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Effect of sugarcane varieties on the development of *Mahanarva fimbriolata* (Hemiptera: Cercopidae)

Efecto de variedades de caña de azúcar en el desarrollo de *Mahanarva fimbriolata* (Hemiptera: Cercopidae)

JOSÉ F. GARCÍA[1], SIMONE S. PRADO[2], JOSÉ D. VENDRAMIM[3] and PAULO S. M. BOTELHO[4]

Abstract: The sugarcane spittlebug, *Mahanarva fimbriolata* (Hemiptera: Cercopidae), is considered the most important pest of sugarcane harvested without the burning of trash, or green cane, in Brazil. The objective of this work was to compare the biology of *M. fimbriolata* on six sugarcane varieties: SP79-1011, SP80-1816, SP80-1842, SP81-3250, RB72454, and RB835486. The experiments were conducted at a temperature of 25 ± 1°C, RH of 70 ± 10%, and a photoperiod of 14:10 [L:D]. Variety RB72454 outperformed the rest, reducing the nymphal population that fed on its roots by 50%. With regard to adults, variety SP81-3250 allowed greater mean longevity of males (38 days) and females (51 days), greater mean oviposition period (46 days), and higher mean fecundity (1215 eggs/female); these parameters were statistically different from those obtained with other varieties. For the eggs, there was no significant effect of variety on developmental time or viability. Consequently, the variety SP81-3250 should be avoided in areas predisposed to the occurrence of *M. fimbriolata*.

Key words: Plant resistance. Antibiosis. Tolerance. *Saccharum*.

Resumen: El salivazo, *Mahanarva fimbriolata* (Hemiptera: Cercopidae), es considerada la principal plaga de la caña de azúcar cosechada sin previa limpieza a fuego, o caña verde, en el Brasil. El objetivo de este trabajo fue comparar la biología de *M. fimbriolata* sobre seis variedades de caña de azúcar: SP79-1011, SP80-1816, SP80-1842, SP81-3250, RB72454 y RB835486. Los experimentos se llevaron a cabo a una temperatura de 25 ± 1°C, UR de 70 ± 10% y un fotoperíodo de 14:10 [L:O]. La variedad RB72454 superó las demás, reduciendo en 50% la población de ninfas alimentadas en sus raíces. En relación con los adultos, la variedad SP81-3250 permitió mayor longevidad promedio de machos (38 días) y de hembras (51 días), mayor periodo promedio de oviposición (46 días) y elevada fecundidad promedio (1215 huevos/hembra); estos parámetros fueron estadísticamente diferentes de los obtenidos en las otras variedades. Para los huevos, no hubo efecto significativo de variedad sobre el periodo de desarrollo o la viabilidad. Siendo así, la variedad SP81-3250 debe ser evitada en áreas propicias para la presencia de *M. fimbriolata*.

Palabras clave: Resistencia de plantas. Antibiosis. Tolerancia. *Saccharum*.

Introduction

Mechanized harvesting in sugarcane areas has substantially increased in Brazil, particularly in the State of São Paulo, where currently one third of the planted area is mechanically harvested. In this system, the trash is not burned and the dry leaves, top shoots, and green leaves that have been chopped are thrown on the soil surface, forming a covering layer of plant material near the base of ratoon stalks and tillers. Because of this practice, crop management changes have been observed and as a consequence, there have been population increases of sugarcane spittlebug, *Mahanarva fimbriolata* (Stål, 1854) (Hemiptera: Cercopidae) in many regions (Dinardo-Miranda *et al.* 2006). This pest was being controlled mainly by burning the sugarcane crops prior to harvesting, which was especially helpful in the destruction of diapausing eggs, and changing the local microclimate (Dinardo-Miranda *et al*. 2001a).

Nymphs of *M. fimbriolata* cause physiological disorders as a result of feeding injuries that reach the roots' phloem vessels, deteriorating them and slowing or preventing the flow of water and nutrients (Gallo *et al.* 2002). The adults cause "froghopper burn" in sugarcane leaves (Guagliumi 1972) and their saliva, injected upon feeding, also cause a reduction in the size and diameter of internodes, which become short and fibrous (Dinardo-Miranda *et al.* 2000; Gonçalves *et al.* 2003). One of the most important control methods against this pest has been the entomopathogenic fungus *Metarhizium anisopliae* (Metsch.) Sorok., 1976 at a concentration of $2.6x10^{12}$ viable conidia/hectare (Leite *et al*. 2005). However, the use of insecticides to control the sugarcane spittlebug is also recommended mainly in situations that require a quick control response, decreasing the high risk of not preventing the potential damage that can be caused by *M. fimbriolata* (Dinardo-Miranda *et al*. 2001b, 2004, 2006).

