CHEMICAL CONTROL OF *PRATYLENCHUS ZEAE* IN SUGARCANE

Vinicius H. F. Abe[1*], José J. Severino[2], Jailson de O. Arieira[2], Jorge L. B. Vecchi[2], Diego B. Rodrigues[2], Marcos V. V. Vedoveto[2] e Cláudia R. Dias-Arieira[2]

[1]Post-Graduate Agronomics Program, State University of Maringa, CEP 87020-900, Maringa, PR, Brazil. E-mail: viniciushfabe@hotmail.com. [2]State University of Maringa, Umuarama Regional Campus, Department of Agriculture, 87507-190, Umuarama, PR, Brazil.

ABSTRACT**:** *The aim of this study was to investigate the effects of nematicides in the control* Pratylenchus zeae *in sugarcane. We began by determining the initial population of phytonematodes in the area. Then stalk cuttings were planted using the conventional system, and treated with Furadan 350 SC, Rugby 200 CS and Actara+Abamectin, applied to the furrow. Untreated plants were used as controls. At 60, 90, 120 and 340 days after treatment (DAT), we evaluated the number of phytonematodes in 100 cm^3 soil and 10 g root; at 30, 60 and 90 DAT, the number of tillers per meter; and at 340 DAT the estimated crop yield. Treatment with Furadan 350 SC and Rugby 200 CS produced better results in controlling the phytonematode in the soil and roots. However, treatment with Furadan 350 SC and Actara+Abamectin resulted in higher sugarcane yield.*

KEYWORDS**:** control, nematicides, root-lesion nematode, *Saccharum* spp.

CONTROLE QUÍMICO DE *PRATYLENCHUS ZEAE* EM CANA-DE-AÇÚCAR

RESUMO: *O trabalho teve como objetivo estudar o efeito de produtos químicos no controle de* Pratylenchus zeae *em área de cultivo de cana de açúcar. Inicialmente determinou-se a população inicial de fitonematoides na área. Em seguida, toletes de cana de açucar foram plantados em sistema convencional, recebendo os tratamentos, Furadan 350 SC, Rugby 200 CS, Actara+Abamectina, aplicados no sulco de plantio, usando plantas não tratadas como testemunhas. Foram amostrados o número de fitonematoides em 100 cm^3 de solo e em 10 g de raiz ao 60, 90, 120 e 340 dias após o tratamento (DAT), número de perfilhos por metro aos 30, 60 e 90 DAT e a produção estimada da cultura aos 340 DAT. Os tratamentos com Furadan 350 SC e Rugby 200 CS apresentaram melhor resultado para o controle de fitonematoide no solo e na raiz. Enquanto os tratamentos com Furadan 350 SC e Actara+Abamectina promoveram maior produtividade final da cana de açúcar.*

PALAVRAS-CHAVE**:** manejo, nematicidas, fitonematoide das lesões radiculares, *Saccharum* spp.

INTRODUCTION

In Brazil, the area of land used for cropping sugarcane is constantly expanding. The area planted with sugarcane for producing sugar and ethanol during the 2013/14 growing season is estimated at 8,799,150,000 hectares, an increase of 3.70% on the 2012/13 growing season. The major sugar-producing states in Brazil are São Paulo (51.31% of total production), followed by Goiás (9.30%), Minas Gerais (8.00%) and Parana (7.04%). Average yield for 2013/14 is estimated at 74,100 kg/ha, compared to 69,407 kg/ha for 2012/13 (Conab,

2013).

Despite the expansion of the crop, various phytosanitary problems are still limiting yield, including phytonematodes that are especially predominant in sandy, low-fertility soils. These parasites are estimated to cause losses of over 20% to Brazil's sugarcane yield. Over 275 phytonematode species of at least 48 genera have been found in the roots and rhizosphere soil in the cane crop, some of which significantly impair yields (Silveira and Herrera., 1995).

