Population survey of phytonematodes in soybean crop in the Middle Plateau region in Rio Grande do Sul

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ABSTRACT

The objective of this study was to determine and quantify the main phytonematodes found in soybean crops in the state of Rio Grande do Sul and to estimate the population level where they are found. Therefore, samples of soil asnd soybean roots were received from 154 municipalities of the Middle Plateau region of Rio Grande do Sul, from 2014 to 2016. After receiving and registering the samples, nematodes were extracted, identified and quantified in each sample. Through these data, it was determined the absolute frequency (AF), relative frequency (RF), absolute density (AD) and relative density (DR) of each nematode genus as well as their average population level in the municipalities. The main genera found in the study were Meloidogyne (found in 7.5% of the samples), Pratylenchus (6.2%), Heterodera (4.3%), Rotylenchulus (1.6%) and Helicotylenchus (22.9%). The species Meloidogyne species was not identified, but for Pratylenchus two species were identified, P. brachyurus and P. zeae. Besides these two genera, others were found, among them Heterodera glycines, Rotylenchulus reniformis and Helicotylenchus dihystera. The most frequently found nematode was H. dihystera, and in relation to population level, Meloidogyne spp. stands out for showing the highest levels in the municipalities in the three years of evaluation.

Keywords: *Heterodera*; *Meloidogyne*; Population level; *Pratylenchus*

1. NTRODUCTION

Soybean is an important crop for the world's economy. It has significantly increased due to scientific and technological advances offered to the productive sector. However, the productivity of this crop depends on several factors, both of biotic and abiotic origin. Regarding the biotic factors, we highlight the phytoparasitic nematodes, which has been reported more frequently in soybean producing regions every year. Over 100 species of nematodes associated with soybean cultivation are mentioned worldwide (Ferraz, 2001). The following species are among the most important phytoparasite species in relation to the occurrence and aggressiveness to the crop: *Heterodera glycines* Ichinohe 1952; *Meloidogyne javanica* (Treub, 1985) Chitwood 1949; *M. incognita* (Kofoid; White, 1919) Chitwood 1949; *M. arenaria* (Neal , 1889) Chitwood 1949; *Pratylenchus brachyurus* (Godfrey, 1929) Filipjev Shuurmans Stekhoven, 1941 and *Rotylenchulus reniformis* Linford (Oliveira, 1940). All of these species cause significant damage to soybean crop, which will depend mainly on population density, crop susceptibility and weather conditions.

In relation to nematodes, root knot neamatodes (*M. javanica* and *M. incognita*) and cyst nematodes (*Heterodera glycinis*) were the subject of concern on many Brazilian soybean farmers a few years ago. However, in recent years, studies related to the survey and identification of nematode species in Brazil have shown that species such as *P. brachyuru* and *R. renifomis* have been reported in several areas associated with potential growth in soybean crops (Dias *et al*., 2010; Miranda *et al.*, 2011).

Since the 1970s, it has been reported that the main nematode species in soybean crops in the state of Rio Grande do Sul belongs to the *Meloidogyne*, *Pratylenchus* and Heterodera genus besides *Helicotylechus* and *Rotylenchulus* with na sperodicaly occurence (Castro *et al*., 2003; Deuner *et al*., 2013; Deuner *et al*., 2015; Kirsch *et al*., 2016; Lehmann *et al*., 1976; Lordello, 1974; Santos *et al*., 2014).

Thus, population surveys are important allies in the identification and quantification of species found in the evaluated areas, providing subsidies for the determination of the damage caused by these pathogens in the most different crops.

However, in order to carry out a suitable nematode management program, it is necessary to identify the species occuring in the area and the population level they are found. Thus, the objective of this work was to determine and quantify the main phytonematoids found in soybean crops in the Middle Plateau region of Rio Grande do Sul, as well as to estimate the population level in which they are found.

2. Materials and methods

Soil and root samples of soybean plants from municipalities of the Rio Grande do Sul Middle Plateau were analyzed from 2014 to 2016. The samples were sent by farmers and technicians from international companies and cooperatives to the Laboratory of Nematology at the University of Passo Fundo, Passo Fundo/RS, with the objective of identifying and quantifying the phytonematodes. After receiving and registering, the samples were stored in a acclimatized environment until processing.

The extraction of nematodes from the soil was performed using 100 cm^3 of soil, which consists of the method of centrifugation, flotation, sedimentation, sieving and separation in sucrose solution (Jenkins, 1964). For root nematode extraction, 10 g of soybean roots were used, which were ground, sieved and centrifuged using sucrose solution by the method of Hussey & Barker (1973) modified by Bonetti & Ferraz (1981). For cyst extraction, the 100 cm^3 soil sieving and paper filtration method was used (Shepherd, 1970).

The number of nematodes per sample was counted on a Peters slide under an optical microscope. The extracted nematodes were identified based on their morphological characteristics. In the analysis of soil cyst extraction, the number of cysts per sample of 100 cm^3 of soil was counted.

Once data was obtained, the incidence and average population level for each nematode species in each municipality evaluated were determined through the levels established by Koenning *et al*. (1999) (Table 1).

