Phytonematode population dynamics in common bean cultivation under crop rotation and no-tillage conditions[1]

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ABSTRACT

Strategies for conserving natural resources and reducing agricultural inputs are the great challenge for agriculture, such as sustainable alternatives to control agricultural pests of high economic impact, e.g. plant-parasitic nematodes. This work aimed to evaluate phytonematode's population dynamics in common bean cultivation grown under crop rotations and no-tillage system. The maize was seeded under pearl millet straw and intercropped with three different crops systems: i) exclusive maize system, ii) maize intercropped with brachiaria and, iii) maize intercropped with crotalaria. The experimental design was a randomized complete block with three treatments (crops systems) and 4 blocks (5 subsamples each block). The common bean was seeded on the straw of exclusive or intercropped maize. The phytonematode population was evaluated in the soil and in the roots in seven moments: (i) fallow; (ii) pearl millet flowering; (iii) pearl millet maturity; (iv) maize flowering; (v) maize maturity; (vi) common bean flowering; and (vii) common bean maturity. The greatest control of the phytonematodes species described in the area was in the maize intercropped with crotalaria treatment, as the phytonematodes population decreased 2.49-fold in this treatment when compared to exclusive maize, resulting in an increase of 11.27% in common bean yield. Therefore, maize intercropped with crotalaria is a viable alternative to reduce phytonematodes infestation in common bean crop.

Keywords: cover crops; *Meloidogyne javanica*; *Phaseolus vulgaris*; *Pratylenchus brachyurus*; *Rotylenchulus reniformis*.

INTRODUCTION

High demand for profitable and sustainable food and the projected population increase will be the major challenge for agriculture in the coming decades (Zhang *et al.*, 2013). Sustainable management practices in agriculture are economic and social important in the worldwide agricultural activity (Isaac *et al.*, 2018). However, biotic factors can limit the application of sustainable agronomic techniques. For example, phytonematodes are among the soil pests considered the most harmful to cultivated plants (Trudgill & Blok, 2001).

Phytonematodes are plant parasites that mainly infect the roots of a wide diversity of crops (Bozbuga *et al.*, 2018). The root-knot nematode (*Meloidogyne* spp.) is considered the most harmful genus economically due to its short cycle (Karssen *et al.*, 2013), high reproductive rate, aggressiveness, wide range of hosts and beyond. In addition, root-knot nematode can infect most plant species, causing greater losses in yield of cash crops, such as common bean (*Phaseolus vulgaris* L.) and maize (*Zea mays* L.) (Dadazio *et al.*, 2016; Mbatyoti *et al.*, 2019). For example, nematodes from genera *Meloidogyne* can cause up to 90% yield losses in common bean growing areas (Da Costa *et al.*, 2019). In

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fact, it was estimated that the economic loss caused by phytonematodes damage in cash crops exceeds US$100 billion a year in the USA (Coyne *et al.*, 2018). The most used control method for all phytonematode's genera is chemical nematicides. Despite their practicality, they are not considered very efficient, due to the short period of protection controlling the population (Van der Putten *et al.*, 2006). Moreover, the use of chemical products is increasingly restricted, as their inappropriate application can damage on population health and environment, as well as causing side effects on other beneficial organisms (Van der Putten *et al.*, 2006). Thus, sustainable control alternatives are key strategies in phytonematodes management, such as the use of cover crops.

In fact, the association of a legume with a cereal is essential for soil fertilization, and the leguminous plant contributes to biological nitrogen (N) fixation through symbiosis with rhizobacteria and mineralized N of plant residues (Giller, 2001). The no-tillage system (NTS) is characterized by soil cover maintenance of one or more straws from previous crops during autumn/winter, considered as ideal conditions in tropical regions (Salton *et al.*, 2001). Furthermore, soil covering can assist in weed control (Büchi *et al.*, 2019; D'Amico-Damião *et al.*, 2020a), including effects in soil pest and disease reduction (Franke *et al.*, 2019; Manandhar *et al.*, 2017), improving soil physical parameters, reducing erosion, increasing water infiltration and improving soil structure (Çerçioðlu *et al.*, 2019). Research activities have been promoting and refining NTS techniques, which was important for the adoption of the technique on approximately 111 million hectares around the world (Derpsch *et al.*, 2010). Currently, NTS is used in more than 32 million hectares in Brazil, with soybeans and maize being the most cultivated crops in NTS (Peixoto *et al.*, 2019).

