Indian Journal of Agricultural Sciences **94** (2): 156–160, February 2024/Article
https://doi.org/10.56093/ijas.v94i2.117500

Current scenario of insect pests and mite on drumstick (*Moringa oleifera*) in south India and their management

N R PRASANNAKUMAR[1]*, P SHIVARAMA BHAT[1], N JYOTHI[1] and S SAROJA[1]

ICAR-Indian Institute of Horticulture Research, Bengaluru, Karnataka 560 089, India

Received: 01 November 2021; Accepted: 28 November 2023

ABSTRACT

The dynamics of insect pests play a crucial role in understanding their occurrence on a crop. Many insect pests infest on drumstick (*Moringa oleifera* Lam.) at various phenophase of the crop and limit the productivity. The present study, on the incidence of arthropods was carried during 2018–2022 at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka, to investigate the current scenario of insect pests as well as beneficial arthropods associated with drumstick and develop appropriate management strategies for major pests. The arthropods found on drumstick were leaf eating caterpillar (*Noorda blitealis*); aphids (*Aphis loti)*; tea mosquito bug (*Helopeltis antonii*); Bihar hairy caterpillar (*Spilosoma obliqua*); stem borer (*Batocera rubus*) and pod fly (*Gitona distigma*). The beneficial insects include coccinellid beetles (*Coccinella septempunctata*); spiders [*Oxyopes shweta* Tikader (*Oxyopidae*)]; *Thomisus* spp. (Thomisidae)*; Nescona* spp. and Braconid (*Disophrys* spp.); pollinators such as little bee (*Apis florea* Fab). and bumble bee (*Bombus* spp.) were recorded on drumstick. The insight gained from the study would help in initiating the appropriate pest management strategies at right time to minimize pesticide residue on the crop.

Key words: Arthropods, Drumstick, Insect pests, Phenophase, Pesticide residue

Drumstick (*Moringa oleifera* Lam.) is cultivated for its nutritious pods, leaves and flowers, used for culinary preparations. The importance of drumstick is steadily increased for its high medicinal and vegetable value, easy to cultivate and fast growing (Islam *et al*. 2021, Mastiholi *et al*. 2023). Drumstick cultivation spans across India, Sri Lanka, Pakistan, Nepal, Philippines, and more. India dominates as the largest producer cultivating 38,000 hectares and yielding 2.20 to 2.40 million tonnes annually. With a productivity of 63 tonnes per hectare, it contributes significantly to a market value of USD 4 billion annually, reaching USD 7 billion in 2016–2017 (Maharshi 2016, Sekhar *et al.* 2017). Major growing states of drumstick in India are Andhra Pradesh (15,665 ha) followed by Tamil Nadu (13,250 ha) and Karnataka (10,280 ha) (Rachana *et al.* 2020). In other states, it occupies an area of 4,613 ha (Sekhar *et al.* 2018). Tamil Nadu is the pioneering state as it has diverse genotypes from different geographical areas (Hegde and Hegde 2013, Sekhar *et al.* 2018).

The production of drumstick is hampered by various biotic and abiotic stresses. Among biotic stresses, insect pests contribute most of the yield losses up to 100% (Saha *et al.* 2014). The area under cultivation of drumstick is increasing gradually. Some notable insect pests on drumstick are bark eating caterpillar [*Indarbela tetraonis* (Indarbelidae: Lepidoptera)]; stem borer [*Indarbela quadrinotata* (Indarbelidae: Lepidoptera)]; bud worm [*Noorda moringae* (Crambidae: Lepidoptera)]; 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 blitealis* (Crambidae: Lepidoptera)], could cause heavy crop losses (Mahesh and Kotikal 2014, David and Ramamurthy 2016, Chandrakar and Gupta 2020). In addition, several predators, parasitoids and pollinators visit drumstick but they have not been properly documented**.** Managing pests in drumstick is challenging due to prolonged vulnerability during crucial growth phases. Issues like pod fly and tea mosquito bug escalate in key cultivation zones. A comprehensive study is crucial to document the role and status of arthropods in drumstick. Seasonal pest incidence data will inform effective management strategies, addressing concerns about global pesticide misuse.

MATERIALS AND METHODS

The study was carried during 2018–2022 at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka on

[1]ICAR-Indian Institute of Horticulture Research, Bengaluru, Karnataka. *Correspondence author email: prasannaent@gmail.com

the incidence of arthropods on the drumstick fields (variety PKM-1). During the survey, all the information such as pest occurrence, severity of the pest incidence, yield loss on drumstick were documented on randomly selected plants in each field and unidentified insects were collected and sent to insect taxonomy lab, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru, Karnataka for identification. The per cent damage/loss caused by major pest was recorded as:

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

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

In other places such as Pallichal and Thiruvanathapuram (Kerala); Periakulam (Tamil Nadu); Thallada and Khammam (Telangana) and Madanapalle (Andhra Pradesh) constant monitoring of the arthropod diversity was carried out.

