ECONOMIC INJURY LEVEL FOR SUGARCANE CAUSED BY THE SPITTLEBUG *Mahanarva fimbriolata* (STÅL) (HEMIPTERA: CERCOPIDAE)

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ABSTRACT: The sugarcane spittlebug, *Mahanarva fimbriolata* (Stål), is currently one of the most important pests of the sugarcane crop in Brazil. In spite of its economic importance, advances in the management of this pest have been limited by the lack of information on the economic injury level. In this study, the economic injury level for *M. fimbriolata* was estimated in a field experiment, over areas harvested in September, applying thiamethoxam at 200 g a.i. ha^{-1} or imidacloprid at 720 g a.i. ha^{-1}. In one of the experiments, insecticide applications were made at pest infestation values of 4.2 (11/12/04), 7.1 (01/11/05), or 16.3 (01/18/05) insects m^{-1}, and in experiment 2 when pest populations were 5.6 (11/12/04), 8.5 (01/11/05), or 15.3 (01/11/05) insects m^{-1}. Control plots without insecticide were maintained. After the applications, spittlebug infestations were estimated monthly, and the experiments were harvested in September 2005. Spittlebug control with the application of insecticides resulted in stalk and sugar yield increases in relation to the control, for both experiments. Applications performed under smaller infestations resulted in higher yields than applications made under higher populations. There were no differences between insecticides in one of the experiments; in the other, however, thiamethoxan contributed to greater yield increases than imidacloprid. Insecticide applications made under lower infestations resulted in greater profits. Regression analyses allowed the estimation of the pest economic injury level to be between 2 to 3 insects m^{-1} for the conditions of this experiment.

Key words: pest, management, control

NÍVEL DE DANO ECONÔMICO EM CANA-DE-AÇÚCAR CAUSADO PELA CIGARRINHA DAS RAÍZES *Mahanarva fimbriolata* (STÅL) (HEMIPTERA: CERCOPIDAE)

RESUMO: A cigarrinha-das-raízes, *Mahanarva fimbriolata* (Stål), é uma das mais importantes pragas da cana-de-açúcar na região Centro-Sul do Brasil. Apesar disso, avanços na implantação de programas de manejo estão sendo limitados pela falta de informações sobre o nível de dano econômico. Neste trabalho, o nível de dano econômico de *M. fimbriolata* foi estimado em experimento em campo, em áreas colhidas em setembro, aplicando thiamethoxam na dose de 200 g a.i. ha^{-1} ou imidacloprid na dose de 720 g a.i. ha^{-1}. Em um dos ensaios, as aplicações de inseticidas foram feitas quando as infestações da praga eram de 4.2 (11/12/04), 7.1 (01/11/05) ou 16.3 (01/18/05) insetos m^{-1} e no ensaio 2, quando as populações da praga eram de 5.6 (11/12/04), 8.5 (01/11/05) ou 15.3 (01/11/05) insetos m^{-1}. Parcelas testemunhas sem inseticida foram mantidas. Após as aplicações, as infestações de cigarrinha foram estimadas mensalmente e os ensaios foram colhidos em setembro de 2005. O controle de cigarrinha pela aplicação de inseticidas resultou incrementos de produtividade de colmos e de açúcar, em relação à testemunha, em ambos os ensaios. Aplicações feitas sob infestações menores resultaram em maiores produtividades do que aplicações feitas com populações mais elevadas. Não houve diferenças entre os inseticidas em um dos ensaios, mas no outro, thiamethoxan contribuiu para maiores incrementos de produtividade do que imidacloprid. Aplicações de inseticidas feitas sob infestações mais baixas resultaram em maiores lucros. Análises de regressão permitiram estimar o nível de dano econômico da praga, nas condições do presente ensaio, entre 2 e 3 insetos m^{-1}.

Palavras-chave: praga, manejo, controle

INTRODUCTION

Currently the sugarcane spittlebug, *Mahanarva fimbriolata* (Stål) (Hemiptera: Cercopidae) is one of the most important pests of the sugarcane crop in the Central-Southern region of Brazil (Dinardo-Miranda et al., 2006). Besides noticeably reducing stalk productivity (Dinardo-Miranda et al., 2001b; 2003; 2004; Macedo et al., 2003), it causes alterations in the quality of the sugarcane, reducing stalk sugar content and increasing fiber content (Dinardo-Miranda et al., 2000; Gonçalves et al., 2003). Losses also extend to sugarcane industrial processes, because dead and dry stalks resulting from the attack of the pest reduce the milling capacity since stalks are often cracked and deteriorated, contaminants make sugar recovery difficult and inhibit fermentation (Dinardo-Miranda, 2003).