In addition, the absolute (AF) and relative (RF) frequencies and absolute (AD) and relative (RD) densities of nematodes were calculated based on the methodology of Thankamony et al. (2002), where the frequency represents the frequency in which nematode species occur among the samples examined. AF = (No. of *Meloidogyne* samples / Total number of samples) x 100 and RF = (*Meloidogyne* spp./sum of the

frequency of all species) x 100. Absolute density is the total nematode population identified and estimated at each sample or set of samples. From this value, the relative density of each nematode genera was calculated, as well as its percentage in relation to the total population of phytonematodes; RD = total population of *Meloidogyne* / Total Nematodes) x 100. All these calculations were performed for each genus of nematodes found in the evaluations.

3. Results and discussion

Over the three years, 3264 samples of soil and roots of soybean plants were analyzed, from a total of 154 municipalities in the state of Rio Grande do Sul, especially in the Middle Plateau region of the state. Due to the nematological analyzes performed, it was found several genera of nematodes classified as plant phytoparasites due to their morphological characteristics, such as *Meloidogyne* (found in 7.5% of the samples), *Pratylenchus* (6.2%), *Heterodera* (4.3 %), *Rotylenchulus* (1.6%) and *Helicotylenchus* (22.9%).

In 2014, four genera of phytoparasitic nematodes associated with the root system of soybean plants and their rhizosphere were found: *Meloidogyne, Pratylenchus, Heterodera* and *Helicotylenchus*. Of these, *Helicotylenchus* and *Meloidogyne* showed the highest absolute and relative frequencies in both soil and root samples, followed by *Pratylenchus* and *Heterodera*. The *Helicotylenchus* nematode had AF of 16.4% in soil and 7.1% in roots, while *Meloidogyne* had AF of 9.8% and 4.7% in soil and roots, respectively. Although *Helicotylenchus* was more frequently found in the evaluated samples, it was observed that *Meloidogyne* presented higher AD values in relation to the other genera found in both soil and root samples. In 2015, in addition to the genera already mentioned in 2014, the genus Rotylenchulus were found. In that year, the nematodes with higher AF in the soil samples were *Helicotylenchus* and *Heterodera*, with 31% and 9.3%, respectively and in the roots, *Helicotylenchus* and *Pratylenchus* with 4.7 and 2.4%, respectively. In relation to AD, *Helicotylenchus* presented larger population of individuals in the soil samples and *Meloidogyne* in the root samples. For 2016, the genera of nematodes found were the same as in 2015, *Meloidogyne*, *Pratylenchus*, *Heterodera*, *Rotylenchulus* and *Helicotylenchus*. Among these, *Helicotylenchus* and *Pratylenchus* had AF of 18.8 and 5.1% in the soil, and 2.3 and 2.1% in the roots, respectively. For the density of nematodes, *Helicotylenchus* presented AD of 43,404 nematodes in soil samples and *Meloidogyne* of 8,379 nematodes in root samples, which are the genera with the highest AD in relation to the others.

Among the nematodes found in the samples, most of those belonging to the genus Meloidogyn could not have been identified at the species level because of the absence of adult females and even males in the populations. When the identification was possible to be carried out, *M. javanica* and *M. incognita* were found. In the case of *Pratylenchus,* two species, *P. brachyurus* and *P. zeae*, were identified in both root and soil samples. The species *H. glycines*, *R. reniformis* and *H. dihystera* were also found.

Figure 1 shows the incidence of nematode species found in each year of evaluation, both in soil and root samples. It can be observed that *H. dihystera*, *Meloidogyne* spp. and *Pratylenchus* spp., are the species most frequently found.

The study of disease occurrence and the knowledge of the population levels of the involved pathogens are important for directing activities and guiding appropriate control measures (Silva et al.,

2000). Thus, population surveys of nematodes are carried out through various educational and research institutions in order to qualitatively and quantitatively identify the main genera and species of nematodes found in a certain area of cultivation.

Many studies have reported the presence of several genera of nematodes in soybean crops in the last years. Those nematodes could either be free-living or plant phytoparasite. However, most of these studies only express their data in a qualitative manner, without showing quantitative data related to the population diversity of phytoparasitic nematodes. These data allow us to relate the damage caused by these nematodes to the different levels of infestation which were found (Arantes et al., 2000).

In 2014, samples were collected from 47 municipalities in the state of Rio Grande do Sul. Of those places, 96% showed an incidence of *H. dihystera*, 64% *Meloidogyne* spp. species, 45% *P. brachyurus*, 21% *H. glycines* and 9% *P. zeae* (Table 1). Among the nematodes considered phytoparasites, *Meloidogyne* spp. showed a high population level in 19.1% of the evaluated municipalities, followed by *P. brachyurus* and *H. glycines* with 2.1% in both soil and soybean root samples. In 2015, samples were collected from 105 municipalities, 95% of which had incidence of *H. dihystera*, 40% *Meloidogyne* spp., 33% *H. glycines*, 32% *P. brachyurus*, 10% *P. zeae* and 10% *R. reniformis*. In that year, 1.9% of the municipalities had high population levels of Meloidogyne spp. and H. glycines (Table 2). For 2016, among the 78 municipalities evaluated, 93.6% had incidence of *H. dihystera*, 52.6% of *P. brachyurus*, 50% of Meloidogyne spp., 14.1% of *R. reniformis*, 11.5% *H. glycines* and *P. zeae*, as well. Among these nematodes, *Meloidogyne* spp. obtained a high population level in 14.1%. For the other nematodes, no high population levels were found in the municipalities (Chart 3).