While studies involving sugarcane have been made for a long time in Brazil, little is known about the use of resistant varieties as an alternative control of the sugarcane spittlebug (Dinardo-Miranda 2001b). Therefore, the objective of this work was to evaluate the biological development of *M. fimbriolata*, a recent pest of sugarcane, on diverse and popular sugarcane varieties currently grown in the State of São Paulo.

Material and Methods

We used insects of the laboratory stock colony, reared according to a technique described by Garcia *et al.* (2007). We use

[1] Dr. Global Cana - Soluções Entomológicas Ltda. Rua Coronel Medeiros, 38 - Centro. CEP: 15.910-000 - Monte Alto - São Paulo - Brazil. Corresponding author: Fax: +55 16 9275-4556. jfgarcia@globalcana.com.br [2] Ph. D. Departamento de Entomologia e Acarologia - ESALQ / USP - Caixa Postal: 09. CEP: 13418-900 - Piracicaba - São Paulo - Brasil. [3] Dr. Prof. Departamento de Entomologia e Acarologia - ESALQ / USP - Caixa Postal: 09. CEP: 13418-900 - Piracicaba - São Paulo - Brasil. [4] Dr. Prof. Departamento de Biotecnologia Vegetal - CCA - UFSCar - Caixa Postal: 153. CEP: 13600-970 - Araras - São Paulo - Brasil.

Table 1. Mean duration and viability ± standard error (S.E.) for the nymphal stage of the sugarcane spittlebug *M. fimbriolata*, on different sugarcane varieties. Temperature: 25±1ºC, RH: 70±10%, photophase: 14 hours.

Varieties	Duration (days)		Viability (%)	
	Mean ± S.E.	V.I.[1]	Mean ± S.E.	V.I.
SP 79-1011	38.04 ± 0.46 a[2]	36.0 - 40.0	64.00 ± 7.84 ab	20.0 - 100.0
SP 80-1816	35.21 ± 0.45 b	34.0 - 38.3	76.00 ± 4.98 ab	60.0 - 100.0
SP 80-1842	35.19 ± 0.35 b	34.0 - 37.3	78.00 ± 6.29 a	40.0 - 100.0
SP 81-3250	37.68 ± 0.53 a	35.0 - 40.3	78.00 ± 5.54 a	40.0 - 100.0
RB72454	36.81 ± 0.59 ab	34.5 - 39.3	50.00 ± 8.56 b	20.0 - 100.0
RB835486	38.35 ± 0.65 a	35.3 - 42.0	58.00 ± 4.67 ab	40.0 - 80.0

[1] V.I. = Variation interval; [2] Means followed by the same letter in the column are not statistically different by Tukey test (P ≤ 0.05).

the varieties SP79-1011, SP80-1816, SP80-1842, SP81-3250, RB72454, and RB835486 that were developed and grown in greenhouses of the Laboratory of Insect Biology of the Departamento de Entomologia e Acarologia at Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ), Universidade de São Paulo (USP), in Piracicaba, SP, Brazil. The studies were conducted at a temperature of 25±1°C, relative humidity of 70±10% and a photoperiod of 14:10 [L:D].

The sugarcane spittlebug biological parameters as duration and viability of the eggs, nymphal stages, pre-oviposition and oviposition period, fecundity, and adult longevity were evaluated. Eggs laid on the third day of oviposition were used to determine the duration of the embryonic period and viability. Eggs were distributed on acrylic plates (6 cm diameter x 2 cm height) and lined with autoclaved filter paper moistened with distilled water. The number of nymphs hatched per plate was recorded daily. The experimental design was completely randomized, with five replicates, consisting of 100 eggs each. Sugarcane seedlings of each variety tested were used to evaluate the duration and viability of the nymphal period. Seedlings were placed in 500mL capacity containers and sealed with a plastic lid containing a vent hole in the centre (2cm diameter). Evaluations were performed daily, and the number of emerged adults was recorded. A completely randomized experimental design was used, with 10 replicates, each consisting of 10 nymphs. To calculate fecundity (number of eggs/female) and oviposition rate (mean number of eggs/day), the oviposition period considered was between the first and last observed day that females laid eggs. The numbers of live and dead females were counted in each evaluation. The values of mean mortality/day and the oviposition period were compared. A completely randomized experimental design was used, with 40 replicates, each consisting of a *M. fimbriolata* pair.

