Damage caused by *Meloidogyne javanica* and *Pratylenchus zeae* to sugarcane cultivars

Leila Luci Dinardo-Miranda[1]; Juliano Vilela Fracasso[1]; Isabella Dinardo Miranda[2]

[1]Instituto Agronômico, Centro de Cana, Rodovia Antonio Duarte Nogueira, km 321, Ribeirão Preto, SP, Brazil, CEP 14001-970. [2]DMLab – Análises agrícolas e Agricultura de Precisão; Av. Patriarca, 1840; Ribeirão Preto, SP, Brasil, CEP 14031-580
Autor para correspondência: Leila Luci Dinardo-Miranda (leiladinardo@iac.sp.gov.br)
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ABSTRACT

Dinardo-Miranda, L.L.; Fracasso, J.V.; Miranda, I.D. Damage caused by *Meloidogyne javanica* and *Pratylenchus zeae* to sugarcane cultivars. ***Summa Phytopathologica***, v.45, n.2, p.146-156, 2019.

Nematodes are important parasites of sugarcane, significantly reducing the yield and the longevity of the crop. Damage caused by them varies with the susceptibility of sugarcane cultivars; thus, it is important for growers to learn the reaction of new genotypes in order to better direct control measures. The objective of this study was to evaluate the damage caused by nematodes to cultivars newly released for commercial planting. Two experiments were conducted in fields infested by *Meloidogyne javanica* and *Pratylenchus zeae*. Both experiments were arranged in split-plot randomized block design. The cultivars were planted in the plots, and two carbofuran 350SC levels, 0 and 7 L ha^{-1}, were applied on two subplots (treated and non-treated subplots). On average, the subplots treated with the nematicide had their yield increased by 10%, compared to non-treated subplots, suggesting that nematodes reduced the yield of cultivars by at least 10%, but such a reduction reached 22% for cultivar IACSP97-7569 in experiment 1 and 17% for CTC20 in experiment 2. Damage was insignificant for cultivars CTC9001, CTC9002, IACSP93-3046, IACSP95-5094, IACSP96-3060, IACSP97-4039 and RB975952 in experiment 1 and for cultivars IACSP97-4039, RB867515 and RB966928 in experiment 2. These cultivars can be considered tolerant to *M. javanica* and *P. zeae*.

Keywords: plant-parasitic nematodes, tolerance, susceptibility.

RESUMO

Dinardo-Miranda, L.L.; Fracasso, J.V.; Miranda, I.D. Danos causados por *Meloidogyne javanica* e *Pratylenchus zeae* a cultivares de cana-de-açúcar. ***Summa Phytopathologica***, v.45, n.2, p.146-156, 2019.

Nematoides são importantes parasitos da cana-de-açúcar, reduzindo significantemente a produtividade e a longevidade da cultura. Os danos causados por eles variam com a suscetibilidade da cultivar, razão pela qual é importante para os produtores conhecer a resposta dos novos genótipos, a fim de direcionar as medidas de controle. Assim, o objetivo do presente trabalho foi avaliar o dano causado por nematoides a cultivares de cana-de-açúcar recém lançadas para plantio comercial. Dois experimentos foram conduzidos em áreas infestadas por *Meloidogyne javanica* e *Pratylenchus zeae*. Ambos os ensaios foram conduzidos segundo o delineamento de blocos ao acaso, com parcelas subdivididas. As cultivares foram plantadas nas parcelas e duas doses de carbofuran 350SC, 0 and 7 L ha^{-1}, foram aplicadas às subparcelas (tratada e não tratada). Na média, subparcelas tratadas com nematicidas produziram 10 % mais que as não tratadas, sugerindo que os nematoides reduziram a produtividade das cultivares em pelo menos 10%, mas a redução atingiu 22 % na cultivar IACSP97-7569, no experimento 1 e 17 % na CTC20, no experimento 2. O dano foi insignificante nas cultivares CTC9001, CTC9002, IACSP93-3046, IACSP95-5094, IACSP96-3060, IACSP97-4039 e RB975952, no experimento 1 e nas cultivares IACSP97-4039, RB867515 e RB966928 no experimento 2. Essas cultivares podem ser consideradas tolerantes *M. javanica* e *P. zeae*.

Palavras-chave: nematoides parasitos de plantas, tolerância, suscetibilidade.