Management trial: Management strategies were worked out for leaf eating caterpillar/webber (*N. blitealis* Walker); tea mosquito bug (*H. antonii)* and stem borer (*Batocera* spp.) in a freshly planted orchard aged 3-year-old.

Management trials were carried out at the research farm of ICAR-Indian Institute of Horticulture Research, Bengaluru, Karnataka in randomised complete block design (RCBD) with 5 treatments comprising of 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, replicated four times with 15 plants per replication. Since drumstick is consumed as both leaf and fruit hence biological origin insecticides except lamda cyhalothrin were chosen in the experiment. Five trees were selected randomly for each replication; from each tree five branches were selected from all directions like east, west, south and north for observation on number of larvae at every 10 days after each spray (Chandrakar and Gupta 2020). Data was subjected to statistical analysis (ANOVA) to evaluate the significance between the treatments (SPSS version 11).

RESULTS AND DISCUSSION

Documentation of arthropod fauna: The arthropod pests and beneficial insects in and around Bengaluru and other parts of Karnataka, Kerala, Tamil Nadu, Telangana and Andhra Pradesh during April 2018–March 2022 are presented in Table 1. The major pests found during the investigation were; leafeating caterpillar (*N. blitealis* Walker), tea mosquito bug (*H. antonii* Signoret), stem borer (*Batocera rubus* Linnaeus) and long horn beetle (*Batocera rufomaculata* De Geer), thrips (*Thrips palmi* Karny), pod flies **(***G. distigma*) and winged fly (*Physiphera aenea* Fabricius) and aphids (*Aphis loti*). The details of the insect pests observed are discussed below.

Leaf eating caterpillar (N. blitealis): The activity of *N. blitealis* found to occur during April–November with peak during June–July. Severe infestation occurred on the new flush of the crop and causes 100 per cent damage. Upon hatching the larvae feed by remaining in a silken web on the under surface of leaf and made them into papery structures. The whole tree will be defoliated in case of severe infestation. Grown up larvae scrape the pods and bore inside the pod thereby making them unfit for consumption. The late larval stage drops down in the soil for pupation. Adults emerged in 6–9 days after pupation. The emerged moths have dark brown forewings and white hind wings with dark brown border.

This pest was also reported as major in several parts of the world (Satti *et al*. 2013, Litsinger 2014). *N. blitealis* was reported in Drumstick, in middle Gujarat in 2017 at Anand Agricultural University, Anand, Gujarat, and the aforementioned damage was also observed by Thumar *et al.* (2017)**.**

Management: Uses of plant protection tactics are important to keep pesticide residue under minimum as drumstick is consumed as fresh leaves. In the present study, Spinosad 45 SC @0.3 ml/L and lamda cyhalothrin 5 EC @0.6 ml/L were effective in the management of *N. blitealis* followed by *Bt* formulation @2 ml/L and neem soap 10 g/L (Table 2). 10 insecticides evaluated against the defoliator, *N. blitealis,* a significant and maximum leaf yield was obtained from 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 with a high net return from indoxacarb sprayed plants (Kumari *et al.* 2015). Similarly, a study reported 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 found effective against leaf eating caterpillar at Vijayapura, Karnataka (Rachana *et al.* 2021).

Aphids (Aphis loti): The pest was found during April–January with peak activity during November–January. Both adults and nymphs congregate and suck the sap from young leaves and twigs including flowers that results in yellowing and drying of the leaf. Similarly, a study by Mahesh and Kotikal (2014), reported about 25% damage from aphids during November–January on drumstick at Bagalkot, Karnataka. Application of neem soap @10 g/L or neem oil @2.5 ml/L was found very effective.

Tea mosquito bug (H. antonii): This pest was recorded mainly during September–January, found feeding on tender flushes resulting in total drying of the emerging flushes. Dark brownish lesions appear initially due to sucking by the bug and later all the lesions will coalesce. The symptom gets aggravated due to the reaction of the tender parts of the tree to salivary secretion injected into the plant tissues at the time of feeding. The damage could be noticed even on developing pods. If unnoticed, about 20–30% yield loss occurs, the loss would be even up to 70% (Table 1).