NTS is efficient because, in the absence of the host plant and in adverse climatic conditions, it tends to decrease nematode population in the soil (McSorley, 1998). Nematode abundance can change over the years, depending on the area's history, host plants availability and its quality, as well as biotic interactions with other organisms (Van der Putten *et al.*, 2006), such as grasses used in a pasture (Ferraz & Freitas, 2004).

Interactions involving nematodes and organic residues incorporation in the soil impact both the physical and biological properties. Therefore, it promotes a favorable environment to the development of antagonistic and/or competing microorganisms with nematodes. In some cases, plants can release compounds that are repellents, attractants, nematotoxics, stimulants, or inhibitors of juvenile hatching nematodes. These plants have a high potential as cover crops and nematode management strategies (Chitwood, 2002).

Although they are not nematicides, egg-hatching stimulants can be used in the field in the host plant absence. Fukuzawa *et al.* (1985) studied the compound glycoeclepino A, derived from triterpenoid and made from the dried roots of beans to control *Heterodera glycines*. Moreover, a pyrrolizidine-type alkaloid is a nematicide synthesized in all tissues of the *Crotalaria spectabilis* species (Marahatta *et al.*, 2012), such as monocrotaline that can inhibit nematodes development, limiting the proliferation, mainly of root-knot forming nematodes (Anene & Declerck, 2016). In addition, *C. spectabilis* is a bad host of migrating nematodes (Thoden *et al.*, 2009). Therefore, the cover crops cited above are sustainable alternatives to reduce damage caused by phytonematodes and increase yield of the main crop. Thus, the objective of this work was to evaluate the phytonematodes' population dynamics in common bean cultivation grown under crop rotation and no-tillage conditions.

MATERIALS AND METHODS

The experiment was carried out under field conditions at the São Paulo State University, Jaboticabal, Brazil (21º14'59''S, 48º17'13''W, at an average altitude of 565 m). The region climate was classified as Aw, according to Köppen's classification. Meteorological data were recorded (Figure 1). The experimental area soil was classified as Eutrophic Red Latosol with clay texture (533 g kg^{-1} of clay, 193 g kg^{-1} of silt and 274 g kg^{-1} of sand).

The experimental area remained fallow (9 months after) before the experiment implementation. Phytonematodes were detected by previous nematode analysis (Table 1). Crop rotation started with the spring sowing (September, 2015) of pearl millet (*Pennisetum glaucum* L.) cv. ADR 300 in total area. Pearl millet plants were desiccated 56 days after seeding (DAS). Thus, the treatments were placed under NTS, which were three different crops: i) exclusive maize system, ii) maize intercropped with brachiaria (*Urochloa ruziziensis*) and iii) maize intercropped with crotalaria *(Crotalaria spectabilis*).

Maize cv. AS 1633 PRO 2 (60,000 plants per ha), brachiaria (10 kg ha^{-1}) and crotalaria (12 kg ha^{-1}) were seeded in the summer season (November, 2015). Plots were composed of 4m-long rows of maize, but border rows and 1m from each side was excluded for further evaluations. Intercropped treatments (ii and iii) were seeded in double inter-row mode. In sowing maize fertilization, 19 kg ha^{-1} of N, 67 kg ha^{-1} of P_2O_5 and 38 kg ha^{-1} of K_2O were used via commercial form 08-28-16. In the topdressing fertilization, 60 kg ha^{-1} of N and 20 kg ha^{-1} of K_2O were applied via commercial formula 30-

00-10 plus 36 kg ha^{-1} of N (urea) and 39 kg ha^{-1} of S via ammonium sulfate, during the phenological stage V_6, according to the recommendations of Raij *et al.* (1997) and Fornasieri Filho (2007). Maize harvest was executed and manually threshed. Grain yield was measured in each useful plot. Yield moisture was standardized to 13%.