Of all the phytonematodes that attack the sugarcane crop, those that cause the biggest losses are the root-knot nematode (*Meloidogyne* Goeldi) and root-lesion nematode, especially *Pratylenchus zeae* Graham (Moura et al., 1998; Starr and Bendezu, 2002). Sugarcane parasitism by *P. zeae* has significantly impaired yields in Brazil. This nematode is a major problem because it reproduces rapidly in the host, reaching high population levels in a short time (Barros et al., 2005), with reproduction factors of over 47 under favorable conditions (Moura and Oliveira, 2009).

Pratylenchus zeae is characterized as a polyphagous nematode that infects, especially, Poaceae. It is a migratory endoparasite which penetrates the roots, destroying the root cortex. The main symptom of root parasitism is the appearance of brownish-red lesions on the roots and, in the aerial part, observed stunted plants, yellowing, and reduction in the number of tillers and the size and diameter of stems (Starr and Bendezu, 2002).

Working on low-yield sugar plantations in the state of Pernambuco, Moura and Almeida (2009) found *P. zeae* in all the samples analyzed. Surveys carried out in sugar plantations in the state of São Paulo and northeastern Parana have pointed to *Pratylenchus* as the most frequently occurring genus (Gomes and Novaretti, 1985; Severino et a., 2010), with *P. zeae* predominant and present in 85% of samples from São Paulo state (Gomes and Novaretti, 1985) and 73% of samples from Parana (Severino et al., 2010). According to Severino et al. (2010), average populations of *P. zeae* range from 68.8 to 273.9 nematodes/100 cm^3 soil. It is estimated that 100 specimens of *P. zeae* per 200 g soil before planting or 250 specimens/200 g soil during the crop cycle are sufficient to cause a significant reduction in sugarcane yield (Stirling and Blair, 2000).

One of the main problems of nematode attacks in sugarcane is the difficulty of controlling the parasite, principally because commercially available cane varieties are usually susceptible (Dinardo-Miranda, 2005; Novaretti, 1995). For this reason, the use of nematicides is the main strategy for controlling nematodes in sugarcane, resulting in significant increases in crop yield (Novaretti, 1984). In soils naturally infested with *P. zeae*, the use of nematicides can increased average yields by 8.6 t/ha (Dinardo-Miranda, 2005). Dinardo-Miranda et al.

(1998) obtained a yield increase equivalent to 41 t/ha by controlling phytonematodes in sugarcane. Moura et al. (1998) reported a significant improvement in plant development, weight and total number of stems at 60 days after application of Carbofuran.

Despite the proven efficacy of conventional nematicides for controlling phytonematodes in sugarcane, research on new chemicals is still necessary in order to reduce the selection pressure on populations resulting from the continued use of one active ingredient. Therefore, the aim of this study was to evaluate the effects of chemicals in the control of *P. zeae* in sugarcane.

MATERIALS AND METHODS

The experiment was conducted in an area of sugarcane on the Fazenda Jangada II plantation in the municipality of Alto Piquiri, Parana (26º56'35.59"S, 53º29'14,40"W) from March/2012 to February/2013, and during this period the minimum and maximum recorded temperatures were 18.6 and 29.2 ºC, with average monthly rainfall of 125.9 mm. The soil is classified as a dystrophic sandy Red Argisol (*Argissolo Vermelho*) and consists of 81% sand, 11% silt and 8% clay. It was prepared for planting and fertilized with 500 kg/ha of 08-24-24 (N-P-K), 2.00 t/ha dolomitic lime and 700 kg/ha gypsum. The soil was furrowed and planted with stalk cuttings of sugarcane cv. RB 867515.

Next, the treatments were applied: control (no chemicals); Furadan 350 SC (Carbofuran) at a concentration of 150 g ai/ha and rate of 5 L/ha, Rugby 200 CS (Cadusafos) at a concentration of 2400 g ai/ha and rate of 12 L/ha, Actara (Thiamethoxam) + Abamectin 250+400 at a concentration of 180+90 g ai/ha and rate of 720+225 g/ha. All treatments were applied in the furrow over the stalk cuttings, using a flat nozzle pressurized sprayer (50 cm spray), and the furrows were then closed over. The following weather conditions were recorded during application of the treatments: temperature 26.7ºC, RH 57%, NW wind at 10 km/h and little cloud cover.

