ABSTRACT
The gill nematode (Meloidogyne spp.) is a widely distributed phytoparasite capable of causing great yield losses in the most diverse cultures. Therefore, the objective of the present work is to evaluate the effect of Bacillus amyloliquefaciens used in the treatment of seeds as a biocontrol agent of Meloidogyne javanica in common bean, and the direct effect of M. javanica on hatching, motility and in vitro mortality. Experiments were conducted in the municipality of Cascavel, Paraná, in a greenhouse and laboratory. A randomized complete block design (DBC) was used, using five different doses of the biocontrol (0, 50, 100, 150 and 200% of the recommended dose), with five replicates for both experiments. The sowing of 3 seeds of cv. IPR Bullfinch was performed in 2 L plastic vessels with autoclaved soil and sand mix. The inoculation of 2000 eggs / J2 of M. javanica per plant was carried out in a sequence. Forty days after inoculation, the plants were removed for evaluation, where vegetative parameters and nematological parameters were analyzed. In the laboratory bacterial / nematological suspensions were added totaling 10mL per plate. Hatching in distilled water was used as control. The chambers were maintained in B.O.D. to 27 +/− 1º C with photoperiod of 12 hours / light. Hatching, motility and mortality were evaluated at 9 and 15 days. Both data were subjected to a regression analysis at 5% probability level, using the statistical software SISVAR, version 5.6. Results showed that the bacterial isolate B. amyloliquefaciens is a potential controller of M. javanica "in vitro", as well as of "in vivo" vegetative and nematological parameters.

Key words: Biological control, Root-Knot nematode, Rizobacterium, Phaseolus vulgaris L.

INTRODUCTION
The common bean (Phaseolus vulgaris L.) belongs to the class Magnoliopsida, order Fabales, family Fabaceae, and originates in the Americas (Vieira et al., 2006; Yokoyama and Stone, 2000). Its genus includes around 55 species, of which the common bean is considered the main genus (DEBOUCK, 1999). It is classified as a self-pollinated species (BURLE et al., 2010), which spreads out from tropical areas to temperate zones, reaching five continents (EMBRAPA, 2010; CTSBF, 2010).

In the field of Agronomy, more than 300 diseases including fungi, viruses and nematodes have affected the common bean (SOARES, 2011). Nematodes from the Meloidogyne spp. genus have a high range of host crops in Brazil (SBN, 2012), leading to great yield losses, higher than 50%, due to plants physiological disorders (SOARES, 2011; DIAS et al., 2010; SBN, 2012; HAEGERMAN et al., 2012).

Alternative methods to control nematodes include the biological control provided by rhizosphere colonization agents such as rhizobacteria, microorganisms capable of promoting protection, which interfere in the stages of the nematode vital cycle (STANGARLIN et al., 2011). In this context, the use of Bacillus spp. shows attractive characteristics such as resistance induction (FU and DONG, 2013), an antagonist and root protection effect, due to its multiplication efficacy in the rhizosphere (HASKY-GUNTER et al., 1998; VAZ et al., 2011). In addition, it stimulates plant growth through the production of phytohormones (VAZ et al., 2011).
Thus, the objective of this work was to evaluate the efficacy of the *Bacillus amyloliquefaciens* in the control of *Meloidogyne javanica* in bean plants to reduce nematodes reproduction and damages caused by these parasites to a culture “in vivo”. This work also analyzes the action of the *Bacillus amyloliquefaciens* on the hatching, motility and mortality of juveniles of second stadium (J2) of “in vitro” *M. javanica*.

**MATERIAL AND METHODOS**

The experimental research was conducted in a private property located in Southern Cascavel, Paraná, latitude 24°97’78.971” S and longitude 53°46’10.042” O, with 100 m² and protected greenhouse cultivation.

The experiment was conducted in a randomized blocks design (RBD), with five treatments and five distinct dosages of *B. amyloliquefaciens* (0, 50, 100, 150 and 200% of the product recommended dosage, respectively), with five replications.

A sand and soil mix was used in the 2:1 proportion. Mix texture was classified as medium, type 2, according to the soil physical analysis opinion (Table 1).

**Table 1. Granulometric Analysis Results (Texture).**

| Description g kg⁻¹ | Clay  | Silt   | Sand  |
|--------------------|-------|--------|-------|
|                    | 270.5 | 132.22 | 597.28|

Soil Class, Medium Type 2.

