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NATURE OF INFESTATION AND MANAGEMENT OF CARDAMOM SCALE *AULACASPIS ELETTARIA* JOSHI AND NAFEESA ON CARDAMOM

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ABSTRACT

The nature of the infestation of cardamom scale (*Aulacaspis elettaria* Joshi & Nafeesa) on small cardamom [*Elettaria cardamomum* (L.) Maton] was illustrated. The percentage of infestation and pest density of *A. elettaria* in the cardamom hill reserves, Kerala, during 2021-2023 were recorded, respectively as 22.4% and 9.6 female scales/ 5 cm length of the pseudostem portion. Lower infestation and higher reduction levels in pest density were reported in plants treated with spiromecifen 22.9 SC (0.7 ml/ l) followed by spinetoram 11.7 SC (0.4 ml/ l), quinalphos 25 EC (2 ml/ l) and thiamethoxam 25 WG (0.2 g/ l). Among the botanicals tested, infestation percentage was reduced and a considerable decline in pest density (30%) was also noticed on plants treated with neem seed kernel extract (5%). The importance of integrated pest management, including the introduction of natural enemies was discussed.

Key words: Armored scale, *Elettaria cardamomum*, production system, Western Ghats, pest, severity, damage, botanicals, biocontrol agents, pesticides

Small cardamom [*Elettaria cardamomum* (L.) Maton; Zingiberaceae], a perennial, herbaceous rhizomatous monocot, is a native of the moist evergreen forests of the Western Ghats of southern India (Ravindran, 2002). India, the world's largest consumer and second-largest producer of cardamom, produces 24,463 tons of dried capsules of commerce from 70,410 ha (Spices Board, 2023). Cardamom cultivation is challenged by abiotic and biotic stresses (Sathyan et al., 2021). Insect pests pose a significant threat to cardamom farming in India and there are more than fifty-six insect pest species known to cause damages to cardamom crop (Gopakumar and Chandrasekar, 2002; Deepthy et al*.,* 2017). Scale insects (Hemiptera: Sternorrhyncha: Coccoidea) are small sap-sucking insects that cause enormous agricultural and horticultural loss and damage. There are about 8,000 described species spread over 30 families worldwide (Ouvrard et al., 2013). Among the scale insects (Coccoidea), the armored scale (Hemiptera: Diaspididae) are the most diverse family, with over 2600 species in 418 genera (GarcíaMorales et al., 2016). *Aulacaspis* Cockerell is one of the largest genera of armored scale insects, with 151 species known across the world (García Morales et al., 2016). A recently described species, *Aulacaspis elettaria* Joshi and Nafeesa, infecting the crop "cardamom", mainly the pseudostems (Joshi et al., 2023; Nafeesa and Viyola, 2023).

Infestation of *A. elettaria* has been noticed mainly during summer months. Complaints from farmers regarding severe infestation of *A. elettaria* are increasing year round in the Cardamom Hill Reserves (CHR), Kerala, mostly due to congenial weather composed of intermittent rainfall and long dry spells. The present study was designed and executed during 2021-2023 to assess the nature and intensity of damage caused by *A. elettaria* in the CHR, Kerala as well as screen select botanicals, biocontrol agents, and newer pesticide molecules against the pest.

MATERIALS AND METHODS

Cardamom plantations with obvious signs of *A. elettaria* infestation were carefully chosen to determine the nature and severity of attack. Scale samples were collected, preserved in alcohol and sent to the NBAIR, Bangalore for identification. Damage assessment was done in seven cardamom hot spot areas in the CHR viz*.,* Vandanmedu (9°42'10" N, 77°11'11" E), Anakkara (9°40'10" N, 77°10'59" E), Anavilasam (9°38'56" N, 77°8'37" E), Santhanpara (9°56'52" N, 77°13'2" E), Kattappana (9°41'25" N, 77°1'38" E), Udumbanchola (9°58'7" N, 77°4'53" E), and Pampadumpara (9°48'1" N, 77°10'1" E). The assessment period ran from December 2021 to November 2023. Three plots of 100 m^2 were marked in each area, and five plants were randomly tagged for recording observations. Observations in hot

spots such as total number of tillers, number of infested tillers, and number of female scales/ 5 cm length of infested tillers were recorded. Sites of aggregation of *A. elettaria* on cardamom and nature of damage to the tillers, panicles, flowers and capsules of commerce were examined. Severity of infestation was determined by the number of female scales/ 5 cm length of the infected pseudostem portion with the aid of a hand lens.

