

The treatment of insect pests and mites on drumsticks (*Moringa oleifera*) in south India at the moment

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ABSTRACT

Understanding the dynamics of insect pests is essential to comprehending their presence on a crop. Drumstick (*Moringa oleifera* Lam.) is infested by several insect pests at different stages of the crop's phenophase, which reduces yield. The current study on the incidence of arthropods was conducted at the ICAR-Indian Institute of Horticultural Research in Bengaluru, Karnataka, between 2018 and 2022 in order to examine the current situation of insect pests as well as beneficial arthropods associated with drumsticks and to develop suitable management strategies for major pests. Leaf-eating caterpillars (*Noorda blitealis*), aphids (*Aphis loti*), tea mosquito bugs (*Helopeltis antonii*), Bihar hairy caterpillars (*Spilosoma obliqua*), stem borers (*Batocera rubus*), and pod flies (*Gitona distigma*) were among the arthropods discovered on drumsticks. Coccinellid beetles (*Coccinella septempunctata*), spiders (*Oxyopes shweta* Tikader (*Oxyopidae*)), *Thomisus* spp. (*Thomisidae*), *Nescona* spp. and Braconid (*Disophrys* spp.), and pollinators such small bees (*Apis florea* Fab) are among the useful insects. and drumsticks were used to record bumble bees (*Bombus* spp.). In order to reduce pesticide residue on the crop, the study's findings would aid in the timely use of suitable pest control techniques.

Key words: Phenophase, pesticide residue, insect pests, drumsticks, and arthropods

Introduction

The nutritious pods, leaves, and blossoms of the drumstick (*Moringa oleifera* Lam.) are grown for use in cooking. Due to their great medicinal and vegetable value, ease of cultivation, and quick growth, drumsticks are becoming more important (Islam et al. 2021, Mastiholi et al. 2023). India, Sri Lanka, Pakistan, Nepal, the Philippines, and other countries all cultivate drumsticks. With 38,000 hectares under cultivation and an annual production of 2.20 to 2.40 million tons, India is the leading producer. It contributes considerably to a market value of USD 4 billion yearly, approaching USD 7 billion in 2016–2017, with a productivity of 63 tons per acre (Maharshi 2016, Sekhar et al. 2017). Andhra Pradesh (15,665 ha), Tamil Nadu (13,250 ha), and Karnataka (10,280 ha) are the major drumstick-growing states in India (Rachana et al. 2020). It covers 4,613 hectares in different states (Sekhar et al. 2018). Due to its numerous genotypes from various geographical regions, Tamil Nadu is the pioneering state (Hegde and Hegde 2013, Sekhar et al. 2018).

Numerous biotic and abiotic factors hinder drumstick production. Insect pests account for up to 100% of production losses among biotic stressors (Saha et al. 2014). The region where drumsticks are grown

IIICAR, Bengaluru, Karnataka: Indian Institute of Horticultural Research. *The author's email address for correspondence, prasannaent@gmail.com, is progressively growing. Aphids [*Aphis craccivora* (*Aphididae*: *Hemiptera*)]; bud midges [*Stictodiplosus moringae* (*Cecidomyiidae*: *Diptera*)]; scale insects [*Ceroplastodes cajani* (*Coccidae*: *Hemiptera*)]; tea mosquito bug [*Helopeltis antonii* (*Miridae*: *Hemiptera*)]; pod fly [*Gitona distigma* (*Drosophilidae*: *Diptera*)]; and leaf-eating caterpillar/webber [*Noorda moringae* (*Crambidae*: *Lepidoptera*)]. Additionally, a number of pollinators, parasitoids, and predators visit drumsticks, although their presence has not been well recorded. Drumstick's extended susceptibility throughout critical development stages makes controlling pests difficult. In important agricultural zones, problems like pod flies and tea mosquito bugs develop. Documenting the function and condition of arthropods in drumsticks requires a thorough investigation. Effective management techniques will be informed by seasonal pest occurrence data, resolving worries about widespread pesticide abuse.