A large number of plant-parasitic nematodes are associated with sugarcane in Brazil, but *Pratylenchus zeae* Graham, *P. brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven, *Meloidogyne javanica* Treub) Chitwood and *M. incognita* (Kofoid & White) are the most important species due to the damage they cause to the crop (10, 17, 19), which varies with the occurring species, the population density, the soil type and the sugarcane cultivar (10). On average, nematodes reduce the yield by around 20 to 40% in the first cycle (plant-cane), reaching more than 50% in cases of large populations and highly susceptible cultivars. In the ratoon, the yield is also reduced, compromising the crop longevity, which needs to be renewed more frequently in infested areas (5, 8, 9, 10, 20).

Management of the infested areas is done by integrating several control tools with the aim of reducing the population of these parasites to a level lower than that capable of causing damage to the crop. Among alternatives to reduce the nematode population in sugarcane fields, at least for a few months, nematicides are undoubtedly the most used method (10).

Although the introduction of resistant cultivars is definitely one of the most useful methods to reduce nematode populations (15), cultivars resistant to at least one economically important nematode species (*M. javanica, M. incognita, P. zeae* and *P. brachyurus*) are currently scarce. Only one of the cultivars commonly planted nowadays (IACSP93-3046) is considered resistant to *M. javanica* (6). Moreover, when resistance is detected in a particular cultivar, it is usually restricted to one nematode species. As two or more nematodes frequently occur in the same field, using a cultivar that is resistant to only one nematode species is not effective (10).

In addition, the damage caused by nematodes is known to vary with the cultivar, as observed by Dinardo-Miranda et al. (6). In a field infested by *M. javanica*, those authors compared the yield of plots treated with the nematicide to that of non-treated plots and estimated that some cultivars had a yield reduction of 8% due to nematodes, while others showed no reduction.

Considering such differences among cultivars for the damage caused by nematodes, it is important for growers to learn the behavior of new cultivars to better direct control measures. Thus, the objective of this study was to evaluate the damage caused by *M. javanica* and *P. zeae* to newly released cultivars.

MATERIAL AND METHODS

Two experiments were conducted: experiment 1 was carried out in Guapiaçu, SP, Brazil (20°46'16"S and 49°08'32"W) and experiment 2 was performed in Ribeirão Preto, SP, Brazil (21°18'31"S and 47°67'12"W), both in sandy soil areas.

Both experiments were arranged in split-plot randomized block design and five (experiment 1) or six (experiment 2) replicates. A plot was represented by 12 10-m furrows spaced 1.5 m apart, and each plot was divided into two sub-plots of 6 furrows. Cultivars were planted in the plots, and two carbofuran 350SC levels, 0 and 7 L ha^{-1}, were applied on the two subplots (treated and non-treated subplots).

The following cultivars were evaluated: CTC9001, CTC9002, CTC9003, IACSP93-3046, IACSP95-5000, IACSP95-5094, IACSP96-3060, IACSP96-7569, IACSP97-4039, RB965902, RB975201, RB975242 and RB975952 in experiment 1, and CTC4, CTC20, IACSP95-5000, IACSP96-3060, IACSP96-7569, IACSP97-4010, IACSP97-4039, RB855156, RB855453, RB867515, RB966928 and SP83-2847 in experiment 2. In both experiments, IACSP95-5000 was used as a susceptible standard (10).

Planting occurred on April 4, 2015, for experiment 1, and on April 14, 2015, for experiment 2. The nematicide was applied on each furrow with a CO_2 pressurized backpack sprayer equipped with 11003 spray tip, at a working pressure of 30 PSI for a 150 L ha^{-1} flow. Immediately after nematicide application, furrows were covered with soil.

Nematode populations were evaluated on June 10, 2015, November 11, 2015, and February 5, 2016, i.e., at two, seven and ten months after planting for experiment 1, and on June 8, 2015, October 10, 2015, and January 8, 2016, i.e., at two, six and nine months after planting for experiment 2. Each of those evaluations consisted in collecting plant roots and soil from the first and sixth furrows of each subplot and extracting nematodes by combining sieving and centrifugation with sucrose solution (3, 13).