Among the population surveys conducted for soybean crop in Brazil in recent years, several genera of nematodes have been found infecting the root system of the plants or in their rhizosphere. Among these genera, *Meloidogyne, Pratylenchus*, *Heterodera* and *Helicotylenchus* are the most frequently found and disseminated throughout the Brazilian territory (Deuner *et al*., 2013; Deuner *et al*., 2015; Franzener *et al*., 2005; Ghissi *et al*., 2013; Kirsch *et al*, 2016; Lopes, 2015; Roese *et al*., 2001; Santos *et al*., 2014; Sharma *et al*., 2002).

In Rio Grande do Sul, one of the first population surveys reported the presence of at least nine genera of plant parasitic nematodes in soybean crops: *Pratylenchus*, *Helicotylenchus*, *Hoplolaimus*, *Tylenchorhynchus*, *Trichodorus*, *Xiphinema*, *Criconemoides*, *Scutellonema* and *Longidorus* (Lehmann *et al*., 1976). Thus, other works with the same genus were carried out later, showing that the genera *Meloidogyne*, *Pratylenchus*, *Heterodera*, *Rotylenchulus* and *Helicotylecnhus* are those most frequently found in soybean soil and root samples in Rio Grande do Sul (Castro, 2003; DEUNER *et al*., 2013; Deuner *et al*., 2015; Ghissi *et al*., 2013; Kirsch *et al*., 2016; Santos *et al*., 2014). These data corroborate the present study, since these genera were the most frequently found in soybean soil and root samples in the three years of evaluation.

In terms of population density, species belonging to the genus *Meloidogyne* obtained higher values than those of *Pratylenchus*. This is because root-knot nematodes have a higher reproductive capacity than cyst nematodes. *Pratylenchus* females are monodelphas (have only one ovary), while *Meloidogyne* females are didelphas (have two ovaries) (Moens & Perry, 2009).

The species *Pratylecnhus* spp. have been found in higher density inside parasitized plant tissues (Takahashi, 2015). This fact could be observed because the AD of this nematode in the soil was not as expressive as that found in soybean roots, which brings us to the high importance that this genus has for plants. Although its reproductive capacity is low, as previously mentioned, its potential for damage has been considered high, since it can be associated with pathogens that cause root rot, therefore enhancing the damage in soybean crop.

Phytonematoids of the genus *Helicotylenchus* are commonly found in high population levels associated with several crops of economic importance. This genus is considered as a nematode of secondary importance. In soybean crops, the presence of this genus of nematode has been reported by several authors (Kirsch *et al*., 2016; Lehmann et al., 1976; Lordello, 1974; Sharma *et al*., 2002; Silva, 2007). However, Machado *et al*. (2015) report damage to the root system of soybean and millet plants when inoculated with *H. dihystera* species. Also, according to the authors, the root symptoms are similar to those observed for *P. brachyurus*. Thus, there is a need to monitor, identify and carry out further works related to the presence of *Helicotylenchus* in collected soil and root samples since their occurrence in crops of economic importance has increased significantly in recent years and also due to their adaptation to annual crops.

Although the nematode population level has remained low in many municipalities, the mere presence of the nematode in the region is already a cause for concern, as it has been admitted that annual crops, especially monocultures, tend to favor species of certain phytononematous genera, which become more abundant after the transformation of native ecosystems into agroecosystems (Goulart & Ferraz, 2003). For example, Mendes & Machado (1992) reported that there are no mild levels of *H. glycines* infestation because any number of cysts other than zero represent potential damage to the crop.

CONCLUSIONS

The main species identified in the population survey are *M. javanica*, *M. incognita*, *P. brachyurus*, *H. glycines*, *R. reniformis* and *H. dihystera*.

The nematode with the highest frequency and density found in soybean cultivation areas in Rio Grande do Sul are *Helicotylenchus*, *Meloidogyne* and *Pratylenchus*.

Pratylenchus species are found in higher density in the root samples of soybean plants.

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Table 1: Population levels of phytoparasitic nematodes in soil and roots of soybean plants.

Level/ Species	*Meloidogyne* spp.		*Pratylenchus* spp.		*H. glycines*	*R. reniformis*
	Soil[1]	Roots[2]	Soil[1]	Roots[2]	Soil[3]	Soil[1]
Low	1-150	1-60	1-50	1-800	1-5	1-200
Mean	151-300	61-120	51-100	801-1600	6-10	201-600
High	>300	>121	>101	>1601	>11	>600

Source: Adapted from Koenning et al. (1999)

[1]Nematodes in 100 cm^3 soil; [2]Nematodes in 10g roots; [3]Cysts in 100 cm^3 of soil.

