malgoa. Leaf cutting damage was ranging from 16.64 per cent in Kalapadi to 29.17 per cent in Prior and Banganapalli.

Laboratory evaluation of neem seed kernel extract 5%, annona seed extract 5%, neem oil 2%, neem oil garlic emulsion 2%, Econeem 1% revealed that annona seed extract 5% was the most effective with lowest leaf feeding (25.81 per

cent) and leaf cutting (34.38 per cent) damage. The mortality of adult and grubs were 43.48 and 83.35 per cent, respectively.

Application of imidacloprid 0.003%, deltamethrin + triazophos 0.05%, triazophos 0.05%, lambdacyhalothrin 0.005% and dimethoate 0.05% on flushes of mango in the laboratory resulted in 90 per cent mortality of both adults and grubs with lambdacyhalothrin 0.005%.

In order to fix the spray schedule, persistence of insecticides were tested and lambdacyhalothrin 0.005% recorded a mortality of 70.06 per cent on ninth day of treatment.

Field experiment with lambdacyhalothrin 0.005%, deltamethrin + triazophos 0.05%, dimethoate 0.05%, and annona seed extract 5% indicated the superiority of lambdacyhalothrin 0.005% against leaf cutting weevil. No leaf cutting damage was seen nine days after treatment whereas the leaf feeding damage was 6.71 per cent.

Based on the results the infestation of mango leaf cutting weevil can be managed effectively by applying lambdacyhalothrin 0.005% on the second day of bud bursting and the chemical could give protection to the new flushes during the vulnerable stage of the plant.