METHODS AND MATERIALS

The ICAR-Indian Institute of Horticultural Research in Bengaluru, Karnataka, conducted the research between 2018 and 2022.

the frequency of arthropods in drumstick fields (PKM-1 variety). Unidentified insects were gathered and sent to the insect taxonomy lab at the University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru, Karnataka, for identification. During the survey, all data, including pest occurrence, severity of pest incidence, and yield loss on drumstick, were recorded on randomly chosen plants in each field. The percentage of damage or loss brought on by the main pest was noted as:

$$\text{Per cent of damage (fruits)} = \frac{\text{No. of fruits infested}}{\text{Total number fruits}} \times 100$$

$$\text{Per cent leaf/ foliage damage} = \frac{\text{No. of leaf damaged in a branch}}{\text{Total No. of leaf in a branch}} \times 100$$

Arthropod diversity was continuously monitored in several locations, including Pallichal and Thiruvananthapuram (Kerala), Periakulam (Tamil Nadu), Thallada and Khammam (Telangana), and Madanapalle (Andhra Pradesh).

Management trial: In a recently planted orchard that was three years old, management techniques were developed for the leaf-eating caterpillar/webber (*N. blitealis* Walker), tea mosquito bug (*H. antonii*), and stem borer (*Batocera* spp.).

At the ICAR-Indian Institute of Horticulture Research research farm in Bengaluru, Karnataka, management trials were conducted using a randomized complete block design (RCBD) with five treatments: lamda cyhalothrin 5 ec @0.6 ml/L; Spinosad 45 sc% @0.3 ml/L; *Bacillus thuringiensis* (Bt) formulation @2 ml/L; neem soap @10 g/L; and control. These treatments were replicated four times with 15 plants per replication. Insecticides of biological origin, with the exception of lamda cyhalothrin, were selected for the experiment since drumsticks are eaten as both fruit and leaves. For each replication, five trees were chosen at random, and five branches from each tree were chosen from the east, west, south, and north to observe the number of larvae every ten days after each spray (Chandrakar and Gupta 2020). To assess the significance between the treatments, data was submitted to statistical analysis (ANOVA) using SPSS version 11.

OUTCOMES AND TALK

Arthropod fauna documentation: Table 1 lists the beneficial insects and arthropod pests found in and around Bengaluru as well as neighboring regions of Karnataka, Kerala, Tamil Nadu, Telangana, and Andhra Pradesh between April 2018 and March 2022. Leaf-eating caterpillars (*N. blitealis* Walker), tea mosquito bugs (*H. antonii* Signoret), long horn beetles (*Batocera rufomaculata* De Geer), thrips (*Thrips palmi* Karny), pod flies (*G. distigma*), winged flies (*Physiphra aenea* Fabricius), and aphids (*Aphis loti*) were the main pests discovered during the investigation. Below is a discussion of the specifics of the insect pests that were noticed.

N. blitealis, a leaf-eating caterpillar: *N. blitealis* was observed to be active from April to November, peaking in June and July. On the crop's fresh flush, there was a severe infestation that resulted in 100% destruction. After hatching, the larvae create papery constructions by feeding by staying in a silken web on the underside of the leaf. If the infestation is severe, the whole tree will be stripped of its leaves. Adult larvae render the pods unsuitable for human eating by scraping them and bore inside of them. In order to pupate, the late larval stage descends into the ground. Six to nine days following pupation, adults emerged. The moths that have emerged have white hind wings with a dark brown border and dark brown forewings.

Additionally, this pest has been identified as a serious problem in a number of global locations (Satti et al. 2013, Litsinger 2014). In 2017, *N. blitealis* was recorded in Drumstick, in middle Gujarat, at Anand Agricultural University, Anand, Gujarat. Thumar et al. also noted the harm stated above (2017).

