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Reaction of Local Cashew (*Anacardium occidentale* L.) Genotypes to Infestation by Tea Mosquito Bug, *Helopeltis antonii* Signoret (Hemiptera: Miridae)

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ABSTRACT: Tea mosquito bug, *Helopeltis antonii* Signoret is an economically important pest of cashew, *Anacardium occidentale* L. in India and is a major constraint in cashew cultivation worldwide. The studies undertaken to manage this pest for the past 5-6 decades documented pesticide spray as the most successful and reliable solution. However, with increased use of pesticides, pest incidence also aggravated and the budget towards pest control increased drastically. Exploring host plant resistance will open up new avenues to manage this big menace and continuous research efforts are being carried out in this line at various centres across India. Fourteen promising accessions collected from major cashew-growing tracts of Kerala that were planted as grafts during 2003-04 in germplasm conservation block of Cashew Research Station, Madakkathara, Kerala, India were screened under field conditions to evaluate their response to tea mosquito bug, *Helopeltis antonii*. Scoring procedure on 0-4 scale, based on the number of necrotic lesions formed by tea mosquito bug while feeding, was followed to assess the susceptibility status. Screening was done consecutively for eight years initiating from 2009-10 when the grafts attained the age of six, and continued till 2016-17. Accessions were classified based on old method of classification as well as matrix method, giving weightage to damage on panicle. The study shows less susceptible nature of seven genotypes, *viz*., Kottarakkara-1, Kainur, Pattannur, Kunjithai, Kottarakkara-2, Aralam-2 and Odakkali with respect to infestation by tea mosquito bug.

Keywords: Cashew genotypes, susceptibility status, tea mosquito bug, host plant resistance, breeding for resistance to biotic stress, *Helopeltis antonii*.

INTRODUCTION

Cashew is an important commercial crop grown in dry and barren lands contributing considerably to foreign exchange of India. The national average annual production is 7.42 tons with an average productivity of 707 kg/ha (DCCD, 2019) and India enjoys a third position in production. The actual production of the crop is not realized due to the infestation by insect pests during the crop phase. Around 50 insect pests were reported from India (Devasahayam and Nair, 1986) of which, only a few were considered as major pests. Tea mosquito bug, *Helopeltis antonii* Signoret (Hemiptera: Miridae) is an economically important insect pest, which alone causes 30-50 per cent yield loss (Abraham and Nair 1981; Sundararaju and Sundarababu 1999b) and even complete yield loss in outbreak situation (Devasahayam and Nair 1986). Cashew stem and root borer is other important pest threatening the crop stand. Leaf miner, *Acrocercops syngramma* Meyrick, apple and nut borer, *Thylacoptila paurosema* Meyrick and flower thrips, *Scirtothrips dorsalis* Hood were also reported to occur regularly but of minor importance.

