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Article

REPRODUCTION OF *Pratylenchus zeae* ON WEEDS

*Reprodução de **Pratylenchus zeae** em Plantas Daninhas*

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ABSTRACT - Weeds can be hosts of root-lesion nematode (*Pratylenchus* spp.), maintaining or increasing their population in the soil. The objective of this study was to evaluate the reaction of 25 weeds species to the nematode *Pratylenchus zeae*. The weed plants were individually inoculated with 1,000 individuals of *P. zeae* and maintained in a greenhouse for 90 days. After this period, eggs and nematodes were extracted, quantified, and the reproduction factor (RF = final population/initial population) was calculated. All tested weeds were susceptible (RF>1) to *P. zeae*, and the species *Brachiaria decumbens*, *Rhynchelytrum repens*, *Digitaria insularis*, *D. horizontalis*, *B. brizantha* were the most susceptible to this parasite.

Keywords: invasive plants, susceptibility, lesion nematode, parasite.

*RESUMO - As plantas daninhas podem ser hospedeiras de nematoides das lesões (**Pratylenchus** spp.), mantendo ou elevando sua população no solo. O objetivo deste trabalho foi avaliar a reação de 25 espécies de plantas daninhas a **Pratylenchus zeae**. As plantas daninhas foram individualmente inoculadas com 1.000 espécimes de **P. zeae** e mantidas em casa de vegetação por 90 dias. Após esse período, os ovos e nematoides foram extraídos e quantificados, sendo calculado o fator de reprodução (FR = população final/população inicial). Todas as plantas daninhas avaliadas comportaram-se como suscetíveis (FR>1) para **P. zeae**, sendo as espécies **Brachiaria decumbens**, **Rhynchelytrum repens**, **Digitaria insularis**, **D. horizontalis** e **B. brizantha** as mais suscetíveis a esse parasita.*

Palavras-chave: plantas invasoras, suscetibilidade, nematoide das lesões, parasita.

INTRODUCTION

Phytonematodes, or plant-parasitic nematodes, are responsible for causing serious constraints to crop systems, leading to reduced yields and loss of quality of agricultural products. Among the main species is the genus *Pratylenchus*, which ranks the second in the most important group of plant-parasitic nematodes in the world, only behind the genus *Meloidogyne* (Moens and Perry, 2009). In Brazil, the most important species of lesion nematodes are *Pratylenchus zeae*, *P. brachyurus* and *P. coffeae*, which cause harvest losses in corn, sugarcane, soybean and coffee, respectively (Goulart, 2008; Severino et al., 2010).

The genus *Pratylenchus* comprises more than 70 species, of which *P. zeae* is recognized as one of the major nematodes responsible for crop losses worldwide (Goulart, 2008). The great relevance of this species is associated with some characteristics of the nematode, including: large geographic distribution, particularly in tropical and subtropical countries; high degree of polyphagia,

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i.e. the ability to parasitize and proliferate in a large number of plants of different families, including weeds; pronounced pathogenic action in various current and perennial crops of economic interest (Ferraz, 1999).

In this context, root-lesion nematodes are widespread, having caused huge damages to diverse cultures in all agricultural regions in the country (Ferraz, 2006; Severino et al., 2010). Yield losses become a matter of great concern especially in cultures of major economic importance such as corn, sugarcane and sorghum (Severino et al., 2010). The greatest economic losses caused by *P. zeae* are reported for sugarcane and corn crops in various regions in the world and Brazil (Blair and Stirling, 2007; Santana et al., 2012). Croplands infested with this pathogen can become infeasible for the cultivation of new crops of these species as well as other cultures equally susceptible to these parasites, making the economic use of the lands unsustainable (Dinardo-Miranda et al., 2008). In studies conducted in sugarcane crops in the northwestern region Rio Grande do Sul, nematodes of the genus *Pratylenchus* were present in 100% of the samples, and the species *P. zeae* was found in more than 90% of the samples tested (Bellé et al., 2014).

