American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Agronomic Characteristics of Common Bean Genotypes Influenced by the Use of Boron

Rodrigo Ribeiro Fidelis[a*], Ricardo de Oliveira Rocha[b], Danilo Alves Veloso[c], Leandro Bortolon[d], Geovane Macedo Soares[e], Elisandra Solange Oliveira Bortolon[f], Taynar Coelho de Oliveira Tavares[g], Sergio Alves de Sousa[h], Liomar Borges de Oliveira[i], Antônio Carlos Francisco de Oliveira[j], Thiago Henrick Viana Leal[k], Myrlla Raynnara de Almeida Barbosa[l], Natan Angelo Seraglio[m], Juliana Marques Ferrari[n]

[a]Federal University of Tocantins., Farm 69-72 Street Badejos, Lot 7 s/n - Jardim Sevilha, Gurupi, 77404-970, Tocantins, Brazil

[b,c,e,g,I,j,k,l,m,n]Federal University of Tocantins -UFT, Farm. 69-72 Street Badejos, Lot 7 s / n - Jardim Sevilha, Gurupi, 77404-970, Tocantins, Brazil

[d,f]Fisheries and Aquaculture, Brazilian Agricultural Research Corporation-EMBRAPA

[h]Federal Institute of Tocantins – IFTO - Tocantins, Brazil

[a]Email: fidelisrr@mail.uft.edu.br, [b] Email: eng.agricola.ricardo@gmail.com

[c]Email: danilo.veloso@hotmail.com , [d]Email: leandro.bortolon@embrapa.br

[e]Email: geovanemacedo@gmail.com, [f]Email: leandro.bortolon@embrapa.br

[g]Email: taynarcoelho@hotmail.com, [h]Email: sergio.sousa@ifto.edu.br

[i]Email: liomarferaborges@gmail.com, [j]Email: antoniooliveirauft@gmail.com

[k]Email: thvleal@gmail.com, [l]Email: myrllarab@gmail.com

[m]Email: natan.seraglio@gmail.com, [n]Email: juliana.ferrari92@gmail.com

Abstract

Boron is an indispensable micronutrient for common bean culture, requiring careful studies in relation to the need and time of application since it presents a narrow range between deficiency and toxicity. The objective of this study was to evaluate the effect of boron application at different times in common bean culture.

----

* Corresponding author.

An experiment was carried out in Gurupi-Tocantins, with four replicates in a factorial scheme 7 x 4, with seven cultivars (Aporé, Diplomata, IPR-Corujinha, IPR-Chopim, IPR-Gralha, CNFC 10467 and Sapphire) and four application times (T1- absence of boron application, T2- application of boron at 15 DAE -days after emergence-, T3- application of boron at 25 DAE, T4- Application of boron at 35 DAE). There was a significant interaction between the time of application of boron and genotypes for the characteristics of one hundred grains and grain yield. There is a difference between genotypes regarding the efficiency and use of boron. The most appropriate times for boron application, taking into account productivity, are 15 DAE for cultivars CNFC 10467 and Diplomata, and 25 DAE for Aporé and IPR-Chopim. Boron fertilization at 35 DAE is not recommended due to the non-responsiveness of the crop.

Keywords: time of application; micronutrient; *Phaseolus vulgaris;* productivity.