After maize harvest (May, 2016), common bean (*Phaseolus vulgaris* L.) cv. IAC Alvorada was sowed with a density of 260,000 plants per hectare in winter season (June, 2016). Plots consisted of 6 rows of 5 m length, but we excluded the border rows and 1m from each side as a useful plot. The experimental design was a randomized complete block with three treatments (crops systems) and 4 blocks (5 subsamples each block). In common bean sowing fertilization, 8 kg ha^{-1} of N, 40 kg ha^{-1} of P_2O_5, and 40 kg ha^{-1} of K_2O were used via commercial formula 04-20-20. Other phytosanitary treatments were carried out according to the recommendations of the Agricultural Defensives Compendium (Tomlin, 2009). Common bean harvest was carried out manually and was mechanically threshed. Grain yields were measured and standardized to 13% moisture in all useful plots.

For phytonematode analysis, root and soil samples were collected in seven moments: (i) fallow, 0 days after experiment installation (DAEI); (ii) pearl millet flowering, 36 DAEI; (iii) pearl millet maturity, 55 DAEI; (iv) maize flowering, 134 DAEI; (v) maize maturity, 220 DAEI; (vi) common bean flowering, 336 DAEI; and (vii) common bean maturity, 382 DAEI. For each root and soil sample, six subsamples were collected using an auger and were used totaling 50 g of roots and 1 L of soil. Samples were processed using 20 g of roots and 100 cm³ of soil, according to the methodology of Coolen & D'herde (1972) and Jenkins (1964), respectively.

The material obtained was evaluated under a microscope at 10x objective lens, using Peters slides. Genera were identified (Mai & Lyon, 1975) and population was estimated (Southey, 1970). *Meloidogyne javanica* was identified based on morphological characteristics of the perennial region (Netscher & Taylor, 1974), the male labial region (Eisenback *et al.*, 1981), and the isoenzyme phenotype for esterase (Esbenshade & Triantaphyllou, 1990). *Pratylenchus brachyurus* was identified based on the morphology of adult females using Castillo & Vovlas (2007). *Rotylenchulus reniformis* was identified by comparing the morphological characteristics of young females with those described in the dichotomous key proposed by Robinson *et al.* (1997).

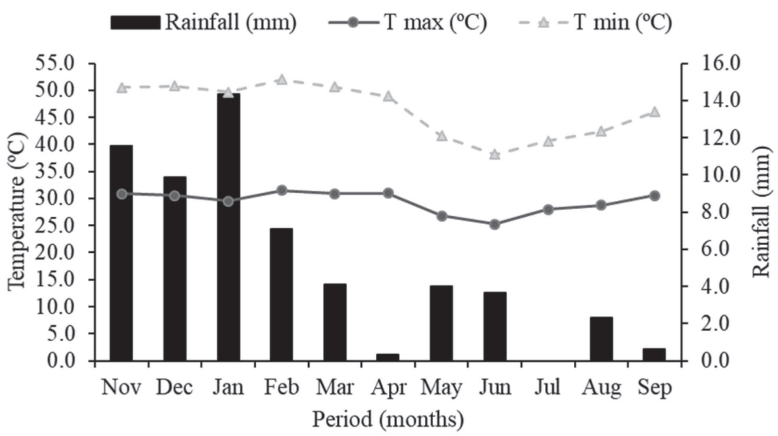

Figure 1: Rainfall (mm), maximum and minimum air temperatures (°C) recorded monthly in the experimental area, from November 2015 to September 2016.