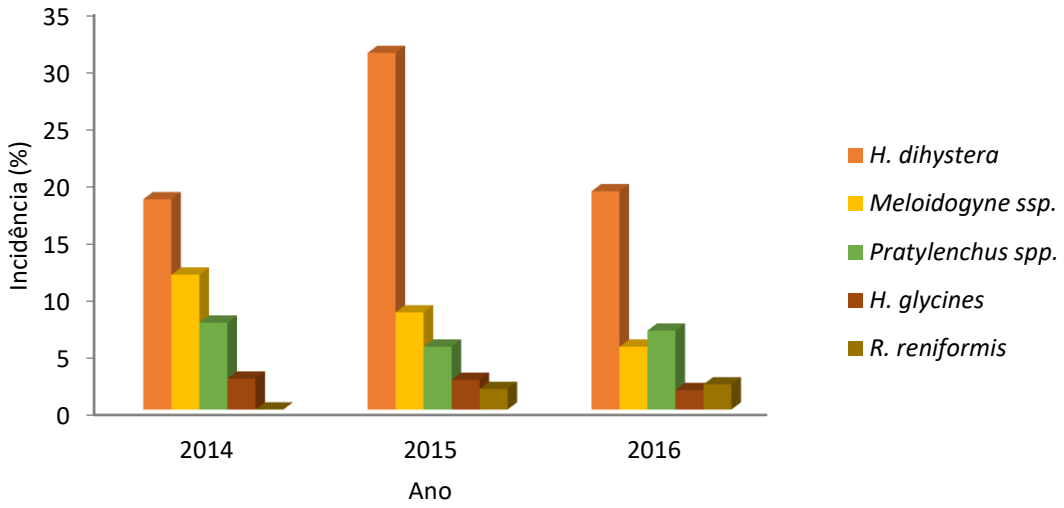
Table 2: Frequency and Density of nematodes found in soil and root samples collected in commercial soybean crops from municipalities of Rio Grande do Sul State from 2014 to 2016. Passo Fundo-RS, 2017

2014										
Genus	No. of samples		Absolute frequency (%)		Relative frequency (%)		Absolute density		Relative density (%)	
	Soil	Roots	Soil	Roots	Soil	Roots	Soil	Roots	Soil	Roots
Meloidogyne	40	19	9.8	4.7	29.2	29.7	19.62	33.37	75.3	75.4
Pratylenchus	19	16	4.7	3.9	13.9	25.0	444	4.29	1.7	9.7
Heterodera	11	0	2.7	0.0	8.0	0.0	146	0	0.6	0.0
Helicotylenchus	67	29	16.4	7.1	48.9	45.3	5.83	6.62	22.4	14.9
2015										
Genus	No. of samples		Absolute frequency (%)		Relative frequency (%)		Absolute density		Relative density (%)	
	Soil	Roots	Soil	Roots	Soil	Roots	Soil	Roots	Soil	Roots
Meloidogyne	75	20	7.4	2.0	14.2	20.6	6,700	10,820	17.2	65.3
Pratylenchus	32	24	3.1	2.4	6.1	24.7	298	1,328	0.8	8.0
Heterodera	95	3	9.3	0.3	18.0	3.1	1,140	64	2.9	0.4
Rotylenchulus	10	2	1.0	0.2	1.9	2.1	1,584	169	4.1	1.0
Helicotylenchus	315	48	31.0	4.7	59.8	49.5	29,200	4,195	75.0	25.3
2016										
Genus	No. of samples		Absolute frequency (%)		Relative frequency (%)		Absolute density		Relative density (%)	

	Soil	Roots	Soil	Roots	Soil	Roots	Soil	Roots	Soil	Roots
Meloidogyne	92	19	5.0	1.0	15.1	18.1	31,821	8,379	38.6	46.7
Pratylenchus	94	38	5.1	2.1	15.5	36.2	836	4,078	1.0	22.7
Heterodera	35	4	1.9	0.2	5.8	3.8	992	57	1.2	0.3
Rotylenchulus	41	2	2.2	0.1	6.7	1.9	52.82	106	6.4	0.6
Helicotylenchus	346	42	18.8	2.3	56.9	40.0	43,404	5,325	52.7	29.7

Source: author's data.

Figure 1: Incidence of (%) nematodes species in soybean root and soil samples collected in the Midlle Platuea region in Rio Grande do Sul. Passo Fundo, 2017



Source: author's data.