1. Introduction

Micronutrients are essential chemical elements for plant growth, required in reduced quantities [1]. Boron is an important micronutrient in the translocation of sugars and the formation of the cell wall [2], and its adequate supply influences the amount of material assimilated by the leaves and the size of the photo-synthesize apparatus [3]. In the process of reproduction of the plants, boron has the important function of stimulating the germination of the pollen grain and the growth of the pollinic tube [4]. These functions allow us to affirm that the correct supply of the micronutrient is capable of elevating the productive potential of crops. Boron presents low mobility in the phloem and, concomitantly, its deficiency is expressed in the younger organs of the plant. Reference [5] affirm that boron deficient bean plants produce few flowers and pods, and may even die even before flowering in extreme cases of disability. Its toxicity is revealed as chlorosis in the older leaves and, subsequently, in the new leaves, evolving to necrosis, and may in some cultures provoke the complete burning of the leaves and the fall of them [1]. The Common bean (*Phaseolus vulgaris L.*) occupies a prominent place in the Brazilian agriculture, being characterized as a strong product in the domestic market, with grains that represent an important source of proteins, vitamins, minerals and carbohydrates in Population diet, besides having remarkable socioeconomic importance [6]. The national production of beans (harvests 1, 2 and 3) for the agricultural year 2017/2018 was 3.1 million tons, with an average yield of 981 kg ha^{-1}, in an area of 3.2 million hectares [7]. Although the national productivity estimates are low, there are producers who already exceed the mark of 3,000 kg ha^{-1}, these values have also been found in research studies [8, 9]. Reference [10], the bean is considered one of the most demanding crops in nutrients. Nutritional balance is often the most important and critical factor in the determination of its productivity. Because of the above, the objective of this study was to evaluate the effect of boron application at different times in the common bean crop.

2. Material and Methods

The experiment was conducted at the experimental station of University Federal of Tocantins, Campus Gurupi (11◦43’45” S, 49◦04’07” W, 280 m of altitude), in the harvest 2014/2015. The result of the chemical and physical analysis of the soil in the layer 0-20 cm before the installation of the experiment was: pH in $CaCl_2$= 5.3; M.O. (%) = 1.7; P (Mel) = 10.4 mg DM^{-3}; K = 71 mg DM^{-3}; Ca + Mg = 2.8 cmol DM^{-3}; H + Al = 2.2 cmol DM^{-3}; Al = 0.0 cmol DM^{-3}; SB = 2.98 cmol DM^{-3}; V = 58%; 715.0 g kg^{-1} of sand; 50.0 g kg^{-1} of silt and

235.0 g kg^{-1} of clay. Soil tillage was performed conventionally. Each experimental plot consisted of four lines of 4.0 m long, spaced 0.45 cm. The sowing was performed aiming to obtain a final stand of 12 plants per linear meter. The two central lines were used as a useful area, despising 0.5 m of each extremity. The sowing fertilization had a dose of 400 kg ha^{-1} of the formulated 5-25-15. The fertilization of 100 kg ha^{-1} of nitrogen, in the form of urea, was divided into two applications, being THE first at 20 DAE (days after emergence) and the second at 30 DAE. The seeds received chemical treatment of fungicide and insecticide. Weed control was performed once with a specific selective herbicide for the bean crop. Three applications of insecticides with physiological and contact action were performed. Desiccation was performed before harvesting, in order to standardize the maturation. The experiment was installed in a 7 x 4 factorial scheme, with seven cultivars and four times of boron application, at a dose of 2.0 kg ha^{-1}, in the form of boric acid, forming the following treatments: T1-Absence of boron application (control); T2-Application of boron to 15 DAE; T3-Application of boron at 25 days DAE; T4-Application of boron to 35 DAE. A randomized block design with four replications was used. The experiment was installed in a 7 x 4 factorial scheme, with seven cultivars and four times of boron application, at a dose of 2.0 kg ha−1, in the form of boric acid, forming the following treatments: T1-Absence of boron application (control); T2-Application of boron to 15 DAE; T3-Application of boron at 25 days DAE; T4-Application of boron to 35 DAE. A randomized block design with four replications was used. The evaluated characteristics were a number of pods per plant, the mass of 100 grains, with values expressed in grams, and grain yield, determined by the grain weight of the usable area in kilograms, corrected to 13% of moisture and transforming the data to kg Ha^{-1}. The experimental data were subjected to analysis of variance, with the application of the F test. For comparisons between the means of treatments, the Tukey test was used at 5% probability.