Yield losses that are due to *P. zeae* in sugarcane crops vary from 20 to 50% per year (Dinardo-Miranda, 2005; Santana et al., 2012). Control of the *P. zeae* species in sugarcane croplands can provide yield gains that can be greater than 15%, compared to the control sample without treatment (Blair and Stirling, 2007). Crops with severe nematode infestation exhibit stunted growth of the aerial part of the plants, necrotic lesions in the rootlets and darkened areas (Goulart, 2008). The absence of sugarcane varieties that are resistant to this nematode, the high toxicity and low efficiency of nematicides, combined with the innate ability of this species to parasitize several plant species, make the control of this species far more difficult (Dias-Arieira et al., 2010; Santos et al., 2012).

The presence of weeds in farming lands interferes negatively with the production process, because of their competition for production resources and environmental conditions such as light, space, water and nutrients (Singh et al., 2010). The release of allelochemicals produced by the weeds and their role as hosts for diseases and pests, among them nematodes, make the cultivation practices much more difficult and lead to reduced yields (Santos and Cury, 2011). Different species of weeds have been recognized as host plants for *Pratylenchus* spp. in diverse regions of the world, contributing to an increase of nematode populations in the soil, thus constraining the establishment of agricultural cultures (Kutywayo and Been, 2006; Bélair et al., 2007; Smiley et al., 2014). In this context, this work aimed to assess the reproductive capacity of *P. zeae* in different species of weeds.

MATERIAL AND METHODS

The experiment was conducted from November 2013 to February 2013 to assess the reaction of 25 different species of weeds (Table 1) to a population of *Pratylenchus zeae* in a greenhouse under a temperature of 25 ^{o}C ± 3 ^{o}C. Sorghum plants (*Sorghum bicolor* cv. BRS 506) were used as control plants susceptible to the lesion nematode. The weeds were identified and classified as per Lorenzi (2011, 2013).

Seeds from different weed species were collected from the agricultural areas in the northwestern region of the state of Rio Grande do Sul and put to germinate in a substrate contained in plastic trays. First were planted the seeds of weeds that have a slower rate of germination and development, followed by the species with fast growth. This ensured a homogenized inoculation development. The substrate utilized in the experiments consisted of a mixture of sand and soil (at a ratio of 2:1), which was disinfected by autoclaving. The soil used in the experiment is classified as dystrophic Red Latosol (Oxisol) with the following physicochemical properties: clay = 61%; water pH value = 9; SMP index = 6.5; organic matter = 3.1%; phosphorus = 10.9 mg dm^{-3}; potassium = 88 mg dm^{-3}; calcium = 5.3 $cmol_c$ dm^{-3}; magnesium = 5.0 $cmol_c$ dm^{-3}; and sulfur = 10 $cmol_c$ dm^{-3}. Fifteen days after emergence, the seedlings were transplanted to two-liter pots containing the substrate, one plant per pot.

The *P. zeae* inoculum was prepared from a pure population identified by the morphological characteristics of the nematode (the species had three rings in the labial region, a flattening in

Table 1 - Family, scientific name and common name of weed species assessed for *Pratylenchus zeae* reproduction

Family	Scientific name	Common name
Amaranthaceae	*Amaranthus hybridus* L.	Slim amaranth
Amaranthaceae	*Amaranthus spinosus* L.	Spiny amaranth
Amaranthaceae	*Amaranthus deflexus* L.	Largefruit amaranth
Asteraceae	*Bidens pilosa* L.	Hairy beggarticks
Asteraceae	*Bidens subalternans* L.	Beggarticks
Asteraceae	*Galinsoga parviflora* Cav.	Gallant-soldier
Brassicaceae	*Raphanus raphanistrum* L.	Wild radish
Convolvulaceae	*Ipomoea grandifolia* (Dammer) O'Donell	Morning-glory
Convolvulaceae	*Ipomoea nil* (L.) Roth.	Morning-glory
Convolvulaceae	*Ipomoea purpurea* (L.) Roth	Morning-glory
Euphorbiaceae	*Euphorbia heterophylla* L.	Mexican fire plant
Malvaceae	*Sida rhombifolia* L.	Arrowleaf sida
Poaceae	*Brachiaria decumbens* Stapf	Signal grass
Poaceae	*Urochloa plantaginea* (Link) R. D. Webster	Plantain signalgrass
Poaceae	*Cyperus rotundus* L.	Nutgrass
Poaceae	*Cenchrus echinatus* L.	Southern sandbur
Poaceae	*Digitaria horizontalis* Willd. (Digho)	Crabgrass; sourgrass
Poaceae	*Digitaria insularis* (L.) Fedde	Sourgrass
Poaceae	*Eleusine indica* (L.) Gaertn	Indian goosegrass
Poaceae	*Lolium multiflorum* Lam.	Ryegrass
Poaceae	*Echinochloa colonum* (L.) Link.	Jungle rice
Poaceae	*Panicum maximum* Jacq.	Guinea grass; buffalo grass
Poaceae	*Sorghum halepense* L.	Johnson grass
Poaceae	*Rhynchelytrum repens* (Willd.) Hubb	Natal grass
Poaceae	*Brachiaria brizantha* (Hochst.) Stapf	Bread grass; sheep grass
Poaceae	*Sorghum bicolor* L.	Sorghum BRS 506