Chart 1: Average population level of the main nematodes found in samples of soybean soil androots in the municipalities of Rio Grande do Sul, in 2014. Passo Fundo-RS, 2017

	Mel.[1]		P. z.[2]		H. g.[3]	P. z.[4]		H. d.[5]		continua...	Mel.		P. z.		H. g.	P. z.		H. d.	
Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root
Almirante Tamandaré do Sul	3532[6]	11348	144	932	0	0	0	172	716	Passo Fundo	37	219	5	24	0	0	0	91	64
Bagé	0	0	0	80	0	0	0	0	240	Pinhalzinho	0	0	0	0	0	0	0	24	0
Boa Vista do Cadeado	0	0	0	0	0	0	0	4	0	Pontão	0	0	1	0	0	0	0	32	10
Boa Vista do Incra	312	100	0	0	1	0	0	24	20	Quinze de Novembro	12	66	0	0	0	0	0	420	134
Campos Borges	0	48	0	16	0	0	0	0	984	Rio Dos Indios	0	0	0	0	0	0	0	4	27
Campos Novos	0	0	0	0	0	0	0	8	20	Ronda Alta	0	0	0	52	0	0	0	36	310
Carazinho	120	20	4	4	0	0	0	120	92	Saldanha Marinho	172	132	0	0	20	0	0	72	68
Catuípe	0	8	0	0	0	0	0	220	152	Salto do Jacuí	2	4	0	10	4	0	0	8	44
Ciriaco	0	0	0	0	0	0	0	68	0	Santa Cecília do Sul	0	0	0	0	0	0	0	41	336
Constantina	4	4	4	0	1	0	0	60	120	Santa Cruz do Sul	0	0	0	0	0	0	0	318	0
Cruz Alta	14	0	0	2	4	0	0	4	36	Santiago	1	0	3	0	3	0	0	117	0
Entre Rios	64	0	7	0	0	0	0	211	0	Santo Antônio do Planalto	3542	0	0	0	0	0	0	29	0
Erechim	0	4	13	102	0	0	40	85	223	São José do Ouro	0	0	8	0	0	0	0	8	0
Garruchos	0	0	68	0	0	4	0	292	0	São Luis Gonzaga	16	0	1	0	0	0	0	19	0
Guarani das Missões	164	1252	0	0	0	0	0	200	48	São Miguel das Missões	540	0	0	0	0	0	0	0	0
Ibiraiaras	0	200	0		0	0	0	0	200	São Paulo das Missões	208	0	4	0	0	0	0	18	0
Ibirapuitã	164	0	0	0	0	0	0	8	0	Sarandi	0	0	0	0	0	0	0	120	88
Ibirubá	50	33	8	1134	0	0	0	102	27	Selbach	40	0	0	0	0	0	0	12	0
Jacuizinho	212	0	0	0	0	0	0	60	0	Sertão	0	0	0	20	0	0	0	0	264
Maçambará	0	0	22	0	0	12	0	2	0	Soledade	0	0	0	0	0	0	0	24	0
Marau	4	0	0	0	0	0	0	20	0	Tapera	761	6483	7	81	0	0	13	168	264
Nicolau Vergueiro	184	2	0	0	0	0	0	0	0	Tenente Portela	16	0	0	0	0	0	0	12	0
Nova Alvorada	0	0	0	0	1	0	0	16	0	Tupanciretã	81	0	0	0	2	0	0	9	0

Source: Author's data.

[1]*Meloidogyne* spp. [2]*Pratylenchus brachyurus*. [3]*Heterodera glycines*. [4]*Pratylenchus zeae*. [5]*Helicotylenchus dihystera*.

[6]Red cells: high level; yellow cells: intermediate level; green cells: low level.

Chart 2: Average population level of the main nematodes found in samples of soybean soil and root in the municipalities of Rio Grande do Sul, in 2015. Passo Fundo-RS, 2017

(To be continued)

	Mel.[1]		P. b.[2]		H. g.[3]	R. r.[4]		P. z.[5]		H. d.[6]		continua...	Mel.		P. b.		H. g.	R. r.		P. z.		H. d.	
Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil	Root	Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil	Root
Água Doce	0	0	0	0	0	0	0	0	0	24	0	Jóia	0	0	4	0	0	0	0	0	0	76	0
Água Santa	4[7]	0	0	0	1	0	0	0	0	644	10	Júlio de Castilhos	2	1	0	0	11	0	0	1	0	216	2
Ajuricaba	56	0	0	0	0	0	0	0	0	8	0	Lagoa dos Três Cantos	57	4,8	5	4	0	0	0	0	0	97	56
Alegrete	2	0	0	0	1	0	0	0	0	84	0	Lagoa Vermelha	0	0	0	0	1	0	0	0	0	73	5
Alto Alegre	246	1371	0	5	0	0	0	0	0	100	15	Maçambara	0	0	0	0	0	0	0	0	0	15	0
Antônio Prado	0	0	0	0	1	0	0	0	0	10	0	Manoel	64	0	0	0	0	0	0	0	0	40	0
Aratiba	0	36	80	0	0	0	0	0	0	280	0	Manoel Viana	8	0	16	0	0	0	0	0	0	0	0
Arroio do Tigre	0	0	0	0	1	0	0	0	0	0	0	Marau	43	0	0	0	0	0	0	0	0	11	0
Arroio Grande	0	0	0	0	2	0	0	0	0	0	0	Marcelino Ramos	0	0	0	0	0	0	0	0	26	168	12
Boa Vista do Cadeado	1	1	1	0	1	1	0	0	0	65	2	Mato Castelhano	1	40	0	2	1	0	0	0	0	10	0
Bom Progresso	0	0	0	0	0	0	0	0	0	36	0	Minas do Leão	0	0	0	0	1	0	0	0	0	220	0
Bossano	0	0	0	3	0	0	0	0	0	41	0	Mormaço	0	0	0	0	2	1208	168	0	0	0	0
Bossoroca	0	0	0	0	4	0	0	0	0	56	0	Muitos Capões	0	0	0	0	0	0	0	0	0	3	0
Bozano	0	0	4	8	0	0	0	0	0	136	60	Nova Alvorada	0	0	0	0	0	0	0	0	0	0	24
Butiá	4	0	0	0	0	0	0	0	0	0	0	Nova Ramada	4	0	0	0	0	0	0	0	0	20	0
Cachoeira do Sul	0	0	0	1	1	0	0	0	0	50	0	Palmeira das Missões	2	0	1	0	7	14	0	0	0	28	0
Caibaté	0	0	0	0	0	0	0	0	0	16	0	Passo Fundo	15	2	1	1	1	0	1	1	0	132	26
Campinas do Sul	180	0	0	0	0	0	0	0	0	16	0	Paulo Bento	0	0	0	8	0	0	0	0	0	96	8
Campo Novo	0	0	0	0	0	0	0	0	0	4	0	Paverama	0	0	0	384	0	0	0	0	24	0	40
Candelária	56	0	0	0	0	0	0	0	0	0	0	Pejuçara	2	0	0	0	0	0	0	0	0	110	0