Incidence of tea mosquito bug commences with the initiation of new flushes in cashew after cessation of south-west Monsoon, usually during September-October months and reaches a peak during December-January months when the trees are in full bloom and thereafter declines. However, the dynamics vary depending on the early, mid and late-flowering cashew types. Panicles are usually more vulnerable than flushes (Sathiamma, 1977; Pillai *et al*., 1984; Beevi *et al*., 1991). Timely application of chemical insecticides after strict monitoring of pest incidence is a reliable strategy. Application of insecticides on a rotational basis during flushing, panicle initiation and nut set stage is the only practical solution to manage this menace. However, at times it poses an undefeatable threat of huge yield loss owing to the 'low-density pest-status' (Vanitha and Raviprasad 2020) indicating that even a very small population can cause massive loss, apart from the hidden nature of infestation. The symptoms are detectable only after 4-5 days of damage and by that time, the flowering laterals might have lost to an unproductive state. However, very often control failures have been reported in outbreak situations with 30 per cent yield loss even in sprayed plots (Sundararaju and Sundarababu 1999b). Insecticides belonging to organophosphates, carbamates, synthetic pyrethroids and neonicotinoids are in use for rotational application. Apart from this, the restrictions on maximum pesticide residue limit imposed by the importing countries necessitate the judicious use of chemical insecticides. In this context, the development and use of cultivars that are less susceptible to tea mosquito bug is one of the viable alternatives and a complementary component in integrated pest management, being environmentally benign and economically feasible. So, host plant resistance should also be considered as a prime concern while targeting yield improvement in breeding experiments to realize the potential yield in any crop. Towards this direction, continuous research efforts are being carried out in various centres and wide arrays of cashew germplasm available in India were being screened periodically for response to tea mosquito bug in the respective locations but none of the accessions was reported resistant (Sundararaju and Sundarababu 1999a; Sundararaju, 2003). However, studies indicated the existence of wide variation among cashew populations in the susceptibility to TMB infestation and some of the accessions with less susceptible status could traced out. Screening of cashew types at Ullal Centre, coastal Karnataka reported 51 promising cashew types (Hiremath, 1991). The results of the screening of 18 accessions including released cultivars and promising hybrids, conducted at the Regional Fruit Research Station, Vengurle from 2004-05 to 2010-11, indicated less damage by the pest on the cultivars M-44/3 (2.77%), 3/33 (2.90%) and NRCC selection-2 (2.99%) (Jalgaonkar *et al*., 2015). According to Vidya *et al*. (2015), the hybrid, H-320 (0.82) and the cultivar, Chintamani-1 (1.12) had the minimum infestation of tea mosquito bug out of 104 accessions screened under AICRP on Cashew at Agricultural Research Station, Chintamani, Karnataka during 2009-11 period.

In earlier field screening studies with the seedling progenies, cashew accessions, *viz*., VTH 153, Kunthur 24, Goa 11/6, VTH 153/ 1, VTH 9/78 and 51 different cashew types in Karnataka, accession No. 665 in Kerala and BLA-39-4 in West Bengal were reported as least susceptible to *H. antonii* (Ghosh and Chatterjee 1987; NRCC 1988; Uthaiah *et al.*, 1994; Hiremath 1991; Sundararaju and John 1993).

Earlier work done at Kerala Agricultural University identified some accessions or varieties less susceptible to tea mosquito bug (Ambika *et al*., 1979; Sathiamma, 1979; Beevi *et al*., 2001; Beevi and Mahapatro 2007). Beevi *et al*. (2001) attempted to categorize the cashew accessions based on damage score into four groups, *viz*., less susceptible (0-0.250), moderately susceptible (0.251-0.500), susceptible (0.501-0.750) and highly susceptible (0.751-1.000). However, none of the accessions were resistant/tolerant to tea mosquito bug. In a screening trial with 68 accessions, Beevi and Mahapatro (2007) documented Amrutha, Damodar and Raghav as least susceptible (LS), and, Priyanka and Anagha as highly susceptible (HS). Dhana variety showed significantly least damage score (0.36 ± 0.05) for three-year screening studies. While, NRCC Sel-2, Vengurle 4 and Priyanka, showed significantly higher damage scores ranging from 0.73 ± 0.09 to 0.92 ± 0.13. Dhana and Bhaskara varieties consistently showed lower damage score values and were grouped under the Moderately Susceptible (MS) category.

Least susceptible types to *H. antonii* contain higher phenols (Annapoorna and Nagaraja 1988) which cannot be always implicated towards resistance since *H. antonii* has a potential salivary detoxification mechanism. Besides, the existence of other antibiosis mechanisms is also remote, since Kunthur 24 and Goa 11/6 accessions had not shown any inhibitory effect on the growth of *H. antonii* (NRCC, 1994). Looking into the economic importance of tea mosquito bug, the present investigation aimed at screening fourteen cashew genotypes to study their susceptibility status to the tea mosquito bug.

MATERIAL AND METHODS

Fourteen accessions procured from major cashew growing tracts of Kerala (Table 1) based on their promising status in yield, extended flowering period, bold nut, big and juicy apple, and planted during 2003-04 in the germplasm conservation block of Cashew Research Station, Madakkathara were monitored for response to tea mosquito bug infestation under field conditions. The research station occupies an area of 90 acres and it lies at 10.5505°N latitude and 76.2659° East longitudes in Madakkathara village of Thrissur district of Kerala, India. The extent of damage by tea mosquito bug was recorded by scoring for the number of necrotic lesions on the 0-4 scale at fortnightly intervals during the crop season from 2009 to 2017 as per Ambika *et al*. (1979).