To make the material sterile in the microbiological sense, a process of soil sterilization was conducted by autoclaving under the temperature of 120ºC, and pressure of 1 Kgf/cm².

Fertilization recommendations were guided by the nutrient contents determined by the soil chemical analysis (table 2).

**Table 2. Soil chemical analysis used in the experiment.**

| Sample | P mg/dm³ | MO g/dm³ | pH CaCl₂ | H +Al cmol⁻¹ dm⁻³ | Al³⁺ 0,01mol/L¹ | K⁺ 0.10 | Ca²⁺ 2.97 | Mg²⁺ 0.74 | SB 3.81 | CTC 6.93 | V 54.95 |
|--------|----------|----------|----------|-------------------|-----------------|---------|---------|---------|--------|---------|---------|
| Description | 2.07 | 5.47 | 6.04 | 3.12 | 0.00 | 0.10 | 2.97 | 0.74 | 3.81 | 6.93 | 54.95 |

According to the results, fertilization included adding to the soil a mineral mix with simple superphosphate (SSP) and 10 g of potassium chloride (KCl), in the proportion of 50 g for each 2 liters of soil.

Seeds inoculation with *B. amyloliquefaciens*, in a common concentration of 3 mL Kg of seed, realized on July, 25 (2017), consisted in mixing seeds with Blindage B® in their due dosages, according to the following established treatments: 0; 1,5; 3,0; 4,5; 6,0 mL Kg of seeds.

Immediately after the treatment, three cv. IPR Curió bean seeds (susceptible to the root-knot nematode) were sown per vase. Manual irrigation was done periodically to maintain soil field capacity. (EMBRAPA, 2010).

Number of emerged plants and thinning evaluation occurred during the V2 stadium (primary leaves open), leaving one plant per vase.

The nematode pure population used during the trial was obtained from tomato roots kept in a greenhouse. Identification was done through electrophoresis and perineal tears. *Meloidogyne* eggs extraction was realized by the method proposed by Hussey e Barker, adapted by Boneti and Ferraz (1981). Inoculum count and calibration was facilitated by nematodes suspension clarification, according to the centrifugal flotation technique proposed by Jenkins (1964).

After the collection of a clear nematode suspension, it was placed in a Peter’s chamber, under an optical microscope and measured for a concentration of 500 eggs and eventual juveniles of second stadium by ml.

Nematodes inoculation was carried out right after thinning, on August, 8 (2017), when each plant was inoculated with a population of 2000 eggs and eventual juveniles of second stadium (J2) of *M. javanica*. They were distributed with the help of a Pasteur pipette 1 mL, in each one of the equally spaced orifices,
perforated on the four opposite sides of the plant, at approximately 2 cm from the plant’s lap, around 4 cm deep.

Forty days after inoculation, plants were removed for an evaluation of the vegetative and nematological parameters. The following vegetative parameters were evaluated: plant height (cm), aerial part fresh matter (g), aerial part dry matter (g), roots fresh matter (g), and root length.

Nematological parameters evaluation included root knot count in the root system and nematodes extraction at 100 cm$^3$ from the soil. The reproduction factor (FR=Pf/Pi) was determined based on the number of eggs and juveniles present in the soil and in the roots of the bean plant submitted to treatment. It was calculated by the relationship between the number of eggs by root system added to the J2 found in the soil (Pf) and the number of eggs used in the inoculum (Pi).

Data were submitted to a regression analysis at 5% of probability, using the SISVAR statistical software, version 5.6.

To evaluate the effect of the rhizobacteria on the hatching, motility and mortality of juveniles of *Meloidogyne javanica*, an in vitro experiment was realized at the Centro Universitário Fundação Assis Gurgacz - FAG - Phytopathology Laboratory, on May, 30 (2017). The experiment used a randomized block design (RBD) with 5 treatments - (0%, 50%, 100%, 150% and 200% of the recommended dosage, equivalent to 3.0 mL/3.0 x 10$^9$ UFC), with 5 replications each, a total of 25 hatching chambers.

*Meloidogyne javanica* eggs extraction was conducted by the method proposed by Hussey and Barker and adapted by Boneti and Ferraz (1981). To facilitate counting and inoculum calibration, the nematodes suspension was clarified according to the centrifugal flotation procedure proposed by Jenkins (1964).

After obtaining a clean and clear suspension, it was counted in a Peters chamber under an optical microscope and assessed for 90 eggs and eventual juveniles.