The yield of each subplot in experiment 1 was obtained on April 4, 2016, considering stalks from the second to the fifth furrow. In this case, the yield was obtained based on the biometric method described by Landell et al. (14); the yields in experiment 2 were obtained on August 10, 2016, by cutting and weighing all stalks from the second to the fifth furrow of subplots.

For statistical analysis, the population data were transformed by using the square root of (x + 1). All data were subjected to analysis of variance, and means were compared according to t test, using the SAS software program (21).

RESULTS AND DISCUSSION

Among the most important nematode species for sugarcane, *M. javanica* and *P. zeae* were identified in both experimental fields.

Two months after planting, *M. javanica* populations were small in experiments 1 and 2, considering both plant roots and soil. *P. zeae* specimens were found in all cultivars, especially in plant roots in experiment 1, but were found at a smaller number and were not obtained from soil in experiment 2, suggesting that the population was particularly small (Tables 1−4). Small nematode populations at the first sampling can be attributed to mild temperatures and low soil moisture due to low rainfall in the areas after planting (Table 5).

Nematode growth and development are directly affected by temperature (18), which also interferes in dormancy, diapause (12) and life cycle (16). In experiments 1 and 2, minimum air temperatures during the first two months after planting were near 15ºC, suggesting that the soil temperature could have reached limiting values for nematode development. However, small populations were probably due to low soil moisture. In tropical areas, as well as in the areas where the present experiments were conducted, of relatively minor seasonal temperature fluctuation, seasonal patterns of rainfall have mayor influence on nematode populations (2). Soil moisture is critical for nematode mobility and activity (22) and was extremely low in the experimental areas soon after planting due to low rainfall (Table 5).

Low temperature and soil moisture also indirectly affect nematode population by interfering in root development. During periods of low air temperatures and, consequently, low soil temperatures, root growth decreases (16, 23), hampering the growth of plant-parasitic nematodes.

On average, two months after planting, nematode populations were smaller in plant roots treated with the nematicide, compared to non-treated ones, in both experiments; however, differences between treated and non-treated subplots in relation to nematode populations were found for a few cultivars (Tables 1 and 3).

In the second sampling, at six or seven months after planting, and in the third sampling, during the rainy season – January or February, the populations of both nematode species were larger than those at the first sampling, in experiments 1 and 2. However, differences between treated and non-treated subplots were observed only for some cultivars (Tables 1−4), suggesting that the nematicide had already lost its efficiency. In experiment 1, on average, plant roots from treated subplots had more nematodes than those from non-treated subplots (Table 1), which is common in commercial areas. This is possibly due to the reduction caused by the nematicide in the nematode population, which consequently provides better root development, compared to non-treated plants; therefore, the conditions for nematode multiplication are better when the product effect ends.

Suitability of host cultivars to nematodes was evaluated by considering data from samplings in which the nematode population was large: in experiment 1, host suitability to *M. javanica* was assessed by considering data from the second and third samplings and host suitability to *P. zeae* was obtained by using data from the three samplings. In experiment 2, only data from the third sampling was considered, both to *M. javanica* and to *P. zeae.*

In experiment 1, the largest populations of *M. javanica* in roots were recorded for cultivars RB975952, RB965902 and IACSP96-3060, which were considered therefore good hosts (Table 6). The smallest population of *M. javanica* was recorded for cultivar IACSP93-3046 (Table 6), which was already reported by Dinardo-Miranda et al. (6) to be resistant to *M. javanica* under field conditions. Dinardo-Miranda and Fracasso (7), carrying out an experiment in 64-L pots, also considered IACSP93-3046 a poor host to *M. javanica* since the reproduction factor of this nematode species was lower than 1 for this cultivar.

Table 1. Population of second-stage juveniles of *Meloidogyne javanica* (Mj) and population of juveniles and adults of *Pratylenchus zeae* (Pz) in roots (50 g) of cultivars, treated (T) and non-treated (NT) with nematicide, according to sampling data in experiment 1.