The experimental design consisted of randomized blocks with four treatments and five replications. Each plot consisted of six furrows 10 meters long, spaced at 1.5 m. A border was formed by the row of plants at the edges of the plots, and a 1-meter section at the beginning and end of each row.

Chemicals were not applied to control pests and diseases in the experimental area, but weeds were controlled by applying 0.3 kg/ha of Provence 750WG, 1.8 L/ha of Volcane, 5.0 L/ha of Ametryn and 0.07 L/ha of Aurora.

At the time of planting, soil samples were taken from each plot for determining the

initial nematode population (Pi). We subsequently evaluated the number of *P. zeae* per 10 g root and 100 cm^3 soil at 60, 90 and 120 days, and then the number of *P. zeae* per 10 g root at 340 days. For all evaluation, each sample obtained from the plots was composite to four subsamples. For nematodes extraction of the soil and roots, we used the methods proposed by Jenkins (Jenkins, 1964) and Coolen and D´Herde (Coolen et al.,1972), respectively. The samples obtained were examined under an optical microscope on a counting Peter's slide. The following vegetative growth parameters were evaluated: number of tillers per meter at 30, 60 and 90 DAT, and average sugarcane yield (t/ha) at 340 DAT.

The results were subjected to analysis of variance and the means compared using the Duncan test at 5% probability. For analysis, the data were transformed by $\sqrt{(x+1)}$.

RESULTS AND DISCUSSION

Treatment with Furadan and Rugby reduced the number of *P. zeae* in the soil and roots by 120 DAT (Table 1). However, at the end of the cycle, none of the chemical products differed statistically from the control. These results could be caused by the short residual effect of the products, which is on average four months (Novaretti et al., 1995). Furthermore, the preciptation was high during the initial months, ranging from 81.2 mm in February to 188.8 mm in May, which could have leached the products, as observed in an earlier study by Novaretti et al. (1984).

The efficacy of nematode chemical control in sugarcane has been shown by various experiments. Evaluating nematicides Terbufos 5G and Carbofuran 5G in the control of sugarcane nematodes, Novaretti et al. (1995) reported that Carbofuran 5G was better at controlling *Meloidogyne* and *Paratrichodorus* Siddiqi, with a residual effect of four months on the soil and six months on the plant. Terbufos 5G significantly reduced the population of both nematodes and satisfactorily controlled *Pratylenchus* Filipjev and *Helicotylenchus* Steiner.

Table 1 - Population of *Pratylenchus zeae* in 100 cm^3 soil and 10 g root of sugarcane subjected to different chemical treatments

Treatment	Initial Pop.	60 Days	90 Days	120 Days	340 Days
		Nematodes in 100 cm^3 soil			
Control	18.6^{ns}	126.4 ab	55.8^{ns}	37.0 ab	-
Furadan 5000 mL	53.6	58.6 b	38.4	15.2 b	-
Rugby 12000 mL	25.4	48.8 b	71.6	20.4 b	-
Actara+Abamectin	114.4	438.8 a	67.4	49.6 a	-
CV (%)	38.2	27.9	25.8	28.6	
		Nematodes in 10 g root			
Control	-	2354.0 ab	2414.0 a	1428.0 a	1022.0^{ns}
Furadan 5000 mL	-	112.0 b	584.0 b	392.0 b	903.0
Rugby 12000 mL	-	244.0 b	632.0 b	804.0 b	917.0
Actara+Abamectin	-	4008.0 a	2044.0 a	1030.0 ab	1072.0
CV (%)		23.4	22.8	26.6	19.8

ns = not significant. Means followed by the same letter in the columns did not differ in the Duncan test at 5% probability. Original data were transformed by $\sqrt{(x+1)}$ for statistical analysis.

Dinardo-Miranda and Garcia (2002) showed that Aldicarb and Carbofuran significantly reduced the population of *P. zeae* when were applied 40 or 60 days after the cane cut. This nematode was also controlled 72 days after applying Carbofuran to cane grown in sandy loam soil (Dias-Arieira et al., 2010). Earlier, Novaretti et al. (1984) had concluded that Furadan 5G at a rate of 60 kg/ha significantly reduced the population of *Meloidogyne javanica* (Treub) Chitwood and *P. zeae*, especially in the first months after application.

