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SOYBEAN CULTIVATION IN A CROP-LIVESTOCK SYSTEM WITH *Azospirillum brasilense* INOCULATION[1]

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ABSTRACT - The objective of this study was to evaluate the phytomorphological parameters of soybean in a crop-livestock system inoculated with *Azospirillum brasilense*. The experiment was conducted in Santa Maria, Brazil, for two agricultural years (2012/2013 and 2013/2014) in a randomized complete block design with three replications. In the winter, the black oat and ryegrass pasture was managed with sheep under different grazing systems: (I) – a conventional grazing (CG) system, where the animals remained in the pasture throughout the experimental period without any pasture height control; (II, III, and IV) – systems with post-grazing pasture heights of 10, 20, and 30 cm, respectively; and (NG) – one control without grazing. All treatments received two nitrogen doses (50 and 100 kg ha^{-1}) and inoculation or no inoculation (*A. brasilense*). The soybean cultivar BMX Potência RR was sown using no-tillage on 16 November 2012 and 1 December 2013. In each plot, seven rows of plants with spacing of 0.45 m were used, and in four rows, the seeds were inoculated with the bacterium *A. brasilense*. The phytomorphological variables and grain productivity were evaluated. In a crop-livestock system, soybean has better productivity when established on black oat and ryegrass pasture managed with post-grazing pasture heights of between 20 and 30 cm. Areas under conventional grazing in the winter led to smaller soybean plants with lower first and last pod heights. Inoculation with *A. brasilense* should not be used alone in soybean cultivation.

Keywords: *Glycine max*. Nitrogen. Grazing. Growth promoters.

CULTURA DA SOJA EM INTEGRAÇÃO LAVOURA-PECUÁRIA E INOCULAÇÃO DE *Azospirillum brasilense*

RESUMO - Objetivou-se com este trabalho avaliar os parâmetros fitomorfológicos da cultura da soja em um sistema de integração lavoura-pecuária e inoculados com *Azospirillum brasilense*. O experimento foi conduzido em Santa Maria, em dois agrícolas (2012/2013 e 2013/2014), num delineamento experimental de blocos casualizados, com três repetições. No período de inverno a pastagem de aveia preta e azevém foi manejada com ovinos em diferentes sistemas de pastejo: (I) - pastejo convencional (PC), onde os animais permaneciam na pastagem por todo o período experimental sem um controle da altura da pastagem, (II,III e IV) - altura da pastagem na saída dos animais de 10, 20 e 30 cm e uma testemunha sem pastejo (SP), três doses de nitrogênio (0, 50 e 100 kg ha^{-1}) e com ou sem inoculação (*Azospirillum brasilense*). A semeadura da soja foi realizada em semeadura direta em 16 de novembro de 2012 e 01 de dezembro de 2013, utilizando-se a cultivar BMX Potência RR. Em cada parcela, se utilizou sete fileiras de plantas com espaçamento de 0,45 m, sendo que em quatro fileiras as sementes foram inoculadas com a bactéria *Azospirillum brasilense*. Foram avaliadas variáveis fitomorfológicas e a produtividade de grãos. Em sistema de integração lavoura-pecuária a cultura da soja possui melhores produtividades quando estabelecida sobre pastagem de aveia preta e azevém manejadas com alturas de pastejo entre 20 e 30 cm. As áreas sob pastejo convencional no inverno proporcionam plantas de soja menores, com menores inserções de primeira e última vagem. A inoculação com *Azospirillum brasilense* não deve ser usada isoladamente na cultura da soja.

Palavras-chave: *Glycine max*. Nitrogênio. Pastejo. Promotores de crescimento.

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INTRODUCTION

Soybean expansion in the state of Rio Grande do Sul, Brazil, is increasing, especially in areas formerly used for cultivating rice and raising beef cattle. The increase in the cultivated area was 7% in the last harvest (2013/2014) relative to the previous year (CONAB, 2014). With the use of legumes such as soybean, the system benefits because the decomposition of the soybean straw releases nutrients, especially nitrogen, allowing the rotation of crops and improving aspects related to the phytosanitary management and soil fertility (ARF et al., 1999).

