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Occurrence, Damage Pattern, and Insecticidal Treatments of Mango Leaf Cutting Weevil *Deporaus marginatus* (Pascoe)

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Abstract
Mango is recognised as one of the most cultivated and preferred fruits in the tropics and subtropics. India is acknowledged as the leading producer of mangoes in the world; however, significant damage to mango trees is caused by a large number of insect pests. Among these, severe damage is caused by the mango leaf-cutting weevils, *Deporaus marginatus*, which attack young mango plants and hinder growth, particularly in new grafts. Small cavities are excavated by the female on either side of the midribs of the leaves, with eggs being laid in each cavity. The leaf is then cut near the base from one edge through the midrib to the other. As a result of these attacks, infested shoots become almost leafless. The growth of the rootstock is delayed, leading to poor success of new grafts. A study was conducted to review the incidence, nature of damage, and management of leaf-cutting weevils in a private mango orchard at Barasat. The highest infestation was recorded in late June, and the lifecycle of *D. marginatus* is completed on average in 20-25 days. Different commercial Insecticide treatments revealed that a combination of chlorpyrifos 50% and cypermethrin 5% EC is effective in reducing pest populations and superior to other modules tested.

Key words: Weevil, Mango, Leaf, Pest, Efficacy, Insecticides.

Introduction

Mango is one of the most extensively cultivated fruits in tropical and subtropical regions [1]. It is famous for its taste, aroma, and sweet scent. India stands as the foremost mango producer in the world, highlighting its significant role in global agriculture. The nation dedicates approximately 2,350 thousand hectares to mango cultivation, resulting in an impressive production of 20772 thousand metric tons. This remarkable output underscores India's rich agricultural heritage and the importance of mangoes in both domestic and international markets [2]. Nevertheless, a substantial number of insect pests cause significant damage to mango trees and their fruits. There are over 175 insect species damaging the mango tree [3,4]. Many of them have been documented as attacking the foliage, flowers, buds, branches, and trunk of mango trees [5]. *Deporus marginatus* Pascoe (Coleoptera: Curculionidae), a species among the foliage feeders, also targets young and newly grafted mango plants [6,7]. This insect is often referred to as the mango leaf cutting weevil. Reports have identified it as a pest affecting mangoes in several countries, including India [8,9], Burma [10], Sri Lanka [11], Malaysia [12], and Bangladesh [13]. *D. marginatus* is characterised by its elongated body and distinctive snout. This species is predominantly found in tropical and subtropical regions, where the climate and biodiversity create an ideal environment for insect life. The life cycle of *D.marginatus* typically consists of four stages: egg, larva, pupa, and adult. Adult insects cause two primary types of damage to new leaf growth: feeding damage and defoliation. Both male and female weevils contribute to feeding damage. Both of these adult weevils feed on the epidermis of young leaves, causing them to turn brown, curl, and crumple. The female weevil made small cavities on both sides of the midribs on the upper surfaces of the leaves for egg laying. Then, it cuts the leaf near its base, slicing from one edge through the midrib to the opposite side edge. Leaves that are damaged and contain eggs ultimately fall to the ground [14,15,16,17]. The larvae burrow into the tissue of fallen leaves, and fully grown larvae pupate in moist soil. Upon emergence, the adults begin a new cycle. When the pest population is high, the feeding of adults alone can cause considerable damage. Infested shoots shed their leaves, become less vigorous, and eventually weaken. Young mango trees are more prone to attacks by leaf-cutting weevils compared to mature trees [18]. A preliminary study indicated that grafted plants of various types suffer more significant damage from this insect. In India, it was reported that leaf-cutting weevils led to 53.9 to 57.4% defoliation in some mango trees [19], and these weevils inflicted up to 53% damage on grafted plants [20]. Research on the biology of this pest has been conducted in several countries. However, comprehensive studies on its management are still insufficient. Since there is little management information available for *D. marginatus* in India, the application of standard insecticides recommended for *D.marginatus* has not consistently yielded effective results for several reasons. Consequently, it is important to investigate both the potential damage and control strategies using both traditional and newer pesticides with low residual toxicity. Therefore, a study was undertaken to evaluate the incidence, nature of damage and efficacy of new insecticide combinations in comparison to conventional insecticides against the mango leaf cutting weevil.