Table 1: Descriptive analysis (mean and SD) of *Meloidogyne javanica*, *Pratylenchus brachyurus* and *Rotylenchulus reniformis* phytonematodes population found in the experimental area when fallow (0 DAEI; soil), during pearl millet flowering stage (36 DAEI; soil + roots) and during pearl millet maturity stage (55 DAEI; soil + roots)

Species	Fallow		Pearl millet flowering		Pearl millet maturity		RF**
	Mean	SD*	Mean	SD*	Mean	SD*	
M. javanica	3.3	5.3	34.7	62.4	1.3	4.6	0.4
R. reniformis	20.7	25.6	103.3	122.4	88.0	146.1	4.3
P. brachyurus	179.3	147.9	432.7	426.5	1190.0	1355.2	6.6

*Standard deviation. Averages are derived from 12 samples composed of 5 subsamples taken from experimental area. **Reproduction factor: RF = final population (pearl millet maturity stage) / initial population (fallow).

Data were transformed to log (x + 5) to reduce the skewness of original data and submitted to analysis of variance by the F test ($p < 0.05$). Mean values were compared by the Tukey test ($p < 0.05$) with AgroEstat® software.

RESULTS

Initial population analysis showed a phytonematode infestation before the pearl millet cultivation (when the experimental area was fallow) and the main phytonematodes species found were *M. javanica*, *P. brachyurus* and *R. reniformis* (Table 1). The predominant phytonematode was *P. brachyurus*, followed by *R. reniformis* and *M. javanica*. During pearl millet cultivation, *M. javanica* was found to have the lowest populations for both evaluated moments (36 and 55 DAEI). The calculated reproduction factor was below 1 which indicates resistance to root-knot nematode (Table 1). *P. brachyurus* and *R. reniformis* population levels increased from 36 DAEI to 55 DAEI. Reproduction factor average of *P. brachyurus* and *R. reniformis* were greater than 1 (RF = 4.3 and 6.6 respectively). This indicates susceptibility to the root-lesion nematode and the reniform nematode. In fact, the cultivation of pearl millet decreased *M. javanica* density in field conditions (Table 1).

In maize's season, no statistically significant difference was observed between treatments for *M. javanica* and *P. brachyurus* populations in either moment (134 and 220 DAEI; Table 2). However, comparing the phytonematode's population evaluated at 220 DAEI with the population at 134 DAEI, all phytonematodes populations were increased (Table 2). *P. brachyurus* population increased 10.7 times when maize was intercropped with *B. ruziziensis*, 5.2 times when maize was in an exclusive system and 3.1 times when maize was intercropped with *C. spectabilis*. *R. reniformis* population in the exclusive maize system at maize maturity was the lowest, even less than those verified in the maize intercropped with brachiaria system (Table 2). On the other hand, *R. reniformis* population in the exclusive maize system did not differ from those in the maize intercropped with crotalaria system (Table 2). A homogeneous population of *M. javanica* occurred given the presence of maize roots as an efficient host in all systems evaluated (Table 2).

P. brachyurus found in common bean crop was higher when succeeded by exclusive maize and maize intercropped with brachiaria crop systems (336 DAEI; Table 3). During the common bean maturation stage, *R. reniformis* population was 6.1 times higher in the common bean that followed maize intercropped with brachiaria than in the common bean that followed maize intercropped with crotalaria (382 DAEI; Table 3). However, no such differences were observed between the intercropped systems and exclusive maize. On the other hand, maize intercropped with brachiaria was not altered when compared with exclusive maize, showing that maize was not a good host for this phytonematode species (Figure 2). It was found that the common bean's yield was significantly higher (11.27%) when cultivated on the straw of maize intercropped with crotalaria (Table 3). However, common bean yield in the maize intercropped with brachiaria system was not changed compared to the other crop systems (Figure 2). Low population levels of phytonematodes (*M. javanica*, *P. brachyurus* and *R. reniformis*) in common bean crop were also observed in this system (Table 3).