the upper portion of the stylet basal nodules, and a predominantly subacute tail with flat end). It was also identified by its morphometric characteristics (body length ranged from 431.80 to 512,61 µm; the stylet varied from 15.09 to 16.03 µm in length; the distance of the region anterior to the vulva was 313.11 to 360.35 µm; and the V values (%) varied from 71.17 and 72.98) (Castillo and Villas, 2007). The samples were obtained from sugarcane plants and maintained in a greenhouse in sorghum plant (*S. bicolor* cv. BRS 506) for five months. The inoculum was obtained following the method proposed by Coolen and D'Herde (1972), and the plants were inoculated five days after transplanting with a suspension of 1000 specimens into three holes of approximately two centimeters in depth, dug around the plant base.

Ninety days after inoculation, the plants root system and 100 cm^3 of homogenized soil were collected for the analyses. The root systems were washed and weighed and then the nematodes were extracted as proposed by Coolen and D'Herde (1972). The samples were examined to determine the number of specimens, using a Peter camera under an optical microscope. The nematodes were extracted from the soil according to the method proposed by Jenkins (1964), and the values were extrapolated to 2,000 cm^3 of soil. From the values obtained, the reproduction factorwas calculated (Oostenbrink, 1966), considering as final population the sum of the total number of nematodes per root system and the number of nematodes present in the soil (Cook and Evans, 1987).

A completely randomized experimental design was used with eight replications. Data were subjected to analysis of variance, and the treatments means were compared by the Scott-Knott test at a probability level of 5%, using the SISVAR software (Ferreira, 2011).

RESULTS AND DISCUSSION

The different species of weeds had a significant difference (p≤0.05%) with regard to the parasitism susceptibility to *Pratylenchus zeae*, based on the final population obtained, number of nematodes per gram of root and reproductionfactor , compared to the control (Table 2). The viability of the nematodes inoculum could be confirmed by the reproduction factor found for the control, *Sorghum bicolor* (Table 2).

By assessing the final population (FP) of the lesion nematode (*P. zeae*), it was possible to classify the plants into four different groups of susceptible hosts to the parasite, according to the descending order of the number of individuals. As a result, *Brachiaria decumbens*, *Rhynchelytrum repens*, *Digitaria insularis*, *D. horizontalis* and *B. brizantha* plants exhibited a final population varying from 6,981 and 6,239 specimens, differing statistically from the other species examined, being therefore the most favorable hosts for the nematode parasitism (Table 2). The *P. zea* hosting behavior of *B. brizantha*, as observed in this study, corroborates the results obtained by Sharma et al. (2001) and Carvalho (2013), who assessed pasturelands in the states of Acre and Mato Grosso do Sul and found this parasite spread in most of the areas examined. It is worth noting that the species of the genus *Brachiaria* spp., particularly *Brachiaria brizantha*, are considered excellent tropical forage plants and have been used as the main species in integrated crop-livestock systems in the Brazilian mid-west because of its rusticity, tolerance to the dry winter in the region and the possibility of using it intercropped with corn (Pacheco et al., 2008). However, because it is a host plant for this parasite, *B. brizantha* should be used only in locations that are