Cultivar	Subplot*	June 10, 2015		November 11, 2015		February 5, 2016	
		Mj	Pz	Mj	Pz	Mj	Pz
CTC9001	T	0 a	1986 a	960 a	4940 a	80 a	7750 a
	NT	0 a	7789 b	0 a	3220 a	20 a	7040 a
CTC9002	T	0 a	2053 a	1900 a	2120 a	170 a	2490 a
	NT	0 a	2367 a	1040 a	2020 a	80 a	3030 a
CTC9003	T	20 a	4267 a	80 a	5700 a	131 a	4011 a
	NT	0 a	6103 a	140 a	3640 b	180 a	3630 a
IACSP93-3046	T	20 a	4776 a	0 a	3080 a	0 a	5640 a
	NT	0 a	5035 a	60 a	3340 a	0 a	4300 a
IACSP95-5000	T	76 a	2497 a	240 a	3640 a	110 a	2600 a
	NT	20 a	3762 a	140 a	3940 a	100 a	1510 a
IACSP95-5094	T	0 a	4710 a	900 a	3340 a	760 a	4273 a
	NT	45 a	6293 a	0 a	4500 a	150 a	4729 a
IACSP96-3060	T	0 a	3468 a	2380 a	3260 a	1672 a	2851 a
	NT	100 b	3850 a	1880 a	1260 b	1230 a	2170 a
IACSP96-7569	T	0 a	5396 a	0 a	3580 a	0 a	3130 a
	NT	0 a	3889 a	240 a	3000 a	40 a	2230 a
IACSP97-4039	T	0 a	3523 a	2040 a	3780 a	90 a	3950 a
	NT	0 a	6992 a	100 a	3460 a	60 a	4650 a
RB965902	T	0 a	3924 a	580 a	1880 a	2540 a	1390 a
	NT	85 a	2083 a	1080 a	1720 a	2400 a	1030 a
RB975201	T	21 a	3684 a	280 a	2500 a	70 a	2506 a
	NT	80 a	3401 a	1400 a	1280 a	250 a	2690 a
RB975242	T	0 a	2357 a	700 a	4120 a	1390 a	4980 a
	NT	40 a	1920 a	1220 a	2200 b	570 a	3160 b
RB975952	T	20 a	2953 a	4480 a	1720 a	722 a	3699 a
	NT	0 a	3303 a	4120 a	1640 a	720 a	2160 b
Mean	T	10 a	3408 a	1065 a	3371 a	642 a	3751 a
	NT	29 b	4824 b	849 a	2797 b	466 a	3296 b

* Treated (T) and non-treated (NT) with nematicide. Means within the same cultivar and in the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

Table 2. Population of second-stage juveniles of *Meloidogyne javanica* (Mj) and population of juveniles and adults of *Pratylenchus zeae* (Pz) in soil (1 L) of cultivars, treated (T) and non-treated (NT) with nematicide, according to sampling data in experiment 1.

Cultivar	Subplot*	June 10, 2015		November 11, 2015		February 5, 2016	
		Mj	Pz	Mj	Pz	Mj	Pz
CTC9001	T	0 a	240 a	108 a	120 a	408 a	2184 a
	NT	12 a	492 b	24 a	132 a	60 a	1758 a
CTC9002	T	12 a	156 a	36 a	60 a	168 a	576 a
	NT	0 a	204 a	0 a	48 a	36 a	480 a
CTC9003	T	36 a	336 a	0 a	84 a	0 a	1200 a
	NT	252 b	432 a	12 a	108 a	108 a	552 b
IACSP93-3046	T	12 a	264 a	0 a	132 a	0 a	1212 a
	NT	0 a	156 a	0 a	204 a	0 a	1128 a
IACSP95-5000	T	0 a	280 a	36 a	192 a	0 a	420 a
	NT	0 a	168 a	0 a	168 a	12 a	456 a
IACSP95-5094	T	0 a	396 a	0 a	84 a	300 a	780 a
	NT	0 a	360 a	0 a	288 b	48 a	1476 b
IACSP96-3060	T	12 a	276 a	420 a	48 a	1956 a	708 a
	NT	0 a	120 a	528 a	36 a	1356 a	696 a
IACSP96-7569	T	0 a	648 a	0 a	12 a	0 a	900 a
	NT	24 a	276 b	24 a	36 a	24 a	912 a
IACSP97-4039	T	0 a	228 a	0 a	120 a	48 a	804 a
	NT	0 a	204 a	0 a	108 a	0 a	1206 a
RB965902	T	0 a	408 a	36 a	60 a	2436 a	552 a
	NT	48 a	204 a	180 a	24 a	3460 a	192 b
RB975201	T	0 a	336 a	0 a	36 a	48 a	468 a
	NT	0 a	204 a	36 a	60 a	204 a	276 a
RB975242	T	0 a	156 a	180 a	72 a	372 a	1128 a
	NT	48 a	288 a	108 a	132 b	72 b	780 a
RB975952	T	0 a	360 a	24 a	24 a	828 a	1380 a
	NT	12 a	324 a	552 a	36 a	756 a	624 b
Mean	T	29 a	297 a	77 a	76 a	531 a	923 a
	NT	5 a	277 a	111 a	109 a	384 b	849 a

