IV INOVAGRI INTERNATIONAL MEETING
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EVALUATION OF NITROGEN FERTILIZATION AND INOCULATION FOR THE CULTURE OF IRRIGATED BEAN IN THE REGION OF CERRADO/PANTANAL ECOTONE

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SUMMARY: The objective of this study was to verify the influence of nitrogen fertilization on irrigated common bean in function of different seasons and modes of nitrogen (N) application, with and without inoculation. The work was conducted in the experimental area of irrigation of the Mato Grosso do Sul University (UEMS) of Aquidauana - MS, with soil of the experimental area classified as Red Yellow Argisol Distrophic, using the IPR-Tangará bean cultivar, sown in the winter period of 2015. The experimental design was a randomized block consisting of twelve treatments (Combinations of N-P-K, P-K and inoculation with different forms of N application in different stages of the culture) and four replications, using Penman-Monteith irrigation management. The productivity, number and mass of nodules and dry mass of plants were evaluated statistically by the Tukey test at 5% probability. The mineral N in sowing and land subdivision via soil under cover had a negative effect on the number of nodules, and the different N times and modes of application did not influence the troductivity in the bean crop.

KEYWORDS: Application of nitrogen, irrigation of the bean, *Phaseolus vulgaris* L.

AVALIAÇÃO DA ADUBAÇÃO NITROGENADA E INOCULAÇÃO PARA A CULTURA DO FEIJOEIRO IRRIGADO NA REGIÃO DO ECÓTONO CERRADO/PANTANAL

RESUMO: Objetivou-se verificar a influência da adubação nitrogenada no feijoeiro irrigado em função de diferentes épocas e modos de aplicação de nitrogênio (N), com e sem

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inoculação. O trabalho foi conduzido na área experimental de irrigação da Universidade Estadual de Mato Grosso do Sul (UEMS) de Aquidauana - MS, com solo da área experimental classificado como Argissolo Vermelho Amarelo Distrófico, utilizada a cultivar de feijão IPR-Tangará, semeado no período de inverno do ano de 2015. O delineamento experimental foi em blocos casualizados constituído de doze tratamentos (Combinações de N-P-K, P-K e inoculação com diferentes formas de aplicação de N em diferentes estágios da cultura) e quatro repetições, utilizando o manejo de irrigação por Penman-Monteith. Foi avaliada a produtividade, número e massa de nódulos e massa seca de plantas, estatisticamente pelo teste de Tukey a 5% de probabilidade. O N mineral na semeadura e parcelamento via solo em cobertura exerceu efeito negativo no número de nódulos, e as diferentes épocas e modos de aplicação de N não influenciaram a produtividade de grãos na cultura do feijoeiro.

PALAVRAS-CHAVE: Aplicação de nitrogênio, irrigação do feijoeiro, *Phaseolus vulgaris* L.

INTRODUCTION

When it comes to the external market, the bean crop (Phaseolos vulgaris L.) is considered to be of little importance in the world scenario, especially in first world countries where its consumption is considered low, whereas in countries where there is legume production , There is also a high internal consumption by its inhabitants, leading to a small exportable surplus, restricting the export of grain by the producing countries (Conab, 2015).

According to Conab (2017), the total area planted with beans in Brazil had an increase of 13.2% in relation to the previous harvest, and the area planted in the agricultural year 2015/2016 of 978.6 thousand hectares. Already in the 2016/2017 harvest the planted area reached 1108 thousand ha. According to Conab, it is estimated that production in the country is 1382 thousand tons, 33.6% more than the previous harvest (1034.3 thousand tons). According to Conab (2016), the bean yield in the country (first, second and third season) in the 2015/2016 harvest was 1115 kg ha^{-1}, with the third harvest bean reaching an average productivity of 1290 kg ha^{-1} , Being cultivated in an irrigation regime.

For the bean crop Pereira et al. (2014) concluded that the crop needs 300 to 600 mm of precipitation to complete its cycle, being one of the determining factors for the development and growth of the bean, even more when allied with the other agroclimatic factors, being able to potentiate the harmful effects to the development, interfering directly with productivity.

Therefore, the irrigation water supply becomes essential for the bean cultivated in the winter where the low precipitation limits the development of the plant and consequently the productivity, making important the use of the system.

