agriculture

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Boron Fertilization Improves the Agronomic Performance of Soybean Genotypes in the Brazilian Cerrado

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Abstract: Currently, Brazil is the largest producer and exporter of soybeans in the world. Most of this cultivation is concentrated in the Cerrado region, which has soils with low boron levels. Boron performs functions that are directly linked to plant performance. The objective of this study was to evaluate the agronomic performance of soybean cultivars with and without boron fertilization. Two field experiments were carried out in the agricultural years 2018/2019 and 2019/2020. Each experiment was carried out in a randomized block design with four replications and 10 soybean cultivars (Desafio, Foco, Bonus, Maracaí, 7067, 7110, 7739, 8372, 7100, and Population). Boron fertilization was carried out at the V3 stage of the crop using ulexite (10% of boron) at a rate of 3194 kg ha^{-1} and 0.0 kg ha^{-1} of B. The application of boron to the soil increased plant height, pod insertion height, number of branches, main stem diameter, and number of pods per plant, in addition to increasing the cycle of these cultivars. The cultivars 7110, 7739 and Desafio did not statistically differ in terms of grain yield in response to boron fertilization. The cultivars Foco, Bonus, Maracaí, 7067, 8372, 7100, and Population responded favorably to this fertilization. Furthermore, genetic breeding programs incorporate advanced strategies, such as the use of boron fertilization, in order to improve the performance of the selected genotypes. Implementing boron fertilization as an integral part of breeding programs helps not only to achieve high-yielding cultivars but also to optimize key agronomic traits. This integrated approach not only boosts breeding research but also provides a solid basis for sustainable and efficient agricultural practices.

Keywords: *Glycine max* L. Merril; grain yield; hundred-grain mass

Citation: Libório, I.F.; Campos, C.N.S.; Cordeiro Santana, D.; Oliveira, I.C.d.; de Oliveira, J.L.G.; Pereira Ribeiro Teodoro, L.; Rojo Baio, F.H.; Theodoro, G.d.F.; Teodoro, P.E. Boron Fertilization Improves the Agronomic Performance of Soybean Genotypes in the Brazilian Cerrado. *Agriculture* **2024**, *14*, 27. https://doi.org/10.3390/agriculture14010027

Received: 25 November 2023
Revised: 14 December 2023
Accepted: 22 December 2023
Published: 23 December 2023

1. Introduction

Currently, Brazil is the largest producer and exporter of soybeans in the world. According to the National Supply Company [1], annual soybean production was estimated at 322.8 million tons, an increase of 18.4% more than in the previous year. The export volume is expected to reach 96.95 million tons of grain. In the Cerrado biome, soybean is the leading crop of economic interest. Notably, more than half of Brazil's soybean production is concentrated in this biome [2]. It is essential to take into account the particular edaphic traits of this biome, the vast majority of which are highly weathered and have accentuated acidity, characterized by low concentrations of essential nutrients for plant development, especially nitrogen, phosphorus, calcium, magnesium, boron, and zinc [3].

Among the nutrients that should receive due attention is boron (B), an essential micronutrient that has a considerably narrow threshold between deficiency and toxicity in soil–plant systems and plays an important role in plant nutrition and health [4]. Among the importance of an adequate supply of boron is its important contribution to the viability of flower fertilization, playing crucial roles in pollen grain germination and pollen tube growth; thus, its deficiency causes low pollination of flowers, which give rises to grains and fruits of interest, which, in particular in grain production, decreases male sterility and grain shocking [5].

Boron plays a crucial role as an enzyme regulator, directly influencing the intrinsic cell membrane structure and function processes, with its contributions extending to cell wall formation, carbohydrate synthesis and transport, protein synthesis, nitrogen fixation, photosynthesis, and plant growth [6–9]. In addition to these metabolic functions, boron provides resistance to water stress and tolerance to salt stress [7,9].

Fertilizing is one of the ways of meeting the plant's needs and making up for possible nutritional deficiencies. Ref. [10] states that B is practically not redistributed in plants, as it is immobile in the phloem, so the appearance of deficiency symptoms occurs in the youngest leaves or growth regions. To supply plants with B, B must be applied to the soil in order to reach the plant's root system and, consequently, for absorption and transportation to the aerial parts. Increasing genetic variability and selecting genotypes that are more resilient and adapted to boron restriction represent a structured strategy to face the current challenges related to food security and agricultural sustainability in food production [11].