* Treated (T) and non-treated (NT) with nematicide. Means within the same cultivar and in the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

Table 3. Population of second-stage juveniles of *Meloidogyne javanica* (Mj) and population of juveniles and adults of *Pratylenchus zeae* (Pz) in roots (50 g) of cultivars, treated (T) and non-treated (NT) with nematicide, according to sampling data in experiment 2.

Cultivar	Subplot*	June 8, 2015		October 20, 2015		January 8, 2016	
		Mj	Pz	Mj	Pz	Mj	Pz
CTC4	T	16 a	800 a	217 a	2250 a	5317 a	4267 a
	NT	16 a	716 a	300 a	3083 a	4767 a	9600 b
CTC20	T	0 a	570 a	367 a	1583 a	1717 a	14350 a
	NT	0 a	1160 b	150 a	3467 a	2300 a	12833 a
IACSP95-5000	T	24 a	553 a	117 a	1917 a	3050 a	4900 a
	NT	0 a	1221 b	400 a	1583 a	2700 a	7617 b
IACSP96-3060	T	17 a	283 a	450 a	1816 a	3533 a	4950 a
	NT	0 a	983 b	1917 a	1500 a	4100 a	4633 a
IACSP96-7569	T	17 a	650 a	50 a	2667 a	2783 a	8383 a
	NT	133 a	1233 b	0 a	1950 a	1167 a	9983 a
IACSP97-4010	T	33 a	450 a	300 a	1533 a	6933 a	6200 a
	NT	0 a	967 b	400 a	2283 a	4800 a	13533 b
IACSP97-4039	T	0 a	1150 a	150 a	1950 a	3483 a	8766 a
	NT	0 a	817 a	250 a	2267 a	1483 b	6167 a
RB855156	T	117 a	751 a	850 a	1683 a	4783 a	6917 a
	NT	186 a	1726 b	200 b	4017 b	9250 a	9533 a
RB855453	T	50 a	516 a	333 a	1550 a	3683 a	4950 a
	NT	39 a	573 a	633 a	2767 a	5917 a	6333 a
RB867515	T	0 a	713 a	833 a	1267 a	5500 a	5250 a
	NT	33 a	1130 a	833 a	3250 b	5467 a	9950 b
RB966928	T	100 a	1000 a	1050 a	1167 a	4300 a	3867 a
	NT	67 a	650 a	517 a	1417 a	1167 b	4500 a
SP83-2847	T	0 a	1166 a	1717 a	2733 a	4500 a	6417 a
	NT	17 a	1015 a	517 b	3883 a	4500 a	9250 b
Mean	T	37 a	717 a	536 a	1843 a	4132 a	6601 a
	NT	41 a	1012 b	509 a	2605 b	3968 a	8661 b

* Treated (T) and non-treated (NT) with nematicide. Means within the same cultivar and in the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

Table 4. Population of second-stage juveniles of *Meloidogyne javanica* (Mj) and population of juveniles and adults of *Pratylenchus zeae* (Pz) in soil (1 L) of cultivars, treated (T) and non-treated (NT) with nematicide, according to sampling data in experiment 2.