According to Binotti et al. (2014), Nitrogen (N) is the element most required by the crop, making studies that seek to optimize the availability of the plant element, since its availability is affected by factors such as: nitrogen source a to be used, the quantity and the method to be used for its application, since the necessity of the element changes as the plant develops.

According to Mercante (2015), because the bean crop uses the Biological Nitrogen Fixation (BNF) for its N supply, inoculation with rhizobia becomes an alternative to maximize productivity and reduce nitrogen fertilization costs. This practice also avoids the contamination of the water table and reduces the emission of greenhouse gases, making even greater the importance of using BNF as a source of N supply to the crop.

Therefore, it is important to study the irrigated bean crop, combining modes and times of nitrogen fertilization with inoculation of the seeds, hoping to find the most appropriate moment for nitrogen fertilization and its substitution by inoculating the seeds in the crop of the common bean submitted to irrigation in the winter period.

METHODOLOGY

The work was conducted in the irrigation experimental area of the State University of Mato Grosso do Sul, University Unit of Aquidauana (UEMS / UUA), with geographical coordinates 20 ° 20' South, 55 ° 48' West and average altitude of 207 meters. The climate of the region, according to the classification of Köppen is Aw, defined as hot tropical sub-humid, with rainy season in summer and dry in winter and average annual rainfall of 1200 mm. The soil is of the type Red-Yellow Distrophic Argisol.

The experiment was conducted under a central pivot irrigation system (1 ha), of the brand FOCKINK®, being evaluated for its uniformity of water application, using the Coefficient of Uniformity of Christiansen (CUC) and Coefficient of Uniformity of Distribution (CUD) (Bernardo et al., 2007). For irrigation management, the Penman-Monteith method was used, with a "p" soil depletion factor of 0.5.

Manually harvested occurred at 80 days after emergence (AED). Fertilization was carried out in all plots at the time of sowing and, for nitrogen fertilization, the different treatments were applied, using urea as the source of N, with a dose of 88.9 kg ha^{-1} of N.

Inoculation was carried out on the day of sowing, using Rhizobium tropici Semia 4077, being carried out only in their respective treatments at the dose of 80 g of the inoculant for each 50 kg of seed.

The experimental design was a completely randomized block with 12 treatments (T1-fertilization of sowing with NPK and without fertilization of cover, T2-fertilization of sowing with NPK and application of the total dose of N in cover in stage V4 (third trefoil completely Open) T3-fertilization of sowing with NPK and application of 1/2 dose of N in coverage in the V3 stage (first fully open trefoil) and 1/2 dose in stage V4 T4 fertilization of sowing with NPK and application of dose (5) foliar (Urea) nitrogen at the R5 stage (pre-flowering), T5-sowing fertilization with NPK and application of 1/2 N foliage (Urea) at the R5 stage and 1/2 at the R6 stage (full flowering) T6-sowing fertilization with NPK and inoculation of the seeds, without fertilization with N; T7-fertilization of sowing with NPK + inoculation of the seeds, with application of total N dose in the V4 stage; Sowing with P-K + seed inoculation, with application of total dose of N in V4 stage coverage; T9-sowing fertilization with N-P-K and application of molybdenum (Mo) foliar leaf in the V4 stage, without N fertilization in coverage; T10-sowing fertilization with P-K and application of total N dose in V4 stage coverage; T11-fertilization of sowing with P-K + inoculation of the seeds, with application of ½ dose of N in coverage in stage V3 and ½ in stage V4; T12-Sowing fertilization with P-K and application of ½ N dose in V3 stage coverage and ½ V4 stage dose) and four replicates.

Each experimental plot was composed of 4 rows of plants with six meters of length with spacing of 0.45 m between rows and seeding density of 15 seeds per meter. The working area of each plot being comprised of the two central rows excluding 0.50 m from the ends of each, by five meters in length, comprising an area of 4.5 m^2. The results were submitted to the Tukey test at 5% probability.

At the end of the crop cycle, the dry mass of plants (MSP) were evaluated, and the aerial part (leaves, stems and branches) of eight plants were collected within the useful area of each plot; Number of nodules per plant (NNP), obtained by counting the nodules of five plants per plot within the useful area, consisting of the collection of the plants, separation of the nodules and subsequent counting of them, and after the count, they were And the yield of grains (kg ha-1), being estimated after the threshing of the pods, whose grains were weighed and then the moisture correction was carried out To 13%, where productivity was obtained in each plot (4.5 m^2) and, subsequently, the productivity estimate in kg ha^{-1}.