The biological data were subjected to analysis of variance and the means were compared by Tukey test (P<0.05), using the SANEST 2.0 software program (Zonta and Machado 1982). The parameters duration and viability of the egg and nymphal stages, pre-oviposition period, oviposition, fecundity, and adult longevity were used to run a cluster analysis (Scott and Knott 1974). This analysis was performed via the Systat 3.0 software program (Wilkinson 1990).

Results and Discussion

The diverse sugarcane varieties studied here influenced the biological parameters evaluated for *M. fimbriolata* nymphs and adults, but did not alter incubation period and viability of the eggs.

The duration and viability of the nymphal stage were statistically different for individuals exposed to the different varieties, ranging from 35 to 38 days. The shortest nymphal periods were observed for the insects reared on the varieties SP80-1816 and SP80-1842 (35 days), while the longest periods were observed for the insects reared on SP81-3250 (37 days), SP79-1011, and RB835486 (38 days). Although an intermediate duration of the nymphal period occurred on variety RB72454 (36 days) as compared to the others, this variety caused a 50% reduction in nymphal viability, differing from values obtained on varieties SP80-1842 and SP81-3250 (28%) (Table 1).

The longevity of sugarcane spittlebug males and females was strongly influenced by the variety on which they fed (Table 2). Longevities of 38 days for males and 51 days for

Table 2. Mean longevity ± standard error (S.E.) of males and females of the sugarcane spittlebug *M. fimbriolata*, on different sugarcane varieties. Temperature: 25±1°C, RH: 70±10%, photophase: 14 hours.

Varieties	Male		Female	
	Mean ± S.E.	V.I.[1]	Mean ± S.E.	V.I.
SP 79-1011	15.40 ± 1.49 b[2]	6.0 - 26.0	21.47 ± 5.63 b	4.0 - 74.0
SP 80-1816	15.10 ± 1.75 b	9.0 - 28.0	21.46 ± 5.78 b	2.0 - 72.0
SP 80-1842	19.36 ± 2.14 b	11.0 - 37.0	24.43 ± 5.45 b	3.0 - 75.0
SP 81-3250	38.25 ± 7.03 a	11.0 - 68.0	51.13 ± 8.60 a	16.0 - 80.0
RB72454	24.50 ± 3.85 b	12.0 - 45.0	35.00 ± 7.55 ab	7.0 - 72.0
RB835486	11.90 ± 1.46 b	7.0 - 20.0	12.80 ± 1.40 b	8.0 - 22.0

[1] V.I. = Variation interval; [2] Means followed by the same letter in the column are not statistically different by Tukey test (P ≤ 0.05).

Table 3. Mean pre-oviposition and oviposition periods ± standard error (S.E.) for females of the sugarcane spittlebug *M. fimbriolata*, on different sugarcane varieties. Temperature: 25±1°C, RH: 70±10%, photophase: 14 hours.

Varieties	Pre-oviposition		Oviposition	
	Mean ± S.E.	V.I.[1]	Mean ± S.E.	V.I.
SP 79-1011	4.00 ± 0.35 a[2]	0.0 – 5.0	17.60 ± 5.61 b	0.0 – 71.0
SP 80-1816	4.46 ± 0.40 a	0.0 – 6.0	16.92 ± 5.49 b	0.0 – 66.0
SP 80-1842	4.14 ± 0.40 a	0.0 – 7.0	20.43 ± 5.40 ab	0.0 – 71.0
SP 81-3250	5.13 ± 0.30 a	4.0 – 6.0	46.00 ± 8.71 a	10.0 - 76.0
RB72454	5.30 ± 0.30 a	3.0 – 6.0	29.20 ± 7.22 ab	5.0 - 67.0
RB835486	4.10 ± 0.55 a	0.0 – 6.0	7.40 ± 1.23 b	0.0 - 15.0