Management: Since drumsticks are eaten as fresh leaves, it is crucial to use plant protection techniques to minimize pesticide residue. The current investigation found that the best treatments for *N. blitealis* were

Spinosad 45 sc @0.3 ml/L and Lamda cyhalothrin 5 ec @0.6 ml/L, followed by Bt formulation @2 ml/L and neem soap 10 g/L (Table 2). When ten pesticides were tested against the defoliator *N. blitealis*, indoxacarb 15.8 ec @0.75 ml/L, emamectin benzoate 5 sg @0.25 g/L, and fipronil 5 sc @1 ml/L treated plants produced a substantial and maximum leaf yield with a high net return from indoxacarb sprayed plants (Kumari et al. 2015). According to a research conducted in Vijayapura, Karnataka, Spinosad aniliprole 18.5, Spinosad 45 sc @0.1 ml/L, indoxacarb 15.8% ec @0.3 ml/L, and emamectin benzoate 5 sg 0.2 g/L were shown to be effective against leaf-eating caterpillars (Rachana et al. 2021). Aphids (*Aphis loti*): The pest was discovered between April and January, peaking between November and January. The sap from young leaves and twigs, including flowers, is sucked by both adults and nymphs, causing the leaves to dry up and become yellow. In a similar vein, aphids caused almost 25% of the damage to drumsticks in Bagalkot, Karnataka, between November and January, according to a research by Mahesh and Kotikal (2014). Neem oil (2.5 ml/L) or neem soap (10 g/L) were shown to be very effective.

The tea mosquito bug (*H. antonii*) is a pest that was mostly seen between September and January. It feeds on fragile flushes, causing the developing flushes to completely dry up. The bug's sucking causes dark brownish lesions to first form, and eventually all of the lesions will unite. When salivary secretion is injected into the plant tissues during feeding, the sensitive regions of the tree respond, exacerbating the illness. Even growing pods showed signs of injury. Approximately 20–30% of the output is lost if it goes unreported; the loss might reach 70% (Table 1).

Management: Table 3 displays the outcomes of the management experiment. Lamda cyhalothrin 5 ec @0.6 ml/L, Spinosad 45 sc @0.3 ml/L, Fipronil 5 sc @1 ml/L, and neem soap @10 g/L were also shown to be beneficial in controlling the insect. Similarly, a 5% concentration of neem seed kernel aqueous extract was discovered, according to Dutta et al. (2013).

Table 1 Documentation of arthropods (pests and beneficial insects) in south India

Pest	Scientific name	Season	Area of activity	Status	Yield loss (%)	Remarks
Leaf eating caterpillar/webber	<i>Noorda blitealis</i>	April–	Bengaluru (Karnataka);	Major	100	Peak during
		November	Pallichal, (Kerala); Thallada, Mandal Khammam (Telangana); Madanapalle (Andhra Pradesh)			June–July
Aphids	<i>Aphis loti</i>	April– January	Bengaluru (Karnataka);	Major	25	Peak during
			Khammam (Telangana);	Minor		November– January
Thrips	<i>Thrips palmi</i>	November– January	Bengaluru (Karnataka); Thallada Mandal, Khammam (Telangana)	Major Minor	40–50	Peak during January
Mites	<i>Tetranychus neocaledonicus</i>	October– November	Bengaluru (Karnataka)	Minor	--	Peak during October
Ash weevils	<i>Myloccerus spp.</i>	June–July	Bengaluru (Karnataka)	Minor	--	M. subfasciatus predominant followed by M. viridanus
Tea mosquito bug	<i>Helopeltis antonii</i>	September–	Bengaluru (Karnataka);	Major	20–30	Feeds on tender