0— No lesions

1— Up to three necrotic lesions/streaks

2— 4-6 coalescing and non-coalescing lesions/streaks

3— Above 6 coalescing and non-coalescing lesions/streaks

4— Lesions/streaks confluent-complete drying of affected shoot/panicle

The number of trees monitored for each accession ranged from two to four depending on the availability of trees in each genotype in the germplasm block. The scoring was performed at fortnightly intervals and the activity continued from November to March of every year depending on the crop phase of each accession (Table 1). The screening was performed from 2009-10 to 2016-17 periods initiating at the age of six and subsequently during the steady bearing stage for seven years. During the 2009-2013 period, all the shoots in 52 leader shoots were scored. A leader shoot on an average bears 5-12 non flowering laterals and 4-10 flowering laterals.

However, from 2013-14 onwards, the nonflowering as well as flowering laterals (panicles) in 52 leader shoots were scored separately and the mean score for nonflowering and flowering laterals was worked out and recorded separately to follow the matrix method of ranking the accessions. The mean score for nonflowering laterals and panicles recorded from 2013-14 onwards was used to classify the accessions based on the matrix method (Beevi and Mohapatro 2007), giving weightage to the damage score on panicle.

The mean of damage score for nonflowering and flowering laterals together for seven years was computed and the accessions were classified based on the old method of categorization (Ambika *et al*., 1979) using the formula,

$$\text{Mean score} = \frac{\text{Sum of all numerical score}}{\text{Total no. of shoots (nonflowering + flowering shoots) in 52 leader shoots}}$$

The recorded observations in mean damage score can be converted into percent incidence using formula (Godase *et al*., 2005).

$$\%\ \text{Shoots/panicle damage} = \frac{\text{Mean score value}}{\text{Maximum score}} \times 100$$

Old method for TMB susceptibility classification

Mean damage score of shoots	Susceptibility status
0-0 to 0.25	Less susceptible
0.251 to 0.50	Moderately susceptible
0.51 to 0.75	Susceptible
0.751 to 1.00	Highly susceptible

Matrix method for TMB susceptibility classification

Shoot → / Panicle ↓	0-0.5	0.5-1.0 and more
0-0.5	Less Susceptible	Susceptible
0.5-1.0 and more	More Susceptible	Highly Susceptible

RESULTS AND DISCUSSION

The present investigation identified seven less susceptible genotypes *viz.,* Kottarakkara-1, Kainur, Kunjithai, Pattannur, Kottarakkara-2, Aralam-2, and Odakkali. During the evaluation period, a severe infestation of tea mosquito bug to the tune of 15-20 per cent infestation was recorded only in the 2014-15 season. In the remaining years, the infestation was very low to the tune of less than ten per cent. Ranking based on the average of the mean score for nonflowering and flowering laterals, the old method, recorded during the 2009-17 period shows the less susceptible status of eight accessions, *viz.,* Kottarakkara-1, Kainur, Kottukkal, Kunjithai, Pattannur, Kottarakkara-2, ARL-2 and Odakkali with a score ranging from 0.102 to 0.391 (Table 2). The remaining six accessions were moderately susceptible. Ranking based on average mean damage score value, the old method, for the period 2013-17 yielded the same eight accessions, as yielded as per the 2009-17 period, as less susceptible. Out of the remaining six, five were moderately susceptible and one was susceptible (Table 2, Fig. 1). However, in the matrix method of ranking, besides the less susceptible eight accessions, two more accessions, Kottukkal and Peechi also categorized as less susceptible types. At the same time, the remaining four accessions were of under susceptible types owing to the comparatively high damage score on panicle, which ranged from 0.513 to 0.678. Analysis of the mean score values recorded during 2014-15 with severe infestation level of 15-20 per cent, following old as well as matrix methods confirmed the less susceptible nature of seven accessions. Out of the remaining seven accessions, four were highly susceptible, three were moderately susceptible in old method, six were highly susceptible and one was susceptible in the matrix method.