[1]*Meloidogyne* spp. [2]*Pratylenchus brachyurus*. [3]*Heterodera glycines*. [4]*Rotylenchulus reniformis*. [5]*Pratylenchus zeae*.

[6]*Helicotylenchus dihystera*. [7]Red cells: high level; yellow cell: intermediate level; green cell: low level.

Chart 3: Average poplation level of the main nematodes found in samples of soybean soil and roots in municipalities of Rio Grande do Sul, 2016. Passo Fundo-RS, 2017

(To be continued)

	Mel.[1]		P. b.[2]		H. g.[3]	R. r.[4]		P. z.[5]		H. d.[6]		continua...	Mel.		P. b		H. g.	R. r.		P. z.		H. d.	
Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil	Root	Municipality	Soil	Root	Soil	Root	cyst	Soil	Root	Soil	Root	Soil	Root
Capão Bonito Do Sul	0	0	0	0	0	0	0	0	0	32	0	Pelotas	6	2	0	0	0	0	0	0	0	78	0
Capão do Cipó	264	0	0	0	0	0	0	0	0	80	0	Pinhal da Serra	0	0	0	0	0	0	0	0	0	321	0
Carazinho	2	0	0	0	5	8	0	2	0	134	0	Pontão	4	0	0	0	0	0	0	0	0	87	0
Carlos Gomes	0	0	0	0	0	0	0	0	0	56	6	Rio Pardo	0	0	0	0	0	0	0	0	0	136	0
Caseiros	0	0	0	0	0	0	0	0	0	60	0	Rolador	0	0	0	0	0	0	0	0	0	11	0
Catuípe	5	0	0	3	0	0	0	0	0	51	6	Ronda alta	4	0	0	0	0	0	0	0	0	8	620
Centenário	0	0	0	0	0	0	0	0	0	92	0	Rondinha	0	0	0	0	0	0	0	0	0	16	0
Chapada	234	0	0	0	0	0	0	0	0	32	0	Rosário do Sul	2	5	1	23	1	0	0	0	0	60	8
Colorado	0	0	0	0	0	0	0	0	0	108	0	Saldanha Marinho	140	0	0	0	0	0	0	0	0	56	0
Coqueiros do Sul	8	0	0	0	0	0	0	0	0	94	5	Salto do Jacui	0	0	0	0	0	0	0	0	0	388	0
Coxilha	37	0	1	0	0	0	0	0	2	79	0	Sananduva	0	0	3	0	1	0	0	1	0	62	0
Cruz Alta	6	0	0	0	3	0	0	0	0	52	0	Santa Bárbara do Sul	5	19	0	0	11	0	0	0	0	76	20
Dois Irmãos da Missões	0	0	0	0	1	0	0	0	0	40	0	Santa Cecilia do Sul	0	0	0	0	0	0	0	0	0	52	4
Dois Lajeados	0	0	0	0	0	0	0	0	0	120	0	Santa Cruz do Sul	0	0	0	0	0	0	0	0	0	168	0
Dom Pedrito	0	0	0	0	1	0	0	0	0	32	4	Santa Maria	0	0	4	0	0	0	0	0	0	40	20
Dr. Mauricio Cardoso	0	0	1	0	0	21	0	0	0	30	0	Santo Antônio das Missões	0	0	2	0	0	0	0	0	0	28	0
Entre Ijuís	0	0	0	0	1	0	0	0	0	26	0	Santo Augusto	1	0	1	0	0	1	0	1	0	61	24
Erebango	0	0	0	0	0	0	0	0	0	60	0	São Gabriel	0	0	0	0	0	0	0	0	0	144	0
Erechim	0	0	0	0	1	0	0	0	1	29	33	São João da Urtiga	0	0	0	0	0	0	0	0	0	20	0
Ernestina	0	0	0	0	0	0	0	0	0	52	0	São Lourenço do Sul	0	0	2	0	2	0	0	0	0	16	0

[1]*Meloidogyne* spp. [2]*Pratylenchus brachyurus*. [3]*Heterodera glycines*. [4]*Rotylenchulus reniformis*. [5]*Pratylenchus zeae*. [6]*Helicotylenchus dihystera*. [7]Red cells: high level; yellow cells: intermediate level; green cells: low level.