A farmer's field in the Vandanmedu area was chosen to screen botanicals, biocontrol agents, and newer pesticide molecules for the management of *A. elettaria* on cardamom. The study was conducted on a 10-year-old green gold (Njallani) cardamom plantation using randomized block design with nine treatments (including control) replicated thrice. There were six observational plants in each treatment to record observations. Botanicals, biocontrol agents, and chemical pesticides were chosen based on previous research information on the management of armored scales, particularly on the genus *Aulacaspis* (Le Lagadec et al., 2009; Mani, 2016; Xiao et al., 2016; Quesada et al., 2018; Fita et al., 2020; Siam and Othman, 2020; Habtegebriel et al., 2020). Four botanicals/bio agents [T_1 - Neem Seed Kernel Extract (NSKE) - 5%; T_2 - aloe + garlic extract – 2%; T_3 - *Verticillium lecanii* dust formulation - 2%; T_4 - red chilli + garlic + cows urine + tobacco extract – 2%] and four chemical insecticides (T_5 - thiamethoxam 25 WG - 0.2 g l^{-1}; T_6 - spiromecifen 22.9 SC - 0.7 ml l^{-1}; T_7 - spinetoram 11.7 SC - 0.4 ml l^{-1}; T_8 - quinalphos 25 EC - 2 ml l^{-1}) were tested.

Quantity of the spray solution for each plant was decided to be 2 l in order to wet (cover) all of the tillers and panicles. NSKE @ 5% was made by soaking 1.8 kg of well-crushed dried neem seed covered with cotton cloth in 5 l of water overnight, and thoroughly squeezed in immersed and then with clean water to collect sufficient extract. Aloe garlic extract @ 2% was prepared by crushing 720 g each of aloe and garlic and soaked in 5 l of water for 72 hr and filtered it through a cotton towel. Tobacco, red chilli and garlic extract with cow urine @ 2% was prepared by adding 720 g of ground garlic and 720 g of red chilli powder in 3 l of water soaked for 72 hr. In another jar 720 g of tobacco waste was weighed and steeped in 2 l of water overnight, and then squeezed. These two preparations were filtered using cotton cloth and mixed with 720 ml of fresh cow urine. In all of the three botanical preparations, the resulting solution was diluted to a spray volume of 36 l. Synthetic and bio pesticides were sprayed as per the dosage mentioned. Four sprays were given at a monthly interval during 2021-22 summer periods. Observations were recorded at 15-day interval. Percentage and intensity of infestation were calculated on the 15th and 30th days after each spray. Data obtained from the study were subjected to statistical analysis (ANOVA) using Web Agri Statistical Package (WASP).

RESULTS AND DISCUSSION

The identity of the scale samples collected from all the study sites (hot spot areas) were confirmed as *A. elettaria.* Infestation was mainly noticed on pseudostem just beneath the older leaf sheaths (Fig. 1). In severely infested plots, the infestation was observed in the basal swollen region of the stem (Fig. 2) as well as panicles (Fig. 3). Infested capsules have changed its green shiny appearance into dirty gloomy appearance (Fig. 4) and upon processing; the capsules became brown dull colour instead of golden green colour (Fig. 5). Both mature and immature scales have aggregated and covered the infected area like a white mat (Fig. 6). Three to five such groups were detected within a single stem in case of heavily infested fields. Yellowing and brownish discoloration was noticed initially on the infected portion of the pseudostem (Fig. 1). Leaves turned to yellow brown and later the pseudostems dried up leaving an unhealthy and dead appearance to the clump (Fig. 7). When the infestation occurred on panicles, browning, shrinking, darkening and drying of the whole panicles including flowers and capsules were noted (Fig. 8). Of the seven major hot spot areas, the infestation percentage varied from 15.6% to 46.9%, with an average infestation of 22.4%; the number of female scales/ 5 cm length of the infected pseudostem was 9.6 which ranged from 5.1 to 19.4.

Data on the infestation at pre treatment, 15th and 30th day after spraying and final observations are given in Table 1. There was a slight decrease in infestation on plants treated with NSKE @ 5% and no increase was noticed with red chilli + garlic + cows urine + tobacco extract @ 2%. Significant difference was noted between the treatments at the 15th and 30th day after spraying and at the end of the experiment. Infestation levels were significantly lower in plants treated with spiromecifen 22.9 SC followed by spinetoram 11.7 SC, quinalphos 25 EC, thiamethoxam 25 WG, red chilli + garlic + cows urine + tobacco extract as well as NSKE at the end. A reduction in population was registered in all the treatments except control and the % reduction was higher in plants sprayed with spiromecifen 22.9 SC followed by spinetoram 11.7 SC, quinalphos 25 EC, thiamethoxam 25 WG and NSKE.

Fig. 1-8. Infestation of *Aulacaspis elettaria* on cardamom 1. pseudostem 2. basal swollen region of the stem 3. panicles 4. uninfested (left) and infested (right) green capsules 5. uninfested (left) and infested (right) dried capsules 6. white mat like colonies 7. infested unhealthy clumb 8. uninfested (left) and infested (right) panicles showing the changes in axils, capsules and flowers