The hypothesis in this research was that different conditions of boron fertilization would lead to changes in the agronomic traits of soybean cultivars. The aim of this study was to evaluate the agronomic performance of soybean cultivars, considering the presence or absence of boron fertilization.

2. Materials and Methods

2.1. Plant Materials and Crop Management

An experiment was carried out in the experimental field of the Federal University of Mato Grosso do Sul, Chapadão do Sul Campus (18°46′26″ S, 52°37′28″ W; average daily altitude of 810 m), in the 2018/2019 and 2019/2020 crop seasons. The region's climate is classified as tropical savannah. The climatic conditions in the two crop seasons are shown in Figure 1. The soil in the experimental area is classified as a dystrophic red Latossolo, with the traits of the 0.00–0.20 and 0.20–0.40 cm layers shown in Table 1.

Table 1. Results of the chemical and physical analyses of the soil.

Depth (cm)	**pH$_{CaCl2}$**	**OM**	**OC**	**Ca**	**Mg**	**Al**	**H+Al**	**K**	**P Mehlich**	**S**	**B**
		g dm^{-3}				**cmol$_c$ dm^{-3}**				**mg dm^{-3}**	
0.00–0.20	5.0	24.0	13.9	2.60	0.60	0.2	3.5	0.1	16.0	24.0	0.4
0.00–0.20	5.0	22.4	13.0	1.20	0.30	0.4	4.7	0.1	3.3	12.4	0.4
Depth (cm)	CEC	V	Cu	Fe	Mn	Zn	Na	Clay	Silt	Sand	
	cmol$_c$ dm^{-3}			mg dm^{-3}—Mehlich 1					(%)		
0.00–0.20	6.8	48.8	0.7	25	10.4	5.2	nd	50.5	5.0	44.5	
0.20–0.40	6.3	25.3	0.1	23	3.4	1.3	nd	53.0	5.0	42.0	

OM: organic matter; OC: organic carbon; CEC: cation exchange capacity; V: base saturation; nd: not detected.

The experiment was carried out in a randomized block design with four replications and nine cultivars (Brasmax Desafio RR, Brasmax Foco IPRO, Brasmax Bônus IPRO, HO Maracaí IPRO, TMG 7067 IPRO, Monsoy 7110 IPRO, Monsoy 7739 IPRO, Monsoy 8372 IPRO, Soy Ouro 7100 IPRO) and a genotype under breeding process, consisting of an F3 soybean line obtained from crossing the Brasmax Bônus IPRO and Brasmax Flx IPRO cultivars. The experimental unit consisted of four 4 m rows for each treatment, spaced 0.45 m apart.