In view of the importance of this pest, there is great interest in the development of an integrated management program to minimize the use of chemical and biological insecticides, with the first applications made only when the insect population exceeds a given economic threshold (Stern et al., 1959). To achieve this, the economic injury level (EIL) must be determined. Most entomologists agree that EIL estimation is one of the most important tasks to implement an integrated pest management program (Headley, 1972; Norgaard, 1976, Mumford & Norton, 1984, Peterson & Hunt, 2003). Nevertheless, studies on the estimation of the EIL of pests for crops are relatively uncommon (Peterson & Higley, 2006).

For sugarcane, Dinardo-Miranda (2003) suggested that the EIL for *M. fimbriolata* would be around 4 insects m^{-1} for sugarcane fields harvested at the end of the cropping season. However, there are no studies available that were conducted specifically for this purpose. Therefore, the objective of this work was to evaluate the effect of the spittlebug chemical control, performed under different infestations, on sugarcane productivity and plantation economic yield, to estimate the economic injury level of the pest.

MATERIAL AND METHOD

Two experiments were conducted in the northern region of the State of São Paulo (20°19' S, 48º18' W) under green cane-harvest areas planted with the variety RB855536. The area in experiment 1 had been harvested for the fifth time on 09/10/04, while the area in experiment 2 had been cut for the second time on 09/16/04. The experiments were carried out in selected homogeneous areas with respect to ratoon sprouting, with a small number of faults. Plots were represented by five 10-m long furrows, spaced 1.6 m in experiment 1 and 1.5 m in experiment 2, distributed in a random block design with six replicates.

Periodic spittlebug infestation evaluations were made, as a criterion to perform thiamethoxam or imidacloprid applications when the populations were approximately 5, 10, and 15 insects m^{-1}. Thus, applications were made in experiment 1 on 11/12/04, 01/11/05, and 01/18/05, when infestations in the area were 4.2, 7.1, and 16.3 insects m^{-1}, respectively. In experiment 2, applications were made on 11/12/04, 01/11/05, and 01/11/05, when infestations in the area were at 5.6, 8.5, and 15.3 insects m^{-1}, respectively. Control plots (without insecticide) were maintained in both experiments, therefore resulting in factorial experiments in which one of the factors corresponded to insecticides (thiamethoxam and imidacloprid) and the other to the three degrees of infestation at the time the insecticides were applied, plus one additional control treatment. The insecticides were applied with a pressurized backpack sprayer, directing the spray to the base of stalks. Thiamethoxam was applied at a rate of 200 g active ingredient (a.i.) ha^{-1}, and Imidacloprid at 720 g a.i. ha^{-1}. These rates are recommended for control of the pest on sugarcane.

After the applications, pest infestations were estimated monthly. For all samplings, 2 m of furrow were evaluated in each plot, counting nymphs and occasional adults present on the roots, as described in Dinardo-Miranda et al. (1999; 2000; 2001a; 2001b; 2003; 2004). To visualize the insects on the roots, the trash was carefully pushed away from the sugarcane furrow and the insects were removed from the root region, in the subsurface soil layer, with a wooden stick 20 cm in length and 0.5 cm in diameter.

Upon harvest, on 09/03/05 and on 09/30/05 for experiments 1 and 2, respectively, stalk productivity was obtained by cutting and weighing the stalks of all furrows in each plot. On the same occasion and immediately before cutting, one sample was taken per plot, consisting of ten stalks collected consecutively in the central furrow, to analyze technological parameters, according to the sugarcane remuneration system based on sucrose content (Fernandes, 2003). Consequently, among other parameters, values for sucrose content (SC, apparent sucrose percentage in the cane) and fiber (percentage of insoluble matter in water contained in the juice) were obtained, as defined by Fernandes (2003).