3. Results and Discussion

There was a significant difference ($P < 0.05$) in the number of pods per plant according to the common bean cultivar. However, no significant difference was detected ($P > 0.05$) due to the time of boron application and the interaction Cultivar versus time of application of this nutrient. A cultivar IPR-Gralha obtained higher mean when there was no application of boron and when applied to 15 DAE and 25 DAE (figures 1A, 1B and 1C), while the lowest averages were obtained by Aporé, Corujinha and Diplomata at 0, 15 and 25 DAE, respectively.

When the boron application occurred to the 35 DAE, the cultivar Safira reached the highest mean (Figure 1D), while the diplomat obtained the lowest mean under the same conditions. Significant differences ($P < 0.05$) were detected in the mass of 100 grains the common bean as a function of cultivar, time of application of boron and interaction cultivar versus time of application. When there was no application of boron, the cultivar that presented the highest mass of 100 grains was IPR-Corujinha, although it did not differ significantly from the cultivars Aporé, IPR-Gralha and CNFC 10467 (table 1).

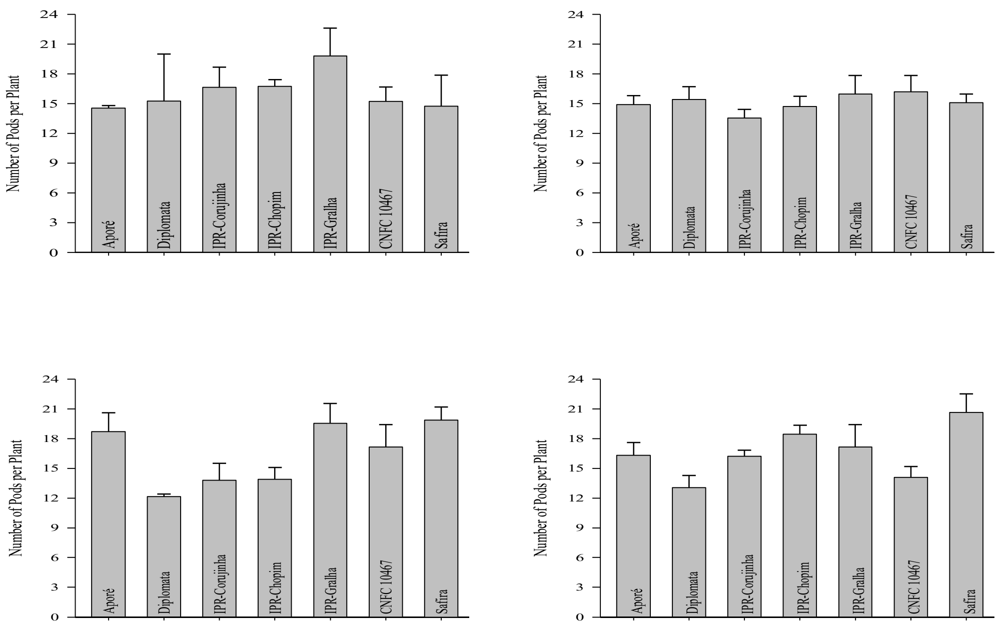

Figure 1: The number of pods per plant of seven common bean cultivars grown under different times of boron application. Absence of boron application (A), boron application 15 DAE (B), boron application 25 DAE (C), boron application 35 DAE (D).

Table 1: Mass of 100 grains (g) of seven common bean cultivars cultivated under different periods of boron application

