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PRODUCTIVITY EVALUATION OF SOYBEAN VARIETIES INOCULATED WITH *Bradyrhizobiumjaponicum* IN NO-TILLAGE SYSTEM UNDER *Urochloaruziziensis* STRAW

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ABSTRACT

Soybean (*Glycine max* (L.) Merril) has been shown great potential productivity in Brazil due to its cultivation conditions and desirable traits of soil and climate. Much of the culture's success is due to the quality and versatility of the genetic material used, especially its phenotypic plasticity. In the western region of the state of São Paulo, its cultivation has been brought benefits, derived in part by the main cultivation system used, no-tillage system, which reduces the use of phytosanitary products that harm the environment and the use of straw from the previous crop. In this work, we aimed to evaluate the agronomic traits of soybean cultivars with different doses of the inoculant *Bradyrhizobium japonicum*, implanted in no-tillage system, aiming to identify those cultivars most adapted to the cultivation conditions. The experiment was conducted at FCAT - Dracena, under a randomized block design in a 3x3 factorial scheme, in which the five cultivars were evaluated: NS 7709 IPRO; NS 6700 IPRO; NS 6906 IPRO; NS 6601 IPRO; e Monsoy – M6210 IPRO. The following traits were evaluated: plant height (Ph), first pod height (Fph), total pods (Tp), number of stems (Ns) and grain yield (Gy). For the inoculant factor we evaluated: control (zero dose), recommended dose and six times the recommended dose. It was performed Analysis of variance and Tukey test to compare the mean performance of cultivars for those that showed significance in ANOVA. The cultivar NS 7709 IPRO showed adequate grain yield estimate (6,044 kg ha^{-1}), standing out numerically in four of the five evaluated traits. It could be the recommended cultivar in west region of São Paulo State – Brazil, where the experiment was conducted. The use of inoculant in doses above the recommended had no effect on the analyzed variables or even obtained results lower than the recommended dose.

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INTRODUCTION

Soybean crop is one of the most important oilseeds in the world due to its high yield and wide adaptability in the most different Brazilian latitudes (RIGON *et al.,* 2012), being used for various purposes. In the state of São Paulo, the result of soybean planting has been satisfactory in recent harvests, showing an increase in cultivated area and productivity (CONAB, 2017). Much of the success of the crop is due to the utilization of improved cultivars that are better adapted to the region's soil and climate conditions and improvements in the production system. According the United States Department of Agriculture (USDA, 2018), the 2018/2019 harvest indicated a 5.3% growth in global soybean production, reaching 354.54 million tons. Brazil is the country with country with the largest soy production, 117 million tons, followed by United States (116 million tons), Argentina (56 million tons) and Paraguay (9.8 million tons). In view of the good production performance, farmers increasingly have been looking for new technologies in order to increase productivity. An example of this is the use of inoculants that contribute to nodulation, aiming at greater nitrogen fixation, consequently increasing crop grain yield (CHIBEBA *et al.,* 2015). Therefore, the use of bacteria of the genus *Bradyrhizobium*, has been shown considerable potential, given its ease of use in production systems. Several authors have shown that the use of this microorganism can influence plant development, stimulating the biological mechanisms of nitrogen fixation and, as a result, stimulating hormones production that act on root development, leading to increase water and nutrients absorption and plant growth. (ZUFFO *et al.,* 2015). Another factor that is capable of improving soybean yield performance is implantation of no-tillage system. This system allows the soil to have greater water retention capacity, preventing nutrient losses and consequently improving root system development. Another observed feature in this system is the reduction of impacts from agricultural operations, particularly against machinery (REICHARDT, *et al.,* 2009). One of the main requirements for no-tillage system to be to implement and managed is the existence of crop rotation, which provides biomass soil coverage and high C/N ratio the next crop. According to MENDONÇA (2012), the persistence of straw in the soil which, confers sustainability to the system, and therefore, the no-tillage system provides a better soil microbiota, given the high organic matter content, leading to greater nutrient recycling and improvements in the physical and biological properties of the soil, increasing its fertility (CORREIA and DURIGAN, 2008).Another feature capable of increasing the high productivity of the crop is the use of irrigation. In addition to providing greater productivity and allowing the optimal use of agricultural space, irrigation allows proper management of water availability during crop development, especially in the most demanding phases of the plant (MANTOVANI; BERNARDO and PALARETTI, 2009).In soybean, the most water-demanding phases are flowering and grain filling, and are capable of causing harmful physiological changes in plants when water deficit occurs. Consequently, inadequate irrigation management can lead to reduced productivity, especially when the plant is in a period susceptible to stress (FERNANDES; RODRIGUES, 1997; EMBRAPA, 2011).In this sense, this study aimed to evaluate the agronomic performance and yield components of soybean cultivars inoculated with different proportions of *Bradyrhizobiumjaponicum*, aiming to identify biological interactions between the microorganism and the cultivars in order to provide a recommendation of cultivars, associated with the no-tillage system.