For the statistical analysis, the spittlebug infestation data x were transformed to log (x + 0.5), and all means were compared by the Tukey test. The economic viability of the treatments was estimated considering the margin of agroindustrial contribution (MAIC), which represents the difference between the expected income generated by the products (sugar and alcohol) and expenses in the agricultural (leaseholds, management practices, harvest, loading, and transport) and industrial sectors (raw material processing) (Fernandes, 2003). MAIC was calculated using the spreadsheet model found in Fernandes (2003). Current prices of August 2006 were adopted (sugar: US$ 0.44 per kg; alcohol: US$ 0.47 per liter; raw material at harvest, loading, and transport costs: US$ 5.61 per ton of sugarcane). The following values were also admitted: sugar pol yield 66%, industrial efficiency 90.5%, and distillery efficiency 87.6%, which are mean values from sugar and alcohol production units, as mentioned by Fernandes (2003).

To estimate the economic injury level for the sugarcane spittlebug, regressions between infestation values at the time of applications were fitted to a resulting MAIC values, considering the value estimated by the regressions as uninfested plant MAIC (expected MAIC in the absence of the pest). The application costs for the thiamethoxam and imidacloprid rates used were considered similar (US$117.00 per hectare for product + application).

RESULTS AND DISCUSSION

No spittlebug population differences were observed between treatments, in both experiments, for the sampling performed on 11/12/04, before applying the insecticides, suggesting that the pest was homogeneously distributed in the areas when the experiments were installed (Tables 1 and 2). At that time, mean infestations were 4.3 and 5.3 insects m^{-1} in experiment 1 and experiment 2 areas, respectively. For this reason, these were considered the infestation values when the first insecticide applications were made.

During the second half of November and throughout December the populations remained low in both experiments, as revealed by the data from the control plots. In January 2005, infestation levels rose again and reached a peak in February 2005 (Tables 1 and 2). Since the infestation levels in the experimental areas increased from January 2005, the other insecticide applications were made starting at that time. Therefore, applications were made in experiment 1 on 01/11/05, when the infestation levels reached 7.1 and 16.3 insects m^{-1}, and in experiment 2 on 01/11/05 and on 01/18/05, when infestation was at 8.5 and 15.3 insects m^{-1}, respectively.

For all sampling performed after the first application of insecticides, beginning on 11/17/04, significant pest infestation differences were observed between the control and the insecticidal treatments, except for the 12/14/04 sampling in experiment 2. At that time, however, pest infestation levels were low in the entire experimental area. Thus, the insecticides were

Table 1 - *M. fimbriolata* infestation (insects m^{-1}) on variety RB855536 as a function of treatments and sampling dates in experiment 1.

Initial infestation / date	Insecticide	Rate g a.i. ha^{-1}	Sampling date											
			11/12/04 (prelim.)	11/17/04	11/23/04	12/07/04	12/14/04	12/21/04	12/28/04	01/05/05	01/11/05	01/18/05	02/10/05	03/18/05
4.2 insects m^{-1} 11/12/04	Imidacloprid	720	4.8	3.6	1.3	1.2	0.3	0.2	0.1	0.7	2.2	2.3	0	0.2
	Thiamethoxam	200	4.1	4.9	1.5	2.3	1.5	0.4	0.3	0.6	2.4	6.3	0.3	0.7
7.1 insects m^{-1} 01/11/05	Imidacloprid	720	4.3	8.9	6.2	4.4	3.6	1.4	1.8	2.3	7.8	1.4	0.3	0
	Thiamethoxam	200	3.1	8.1	5.0	4.5	3.5	2.5	2.0	2.5	6.8	2.6	0.5	0
16.3 insects m^{-1} 01/18/05	Imidacloprid	720	3.5	6.1	6.4	4.4	3.1	3.4	3.1	3.2	6.3	16.3	1.2	0.1
	Thiamethoxam	200	4.9	4.9	6.4	3.8	2.8	2.8	2.1	3.3	5.8	16.3	3.5	0.3
Control			4.2	6.8	5.3	4.4	3.1	3.9	4.0	3.2	7.4	14.4	20.0	2.1
4.2 insects m^{-1} - 11/12/04				4.3	1.4	1.8	0.9	0.3	0.2	0.7	2.3	4.3	0.2 a	0.5 b
7.1 insects m^{-1} - 01/11/05												2.0	0.4 a	0 a
16.3 insects m^{-1} -01/18/05													2.4 b	0.2 ab
Imidacloprid				3.6	1.3	1.2 a	0.3	0.2	0.1	0.7	2.2	1.9 a	0.5	0.1
Thiamethoxam				4.9	1.5	2.3 b	1.5	0.4	0.3	0.6	2.4	4.5 b	1.5	0.3
F (initial infestation)												1.62^{NS}	13.56**	4.70**
F (product)				0.50^{NS}	0.21^{NS}	7.42*	2.69^{NS}	0.42^{NS}	0.06^{NS}	0.13^{NS}	0.69^{NS}	5.28*	2.30^{NS}	2.91^{NS}
F (product × initial infestation)												0.25^{NS}	0.32^{NS}	1.05^{NS}
F (control × factorial)			0.37^{NS}	8.48**	57.78**	22.80**	36.59**	20.62**	20.16**	28.06**	38.06**	56.61**	137.68**	75.26**
CV (%)			37.7	18.4	23.2	27.5	41.3	65.6	76.9	44.1	26.2	36.8	54.5	6.1