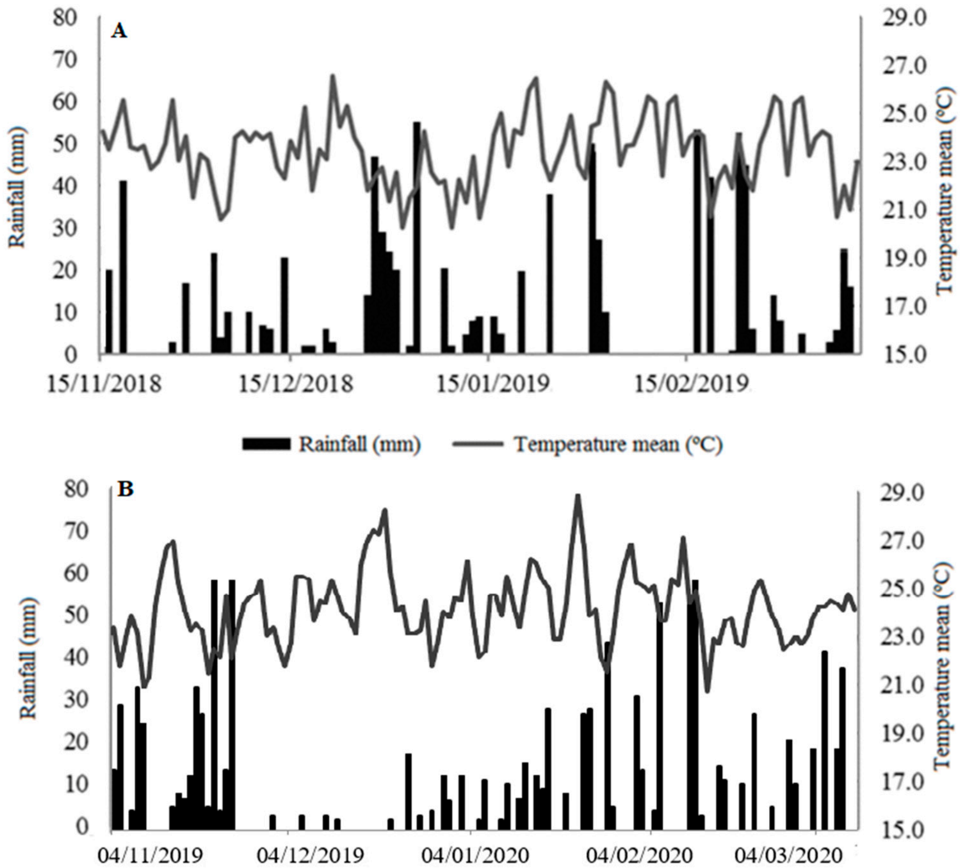

Figure 1. Weather conditions for the 2018/2019 (**A**) and 2019/2020 (**B**) crop seasons.

Before the experiment was carried out, 846.22 kg ha^{-1} of lime with a relative total neutralizing power (PRNT) of 90%, 31% CaO, and 21% MgO with a granulometry of 2 mm was applied to raise base saturation to 60%, which was followed by harrow tillage to incorporate the lime. In both years of the experiment, the rows were opened and fertilized mechanically with a five-row seeder at a spacing of 0.45 m between rows. The base fertilizer used was 250 kg ha^{-1} of a 00-20-20 formulation. Sowing was carried out manually on October 19 in both years, with a distribution of 15 seeds m^{-1}.

The seeds were treated with fungicide (carbendazim 150 g L^{-1} + tiran 350 g L^{-1}) at a dose of 0.20 L of a commercial product for every 100 kg of seeds, and with insecticide (bifenthrin 135 g L^{-1} + imidacloprid 165 g L^{-1}) at a dose of 0.70 L of a commercial product for every 100 kg of seeds, in order to guarantee protection against attacks by pests and soil fungi. For biological nitrogen fixation (BNF), the seeds were inoculated with bacteria of the *Bradyrhizobium* genus, using a dose of 0.20 L of concentrated liquid inoculant for every 100 kg of seeds. At stage V3 of the crop, we applied the herbicide glyphosate (480 g L^{-1}) at a rate of 3.50 L ha^{-1} of a commercial product and the insecticide methomyl (215 g L^{-1}) at a rate of 1.00 L ha^{-1} of a commercial product. Still at the V3 stage, boron fertilization was carried out using Ulexyta (10% boron), finely milled at a rate of 3.19 kg ha^{-1} kg ha^{-1} of B. Agricultural gypsum was also applied at a rate of 333.33 kg ha^{-1} to act as a filler, facilitating the manual distribution of B between the rows.

The first fungicide application was carried out at the R1 stage of the crop to control rust and leaf spots using two products: macozeb (750 g kg^{-1}) at a rate of 3.00 kg ha^{-1} of a commercial product and trifloxystrobin (150 g L^{-1}) + proti-oconazole (175 g L^{-1}) at a rate of 0.40 L ha^{-1} of a commercial product, as an adjuvant soybean oil methyl ester (720 g L^{-1}) was applied at a rate of 0.20 L ha^{-1} of the commercial product. An insecticide was also applied to manage caterpillars and bedbugs, thiamethoxam (141 g L^{-1}) + Lambda-cyhalothrin (106 g L^{-1}), at a rate of 0.25 L ha^{-1} of a commercial product.

Potassium fertilizer was also applied at R1, when 120 kg ha^{-1} of KCl (72 kg ha^{-1} of K_2O) was applied. At stage R5.1, the second fungicide application was made to manage rust and leaf spots, using the product picoxystrobin (26.66 g L^{-1}) + tebuconazole (33.33 g L^{-1}) + mancozeb (400.00 g L^{-1}) at a rate of 2.6 L ha^{-1}, with soybean oil methyl ester (720 g L^{-1}) applied as an adjuvant at a rate of 0.2 L ha^{-1} of a commercial product. At the same time, an insecticide was applied to manage caterpillars and bedbugs, thiamethoxam (141 g L^{-1}) + lambda-cyhalothrin (106 g L^{-1}), at a rate of 0.25 L ha^{-1} of the commercial product, after which another application of the same product was made when the crop was at stage R5.4. The third fungicide application for rust management was carried out at stage R5.5, in which the following products were used: macozeb (750 g kg^{-1}) at a rate of 3 kg ha^{-1} of a commercial product, and azoxystrobin (300 g kg^{-1}) + benzovindiflupir (150 g kg^{-1}) at a rate of 0.4 L ha^{-1} of the commercial product. At stage R7 of the crop, an insecticide was applied to manage bedbugs, using the product acephate (970 g kg^{-1}) at a rate of 900 g ha^{-1}.