	Times				
Genotype	**0 DAE**	**15 DAE**	**25 DAE**	**35 DAE**	**Average**
Aporé	22,77 ± 0,98 ABa	25,57 ± 0,57 Aa	22,53 ± 0,75 BCa	22,84 ± 0,52 BCDa	23,43
Diplomata	19,82 ± 1,75 BCc	23,59 ± 0,35 ABCb	29,09 ± 0,68 Aa	27,22 ± 1,11 Aa	24,93
IPR-Corujinha	24,49 ± 1,52 Aab	23,30 ± 0,50 ABCab	21,36 ± 1,27 BCb	25,09 ± 1,48 ABa	23,56
IPR-Chopim	16,93 ± 0,31 Cc	23,95 ± 0,49 ABb	21,19 ± 0,93 BCab	18,83 ± 1,99 Dbc	20,22
IPR-Gralha	22,03 ± 0,74 ABab	20,99 ± 0,57 BCb	24,64 ± 1,23 Ba	23,07 ± 0,67 BCab	22,68
CNFC 10467	21,58 ± 0,28 ABa	19,62 ± 0,67 Ca	22,26 ± 0,54 BCa	20,20 ± 1,39 CDa	20,91
Safira	18,80 ± 0,42 BCa	20,25 ± 0,80 BCa	19,16 ± 0,27 Ca	21,13 ± 0,45 BCDa	19,83
Average	**20,92**	**22,47**	**22,89**	**22,62**	

Averages followed by the same letters, uppercase in the columns and lowercase in the rows, do not differ from each other by the Tukey test at 5% probability. When boron was applied at 15 DAE, the cultivar Aporé was higher in 100 grains, although it did not differ from the cultivars IPR-Chopim, Diplomata, and IPR-Corujinha (table 2). At 25 DAE, diplomat and IPR-Gralha showed to be superior. With application to 35 DAE, the largest mass was obtained by the diplomat cultivar, which in turn did not differ from IPR-Corujinha. Also, according to table 2, it can be affirmed that the use of boron results in an increase in the grain mass of the cultivars Diplomata and IPR-Chopim. The cultivars Aporé, IPR- Corujinha, IPR-Gralha, CNFC 10467 and Safira did not have their grain masses increased with the application of boron. Significant differences in grain yield of common bean were detected as a function of the cultivar ($P < 0.05$), time of application of boron ($P < 0.01$), and cultivar interaction versus application time ($P < 0.05$). It is observed that the cultivar IPR-Corujinha showed a decrease in grain yield as the boron applications became later (Figure 2). The other cultivars showed an increase in yield until the moment when the application of boron occurred close to 25 DAE, presenting a decrease when applied to the 35 DAE.