^{NS}non-significant; *,**Significant at 5 and 1%, respectively. For the 11/12/04 data, the statistical analysis was made considering a random block design.

Table 2 - *M. fimbriolata* infestation (insects m^{-1}) on variety RB855536 as a function of treatments and sampling dates in experiment 2.

Initial infestation / date	Insecticide	Rate g a.i. ha^{-1}	Sampling date										
			11/12/04 (prelim.)	11/17/04	11/23/04	12/07/04	12/14/04	12/21/04	12/28/04	01/05/05	01/11/05	02/10/05	03/18/05
5.6 insects m^{-1} 11/12/04	Imidacloprid	720	5.8	3.3	1.0	0.4	0.1	0	0.1	1.0	1.6	1.1	0.5
	Thiamethoxam	200	5.3	3.1	1.3	0.4	1.0	0.3	0.3	0.7	2.2	1.6	1.4
8.5 insects m^{-1} 01/11/05	Imidacloprid	720	5.7	4.7	2.6	1.3	1.3	0	2.3	6.5	8.3	0.8	0.3
	Thiamethoxam	200	5.3	5.4	3.9	1.0	1.3	0.8	1.0	4.8	8.7	0.8	0.3
15.3 insects m^{-1} 01/11/05	Imidacloprid	720	5.8	4.8	4.9	2.6	0.9	0.8	2.1	7.3	13.8	1.3	0.8
	Thiamethoxam	200	6.8	6.8	1.9	1.3	0.8	0.5	2.0	4.3	16.8	3.9	0.3
Control			5.9	5.9	3.9	1.8	0.7	1.0	0.8	8.3	12.0	23.3	5.8
5.6 insects m^{-1} - 11/12/04				3.2	1.2	0.4	0.6	0.2	0.2	0.9	1.9	1.4	1.0
8.5 insects m^{-1} - 01/11/05												0.8	0.3
15.3 insects m^{-1} -01/11/05												2.6	0.6
Imidacloprid				3.3	1.0	0.4	0.1	0	0.1	1.0	1.6	1.1	0.5
Thiamethoxam				3.1	1.3	0.4	1.0	0.3	0.3	0.7	2.2	2.1	0.7
F (initial infestation)												1.67^{NS}	1.38^{NS}
F (product)				0.26^{NS}	0.36^{NS}	0.40^{NS}	0.69^{NS}	0.91^{NS}	1.08^{NS}	0.01^{NS}	0.44^{NS}	2.20^{NS}	0.07^{NS}
F (product × initial infestation)												0.69^{NS}	1.09^{NS}
F (control × factorial)			0.36^{NS}	3.74**	10.95**	8.65**	1.71^{NS}	4.13*	11.81**	57.79**	43.74**	56.32**	13.18**
CV (%)			24.9	32.2	52.7	72.6	122.4	147.6	86.1	32.4	27.1	59.3	108.5

^{NS}non-significant; *,**Significant at 5 and 1%, respectively. For the 11/12/04 data, the statistical analysis was made considering a random block design.

quite effective in reducing the spittlebug population, and were different between themselves only for the 12/07/04 and 01/18/05 samplings in experiment 1, in which the thiamethoxam treatment presented a higher population than the imidacloprid treatment (Tables 1 and 2). The results observed here with regard to the similar performance between imidacloprid and thiamethoxam in reducing spittlebug populations, are in agreement to those reported by Dinardo-Miranda et al. (2006).

