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STATUS OF THE FLAT GRASS SCALE, *ACLERDA TAKAHASHII* KUWANA (HEMIPTERA: ACLERDIDAE) AND MORPHOLOGICAL CHARACTERS ASSOCIATED WITH RESISTANCE IN WILD SUGARCANE (*SACCHARUM SPONTANEUM* L.)

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Abstract

Status of the flat grass scale, Aclerda takahashii Kuwana (Hemiptera: Aclerdidae) and the morphological characters associated with resistance in the international collection of S. spontaneum maintained as a part of world sugarcane germplasm at the ICAR-Sugarcane Breeding Institute-Research Centre(SBI-RC), Kannur, Kerala was examined. The scale appeared in May coinciding with cane formation and the infestation increased during the post-monsoon period which continued until harvest. They were noticed in both internodal and nodal regions of the entire sugarcane stalks hidden inside the leaf sheath. The 79 accessions were grouped into three categories on the basis of infestation rate in which 62 were found to be least susceptible, 15 were moderately susceptible and 2 accessions were found as highly susceptible. In the least susceptible category, 27 accessions constituting about 34% of the total accessions were found to be totally free from the Aclerda takahashii attack under field condition. The highest infestation was recorded in the accession Djantoer 1. Non-parametric analysis of infestation parameters indicated that the accessions having different origin showed significant difference with respect to infestation rate and percent intensity. The highest and lowest infestation rate was recorded in Japan collections and US collections, respectively. Among quantitative stalk characteristics, leaf sheath length was found to be a significant morphological feature associated with infestation rate with positive correlation.

Keywords: *flat grass scale, Aclerda takahashii, Saccharum spontaneum, accessions, morphological resistance.*

Introduction

Among the different pests attacking sugarcane, scale insects play a vital role in hampering the cane development and growth by appearing from the mid-stage of crop and persisting upto harvest. Nearly thirty species have been recorded to invade the stem and colonise profusely in the internodal region under the leaf sheath. Scale insects belonging to the families Aclerdidae, Asterolecaniidae, Coccidae and Diaspididae have been recorded to colonize the stem and leaf of sugarcane (Easwaramoorthy and Kurup, 1986; Krishnamurthi and Mahadevan, 2002). The scale insect family Aclerdidae currently includes 5 genera with 58 species (ScaleNet – Ben-Dov et al. 2012) distributed mainly in hot and dry, often semi-desert regions of the world. Most of the species are connected with grasses (Poaceae), inhabiting leaf sheathes, they demonstrate very specialized morphological characters such as the absence of legs and strong reduction of antennae, unique anal apparatus, unique invaginated setae, and others (McConnell, 1954; Gavrilov-Zimin, 2012). One of those species, *Aclerda takahashii* Kuwana (Hemiptera: Aclerdidae) is known as flat grass scale and widely distributed in tropical zones of the world. Mukunthan and Nirmala (2002) reported *A. takahashii* as a new pest of sugarcane from Coimbatore, Tamil Nadu and

entire body colour appears pale orange with brownish tinge in the posterior and the anterior part is somewhat flattened compared to the posterior part of the body. Late adult female's abdomen becomes heavily sclerotized and dark brownish with somewhat dome-shaped in the middle. During the study period, often populations of *A. takahashii* co-occurred with populations of pink sugarcane mealybug, *Saccharicoccus sacchari* (Cockerell), occasionally side-by-side(Plate 1, Image 1), but the species are easily distinguished from the latter with colour, shape, smooth body and absence of dusted powdery wax and dorsal linings on the surface. Very often, the parasitized adult scale insects spotted in the field (Plate 1, Image 3). Interestingly, multiple parasitoids belong to different species (multiple parasitism) as well as same species (super parasitism) have emerged from single parasitized grown up individual under laboratory conditions. This phenomenon of supporting multiple or super parasitism might be attributed to its large body size. However, the associated natural enemies such as parasitoids and predators noticed in the field conditions are yet be identified which might throw some light on existing level of natural control.

