

RESEARCH/INVESTIGACIÓN

CROP ROTATION FOR *PRATYLENCHUS BRACHYURUS* CONTROL IN SOYBEAN

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ABSTRACT

Rodrigues, D. B., C. R. Dias-Arieira, M. V. V. Vedoveto, M. Roldi, H. F. D. Molin, and V. H. F. Abe. 2014. Crop rotation for *Pratylenchus brachyurus* control in soybean. *Nematropica* 44:146-151.

In recent years, the root-lesion nematode (*Pratylenchus brachyurus*) has been responsible for damage and economic losses in various crops and numerous regions throughout Brazil. The aim of this study was to evaluate the effects of succession cropping on the population of *P. brachyurus* in soybean. Two experiments were carried out in the greenhouse, using soil naturally-infested with nematodes and the following cropping sequence: soybean (90 d)-treatment (60 d)-soybean (60 d). The treatments were soybean (control), maize, brachiaria grass, intercropped maize-brachiaria, crotalaria, oilseed radish, stylosanthes, and fallow. In the first experiment, the nematode population under brachiaria and intercropped maize-brachiaria was lower than with maize and soybean, but in the second experiment, there was no statistical differences compared to maize. Crop succession with crotalaria, oilseed radish, stylosanthes and fallow promoted the greatest reductions in the population of *P. brachyurus*.

Key words: brachiaria, crotalaria, oilseed radish, root-lesion nematode, stylosanthes.

RESUMO

Rodrigues, D. B., C. R. Dias-Arieira, M. V. V. Vedoveto, M. Roldi, H. F. D. Molin, e V. H. F. Abe. 2014. Sucessão de culturas no manejo de *Pratylenchus brachyurus* em soja. *Nematropica* 44:146-151.

Nos últimos anos, os nematoides das lesões radiculares, *Pratylenchus brachyurus*, têm causado danos elevados e perdas econômicas em diversas culturas, em várias regiões brasileiras. Portanto, o trabalho teve como objetivo avaliar o efeito de plantas usadas em sucessão com a soja sobre a população de *P. brachyurus*. Dois experimentos foram conduzidos em casa de vegetação, com solo naturalmente infestado pelo nematoide, usando a sequência de cultivo: soja (90 dias)-tratamento (60 dias)-soja (60 dias). Os tratamentos avaliados foram soja (testemunha), milho, braquiária, consórcio milho-braquiária, crotalária, nabo forrageiro, estilosantes e pousio. No primeiro experimento, a população do nematoide nos tratamentos braquiária e consórcio milho-braquiária foram inferiores ao milho e à soja, porém no segundo experimento não diferiram estatisticamente do milho. A sucessão de culturas com crotalária, nabo forrageiro, estilosantes e pousio promoveram as maiores reduções na população de *P. brachyurus*.

Palabras clave: braquiária, crotalária, estilosantes, nabo forrageiro, nematoide das lesões radiculares.

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the most crucial crop species in the Brazilian economy because it is easy to grow and its products and derivatives have a wide range of uses (Paiva *et al.*, 2006). In Brazil, soybean production is characterized as monoculture, which causes some phytosanitary problems, such as increased infestation by pathological agents. Around 50 types of pathogens have already been recorded as causing economic

damage to the crop (Yorinori, 2002), and one of the major is the nematode, which causes losses that are increasing annually (Alves *et al.*, 2011).

Pratylenchus brachyurus (Godfrey) Filipjev and Schuurmans Steekhoven is currently the most important nematode species in soybean production regions of Brazil with high populations impairing yields by 30 to 50% (Ferraz, 2006; Inomoto, 2011). Nematode control is a complex problem demanding an integrated management strategy. One technique for sustainable management and damage limitation is

crop rotation or succession planting using nematode-resistant species (Ferraz, 2006; Inomoto, 2011). The use of non-host or nematode-antagonistic plants is seen as an important strategy since, in addition to reduced nematode populations, they help improve the physical and chemical properties of the soil (Souza and Pires, 2007).

Intercropping maize (*Zea mays* L.) with forage species is one alternative for maintaining crop profitability, increasing residues and nutrients in the soil, and generating a higher economic return in short-growing-season soybean-maize succession (Cecon, 2007). Grasses used as forage can be a viable alternative for rotation with soybean since livestock farming provides a sound alternative for many soybean growers suffering from nematode problems (Valle *et al.*, 1996). However, the reproduction factor of *P. brachyurus* in *Brachiaria brizantha* (Hochst. ex Rich.) Stapf, which is usually used to integrate cropping and livestock farming, is higher than one (Inomoto *et al.*, 2007; Dias-Arieira *et al.*, 2009). According to Gallaher *et al.* (1988), depending on the level of susceptibility of cover plants to this type of pathogen, the population can increase to densities that can harm the summer crop.