MATERIALS AND METHODS

The experiment was conducted in the Experimental Area of the College of Agricultural and Technological Sciences of São Paulo State University (UNESP), Campus of Dracena, in the coordinates: Latitude 21°29'S and Longitude 51°52'W, average altitude of 420m. According to the Köeppen classification, the prevailing climate in the region is Aw, and annual average climate data: temperature 24°C, relative humidity 64.23% and rainfall of 1261mm per year. The soil was classified according to the Brazilian classification system as dystrophic red yellow argisol (EMBRAPA, 2013).Five soybean cultivars were evaluated: NS 7709 IPRO; NS 6700 IPRO; NS 6906 IPRO; NS 6601 IPRO; and Monsoy - M 6210 IPRO. The experiment was carried out in a field under a randomized block design in a 5x3 factorial scheme with three replications. It was considered the factor Cultivar, with 5 levels and the factor Inoculant, with 3 levels, as follows: D1 - zero concentration; D2 - manufacturer recommended concentration (1X); and D3 – 6 times the recommended concentration. Commercial inoculant with *Bradyrhizobiumjaponicum* was used. The experimental unit consisted of five lines of five meters from which the three central lines of three meters each were evaluated. The cultivars were manually sown under no-tillage system under *Urochloaruziziensis* brachyria straw and maize straw, on November of 2018. For soil preparation, a fertilizer seeder was set up for no-tillage system was used, composed of 5 rows spaced 0.45 m between rows, equipped with a straw cutting disc.In the experimental unit, the following characteristics were evaluated: grain yield (Gy), plant height (Ph), first pod insertion height (Fph), number of total pods (Tp) per plant and number of stems (Ns). For Gy evaluation, the plants were collected in three central lines of three meters of each plot and submitted to the mechanical harvest and, after threshing, the grains were weighed and the correction was made to 13% of humidity. For evaluation of Ph, Fph, Tp and Ns, ten plants were randomly taken within the experimental unit. For H, the distance from the base of the stem to the apical end of the plant was measured with a ruler graduated in centimeters. For Fph, the distance between the base of the stem and the insertion of the first pod was measured. For Tp, the number of pods produced was counted. For Ns, the number of stems was counted. The plants were manually harvested, dried, and mechanically debranched with the 150 PV MaqTronharvester.
Irrigation management was performed based on reference evapotranspiration (ETo) obtained by Campbell Scientific CR10X Weather Station, estimated by the Penman-Monteith method (ALLEN *et al.,* 1998) and multiplied by the crop coefficient (Kc) of the soybean phenological phases. The irrigation system used was the conventional sprinkler system, consisting of 2 lines with 6 Fabrimar sprinklers spaced every 12m between the lines, 7.0 mm h^{-1}, 20 mca and 4-day watering shift.