However, soybean cultivation in areas under a crop-livestock system is highly discussed; a main obstacle consists of issues related to soil physics and soil compaction (SPERA et al., 2004; LANZANOVA et al., 2007), mainly in the surface soil layer (until 5 cm in depth). Therefore, it is necessary to understand how much residual forage biomass should remain on the soil post-grazing without compromising the productivity of the system (LUNARDI et al., 2008; LOPES et al., 2009) and what this would represent in terms of grazing height management. In the case of soybean, biological fixation supplies all nitrogen demand through the plant's interaction with *Bradyrhizobium* bacteria (HUNGRIA et al., 2005), generating annual savings of approximately US $7 million in nitrogen fertilizers (HUNGRIA; NOGUEIRA; ARAUJO, 2013), preserving the production environment, and avoiding water table contamination.

Another group of microorganisms are the associative bacteria, capable of promoting plant growth by various biological processes; this group includes the *Azospirillum* genus. These microorganisms can promote plant growth through several biological processes including biological nitrogen fixation in grasses (ASHRAF; RASSOL; MIRZA, 2011); the production of phytohormones such as indole acetic acid (KUSS et al., 2007); induction of plant resistance to diseases (CORREA et al., 2008); improvements in photosynthetic parameters such as chlorophyll content and stomatal conductance (BARASSI et al., 2008); and greater radicular root system development (BASHAN; HOLGUIN; DE-BASHAN, 2004), which results in a higher potential for the absorption of water and nutrients, making the plants less susceptible to periods of stress (STEENHOUDT; VANDERLEYDEN, 2000).

In soybean cultivation, some results showed the feasibility of using *A. brasilense* when co-inoculated with *Bradyrhizobium japonicum* (HUNGRIA; NOGUEIRA; ARAUJO, 2013), indicating that inoculants can be used in a wide range of agricultural systems, replacing the application of mineral nitrogen. However, the practical application of inoculation with *A. brasilense* is still an unknown because of the inconsistency of the results (BALDANI; BALDANI, 2005), and studies on the isolated application of *A. brasilense* inoculation are limited or nonexistent.

The objective of this study was to evaluate the phytomorphological parameters of soybean cultivated in a crop-livestock integration system and inoculated with *A. brasilense*.

MATERIAL AND METHODS

The experiment was conducted in two agricultural years (2012/2013 and 2013/2014), in Estância Velha, Boca do Monte district, in the municipality of Santa Maria, central region of Rio Grande do Sul state (RS), Brazil, with geographic coordinates 29°41′51.07″S and 54°02′30.42″W, at an altitude of 195 m. The climate of the region is Cfa, which is subtropical humid according to the Köppen classification (NIMER, 1989). The area used was approximately 0.36 ha in a crop-livestock system, with pasture formed by the intercropping of black oat and ryegrass in the winter with soybean cultivation in the summer.

The soil of the experimental site is classified as sandy dystrophic Red Argisol (EMBRAPA, 2006), and its chemical analysis yielded the following results: pH ($CaCl_2$) = 4.10; organic matter [OM] (g dm^{-3}) = 21.44; P (mg dm^{-3}) = 1.79; K (cmolc dm^{-3}) = 0.80; Cu (mg dm^{-3}) = 1.19; Fe (mg dm^{-3}) = 175.78; Zn (mg dm^{-3}) = 1.36; Mn (mg dm^{-3}) = 118.23; Al^{3+} (cmolc dm^{-3}) = 0.96; H+Al (cmolc dm^{-3}) = 6.21; Ca (cmolc dm^{-3}) = 1.82; Mg (cmolc dm^{-3}) = 1.13; SMP index = 5.70; base sum [BS] (cmolc dm^{-3}) = 3.75; V (%) = 37.65; and Al Sat. (%) = 20.38.