		January	Periyakulam (Tamil Nadu)			flushes resulting in drying. On tender			
Bihar caterpillar	hairy <i>Spilosoma obliqua</i>	April–May	Bengaluru (Karnataka)	Minor	--	shoots in young plants			
Lymantrid caterpillar	Yet to determined	be July	Bengaluru (Karnataka)	Minor	--	Defoliator			
Eurybrachids	<i>Eurybrachis tomentosus</i>	November–December	Bengaluru (Karnataka)	Minor	--	Sap feeders on young shoots			
Stem borer/horn beetle	<i>Long Batocera rubus</i>	Throughout the year	Bengaluru (Karnataka); Periyakulam (Tamil Nadu)	Major	--	Severe cases result in the death of the tree			
Pyrrochorid bug	<i>Dysdercus</i> spp.	July–August	Bengaluru (Karnataka)	Minor	--	Sap feeders on young shoots			
Pod fly	<i>Gitona distigma</i> (Drosophilidae)	April–May	Bengaluru (Karnataka)	Major	50–60	-			
	<i>Physiphora aenea</i> (Ulididae)	May–June	Bengaluru (Karnataka)	Major	50–80	Reported for the first time on drumstick			
Chafer beetles	<i>Oxycetonia</i> <i>versicolor</i>	May–June	Bengaluru (Karnataka); Madanapalli (Andhra Pradesh)	Minor	-	Drying of pods			
Natural enemies									
Coccinellid beetles	<i>Cocinella septmpunctata</i> Linnaeus	-	Predator						
<i>Cheilomenus sexmaculatus</i> (Fabricius)									
-	Predator								
<i>Anegleis cardoni</i> (Weise)	-	Predator							
Spiders <i>Oxyopes shweta</i> (Oxyopidae)	-	Predator							
<i>Thomisus</i> spp. (Thomisidae)	-	Predator							
<i>Nescona</i> spp.	-	Predator							
<i>Oxyopes shweta</i> (Oxyopidae)	-	Predator							
<i>Thomisus</i> spp. (Thomisidae)	-	Predator							
<i>Nescona</i> spp.	-	Predator							
Braconid <i>Disophrys</i> spp.	-	Parasitoid							
Pollinators									
Rock bee	<i>Apis dorsata</i>		Predominant						
Indian hive bee	<i>Apis cerana indica</i>		Predominant						
Bumble bee	<i>Bombus</i> spp.		Less Predominant						

Table 2 Efficacy of insecticides for the management of leaf eating caterpillar (*N. blitealis*) larvae (no./branch)

Treatment	Pre-count	10 days after			
		I spray	II spray	III spray	IV spray
Lamda cyhalothrin @0.6 ml/L	11.2	7.6 ^a	4.5 ^a	1.8 ^a	1.3 ^a
Spinosad @0.3 ml/L	10.9	8.4 ^a	5.7 ^{ab}	2.1 ^a	1.5 ^a
<i>Bacillus thuringiensis</i> (Bt) formulation @2 ml/L	11.5	9.1 ^{ab}	7.0 ^b	2.6 ^a	2.0 ^a
Neem soap 10 g/L	12.2	10.1 ^{bc}	9.0 ^c	7.0 ^b	3.2 ^b
Control	10.0	11.1 ^c	10.3 ^c	9.1 ^c	6.3 ^c
CD (<i>P</i> =0.05)	NS	1.6	1.4	1.5	1.6

Table 3 Efficacy of insecticides for the management of tea mosquito bug (*Helopeltis antonii*)

Treatment	Shoot damage due to tea mosquito bug infestation (%)			
	Pre-count	10 days after		
		I spray	II spray	III spray
Lamda cyhalothrin @0.6 ml/L	52.0 (46.15)	29.0 a (32.58)	13.0 a (21.13)	4.0 a (11.54)
Spinosad @0.3 ml/L	51.0 (45.57)	31.0 a (33.23)	16.0 ab (23.58)	6.0 a (14.18)
Fipronil @1 ml/L	39.0 (38.65)	35.0a (36.27)	19.0 b (25.84)	8.0 a (16.43)
Neem soap @10 g/L	45.0 (42.13)	31.0 a (33.83)	16.0 ab (23.58)	10.0 a (18.44)
Control	52.0 (46.15)	68.0b (55.55)	56.0 c (48.45)	53.0 b (46.72)
CD ($P=0.05$)	NS	8.3	5.8	7.2
CV%	-	13.8	15.7	28.7

application of 250 kg of neem cake per hectare. strict adherence to phyto-sanitation, including gathering and disposing of infected pods. From blooming until 15 days before to pod harvest, the need-based alternating treatment of spinosad 45 sc (0.3 ml/L) and lamda cyhalothrin 5 ec (0.6 ml/L) at weekly intervals shown to be very successful in controlling pod fly. Another research indicated that Spinosad 45 sc at 0.20 ml/L and emamectin benzoate 5 sg at 0.25 g/L were similarly effective (Math et al. 2014).

