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Technical and Economic Viability of Wheat with Forms of Application and Doses of Boron

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Abstract

Boron is one of the most limiting micronutrients in grains production system in Brazil. In this way, the objective was to evaluate the effect of forms of application and doses of boron in irrigated wheat grain yield evaluating the economic terms in Cerrado region. The experiment was conducted in no-tillage system in an Oxisol with clay texture in Selvíria, MS, Brazil. The experimental design was a randomized block design with four replicates, arranged in a 4 × 3 factorial scheme: four doses of boron (0, 1, 2 and 4 kg ha^{-1}) with boric acid source (B = 17%); and three apllication forms: a) in desiccation of the predecessor straw, together with herbicide; b) at the time of sowing, in soil along with the formulated fertilization seeding and c) via leaf tissue with the application of post emergent herbicide. The application of 2 kg ha^{-1} provides greater grain yields, but the highest economic return was obtained at the dose of 1 kg ha^{-1}, with application in soil, ensuring profitability from production of irrigated wheat in the Cerrado.

Keywords: *Triticum aestivum*, borated fertilization, boron time application, total operational cost, grain yield

1. Introduction

Wheat (*Triticum aestivum* L.) is an annual cycle plant, considered among the cool season cereal, one that has greater economic importance, with large grain yield capacity (Teixeira Filho et al., 2010; Marini et al., 2011; Teixeira Filho et al., 2012, 2014; Theago et al., 2014). The cereal occupies over 17% of cultivable land in the world and represents approximately 30% of world grain production. In the period from 2012 to 2016, the annual average area of wheat cultivated worldwide was approximately 220 million hectares, reaching 734 million tons in the 2015/2016 harvest (USDA, 2016).

Fertilization is recognized as one of the factors that favors the productivity and sustainability of the activity (Araújo, 2011; Galindo et al., 2016, 2017a, 2017b), and among the nutrients that most affect productivity, boron (B) is the most limiting micronutrient for crops, especially in tropical soils, which are generally low in B available and low in organic matter, a major source of this nutrient to plants, which culminates in inadequate plant nutrition (Souza et al., 2011).

Boron is an essential element to plant growth, participating in several processes, such as sugar transport, lignification, cell wall structure, carbohydrate metabolism, RNA metabolism, respiration, indole acetic acid (IAA) metabolism, phenolic metabolism, ascorbate metabolism, besides have function in cell wall synthesis and plasma membrane integrity (Reis et al., 2008; Calonego et al., 2010; Trautmann, 2014; Foloni et al., 2016). According to Metwally et al. (2017), B influences the germination of the pollen grain and pollen tube growth, increases flower glue and granulation and causes less male sterility and less grain puffiness. In addition to the better fertilization of flowers and grain formation, B interferes with the retention of newly formed spikes, besides acting on meristem growth, cell differentiation, maturation, cell division and plant growth (Tahir et al., 2009;

Muhmood et al., 2014), and boron deficiency is the most common micronutrient limitation in plants (Raimundi et al., 2013; Gomes et al., 2017).

As a result of its low mobility within the phloem, there is a need for a constant availability or supply of this nutrient during the vegetative phase of the plants (Calonego et al., 2010; Mantovani et al., 2013), being important studies about the ideal moment management of fertilized fertilization. However, there are few studies on B fertilization in wheat cultivation focusing on the best application method associated with the appropriate dose of this nutrient.

In view of above, and due to the lack of information about this interaction, the hypothesis of this study was that there may be a synergic effect between forms of application and boron doses, thus allowing a higher efficiency of boron fertilization. Therefore, the objective of this work was to evaluate the effect of boron doses associated to forms of application of this nutrient on wheat grain yield and economic analysis in Brazilian Cerrado.

2. Methods

2.1 Field Sites and Material Description

The research was conducted at the experimental station located in Selvíria, Mato Grosso do Sul (20°22′ S, 51°22′ W, altitude of 335 m), Brazil, in 2016. The average temperature was 23.5 °C, the annual average precipitation was 1,370 mm, and the annual average relative air humidity was 70-80% (Figure 1). The soil in the experimental area was classified as Oxisol (Latossolo Vermelho distrófico), clayed texture (Embrapa, 2013).