Significant pest infestation differences owing to the infestation at the time of applications (initial infestation) were observed in experiment 1 only. In this experiment, for the sampling made on 02/10/05, treatments that received insecticide under higher infestations (16.3 insects m^{-1}) had larger populations than treatments that received insecticides under lower infestations (4.2 or 7.1 insects m^{-1}). For the sampling conducted on 03/18/05, however, the lowest spittlebug infestations were found for plots that received insecticides when the initial infestation was at 7.1 insects m^{-1}. However, the differences observed at that occasion can be disregarded, since the populations were very low (Tables 1 and 2).

No significant interactions between products and infestation levels were observed at the time applications were performed, for both experiments (Tables 1 and 2). No differences were observed at harvest for sugarcane sucrose content and fiber values, in both experiments, revealing that the pest did not interfere significantly on sugarcane quality (Tables 3 and 4). A similar observation was reported by Dinardo-Miranda et al. (2006), who also worked with the variety RB855536. The authors observed that the infestation at the population peak reached 19 insects m^{-1}, and no reductions in sugarcane pol contents or increases in fiber contents were observed due to pest attack. However, there are several studies in the literature in which such alterations have been observed. For instance, in areas where populations of the pest reached values higher than 35, 40, or 50 insects m^{-1}, as for Dinardo-Miranda et al. (2003; 2004). As a result, in the present experiment, populations were not sufficiently high to cause significant alterations in sugarcane sucrose content and fiber values, for the sugarcane variety under consideration.

Although no changes occurred in these parameters, there was a significant interference of treatments on stalk productivity and, consequently, on pol productivity. For both experiments, the stalk and sucrose

Table 3 - Sucrose content (SC, apparent sucrose percentage in the cane), fiber (%), and stalk yield (TCH - t ha^{-1}) and sucrose yield values (TSH - t ha^{-1}) for different treatments, in experiment 1.

Initial infestation / date	Insecticide	Rate g a.i. ha^{-1}	SC	Fiber	TCH	TSH
4.2 insects m^{-1}11/12/04	Imidacloprid	720	16.80	10.88	113.8	19.12
	Thiamethoxam	200	16.22	11.13	119.2	19.33
7.1 insects m^{-1}01/11/05	Imidacloprid	720	17.09	10.96	114.1	19.50
	Thiamethoxam	200	16.72	10.90	107.4	17.96
16.3 insects m^{-1} 01/18/05	Imidacloprid	720	16.71	10.70	107.7	18.00
	Thiamethoxam	200	16.30	10.70	109.2	17.80
Control			16.72	10.73	101.6	16.99
4.2 insects m^{-1} - 11/12/04			16.51	11.00	116.5 a	19.23 a
7.1 insects m^{-1} - 01/11/05			16.91	10.93	110.8 b	18.73 a
16.3 insects m^{-1} -01/18/05			16.51	10.70	108.5 b	17.91 b
Imidacloprid			16.86	10.84	111.9 a	18.86 a
Thiamethoxam			16.41	10.91	111.9 a	17.91 a
F (initial infestation)			2.82^{NS}	1.47^{NS}	14.17**	6.42**
F (product)			2.95^{NS}	0.17^{NS}	0.08^{NS}	1.28^{NS}
F (product × initial infestation)			0.73^{NS}	0.39^{NS}	9.91**	2.19^{NS}
F (control × factorial)			0.01^{NS}	0.54^{NS}	41.49**	18.08**
CV (%)			3.5	4.1	3.3	4.9

^{NS}non-significant; *, **Significant at 5 and 1%, respectively.

Table 4 - Sucrose content (SC, apparent sucrose percentage in the cane), fiber (%), and stalk yield (TCH - t ha^{-1}) and sucrose yield values (TSH – t ha^{-1}) for different treatments, in experiment 2.