Next, they were added to each hatching chamber of 9 mL of bacterial suspension previously prepared in a Becker with 100 mL of distilled water with the due dosages for each treatment, using the Blindage B® product formulated through *Bacillus amyloliquefaciens*. Then, 1 mL of *Meloidogyne javanica* suspension was added separately to each hatching chamber, a total of 10 mL per plate. Next, circular moves were done to promote suspension homogenization.

Hatching with distilled water was used as control. Chambers were kept in B.O.D. at 27 +/- 1 ºC with photoperiod of 12 hours/light. Suspension (2 mL) was collected in regular intervals (9 and 15 days), with the help of a Peters chamber under an optical microscope to evaluate hatching and estimate the number of mobile and immobile J2, considered dead and alive, respectively (SOUTHEY, 1970).

Later, data were submitted to a Linear and Quadratic Regression analysis at 5% of probability, using the SISVAR statistical method, version 5.6.

**RESULTS AND DISCUSSION**

Observations of the direct antagonistic effect of *Bacillus amyloliquefaciens* dosages on the number of *M. javanica* eggs hatched at 9 days from incubation show, through a polynomial regression analysis of second order ($x^2$), a better data representation. However, 15 days from incubation, no significance was found for the polynomial regression of second order, being the linear regression applied for data exposition. Means for the eggs variables increased in both evaluations, showing the effect of treatments on hatching. These were the means at 9 days of incubation: (T0: 25,3333; T1: 38,4444; T2: 40,1098; T3: 43,8601; T4: 40,4444). On the 15th day of evaluation, the control obtained almost 100% of hatching in relation to the other treatments, which retarded eggs hatching, according to the following means (T0: 4,6667; T1: 10,2222; T2: 12,4444; T3: 14,4444; T4: 16,6667).

In regards to the eggs hatching variable, results showed that, with the increase in the concentration of *Bacillus amyloliquefaciens*, there was a reduction in eggs hatching in relation to the control without the application of the product, showing an ovicide “in vitro” action, under the conditions of the present work. Treatment (150% of the dosage - T3) at 9 days showed the largest number of eggs present in the hatching chamber.

This effect was maintained when verifying hatching percentage after 15 days of incubation. However, there was a difference between treatments T3 and T4 since T4 surpassed the reduction in number of hatched eggs, according to figure 1. These results are due to the fact that the *Bacillus* spp. species produces endotoxins that interfere in the reproductive cycle of nematodes, especially during the ovipositioning and hatching of juveniles. That is, they damage the eggs outer layer, inhibiting hatching and reducing it on juveniles (MACHADO et al., 2012).
Figure 1. The effect of different dosages of \textit{B. amyloliquefaciens} on \textit{M. javanica} eggs hatching at 9 and 15 days after incubation, in hatching chambers (A: 9 days; B: 15 days).

According to Alves (2011), some plant growth promoting rhizobacteria (RPCPs), among them the \textit{Bacillus} sp., produce lytic enzymes such as chitinase and protease, which degrade the egg membranes of the \textit{Meloidogyne} sp. Species, while others attract the hatching of J2, causing mortality of infecting forms.

In regards to the motility variable, the number of mobile juveniles showed, with the increase in \textit{B. amyloliquefaciens} concentration, a reduction in the number of mobile J2 found on the 9th day (T0: 70,0000; T1: 48,2222; T2: 36,5368; T4: 37,3333) and 15th day (T0: 86,8888; T1: 66,2222; T2: 56,0000; T3: 45,3333; T4: 39,7778) of incubation. Day 9 (T3) and day 15 (T4) were the most efficient, as shown by figure 2.

According to Ferreira (2015), who evaluated \textit{Bacillus} sp. species in the control of \textit{Meloidogyne javanica} \textit{in vitro}, the treatment with \textit{Bacillus amyloliquefaciens}, showed a reduction by 73% in eggs hatching compared to the control (water), showing its ovicide control effect as well as a juvenicide action, causing 6% of mortality in relation to the control (water).

Figure 2. Effect of different dosages of \textit{B. amyloliquefaciens} on the motility of \textit{M. javanica} at 9 and 15 days after incubation in hatching chambers (A: 9 days; B: 15 days).

The nematostatic effect originated from the dosages of \textit{B. amyloliquefaciens} was also represented in the control dosages (T3 and T4), being that, on the 9th day, the linear regression \((x)\) showed a more favorable representation of the data obtained and on the 15th day, the quadratic regression \((x^2)\) was more relevant for data exposition, according to figure 3 below.