DISCUSSION

Sustainable alternatives have been proposed to improve traditional production systems in order to

Table 2: Analysis of variance of *Meloidogyne javanica*, *Pratylenchus brachyurus*, *Rotylenchulus reniformis* and total nematode population found in the crop rotation systems samples during maize flowering stage (134 DAEI; soil + roots) and maize maturity stage (220 DAEI; soil + roots). I_{EM} = exclusive maize, I_{M+B} = maize + *Urochloa ruziziensis* and I_{M+C} = maize + *Crotalaria spectabilis*

Treatments	*M. javanica*		*P. brachyurus*		*R. reniformis*		Nematodes	
Crop Systems	Flowering	Maturity	Flowering	Maturity	Flowering	Maturity	Flowering	Maturity
	Soil (100 cm³) and roots (20 g)							
I_{EM}	60a	272a	536a	2794a	32a	16b	626a	3080a
I_{M+B}	60a	330a	536a	5720a	30a	186a	822a	6236a
I_{M+C}	96a	314a	936b	2980a	30a	122ab	1064a	3416a
CV (%)	38.69	27.03	22.62	8.75	49.36	28.05	16.72	8.49
LSD	1.21	1.20	1.17	0.60	1.19	0.97	0.92	0.59
Test F	0.47^{ns}	1.09^{ns}	0.60^{ns}	1.66^{ns}	0.22^{ns}	4.77^{*}	0.63^{ns}	1.59^{ns}

*Mean values (untransformed data) followed by the same lowercase letter in the columns did not differ by Tukey's test at 5% probability. The statistics were based on transformed data for log (x + 5). Mean values represent an average of 4 samples (*n* = 4) composed of 5 subsamples in each crop system. * ($p < 0.05$), ** ($p < 0.01$) and ns (not significant), respectively by the F test. Coefficient of variation (CV). Least significant difference (LSD).

reduce environmental impacts of agriculture. One alternative is NTS, which has been adopted around the world (Holland, 2004) and has numerous benefits. NTS can increase soil biodiversity, which minimizes agricultural system disturbances due to decomposition performed by filamentous fungi (Adl *et al.*, 2006). However, highly harmful pest control experiments—e.g., nematode experiments—were concentrated in greenhouses (Santana-Gomes *et al.*, 2018). Therefore, in order to investigate nematode population dynamics in NTS, we decided to verify the effect of different crop rotation systems on nematode population and common bean yield.

The pearl millet and Sudan grass crops are the most commonly-used cover crop species due to their high dry matter production. However, evidence of their ability to control nematodes is mixed. For instance, in this study, pearl millet cv. ADR 300 increased reniform nematode population (Table 1). On the order hand, Gabriel *et al.* (2018) observed that the 'BRS1501' pearl millet was resistant to three species: *M. ethiopica*, *M. incognita* and *M. javanica* with RF = 0.18, 0.68 and 0.46 respectively and, susceptible to *P. brachyurus* with RF = 1.02. Additionally, Ribeiro *et al.* (2002) reported the resistance of pearl millet hybrids 9938008, CMS 03, CMS 01, CMSXS 760, CMSXS 762, and 9317484 to *M. incognita* and *M. javanica*, as observed in our analyses (Table 1). Differently than what Inomoto *et al.* (2008) reported, pearl millet cv. BRS1501 was susceptible to *M. javanica* races 2 and 4. In fact, Dias-Arieira *et al.* (2003) found that *P. americanum* favored the reproduction of *M. javanica* and *M. incognita*. Moreover, Asmus *et al*. (2008) reported that pearl millet could be a good option for reniform nematode (*R. reniformis*) management.

Moreover, crop systems with brachiaria reduced *M. javanica* and *R. reniformis* populations. However, this forage species was hosted by *P. brachyurus* in our experiment (Table 2), corroborating the results of Cunha *et al.* (2015). Inomoto (2011) found that maize is a host for *P. brachyurus* corroborating our results again, in other words, all treatments were able to increase the root lesion nematode population (Table 2). Gardiano *et al*. (2014) evaluated *R. reniformis* reproduction in naturally infested soils and found low reproduction in white oats cv. IPR126, black oats cv. IAPAR61, triticale cv. IPR111, rye cv. IPR89, sorghum cv. SI03204, pearl millet cv. BRS1501 and *B. ruziziensis*. In addition, maize cv. IPR 115 showed RF of 0.63, which was not considered a good host for *R. reniformis*. Windham & Lawrence (1992) tested 50 commercial maize hybrids, all of them were poor hosts for *R. reniformis*, corroborating with our results (Table 2). In fact, poaceae species are used in crop rotation as cover crops because they have a low reproduction rate for *R. reniformis* and high management efficiency in areas with high infestation (Asmus *et al.*, 2008). Thus, maize was an important management practice in crop rotation systems to reduce *R. reniformis* population (Table 3), limiting the effects on common bean yield (Figure 2).