There was no statistical difference in the number of tillers at 60 and 90 DAT (Table 2). However, the Furadan and Actara+Abamectin treatments increased the yield by 22.00 and 25.17%, respectively, compared to the control (Table 2). According to experiments conducted by Dinardo-Miranda (2001) in areas of low phytonematode population, Carbofuran increased yield by 7.8%. As the nematode populations were low, the author attributed the results to the direct effect of the product on the plants (phytotonic effect) and a reduction in the phytopathogenic microorganisms in the soil.

Table 2 - Number of tillers 30, 60 and 90 days after treatment (DAT), yield (t/ha) and percentage increase in yield (compared to the control) of sugarcane subjected to different nematocide treatments

Treatment	Tillers 30 DAT	Tillers 60 DAT	Tillers 90 DAT	Yield (t/ha)	% increase
Control*	15.80 b	20.00^{ns}	15.10^{ns}	73.83 b	-
Furadan 5000 mL	18.00 a	18.90	14.40	90.07 a	22.00
Rugby 12000 mL	16.20 ab	18.40	15.90	75.33 b	2.03
Actara+Abamectin	15.40 b	20.40	15.70	92.41 a	25.17
CV (%)	14.5	16.2	15.8	15.2	-

ns = not significant. Means followed by the same letter in the columns did not differ in the Duncan test at 5% probability. Original data were transformed by √(x+1) for statistical analysis.

In a study conducted by Sudararaj and Metha (Sundararaj and Metha, 1994), was observed that an increase in the initial population of *P. zeae* proportionally reduced the sugarcane yield inside the experimental units. When the initial population increased from 100 to 1,000 specimens, the weight of sugarcane reduced by between 22.2 and 38.7 %, depending on the cultivar. Therefore, the use of nematicides is probably a good short-term solution, increased considerably the yields (Dinardo-Miranda and Garcia, 2002; Novaretti et al.,1984).

According to Dinardo-Miranda (2005), the increase in yield produced by using nematicides varies according to the plant variety, phytonematode population level and soil type. Dinardo-Miranda (2001) observed that Carbofuran produced an average increase of 30% compared to plots not treated with nematicide in areas with high populations of *Meloidogyne incognita* (Kofoid and White) Chitwood. The increase varied according to the plant variety, and was around 40 t/ha for varieties such as RB72454, RB785148, RB835486 and RB845257. According to Novaretti et al. (1985), the use of nematicides in areas infested with *M. incognita* produced average yield increases of 50%, with peak at 118% for the SP71-799 variety.

Applying Aldicarb 150G at a rate of 12 kg/ha increased yields of the IAC86-2480 cultivar by 17.3 t/ha and IAC91-5155 by 38.1 t/ha (Dinardo-Miranda and Garcia, 2002). Novaretti et al. (1985) observed that applying Carbofuran 5G controlled the population of nematodes in the soil for four months and, after this period, the population began to increase again, but the yield of the treated plot was 26.51 t/ha higher than that of the non-treated plot.

Despite the impressive results obtained in this and other studies, various authors think it necessary to use an integrated management system for efficiently controlling these phytopathogens, since nematode populations rapidly recover and new methods are required to protect the ratoons (Barros et al., 2000; Chaves et al., 2002; Dinardo-Miranda, 2005; Moura, 2005).

CONCLUSION

Furadan 350 SC and Rugby 200 CS controlled *P. zeae* up to 120 DAT. Yield was increased by treatment with Furadan and Actara+Abamectin.

REFERENCES

BARROS, A.C.B.; MOURA, R.M.; AND PEDROSA, E.M.R. Aplicação de Terbufós no controle de *Meloidogyne incognita* raça 1 e *Pratylenchus zeae* em cinco variedades de cana-de-açúcar no Nordeste. Parte 1 – Efeitos na Cana Planta. **Nematologia Brasileira**, Brasília, v.24, n.1, p.73-78, 2000.