[1] V.I. = Variation interval; [2] Means followed by the same letter in the column are not statistically different by Tukey test ($P \leq 0.05$).

females were verified on variety SP81-3250, which was significantly higher than on the other genotypes. This could lead to an increase in the number of eggs laid, and since the adults live to feed for a longer period, increased crop damage may result. The female pre-oviposition period was not affected by the varieties used to rear the insects. However, the oviposition period showed statistical differences between the varieties. Insects reared on the variety SP81-3250 showed the longest oviposition period (46 days), been statistically different from the period recorded on varieties RB835486 (7 days), SP 79-1011 (17 days), and SP 80-1816 (18 days) (Table 3). Females exposed to the variety SP81-3250 showed the highest mean fecundity of 1,215 eggs, differing statistically from those females maintained on the other varieties (Table 4). Regardless of the variety on which nymphs and adults were reared, the varieties did not significantly influence the mean incubation period (18 days) and egg viability, which varied from 83% for the variety SP79-1011 to 97% for the variety SP81-3250 (Table 5).

The cluster analysis allowed the formation of three groups of different levels of resistance between the varieties, taking into consideration the duration and viability of the egg and nymphal stages, longevity of males and females, pre-oviposition and oviposition periods, and fecundity as parameters (Fig. 1). Fecundity was the most important variable used for the formation of groups; this result was also clear from the cluster analysis ("F"=21.84). Therefore, the first group consisted of varieties SP79-1011, SP80-1816, and RB835486, with mean fecundity values of 254.5; 333.2; and 143 eggs per female, respectively; the second consisted of varieties SP80-1842 and RB72454, with 479.9 and 559.9 eggs/female, respectively; and the third was formed by variety SP81-3250, with the highest mean number of eggs per female, totaling 1,215 eggs.

Here we showed that the variety SP81-3250 supports an increased number of eggs and consequently, a higher number of individuals per generation, which may suggest damage to the crop. Therefore, we concluded that this variety is not indicated for areas which potentially favor the occurrence of the pest. There is little information available in the literature on sugarcane resistance to the pest *M. fimbriolata*. The population of *M. fimbriolata* was evaluated during field observations at 10 sugar/alcohol mills in the State of São Paulo from 1999 to 2002. Nymphs/linear meter of sugarcane were counted over approximately 60,000 hectares. Based on the percentage of areas with infestations higher than 5 nymphs/meter, it was verified that no field planted with variety SP79-1011 reached a level this high. Varieties RB72454 and RB835486 showed values between 1 and 9%; for SP80-1816 values were between 10 and 19%; while for SP80-1842 and SP81-3250, 20% of the areas showed densities equal to or higher than 5 nymphs/meter (Stingel 2005). Comparing this information with the biological parameters obtained in the laboratory, there is strong evidence that varieties do affect the incidence of sugarcane spittlebug. For example, the variety SP81-3250, which allowed greater longevity of males and females, longer oviposition period, and higher fecundity, was listed as the variety with the highest natural infestation of the pest.

These results emphasize the necessity for detailed studies on the resistance of various sugarcane varieties to the spittlebug *M. fimbriolata* in Brazil. In the past, Guagliumi (1972) verified that varieties POJ 2878, Caianã, Pitú, and Criola (unused nowadays) showed greater susceptibility to the attack of *Mahanarva rubicunda indentata* (Walker, 1858) adults (Hemiptera: Cercopidae). Due to a tight leaf sheath disposition, the varieties Co 331, and CP-5122 made it harder for nymphs to enter and develop on the plants. Conversely, varieties CB-5022, CB-4077, and CB-47355 were more easily exposed not only to nymphs, but also to abiotic factors, and natural enemies, because they possessed a trait by which older leaves were shedded. Based on field observations, other authors, like Pickles (1933, 1942) and Fewkes (1969), reported that some sugarcane varieties are less susceptible to the attack of leafhoppers than others. Dinardo-Miranda *et al.* (2001a) showed that *M. fimbriolata* severely attacked the varieties IAC83-2396, SP80-1842 e RB825336. However, the varieties IAC82-3092, IAC87-3187 e PO86-1107 presented

Table 4. Mean fecundity ± standard error (S.E.) of the sugarcane spittlebug *M. fimbriolata*, on different sugarcane varieties. Temperature: 25±1°C, RH: 70±10%, photophase: 14 hours.