The flowering laterals (panicles) recorded higher mean scores compared to non-flowering laterals (shoots) during all seasons of observation (Fig. 2). The vulnerability of panicles to shoots as revealed from the damage score in the present study conforms to earlier findings (Pillai *et al.,* 1984; Beevi *et al.,* 1991). Screening done by Ambika *et al.* (1979) at Cashew Research Station, Madakkathara reported one F1 hybrid BLA-139 as least susceptible. Screening of accessions at Vittal, Karnataka documented VTH-153 as least susceptible (Sathiamma, 1979). An exhaustive screening of 68 accessions including released varieties at the Cashew research station, Madakkathara during the 1991-96 period documented 11 less susceptible, five moderately susceptible, 38 susceptible and 13 highly susceptible accessions (Beevi and Mohapatro 2007). The accessions of Regional Fruit Research Station, Vengurle, Maharashtra, *viz.,* Vengurle-1, Vengurle-6 and Vengurle-8 were recorded as less susceptible with 0.19,0.22,0.24 mean damage scores out of 18 accessions screened during 2012-14 period (Navik and Godase 2019). Similarly, the variety Ullal -1 recorded the lowest TMB damage (61.85%) followed by C.R.S-1(69.10%) (Lakshmana *et al*., 2020). According to them, none of the yielding cultivars has shown resistant reactions to tea mosquito bug infestation.

In the present screening, seven accessions can be considered as less susceptible based on the consistency in susceptibility status in both classification methods, even in the year, 2014-15 recorded with comparatively high damage intensity.

Characterization of the less susceptible accessions at the biochemical level, *viz.*, sugar, carbohydrate, phenol and enzymes need to be performed to confirm the susceptibility status of the accessions. Some defensive compounds may be either produced constitutively or in response to plant damage in addition to the plant-released volatile organic compounds. Earlier studies reported higher phenol content in the least susceptible types (Annapoorna and Nagaraja 1988; Bindu and Beevi 2002). Among the seven varieties of cashew screened against tea mosquito bug under field conditions at Paria, Gujarat, Vengurla-3 and Vengurla-7 were classified under the moderately susceptible category, whereas Vengurla-1, 2, 4, 5 and 6 were categorized as highly susceptible. Early flowering varieties suffer more damage than mid-flowering varieties (Damasia *et al*., 2021). According to them, susceptibility increased with an increase in starch, total amino acid and total sugar while, decreasing with an increase in total phenol content in the tender shoots of cashew. However, according to Beevi and Mohapatro (2007), this cannot be implicated towards resistance, since tea mosquito bug potentially has a salivary detoxification mechanism. Any antibiosis mechanism has not been known in this aspect. However, the cultivars, Goa, 11/6 and Kunthur, though found less susceptible, were not shown any inhibitory effects on the growth of tea mosquito bug (Sundararaju and Sundarababu 1999b; Sundarababu, 2003). Phenols are secondary metabolites that play an important role in imparting resistance against herbivores (Chelliah and Sambandam 1971). A study documented the role of secondary metabolites such as tannins and phenols, and the enzyme, polyphenol oxydase in imparting resistance in cashew to tea mosquito bug (Nimisha *et al*., 2019). According to them, the total leaf protein was found to be higher in the less susceptible variety Damodar (0.9925 mg g^{-1}) and the least in the highly susceptible Madakkathara-1 (0.6729 mg g^{-1}). Likewise, the total phenol and tannin were higher in the less susceptible Damodar (69.834 mg g^{-1} and 4.276 mg g^{-1}, respectively) and Raghav (67.207 mg g^{-1} and 4.420 mg g^{-1}, respectively); with the least values being in the highly susceptible Anagha and Madakkathara-1. The activity of polyphenol oxidase was more in Damodar (0.003158 EU g^{-1} min^{-1}) and the least in Anagha (0.001406 EU g^{-1} min^{-1}). These observations on the biochemical changes conclude that there is significant variation in the infestation reactions of tea mosquito bug in the highly susceptible and less susceptible cashew varieties. Also, the defensive molecules such as tannin and phenols and the defensive enzymes like polyphenol oxidase and phenylalanine lyase were more in the less susceptible varieties Damodar and Raghav.