RESULTS AND DISCUSSION

No significant differences were observed in relation to the variables, dry mass of nodules, dry mass of plants, and grain yield (Table 1). There was only difference in the number of nodules (Table 2), where T1 differed from the other treatments superior to them. This fact suggested that the presence of mineral N applied in the cover can decrease the number of nodules in the roots and, consequently, the efficiency of the BNF.

In studies conducted by Barros et al. (2013), it was concluded that nitrogen fertilization may have an inhibitory effect on nodulation when the amount of N applied increases. However, in low sowing times, nodule growth and higher FBN are observed, and Corsini (2014), higher doses of N in coverage has a negative effect on the number and mass of nodules. Therefore, Mercante (2015) reported that a dose of 20 kg of N applied at sowing associated with inoculation was enough to reach yield equivalent to the application of 160 kg of N.

The treatments did not differ in relation to the variable dry mass of plants, regardless of the seasons and modes of application of mineral N, with or without seed inoculation. This result corroborates those obtained by Romanini Júnior et al. (2007) who also did not find differences in the treatments with respect to this variable. The authors observed that the increase in dry mass occurred only when the doses of mineral N were increased, aspect not studied in this work.

Regarding grain yield, despite the experiment being conducted under an irrigation system, the yields obtained were considered well below expectations, with T8 being the highest productivity treatment yielding 803.6 kg ha^{-1} (table 1), a productivity that is 22.65% lower than the national average that according to Conab (2016), the yield of winter beans is 1039 kg ha-1.

In spite of the average minimum temperature of 17.9 ºC, average 24.3 ºC and maximum 30.7 ºC (Figure 1) were within the range considered ideal for the crop, during the conduction of the experiment high temperature peaks in the reproductive period were observed Exceeded 35 °C.

According to Pereira et al. (2014), high temperatures in the cycle of the bean cause the plant to go into the process of abortion of the reproductive organs and above 35 ° C there is almost no pod formation, which may explain the low yields achieved in the present study (Figure 1).

Barbosa & Gonzaga (2012) concluded that higher yields are obtained in regions where temperatures range between 17 ºC to 25 ºC, a thermal range considered appropriate for the species, where temperature is the climatic element that most influences the percentage of revenge pods, with the high temperatures exerting harmful effect on the flowering and the fruiting of the bean.

CONCLUSIONS

Based on the results of this work, for Northeast / Pantanal-like regions, the mineral N applied at sowing and in land subdivision in soil cover had a negative effect on the number of nodules in the roots;

The different times and modes of application of N did not influence grain yield in the bean crop.

Conditions of high temperatures, above 35°C, common in the Ecotono / Pantanal region caused low bean pod formation and decreased productivity.

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TABLES

Table 1. Mean values of dry mass of nodules (MSN), dry mass of plants (MSP) and grain yield.

Treatments	MSP (g)	MSN (g/planta)	Productivity (kg/ha)
1	8,535 a	0,035 a	577,4 a
2	7,300 a	0,015 a	707,8 a
3	8,388 a	0,014 a	677,4 a
4	6,783 a	0,021 a	498,9 a
5	6,010 a	0,031 a	536,1 a
6	5,258 a	0,040 a	759,8 a
7	6,618 a	0,021 a	718,1 a
8	6,998 a	0,023 a	803,6 a
9	6,198 a	0,035 a	688,1 a
10	6,125 a	0,026 a	748,3 a
11	6,115 a	0,024 a	466,6 a
12	4,853 a	0,020 a	526,8 a
Média	6,598	0,026	642,41
CV (%)	29,456	42,66	49,751

T1 = NPK at sowing, without cover fertilization; T2 = NPK at sowing and N at coverage in stage V4; T3 = NPK at sowing, ½ of cover N in V3 and ½ in V4; T4 = NPK at sowing and foliar application of N at R5; T5 = NPK at sowing ½ N foliar at R5 and ½ at R6; T6 = PK at sowing + seed inoculation, without N in coverage; T7 = NPK at sowing + seed inoculation, with N in V4 cover; T8 = PK at sowing + seed inoculation, with N in V4 cover; T9 = NPK in sowing and foliar application of Molybdenum (Mo) in V4; T10 = P-K at sowing + N in cover at V4; T11 = PK at sowing + inoculation with ½ N dose in V3 and ½ V4 dose; T12 = PK at sowing with ½ dose of N in V3 and ½ dose in V4. Means followed by equal letters in the columns do not differ from each other by the Tukey test at 5% probability.