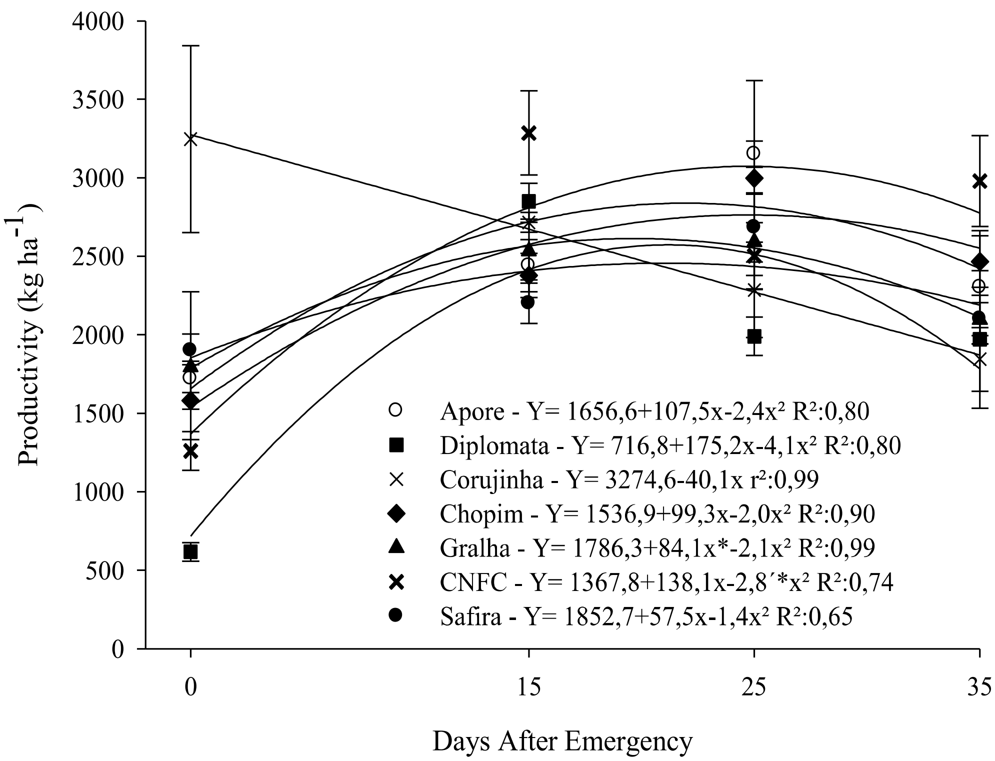

Figure 2: Grain yield (kg ha-1) of seven common bean cultivars grown under different times of boron application

It is observed that the average grain yield of the common bean was higher for most cultivars when the boron fertilization was performed, which evidences the importance of the micronutrient in this trait. The fact that boron influenced agronomic traits (one hundred grains and grain yield) of the bean crop demonstrates the importance of this micronutrient for culture and is related to physiological processes, mainly linked to the reproduction of the plant. Boron is capable of influencing pollen grain germination and the growth of polytonic tube, decreases the abortion of flowers and the grain filling, causes less male sterility and less grain rottenness [11]. Although there was no interaction between application time and cultivars for the characteristic number of pods per plant, it is possible to notice that there was an increase, in relation to the control, for some cultivars. Reference [12], testing different doses of boron in the foliar application and cover, also did not notice the effect of boron on the characteristic number of pods per plant. There was also no significant influence of the doses of B applied via foliar on the characteristic number of pods per plant, in a study carried out by [13]. Reference [12] did not find a significant effect of boron on the characteristic mass of 100 grains, differing from the present study. The adequate nutrient supply provides better conditions for the plant to photoassimilate and translocates the sugars produced, resulting in well-formed grains and elevating their mass. The time of application reflected in higher averages for the characteristic mass of 100 grains when it occurred at 15 DAE. In the soil solution, boron is found in the soluble fraction as boric acid (H_3BO_3), reaching the roots via mass flow [14]. This fact explains the highest averages achieved, because the source of boron used is the same as absorption by the plants, resulting in a better supply of the micronutrient. The average grain yield was higher, regardless of the time of application, when compared to the control. Although there was no increase in the number of pods per plant, the productivity was still higher due to the facts exposed above. The cultivars showed differences in the efficiency of micronutrient utilization. Those that have greater ease of absorption and transport of nutrients and water within the plant have greater efficiency, being influenced by the environment. The environment influences the phenotypic manifestation through the genotype X environment interaction, favoring or not the expression of positive characteristics [15], which explains the fact that distinct genotypes present different responses for The characteristics evaluated in relation to the time of application of the micronutrient.

4. Final considerations

Boron resulted in higher yields independent from the time of application, there was a difference between the genotypes regarding the efficiency and utilization of boron, and the cultivars Aporé, IPR-Corujinha, and IPR-Gralha were more efficient, the highest yields of common bean were achieved with borated fertilization performed at 15 and 25 days after emergence.

References

[1]. BRUNES, A. P.; MENDONÇA, A. O.; OLIVEIRA, S.; LEMES, E. S.; LEITZKE, I. D.; VILLELA, F. A. Produção, qualidade e expressão isoenzimática de semente de trigo produzidas sob diferentes doses de boro. **Revista Brasileira de Biociências**, v.14, n.3, p. 137-144, 2016.

[2]. SILVA, K. S.; SANTOS, E. C. M.; BENETT, C. G. S.; LARANJEIRA, L. T.; EBERHARDT NETO, E.; COSTA, E. Produtividade e desenvolvimento de cultivares de repolho em função de doses de boro. **Horticultura Brasileira**, v.30, n.3, 2012.

[3]. CAPONE, A.; DARIO, A. S.; MENEGON, M. Z.; FIDELIS, R. R.; BARROS, H. B. Resposta de cultivares de girassol a doses crescentes de boro na entressafra do Cerrado Tocantinense. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, v.11, n.1, p. 43-48, 2016.