In intercropped systems, the simultaneous establishment of cover crop and the main crop occurs under interspecific competition. Consequently, the cash crop can lose yield to the cover crop due competition.

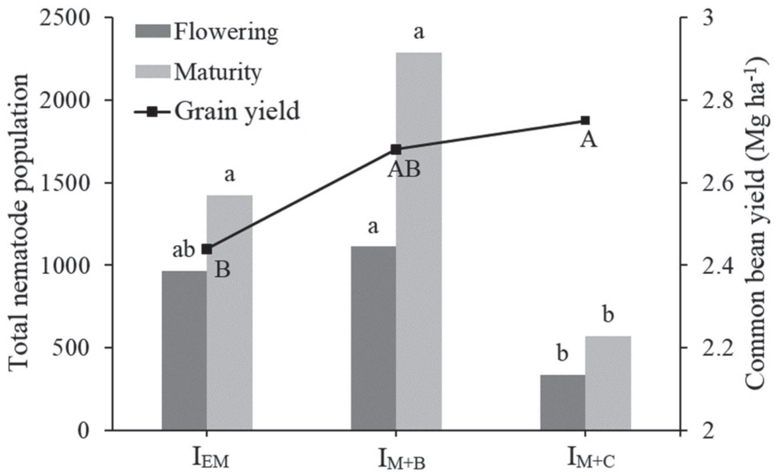

Figure 2: Bars represent total nematode population found in the crop rotation systems samples during common bean flowering stage (336 DAEI; soil + roots) and common bean maturity stage (382 DAEI; soil + roots). Line represents common bean yield (n = 20) under different crop systems: I_{EM} = exclusive maize, I_{M+B} = maize + *Urochloa ruziziensis* and I_{M+C} = maize + *Crotalaria spectabilis*. Mean values followed by equal letters do not differ by Tukey's test at 5% probability. Lower letters compare total nematode population (n = 4) in each common bean stage (flowering or maturity) and capital letters compare common bean grain yield (n = 20). The common bean yield data were adapted from D'Amico-Damião *et al.* (2020b).

However, maize was considered an excellent competitor with small plants, since its initial growth is accelerated (Ozier-Lafontaine *et al.*, 1997), which was observed in our work (Table 2). In fact, agronomic viability in maize production and the forage establishment for straw production were demonstrated (D'Amico-Damião *et al.*, 2020b), with no significant losses in yield due to competition between plants (Jakelaitis *et al.*, 2004; Alvim *et al.*, 1989; Duarte *et al.*, 1995).

Nematode suppression such as *M. incognita*, *Pratylenchus* spp. through the use of non-host and/or resistant cover crops (such as sunnests, among others) was verified previously by Briar *et al.*, (2016). Furthermore, there was an increase for predatory nematode population of three orders *Dorylaimida*, *Mononchida* and *Diplogasterida* (Bilgrami & Brey, 2005). Other microbial species were developed including fungi and bacteriaspecies of *Trichoderma*, *Penicillium*, *Aspergillus*, *Bacillus*, *Pseudomonas*, *Pantoea* and *Actinomycetes*, which stimulate nutrient mineralization, indicating improvement in soil quality. In general, the nematode suppression obtained by these management changes is a long-term strategy. Probably, the increase in microbial activity in the soil will be a great competitor to plant parasitic nematode populations and develop a great microbiological balance in the soil (Oka, 2010).