2.2. Experimental Treatments and Measurements

Five plants were randomly selected from each plot to assess the following traits: first pod insertion height (PIH, cm), plant height (PH, cm), main stem diameter (SD, cm), number of branches per plant (NBP), number of pods per plant (NP), hundred grain mass (HGM), number of days to maturity (DM), and grain yield (GY). PIH and PH were measured using a tape measure. The SD variable was assessed using a digital caliper. DM corresponded to the days when 50% of the plot emerged and 50% of the plants matured. HGM was assessed using an analytical precision scale and corrected to 13% humidity. The variables PIH, PH, SD, NBP, NP, and HGM were evaluated in five plants from each experimental unit. GY was assessed by manually harvesting the central 6 m of each experimental unit, correcting the moisture content to 13% and extrapolating to kg ha^{-1}.

2.3. Statistical Analysis

Initially, data were submitted to individual analysis of variance, considering all effects as fixed. After checking that the ratio between the largest and smallest mean squares of the residuals did not exceed 7.0, a joint analysis was carried out, according to the model described in Equation (1). The Scott and Knott (1977) test was used to group the means.

$$\mathbf{Y_{ijkl}} = \mu + \mathbf{B_l} + \mathbf{C_i} + \mathbf{B_j} + \mathbf{S_k} + [\mathbf{C} \times \mathbf{B}]_{ij} + [\mathbf{C} + \mathbf{S}]_{ik} + [\mathbf{B} \times \mathbf{S}]_{jk} + [\mathbf{C} \times \mathbf{B} \times \mathbf{S}]_{ijk} + \varepsilon_{ijkl} \quad (1)$$

where $\mathbf{Y_{ijkl}}$ is the observation of the lth block evaluated in the ith cultivar in the jth boron fertilization in the kth harvest; $\mathbf{B_l}$ is the block effect considered as fixed; $\mathbf{C_i}$ is the cultivar effect considered as fixed; $\mathbf{B_j}$ is the effect of boron fertilization considered as fixed; $\mathbf{S_k}$ is the crop effect considered as random; $[C \times B]_{ij}$ is the interaction between cultivars and boron fertilization considered as fixed; $[\mathbf{C} \times \mathbf{S}]_{ik}$ is the interaction between cultivars and crops considered to be random; $[\mathbf{B} \times \mathbf{S}]_{jk}$ is the interaction between boron fertilization and crops considered as random; $[\mathbf{C} \times \mathbf{B} \times \mathbf{S}]_{ijk}$ is the interaction between cultivars, boron fertilization, and crops considered as random; ε_{ijkl} is the error associated with the observation $\mathbf{Y_{ijkl}}$.

Statistical analyses were carried out using Sisvar [12] and Rbio [13] software following the criteria recommended in [14].

3. Results

There were significant differences between the different cultivars (C) in relation to all traits analyzed, as shown in Table 2. The application of boron fertilizer (B) influenced all the traits, except for the hundred-grain mass (HGM). It should be noted that the cultivar × boron interaction (C × B) was only significant for GY, suggesting variations in production performance depending on the presence or absence of boron. It is important to note that the random effect related to the harvest (S) and its corresponding interactions (considered random) with the other effects proved to be statistically significant for most of the variables analyzed. This result suggests an influence of the harvest factor on the traits evaluated, indicating a seasonal response influenced by different environmental conditions.

Table 2. Mean square of the analysis of variance for the traits plant height (PH, cm), first pod insertion height (PIH, cm), number of branches per plant (NB), main stem diameter (SD, cm), number of pods per plant (NP), number of days to maturity (DM), hundred-grain mass (HGM), and grain yield (GY) evaluated in ten soybean cultivars grown in the presence and absence of boron fertilization.