Other species such as stylosanthes (*Stylosanthes capitata* Vog.+ *Stylosanthes macrocephala* Ferreira and Costa) and oilseed radish (*Raphanus sativus* L. var. *oleiferus* Metzg.) are cited as poor hosts of *P. brachyurus* (Carvalho *et al.*, 2010; Chiamolera *et al.*, 2012) and need to be studied in relation to crop succession. Therefore, the aim of this study was to evaluate the effects of soybean succession plants on the reproduction of *P. brachyurus*.

MATERIALS AND METHODS

Two experiments were conducted in the greenhouse at the State University of Maringá, Umuarama Regional Campus (23°47'28.46"S, 53°15'23.46" W, altitude approximate of 430 m) at different times of year: experiment 1 from November 2011 to June 2012 (average minimum and maximum temperatures: 19.0 and 29.3°C) and experiment 2 from July 2012 to February 2013 (average minimum and maximum temperatures: 19.2 and 30.4°C).

The experimental design was fully randomized with eight treatments and eight replications consisting of: soybean cv. BMX Potência RR, used as a control; maize hybrid DKB 399 PRO; brachiaria (*B. brizantha* cv. Piaã); intercropped maize-brachiaria; crotalaria (*Crotalaria juncea* L.); oilseed radish; stylosanthes cv. BRS Campo Grande II (*S. capitata*+ *S. macrocephala*, 80+20%), and fallow.

Initially, soil naturally infested with *P. brachyurus* (identified using the taxonomic keys proposed by Frederick and Tarjan (1989) and Nickle (1991)), obtained from a soybean and maize cropping area and classified as a typical dystrophic Red Oxisol (Latossolo

Vermelho) (81.9% sand; 3.4% silt; 14.7% clay), was homogenized and placed in 4-L pots in which 3 soybean cv. BMX Potência RR seedlings were grown for 90 d. The shoot was then discarded and the roots removed, gently washed, chopped into 2-cm pieces, and placed in 1,000-L fiber boxes, filled with soil. The roots and soil were then carefully homogenized, removing eight soil samples of 100 cm³ for determining the initial nematode population and confirming homogenization of the substrate. Nematodes were extracted from soil using the methods described by Jenkins (1964). The figures for initial populations were 477 and 882 *P. brachyurus* specimens/100 cm³ soil for experiment 1 and experiment 2, respectively.

The soil was redistributed in pots, and the plant species used as treatments were sown using soybean as the control. Two seeds were planted in each pot, and the pots were thinned to leave one plant per pot. After 60 d, the plant shoots were collected, chopped into 2-cm pieces, and used as soil cover. The root system remained in the pots and the superficial layer (10 cm) was turned over before depositing the cover material. Soybean was then sown and left to grow for a further 60 d. Due to the underdevelopment of the plants in experiment 1, the soil was corrected with 3 g/pot (1,500 kg/ha) dolomitic calcareous and 1 g/pot (500 kg/ha) phosphorus prior to soybean planting in experiment 2.

After 60 d, the plants were collected for vegetative parameter analysis: plant height, shoot and root fresh weight, and shoot dry weight (after drying in a fan oven at 65°C until the weight remained constant); the nematological parameters analyzed were: number of nematodes in the roots, subsequently divided by the root fresh weight to obtain nematodes per gram of root, and the number of nematodes in 100 cm³ soil. The nematodes were extracted from the roots and soil (100 cm³) using the methods proposed by Coolen and D'Herde (1972) and Jenkins (1964), respectively. Nematodes were counted on Peters plates under an optical microscope.

Analysis of variance was performed. For analysis, the data was transformed by square root (x+1), and the Tukey test at 5% significance was used for comparing means.

RESULTS

Plant height was greater than the control after maize-brachiaria and brachiaria alone in experiment 1 (Table 1). In experiment 2, the treatments did not differ statistically from the control (Table 1). The fresh and dry weights of the soybean shoots in experiment 1 were statistically higher for the maize-brachiaria, brachiaria, crotalaria, stylosanthes, and fallow treatments. However, the results of experiment 2 were different, with higher fresh weight for soybean grown after stylosanthes, maize and fallow, and higher dry weight for succession planting with maize and

Table 1. Average height and shoot fresh (SFW) and dry (SDW) weight of soybean grown after species recommended for succession planting in soil naturally infested with *Pratylenchus brachyurus* in two separate experiments.