At the peak of infestation, numerous scales were found on the surface of the stalks, giving sticky appearance with honey dew secretion which led to black sooty mould formation. The population and infestation was not as severe as that of sugarcane scale, *Melanaspis glomerata* with the latter causing the encrustation of entire surface giving a greyish black appearance (Mahesh et al. 2017, unpublished data). Canes with large colonies of both *M. glomerata* and *A.takahashii* exhibited stunted growth and were thinner than healthy canes. *A. takahashii* infestation varied widely among the accessions of *S. spontaneum* with the infestation rate (stalk basis) ranges from 0.00-73.33% and intensity (nodal basis) ranges from 0.00-79.37% with showing no significant correlation with each other.

Categorization of accessions

The 79 accessions of *S. spontaneum* assessed for scale insect damage were grouped into three categories based on the infestation rate as per the grading suggested by Radadia and Shinde (2013). When all 79 accessions

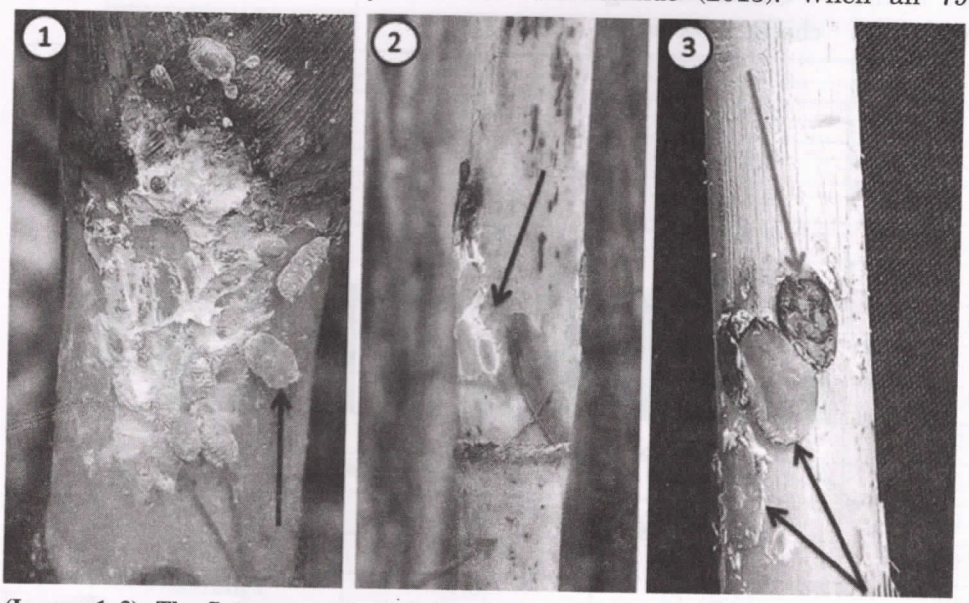

Plate 1 (Images 1–3). The flat grass scale, *Aclerda takahashii* on wild sugarcane (*Saccharum spontaneum* stem beneath leaf sheath (removed) (Note: Image 1. *Aclerda takahashii* (black arrow) and sugarcane pink mealybug, *Saccharicoccus sacchari* (red arrows). Image 2. *Aclerda takahashii* mixed-age populations (black arrow) and sugarcane scale, *Melanaspis glomerata*(red arrow). Image 3. *Aclerda takahashii* adult (black arrows) and parasitized adult (white arrow) females).

were considered on the basis of infestation rate, 62 (78.5%) were placed in least susceptible, 15 (19.0%) in moderately susceptible and 2 (2.5%) in highly susceptible categories (Table 1). In the least susceptible category (0-10%), 27 accessions constituting about 34 % of the total accessions (n=79) were found to be totally free from the *A. takahashii* attack under field condition.

The accessions examined for scale insect attack in the present study comprised world collection from Indonesia (36), United States (15), India (15), Papua New Guinea (3), Philippines (3), Japan (2), Taiwan (2), Vietnam (1), Burma (1) and Guam (1). Non-parametric analysis based on Kruskal-Wallis test of infestation rate (χ^2=17.443; df=9; N=79; P=0.042) and percent intensity (χ^2=23.248; df=9; N=79; P=0.006) with accessions categorized as of different origin showed significant difference. The highest infestation rate and percent intensity were recorded in Japan collections (Mean rank= 56.75) and Philippines collections (Mean rank= 77.00), respectively. Amongst all, the lowest infestation rate (Mean rank= 23.5) was recorded in the US collections (Figure 1). Further, we have checked whether any significant difference in infestation parameters exists between collections of Indian origin and other countries using Mann-Whitney non- parametric test. It was found that Indian collections infestation rate (mean rank= 18.57) significantly differed (Mann-Whitney U=158.50; P=0.018) that of Indonesian collections (mean rank= 29.10) and percent intensity significantly differed (Wilcoxon W =120.00; P=0.002) from Philippines collections. Moreover, infestation rate of Indonesian collections (mean rank= 30.67) significantly differed (Mann-Whitney U=102.00; P < 0.0001) from US collections (mean rank= 14.80).