SV	DF	PH	PIH	NB	SD	NP	DM	HGM	GY
Block	3	13.85 ns	7.24 ns	1.54 ns	6.50 ns	14.92 *	0.65 ns	3.45 ns	1179.43 ns
Cultivar (C)	9	2060.45 *	25.65 *	12.04 *	6.43 *	24.66 *	28.81 *	23.63 *	9179.10 *
Boron (B)	1	329.96 *	101.50 *	3.51 *	6.69 *	9.63 *	8.10 *	0.91 ns	117,823.53 *
Crop Season (S)	1	1565.93 *	88.92 *	1.33 ns	42.44 *	210.77 *	58.40 *	20.67 *	241,526.41 *
C × B	9	45.61 ns	7.07 ns	1.75 ns	2.04 ns	3.39 ns	2.70 ns	1.84 ns	6662.49 *
C × S	9	195.11 *	32.47 *	5.22 *	4.67 *	20.60 *	44.35 *	18.77 *	40,149.42 *
B × S	1	353.40 *	83.40 *	5.00 ns	1.64 ns	5.22 ns	14.40 *	6.43 ns	26,082.98 *
C × B × S	9	21.74 ns	12.53 ns	1.61 ns	2.04 ns	2.44 ns	3.15 ns	4.25 ns	7731.61 *
Error	117	33.61	10.75	1.40	2.09	5.37	2.67	2.30	1907.63 *
CV (%)		7.43	14.73	15.49	19.67	11.42	1.48	9.18	14.95

ns and *: not significant and significant at 5% probability by the F test, respectively; SV: source of variation; DF: degrees of freedom; CV: coefficient of variation.

Cultivars 7739, Maracaí, 7067, and Population had the highest PIH means (Table 3). The bonus cultivar had the highest PH means. Cultivars 7739, 8372, and Population had the highest NB. The cultivars Foco, Bônus, 7739, 7067, Desafio, 837,2 and Population had the highest SD means. The cultivars with boron fertilization had higher means for PIH, NB, and SD, but there was no statistical difference between the means of the cultivars with and without boron fertilization for PH. Although these traits are strongly influenced by the environment, they are directly linked to the genetic constitution of each cultivar.

Table 3. Grouping of means for the traits plant height (PH, cm), first pod insertion height (PIH, cm), number of branches per plant (NB), and main stem diameter (SD, cm) evaluated in ten soybean genotypes grown in the presence and absence of boron fertilization.

Cultivar	**PIH (cm)**	**PH (cm)**	**NB**	**SD (mm)**
7067	13.66 a	75.96 d	2.86 b	7.79 a
7110	11.72 b	64.27 e	2.93 b	6.57 b
7739	15.90 a	70.04 d	4.89 a	7.86 a
8372	13.01 b	91.46 b	4.41 a	7.55 a
Bônus	12.78 b	97.59 a	3.51 b	7.87 a
Desafio	12.94 b	69.67 d	2.65 b	7.57 a
Maracaí	14.21 a	70.99 d	2.17 b	6.57 b
Foco	11.49 b	75.64 c	2.76 b	8.01 a
Population	13.91 a	91.75 b	4.10 a	7.52 a
Soy Ouro	13.03 b	73.01 c	3.12 b	6.29 b
Boron fertilization	PIH (cm)	PH (cm)	NB	SD (mm)
With	14.06 a	79.47 a	3.49 a	7.62 a
Without	12.46 b	76.60 a	3.19 b	7.09 b

Means followed by different letters in the same column differ according the Scott–Knott test at 5% probability.

Regarding the number of days to maturity (DM), cultivar 8372 had the highest means, which characterized it as the latest cultivar among those evaluated, while genotypes 7110, Maracaí, and Soy Ouro were the earliest (Table 4). Cultivar 7739 had the highest NB. The cultivars Maracaí, Bônus, 7739, 7110, 7067, and Population had the highest HGM. The cultivars under boron fertilization had higher DM and NP means. There was no statistical difference between the means of the cultivars with and without boron fertilization for HGM.

Table 4. Grouping of means for the traits number of days to maturity (DM), number of pods per plant (NP), and hundred-grain mass (HGM) evaluated in ten soybean genotypes grown in the presence and absence of boron fertilization.