In the crop-livestock system established in the winter (black oat and ryegrass), the following management practices were used: (I) - conventional grazing (CG), where the animals remained in the pasture throughout the experimental period without any grazing height control; (II) – post-grazing pasture height of 30 cm (A30); (III) - post-grazing pasture height of 20 cm (A20); (IV) post-grazing pasture height of 10 cm (A10); and (V) - no grazing (NG). The animals used for grazing were Corriedale sheep with a mean age of 1 year; five sheep were used per experimental unit. For nitrogen fertilization management, the experimental units were managed as follows: without nitrogen fertilization; 50 kg of nitrogen ha^{-1}, and 100 kg of nitrogen ha^{-1}.

The summer experiment was established over the winter experimental plots, and each plot measured 4 x 4 m. The experiment was carried out according to the randomized block design with three replicates. The treatments consisted of soybean (with and without inoculation of *A. brasilense*) sown on the plots under the winter management previously described.

Sowing was carried out using no-tillage on 16 November 2012 and 1 December 2013. The cultivar BMX Potência RR was used. For soybean cultivation, seven rows with 0.45-m spacing between rows and a density of 350,000 plants ha^{-1} was used, and in four rows, the seeds were inoculated with the *A. brasilense* bacterium (strains Abv5 and Abv6), at a concentration of 2 x 10^8 colony forming units per mL of product, where 5 mL of the liquid inoculant was used per kilogram of seed; seed inoculation was not performed in three rows. *Bradyrhizobium* inoculation was not used. Base dressing was performed with 350 kg ha^{-1} of 05-20-20 NPK fertilizer. The other crop treatments were applied according to the technical recommendations for soybean.

In the two agricultural years, the heights of insertion of the first pod (FPH) and the last pod (LPH) were measured in five plants harvested at random from each plot. Of these five plants, the number of pods per plant (NPP), number of grains per pod (NGP), and weight of the grains were determined to calculate the one-thousand grain weight (TGW). To evaluate productivity, the plants were harvested manually from three rows measuring 2 m in length; these plants were threshed with a thresher, the grains were weighed, and the values corrected to 13% moisture and expressed in kg ha^{-1}. Subsequently, the TGW was estimated, and the data are expressed in grams, corrected to 13% moisture.

The data were subjected to analysis of variance, and when significant, the Duncan test was used to compare means; a 5% probability level was adopted. The statistical software SOC was used for the analyses (EMBRAPA, 1997).

RESULTS AND DISCUSSION

In the agricultural year of 2012/2013, no interaction occurred with the variables FPH, LPH, NGP, and TGW, making a study necessary of the main effects of each treatment (Table 1 and Table 2). In 2012, the residual forage weights were 3,287, 2,247, 2,088, 1,723, and 1,186 kg of dry matter (DM) ha^{-1} for the NG, 30-cm, 20-cm, 10-cm, and CG treatments, respectively. In 2013, the residual forage weights were 4,146, 2,414, 2,252, 1,277, and 1,182 kg DM ha^{-1} for the NG, 30-cm, 20-cm, 10-cm, and CG treatments, respectively. In a continuous grazing system, Lopes et al. (2009) and Silva et al. (2014) evaluated different grazing heights (10, 20, 30, and 40 cm and no grazing) in black oats and ryegrass and did not find differences in the soybean productivity. In turn, Lunardi et al. (2008) found that soybean productivity was higher when using low grazing intensity with lambs and that the continuous or rotational grazing method is not a determinant of productivity.

FPH was lower when the pasture was managed with CG, which was also found for LPH. This result can be explained because intense grazing maintains a low leaf area index that results in lower shoot (BALBINOT JUNIOR et al., 2009) and root biomass production in forage plants, which can limit nutrient absorption, water infiltration into the soil, gas exchange, and, consequently, the development of the successor crop. This yield component has a strong influence on the productivity because the lower the insertion height of the pod, the greater the mechanical losses at the time of harvest, as the cutting platform of the harvester acts at a minimum height from the surface (NEPOMUCENO et al., 2007). The LPH is related to the height of the plants; therefore, in the CG treatment, the soybean plants were shorter, which is explained by the animal management method—the animals remained longer in these plots, which may have altered the soil physical attributes—and by the smaller residual forage mass of this treatment, which is not recommended when using the no-tillage system (NICOLOSO; LANZANOVA; LOVATO, 2006).