During the \textit{“in vitro”} assay, when the bacterial effect on the J2 of \textit{M. javanica} mortality was also evaluated, treatments (T3: 19,6030 e T4: 22,2222) showed more efficacy in relation to mortality than T1: 13,3333 and T2: 13,8077. However, all treatments were superior when compared to the control (T0: 4,6667) 9 days after incubation. Similarly, for the mortality evaluation after 15 days of incubation, the best treatments were maintained, being (T3: 40,2222) and (T4: 43,5556) J2 dead, in relation to (T0: 8,8889; 0.0009x^2 + 0.2482x + 26.087
\(R^2 = 0.9548\)

\(y = 0.0564x + 6.0444\)
\(R^2 = 0.9437\)

\(y = 0.0011x^2 - 0.3697x + 68.431\)
\(R^2 = 0.9491\)

\(y = 0.0009x^2 - 0.4004x + 86.121\)
\(R^2 = 0.9952\)
T1: 23,5555 and T2: 31,5556).

Figure 3. Effect of different doses of \textit{B. amyloliquefaciens} on the mortality of \textit{M. javanica} at 9 and 15 days after incubation in hatching chambers (A: 9 days; B: 15 days).

Similar studies were observed by Xiang et al. (2017) during the evaluation of rhizobacteria lineages of the \textit{Bacillus} spp. genus, which caused mortality of J2 \textit{in vitro}\textsuperscript{1} \textit{Meloidogyne incognita}.

In an \textit{“in vitro”}\textsuperscript{1} study with \textit{Bacillus amyloliquefaciens}, Mota et al. (2017) observed high mortality of mobile forms of nematodes of the \textit{Meloidogyne} spp genus. Zhou et al. (2016) and Torres et al. (2017), in a study with \textit{Bacillus amyloliquefaciens}, noticed an effective action on the reduction of nematodes \textit{in vitro} and \textit{“in vivo”}\textsuperscript{1} greenhouse assays, according to the infectious forms observed in Figure 4.

Figure 4. Eggs and juveniles (J2) of \textit{M. javanica} controlled by \textit{B. amyloliquefaciens}. (A: Eggs and Live J2; B: Juvenile of Second Stadium (J2)).

Thus, in this \textit{“in vitro”}\textsuperscript{1} study, the \textit{Bacillus amyloliquefaciens} caused a reduction in J2 hatching and mortality and an increase in \textit{M. javanica} death for all concentrations; however, (T3 e T4) stood out when compared to the control and other treatments, thus showing potential to mitigate the damages caused by this parasite.

Evaluation of the influence of bacteria of the \textit{Bacillus} spp. genus on bean growth showed that all treatments promoted significant increase in plant height in relation to the control.

Evaluation of the root length of seedlings treated with rhizobacteria showed that as the dosage of the \textit{Bacillus amyloliquefaciens}-based biological product increases, there is an increase in root length. Oliveira et al. (2016) found similar results when evaluating the initial growth of bean plants inoculated with \textit{Bacillus} spp., obtaining an increase in seedling length and primary root of bean plant seedlings.

Means for plant height (cm) affected by product dosages were (TO: 13, 94; T1: 15,32; T2: 16,34; T3: 16,86; T4: 17,54), represented by the linear regression analysis. As for root length ((cm), results showed a similar increase in the data collected (TO: 27,28; T1: 31,08; T2: 32,90; T3: 33,12; T4: 35,16), as shown by Figure 5.
In view of the above, the growth of the aerial part and bean root extension submitted to seed treatment with bacterial suspension (APFM (T0: 1.0111; T1: 1.2092; T2: 1.2622; T3: 1.3563; T4: 1.7835) corresponded to the data presented previously. The increase in aerial part dry matter (APDM (T0: 0.2545; T1: 0.2860; T2: 0.3277; T3: 0.3541; T4: 0.4800), and root system fresh matter (RSFM (T0: 1.5280; T1: 1.8421; T2: 2.0298; T3: 2.3379; T4: 3.0017) also corresponded to previously presented data. These results showed that, as the dosages of the product (*Bacillus amyloliquefaciens*) increased, the values also increased, affecting plant development in the experiment positively, as shown by the regression analysis in Figure 6. However, a slight drop in aerial part growth was observed, a typical symptom of a *M. javanica* attack.