Chart 2 – Average population level of the main nematodes found in samples of soybean soil and roots in the municipalities of Rio Grande do Sul, in 2015. Passo Fundo-RS, 2017

(Conclusion)

	Mel.[1]		P. b.[2]		H. g.[3]	R. r.[4]		P. z.[5]		H. d.[6]		continua...	Mel.		P. b		H. g.	R. r.		P. z.		H. d.	
Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil	Root	Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil	Root
Esmeralda	0	0	0	0	1	0	0	0	0	158	27	São Luiz Gonzaga	1	0	1	0	2	0	0	1	0	17	0
Espumoso	0	0	0	0	0	0	0	0	0	38	0	São Martinho	0	0	0	0	0	0	0	0	0	32	0
Fortaleza dos Val Valos	3	0	2	0	1	0	0	0	0	77	0	São Miguel das Missões	0	0	0	0	2	0	0	0	0	4	0
Garruchos	6	0	0	0	0	0	0	0	0	44	0	Sarandi	0	0	0	0	0	0	0	0	0	24	0
Gentil	0	0	0	0	0	0	0	0	0	48	3	Sede Nova	0	0	0	0	0	0	0	0	0	0	0
Giruá	0	0	0	0	0	0	0	0	0	4	0	Sertão	0	0	0	30	0	0	0	0	0	43	186
Humaitá	0	0	0	0	0	0	0	0	0	56	0	Severino de Almeida	0	0	0	4	0	0	0	0	0	380	28
Ibirubá	0	0	8	300	0	60	0	0	90	62	30	Tapejara	0	0	0	0	0	0	0	0	0	32	0
Ijuí	82	18	1	3	1	0	0	0	0	144	20	Tio Hugo	4	2	0	0	1	0	0	0	0	27	0
Ipê	12	0	0	0	0	0	0	0	0	80	0	Três de Maio	1	0	1	0	0	0	0	0	0	88	0
Ipiranga do Sul	0	0	0	0	0	0	0	0	0	56	0	Tupanciretã	85	0	1	0	5	1	0	0	0	51	0
Jari	268	640	0	8	0	0	0	0	0	160	72	Vacaria	0	0	0	1	1	0	0	0	0	62	38
												Vila Lângaro	0	0	12	0	0	0	0	0	0	24	0

[1]*Meloidogyne* spp. [2]*Pratylenchus brachyurus*. [3]*Heterodera glycines*. [4]*Rotylenchulus reniformis*. [5]*Pratylenchus zeae*. [6]*Helicotylenchus dihystera*. [7]Red cells: high level; yellow cell: intermediate level; green cell: low level.

Chart 3: Average poplation level of the main nematodes found in samples of soybean soil and roots in municipalities of Rio Grande do Sul, 2016. Passo Fundo-RS, 2017

(To be continued)