Roundup WG (glyphosate) herbicide was applied for weed control at a dose of 1.2 kg in 240 L of water per ha on December, 2018, and again on January at the dose. of 1.5 kg in 250L/ha. The fungicide Nativo was applied at a dose of 0.5 L ha^{-1} on 12/24/2018, and fungicide Opera at a dose of 500 mL ha^{-1} on 11/01/2019, in order to control soybean rust. For control of caterpillars and bedbugs were applied Engeo insecticide at the dose of 0.15 L ha^{-1} on 11/01/2019, and Orkestra SC insecticide at the dose of 0.35 mL ha^{-1} on January 31. The harvest was carried out on March 27, 1919, after which the material was drying and subsequent evaluation on April 11, 2019.For data analysis, ANOVA was performed considering the randomized block design in a factorial scheme, considering the factors Variety with i = 5 levels and Inoculant with j = 3 levels, in k = 3 repetitions. The adopted model was: $Y_{ijk} = m + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varpi_k + e_{ijk}$, where Y_{ijk} corresponds to the observed value for the studied variable referring to the treatment *i* in the block *j*; m, the average of all experimental units for the variable under study; α_i, the effect of the particular variety *i* on the observed value Y_{ijk}; β_j, the effect of the inoculant *j* on the observed value Y_{ij}; $(\alpha\beta)_{ij}$, the effect of interaction; ϖ_k, to block effect; and e_{ij}, the experimental error. For traits whose ANOVA was significant, the Tukey test ($p<0.05$) was performed. All statistical analysis was performed using routines developed by the authors in Software R (R Core Team, 2019).

RESULTS AND DISCUSSION

In Table 1 is shown the results of the analysis of variance for the traits plant height (Ph), first pod height (Fph), total pods (Tp), number of stems (Ns) and grain yield (Gy). For all traits, except Fph for the Cultivar factor, significance was detected in ANOVA, indicating that in such cases there is at least one cultivar whose mean differs from the others, while for the Inoculant factor, only for Tp was detected significance. For such cultivars, the Tukey test (p <0.05) was performed to compare the cultivars (Table 2).

Table 1. Analysis of variance for evaluated traits in five soybean cultivars

FV		QM				
	df	Ph	Fph	Ns	Tp	Gy
Block	2	81.50	6.34	0.68	98.56	436639
Cultivar	4	740.29*	11.52^{ns}	18.83*	1961.31*	5693029*
Inoculant	2	43.70^{ns}	11.38^{ns}	0.30^{ns}	825.15*	2418533^{ns}
Interaction	8	52.26^{ns}	3.18^{ns}	0.89^{ns}	283.15^{ns}	777622^{ns}
Residue	28	35.61	4.71	0.68	212	886447
CV (%)		5.13	12.18	21.04	18.97	18.11

* p< 0,05; ns – non significant. CV – Coefficient of variation.

Table 2. Mean comparison test for evaluated traits related to soybean cultivars

	Mean				
Cultivar	Ph	Fph	Ns	Tp	Gy
NS 7709	128.6 a	18.78	4.82 a	74.82 b	6044.80 a
M 6210	111.24 b	15.89	5.93 a	99.96 a	5398.32 ab
NS 6700	122.53 a	18.33	2.24 c	77.89 b	4085.16 c
NS 6906	112.67 b	18.26	3.53 b	59.35 b	4715.54 bc
NS 6601	106.27 b	17.93	3.18 bc	71.69 b	5747.40 ab

Treatments followed by the same letter do not differ by mean of Tukey test (p<0.05).

Table 3. Mean comparison test for evaluated traits related to inoculant doses

Inoculant dose	Mean				
	Ph	Fph	Ns	Tp	Gy
Zero	115.05	18.81	3.79	69.56 b	5449
1x	118.21	17.57	4.07	76.29 ab	4735.11
6x	115.51	17.13	3.97	84.37 a	5410.62

Treatments followed by the same letter do not differ by mean of Tukey test (p<0.05).