Domestic and international demand for cardamom produce (spicy aromatic capsule) is mainly based on its physical and chemical attributes. *Aonidiella* sp., *Aulacaspis* sp., *Diaspis* sp., *Pulvinaria* sp. and *Saissetia coffeae* were the scale insects reported on cardamom and the leaves, panicles and pseudostem were the usual sites of infestation (Gopakumar and Chandrasekar, 2002; Murugan et al., 2016). During the survey, we didn't notice the infestation caused by other reported scale insect species in the hotspot areas. *A. elettaria* prefers a concealed type of aggregation site below the dried leaf sheath in pseudostem. This may be one of its adaptations to survive in a pesticide intensive situation. Scale infested dull brown coloured capsule will not fetch reasonable price even in the domestic market. Cardamom plantations in Kerala contributes nearly 90% of India's production (Spice Board, 2023) and the spread of *A. elettaria* will be deleterious to this unique production system in future. When analyzing the related species of *Aulacaspis,* the white mango scale *Aulacaspis tubercularis* Newstead was observed as a new, fast-spreading insect pest of mango; damages mango, causing 50 to 100% losses (Belachew and Jenber, 2022). The cycad scale *Aulacaspis yasumatsui* Takagi, is a major threat to native and ornamental cycads in the US, the Pacific, and Asia (Ouvrard et al*.,* 2013).

Among three botanical preparations tested, the

Table 1. Infestation of Aulacaspis elettaria at pre treatment, mean of the 15th and the 30th day after spraying and at the end of the screening experiment

Treatments	Observations on % infestation on the tillers				Observations on intensity of infestation (Number of female scales/ 5 cm length of the pseudostem portion)				
	Pre treatment	Mean of the 15th day	Mean of the 30th day	Final observation	Pre treatment	Mean of the 15th day	Mean of the 30th day	Final observation	% reduction in population
T_1	10.613	9.466^{bc}	10.959^{cd}	10.246^{cd}	6.667	3.861^{bc}	4.028^{cd}	4.667^{c}	30.00
T_2	10.338	16.073^{a}	17.290^{ab}	18.992^{b}	8.889	6.222^{b}	7.333^{ab}	7.444^{b}	16.26
T_3	11.229	13.929^{ab}	15.332^{bc}	16.837^{bc}	10.00	6.278^{b}	6.972^{b}	8.222^{b}	17.78
T_4	8.878	9.513^{bc}	9.148^{d}	9.472^{cd}	5.000	4.333^{bc}	5.139^{bc}	4.000^{c}	20.00
T_5	8.185	8.684^{cd}	9.133^{d}	8.818^{de}	5.889	3.389^{bc}	3.333^{cd}	3.333^{c}	43.40
T_6	6.096	4.068^{d}	3.710^{e}	1.593^{e}	5.222	1.694^{c}	1.444^{d}	0.333^{d}	93.62
T_7	6.034	6.648^{cd}	6.561^{de}	4.373^{de}	9.556	4.667^{bc}	3.944^{cd}	3.111^{c}	67.44
T_8	9.161	8.55^{cd}	9.397^{d}	8.056^{de}	8.000	5.000^{bc}	4.528^{bc}	4.111^{c}	48.61
T_9	6.767	18.459^{a}	20.816^{a}	27.667^{a}	7.000	11.583^{a}	10.25^{a}	11.444^{a}	-63.49
CV	24.805	25.758	24.799	36.266	34.996	37.242	32.484	29.923	
CD(0.01)	NS	6.511	6.726	10.192	NS	4.641	4.043	3.701	
CD(0.05)	NS	4.726	4.881	7.397	NS	3.369	2.935	2.686	

infestation percentage was less on plants treated with NSKE and considerable reduction in pest density (30%) was also noticed. This result corroborates with the results of Fita et al. (2020) on *A. tubercularis.* Siam and Othman (2020), found that combination of garlic and aloe was an effective botanical preparation in reducing the population of *A. tubercularis* in mango. In contrast to the above study, only a slight reduction in pest intensity was obtained with aloe garlic extract over *A. elettaria*. Among treatments, plants treated with spiromecifen 22.9 SC (a lipid biosynthesis inhibitor) showed a significant drop in infestation, this result goes with that of Quesada et al. (2018), where the lipid biosynthesis inhibitors spirotetramat and spiromesifen considerably reduced the abundance of armored scales.

Once established, scale insects are very difficult to control. Regular application of pesticides to control the scales will be detrimental to natural enemies. Time bound trashing (removal of dried and infected plant parts from the cardamom clumps) will disrupt the concealed habitat of the *A. elettaria* and the colonies can be exposed to the spray schedules followed in the farming system. Even though *V. lecanii* strain tested was not found desirable on the management of *A. elettaria*, initiatives to collect and isolate effective entomopathogenic fungal strains from the scale infested cardamom fields will be required. Joshi et al. (2023) have reported frequent occurrence of predatory coccinellids and chrysopids in the cardamom plantations infested with *A. elettaria.* Careful and need based selection of less toxic and more specific botanicals and chemical pesticides are also needed to maintain and conserve such natural enemies and pollinators of production ecosystem.

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AUTHOR CONTRIBUTION STATEMENT

The authors, NM conceived and designed the experiment and performed the field and laboratory studies in consultation with MM. NM and MM analyzed the data. NM drafted the manuscript and MM revised the manuscript. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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