Cultivar	**DM**	**NP**	**HGM (g)**
7067	104.69 f	48.18 c	17.03 a
7110	101.13 g	43.13 c	17.28 a
7739	112.88 d	81.13 a	17.31 a
8372	129.44 a	60.64 b	14.71 b
Bônus	122.19 b	66.58 b	17.66 a
Desafio	104.69 f	55.58 c	15.51 b
Maracaí	101.88 g	43.88 c	17.64 a
Foco	106.06 e	58.65 b	15.65 b
Population	118.88 c	60.79 b	17.70 a
Soy Ouro	100.69 g	41.21 c	14.84 b
Boron fertilization	DM	NP	HGM (g)
With	111.12 a	58.01 a	16.60 a
Without	109.00 b	53.93 b	16.40 a

Means followed by different letters in the same column differ according to the Scott–Knott test at 5% probability.

Grain yield showed a significant interaction between the cultivars and boron fertilization (Table 5). In the presence of boron fertilization, the Maracaí cultivar obtained the highest means. In the absence of fertilization, cultivars 7110, 7739, Maracaí, and Foco had the highest means. With the exception of cultivars 7110, 7739, and Desafio, all the other cultivars showed increased grain yield in response to the application of boron to the soil.

Table 5. Significant interactions between soybean cultivars and boron fertilization for the grain yield (GY, kg ha^{-1}).

Cultivar	**Boron Fertilization**	
	With	**Without**
7067	2905.94 cA	2292.04 bB
7110	2899.01 cA	2791.19 aA
7739	3216.23 bA	3071.32 aA
8372	3313.12 bA	2190.49 bB
Bônus	3266.46 bA	2500.32 bB
Desafio	2967.66 cA	2806.36 cA
Maracaí	3834.75 aA	3033.54 aB
Foco	3230.99 bA	2857.64 aB
Population	3092.82 cA	2313.23 bB
Soy Ouro	3356.69 bA	2477.61 bB

Capital letters compare the presence and absence of boron fertilization using the Scott–Knott test at 5% probability, while lowercase letters group soybean cultivars.

4. Discussion

4.1. Effects on Soybean Agronomic Performance

Micronutrients are required in low amounts by plants, but they are also essential for the growth and development of plant species [15]. Therefore, micronutrient levels in the soil below those required by the plants lead to significant losses in production [16]. Ref. [17] stated that the practice of boron fertilization is one of the ways of guaranteeing high yields. However, few producers adopt this practice due to low technical knowledge, and it is neglected by most of the others, which is a factor that could limit yields and, in a short time, put food security at risk.

In addition to paying attention to fertilization, it is important to note that genotypes require different amounts of nutrients. Thus, selecting genotypes that are responsive to fertilization should be based on those that grow well in poor fertility soils, as well as on the responsiveness of the plant to boron, since there is a slight difference between the need for boron and boron toxicity among the genotypes of the same species [18].

The PIH variable is taken into account in breeding programs to facilitate mechanized harvesting, for which a height between 10 and 15 cm is considered optimal [19,20]. Cultivars below this height range can be physically damaged by stones or other debris on the soil surface [21]. In this way, all the genotypes evaluated here achieved a PIH suitable for mechanized harvesting, especially 7739, Maracaí, 7067, and the Population.

In addition to PIH, other important agronomic traits to take into account, especially when developing new cultivars, are plant height and stem diameter, which are positively correlated and affect lodging and, hence, grain yield and quality [22,23]. These traits are highly inheritable and can be selected in the first years of the breeding program [24]. Another trait with high heritability and a direct relationship with yield is NB [25], whose highest means were achieved for cultivars 7739, 8372, and the Population.

PH did not differ significantly in relation to the presence or absence of boron. de Souza Domingues [26] found similar results when evaluating different rates of leaf B, where they found no statistical difference in plant height and pod insertion height. However, Ref. [27] obtained contrasting findings when evaluating the effect of boron fertilization on the plant height in soybean, in which the plants responded positively to the fertilization.

The other analyzed variables showed significant sensitivity to the presence of boron, which has a marked influence on photosynthesis and water-use efficiency in soybeans [28–30]. Boron plays a crucial role in the biological and physiological processes of soybeans. The nutrient is involved in various metabolic pathways and has an essential role in the structural and functional integrity of cell walls and membranes, directly influencing key processes such as cell division and elongation, ion flow through membranes, and phenol metabolism and transport [31,32].