In the agricultural year 2013/2014, double interactions (grazing management vs. N doses in the pasture, grazing management x inoculation, and N doses in the pasture x inoculation) were tested for FPH (Table 1 and Table 2). For the grazing management factor, the plants in the NG treatment had higher FPH and LPH values and consequently were taller plants. The environmental conditions under which the experiment was conducted impaired crop development, and soon after sowing, a period of drought occurred. The effects of the changes caused by animal trampling on the soil physical attributes makes them detrimental to the development of the summer crop; these effects were enhanced by the water restriction condition (FLORES et al., 2007). Therefore, under the no-grazing treatment (absence of animals), the residual forage mass was greater, favoring the maintenance of soil moisture for a longer period of time. However, this was not reflected in the grain productivity values, as soybean has compensation mechanisms (ANDRADE; ABBATE, 2005), i.e., shorter plants with more branches, which increases the number of pods per plant and consequently the productivity.

As for the residual nitrogen effect on the pasture, no standard response was observed in the FPH values, as they varied according to the type of grazing management and inoculation applied. For LPH, when the seeds were inoculated with *A. brasilense*, a residual effect of the nitrogen applied to the pasture was observed; that is, the values of the LPH were higher when 50 and 100 kg of N ha^{-1} were used. For the factor of seed inoculation with *A. brasilense*, the FPH and LPH values were not different or were lower when using inoculation, and this response varied according to the grazing managements and N doses applied. The absence of positive results from the inoculation can be explained by the soil chemical characteristics at the experimental site, since this type of microorganism displays higher growth at pH values between 7 and 8 (RAHMAN et al., 2006), and by the fact that the area had already been cultivated with soybean in previous years and consequently has a population of soil microorganisms specific to the crop, leading to competition for space and nutrient substrate with *Azospirillum*, making its association with soybean plants difficult. In previously cultivated soils, existing *Bradyrhizobium* populations have efficient strains in adequate numbers that are highly competitive for infection sites. Therefore, the response to seed inoculation is only observed in new areas of soybean cultivation (BÁRBARO et al., 2009).

In the agricultural year 2012/2013, the NGP was lower in the non-grazed areas (NG), which did not reflect the grain productivity, as the NPP in this treatment was equal to or higher than the other treatments (Table 1 and Table 2). In the agricultural year 2013/2014, the NGP did not differ between treatments, and the mean value was 2.33 grains per pod. Among the grain yield components, the NGP is the one that presents the lowest variation among the different cultivation situations, demonstrating the stability of cultivars (MUNDSTOCK; THOMAS, 2005).

The TGW did not differ among treatments in the agricultural year 2012/2013, and the mean value was 139.66 g. For the agricultural year 2013/2014, no interaction occurred between the treatments for TGW, and for the grazing management factor, higher soybean TGW values were observed in the NG, 30-cm, and CG treatments, with smaller values observed for the 10-cm and 20-cm treatments. With this result, when greater residual forage mass (NG) or lower residual forage mass (CG) was observed, grain filling was not affected. By contrast, Lunardi et al. (2008) found the highest TGW values in areas grazed in the winter, with values of 136.1 g. No residual effect was observed from the nitrogen applied to the pasture on TGW.

The NPP is the yield component that is most affected by the different management practices. However, soybean displays high plasticity (SILVA et al., 2014); that is, it can adapt to environmental and management conditions through changes in plant morphology and yield components. A residual effect of the nitrogen applied to the pasture was observed on the NPP in the CG treatment, which had higher NPP values when 100 kg of N ha^{-1} was applied, unlike the NG treatment, which had lower NPP values. The explanation for this result is that the greater residual forage mass of the NG treatment probably immobilized a greater amount of nutrients than in grazed areas, where forage is transformed into urine and feces, accelerating the nutrients cycling in the system (LUNARDI et al., 2008). The transfer of N from the pasture via animal urine and feces to the successor crop decreased the effects of nutrient immobilization in the straw, favoring N recycling in the system.