Table 2. Mean number of nodules (NN) in common bean roots.

Treatments	NN
1	25,30 a
2	8,45 bc
3	3,80 c
4	7,60 bc
5	11,35 b
6	9,10 b
7	6,60 bc
8	8,10 bc
9	11,20 b
10	8,05 bc
11	9,90 b
12	8,15 bc
Média	9,80
CV (%)	21,11

T1 = NPK at sowing, without cover fertilization; T2 = NPK at sowing and N at coverage in stage V4; T3 = NPK at sowing, ½ of cover N in V3 and ½ in V4; T4 = NPK at sowing and foliar application of N at R5; T5 = NPK at sowing ½ N foliar at R5 and ½ at R6; T6 = PK at sowing + seed inoculation, without N in coverage; T7 = NPK at sowing + seed inoculation, with N in V4 cover; T8 = PK at sowing + seed inoculation, with N in V4 cover; T9 = NPK in sowing and foliar application of Molybdenum (Mo) in V4; T10 = P-K at sowing + N in cover at V4; T11 = PK at sowing + inoculation with ½ N dose in V3 and ½ V4 dose; T12 = PK at sowing with ½ dose of N in V3 and ½ dose in V4. Means followed by equal letters in the columns do not differ from each other by the Tukey test at 5% probability.

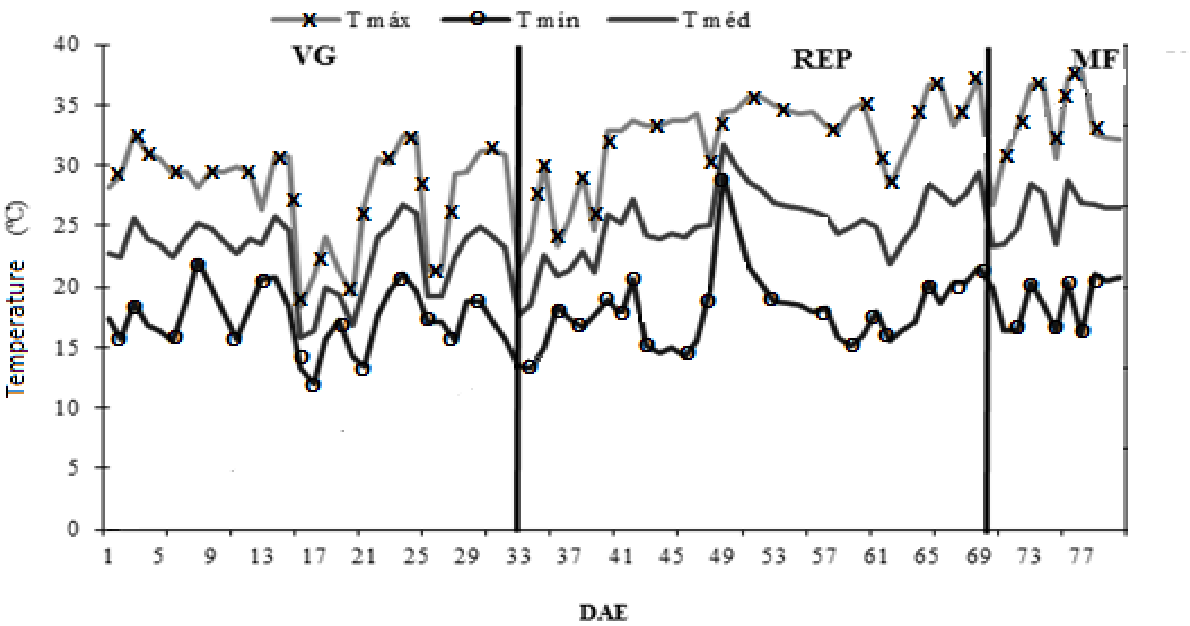

Figure 1. Mean, minimum and maximum temperatures (ºC) throughout the crop cycle during the experiment. DAE = days after the emergency. (VG) = vegetative development, REP = flowering and grain filling and MF = physiological maturation.