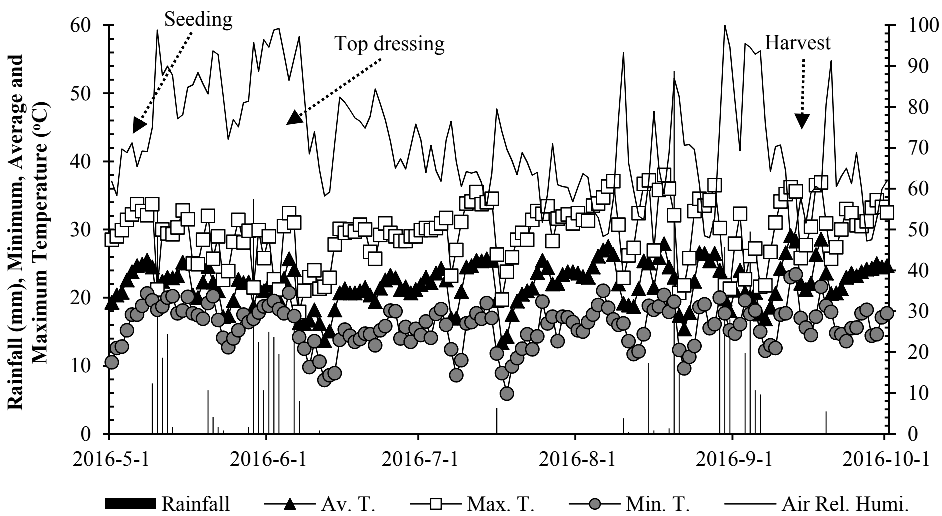

Figure 1. Rainfall, air relative humidity, and maximum, average, and minimum temperatures obtained from the weather station located on the Education and Research Farm of FE/UNESP during wheat cultivation in the period of May to October 2016

2.2 Experimental Design

The experimental design was randomized blocks, with four replications and a 4 × 3 factorial design: four boron doses (0, 1, 2 and 4 kg ha^{-1}) with boric acid source (B = 17%); and three apllication forms: a) in desiccation of the predecessor straw, together with herbicide (2 weeks before wheat sowing); b) at the time of sowing, in soil along with the formulated fertilization seeding and c) via leaf with the application of post emergent herbicide (20 days after emergence). The experimental plots were composed of twelve 5-m lines spaced at a distance of 0.17 m, and the useful area of the plot considered was the central eight lines, with the exclusion of 0.5 m from the ends.

The chemical attributes of the soil (depth of 0-0.20 and 0.20-0.40 m) were determined in 2016 before the initiation of the experiment, following the methodology proposed by Raij et al. (2001). The following results were obtained: 0-0.20 m layer: 19 mg dm^{-3} P (resin); 10 mg dm^{-3} of $S\text{-}SO_4$; 21 g dm^{-3} organic matter; 5.0 pH ($CaCl_2$); K, Ca, Mg, H + Al and Al = 2.1; 19.0; 13.0; 28.0 and 1.0 $mmol_c$ dm^{-3}, respectively; Cu, Fe, Mn, Zn (DTPA) = 3.1; 20.0; 27.2 and 0.8 mg dm^{-3}, respectively; 0.17 mg dm^{-3} B (hot water) and 55% base saturation; and in the 0.20-0.40 m layer: 17 mg dm^{-3} P (resin); 30 mg dm^{-3} of $S\text{-}SO_4$; 16 g dm^{-3} organic matter; 4.8 pH

($CaCl_2$); K, Ca, Mg, H + Al and Al = 1.2; 11.0; 8.0; 28.0 and 2.0 $mmol_c$ dm^{-3}, respectively; Cu, Fe, Mn, Zn (DTPA) = 2.1; 10.0; 10.7 and 0.2 mg dm^{-3}, respectively; 0.11 mg dm^{-3} B (hot water) and 42% base saturation.