Treatment	Experiment 1			Experiment 2		
	Height (cm)	SFW (g)	SDW (g)	Height (cm)	SFW (g)	SDW (g)
Maize+brachiaria	56.25 a	9.80 a	2.50 a	71.50 ab	50.55 c	26.56 ab
Brachiaria	55.00 a	5.88 b	1.53 b	77.50 ab	55.89 c	20.20 b
Crotalaria	50.25 ab	5.44 b	1.37 b	83.87 a	60.72 bc	18.96 b
Oilseed radish	44.38 b	3.44 c	0.92 c	73.24 ab	74.80 ab	27.68 ab
Stylosanthes	53.88 ab	5.66 b	1.40 b	82.63 a	78.58 a	21.78 b
Fallow	46.62 ab	5.70 b	1.46 b	68.75 b	84.48 a	31.63 a
Maize	50.25 ab	4.69 bc	1.18 bc	85.00 a	79.23 a	36.82 a
Soybean	45.12 b	3.77 c	0.92 c	72.50 ab	66.40 bc	22.02 b
CV (%)	8.37	13.91	13.42	10.72	14.95	15.31

Means followed by the same letter in the columns did not differ in the Tukey test at 5% probability
Data were transformed by $\sqrt{(x+1.0)}$ for statistical analysis

Table 2. Average soybean root fresh weight (RFW), nematodes per gram of root and nematodes per 100 cm³ soil after the species recommended for the succession planting in soil naturally infested with *Pratylenchus brachyurus* in two separate experiments.

Treatment	Experiment 1			Experiment 2		
	RFW (g)	Nematodes		RFW (g)	Nematodes	
		g root	100 cm ³		g root	100 cm ³
Maize+brachiaria	7.89 a	99.34 b	26.75 ab	49.34 a	208.00 b	36.87 ab
Brachiaria	4.07 c	117.15 b	23.13 ab	41.89 ab	216.28 b	33.75 ab
Crotalaria	5.91 ab	19.86 c	0.00 b	37.45 b	48.58 c	3.37 c
Oilseed radish	4.93 bc	56.53 bc	11.63 b	48.94 a	103.29 c	18.37 bc
Stylosanthes	4.87 bc	34.26 c	0.00 b	48.41 a	45.03 c	6.87 c
Fallow	7.07 a	15.96 c	0.00 b	51.68 a	24.00 c	3.50 c
Maize	3.62 c	193.98 a	49.75 a	46.76 a	267.30 b	49.62 a
Soybean	3.98 c	233.24 a	30.50 ab	43.70 ab	681.92 a	68.75 a
CV (%)	21.12	23.46	24.35	19.23	22.74	20.86

Means followed by the same letter in the columns did not differ in the Tukey test at 5% probability
Data were transformed by $\sqrt{(x+1.0)}$ for statistical analysis

fallow (Table 1). In general, experiment 1 showed poorer plant development for soybean in succession with oilseed radish (Table 1).

The maize-brachiaria, crotalaria, and fallow treatments increased soybean root fresh weight in experiment 1 compared to continuous soybean cropping; whereas in experiment 2, none of the treatments differed statistically from the control (Table 2). In experiment 1, with the exception of maize, all treatments significantly reduced the number of nematodes per gram of soybean root by comparison with the control. The lowest means were observed for

crotalaria, stylosanthes and fallow treatments (Table 2). In experiment 2, all treatments controlled the nematodes by comparison with continuous soybean cropping. In succession with maize, brachiaria and maize-brachiaria, the means were lower than for continuous soybean planting but higher than for the other treatments (Table 2).

In terms of the root-lesion nematode population density in soil, none of the treatments differed statistically from the control in experiment 1. In experiment 2, crotalaria, oilseed radish, stylosanthes, and fallow significantly reduced the number of

nematodes (Table 2).

DISCUSSION

In these experiments, considerable variability was noted among the rotation plants that stimulated higher vegetative development of soybean. For instance, intercropped maize-brachiaria increased soybean development in experiment 1, but not in experiment 2.

Various factors, such as the time of year at which the experiments were conducted, may have influenced these results. In experiment 1, the soybean growing period terminated in winter when the average temperature over the final 60 d of the study was 19.7°C. During this period, there was also a shorter photoperiod. Both of these factors could have impaired plant development. These conditions were not present in experiment 2 because the soybean was grown during the summer with an average temperature over the 60 d growth period of 31.7°C, and longer photoperiod – conditions that are optimal for crop development (Martins *et al.*, 1999; Peixoto *et al.*, 2000). Another factor that could have contributed to the differences observed was the fertilizer applied in the second experiment, which would naturally have increased soybean plant development.