Cerqueira *et al.* (2015) and Clemente and Paiva (2016) evaluated the influence of the *Bacillus* spp. on common bean growth and detected a significant increase in APFM, RSFM and APDM.

According to Muthulakshmi *et al.* (2010), this combination of bio-controllers constitutes a way to reach nematode control and plant growth.

When validating the number of root knots in the bean plant roots, it was possible to verify a reduction in the root knots caused by a nematodes attack. Abdollahi and Akramipoor (2014) obtained similar results, attesting the biological control of nematode parasites of plants, impeding the attack and multiplication of radicular cells, being antagonists to active infecting forms (J2).

Based on the number of J2 in the root system (N. J2/RS) and number of J2 in the soil (N. J2/Soil) data for each treatment, there was a decrement as the dosages of *Bacillus amyloliquefaciens* increased.
When comparing the means for number of juveniles in the root system and in the soil, all treatments reduced the percentage of juveniles significantly. Similar results were found when testing the action of the bacterial isolate “in vitro”, which demonstrated, at both 9 and 15 days, an attenuation in the number of J2, as the dosage increased, attesting its “in vivo” juvenicide action, with the same manipulated dosages, as seen in Figure 7.

Figure 7. Number of J2 in the soil (Number J2/Soil) (A) and number of J2 in the root system (Number J2/RS) (B) according to treatments with Bacillus amyloliquefaciens.

As for the bacterial suspension inoculation (Bacillus amyloliquefaciens) for ovicide control in the soil and roots, treatment means (Fig 8) showed a reduction in the amount of eggs (N. Eggs/RS) and eggs in the soil (N. Eggs/Soil), when compared to those for the control. However, as the dosage was being administered in the specific amount, the number of eggs present in the soil was reduced compared to the control.

These results can be justified by the smaller number of juveniles found in the soil due to their hatching action and the action of microbial agents on egg laying reduction, interfering in the reproductive cycle (Ciancio et al., 2016; Rao et al., 2017).

Figure 8. Number of eggs in the root system (Number of Eggs/RS) (A) and number of eggs in the soil (Number of Eggs/Soil) (B), according to treatments with Bacillus amyloliquefaciens.

As a result, the number of eggs by root system (number of Eggs/RS) found in the soil (Number J2/Soil) was calculated to determine final population (Fp) for this study. Through the polynomial regression analysis of second order (x²), which obtained greater data representation, it was possible to notice the nematosthetic effect of the genus (Bacillus spp.) bacteria, according to figure 9.
After the quantification of eggs and juveniles (J2) of *M. javanica*, the reproduction factor was obtained (RF = Fp/Pi), after the division of the final population (Fp) by the initial inoculum population (Ip= 2000 eggs). Data were transformed by a regression analysis of second order (x^2), which showed a significant difference between the data (P < 0.05).

Results showed that the (T3: 150% and T4: 200%) dosages showed greater control aptitude in the bean, according to figure 10.

![Figure 9](image1.png)

**Figure 9.** Final population (Fp) of nematode obtained at the end of the experiment, figured by the relationship between number of eggs by root system plus the J2 found in the soil.

![Figure 10](image2.png)

**Figure 10.** Reproduction factor (RF = Pf/Pi) in conformity with the dosages for treatments with *Bacillus amyloliquefaciens*.

Oliveira *et al.* (2016) studied the influence of *Bacillus subtilis* on the biological control of nematodes in bean plants applied via seed. He obtained significant management results 30 days after seeding, in a naturally infested field. In thesis, the *Bacillus* spp. acted effectively on the control of *Meloidogyne* spp. in the soil, being suppressive on nematodes (Morgado *et al.*, 2015).

According to Santos *et al.* (2013) products that have an effect on *M. incógnita* and *M. javanica*, mortality can cause a reduction in the number of nematodes that penetrate the roots, and, consequently, a reduction in other nematological variables, also affecting the reproduction factor.

Based on these findings, Esser *et al.* (2017) was able to demonstrate the root penetration inhibiting potential of the bioematicide, when testing its effect on the control of *Pratylenchus brachyurus* in corn crops, using dosages similar to those used in this work, 45 days after emergence. It created a protective biofilm in the roots, reducing reproducibility, differing significantly from the control.

Similarly, Máscia (2017) observed, during a regression analysis, a reduction in the number of nematodes
with increasing dosages of Bacillus amyloliquefaciens in the roots, when using it in soybean crops for the control of Pratylenchus brachyurus.