Management: The results from the management trial are presented in Table 3. The management includes; spraying of lamda cyhalothrin 5 EC @0.6 ml/L and Spinosad 45 SC @0.3 ml/L. Fipronil 5 SC @1 ml/L and neem soap @10 g/L were also found effective in management of the bug. Similarly, Dutta *et al.* (2013) reported that aqueous extract of neem seed kernel at 5 per cent concentration was found

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	*Noorda blitealis*	April–November	Bengaluru (Karnataka); Pallichal, (Kerala); Thallada, Mandal Khammam (Telangana); Madanapalle (Andhra Pradesh)	Major	100	Peak during June–July
Aphids	*Aphis loti*	April–January	Bengaluru (Karnataka); Khammam (Telangana);	Major Minor	25	Peak during November–January
Thrips	*Thrips palmi*	November–January	Bengaluru (Karnataka); Thallada Mandal, Khammam (Telangana)	Major Minor	40–50	Peak during January
Mites	*Tetranychus neocaledonicus*	October–November	Bengaluru (Karnataka)	Minor	--	Peak during October
Ash weevils	*Myllocerus* spp.	June–July	Bengaluru (Karnataka)	Minor	--	*M. subfasciatus* predominant followed by *M. viridanus*
Tea mosquito bug	*Helopeltis antonii*	September–January	Bengaluru (Karnataka); Periyakulam (Tamil Nadu)	Major	20–30	Feeds on tender flushes resulting in drying.
Bihar hairy caterpillar	*Spilosoma obliqua*	April–May	Bengaluru (Karnataka)	Minor	--	On tender shoots in young plants
Lymantrid caterpillar	Yet to be determined	July	Bengaluru (Karnataka)	Minor	--	Defoliator
Eurybrachids	*Eurybrachis tomentosus*	November–December	Bengaluru (Karnataka)	Minor	--	Sap feeders on young shoots
Stem borer/Long horn beetle	*Batocera rubus* *Batocera rufomacualta*	Throughout the year	Bengaluru (Karnataka); Periyakulam (Tamil Nadu)	Major	--	Severe cases result in the death of the tree
Pyrrochorid bug	*Dysdercus* spp.	July–August	Bengaluru (Karnataka)	Minor	--	Sap feeders on young shoots
Pod fly	*Gitona distigma* (Drosophilidae)	April–May	Bengaluru (Karnataka)	Major	50–60	-
	Physiphora aenea (Ulididae)	May–June	Bengaluru (Karnataka)	Major	50–80	Reported for the first time on drumstick
Chafer beetles	*Oxycetonia versicolar*	May–June	Bengaluru (Karnataka); Madanapalli (Andhra Pradesh)	Minor	-	Drying of pods
Natural enemies						
Coccinellid beetles	*Cocinella septmpunctata* Linnaeus	-			Predator	
	Cheilomenus sexmaculatus (Fabricius)	-			Predator	
	Anegleis cardoni (Weise)	-			Predator	
Spiders	*Oxyopes shweta* (Oxyopidae)	-			Predator	
	Thomisus spp. (Thomisidae)	-			Predator	
	Nescona spp.	-			Predator	
	Oxyopes shweta (Oxyopidae)	-			Predator	
	Thomisus spp. (Thomisidae)	-			Predator	
	Nescona spp.	-			Predator	
Braconid *Disophrys* spp.		-			Parasitoid	
Pollinators						
Rock bee	*Apis dorsata*		Predominant			
Indian hive bee	*Apis cerana indica*		Predominant			
Bumble bee	*Bombus* 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]
Bacillus thuringiensis (*Bt*) formulation @2 ml/L	11.5	9.1 [ab]	7.0[b]	2.6 [a]	2.0 [ab]
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 (*P*=0.05)	NS	1.6	1.4	1.5	1.6
CV%	-	11.3	12.1	21	15.9

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

Values in the parentheses are arc sine transformed values.

to be effective against tea mosquito bug in the laboratory conditions in terms of antifeedant activity, hatching percentage, oviposition period and nymphal duration.

Pod fly (G. distigma *and* P. aenea): *G. distigma* was reported for the first time from India during 1997 (Ragumoorthi and Subba Rao 1997), and has become one of the most serious pests of drumstick. Infestation of the fly starts from fruit initiation and persists till harvesting stage, affected pods later dry from tip. In addition, it also causes splitting of fruits from tip through which gum exudates ooze out. In recent past, the pod fly has attained a major pest status in southern India by causing 50–60% damage (Math *et al*. 2014).

Another pod fly, *P. aenea* was observed for the first time from India in the present study causing severe damage up to 50–80 per cent. It was morphologically confirmed with the taxonomists from University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru.