Varieties	Fecundity	
	Mean ± S.E.	**V.I.[1]**
SP 79-1011	254.47 ± 68.46 b[2]	0.0 - 908.0
SP 80-1816	333.15 ± 115.65 b	0.0 - 1,476.0
SP 80-1842	479.93 ± 137.06 b	0.0 - 1,563.0
SP 81-3250	1,215.00 ± 200.02 a	281.0 - 1,732.0
RB72454	559.90 ± 161.78 b	62.0 - 1,621.0
RB835486	143.00 ± 23.84 b	0.0 - 234.0

[1] V.I. = Variation interval; [2] Means followed by the same letter in the column are not statistically different by Tukey test ($P \leq 0.05$).

Table 5. Mean duration and viability ± standard error (S.E.) of eggs of the sugarcane spittlebug *M. fimbriolata*, on different sugarcane varieties. Temperature: 25±1°C, RH: 70±10%, photophase: 14 hours.

Varieties	Duration (days)		Viability (%)	
	Mean ± S.E.[1]	V.I.[2]	Mean ± S.E.	V.I.
SP 79-1011	18.73 ± 0.26	18.1 - 19.3	83.00 ± 1.73	80.0 - 88.0
SP 80-1816	18.65 ± 0.30	18.1 - 19.4	86.00 ± 2.94	80.0 - 92.0
SP 80-1842	18.30 ± 0.05	18.2 - 18.4	92.50 ± 4.35	80.0 - 100.0
SP 81-3250	18.15 ± 0.23	17.7 - 18.8	97.25 ± 0, 95	96.0 - 100.0
RB72454	18.64 ± 0.35	18.0 - 19.4	91.00 ± 2.89	84.0 - 98.0
RB835486	18.46 ± 0.29	17.9 - 19.0	91.00 ± 4.65	78.0 - 100.0

[1] There were no statistical differences between means; [2] V.I. = Variation interval.

lower level of infestation by *M. fimbriolata* (Dinardo-Miranda *et al.* 1999, 2001a).

According to Fennah (1939), the fact that *Aeneolamia varia saccharina* (Distant, 1909) (as *Tomaspis saccharina* Distant, 1909) adults (Hemiptera: Cercopidae) are attracted differently to the odor of leaves from different varieties demonstrates that this factor could be responsible for the resistance of varieties to this leafhopper. Such a resistance mechanism, however, would only be effective when the pest was offered a free choice between varieties, which normally does not occur in commercial plantations in large areas. Ideally, varieties with physiological or morphological resistance factors would be selected; these varieties would be less suitable for the development of nymphs and, survival and oviposition of adults. Some biological parameters, such as longevity of adults, oviposition period, and fecundity, proved to have a potential for use in variety breeding, in order to select materials to be used in regions and/or conditions that are restrictive to sugarcane cultivation due to the attack of this pest. By using the sugarcane gene bank, this information would allow the incorporation of genes that would regulate the production of chemical substances that confer variety resistance by antibiosis; these characters would then be associated with other desirable agronomic parameters.

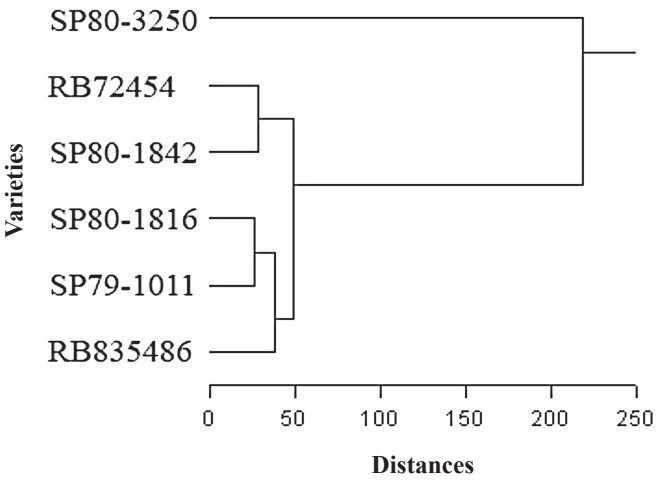

Figure 1. Phenogram representing the similarity between the varieties tested according their effect on the biology of *Mahanarva fimbriolata* (Stål, 1854) (Hemiptera: Cercopidae).

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