According to Shilpa *et al*. (2022), the cocoa hybrids classified as highly resistant had significantly higher phenol content than those classified as susceptible and the significantly low phenol content in the susceptible hybrids suggests that phenolics have a function in mediating resistance to tea mosquito bug in cocoa. So, elucidation of biochemical basis in cashew will probably help to identify resistant varieties even in the graft stage itself. This response in biochemistry can also be utilized for developing molecular markers for the less susceptibility category by studying further biochemical modulations in genotypes with different reactions to this pest.

Table 1: Basic details of cashew genotypes used in the screening study.

Sr. No.	IC No.	Name of the accessions	Source of collection	Promising nature	Crop season
1.	301773	Kottarakkara-1	Kottarakkara, Kollam	Very bold nut	December - March
2.	301775	Kottarakkara-3	Kottarakkara, Kollam	Two flowering period	Dec. - Jan. & April-May
3.	301777	Kottarakkara-5	Kottarakkara, Kollam	Extended flowering period	December - February
4.	301783	Mannur	Mannur, Palakkad	Bold nut and good yield	December - February
5.	301781	Kainur	Kainur, Thrissur	high yield	December - March
6.	301782	Ummannur	Ummannur, Kollam	Extended flowering period	December - July
7.	301778	Kottukkal	Kottukkal, Kollam	Bold nut and high yield	December - February
8.	301784	Peechi	Peechi, Thrissur	high yield	November - April
9.	301780	Kunjithai	N. Paravoor, Ernakulam	high yield	December - February
10.	302005	Pattannur	Pattannur, Kannur	high yield	December - February
11.	302029	ARL-1	Aralam, Kannur	high yield	December - February
12.	301774	Kottarakkara-2	Kottarakkara, Kollam	Big apple type	November - February
13.	302030	ARL-2	Aralam, Kannur	high yield	December - February
14.	-	Odakkali	Odakkali, Ernakulam	high yield	December - February

Table 2: Mean damage score and susceptibility status for cashew accessions of CRS, Madakkathara.

Sr. No		Mean damage score (0-4 scale) and susceptibility status of cashew accessions														
		2009-17		2013-17							2014-15 (Severe TMB infestation year)					
				NFL		FL		Mean	Old	New	NFL	FL	Mean	Old	New	Pest incidence (%)
1.	KTR-1	0.229	LS	0.151	LS	0.230	LS	0.191	LS	LS	0.030	LS	0.100	LS	LS	2.5
2.	KTR-3	0338	MS	0.365	MS	0.540	S	0.453	MS	S	0.440	HS	0.980	HS	HS	24.5
3.	KTR-5	0257	MS	0.279	MS	0.513	S	0.396	MS	S	0.040	HS	0.680	HS	HS	17.0
4.	Mannur	0.364	MS	0.381	MS	0.678	S	0.529	S	S	0.250	HS	1.145	HS	HS	28.6
5.	Kainur	0.208	LS	0.116	LS	0.190	LS	0.153	LS	LS	0.060	LS	0.155	LS	LS	3.9
6.	Ummannur	0.391	MS	0.298	MS	0.515	MS	0.406	MS	S	0.080	HS	0.790	HS	HS	19.8
7.	Kottukkal	0.208	LS	0.219	LS	0.378	MS	0.298	MS	LS	0.150	HS	0.510	MS	HS	12.8
8.	Peechi	0.298	MS	0.248	LS	0.413	MS	0.330	MS	LS	0.110	HS	0.520	MS	HS	13.0
9.	Kunjithai	0.302	MS	0.171	MS	0.235	LS	0.203	LS	LS	0.130	LS	0.070	LS	LS	1.75
10.	Pattannur	0.109	LS	0.045	LS	0.075	LS	0.060	LS	LS	0.000	LS	0.040	LS	LS	1.0
11.	Aralam-1	0.117	LS	0.093	LS	0.185	LS	0.139	LS	LS	0.000	S	0.290	MS	S	7.3
12.	KTR-2	0.155	LS	0.064	LS	0.128	LS	0.096	LS	LS	0.000	LS	0.165	LS	LS	4.1
13.	Aralam-2	0.102	LS	0.045	LS	0.058	LS	0.051	LS	LS	0.000	LS	0.085	LS	LS	2.0
14.	Odakkali	0.137	LS	0.033	LS	0.048	LS	0.040	LS	LS	0.000	LS	0.005	LS	LS	0.1