Table 2 - Reproductive capacity of *Pratylenchus zeae* in weeds, as expressed in final population (FP), number of nematodes per gram of root (Nem g^{-1}), and reproduction factor (RF)

Species	FP	Nem g^{-1}	RF[(1)]	Reaction[(2)]
Brachiaria decumbens	6,981 A	115.77 C	6.98	S
Rhynchelytrum repens	6,762 A	211.31 B	6.76	S
Digitaria insularis	6,760 A	293.91 A	6.76	S
Digitaria horizontalis	6,326 A	170.81 C	6.32	S
Brachiaria brizantha	6,239 A	101.94 C	6.24	S
Urochloa plantaginea	5,873 A	135.32 C	5.87	S
Sorghum halepense	4,543 B	105.58 C	4.54	S
Panicum maximum	3,872 B	94.44 D	3.87	S
Bidens subalternans	3,537 B	135.77 C	3.53	S
Eleusine indica	3,290 B	96.76 D	3.29	S
Bidens pilosa	2,796 C	82.06 D	2.79	S
Cenchrus echinatus	2,775 C	120.65 C	2.78	S
Cyperus rotundus	2,753 C	94.83 D	2.75	S
Amaranthus deflexus	2,541 C	46.18 E	2.54	S
Euphorbia heterophylla	2,450 C	72.06 D	2.45	S
Amaranthus spinosus	2,212 C	40.96 E	2.21	S
Amaranthus hybridus	2,109 C	39.62 D	2.10	S
Echinochloa colonum	1,954 C	43.42 E	1.95	S
Ipomoea purpurea	1,755 D	83.33 D	1.75	S
Lolium multiflorum	1,649 D	51.25 E	1.64	S
Ipomoea grandifolia	1,435 D	59.58 E	1.43	S
Galinsoga parviflora	1,294 D	43.73 E	1.29	S
Ipomoea nil	1,239 D	58.57 E	1.23	S
Sida rhombifolia	1,156 D	26.74 D	1.15	S
Raphanus raphanistrum	1,034 D	23.23 D	1.03	S
Sorghum bicolor (C)	17,336 -	226.42 -	17.33	S
VC (%)	17.94	15.43	-	-

Means followed by the same letter in columns do not differ statistically by the Scott-Knott test at 5% probability. C = susceptible control; [(1)] RF = final population of specimens (FP) / initial population of specimens (iP = 1,000); [(2)] Reaction: R = resistant (RF < 1); S = susceptible (RF> 1).

free from *P. zea* in order to prevent its proliferation, loss of the forage potential, and infestation of subsequent commercial crops, thus becoming a major phytosanitary problem (Kluthcouski et al., 2003). In addition, *B. brizantha* and *B. decumbens* have also been associated with the multiplication of *P. brachyurus*, another important plant-parasitic nematode in Brazil (Queiróz et al., 2014).

The plant species *Ipomoea purpurea*, *Lolium multiflorum*, *I. grandifolia*, *Galinsoga parviflora*, *I. nil*, *Sida rhombifolia* and *Raphanus raphanistrum* were the ones that exhibited the smaller nematode population, varying from 1,755 to 1,034 specimens per plants' root system (Table 2). However, despite having fewer nematodes, compared to the other plant species, they still were susceptible to and hosts for this parasite. It should be remembered that plants of the genus *Ipomeia* have been characterized as susceptible to infestation by other species of nematodes of agricultural concern, such as *Meloidogyne incognita*, *M. javanica* and *P. brachyurus*, thus becoming potential hosts for these parasites, aggravating their spread and crop damages (Antônio and Lehman, 1978; Mônaco et al., 2009; Bellé et al., 2015).

The susceptibility of sourgrass (*Digitaria insularis*) to *P. zea* may increase crop losses, because this species has already caused severe damages to soybean and corn crops. This is because this species has the potential to outcompete the desired cultivated plants, an ability to spread throughout the farming lands and an evolved resistance to glyphosate-based herbicides, the main molecule used in its control (Carvalho et al., 2011; Melo et al., 2012). Therefore, when characterized as a host for nematodes, sourgrass becomes another undesirable condition in crops cultivation, requiring special care in management practices.