There is a concern in soybean breeding programs about the physiological maturity of cultivars, which is an essential parameter in the selection of new cultivars [33]. Our findings show that cultivars 7110, Maracaí and Soy Ouro are earlier; the absence of boron fertilization also contributed to the earliness of the genotypes evaluated. The use of B, especially when applied together with calcium, can promote better vegetative development [34], thus contributing to longer days to maturity.

Galeriani et al. [35] reported that the boron can promote flower retention and pod setting, thus contributing to an increased number of pods per plant, which in turn has a direct impact on yield. The main focus of soybean breeding is to increase grain yield [36] but there are other factors that improve yield, such as an increased number of pods per plant [37].

Soybean is one of the crops that is most sensitive to boron, regardless the boron uptake and use efficiency of the genotypes [38]. Despite all the contributions of boron to the formation of soybean grains, HGM was not affected by boron fertilization. Ref. [39] found similar results when evaluating the effect of boron fertilization and did not verify a higher grain yield. These findings are similar to the study carried out by [26], who, when assessing the effects of B and Zn leaf fertilization, found no increase in HGM.

4.2. Future Perspectives

Plants grown under optimal nutrient conditions grow normally and have greater yields. When their nutritional status is unbalanced, plants can suffer and show visual symptoms, as well as undergoing other abiotic stresses, and reduced yields. Often, when a nutrient is unbalanced, it can also affect other nutrients in the plant [27].

Boron has a direct influence on yields due to its requirement in the reproductive phase for microsporogenesis, pollen tube growth, and postfertilization embryogenesis. It is directly responsible for the formation of new organs in which its deficiency leads to the formation of incomplete or damaged embryos, seed abortion, and deformed fruits [38,40].

Rosolem et al. [41] found higher soybean yields in soils with a higher B content. It can be seen that cultivars 7110, 7739, and Desafio are more resistant to B deficiency. On the other hand, cultivar Soy Ouro showed a greater gain in yield under boron fertilization, showing high responsiveness to this micronutrient.

Breeding programs are key players in the agricultural context, filling a crucial role by promoting an increase in genetic variability. This increase in variability, in turn, leads to the broadening of the available genetic base. These programs not only contribute to genetic diversification but also make it possible to carefully select the most promising genotypes in a population. This selection is guided not only by conventional grain yield standards but also takes into account the intrinsic capacity of these genotypes to overcome environmental adversities.

Furthermore, genetic breeding programs incorporate advanced strategies, such as the use of boron fertilization, in order to improve the performance of the selected genotypes. Implementing boron fertilization as an integral part of breeding programs helps not only to achieve high-yielding cultivars but also to optimize key agronomic traits. This integrated approach boosts breeding research and provides a solid basis for sustainable and efficient agricultural practices. Future studies should be carried out in other locations around the world to evaluate other agronomic variables of interest in different genetic materials, in order to have an even broader understanding of the effects of B fertilization on plants and an efficient selection of more responsive genotypes to boron.

5. Conclusions

Boron fertilization improves soybean agronomic performance by increasing plant height, pod insertion height, number of branches, stem diameter, number of pods per plant, and cycle.

The cultivars Foco, Bonus, Maracaí, 7067, 8372, 7100, and Population showed an increase in grain yield under boron fertilization.

Author Contributions: Conceptualization, I.F.L. and P.E.T.; methodology, C.N.S.C. and P.E.T.; software, D.C.S. and L.P.R.T.; validation, I.C.d.O., J.L.G.d.O., L.P.R.T., F.H.R.B. and G.d.F.T.; formal analysis, P.E.T.; investigation, I.F.L.; resources, P.E.T.; data curation, P.E.T. writing—original draft preparation, I.F.L.; writing—review and editing, P.E.T., D.C.S. and G.d.F.T.; visualization, C.N.S.C.; supervision, P.E.T.; project administration, C.N.S.C.; funding acquisition, P.E.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: Data are available from corresponding author on reasonable request.

Acknowledgments: The authors would like to thank the Universidade Federal de Mato Grosso do Sul (UFMS), Universidade do Estado do Mato Grosso (UNEMAT), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (grant numbers 303767/2020-0, 306022/2021-4, and 304979/2022-8), and Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT) (TO numbers 88/2021, 07/2022, 318/2022, and 94/2023), and SIAFEM (numbers 30478, 31333, 32242, and 33111). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brazil (CAPES)—Financial Code 001.

Conflicts of Interest: The authors declare no conflict of interest.

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