In experiment 1, the soybean grown in succession with oilseed radish showed the least growth. Tokura and Nóbrega (2002) observed allelopathic effects of oilseed radish extracts on soybean development. The fact that this effect was not repeated in the second experiment could be due to the higher temperatures, which may have accelerated the decomposition of the plant residues, so that the soybean was not adversely affected.

The nematode parameters that were measured confirmed the potential of crop succession for controlling *P. brachyurus*. In experiment 1, brachiaria grown on its own or intercropped with maize significantly reduced the nematode population compared to maize and soybean. In experiment 2, despite the absence of a significant difference for the maize, mean nematode population was numerically lower than that of the soybean. Similar results were obtained by Inomoto *et al.* (2007) and Dias-Arieira *et al.* (2009), who reported that, despite the fact that *P. brachyurus* reproduced in *B. brizantha*, the reproduction factor (RF) was significantly lower than for soybean.

Intercropping maize and brachiaria is an important activity during the short growing season in Brazil (Ceccon, 2007) and is possible due to the difference of time and space between the two species in the accumulation of biomass. The brachiaria does not adversely impact maize yield when the system is properly deployed (Borghi and Crusciol, 2007). However, in areas with high population density of *P. brachyurus*, intercropping must be used with care, since nematodes benefit from succession planting of

host plants. This is the case in western-central Brazil where soybean and maize are cropped in succession or maize is intercropped with brachiaria. The no-tillage system adopted in these cases can increase the population of *P. brachyurus* in crops such as soybean (Inomoto *et al.*, 2008).

It is important to note that brachiaria species vary in susceptibility to root-lesion nematodes, and *B. brizantha* has been cited as the main host of *P. brachyurus* (Inomoto *et al.*, 2007). The same authors reported that *Brachiaria humidicola* (Rendle) Schweickt and *B. dyctioneura* (Fig. and De Not.) were poor hosts for this nematode and, therefore, might be good alternatives for cropping in areas with high nematode populations.

The use of crotalaria for controlling nematodes is already known and has been tested in various pathosystems involving *Meloidogyne* spp. (Inomoto *et al.*, 2006; Charchar *et al.*, 2009; Santana *et al.*, 2012a), *P. zaeae* Graham (Santana *et al.*, 2012b) and *P. brachyurus* (Inomoto *et al.*, 2006; Machado *et al.*, 2007). In our study, crotalaria suppressed nematode populations in both root and soil. However, Machado *et al.* (2007) emphasizes that, although it is not a good host, *C. juncea* can induce a slight increase in the nematode population with an RF higher than 1. Additional field studies are therefore needed in areas with varying levels of nematode populations.

In both our experiments, oilseed radish significantly reduced the nematode population by comparison with soybean and maize. Similarly, Chiamolera *et al.* (2012) reported that planting oilseed radish in the short growing season reduced the population of *P. brachyurus* in maize with RF < 1 in a field trial and an RF of 1.07 in the greenhouse. According to Brown and Morra (1997), it is possible that the mechanism for the action of oilseed radish and other brassicas is a combination of the capacity of these species to act as traps and the release of nematotoxins (mainly isothiocyanates) via root exudates or during decomposition.

Stylosanthes produced promising results, reducing nematode populations in both experiments. Santos *et al.* (2011) reported that *S. capitata* and *S. macrocephala* were resistant to *P. brachyurus*, and can therefore be recommended for soybean succession. Stylosanthes also has the advantage, as shown in other studies, of being effective in controlling *Meloidogyne incognita* (Kofoid and White) Chitwood race 3 (Gonzaga and Ferraz, 1994) and *P. zaeae* (Obici *et al.*, 2011), and is therefore a sound option for succession planting in mixed population areas. In addition, *B. brizantha* and *C. spectabilis* are also resistant to *Meloidogyne* spp. (McSorley, 1999; Dias-Arieira *et al.*, 2003) and can be used for the same purpose.

According to the data obtained, the fallow treatment was effective in controlling *P. brachyurus* and is a simple tactic to reduce nematode populations. This control is based on two principles: death by

starvation, since nematodes have no alternative to parasitism and need a live host to complete their cycle, and death by desiccation and excessive heat when the soil is tilled (Heald, 1987). However, although fallow is an effective solution to nematodes, leaving land fallow is not always attractive because of soil exposure to erosion by wind and rain, loss of organic matter, reduction in fertility or nutrient retention, and reduction in the population density of beneficial microorganisms (McSorley and Gallaher, 1994).

Succession planting with crotalaria, oilseed radish, stylosanthes, and fallow caused the most significant reductions in the population of *P. brachyurus*. Growing brachiaria and intercropped maize-brachiaria reduced the nematode population by comparison with soybean, but did not differ from maize in one of the experiments. These results were obtained in a greenhouse, and field research is needed for confirmation.

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