The parasitism capacity of the lesion nematode (Table 2) in ryegrass (*L. multiflorum*) and wild radish (*R. raphanistrum*) increases the concern about the presence of this species in farming areas. In this regard, it is important to emphasize that species like *L. multiflorum* and *R. raphanistrum* are often used as forage and ground cover plants in integrated crop-livestock and no-till farming systems, respectively (Machado and Assis, 2010). Furthermore, in the last crop seasons, ryegrass has exhibited resistance to the herbicides used in its control, causing harvest losses in winter and spring-summer cultures and enabling its perpetuation in the area (Roman et al., 2004; Costa and Rizzardi, 2014). In this scenario, the use of these plant species in the cultivation systems or their presence as invasive plants should be maintained only in areas not contaminated with this parasite to prevent its proliferation and damages to subsequent crops.

The number of nematodes per gram of roots (Table 2) ranged from 293.9 to 23.23 individuals, *D. insularis* being the weed plant with the highest value. In contrast, the *Amaranthus deflexus*, *A. spinosus*, *Echinochloa colonum*, *L. multiflorum*, *I. grandifolia*, *G. parviflora*, *I. nil* and *R. raphanistrum* species showed the lowest number of the parasite. However, all plants assessed were parasitized and, therefore, characterized as susceptible to *P. zeae* (Table 2). Weed species like that of the genus *Amaranthus* spp. has become a problem in the agricultural areas of the Brazilian *Cerrado* (savanna region), especially in areas grown with cotton, where farmers have encountered difficulties in controlling them with chemicals. Furthermore, these species are hosts for other nematode species, such as *Pratylenchus brachyurus*, *M. incognita*, *M. javanica* and *M. paranaenses* (Mônaco et al., 2009; Bellé et al., 2015), which indicates the capacity of all these parasites and *P. zeae* to maintain and increase their populations in soil.

The results of this study demonstrate the nematode ability to survive and increase its population in soil, requiring a high level of control of the weeds in areas where this pathogen is present. It is important to underline that most of the weeds studied can also be hosts for several other species of phytonematodes of the genus *Meloidogyne*, also known as gall nematodes, besides hosting some species of fungi, e.g., *Colletotrichum* sp., and pest insects, such as aphids, which transmit viruses (Maziero et al., 2007; Miléo et al., 2007; Mônaco et al., 2009; Bellé et al., 2015).

The other weed species that were identified as being susceptible to the lesion nematode are widespread in most of the agricultural lands in Brazil, including crop areas cultivated with soybean, corn, rice and wheat. Linked with the ability of harboring diseases and parasites, plants of the genera *Cyperus*, *Bidens*, *Echinochloa* and the species *Euphorbia heterophylla*, *Eleusine indica* and *Sorghum halepense* indicated resistance to one or more herbicides commonly used in annual crops, thus aggravating their presence in crop areas (Heap, 2016). Thus, based on the identification of these weeds as hosts for *P. zeae*, it is necessary to adopt management practices that enable proper control of the species in order to diminish or cease the pathogen infestation development (Dias et al., 1995). It is worth noting that in nematode-infected areas, the losses caused by weeds increase significantly, once many of the weed species are natural hosts for these parasites, harboring them in the absence of cultivated plants and making more difficult both the pathogen control and the management of infested crops (Lordello et al., 1988).

The findings allow inferring that the weeds species studied behave as good hosts for *P. zeae*, thus contributing to maintaining and increasing this nematode population in the field. Based on the findings, special care should be taken when selecting the cultures to be implemented and the subsequent vegetable species, whether a commercial crop or not, in order to minimize the damages caused by the phytonematode. Still in this context, the control of invasive weeds becomes an issue of major importance, given their high degree of susceptibility and great potential for being hosts for the nematode under study, due to the the polyphagous action of this pathogen. This may pose serious consequences to the croplands where this plant-parasitic nematode is present, particularly in large areas grown with corn and sugarcane, where it is widespread Therefore, weeds control becomes a practice of vital importance for the management of this phytonematode, especially regarding the selection of the most appropriate herbicides to the cultures and during the inter-harvest season, aiming to control the host plant and prevent the reproduction of the parasite, in order to reduce the damages caused to commercial crops (Bellé et al., 2015). Knowledge on the *P. zeae* polyphagia and on the vast range of plant hosts is of key importance for a proper decision- making on the most efficient management of this pathogen.