**CONCLUSIONS**

The rhizobacterial isolate (Bacillus amyloliquefaciens) showed ovicidal and juvicidal effects on Meloidogyne javanica, causing hatching and motility reduction in juveniles (J2), and, consequently, an increase in Meloidogyne javanica mortality, in both concentrations. However, treatments (T3 - 150% dosage and T4 - 200% dosage) stood out in relation to the control, in an “in vitro” study, at 9 and 15 days of incubation, in a hatching chamber, in B.O.D.

In an “in vivo” study, seeds treatment with Bacillus amyloliquefaciens showed satisfactory results for the beans vegetative parameters such as plant height, root system length, aerial part fresh matter (APFM) and root system fresh mass (RSFM).

Treatments acted on the nematological parameters, showing their root bactericidal effect on root-knot number (RKN) plant roots, number of eggs and juveniles in the root system and soil, and consequential mitigation of the nematode reproduction factor, showing suppressive action on Meloidogyne javanica.

**REFERENCES**

Abdollahi M. and Akramipoor N (2014) Application of bactéria in biological controlo of plant. Parasitic Nematodes 2:1-21.

Alves GCS, Santos JM, Soares PLM, Jesus FG, Almeida J and Thuler RT (2011) Avaliação in vitro do efeito de rizobactérias sobre Meloidogyne incognita, M. javanica e Pratylenchus zeae. Revista Arquivos do Instituto Biológico 78:557-564.

Boneti JIS and Ferraz S (1981) Modificação do método de Hussey e Barker para extração de ovos de Meloidogyne exigua de raízes de cafeeiro. Fitopatologia Brasileira 6: 553.

Burle ML, Fonseca JR, Kami JA and Gepts P (2010) Microsatellite diversity and genetic structure among common bean (Phaseolus vulgaris L.) landraces in Brazil, a secondary center of diversity. Theoretical and Applied Genetics 121:801-813.

Cerqueira WF, Morais JS, Miranda JS, Mello IKS and Santos AFJ (2015) Influência de bactérias do gênero Bacillus sobre o crescimento do feijão comum (Phaseolus vulgaris L.). Enciclopedia Biosfera, Centro científico conhecer. Goiânia-GO, 11(20):82.

Ciancio A, Pieterse EM and Mercado-Blanco J (2016) Harnessing useful rhizosphere microorganisms for pathogen and pest biocontrol. Frontiers in Microbiology 7(1):1-9.

Clemente CC and Paiva SR (2016) O efeito da remoção da palha de cana de açúcar na população de nematoides do solo e raiz em duas distintas situações edafoclimáticas. Dissertação de Mestrado, Universidade de São Paulo.

Comissão Técnica Sul-Brasileira De Feijão (CTSBF) (2010) Informações técnicas para o cultivo de feijão na Região Sul brasileira 2009. Epagri, Florianópolis.

Debouck DG (1999) Diversity in Phaseolus species in relation to the common bean Singh SP (ed.) Common bean improvement in the twenty-first century. Kluwer: Dordrecht the Netherlands, p. 25-52.

Dias WP, Garcia A, Silva JFV and Carneiro GES (2010) Nematoides em Soja: Identificação e Controle. Embrapa, Londrina. Circular Técnica 76:8.
Embrapa Milho e Sorgo (2010) Sistema de Produção. http://www.cnpms.embrapa.br/publicacoes/milho_6_ed/glossario.htm. Acesso 3 abr. 2017.

Esser R, Silva MSG, Trevisan M, Arantes LG, Ferro H and Freire ES (2017) Bacillus amyloliquefaciens BV03 controla Pratylenchus brachyurus no cultivo de milho. 34º Congresso Brasileiro de Nematologia. SBN, Vitória.

Ferreira JR (2015) Espécies de Bacillus no controle de Meloidogyne incógnita e Meloidogyne javanica in vitro e na cana de açúcar. Dissertação de Mestrado, Unesp, Campus de Jaboticabal, 1:1-72.

Fu ZQ and Dong X (2013) Systemic acquired resistance: turning local infection into global defense. Annual Review of Plant Biology 64:839-863.

Haegeman A, Mantelin S, Jones JT and Gheysen G (2012) Functional roles of effectors of plant-parasitic nematodes. Gene 492(1):19-31.