Cultivar	Subplot*	June 8, 2015		October 20, 2015		January 8, 2016	
		Mj	Pz	Mj	Pz	Mj	Pz
CTC4	T	0 a	0 a	0 a	43 a	1910 a	540 a
	NT	0 a	0 a	33 b	63 a	2780 a	760 a
CTC20	T	0 a	0 a	0 a	10 a	510 a	1050 a
	NT	0 a	0 a	0 a	10 a	530 a	1280 a
IACSP95-5000	T	0 a	0 a	0 a	53 a	420 a	430 a
	NT	0 a	0 a	0 a	60 a	1810 b	960 b
IACSP96-3060	T	0 a	0 a	0 a	0 a	1700 a	210 a
	NT	0 a	0 a	0 a	90 b	2070 a	300 a
IACSP96-7569	T	0 a	0 a	0 a	76 a	950 a	1100 a
	NT	0 a	0 a	0 a	180 b	970 a	700 a
IACSP97-4010	T	0 a	0 a	0 a	33 a	1690 a	520 a
	NT	0 a	0 a	0 a	53 a	2730 a	1190 b
IACSP97-4039	T	0 a	0 a	0 a	60 a	120 a	610 a
	NT	0 a	0 a	0 a	130 a	130 a	470 a
RB855156	T	0 a	0 a	0 a	43 a	3290 a	380 a
	NT	0 a	0 a	0 a	10 a	8820 b	810 b
RB855453	T	0 a	0 a	0 a	0 a	840 a	230 a
	NT	0 a	0 a	0 a	120 b	1490 a	1020 b
RB867515	T	0 a	0 a	0 a	20 a	1740 a	440 a
	NT	0 a	0 a	0 a	180 b	2260 a	710 a
RB966928	T	0 a	0 a	0 a	0 a	1310 a	290 a
	NT	0 a	0 a	0 a	20 a	320 b	300 a
SP83-2847	T	0 a	0 a	0 a	33 a	2390 a	720 a
	NT	0 a	0 a	20 b	10 a	3280 a	630 a
Mean	T	0 a	0 a	0 a	31 a	1406 a	543 a
	NT	0 a	0 a	4 a	60 b	2267 b	760 b

* Treated (T) and non-treated (NT) with nematicide. Means within the same cultivar and in the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

Table 5. Rainfall (mm month^{-1}) and temperature means recorded during the period when experiments 1 and 2 were conducted.

Month/Year	Maximum temperature (ºC)	Minimum temperature (ºC)	Mean Temperature (ºC)	Rainfall (mm)
		Experiment 1		
April 2015	29.9	17.2	23.6	84.9
May 2015	27.9	15.8	21.8	65.9
June 2015	28.9	15.1	22.0	6.4
July 2015	28.4	15.8	22.1	24.0
August 2015	31.9	14.9	23.4	10.5
September 2015	33.1	18.6	25.9	97.8
October 2015	34.6	19.1	26.9	32.0
November 2015	32.4	20.6	26.5	135.8
December 2015	30.9	20.7	25.8	69.6
January 2016	30.8	20.8	25.9	298.5
February 2016	31.0	20.8	25.9	275.4
March 2016	31.9	20.1	26.0	162.6
April 2016	32.5	17.3	24.9	20.8
May 2016	27.7	13.9	20.8	98.2
June 2016	26.0	13.4	19.7	81.8
July 2016	29.6	10.4	20.0	0.2
August 2016	30.7	12.1	21.4	35.8
		Experiment 2		
April 2015	29.1	17.5	23.3	29.1
May 2015	25.8	14.9	20.4	94.4
June 2015	26.1	14.1	20.1	25.6
July 2015	26.3	14.3	20.3	13.6
August 2015	29.2	14.5	21.9	3.3
September 2015	30.6	17.5	24.0	93.0
October 2015	33.6	19.9	26.7	53.2
November 2015	30.5	19.7	25.1	210.3
December 2015	30.1	19.0	24.5	148.3
January 2016	28.9	20.0	24.5	356.5
February 2016	31.2	20.0	25.6	226.7
March 2016	30.0	19.5	24.8	141.0
April 2016	30.9	17.8	24.3	6.7
May 2016	26.6	14.3	20.5	98.5
June 2016	24.8	12.4	18.6	75.9
July 2016	27.8	12.4	20.1	0
August 2016	28.5	13.3	20.9	35.7

Table 6. Population of second-stage juveniles of *Meloidogyne javanica* and population of juveniles and adults of *Pratylenchus zeae* in roots (50 g) of cultivars (mean of treated and non-treated subplots) in experiment 1.