REFERENCES

Antônio H., Lehman P.S. **Nota sobre a ocorrência de nematoides do gênero *Meloidogyne* em algumas plantas daninhas no estado do Paraná e do Rio Grande do Sul**. Londrina: Sociedade Brasileira de Nematologia, 1978.

Bélair G. et al. Reproduction of *Pratylenchus penetrans* on 24 common weeds in potato fields in Québec. **J Nematol.** 2007;39:321-6.

Bellé C. et al. Fitonematoides associados à cultura da cana-de-açúcar no Rio Grande do Sul, Brasil. **Nematropica**. 2014;44:207-17.

Bellé C. et al. Capacidad hospedadora de plantas adventicias a *Pratylenchus brachyurus* en el noroeste de Rio Grande del Sur, Brasil. **Nematropica**. 2015;45:144-9.

Blair B.L., Stirling, G.R. The role of plant-parasitic nematodes in reducing yield of sugarcane in fine-textured soils in Queensland, Australia. **Aust J Exp Agric.** 2007;47:620-34.

Carvalho C. et al. Densidade populacional de *Pratylenchus* spp. em pastagens de *Brachiaria* spp. e sua influência na disponibilidade e na qualidade da forragem. **Rev Ceres**. 2013;60:30-7.

Carvalho L.B. et al. Detection of sourgrass (*Digitaria insularis*) biotypes resistant to glyphosate in Brazil. **Weed Sci.** 2011;59:171-6.

Castillo P., Vovlas N. **Pratylenchus** (Nematoda: Pratylenchidae): diagnosis, biology, pathogenicity and management. Leiden: Brill, 2007. 530 p. (Nematology Monographs and Perspectives, 6)

Cook R., Evans K. Resistance and tolerance. In: Brown R.H., Kerry B.R. editors. **Principles and practice of nematode control in crops**. New York: Academic Press, 1987. p.179-231.

Coolen W.A., D'herde C.J. **A method for the quantitative extraction of nematodes from plant tissue**. Ghent: State Nematology and Entomology Research Station, 1972. 77p.

Costa L.O., Rizzardi M.A. Resistance of *Raphanus raphanistrum* to the herbicide metsulfuron-methyl. **Planta Daninha**. 2014;32:181-7.

Dias W.P. et al. Hospedabilidade de algumas ervas daninhas ao nematoide de cisto da soja. **Nematol Bras.** 1995;19:9-14.

Dias-Arieira C.R. et al. Reação de variedades de cana-de-açúcar aos nematoides-das-galhas. **Nematol Bras.** 2010;34:198-203.

Dinardo-Miranda L. Manejo de nematoides em cana-de-açúcar. **J Cana**. 2005;141:64-9.

Dinardo-Miranda L. et al. Influência da época de aplicação de nematicidas em soqueiras sobre as populações de nematoides e a produtividade da cana-de-açúcar. **Bragantia**. 2008;67:p.179-90.

Ferraz L.C.C.B. O nematoide *Pratylenchus brachyurus* e a soja sob plantio direto. **R Plantio Direto**. 2006;96:23-7.

Ferraz L.C.C.B. Gênero *Pratylenchus* – os nematoides das lesões radiculares. **Revisão Anual Patol Plantas**. 1999;7:157-95.

Ferreira D.F. Sisvar: a computer statistical analysis system. **Ci Agrotecnol.** 2011;35:1039-42.

Goulart A.M.C. **Aspectos gerais sobre nematoides das lesões radiculares (Gênero *Pratylenchus*)**. Planaltina: Embrapa Cerrados, 2008. 27p. (Documentos, 219)

Heap I. **International survey of herbicide resistant weeds**. [accessed on: 04 Apr. 2016]. Available at: <http://www.weedscience.org/In.asp>.