Initial infestation / date	Insecticide	Rate g a.i. ha^{-1}	SC	Fiber	TCH	TSH
5.6 insects m^{-1}11/12/04	Imidacloprid	720	16.79	11.16	105.7	17.75
	Thiamethoxam	200	16.67	11.20	109.4	18.24
8.5 insects m^{-1}01/11/05	Imidacloprid	720	16.35	11.26	99.0	16.19
	Thiamethoxam	200	16.70	11.37	102.3	17.08
15.3 insects m^{-1} 01/11/05	Imidacloprid	720	16.64	11.34	98.9	16.46
	Thiamethoxam	200	16.67	11.50	101.6	16.94
Control			16.66	11.26	84.3	14.04
5.6 insects m^{-1} - 11/12/04			16.73	11.18	107.6 a	18.00 a
8.5 insects m^{-1} - 01/11/05			16.53	11.32	100.7 b	16.63 b
15.3 insects m^{-1} -01/11/05			16.66	11.42	100.3 b	16.70 b
Imidacloprid			16.59	11.25	101.2 b	16.72 b
Thiamethoxam			16.68	11.35	104.4 a	17.42 a
F (initial infestation)			0.36^{NS}	0.56^{NS}	15.58**	8.48**
F (product)			0.19^{NS}	0.29^{NS}	7.38**	4.39*
F (product × initial infestation)			0.49^{NS}	0.03^{NS}	0.07^{NS}	0.20^{NS}
F (control × factorial)			0.01^{NS}	0.03^{NS}	135.89**	57.84**
CV (%)			3.5	3.9	3.6	5.0

^{NS}non-significant; *, **Significant at 5 and 1%, respectively.

productivities in the control treatment were significantly smaller than the average values obtained for treated plots. For experiment 1, the insecticidal treatments produced, on average, 10.3 t ha^{-1} stalks and 1.62 t ha^{-1} sucrose above the control, while in experiment 2 the insecticidal treatments produced, on average, 18.5 t ha^{-1} stalks and 3.03 t ha^{-1} sucrose above the control. These data reveal that controlling the pest resulted in productivity increases in both experiments (Tables 3 and 4), confirming the results obtained by several authors who also observed productivity increases in sugarcane fields infested with the spittlebug, as a consequence of chemical pest control (Dinardo-Miranda et al., 2001a; 2001b; 2002; 2004; 2006; Novaretti et al., 2001; Macedo et al., 2003).

Although no spittlebug infestation differences were detected between insecticides in most samplings of both experiments (Tables 1 and 2), differences were observed between them with regard to stalk and sucrose productivity in experiment 2. The thiamethoxam treatment provided stalk and consequently sucrose productivities higher than those obtained with the imidacloprid treatment. No differences were observed between insecticides in experiment 1 (Table 3). These data partially agree with those of Dinardo-Miranda et al. (2006), who worked with the same two products at the same rates employed this work and concluded that they contributed to similar productivity increases.

For both experiments, infestation at application date (initial infestation) had a great influence on stalk and sucrose productivity. For experiment 1, insecticide treatments applied under an infestation of 4.2 insects m^{-1} resulted in greater stalk productivities than for treatments in which the insecticides were applied under infestations of 7.1 and 16.3 insects m^{-1}, and greater stalk productivity than in applications made under an infestation of 16.3 insects m^{-1} (Table 3). For experiment 2, applications made under an infestation of 5.6 insects m^{-1} provided greater stalk and sucrose productivities than treatments made under higher infestations (Table 4). In addition to the initial infestation interference, however, the productivity results also received the influence of the pest attack exposure time of the crop. Because this was a field trial using natural infestations, plots that received the insecticides under heavier infestations spent more time under attack by the pest than those treated under lower infestations. The interference of this factor, however, could not be avoided because the experiment was conducted in the field; it only did not occur in experiment 2, where applications under initial infestations of 8.5 and 15.3 insects m^{-1} were made on the same day.

The data obtained in this study corroborate to observations made by Dinardo-Miranda et al. (2004), who obtained higher productivities, since a control was performed more rapidly in experiments where applications were made in several seasons. These authors concluded that sugarcane spittlebug control should be performed as early as possible, preferably at the beginning of the pest occurrence period, when no irreparable damage to the crop was caused. When control is performed late in the season, the crop would spend a long period under high infestation, suffering significant damage, with reductions in productivity even after application.

The interaction between the product and infestation at application time (initial infestation) proved to be significant for stalk productivity in experiment 1 only. Therefore, when imidacloprid was used, the treatment under infestation of 16.3 insects m^{-1} resulted in smaller productivity in relation to the other treatments. On the other hand, when thiamethoxam was used, the application under an initial infestation of 4.2 insects m^{-1} provided higher productivities than applications made under infestations of 7.1 or 16.3 insects m^{-1} (Tables 3 and 4).

From an economic point of view, *M. fimbriolata* control was more advantageous when carried out soon, as reflected by the sugarcane stalk and pol productivities observed in both experiments (Tables 5 and 6). On average (mean applications made under three pest infestation levels in both experiments), controlling the pest resulted in similar net revenues for both insecticides, US$639 for imidacloprid and US$648 per hectare for thiamethoxam.