In Table 3, the mean values obtained in each dose of inoculant are shown. Although not significant, Fph represents a fundamental trait during harvesting procedures as it is associated with its mechanization process, which can influence productivity loss and reduced profit for farmers (OLIVEIRA *et al.,* 2018). According to Bertolin, *et al.* (2010), cultivars FpH equal to or greater than 10 cm are desirable for mechanical harvesting. It is important to point out that all evaluated cultivars provided satisfactory estimates, with an average of 17.84 centimeters for this trait. Plant height is a trait highly influenced by the cultivation environment, mainly due to sowing density, nutrient availability, and soil compaction that affect the root development of the plant (SOUZA *et al.,* 2013. ROSOLEM, CA; ALMEIDA, ACS; SACRAMENTO, LVS; 1994). For this trait, cultivars NS 7709 and NS 6700 showed statistically higher averages, with 128.6 cm and 122.53 cm, respectively, followed by cultivars NS 6906 (112.67 cm), Monsoy - M6210 (111.24 cm) and NS 6601 (106.27 cm).The traits coefficients of variation ranged from 5.13 (low) for Ph to 21.04 (high) for Ns. According to PIMENTEL-GOMES (1990), CV is classified as low when below 10%, medium when it is in the range of 10 to 20%, high when it is between 20 and 30%, and very high, when above 30%.Nh showed significance in ANOVA, highlighting the cultivars Monsoy - M6210 (5.93 stems) and NS 7709 (4.82 stems) with higher averages than the others. They were followed by cultivars NS 6906 with 3.53 stems, NS 6601 with 3.18 stems, and NS 6700 with 2.24 stems. For Tp, the cultivar Monsoy - M 6210 was statistically superior to the others with 99.96 pods per plant, followed by cultivars NS 6700, NS 7709, NS 6601 and NS 6906, with 77.89; 74.82; 71.69 and 59.35 pods, respectively. Both Ns and Tp in a plant are traits influenced by plant density. The higher density leads to a higher height by stimulating the vertical development of the plant architecture due to competition between them. However, this vertical development is associated with plant survival, causing very tall plants to have their lateral growth and later development of pods impaired by the lack of space. Also, the higher height leads to susceptibility to lodging because the main stem is usually thinner than desired (SANTOS *et al.,* 2018). The lower plant density, in turn, leads to lower height plants, and therefore are more tolerant to lodging, and with higher production of stems and pods, although their short stature can make harvesting difficult if the stems are placed very close to the soil (SANTOS *et al.* 2018).In Table 2 is shown the results of the mean comparison tests for the cultivars. It was verified that the cultivars NS 7709, NS 6601 and Monsoy - M6210 provided statistically higher average estimates for Gy, with 6044.8 kg ha^{-1}, 5747.4 kg ha^{-1} and 5393.32 kg ha^{-1}, respectively, followed by cultivars NS 6906 (4715.54 kg ha^{-1}) and NS 6700 (4085.16 kg ha^{-1}). According to Conab (2019), the average obtained for Pg in the state of São Paulo - Brazil was 3039 $kg.ha^{-1}$ in the 2018/2019 harvest. The cultivars investigated during the experiment presented yield estimates higher than those verified in the state. For the inoculant dose factor (Table 3), only the Tp variable showed different significant estimates. Dose 6 times more than recommended resulted in an average of 84.37 pods per plant, followed by the recommended dose with an average result of 76.29 pods per plant, and the control (zero dose) with an average of 69, 56 pods per plant. According to Campos (1999), the response of soybean cultivars to inoculation depends on the characteristics of each soil, mainly because some *Bradyrhizobium* strains, although highly efficient, do not always promote the increase in grain yield due to the competition with soil microorganisms. Still, some researchers believe that the modifications resulting from soil usage under no-tillage system for long years may favor the development of soil bacteria, thus reducing the effect of inoculation, due to its characteristic of favoring the resident soil microbiota (OLIVEIRA and VIDOR, 1984).

Conclusion

The cultivar NS 7709 IPRO showed an adequate yield estimate (6044.80 kg ha^{-1}), standing out numerically in four of the five evaluated traits, considering the implementation of the experiment with installed irrigation system, and may be the recommended for in Sao Paulo state region, where the study was conducted. No influence related to the inoculant was found on soybean traits, except for the trait number of pods, which responded positively with the increase of the dose. This response, however, was not reflected in increased crop productivity.

Conflicts of interest: The authors declare that they have no conflicts of interest.

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REFERENCES

Allen, R.G., Pereira, L.S., Raes, D., Smith, M. Crop Evapotranspiration: Guidelines for computing crop water requirements. FAO, 1998. 300 p. (FAO IrrigationandDrainagePaper, 56)

Bertolin, DanilaComelis*et al*. Aumento da produtividade de soja com a aplicação de bioestimulantes. Bragantia, p. 339-347, 2010.

Campos, Ben-HurCostade. Dose de inoculante turfoso para soja em plantio direto. Ciência Rural, v. 29, n. 3, p. 423-426, 1999.

Chibeba, A. M., Guimarães, M. F., Brito, O. R., Nogueira, M. A., Araujo, R. S., Hungria, M. Co-inoculation of soybean with *Bradyrhizobium* and *Azospirillum* promotes early nodulation. *American JournalofPlantSciences,* v. 6, n. 10, p. 1641, 2015.