The grain productivity results did not show a standard pattern from the applied treatments and depended on the environmental conditions of each agricultural year. In the agricultural year of 2012/2013, soybean productivity did not vary according to the grazing management (Table 2). Notably, in this agricultural year, the climatic conditions were favorable for soybean growth. Similar results were found by Silva et al. (2014), as different grazing heights with cattle in a continuous grazing system had no effect on the productivity of soybeans grown in succession. This result was attributed to the favorable climatic conditions and to soybean being a hardy crop that displays some plasticity to adapt to different grazing strategies during the winter, provided that the soil quality is not severely reduced.

In the agricultural year of 2013/2014, the grain productivity was higher in areas where the grazing was less intense (20 and 30 cm) and in areas that were not grazed (NG). Notably, in the agricultural year of 2013/2014, a drought occurred shortly after soybean sowing, and soybean yields were lower compared to those of 2012/2013. Where greater residual forage mass was observed, the soil moisture was assumed to have been maintained for a longer time, thereby favoring crop development. Lopes et al. (2009) emphasized that the lower soil cover in the treatments with lower post-grazing pasture height not only causes lower soil moisture but also allows a greater weed infestation. These results corroborate those found by Nicoloso, Lanzanova, and Lovato (2006), who obtained reduced soybean grain productivity with increased cattle grazing frequency under black oat and ryegrass pasture, and the 14-day interval between each grazing reduced the soybean productivity by more than 780 kg ha^{-1} relative to the treatment not grazed in the winter. In turn, Lunardi et al. (2008), even under a water deficit condition, found higher NPP values in areas that were grazed, and the combination of NPP and TGW determined 32.5% higher yield in these areas, indicating that the presence of grazing by lambs in ryegrass in a crop-livestock system favored soybean yield.

As for the residual effect of the nitrogen applied to the pasture, no standard response in soybean productivity was observed. Nitrogen in the form of ammonium (NH_4^+) derived from mineral fertilizer formulations is preferentially absorbed by the plants along with nitrate (NO_3^-). Ammonium interferes in the development and survival of soil bacteria, impairing the functioning of the bacterial nitrogenase complex and reducing biological nitrogen fixation, which is a natural process in soybean cultivation (RUDNICK et al., 1997).

Table 1. Height of first pod insertion (HFPI, cm), height of insertion of the last pod (HILP, cm), number of grains per pod (NGP) and mass of one thousand grains (MTG, g) Crop-livestock.