The experimental area has been cultivated with annual crops for more than 27 years, and the no-tillage system has been used for the past 10 years, with corn as predecessor crop. The corn straw was collected to estimate the accumulation of nutrients: 62.3; 11.5; 45; 44.5; 17.8 and 15.8 kg ha^{-1} of N, P, K, Ca, Mg and S, respectively, and 217.9; 178.1; 1940.9; 1210.8 and 267.1 g ha^{-1} of B, Cu, Fe, Mn and Zn, respectively.

The herbicides used in the experimental areas were glyphosate (1800 g ha^{-1} of a.i.) and 2,4-D (670 g ha^{-1} of a.i.) for desiccation, and the products were applied 2 weeks before wheat cultivation. On the basis of the results of soil analysis and the need to increase base saturation to 70%, as recommended by Cantarella et al. (1997), 1.2 t ha^{-1} of dolomitic limestone (Relative total neutralizing power = 80%, CaO = 28% and MgO = 20%) were applied to the soil 60 days before sowing wheat in 2016. Furthermore, on the basis of the results of soil analysis and culture requirements, 275 kg ha^{-1} of the formula 08-28-16 were supplied for sowing fertilization. For seed treatment, the fungicides carbendazim + thiram (45 g + 105 g of a.i. per 100 kg of seed) and the insecticides imidacloprid + thiodicarb (45 g + 135 g of a.i. per 100 kg of seed) were used.

The wheat crop was irrigated using a center pivot sprinkling system, with a mean water depth of 14 mm and an irrigation interval of approximately 72 h. The cultivar used was CD 1104 with mechanical seeding on May 3, 2016 with a density of 70 seeds per meter. The seedlings emerged 5 days after sowing on May 8, 2016.

The weeds was managed with the application of the herbicide metsulfuron-methyl (3 g ha^{-1} of a.i.), 20 days after emergence (DAE) of wheat. Nitrogen fertilization was performed manually on June 8, 2016 with 30 DAE, with urea as source (45% N) and the fertilizer was spread on the soil surface without incorporation on the sides and at approximately 8 cm from the sowing lines to avoid contact of the plants with the fertilizer at the dose of 140 kg ha^{-1} of N. After topdressing fertilization, the area was irrigated by sprinkling (depth of 14 mm) at night to minimize losses by volatilization of ammonia, which is common in irrigated wheat. The plants in useful area of the plot were harvested manually at 120 DAE on September 8, 2016.

2.3 Analytical Procedures

After mechanical tracking, the grains were quantified, and the data were transformed into kg ha^{-1} and corrected for 13% moisture (wet basis) and transformed into 60-kg sacks. The results were subjected to analysis of variance (F test) and Tukey's test at a level of significance of 5% for the comparison of the average yields obtained with different B application forms. The regression equations were adjusted to the effect of B doses using the Sisvar software (Ferreira, 2011).

For the economic analysis, the structure based on the total operating production costs (TOC) used by the Institute of Agricultural Economics (IEA) was adopted, according to Matsunaga et al. (1976), consisting of the sum of operating expenses: operations performed, inputs (fertilizers, seeds, pesticides, etc.), labor, machinery, and irrigation, named effective operating costs (EOC). In this study, besides the TOC, other operating expenses and interests were included, considering 5% of the EOC (Matsunaga et al., 1976), thus resulting in the total operating cost (TOC), which was extrapolated to one hectare. This methodology has been already used in several studies on economic evaluation in crops such as Kaneko et al. (2010), Garcia et al. (2012), and Galindo et al. (2017).

To determine the profitability of the involved treatments, profitability analyses were carried out following Martin et al. (1998). To this end, the following variables were determined: gross revenue (GR) (in R$), as the product of the amount produced (in number of 60-kg sacks) by the average sale price (in R$); operating profit (OP), as the difference between the gross revenue and total operating cost; profitability index (PI), understood as the ratio between operating profit (OP) and the net revenue (NR), in percent; equilibrium price, given a certain total operating production cost, as a the minimum price calculated to cover this cost, considering the average productivity of the producer; equilibrium yield, given a certain total operating production cost, as the minimum productivity to cover this cost, considering the average price paid to the producer.