Companhia Nacional de Abastecimento, CONAB. Monitoramento agrícola – Safra 2016/17. Acomp. safra bras. grãos, v. 4 Safra 2016/17 - Oitavo levantamento, Brasília, p. 1-144, 2017.

Conab. Companhia nacional de abastecimento. Acompanhamento da safra brasileira: grãos. Oitavo levantamento, maio 2019, v. 6, n. 8, 2019.

Correia, N.M., Durigan, J.C. 2008. Culturas de cobertura e sua influência na fertilidade do solo sob sistema de plantio direto (SPD). Biosci. J., Uberlândia, v. 24, n. 4, p. 20-31.

Empresa Brasileira de pesquisa Agropecuária - embrapa. Sistema brasileiro de classificação de solos. 3.ed. Brasília, 2013. 353p.

Empresa brasileira de pesquisa agropecuária - Tecnologias de produção de soja – região central do Brasil 2012 e 2013. Londrina: Embrapa Soja, 2011. 261 p. (Embrapa Soja. Sistemas de Produção, 15)

Fernandes, E. J.,Rodrigues, T. J. D.1997. Desenvolvimento da cultura da soja submetidas a três regimes de irrigação. Engenharia Agrícola, Jaboticabal, v. 17, n. 1, p. 44-56.

Mantovani, Everardo Chartuni; Bernardo, Salassier; Palaretti, Luiz Fabiano. Irrigação: princípios e métodos. Viçosa. UFV - Universidade Federal de Viçosa, 2009.

Mendonça, V. Z. 2012. Consorciação de milho com forrageiras: produção de silagem e palha para plantio direto de soja. Abril 2012. 72p. Dissertação (Mestrado em Agronomia) – Faculdade de Engenharia, Universidade Estadual Paulista. Ilha Solteira – SP.

Oliveira, L.A., Vidor, C. 1984. Seleção de estirpes de Rhizobiumjaponicum em soja. II. Capacidade competitiva por sítios de nódulos. Revista Brasileira de Ciência do Solo, Campinas, v. 8, n. 1, p. 43-47.

Oliveira, Giovani Andreazza de *et al*. Componentes de produção, produtividade, adaptabilidade e estabilidade fenotípica de materiais de soja no Paraná. 2018.

Pimentel-Gomes, Frederico. Curso de estatística experimental. Piracicaba: Nobel, 1990.

Core Team R. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.URL https://www.R-project.org/.

Reichardt, K.,Timm, L. C., Silva, A. L., Bruno, I. P. O SPD mantendo o equilíbrio dinâmico da matéria orgânica. 2009

Rigon, J. P. G., Capuani, S.,Brito Neto, J. F.,Rosa, G. M.,Wastowski, A. D., Rigon, C. A. G. 2012. Dissimilaridade genética e análise de trilha de cultivares de soja avaliada por meio de descritores quantitativos. Revista Ceres, v. 59, n. 2.

Rosolem, Ciro Antonio; Almeida, Ana Cristina da Silveira; Sacramento, Luiz Vitor Silva do. Sistema radicular e nutrição da soja em função da compactação do solo. bragantia, p. 259-266, 1994.

Santos, Guilherme Xavier Lúcio*et al.*2018. Efeito da densidade de plantas nas características agronômicas de dois genótipos de soja no noroeste paulista. *Nucleus,* p. 115-124.

Souza, Clovis Arruda *et al.*2013. Arquitetura de plantas e produtividade da soja decorrente do uso de redutores de crescimen to Plant architecture and productivity of soy be an affected by plant growth retardants. *Bioscience Journal,* v. 29, n. 3.

USDA – United States Department of Agriculture. World Agricultural Supply and Demand Estimates (WASDE 577). 2018.

Zuffo, A. M., Rezende, P. M., Bruzi, A. T.,Oliveira, N. T., Soares, I. O., Neto, G. F. G., Cardillo, B. E. S.,Silva, L. O. 2015. Coinoculação de *Bradyrhizobiumjaponicum* e *Azospirillum brasilense* na cultura da soja. *Revista de Ciências Agrárias*, v. 38, n. 1, p. 87-93.

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