Soybean 2012/2013						
		HFPI	HILP	NGP	MTG	
Crop-livestock	WG	12.82 bc*	76.25 a	2.25 b	Average	139.66
	30 cm	14 a	75.42 a	2.32 a	CV (%)	6.71
	20 cm	13.42 abc	73.67 a	2.34 a		
	10 cm	13.75 ab	75.36 a	2.38 a		
	PC	12.49 c	68.45 b	2.35 a		
N na pastagem	0 kg ha^{-1}	13.18	73.34	2.34		
	50 kg ha $^{-1}$	13.4	74.69	2.33		
	100 kg ha^{-1}	13.31	73.46	2.31		
Inoculation (soybean)	With *Azospirillum*	13.17	74.21	2.33		
	Without *Azospirillum*	13.42	73.45	2.32		
Soybean 2013/2014						
Height of insertion of the last pod (HILP)						
		Grazing management				
		PC	30 cm	20 cm	10 cm	SP
N na pastagem	0 kg ha^{-1}	8.85 ab D	11.89 BC	12.99 AB	10.31 a CD	14.43 b A
	50 kg ha^{-1}	7.14 b D	10.25 C	14.52 B	8.17 b D	16.57 a A
	100 kg ha^{-1}	9.44 a C	10.19 C	13.05 B	9.02 ab C	15.85 ab A
Inoculation (soybean)	With *Azospirillum*	8.34 D	10.07 C	13.08 B	7.61 b D	15.81 A
	Without *Azospirillum*	8.61 C	11.48 B	13.96 A	10.72 a B	15.42 A
Inoculation (soybean)	N on pasture	0 kg ha^{-1}	50 kg ha^{-1}	100 kg ha^{-1}		
	With *Azospirillum*	10.73 b	10.51 b	11.7		
	Without *Azospirillum*	12.65 a	12.14 a	11.32		
Height of insertion of the last pod (HILP)						
		Grazing management				
	N on pasture	PC	30 cm	20 cm	10 cm	SP
	0 kg ha^{-1}	59.11 a D	70.67 BC	74.95 AB	65.07 C	78.52 b A
	50 kg ha^{-1}	50.88 b D	69.77 BC	73.77 AB	66.5 C	87.93 a A
	100 kg ha^{-1}	57.68 a D	69.84 B	76.73 A	63.45 C	81.66 b A
Inoculation (soybean)	N on pasture	0 kg ha^{-1}	50 kg ha^{-1}	100 kg ha^{-1}		
	With *Azospirillum*	65.09 b B	66.05 b AB	69.06 A		
	Without *Azospirillum*	74.24 a	73.50 a	70.68		
Mass of one thousand grains (g)						
Grazing management		N on pasture		Number of grains per pod (NGP)		
PC	126.88 ab	0 kg ha^{-1}	125.5	Average	2.33	
30 cm	128.90 ab	50 kg ha^{-1}	127.28	CV (%)	7.22	
20 cm	124.37 b	100 kg ha^{-1}	128.2			
10 cm	122.47 b	With *Azospirillum*	122.00 b			
SP+	132.34 a	Without *Azospirillum*	131.99 a			

+ Continuos grassing (CG), Without grassing (WG).

Soybean grain productivity was similar or higher in treatments where no inoculation with *A. brasilense* was used. Similar results were found by Bárbaro et al. (2009), where the co-inoculation of *A. brasilense* with *Bradyrhizobium* did not promote an increase in most of the parameters evaluated, especially in soybean productivity when soybeans were cultivated in an area already established with the crop. Factors such as soil moisture and fertility and the interaction of *A. brasilense* with other soil microorganisms and primarily with the plant lead to the production of different substances in the *A. brasilense* exudates due to the inoculates' intrinsic genetic characteristics and can explain the inferior results of the inoculation with *A. brasilense*. Another explanation is that, under conditions of low N levels in the soil, the association with the bacterium *A. brasilense* can represent a high cost for the plant, since these bacteria are extremely dependent on the carbon sources made available by the plant and all the factors that influence the bacteria associated with it (BALDANI; BALDANI, 2005). *A. brasilense* cannot compete with the native *Bradyrhizobium* bacteria, as the bacteria are probably superior competitors, causing competition with soybean.

The results suggest that the presence of sheep grazing at moderate intensities does not affect the subsequent cultivation of the soybean, thus increasing the income of the producer, who has the opportunity to use the areas during the off-season. *A. brasilense* inoculation in soybean alone was not an efficient practice for productivity increases, which suggests that more experiments should be conducted under different management conditions and with more cultivars, since the perfect association between plant and bacterium is dependent on the environmental and soil conditions and on the interaction between the microorganism and the host.

Table 2. Number of pods per plant (N**P**P) and grain yield (kg ha^{-1}) of soybean crop in crop-livestock integration system.