	Mel.[1]		P. b.[2]		H. g.[3]	R. r.[4]		P. z.[5]		H. d.[6]		continua...	Mel.		P. b.		H. g.	R. r.		P. z.			H. d.
Município	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil	Root	Municípaity	Soil	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil
Água Santa	0	0	0	4	0	0	0	0	0	7	17	Nicolau Vergueiro	0	0	4	0	0	0	0	0	0	292	0
Alegrete	5	0	1	0	0	0	0	1	0	52	0	Pantano Grande	0	0	0	0	0	0	0	0	0	526	0
Alto Alegre	20	273	1	36	0	0	0	0	0	67	137	Passo Fundo	2	0	2	2	0	0	0	0	0	64	11
Arroio do Ratos	0	0	8	0	0	0	0	0	0	1672	0	Pejuçara	1	0	1	0	0	0	0	1	0	79	1
Boa vista do Cadeado	102	0	1	4	0	0	0	0	0	155	31	Pelotas	0	0	5	57	0	0	0	0	0	131	61
Boa Vista do Incra	54	10	2	0	1	0	0	0	0	185	1	Pontão	334	16	0	61	0	0	0	0	0	38	0
Bossoroca	6	0	2	0	0	34	0	0	0	62	0	Rio Pardo	0	0	0	0	0	0	0	8	0	253	0
Barracão	0	0	0	4	0	0	0	0	0	30	3	Ronda Alta	118	0	0	27	0	0	0	0	0	57	0
Cachoeira do Sul	57	0	4	3	0	0	0	0	0	32	5	Rosário do Sul	4	10	0	0	0	0	0	0	0	246	90
Caibaté	380	0	0	0	0	0	0	0	0	68	0	Saldanha Marinho	20	0	0	0	0	0	0	0	0	36	0
Candelária	587	123	4	8	0	0	0	2	3	2	0	Salto do Jacuí	1090	906	3	16	0	0	0	0	0	129	31
Capão Bonito do Sul	0	0	0	5	1	0	0	0	0	25	3	Santa Bárbara do Sul	196	0	2	0	0	3	0	0	0	72	0
Capão do Cipó	0	0	1	0	3	0	0	0	0	34	0	Santa Cecília do Sul	0	0	0	0	0	0	0	0	0	20	0
Colorado	0	0	3	2	1	0	0	1	0	53	1	Santa Maria	12	0	0	160	0	0	0	0	0	32	0
Condor	0	35	0	35	0	0	0	0	0	32	142	Santa Rosa	290	0	2	0	0	131	0	0	0	80	0
Coronel Bicaco	0	0	4	0	0	0	0	0	0	0	0	Santiago	364	0	9	0	0	0	0	0	0	291	0
Cruz Alta	168	0	4	109	6	0	0	0	0	132	3	Santo Ângelo	0	0	0	0	0	0	0	0	0	76	0
Dr. Maurício Cardoso	6	0	3	0	0	58	0	0	0	71	0	Santo Antônio das Missões	26	0	1	0	1	5	0	0	0	45	0
El dourado do Sul	0	0	0	0	0	0	0	0	0	24	0	Santo Augusto	0	0	14	2	0	0	0	6	7	60	110
Ernestina	296	32	0	24	0	0	0	0	0	216	24	São Borja	0	0	0	0	0	0	0	0	0	128	0
Esmeralda	0	1	0	0	1	1	0	0	0	38	0	São Franscisco de Assis	101	0	2	1	0	0	0	2	0	178	3
Espumoso	0	0	0	0	0	0	0	0	0	32	0	São Francisco de Paula	0	0	0	0	0	0	0	0	0	48	0
Estação	0	0	1	0	0	0	0	0	0	12	0	São Gabriel	0	0	0	0	0	0	0	0	0	66	395
Flores da Cunha	376	1568	0	0	0	0	0	0	0	236	8	São Lorenço do Sul	504	0	0	0	0	0	0	0	0	104	0
Fortaleza Dos Valos	562	0	0	0	0	0	0	0	0	86	0	São Miguel das Missões	0	0	0	0	0	0	0	0	0	73	3
Garruchos	176	0	0	0	3	0	0	0	0	19	0	São Sepé	0	0	4	35	0	0	0	0	0	40	70

Chart 3: Average population level of the main nematodes found in samples of soubean soil and roots in muncipalities in the state of Rio Grande do Sul, 2016. Passo Fundo-RS, 2017

(Conclusion

	Mel.[1]		P. b.[2]		H. g.[3]	R. r.[4]		P. z.[5]		H. d.[6]		continua...	Mel.		P. b.		H. g.	R. r.		P. z.			H. d.
Municipality	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil	Rootz	Município	Soil	Soil	Root	Soil	Root	Cyst	Soil	Root	Soil	Root	Soil
Gentil	0	0	0	0	0	0	0	0	0	44	0	Sertão	1	0	0	17	0	0	0	0	3	68	57
Getúlio Vargas	0	0	0	0	0	0	0	0	0	88	0	Soledade	0	0	0	0	0	0	0	0	0	16	0
Guarani das Missões	0	0	0	0	0	0	0	0	0	108	0	Tenente Portela	0	0	0	0	0	31	35	0	0	3	62
Independência	0	0	0	0	0	32	0	0	0	108	0	Três de Maio	13	1	4	5	0	10	0	0	0	134	0
Ipiranga do Sul	0	0	4	0	0	0	0	0	0	16	0	Triunfo	580	0	0	0	0	0	0	0	0	8	
Júlio de Castilhos	19	0	0	0	0	0	0	0	0	7	0	Tucunduva	0	0	0	0	0	250	0	0	0	94	0
Manoel Viana	2	0	2	0	0	0	0	1	0	223	0	Tupanciretã	57	8	0	0	0	0	0	0	0	15	0
Marau	24	0	6	3	1	0	0	0	0	42	5	Tuparendi	0	0	0	0	0	312	0	0	0	0	0
Minas do Leão	0	0	0	0	0	0	0	0	0	240	0	Unistalda	122	0	0	0	0	0	0	0	0	124	0
Montauri	0	0	12	0	0	0	0	0	0	104	0	Victor Graeff	0	0	0	0	0	0	0	0	0	52	40
Muitos Capões	0	0	0	0	0	0	0	0	0	4	0	Vitória das Missões	0	0	0	0	0	0	0	0	0	12	0
Não-Me-Toque	0	0	2	0	0	0	0	0	0	76	0	Vale do Sol	636	5	0	0	0	0	0	0	0	0	0
Novo Machado	0	0	0	0	0	0	0	0	0	0	0	Vacaria	0	0	0	0	0	0	0	0	0	0	0

[1]*Meloidogyne* spp. [2]*Pratylenchus brachyurus*. [3]*Heterodera glycines*. [4]*Rotylenchulus reniformis*. [5]*Pratylenchus zeae*. [6]*Helicotylenchus dihystera*. [7]Red cells: high level; yellow cells: intermediate level; green cells: low level.