Materials and methods

From May to July 2022, a field experiment took place at a mango orchard in Barasat, West Bengal, India, coinciding with the emergence of new mango leaves. The location of the experimental site is at 23° N latitude and 89° E longitude, with an elevation of 9.75 meters above mean sea level. To determine the extent of young mango leaves affected by the mango leaf cutting weevil, the investigation focused on identifying specific symptoms of infestation. These symptoms included leaves that were curled and crumpled, those exhibiting blade cut injuries, and small cavities on the leaves that contained eggs. Every five days, observations were conducted over a span of sixty days after the emergence of the new flush. Ten mango plants, aged between five to ten years and of the Himsagar variety, were chosen and maintained without the use of insecticidal sprays. The occurrence of *D. marginatus* was determined by examining the extent of damage present. To determine the level of infestation by *D. marginatus*, 200 young leaves were randomly picked from various sides of each tree. Each tree was treated as an individual replication. Leaves that displayed typical infestation signs and symptoms were tallied and then expressed as percentage values. The percentage of infestation caused by *D. marginatus* was obtained using the following formula: Infestation (%) =Total number of infested young leaves /Total number of young leaves observed ×100. Fallen cut leaves were collected and examined under a microscope to identify small cavities containing eggs. During periods of high infestation, the experimental site was frequently visited to observe and record the feeding technique and damage patterns caused by adult weevils on young leaves. The effectiveness of various insecticide applications (Table 1) on mango *D. marginatus* was evaluated in the same orchard using selected uniform plants (cv. Himsagar). The study was conducted using a randomised block design, with three repetitions per treatment and a control of water spray. One tree served as one replication. The experiment consisted of five treatments. The selection of insecticides was based on farmers' information and literature reports. Ethion, acephate, and chlorpyrifos belong to the organophosphate insecticides. Organophosphates are a class of chemicals known for their ability to inhibit the enzyme acetylcholinesterase (AChE). Insecticides bind to the active site of AChE, preventing it from catalysing the breakdown of acetylcholine in the synaptic cleft. This results in an accumulation of acetylcholine, leading to continuous stimulation of the postsynaptic receptors. The excessive buildup of acetylcholine causes prolonged nerve impulses, which can lead to symptoms of toxicity in insects, such as twitching, paralysis, and ultimately death. Cypermethrin, fenvalerate and lambda-cyhalothrin belong to the chemical class of synthetic pyrethroids, which are insecticides modelled after natural pyrethrins derived from *Chrysanthemum* flowers. They primarily act on insects' nervous systems. Specifically, it binds to the voltage-gated sodium channels, delaying their closing. This leads to prolonged depolarisation, resulting in hyperexcitation of the nerve cells. Ultimately, this disrupts normal nerve impulse transmission, causing paralysis and death in the target insects. Diafenthiuron is a systemic insecticide that belongs to the chemical class of thioureas. Its mode of action involves the inhibition of acetylcholinesterase. Disrupting this enzyme's activity leads to paralysis and eventual death of the insect. Additionally, it has ovicidal properties. The quantity of each insecticide and their combinations needed for the specific treatment dose to spray the replicated plots in the mango experiment was determined based on the active ingredient in their commercial formulations. The calculated amount of pesticides for each replicated plots were dilute with water and these were sprayed separately with the help of foot sprayer. For thorough coverage of the trees, a spray fluid of three litres per tree was used and applied, taking the necessary care to avoid drift. The first spray was given on 20 May, 2022 and the second spray on 5 June, 2022. The observation was taken from 3 days and 6 days after first spray and second spray. As adult weevils are active flyers, it is difficult to count the population of the weevils. Thus, in the present study, damaged leaves were counted to determine the efficacy of different insecticidal treatments. To determine the percentage of infestations, a random selection of 500 leaves was taken from a branch. After each application of spray, the extent of damage was evaluated by comparing the total number of leaves to those that were infested. To assess the impact of insecticides on infestations, an analysis of variance (ANOVA) was conducted. The arcsine transformation was employed to ensure the assumptions of ANOVA were met.