Management: Management of pod fly includes soil application of neem cake @250 kg/ha. Strict following of phyto-sanitation such as collection and burial of infested pods. Need based alternate application of spinosad 45 SC (0.3 ml/L) and lamda cyhalothrin 5 EC (0.6 ml/L) at weekly intervals starting from flowering till 15 days before harvest of the pods showed very effective in the management of pod fly. In another study, emamectin benzoate 5 SG at 0.25 g/L and Spinosad 45 SC at 0.20 ml/L were also found effective (Math *et al.* 2014).

Minor insect pests: Ash weevil (*Myllocerus subfaciatus)* occurred in the minor form. The sap feeders (*Dysdercus* spp.) and (*Eurybrachis tomentosus)* were found active during July–November. While *T. palmi* was noticed peak during November–January with damage of 40–50 per cent. Bihar hairy caterpillar *S. oblique* and lymantrid caterpillar were also found occurring occasionally by causing damage to the drumstick foliage (Table 1).

Natural enemies of pests of drumstick and pollinators: The natural enemies found in drumstick ecosystem include coccinellids, *Cocinella septumpunctata* (Linn); *Cheilomenus sexmaculatus* (Fab.) and *Anegleis cardoni* (Weisi); spiders, (*Oxyopes shweta* Tikader) Oxyopidae; (*Thomisus* spp.) Thomisidae, (*Nescona* spp.) and braconid wasp (*Disophrys* spp.). Visiting pollinators on drumstick were rock bee [*Apis dorsata* (Fab.)]; Indian hive bee [*Apis cerena indica* (Fab.)], little bee [*Apis florea* (Fab.)] and bumble bee (*Bombus* spp.) (Table 1).

Ecological engineering and phenology-based management practices: Ecological engineering for pest management is a new paradigm to enhance the natural enemies of pests in an agro ecosystem. This technique relies on use of cultural tactics to bring about habitat manipulation and enhance natural enemies of pests in the crop micro and macro environment (Keerthi *et al*. 2020). In order to enhance the activity of natural enemies and pollinators castor was grown as border crop during cropping season and their activity was monitored. Activity of rock bee (*A. dorsata*); Indian hive bee (*A. indica*) and little bee (*A. florea*) was recorded both on border crop and main crop. Bee pollinators were active in castor during 10:00 AM to 11:30 AM**.** The predators such as *C. septumpuncta, C. sexmaculatus, A. cardoni* and spiders were also found on the border and main

crop. Intercropping of lucerne with cotton crop helped in maintenance of the pest population below ETL and also increases survival of predators and parasitoids (Smith *et al.* 1972). Likewise, crape myrtle [*Lagerstroemia indica* (L.)] is a promising woody perennial host for aphid, growing of crape myrtle reduce the incidence of aphid complex on main crop and it also increase the activity of *Coccinellidae, Syrphidae, Chrysopida* diversity (Mizell *et al*. 1987).

Study of different pest population on crops gives important idea to researcher regarding the management of the pest, use of appropriate pesticide at right time and develops a good management practice to improve the better yield of the crop. The present study gives the better information about the all the pest of drumstick and its management. The spinosad and lamda cyhalothrin were effective in the management of *N. blitealis* similarly neem soap found effective against the aphids. The information generated in the study would help in initiating the appropriate use of insecticides having low residual effect and pest management strategies at right time to minimize pesticide residue on the crop.

Note: Insecticides mentioned in the MS are not under label claim. These are the based on only experimental results.

REFERENCES

Chandrakar T and Gupta A K. 2020. Seasonal incidence of insect pests on drumstick (*Drumstick oleifera* Lamk). *Journal of Entomology and Zoology Studies* **8**(4): 1384–87.

David B V and Ramamurthy V V. 2016. *Elements of Economic Entomology*, 8th edn. 147–48. Brillion Publishing, New York, USA.

Dutta P, Reddy S G E and Borthakur B K. 2013. Effect of neem kernal aqueous extract (NKAE) in tea mosquito bug, *Helopeltis theivora* waterhouse (Heteroptera: Miridae). *Munis Entomology and Zoology* **8**(1): 213–18.

Hegde S and Hegde V. 2013. An overview of drumstick production in Ethiopia. *International Journal of Science and Research* **4**(4): 826–29.

Islam Z, Islam S M R, Hossen F, Mahtab-Ul-Islam K, Hasan M R and Karim R. 2021. *Moringa oleifera* is a prominent source of nutrients with potential health benefits. *International Journal of Food and Nutrition* 6627265. doi: 10.1155/2021/6627265

Keerthi M C, Sharma R K, Suroshe S S and Sinha S R. 2020. Ecological engineering in cauliflower for aphid management. *The Indian Journal of Agricultural Sciences* **90**(7): 1356–58.