Ash weevil (*Myloccerus subfaciatus*) was one of the minor insect pests. The sap feeders *Eurybrachis tomentosus* and *Dysdercus* spp. were seen to be active from July to November. *T. palmi*, on the other hand, peaked between November and January with 40–50% damage. Additionally, it was discovered that the lymantrid caterpillar and Bihar hairy caterpillar *S. oblique* sometimes caused harm to the drumstick leaf (Table 1).

Natural enemies of pollinators and drumstick pests: The drumstick ecosystem's natural enemies include spiders, *Cheilomenus sexmaculatus* (Fab.) and *Anegleis cardoni* (Weisi); coccinellids, *Cocinella septumpunctata* (Linn);

Arc sine altered values are those in parenthesis.

in terms of antifeedant effectiveness, hatching %, oviposition time, and nymphal length, to be effective against the tea mosquito insect under laboratory circumstances.

Pod fly (*G. distigma* and *P. aenea*): One of the most dangerous drumstick pests, *G. distigma* was initially documented from India in 1997 (Ragumoorthi and Subba Rao 1997). Fly infestation begins from fruit commencement and continues until harvesting, at which point the afflicted pods dry up from the tip. Additionally, it causes fruits to split at the tip, which allows gum exudates to seep out. By inflicting 50–60% damage, the pod fly has recently become a serious pest in southern India (Math et al. 2014).

In the current research, *P. aenea*, another pod fly, was discovered for the first time in India and caused up to 50–80% serious damage. The taxonomists from the University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru, verified its morphology.

Management: Soil management is part of pod fly management.

(*Oxyopes shweta* Tikader) Oxyopidae; (*Thomisus* spp.) Thomisidae; (*Nescona* spp.) and braconid wasp (*Disophrys* spp.). Rock bees [*Apis dorsata* (Fab.)], Indian hive bees [*Apis cerana indica* (Fab.)], small bees [*Apis florea* (Fab.)], and bumble bees (*Bombus* spp.) were among the pollinators that visited drumsticks (Table 1).

Management techniques based on phenology and ecological engineering: A novel approach to strengthening bugs' natural adversaries in an agricultural setting is ecological engineering. According to Keerthi et al. (2020), this method depends on the use of cultural strategies to manipulate habitat and strengthen pests' natural enemies in the crop micro and macro environment. Castor was cultivated as a border crop throughout the cropping season to increase the activity of pollinators and natural enemies, and their activity was tracked. On both the main crop and the border crop, the activity of rock bees (*A. dorsata*), Indian hive bees (*A. indica*), and small bees (*A. florea*) was noted. Between 10:00 and 11:30 in the morning, bee pollinators were busy in Castor. Additionally, predators including *C. septumpuncta*, *C. sexmaculatus*, *A. cardoni*, and spiders were discovered on the border and main

crop. Intercropping lucerne with cotton crop promotes the survival of parasitoids and predators and helps maintain the pest population below ETL (Smith et al. 1972). Similarly, cultivating crape myrtle [*Lagerstroemia indica* (L.)] is a potential woody perennial host for aphids; it increases the activity of Coccinellidae, Syrphidae, and Chrysopida variety and decreases the incidence of aphid complex on the main crop (Mizell et al. 1987).

Researchers may learn a lot about managing pests, using the proper insecticide at the right time, and developing excellent management practices to increase agricultural output by studying various pest populations on crops. The current research provides greater knowledge on all drumstick pests and how to handle them. Neem soap was shown to be beneficial against aphids, much as spinosad and lambda cyhalothrin were efficient in controlling *N. blitealis*. In order to reduce pesticide residue on crops, the data produced by the research would be useful in starting the proper application of insecticides with minimal residual effects and pest control techniques at the appropriate time.

Note: The insecticides listed in the MS are not covered by the label claim. These are solely based on experimental findings.

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