Results and discussions

The leaves of mango trees are produced three times a year. The first set of leaves was observed in February-March, the second in June, and the third in September-October. During the study, the highest activity of *D. marginatus* was recorded in late June when the infestation level reached its maximum (46%). A similar observation was reported by Singh and Pandey [21]. However, Heavy infestation in Maharashtra was reported by Bhole et al. [22] from July to October**.** Adult weevils attacked new flushes of leaves and completely destroyed them, leaving only the stems. Young trees suffer more than the older ones. The adult *D. marginatus* is described as light almond-coloured, with very hard, black upper wings. It is observed that leaf infestation by adult weevils usually occurs in the morning and at night. Small cavities are initially made by the female weevil on the distal part of the upper surface of the leaves, and 3-6 eggs are laid inside them, which are then closed with a sticky secretion. In total, 100-200 eggs are laid under each leaf. Sometimes, the female excavates cavities simultaneously during mating with the male weevil. Afterwards, the female begins cutting the dorsal surface of the proximal part of the leaf like a scissors. The cutting started from one side and proceeded to the other at a right angle to the midrib. It was observed that they avoided the hard part of the midrib, moved to the soft underside of the leaves, and cut the leaves completely. They also consumed the juice that oozes out from the cut part. Besides cutting the leaf, they eat the soft tissue cells of the upper layer. They then throw the cut leaves on the ground beneath the tree. The eggs fall along with these cut leaves. Within two days, the eggs hatch out, and the larvae enter the soft part of the leaf, beginning to eat the cell walls. This dry phase lasts for eleven days. After that, they emerged from the dry leaves, and pupate in the soil. After eight days, the nymph emerged from the pupal chamber. Thus, their life cycle is completed within twenty-one to twenty-five days on average. Within six days of the emergence of the nymphs, mating begins again, and the plant is continued to be fed on by them. This insect can also be found on mango trees of different varieties. However, *D. marginatus* infestation has also been reported in *Litchi chinensis Sonn.* [23] and in cashew plants [24]. As soon as the leaves of the mango tree are cut, the amount of green part of the tree is reduced considerably. The cut leaves are seen lying on the ground at the base of the tree. That branch is bare of leaves and grows like a stick. After a few days, leaves start growing there again. Due to repeated cutting of leaves on those branches, the tip of the branch cannot grow or mature easily. This disrupts the plant's food supply, leading to reduced growth, yield loss, and economic harm to agricultural systems.

Table 1. List of insecticides selected for treatment against *D.marginatus* with trade names and recommended doses.

Treatment	Insecticides	Dose	Commercial name	Type	Mode of action
T1	Ethion 40% + Cypermethrin 5% EC	1.5ml/ L	Nagata	Organophosphate & synthetic pyrethroid	Contact and stomach
T2	Chlorpyrifos 50% + Cypermethrin 5% EC	1.5 ml/L	Nurocombi	Organophosphate & synthetic pyrethroid	Contact, systemic & stomach
T3	Acephate 25%+Fenvalerate 3% EC	1ml/L	Sardar	Organophosphate & synthetic pyrethroid	Systemic and contact
T4	Diafenthiuron 50% WP	1gm/L	Pegasus	Thiourea	Contact and stomach
T5	Lambda - Cyhalothrin 5% EC	0.5 ml/L	Agent plus	Synthetic pyrethroid	Stomach & contact
Control	Water				

Table 2. Mean effect of two sprays of applied insecticides against *D.marginatus*. NS- Non-significant; DAS-Days after spray;(Figure in parentheses are arcsine transformed values); Means are not significantly different at p=0.05

Treatment	Pre treatment Count (% of damaged leaves)	Percentage of damaged leaves					
		First spray			Second spray		
		3 DAS	6 DAS	Mean	3 DAS	6 DAS	Mean
T1	29.33	24.66 (29.77)	23.33 (28.88)	23.99 (29.32)	21.33 (27.50)	17.33 (24.60)	19.33 (26.08)
T2	29.66	21.00 (27.27)	18.33 (25.34)	19.60 (26.27)	15.33 (23.05)	10.66 (19.05)	12.99 (21.12)
T3	30.00	26.33 (30.87)	25.33 (30.21)	25.83 (30.54)	23.66 (29.10)	21.66 (27.73)	22.66 (28.42)
T4	28.33	26.00 (30.65)	25.66 (30.43)	25.83 (30.54)	22.33 (28.19)	20.33 (26.80)	21.33 (27.50)
T5	30.66	23.66 (29.10)	23.33 (28.88)	23.49 (28.99)	20.33 (26.80)	18.00 (25.10)	19.16 (25.95)
Control	26.66	36.33 (37.06)	38.66 (38.44)	37.49 (37.75)	44.66 (41.93)	47.33 (43.46)	45.99 (42.69)
CD at 5%	NS	1.82	1.33	1.58	1.48	1.76	1.62
SEm (±)	NS	0.62	0.54	0.45	0.60	0.50	0.55

Table 3. Overall mean effect of two sprays of insecticides against *D.marginatus*.