Crotalaria is considered a suppression plant for different phytonematode species, mainly *C. spectabilis* (Table 3). As a consequence, it has been used as a cover crop in intercropping systems and as a green manure due to its biological nitrogen fixation (Wang *et al.*, 2002). In addition, brachiaria was also important to contribute to the straw amount in the NTS (D'Amico-Damião *et al.*, 2020b) and, to stimulate the biological activity in the soil (Lal, 2004). Indeed, maize intercropped with crotalaria decreased the initial population of all important nematode species (*P. brachyurus*, *M. javanica*, and *R. reniformis*) for the next crop, which was highlighted as a good management control for phytonematodes studied (Figure 2). The maize intercropped with brachiaria system was also satisfactory, as the yield did not differ from the greater yield obtained in the maize intercropped with crotalaria treatment (Table 3). Probably, the straw input improves organic matter decomposition increasing biodiversity and improving soil characteristics (Poeplau & Don, 2015). The intercropped systems promoted better conditions for plant development and yield gain when compared to the exclusive maize (Figure 2).

Several studies reported that crotalaria can suppress nematode occurrence better than nematicides, as they continue to suppress them even after the crop has already been implanted. Overall, crotalaria reduces nematode populations acting mainly as non-host and/or resistant crop, as well as producing toxic or inhibitory allelochemicals (Chitwood, 2002) and improving survival conditions for antagonistic fauna and flora. Thus, with the cover crops benefits, common bean was able to tolerate the nematodes' presence without yield reduction (Oka *et al.*, 2007).

This research provided a useful nematode control management workflow for common beans in areas infested with *M. javanica*, *P. brachyurus* and *R. reniformis* using maize intercropped with cover crops as a tool. Intercropped systems were successfully able to reduce nematode population and increase common beans yield. These findings can support further development of more precise soil-borne parasites control methods. Nematode species present in the field (identification) and cover crop adaptability has to be accounted. Future studies should evaluate multiple cover crops to be intercropped with maize and/or treatments with cover crops only in order to improve regional recommendations.

Table 3: Analysis of variance of *Meloidogyne javanica*, *Pratylenchus brachyurus*, *Rotylenchulus reniformis* and total nematode population during common bean flowering stage (336 DAEI; soil + roots) and common bean maturity stage (382 DAEI; soil + roots). I_{EM} = exclusive maize, I_{M+B} = maize + *Urochloa ruziziensis* and I_{M+C} = maize + *Crotalaria spectabilis*

Treatments	***M. javanica***		***P. brachyurus***		***R. reniformis***		**Nematodes**	
Crop Systems	**Flowering**	**Maturity**	**Flowering**	**Maturity**	**Flowering**	**Maturity**	**Flowering**	**Maturity**
	Soil (100 cm³) and roots (20 g)							
I_{EM}	207a	330a	620ab	504a	138ab	586ab	966ab	1422a
I_{M+B}	2a	115a	631a	928a	478a	1240a	1112a	2284a
I_{M+C}	80a	188a	216b	179b	42b	203b	339b	570b
CV (%)	62,24	45,34	14,48	21,46	42,93	33,10	13,07	17,66
LSD	0,51	0,61	0,28	0,39	0,54	0,57	0,27	0,39
Test F	$2{,}79^{ns}$	$1{,}99^{ns}$	$9{,}33^{**}$	$10{,}55^{**}$	$4{,}32^{*}$	$6{,}98^{**}$	$10{,}40^{**}$	$9{,}57^{**}$

*Mean values (untransformed data) followed by the same lowercase letter in the columns did not differ by Tukey's test at 5% probability. Statistics were based on transformed data for log (x + 5). Mean values were derived from 4 samples (*n* = 4) composed of 5 subsamples in each crop system. * ($p < 0.05$), ** ($p < 0.01$) and ns (not significant), respectively by the F test. Coefficient of variation (CV). Least significant difference (LSD).

CONCLUSIONS

Pearl millet increased *P. brachyurus* infestation in the crop area analyzed. *R. reniformis* and *P. brachyurus* species increased their infestation in common bean when cultivated under maize intercropped with brachiaria and exclusive maize systems. The maize intercropped with crotalaria system reduces *P. brachyurus*, and *R. reniformis* nematodes population in the common bean crop compared to the maize intercropped with brachiaria system. The best system for nematode control and further common beans cultivation was maize intercropped with crotalaria.

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