Cultivar	*Meloidogyne javanica*	*Pratylenchus zeae*
CTC9001	265 def	5454 a
CTC9002	798 bc	2347 de
CTC9003	133 def	4558 ab
IACSP93-3046	15 f	4362 ab
IACSP95-5000	148 def	2992 cd
IACSP95-5094	453 cdef	4641 ab
IACSP96-3060	1790 a	2809 cde
IACSP96-7569	70 ef	3538 bc
IACSP97-4039	573 bcde	4393 ab
RB965902	1650 a	2004 e
RB975201	500 bcde	2677 de
RB975242	970 bc	3123 cd
RB975952	2510 a	2579 de

Means within the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

Table 7. Population of second-stage juveniles of *Meloidogyne javanica* and population of juveniles and adults of *Pratylenchus zeae* in roots (50 g) of cultivars (mean of treated and non-treated subplots) in experiment 2.

Cultivar	*Meloidogyne javanica*	*Pratylenchus zeae*
CTC4	5042 a	6933 bcd
CTC20	2008 cd	13592 a
IACSP95-5000	2875 bcd	6258 bcd
IACSP96-3060	3817 abc	4792 de
IACSP96-7569	1975 d	9183 b
IACSP97-4010	5867 a	9867 b
IACSP97-4039	2483 cd	7467 bcd
RB855156	7017 a	8225 bc
RB855453	4800 ab	5642 cde
RB867515	5483 a	7600 bcd
RB866928	2733 cd	4183 e
SP83-2847	4500 abc	7833 bc

Means within the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

Table 8. Crop stand (stalks.m^{-1}), stalk weight (g), yield (ton.ha^{-1}) of each cultivar, treated (T) and non-treated (NT) with nematicide at the furrow, and yield increase (%) due to nematicide, in experiment 1.

Cultivar	Subplot*	Stand (stalks.m^{-1})	Stalk weight (g)	Yield (ton.ha^{-1})	Yield increase (%)
CTC9001	T	11.0 a	2.28 a	167 a	4
	NT	10.0 b	2.40 a	160 a	
CTC9002	T	11.1 a	1.91 a	141 a	- 4
	NT	11.6 a	1.91 a	148 a	
CTC9003	T	13.7 a	1.87 a	171 a	8
	NT	12.8 b	1.83 a	157 b	
IACSP93-3046	T	14.3 a	1.76 a	168 a	6
	NT	13.5 a	1.76 a	158 a	
IACSP95-5000	T	12.3 a	2.00 a	165 a	11
	NT	11.2 b	1.94 a	147 b	
IACSP95-5094	T	13.0 a	2.07 a	179 a	4
	NT	12.4 a	2.09 a	172 a	
IACSP96-3060	T	13.3 a	1.75 a	155 a	7
	NT	12.0 b	1.80 a	144 a	
IACSP96-7569	T	11.8 a	2.51 a	196 a	22
	NT	9.6 b	2.38 a	152 b	
IACSP97-4039	T	12.6 a	1.83 a	154 a	5
	NT	11.7 a	1.83 a	147 a	
RB965902	T	11.9 a	2.20 a	174 a	17
	NT	10.6 b	2.03 b	144 b	
RB975201	T	11.7 a	2.30 a	179 a	11
	NT	10.2 b	2.35 a	160 b	
RB975242	T	11.4 a	2.63 a	201 a	17
	NT	10.9 a	2.29 b	167 b	
RB975952	T	11.7 a	1.80 a	141 a	6
	NT	10.9 b	1.83 a	133 a	
Mean	T	12.2 a	2.06 a	169 a	10
	NT	11.4 b	2.04 a	153 b	

* Treated (T) and non-treated (NT) with nematicide. Means within the same cultivar and in the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

Although cultivar RB965902 presented one of the largest populations of *M. javanica*, it was the poorest host to *P. zeae*, which had the smallest population in this cultivar. The largest population of *P. zeae* was observed for CTC 9001 (Table 6).

In experiment 2, the populations of *M. javanica* were largest in roots of RB855156, IACSP97-4010, RB867515 and CTC4, and smallest in IACSP96-7569. Considering *P. zeae*, the population was largest in CTC20 and smallest in RB966928 (Table 7).

Although cultivar RB966928 was the poorest host to *P. zeae* in the present study, it was considered a good host to this species in studies conducted in pots by Bellé et al. (1), showing a reproduction factor of 8.5. Those authors also considered RB966928 a good host to *M. javanica*, since the reproduction factor was 36.4.