Kumari M S B, Kotikal Y K, Narabenchi G B and Nadaf A M. 2015. Bio-efficacy of insecticides, botanicals and biopesticide against the leaf eating caterpillar, *Noorda blitealis* Walker on drumstick. *Karnataka Journal of Agricultural Sciences* **28** (2): 193–96.

Litsinger J A. 2014. Pesticide evaluation and safe use practices for USAID and Catholic Relief Services (CRS) project in niger on Development Food Aid Program (DFAP). 14 January–28 February, pp. 148.

Maharshi D P. 2016. Drumstick production and application. *(In) Proceedings of 4th Global Drumstick Meet*, Advance Biofuel Centre, Jaipur, India.

Mahesh M and Kotikal Y K. 2014. Studies on insect pests of drumstick, *Moringa oliefera* Lamk. *Indian Journal of Plant Protection* **42**: 461–64.

Mastiholi A B, Biradar I B, Gopali J B, Rudresh D and Prasanna S M. 2023. Performance of moringa (*Moringa oleifera*) and soil health under organic nutrition. *The Indian Journal of Agricultural Sciences* **93**(4): 387–91.

Math M, Kotikal Y K and Narabenchi G. 2014. Management of drumstick pod fly, *Gitona distigma* (Meigen). *International Journal of Advances in Pharmacy, Biology and Chemistry* **3**(1): 54–59.

Mizell R F and Schiffhauer D E. 1987. Seasonal abundance of the crape myrtle aphid, *Sarucallis kahawaluokalani*, in relation to the pecan aphids, *Monellia caryella* and *Monelliopispecanis* and their common predators. *Entomophaga* **32**: 511–20.

Ragumoorthi K N and Arumugam R. 1992. Control of drumstick fruit fly *Gitona* spp. and leaf caterpillar *Noorda blitealis* (Walker) with insecticides and botanicals. *Indian Journal of Plant Protection* **20**(1): 61–65.

Ragumoorthi K N and Subba Rao P V. 1997. First report of a Palaearctic species of drumstick fruit fly *Gitona distigma* (Meigen) in India. *Pestology* **21**: 50–53.

Rachana K B, Jagginavar S B, Prakash H T and Biradar S A. 2020. Studies on insect pests of drumstick and their natural enemies in northern dry zone climate of Karnataka, India. *International Journal of Current Microbiology and Applied Sciences* **9**(12): 2175–80.

Rachana K B, Jagginavar S B and Prakash H T. 2021. Management of defoliator insect pest, *Noorda blitealis* Walker (Lepidoptera: Crambidae) in drumstick. *Journal of Entomology and Zoology Studies* **9**(1): 694–99.

Rockwood J L, Anderson B G and Casamatta D A. 2013. Potential uses of *Drumstick oleifera* and an examination of antibiotic efficacy conferred by *M. oleifera* seed and leaf extracts using crude extraction techniques available to underserved indigenous populations. *International Journal of Phytothearpy Research* **3**(2): 61–71

Saha, Nithya C and Ray S N. 2014. Integrated pest management approaches for the insect pests of drumstick (*Drumstick oleifera* L.). *Popular Kheti* **2**(2): 131–36.

Satti, Abdalla A, Nasr, Osman El-Hag and Fadelmula. 2013. New record and preliminary bio-ecological studies of the leaf caterpillar; *Noorda blitealis* Walker (Lepidoptera: Pyralidae) in Sudan. *International Journal of Science and Nature* **4**: 576–81.

Sekhar C, Venkatesan N and Vidhyavathi A. 2017. Post-harvest processing of drumstick and socio-economic appraisal of drumstick orchards in Tamil Nadu. *Horticulture International Journal* **7**(30): 275–87.

Sekhar C, Venkatesan N and Vidhyavathi A. 2018. Factors influencing drumstick cultivation in Tamil Nadu-An economic analysis. *Horticulture International Journal* **2**(5): 223–30.

Smith R F and Reynolds H T. 1972. Effects of manipulation of cotton agro-ecosystems on insect populations. *The Careless Technology: Ecology and International Development*, pp. 373–406. Farvar M T and Milton J P (Eds). The Natural History Press, Garden City, New York, USA.

Thumar R K, Borad M G, Padaliya S R and Borad P K. 2017. First report of leaf eating caterpillar *Noorda blitealis* Walker (Lepidoptera: Crambidae) infesting drumstick, *Drumstick oleifera* Lam. from middle Gujarat. *Trends in Biosciences* **10**(22): 4324–25.