Soja 2012/2013						
NPP						
		Grazing management				
	N on Pasture	CG+	30 cm	20 cm	10 cm	SP
With *Azospirillum*	0 kg ha^{-1}	**β 61.5 BC	57.91 C*	α 78.75 a A	α 72.98 a AB	α 80.6 A
	50 kg ha $^{-1}$	α 90.05 a A	57.9 B	β 57.45 B	αβ 62.1 B	α 86.5 A
	100 kg ha^{-1}	α 85.15 a A	55.9 a B	α 83.41 a A	β 54.1 B	β 65.15 B
Without *Azospirillum*	0 kg ha^{-1}	β 50.93 B	48.55 B	46.8 b B	β 50.00 b B	α 80.5 A
	50 kg ha $^{-1}$	β 55.83 b B	48.05 B	56.85 B	α 68.96 A	αβ 74.86 A
	100 kg ha^{-1}	α 70.25 b A	43.7 b C	50.7 b BC	β 54.8 BC	β 63.15 AB
Soybean Grain Productivity (kg ha^{-1})						
With *Azospirillum*	0 kg ha^{-1}	α 3171.65 AB	3023.88 AB	2771.02 b B	3028.33 AB	αβ 3261.58 A
	50 kg ha $^{-1}$	α 3106.58	3075.5	2992.42	2945.11 b	β 2843.02 b
	100 kg ha^{-1}	β 2452.10 b C	2935.38 b B	2835.66 CB	3065.94 AB	α 3382.48 A
Without *Azospirillum*	0 kg ha^{-1}	2912.04 B	3359.22 A	α 3473.24 a A	αβ 207.82 AB	β 2843.36 B
	50 kg ha $^{-1}$	3236.15 AB	3352.3 AB	β 2945.91 B	α 3517.48 a A	α 3478.45 a A
	100 kg ha^{-1}	3055.04 a AB	3510.81 a A	αβ 3128.72 AB	β 3013.03 B	α 3387.71 AB
Soybean 2013/2014						
Number of pods per plant						
With *Azospirillum*	0 kg ha^{-1}	α 96.45 A	85.65 AB	α 89.06 A	81.7 AB	β 70.73 B
	50 kg ha^{-1}	β 64.21 b C	97.85 a A	β 70.63 C	90.55 b AB	β 77.16 BC
	100 kg ha^{-1}	β 71.7 B	86.18 AB	αβ 81.33 b AB	84.26 AB	α 94 A
Without *Azospirillum*	0 kg ha^{-1}	86.61 AB	91.2 AB	α 99.43 A	β 93.96 AB	76.7 B
	50 kg ha^{-1}	93.43 a B	77.11 b B	β 78.6 B	α 115.98 a A	80.56 B
	100 kg ha^{-1}	77.4 B	77.26 B	α 105.5 a A	β 80.83 B	82.9 B
Soybean Grain Productivity (kg ha^{-1})						
With *Azospirillum*	0 kg ha^{-1}	α 1897 ABC	2269.52 A	2173.92 b AB	β 1639.9 C	β 1816.39 b BC
	50 kg ha^{-1}	β 1089.24 b B	2243.07 A	2487.63 A	α 2082.74 A	α 2335.77 A
	100 kg ha^{-1}	α 2131.27	2163.51 b	2331.76 a	αβ 2028.62	α 2227.72
Without *Azospirillum*	0 kg ha^{-1}	1991.18 BC	2265.22 AB	α 2584.70 a A	1788.05 C	2461.06 a A
	50 kg ha^{-1}	2177.66 a	2433.69	α 2212.59	2048.95	2332.52
	100 kg ha^{-1}	2258.61 AB	2572.99 a A	β 1771.14 b C	2073.7 BC	2431.56 AB

*Distinct upper case letters and lower case distinct letters in column treatments differ by 5% probability by Duncan test. **Separate Greek letters in the column represent the difference between the nitrogen doses within each level of inoculation and grazing management. + Continuos grassing.

CONCLUSION

Soybean yields are greater in a crop-livestock system when established under black oat and ryegrass pasture managed with post-grazing heights between 20 and 30 cm. Areas under conventional winter grazing led to smaller soybean plants with lower first and last pod heights. Inoculation with *A. brasilense* alone is not indicated for soybean cultivation.

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