Morphological characters vs. Aclerda takahashii incidence

Morphological basis of resistance was studied based on relationship between *Aclerda takahashii* infestation parameters and several quantitative and qualitative stalk morphological characters of *S. Spontaneum* using correlation and multivariate regression analysis.

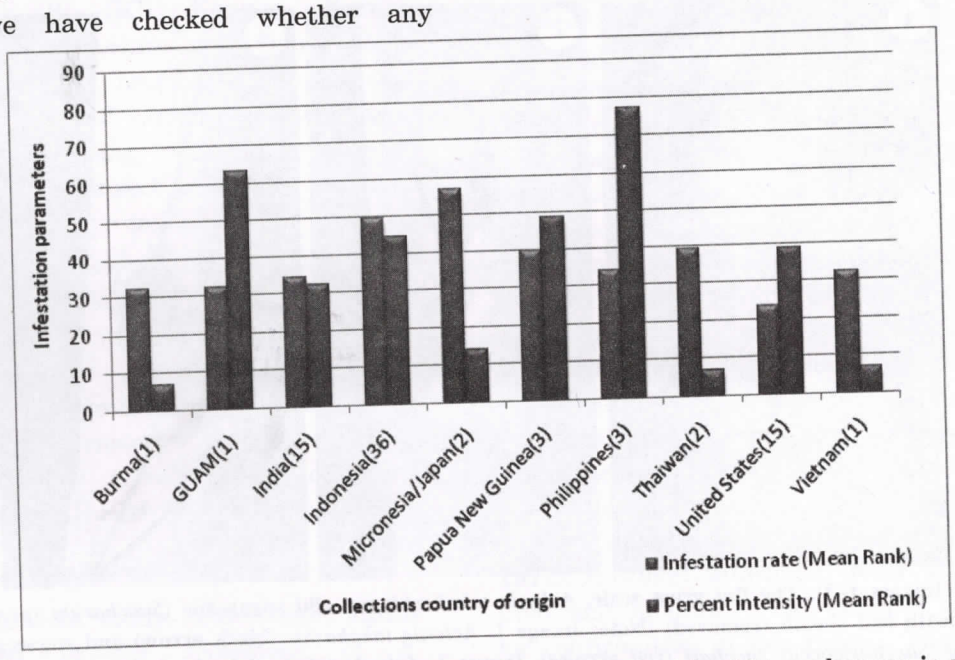

Figure 1. Infestation parameters in collections of different country of origin. (Note: values are in mean rank; values in bracket of each country origin denotes the total number of collections)

Table 1. Categorization of *Saccharum spontaneum* accessions on the basis of *Aclerda takahashii* infestation rate (Figures in parenthesis are percent values for each category)

Category	Infestation (%)	No. of accessions
Least susceptible	0.0-10.0	62 (78.5)
Moderately susceptible	10.0-35.0	15 (19.0)
Highly susceptible	35.0	2 (2.5)

Table 2. Status of *Saccharum spontaneum* accessions on the basis of *Aclerda takahashii* infestation rate