LS: Less susceptible, MS: Moderately susceptible, S: Susceptible HS: Highly susceptible; NFL-Non-flowering laterals; FL-Flowering laterals
Old method (Ambika *et al*., 1979); New (Matrix) method (Beevi and Mohapatro 2007); KTR-Kottarakkara

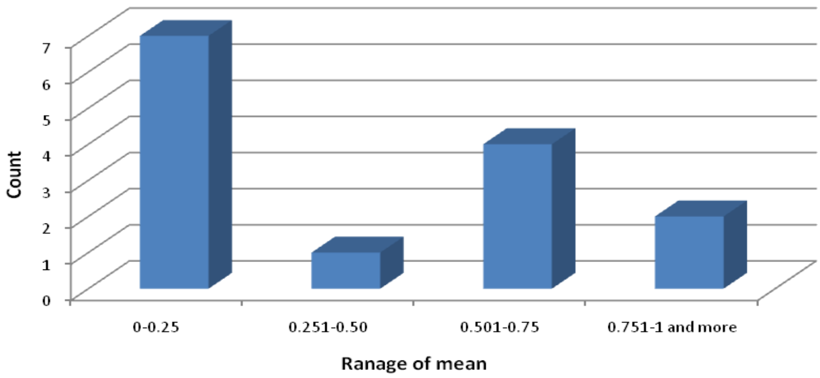

Fig. 1. Frequency distribution of tea mosquito bug damage score in cashew accessions during 2014-15 at CRS, Madakkathara.

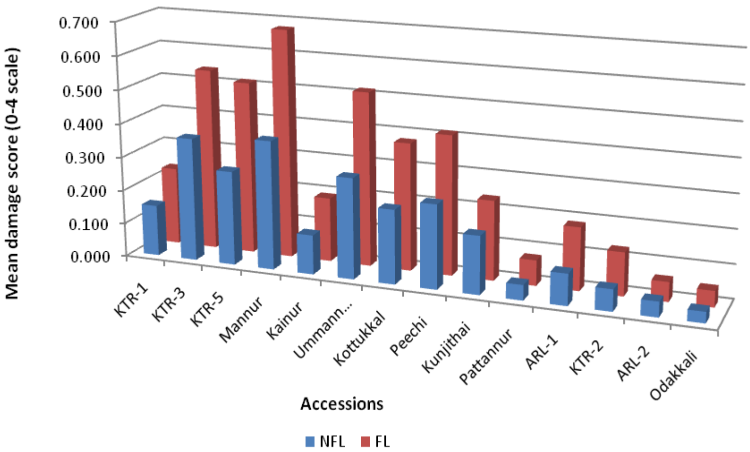

Fig. 2. Comparison of mean damage score on non-flowering (NFL) and flowering laterals (FL) of cashew accessions during 2013-14 to o 2016-17 at CRS, Madakkathara.

CONCLUSIONS

Variable reaction is exhibited among cashew germplasm accessions towards the infestation by tea mosquito bug. The less susceptible types can be utilized as source of resistance or tolerance for developing crop cultivars, which readily produce the inducible response upon mild infestation, and can serve as one of the components of integrated pest management for sustainable crop production.

FUTURE SCOPE

The results of the study yielded promising accessions that can be utilized as a breeding stock towards improving genetic source of host plant resistance to insect pest, *Helopeltis antonii.* However, the exact morphological and biochemical mechanisms through which the host plant expresses the resistance or tolerance need to be studied to exploit the full potential of the genetic stock. All the accessions throughout India, that were documented from different centres under less susceptible category need to be screened and their reaction is to be correlated with biochemical and morphological parameters.

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Conflicts of Interest. None.

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