[4]. LEMISKA, A.; PAULETTI, V.; CUQUEL, F. L.; ZAWADNEAK, M. A. C. Produção e qualidade da fruta do morangueiro sob influência da aplicação do boro. **Ciência Rural**, v.44, n.4, p. 622-628, 2014.

[5]. OLIVEIRA, I. P.; ARAUJO, R. S.; DUTRA, L. G.; Nutrição Mineral e Fixação Biológica de Nitrogênio. In: ARAÚJO, R.S.; RAVA, C. A.; STONE, L. F.; ZIMMERMANN, M. J. de O. (Coord.).

Cultura do Feijoeiro Comum no Brasil. Piracicaba: POTAFOS, 1996, p. 169-221.

[6]. CARVALHO, J. J.; SAAD, J. C. C.; BASTOS, A. V. S.; NAVES, S. S.; SOARES, F. A. L.; VIDAL, V. M. Teor e acúmulo de nutrientes em grãos de feijão comum em semeadura direta, sob déficit hídrico. **Irriga**, edição especial 01, p. 104-117, 2014.

[7]. Companhia Nacional de Abastecimento (CONAB). Acompanhamento da safra brasileira de grãos: safra 2018/2019, 4º levantamento. 2019. Disponível em: https://www.conab.gov.br/component/k2/item/download/23999_57b97f236e2bf03f1f87c796a16fab99. Acesso em: 13/01/2019.

[8]. SORATTO, R. P.; SOUZA-SCHLICK, G. D.; FERNANDES, A. M.; OLIVEIRA, L. F. F. A. Crescimento e produtividade de duas cultivares de feijão em função de doses de ácido 2,3,5-triiodobenzoico. **Ciência Rural**, v.45, n.12, p. 2181-2186, 2015.

[9]. SALGADO, F. H. M.; FIDELIS, R. R.; CARVALHO, G. L.; SANTOS, G. R.; CANCELLIER, E. L.; SILVA, G. F. Comportamento de genótipos de feijão, no período da entressafra, no sul do estado de Tocantins. **Bioscience Journal**, v.27, n.1, p. 52-58, 2011.

[10]. BINOTTI, F. F. S.; ARF, O.; ROMANINI JUNIOR, A.; FERNANDES, F. A.; SÁ, M. E.; BUZETTI, S. Manejo do solo e da adubação nitrogenada na cultura do feijão de inverno irrigado. **Bragantia**, v.66, n.1, p.121-129, 2007.

[11]. MALAVOLTA, E.; VITTI, G. C.; OLIVEIRA, S. A. Avaliação do estado nutricional de plantas: princípios e aplicações. Piracicaba: Potafos, 1997. 308p.

[12]. REIS, C. J.; SORATTO, R. P.; BÍSCARO, G. A.; KULCZYNSKI, S. M.; FENANDES, D. S. Doses e modos de aplicação de boro na produção e qualidade fisiológica de sementes de feijão em solo de cerrado. **Ceres**, v.55, n.4, p. 258-264, 2008.

[13]. OLIANI, D.; TEIXEIRA, C. M.; BONILHA, M. A. F. M.; CASSIA, M. T. Adubação foliar com boro e manganês na cultura do feijão. **FAZU em Revista**, n.8, p. 9-14, 2011.

[14]. MATIELLO, E. M.; RUIZ, H. A.; SILVA, I. R.; BARROS, N. F.; NEVES, J. C. L.; BEHLING, M. Transporte de boro no solo e sua absorção por eucalipto. **Revista Brasileira de Ciência do Solo**, v.33, n.5, p. 1281-1290, 2009.

[15]. TORRES FILHO, J.; OLIVEIRA, C. N. G. S.; SILVEIRA, L. M.; NUNES, G. H. S.; SILVA, A. J. R.; SILVA, M. F. N. Genotype by environment interaction in Green cowpea analyzed via mixed models. **Revista Caatinga**, v.30, n.3, p. 687-697, 2017.