Jenkins W.R. A rapid centrifugal-flotation technique for separating nematodes from soil. **Plant Dis Reporter**. 1964;48:692.

Kluthcouski J. et al. **Integração lavoura-pecuária**. Santo Antônio de Goiás: Embrapa Arroz e Feijão; 2003. 570p.

Kutywayo W., Been T.H. Host status of six major weeds to *Meloidogyne chitwoodi* and *Pratylenchus penetrans*, including a preliminary field survey concerning other weeds. **Nematology**. 2006;8:647-57.

Lordello R.R.A. et al. Multiplicação de *Meloidogyne javanica* em plantas daninhas. **Nematol Bras.** 1988;12:84-92.

Lorenzi H. **Manual de identificação e controle de plantas daninhas:** plantio direto e convencional. São Paulo: Instituto Plantarum, 2011.

Lorenzi H. **Plantas daninhas do Brasil**. 4ª.ed. Nova Odessa: Instituto Plantarum; 2013.

Machado L.A.Z., Assis P.G.G. Produção de palha e forragem por espécies anuais e perenes em sucessão à soja. **Pesq Agropec Bras.** 2010;45:415-22.

Maziero H. et al. Plantas infestantes hospedeiras de *Rhopalosiphum rufiabdominalis* (Sasaki) (Hemiptera: Aphididae) em áreas de cultivo de arroz irrigado. **Neotr Entomol.** 2007;36:471-2.

Melo M.S.C. et al. Alternativas para o controle químico de capim-amargoso (*Digitaria insularis*) resistente ao glyphosate. **Rev Bras Herbic.** 2012;11:195-203.

Miléo L.J. et al. Plantas daninhas hospedeiras alternativas de *Colletotrichum guaranicola* em cultivos de guaraná no Estado do Amazonas. **Planta Daninha**. 2007;25:771-82.

Moens M., Perry R. Migratory plant endoparasitic nematodes: A group rich in contrasts and divergence. **Ann Rev Phytopathol.** 2009;37:313-32.

Mônaco A.P.A. et al. Reação de espécies de plantas daninhas a *Meloidogyne incognita* Raças 1 e 3, a *M. javanica* e a *M. paranaensis*. **Nematol Bras.** 2009;33:235-42.

Oostenbrink M. Major characteristic of relation between nematodes and plants. **Mededelingen Landbouwhogeschool.** 1966:66:1-46.

Pacheco L.P. et al. Desempenho de plantas de cobertura em sobressemeadura na cultura da soja. **Pesq Agropec Bras.** 2008;43:815-23.

Queiróz C.A. et al. Reação de acessos e cultivares de *Brachiaria* spp. e *Panicum maximum* à *Pratylenchus brachyurus*. **Summa Phytopathol.** 2014;40:226-30.

Roman E.S. et al. Resistência de azevém (*Lolium multiflorum*) ao herbicida glyphosate. **Planta Daninha**. 2004;22:301-6.

Santana S.M. et al. Manejo de *Pratylenchus zeae* por plantas antagonistas, em solos de áreas de cultivo de cana-de-açúcar. **Nematropica**. 2012;42:63-71.

Santos D.A. et al. Reaction of sugarcane genotypes to *Pratylenchus brachyurus* and *P. zeae*. **Inter J Food Agric Environ.** 2012;10:585-7.

Santos J.B., Cury J.P. Picão-preto: uma planta daninha especial em solos tropicais. **Planta Daninha**. 2011;29:1159-71.

Severino J.J. et al. Nematodes associated with sugarcane (*Saccharum* spp.) in sandy soils in Parana, Brazil. **Nematropica**. 2010;40:111-9.

Sharma R.D. et al. Nematóides associados ao capim *Brachiaria brizantha* cv. Marandu no Estado do Acre, Brasil. **Nematol Bras.** 2001;25:217-22.

Singh S.K. et al. Weed host of root-knot nematodes and their distribution in Fiji. **Weed Technol.** 2010;24:607-12.

Smiley R.W. et al. Selected pacific northwest rangeland and weed plants as hosts of *Pratylenchus neglectus* and *P. thornei.* **Plant Dis.** 2014;98:1333-40.