The cultivar RB966928 was also considered a good host to *M. javanica* by Dias-Arieira et al. (4) in a study using pots; the reproduction factor of *M. javanica* in roots was 2.7. Those authors also considered good hosts to *M. javanica* the cultivars CTC4, RB855156 and RB867515, which presented the largest *M. javanica* populations in experiment 2 (Table 3).

Comparing the experimental fields, nematode populations were different but, in general, the cultivars presented similar behavior. IACSP96-3060, for example, was one of the cultivars with the largest

Table 9. Yield (ton.ha^{-1}) of each cultivar, treated (T) and non-treated (NT) with nematicide at the furrow, and yield increase (%) due to nematicide, in experiment 2.

Cultivar	Subplots*	Yield (ton.ha^{-1})	Yield increase (%)
CTC4	T	122 a	16
	NT	102 b	
CTC20	T	130 a	17
	NT	108 b	
IACSP95-5000	T	104 a	13
	NT	91 b	
IACSP96-3060	T	130 a	8
	NT	120 b	
IACSP96-7569	T	128 a	12
	NT	113 b	
IACSP97-4010	T	108 a	15
	NT	92 b	
IACSP97-4039	T	111 a	4
	NT	107 a	
RB855156	T	92 a	8
	NT	85 b	
RB855453	T	114 a	8
	NT	105 b	
RB867515	T	127 a	1
	NT	126 a	
RB966928	T	116 a	2
	NT	114 a	
SP83-2847	T	106 a	11
	NT	94 b	
Mean	T	116 a	10
	NT	105 b	

* Treated (T) and non-treated (NT) with nematicide. Means within the same cultivar and in the same column, followed by the same letter, are not significantly different (t test, $p \leq 1$).

M. javanica populations in both experiments; similarly, IACSP96-7569 was one of the cultivars that presented the smallest populations of this species. The cultivar IACSP96-3060 also presented one of the smallest *P. zeae* populations in both experiments (Tables 6 and 7).

Using the nematicide improved the crop stand, increasing the number of stalks per meter of furrow for most cultivars in experiment 1, except for CTC9002, IACSP95-5094 and IACSP97-3047. For these cultivars, there was no difference between the treated and the non-treated subplots considering the crop stand (Table 8). On the other hand, stalk weight was less influenced by the use of the nematicide; the stalks of treated subplots were heavier than those of non-treated subplots only for cultivars RB965902 and RB975242 (Table 8). Therefore, these results show that, in the present study, nematodes impacted the yield especially by reducing the crop stand, expressed as number of stalks per meter. On average, subplots treated with the nematicide presented 7% more stalks (0.8 tillers.m^{-1}) than non-treated subplots (Tables 8).

For all cultivars, except CTC9002, the yield was higher in treated subplots, compared to non-treated subplots, but this difference was only significant for cultivars CTC9003, RB965902, RB975201, RB975242, IACSP95-5000 and IACSP96-7569. For these cultivars, the difference between treated and non-treated subplots varied from 8% for CTC9003 to 22% for IACSP97-3049. On average, the use of the nematicide increased the yield by 10%, suggesting that the damage caused by nematodes to sugarcane, under the conditions of experiment 1, was a reduction of at least 10% in the yield (Table 8).

The same reduction in the yield due to nematodes was observed in experiment 2, but the increase in the yield due to nematode control was not significant for cultivars RB867515, IACSP97-4039 and RB966928 (Table 9).

Since some cultivars did not show significant differences in yield between treated and non-treated subplots but, in general, presented a large population of at least one nematode species in their roots, they could be considered tolerant to nematodes, according to the criteria adopted by Dropkin and Nelson (11). In fact, the following cultivars are more tolerant to nematodes: CTC9001, CTC9002, RB975952, IACSP93-3046, IACSP95-5094, IACSP96-3060 and IACSP97-4039 (experiment 1), and RB8675-15, IACSP97-4039 and RB96-6928 (experiment 2); however, it is important to consider that even these cultivars had greater production in subplots treated with the nematicide, compared to non-treated subplots (Tables 8 and 9). This suggests that, under higher infestations, especially during the initial development of plants, damage due to nematodes could be significant. In both trials, nematode populations remained relatively small during the beginning of the crop development, as observed in the first sampling, at two months after planting. Since plants are more susceptible to the action of nematodes when they are younger, the damages would probably have been greater if the planting had been done during the rainy season, which is more favorable to a more rapid growth of nematode populations.

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