Category	Accession#	Infestation rate (%)	Accession#	Infestation rate (%)
Least susceptible	Iritty 2@	0.00	Pamba@	3.33
	Iritty 3@	0.00	Saigon	3.33
	Taiwan 42	0.00	S.S. Burma	3.33
	SES 106B@	0.00	SES 20@	3.33
	SH 61-4-1@	0.00	IK 76-57	3.33
	SH 61-4-3@	0.00	IN 84-42	3.33
	US 56-1-5	0.00	SH 59-1-2@	4.17
	US 56-10-14	0.00	Mandalay	6.67
	US 56--19-1	0.00	Ponape 1	6.67
	US 56-20-1	0.00	Swayambawa	6.67
	US 57-3-2	0.00	SES 24@	6.67
	US 57-71-5	0.00	US 56-15-2	6.67
	US 57-73-3	0.00	US 57-2-2	6.67
	US 57-118-1	0.00	US 59-1-2	6.67
	US 57-118-4	0.00	IK 76-49	6.67
	US 57-170-1	0.00	IK 76-61	6.67
	US 59-1-1	0.00	IS 76-132	6.67
	IK 76-46	0.00	IS 76-152	6.67
	IS 76-192	0.00	IS 76-196	6.67
	IS 76-194	0.00	IS 76-216	6.67
	IS 76-201	0.00	IS 76-222	6.67
	IS 76-207	0.00	NG 77-169	6.67
	NG 77-56	0.00	IN 84-12	6.67
	IN 84-38	0.00	SES 600@	8.00
	IN 84-88	0.00	IMP 569	10.00
	PAL 84-5	0.00	US 56-16-1	10.00
	PAL 84-12	0.00	IK 76-10	10.00
	Iritty 1@	3.33	IK 76-66	10.00
	Karango	3.33	IS 76-217	10.00
	Nilambur 1@	3.33	NG 77-190	10.00
	Nilambur 2@	3.33	IN 84-35	10.00

Category	Accession#	Infestation rate (%)	Accession#	Infestation rate (%)
Moderately susceptible	SES 184A@	12.00	IS 76-128	16.67
	Taiwan 96	12.50	IS 76-164	16.67
	IK 76-20	13.33	IS 76-180	16.67
	IK 76-41	13.33	PLAG 84-8	20.00
	Ponape 2	16.00	IS 76-151	25.00
	Djantoer 2	16.67	IS 76-173	26.67
	IK 76-74	16.67	IMP 558	33.33
	IM 76-238	16.67	,	
Highly susceptible	SES 340@	40.00	Djantoer 1	73.33

(a) Relationship of quantitative stalk characteristics with attack rates

Correlation analysis among quantitative stalk characteristics and scale attack parameters (Table 3) indicated that leaf sheath length was positively and significantly correlated with infestation rate (Pearson's r= 0.232; *P*= 0.039). However, correlation of infestation parameters with all other individual characteristics were not statistically significant. Further, multivariate regression analysis indicated that all quantitative stalk characteristics together significantly influenced the infestation rate (*F*= 2873.0; df= 5; $P < 0.00001$) (Table 4). Five stalk characteristics *viz.*, stalk height, stalk thickness, internode length, leaf sheath length and root band width have significantly contributed and explained 99.5% (R^2 value= 0.995) of variations in the infestation rate. In addition, forward and stepwise regression analysis showed that two stalk parameters viz., stalk thickness and root band width did not significantly contribute to the variations in the infestation rate. Interestingly, stalk height and leaf sheath length alone could significantly explain 92.9% variations (R^2 value= 0.929; *F*= 500.17; df= 5; $P < 0.00001$) observed in the infestation rate. The negative relationship of percent intensity with all stalk characteristics gave us the impression that *A. takahashii* inclined towards sedentary behaviour which led to minimized spread from one internode to other within the stalk which further needs confirmation. Besides, there was no significant correlation observed between infestation rate and percent intensity among accessions.

Based on the test results of multiple linear regression analysis, the best linear regression model equation chosen for infestation rate as follows:

$$Y= 0.116 + 3.000\ X_1 - 1.002\ X_2 - 0.967X_3$$

Where Y= infestation rate; X_1 – leaf sheath length; X_2 – stalk height; X_3 – internode length

(b) Relationship of qualitative stalk characteristics with attack rates

Infestation parameters did not significantly vary among accessions based on groupings of five qualitative stalk characteristics *viz.*, leaf sheath colours, leaf sheath hairiness, internode wax, ring band colour and growth ring colour by Non-parametric Kruskal-Wallis test.

Conclusion

The flat grass scale, *Aclerda takahashii* was found to be a minor pest with 27 accessions constituting about 34 % of the total accessions (*n*=79) were found to be totally free from the *Aclerda takahashii* attack under field conditions. Amongst all accession, the US collections were found to be less preferred by *A. takahashii* with the lowest infestation rate.