MAIC regression lines for each insecticide due to spittlebug infestation at control time (initial infestation) were prepared for both experiments. In relation to this, the maximum infestation values attained in control plots (20.0 and 23.3 insects m^{-1} in experiments 1 and 2, respectively) were related to the MAIC obtained for the control (US$5,523 and US$4,561 per ha in experiments 1 and 2, respectively).

For experiment 1, considering the MAIC values of treatments involving imidacloprid, the following equation was obtained: $Y = 6{,}549.40 – 47.4 X$, where Y represents MAIC (US$ ha^{-1}) and X the spittlebug infestation (insects m^{-1}), with $r^2 = 0.89$. The F and p values found in the statistical analyses were 16.99 and 0.05, respectively. In the same way, for thiamethoxam treatments, the equation that best represents MAIC due to initial spittlebug infestation is given by $Y = 6{,}246.60 – 36.1 X$, with $r^2 = 0.79$, with F and p values of 7.35 and 0.10, respectively. Consequently, the significance of the data for both straight lines can be considered adequate for entomological studies (Figure 1).

According to experiment 1 and considering an insecticidal treatment cost of US$117.00 per hectare, the economic injury level of the pest would be approximately 2.5 insects m^{-1} for imidacloprid applications and 3.2 for thiamethoxam.

With respect to experiment 2, the MAIC values for imidacloprid treatments resulted in $Y = 5{,}984.4 - 57.2 X$, with $r^2 = 0.81$, and F and p values of 8.43 and 0.10, respectively. For thiamethoxam treatments,

Table 5 - Margin of agroindustrial contribution (MAIC, US\$ ha^{-1}) for different treatments, MAIC variation of treatments in relation to the control (B, US\$ ha^{-1}), cost of the insecticide treatment (C = product + application, US\$ ha^{-1}), and net revenue obtained with different treatments (B - C, US\$ ha^{-1}) in experiment 1.

Treatment	Initial infestation (application date)	MAIC	MAIC variation	Cost of treatment	Net revenue
		US\$ ha^{-1}	B, US\$ ha^{-1}	C, US\$ ha^{-1}	B-C, US\$ ha^{-1}
Imidacloprid	4.2 insects m^{-1} 11/12/04	6226	703	117	586
Thiamethoxam		6256	733	117	616
Imidacloprid	7.1 insects m^{-1} 01/11/05	6345	822	117	705
Thiamethoxam		5835	312	117	195
Imidacloprid	16.3 insects m^{-1} 01/18/05	5849	326	117	209
Thiamethoxam		5772	249	117	132
Control		5523	-	-	-

MAIC represents the difference between the expected income generated by the products and expenses in the agricultural and industrial sectors, according to Fernandes (2003). Treatment cost includes insecticide plus application.

Table 6 - Margin of agroindustrial contribution (MAIC, US\$ ha^{-1}) for different treatments, MAIC variation of treatments in relation to the control (B, US\$ ha^{-1}), cost of the insecticide treatment (C = product + application, US\$ ha^{-1}), and net revenue obtained with different treatments (B - C, US\$ ha^{-1}) in experiment 2.

Treatment	Initial infestation (application date)	MAIC	MAIC variation	Cost of treatment	Net revenue
		US\$ ha^{-1}	B, US\$ ha^{-1}	C, US\$ ha^{-1}	B-C, US\$ ha^{-1}
Imidacloprid	5.6 insects m^{-1} 11/12/04	5769	1208	117	1091
Thiamethoxam		5927	1366	117	1249
Imidacloprid	8.5 insects m^{-1} 01/11/05	5247	682	117	565
Thiamethoxam		5549	988	117	871
Imidacloprid	15.3 insects m^{-1} 01/11/05	5355	794	117	677
Thiamethoxam		5501	940	117	823
Control		4561	-	-	-

MAIC represents the difference between the expected income generated by the products and expenses in the agricultural and industrial sectors, according to Fernandes (2003). Treatment cost includes insecticide plus application.