BARROS, A.C.B.; MOURA, R.M.; PEDROSA, E.M.R. Estudo de interação variedade-nematicida em cana-de-açúcar em solo naturalmente infestado por *Meloidogyne incognita*, *M. javanica* e *Pratylenchus zeae*. **Nematologia Brasileira**, v.29, n.1, p.39-46, 2005.

CHAVES, A.; PEDROSA, E.M.R.; MELO, L.J.O.T. Efeito do carbofuran, torta de filtro e variedades sobre a densidade populacional de fitonematóides em áreas com mau desenvolvimento da cana-de-açúcar. **Nematologia Brasileira**, Brasília, v.26, n.1, p.167-176, 2002.

CONAB. **Acompanhamento da safra brasileira: cana-de-açucar. Safra 2013/2014**. Companhia Nacional de Abastecimento, Brasília, DF. Disponível em: http://www.conab.gov.br/OlalaCMS/uploads/arquivos/13_08_08_09_39_29_boletim_cana_portugues_-_abril_2013_1o_lev.pdf, 2013.

COOLEN, W.A.; D'HERDE, C.J.A. **Method for the quantitative extraction of nematodes from plant tissue**. Ghent, Belgium. State Nematology and Entomology Research Station, 1972. . 77p

DIAS-ARIEIRA, C.R.; SANTANA, S.M.; ARIEIRA, J.O.; RIBEIRO, R.C.F.; VOLK, L.B.S. Efeito do carbofurano na população de nematoides e no rendimento da cana-de-açúcar em solos arenosos do Paraná. **Nematologia Brasileira**, Piracicaba, v.34, n.2, p.118-122, 2010.

DINARDO-MIRANDA, L.L. Efeito de Carbofuran sobre a cana-de-açúcar infestada ou não por nematóides. **Summa Phytopathologica**, Botucatu, v.27, n.4, p.436-438, 2001.

DINARDO-MIRANDA, L.L. Manejo de nematoides em cana-de-açúcar. **Jornal Cana**, Ribeirão Preto, p.64-69, 2005.

DINARDO-MIRANDA, L.L.; GARCIA, V. Efeito da época de aplicação de nematicidas em soqueiras de cana-de-açúcar. **Nematologia Brasileira**, Brasília, v.26, n.2, p.177-180, 2002.

DINARDO-MIRANDA, L.L.; MENEGATTI, C.C.; GARCIA, V.; SILVA, S.F.; ODORISI, M. Reação de variedades de cana-de-açúcar a *Pratylenchus zeae*. **STAB - Açúcar, Álcool e Subprodutos**, Piracicaba, v.17, n.2, p.39-41, 1998.

DINARDO-MIRANDA, L.L.; GARCIA, V.; PARAZZI, V. Efeito de inseticidas no controle de *Mahanarva fimbriolata* (Stal) (Hemiptera: Cercopidae) e de nematóides fitoparasitos, na qualidade tecnológica e na produtividade da cana-de-açúcar. **Neotropical Entomology**, Londrina, v.3, n.4, p.609-614, 2002.

DINARDO-MIRANDA, L.L.; GIL, M.A.; GARCIA, V.; COELHO, A.L. Atividade de variedades de cana-de-açúcar em plantio de ano com nematicidas em área infestada por *Pratylenchus zeae*. **Nematololologia Brasileira**. v.28, p.23-26, 2004.

GOMES, R.S.; NOVARETTI, W.R.T. Levantamento de nematóides parasitos da cana-de-açúcar na usina Bonfim. **Sociedade Brasileira de Nematologia**, Piracicaba, v.9, p.135-141, 1985.

JENKINS, W.R. A rapid centrifugal-flotation technique for separating nematodes from soil. **Plant Disease Reporter**, v.48, n.9, p.692, 1964.

MOURA, R.M. Controle integrado dos nematóides da cana-de-açúcar no Nordeste, Brasil. In: CONGRESSO BRASILEIRO DE NEMATOLOGIA, 25, 2005, Piracicaba. **Anais**. Piracicaba: SBN, p.49-55, 2005.