Hasky-Gunter K, Hofmann-Hergarten S and Sikora RA (1998) Resistance against the potato cyst nematode Globodera pallida systematically induced by the rhizobacteria Agrobacterium radiobacter (G12) and Bacillus sphaericus (B43). Fundamental and Applied Nematology 21(5):511-517.

Jenkins WR (1964) A rapid centrifugal flotation technique for separating nematodes from soil. Plant Dist. Rept, 48:692.

Machado V, Berlitz DL, Matsumura ATS, Santin RCM, Guimarães A, Silva ME and Fiuza LM (2012) Bactérias como agentes de controle biológico de fitonematóides. Oecologia Australis 16: 165-182.

Máscia R (2017) Bacillus amyloliquefaciens e Trichoderma no manejo de Pratylenchus brachyurus na cultura da soja. Instituto Federal Goiano, Goias.

Morgado TDT, Guerra TJ, Araujo FF and Mazzuchelli LCR (2015) Effectiveness and persistence of biological control of nematodes in sugarcane. African journal of agricultural research 10(49):4490-4495.

Mota SM, Gomes BC, Souza Júnior IT and Moura BA (2017) Bacterial selection for biological control of plant disease: criterion determination and validation. Environmental Microbiology 48(1):1517-1568.

Muthulakshmi M, Devrajan K and jonathan EI (2010) Biocontrol of root knot nematode, Meloidogyne incognita (Kofoid and White) Chitwood in mulberry (Morus alba L.). Journal of Biopesticides 3:479-482.

Oliveira GRF, Silva MS, Marciano TYF, Proença SL and Sá ME (2016) Crescimento inicial do feijoeiro em função do vigor de sementes e inoculação com Bacillus subtilis. Bioeng 10(4):439-448.

Rao MS, Kamalnath M, Umamaheswari R, Rajinikanth R, Prabu P, Priti K, Grace GN, Chaya MK and Gopalakrishnan C (2017) Bacillus subtilis IIHR BS-2 enriched vermicompost controls root knot nematode and soft rot disease complex in corrot. Scientia Horticulturae 218:56-62.

Santos ES, Lacerda JT, Carvalho RA and Cassimiro CM (2013) Produtividade e controle de nematoides do inhame com plantas antagônicas e resíduos orgânicos. Tecnologia & Ciência Agropecuária 3(2):1-5.

Sociedade Brasileira De Nematologia (SBN) (2012) Nematoides em feijão: perdas de 10% podem chegar a 50%. http://nematologia.com.br/2011/12/nematoides-em-feijao-perdas-de-10-podem-chegar-a-50/. Acessado 17 março 2017.

Soares RM (2011) Manejo de doenças radiculares da soja causada por pythium, phytophthora e rhizoctonia. Embrapa Soja, Londrina.
Southey JF (1970) Laboratory methods for work with plant and soil nematodes. 5th ed. Ministry of Agriculture Fisheries and Food, London UK.

Stangarlin JR, Kuhn OJ, Toledo MV, Portz RL, Schwan-Estrada KRF and Pascholati SF (2011) A defesa vegetal contra fitopatógenos. Scientia Agrária Paranaensis 10(1):18-46.

Torres M, Brandon CP, Sabaté DC, Petrozelli G, Balsells RE and Audisio MC (2017) Biological activity of the lipopeptide-producing Bacillus amyloliquefaciens PGPB CA1 on common bean Phaseolus vulgaris L. pathogens. Biol Control 105:93-99.

Vaz MV, Canedo EJ, Machado JC, Vieira BS and Lopes EA (2011) Controle biológico de Meloidogyne javanica e Meloidogyne incognita com Bacillus subtilis. Perquirere 8:203.

Vieira C, Paula Júnior TJ and Borém A (2006) Feijão. UFV, Viçosa, MG.

Xiang NI, Lawrence SK, Kloepper WJ, Donald AP, McInroya J and Lawrence GW (2017) Biological Control of Meloidogyne incógnita by Spore-forming Plant Growth-promoting Rhizobacteria on Cotton. APS Journals, Plant Disease 101(5):774-784.

Yokoyama LP and Stone LF (2000) Cultura do feijoeiro no Brasil: Características da produção. Embrapa Arroz e Feijão, Santo Antônio de Goiás, 75p.

Zhou L, Yuen G, Wang Y, Wei L and JI G (2016) Evaluation of bacterial biological control agents for controlo of root-knot nematode disease on tomato. Crop Protection 84:8-13.

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