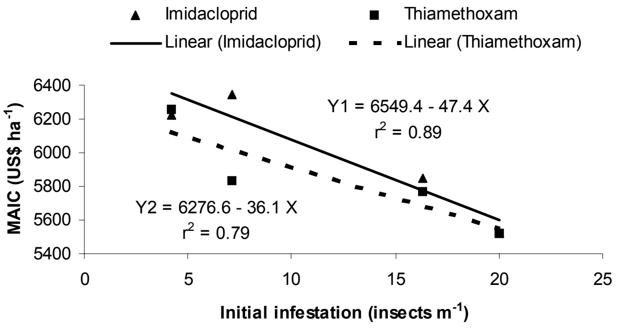

Figure 1 - Margin of agroindustrial contribution (Y = MAIC, US\$ ha^{-1}) for sugarcane variety RB855536 as a function of sugarcane spittlebug infestations at the time of chemical treatment (X, insects m^{-1}), where Y_1 (MAIC-1) is related to imidacloprid and Y_2 (MAIC-2) to thiamethoxam, all for experiment 1.

Y = 6,301.8 – 69.6 X, with r^2 = 0.89, and F and p values of 16.43 and 0.05, respectively. Consequently, the significance of the data for both straight lines can also be considered adequate for entomological studies (Figure 2). For experiment 2, considering an insecticidal treatment cost of US\$117.00 per hectare, the economic injury level of the pest would be approximately 2.0 insects m^{-1} for imidacloprid and 1.7 for thiamethoxam. These data allow the spittlebug EIL, for sugarcane harvested at the end of the cropping season (September), to be estimated between 2 and 3 insects m^{-1}.

Although changes in the prices of final products and production costs occurred in recent years, the values now obtained are very close to those found by Dinardo-Miranda (2003), who analyzed a variety

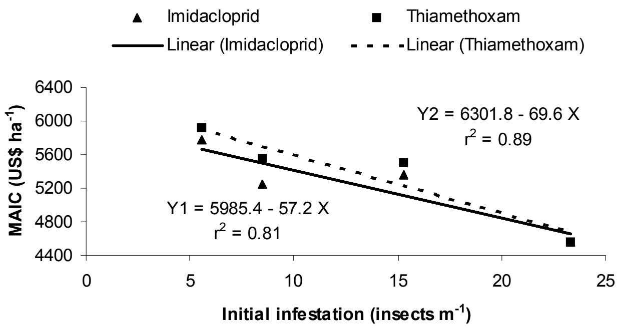

Figure 2 - Margin of agroindustrial contribution (Y = MAIC, US$ ha^{-1}) for sugarcane variety RB855536 as a function of sugarcane spittlebug infestations at the time of chemical treatment (X, insects m^{-1}), where Y_1 (MAIC-1) is related to imidacloprid and Y_2 (MAIC-2) to thiamethoxam, all for experiment 2.

of data from experimental and commercial areas and suggested that the EIL for sugarcane fields harvested at the end of the cropping season, like in the present experiment, would be around 4 leafhoppers m^{-1}. On the other hand, the values estimated in our work contradict Macedo & Macedo (2004), who concluded that the economic injury level for sugarcane spittlebug would be between 8 and 10 nymphs m^{-1}. The above-mentioned authors, however, did not provide further details on the subject, such as the sugarcane development stage to which this level was referred.

Obviously, in addition to final product prices and production costs, many factors interfere with the economic injury level determination, as discussed by Pedigo et al. (1986). Among these are plant age when injured, injury intensity, variety, and environmental conditions. Sugarcane cultivation involves ratoon fields harvested from April to November, a number of planted varieties, and quite diverse environmental conditions, which makes it a very complex task to define an EIL for the sugarcane spittlebug. However, defining an EIL is of extreme importance, given the magnitude of the pest infestation under the conditions of the State of São Paulo. The value estimated in this study, between 2 and 3 insects m^{-1}, should be appropriate for susceptible varieties, harvested at the end of the cropping season, as in the present experiment. A higher EIL value than the one established here is to be used with varieties harvested at the beginning of the cropping season, since the crop can withstand larger populations of the pest without being damaged, because it will be at a more advanced stage of development when the spittlebug occurs (Dinardo-Miranda et al., 1999; 2001a; Dinardo-Miranda, 2003).

Considering that the economic threshold is defined as "the population density at which control measures should be iniciated to prevent an increasing pest population from reaching the economic injury level" (Stern et al., 1959) and considering that the sugarcane spittlebug control is made with insecticides, with a fast initial effect, the economic threshold is similar to the economic injury levels. However, when the control is based on biologycal methods, like fungus *Metarhizium anisopliae* applications, which act slowly, the economic threshold is much lower than the economic injury level.

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