MOURA, R.M.; ALMEIDA, A.V. Estudos preliminares sobre a ocorrência de fitonematóides associados à cana-de-açúcar em áreas de baixa produtividade agrícola no estado de Pernambuco. In: REUNIÃO BRASILEIRA DE NEMATOLOGIA, 5, 1981, Piracicaba. **Anais.** Piracicaba: SBN, p.213-220.

MOURA, R.M.; OLIVEIRA, I.S. Controle populacional de *Pratylenchus zeae* em cana-de-açúcar em dois ambientes edáficos no Nordeste do Brasil. **Nematologia Brasileira**, Piracicaba, v.33, n.1, p.67-73, 2009.

MOURA, R.M.; MACEDO, M.E.A.; SILVA, E.G.; SILVA, I.P.. Efeito da aplicação de carbofuran em cana-de-açúcar variedade CB45-3. **Fitopatologia Brasileira**, Brasília, v.23, n.4, p.503, 1998.

MOURA, R.M.; PEDROSA, E.M.R.; MARANHÃO, S.R.V.L.; MACEDO, M.E.A.; SILVA, E.G.; LIMA, R.F. Ocorrência dos nematóides *Pratylenchus zeae* e *Meloidogyne* spp. em cana-de-açúcar no nordeste do Brasil. **Fitopatologia Brasileira**, Brasília, v.25, n.1, p.101-103, 2000.

NOVARETTI, W.R.T.; NELLI, E.J.; DINARDO-MIRANDA, L.L.; CARDERAN, J.O. Influência da época de plantio da cana-de-açúcar no controle químico de nematóides. **Nematologia Brasileira**, Piracicaba, v.8, p.218-231, 1984.

NOVARETTI, W.R.T.; CARDERÁN, J.O.; TOTINO, L.C. Efeito fitotóxico do EDB em cana-de-açucar. **Nematologia Brasileira**, Piracicaba, v.9, p.153-160, 1985.

NOVARETTI, W.R.T.; NELLI, E.J.; CARDERÁN, J.O. Testes de novos nematicidas em cana-de-açúcar. **Nematologia Brasileira**, Piracicaba, v.19, p.123-133, 1995.

SANTOS, D.A.; DIAS-ARIEIRA, C.R.; SOUTO, E.R.; BIELA, F., CUNHA, T.P.L.; ROGERIO, F.; SILVA, T.R.B.; MILANI, K.F. Reaction of sugarcane genotypes to *Pratylenchus brachyurus* and *P. zeae.* **Journal of Food, Agriculture & Environment**, Helsinki, v.10, n2, p.585-587, 2012.

SEVERINO, J.J.; DIAS-ARIEIRA, C.R.; TESSMANN, D.J. Nematodes associated with sugarcane (*Saccharum* spp.) in sandy soils in Paraná, Brazil. **Nematropica**, Auburn, v.40, n.1, p.111-124, 2010.

SILVEIRA, D.; HERRERA, O.J. Principales problemas nematologicos de cuba. In: CONGRESSO INTERNACIONAL DE NEMATOLOGIA TROPICAL, 1995, Rio Quente. **Anais**. Rio Quente: ONTA/SBN, p.165-171.

STARR, J.J.; BENDEZU, I.F. Ectoparasitos nematodes. In: STARR, J.L.; COOK, R.; BRIDGE, J. (Eds). Plant Resistance to Parasitic Nematodes. Cambridge: **CABI Publishing**. p.229-239, 2002.

STIRLING, G.R.; BLAIR, B. Nematodes. In: ROTT, P.; BAILEY, R.A.; COMSTOCK, J.C.; CROFT, B.J.; SAUMTALLY, A.S. (eds). A Guide to Sugarcane Diseases. Montpellier: CIRAD/ISSCT, **CIRAD Publications Service**. p.299-305, 2000.

SUNDARARAJ, P.; METHA, U.K. Influence of the lesion nematode, *Pratylenchus zeae*, on yield and quality characters of two cultivars of sugarcane. **Nematologia Mediterranea**, Bari, v.22, n.1, p.65-67, 1994.