Treatment	Insecticides	Overall damaged leaves after 1st and 2nd spray (mean %)	Overall decrease /increase of infestation (mean %)
T1	Ethion 40% + Cypermethrin 5% EC	21.66	-7.67
T2	Chlorpyrifos 50% + Cypermethrin 5% EC	16.29	-13.37
T3	Acephate 25%+Fenvalerate 3% EC	24.24	-5.76
T4	Diafenthiuron 50% WP	23.58	-4.75
T5	Lambda - Cyhalothrin 5% EC	21.32	-9.34
Control	Water spray	41.74	+15.08

The impact of insecticidal applications on leaf-cutting weevils during the 2022 season is presented in Table 2. It is clearly indicated that all chemical treatments performed significantly better than the control. Three days after the first spray, the lowest infestation was observed with chlorpyrifos 50% + cypermethrin 5% EC, followed by lambda-cyhalothrin 5% EC. The infestation was recorded at 24.66% and 26% respectively, after treatment with ethion 40% +

cypermethrin 5% EC and diafenthiuron 50% WP. It was observed that acephate 25% + fenvalerate 3% EC was less effective than all other insecticides. The lowest average infestation was recorded with chlorpyrifos 50% + cypermethrin 5% EC, followed by ethion 40% + cypermethrin 5% EC and lambda-cyhalothrin 5% EC, as observed 6 days after the first spray. It was also noted that diafenthiuron 50% WP was less effective than all other insecticides used 6 days after the first spray. It was observed after first spray, average highest performance was achieved by chlorpyrifos 50% + cypermethrin 5% EC (19.6%), followed by lambda-cyhalothrin 5% EC (23.49%), while the lowest infestation reduction was recorded in acephate 25% + fenvalerate 3% EC and diafenthiuron 50% WP (25.83%). Three days following the second spray, it was observed that the lowest average infestation rate of 15.33% resulted from the combination of chlorpyrifos 50% and cypermethrin 5% EC, with lambda-cyhalothrin 5% EC coming next at 20.33%. Among all the insecticides applied, the least effective was found to be the combination of acephate 25% and fenvalerate 3% EC, with an infestation rate of 23.66% after the same period. Six days after the second spray, observations showed the lowest average infestation in chlorpyrifos 50% + cypermethrin 5% EC at 10.66%, followed by ethion 40% + cypermethrin 5% EC at 17.33%. Diafenthiuron 50% WP did not show a significant reduction in infestation. It was also noted that acephate 25% + fenvalerate 3% EC was less effective, with an infestation level of 21.66% after six days. Mean of the second spray showed that chlorpyrifos 50% + cypermethrin 5% EC (12.99 %) achieved the best performance, followed by lambda-cyhalothrin 5% EC (19.16 %), and the lowest infestation reduction was recorded in acephate 25%+fenvalerate 3% EC (22.66%). It is clearly showed from Table 3 that, following two sprays, the effectiveness of various insecticidal treatments in reducing *D. marginaatus* infestation ranked as follows: chlorpyrifos 50% + cypermethrin 5% EC was the most effective, followed by lambda-cyhalothrin 5% EC, then ethion 40% + cypermethrin 5% EC, acephate 25% + fenvalerate 3% EC, and finally diafenthiuron 50% WP. In conclusion, *Deporaus* marginatus is a serious pest of mango that can cause significant economic consequences in agricultural systems. Understanding the extent of this damage, it is crucial to develop effective management strategies to protect mango trees. Finally, the study revealed that the combination of chlorpyriphos 50% and cypermethrin 5% EC was the most effective insecticide for controlling *D. marginatus* population compared to other insecticides.

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