The average prices were quoted in the region of Selvíria, MS, Brazil, in 2017 (average of three years ago 2015, 2016 and 2017, according to IEA, 2017). In this study, simulations were performed as if each experimental treatment represented commercial crops. To help elaborate the data, especially concerning the machine-hour rate, the machine yield, the inputs utilized, and the price of the sack of wheat, the grain producers of the region were interviewed, considering the prices paid for the inputs for the 2016/2017 crop. To facilitate the discussion, the values referring to the yields were transformed into 60-kg sacks, which was the basic unit of sale by local producers. The cost of the sack of wheat for the municipality of Selvíria (average of three years ago) was

R$40.67 per unit produced. As regards the boron source, boric acid, the price paid by the farmer was R$3,960.00 per ton.

3. Results and Discussion

3.1 Technical Analysis: Wheat Grain Yield

The application of B doses in the soil resulted in higher grain yield as compared to straw and leaf application. The increase in grain yield was of 7.29 and 10.17 bags of 60 kg ha^{-1} in relation to the application through leaf tissue and straw, respectively, equivalent to 10.15 and 14.16% (Table 1).

In relation to the boron doses, there was an adjustment to the quadratic function up to the approximate dose of 2 kg ha^{-1} of B, that is, the increase of B doses up to 2 kg ha^{-1} provided an increase in wheat grain yield. The increase in yield, in the absence of borated fertilization up to the dose of 2 kg ha^{-1} was 9.74 bags of 60 kg ha^{-1}, equivalent to 13.84% (Table 1, Figure 2).

Table 1. Wheat grain yield affected by boron doses and forms of application. Selvíria MS, Brazil, 2016

	Grain Yield (60 kg sack ha^{-1})
Doses	
0	60.65
1	68.24
2	70.39
4	64.71
Forms	
Straw	61.67 b
Soil	71.84 a
Leaf	64.55 b
L.S.D. (5%)	7.11
Overall Mean	66.00
C.V. (5%)	10.51
Teste F	
DOSES	9.390^{**}
FORMS	6.952^{**}
DXF	1.921^{ns}

Note. The letters correspond to a significant difference at 5% probability level ($p \leq 0.05$). ** and *: significant at $p < 0.01$ and $0.01 < p < 0.05$, respectively.

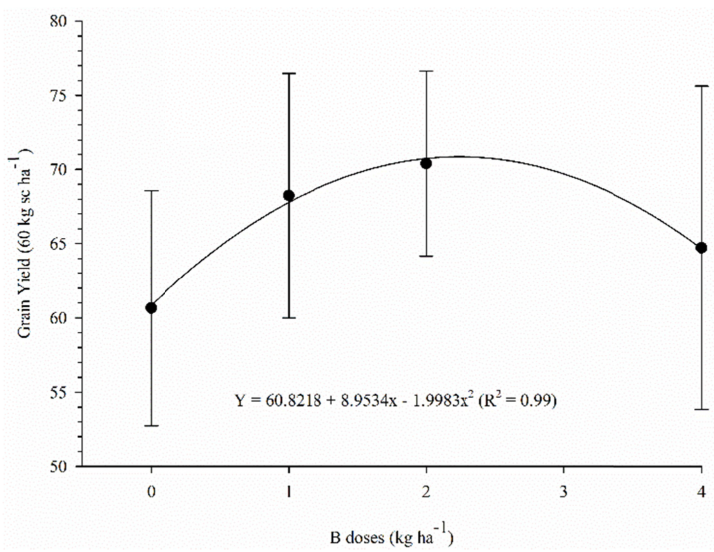

Figure 2. Grain Yield in function of B doses. Selvíria, MS, Brazil, 2016. Error bars indicate the standard error of the mean (n = 4)

The requirement of wheat culture, the sensitivity of the system root of annual crops with respect to B is in the order of wheat > common beans > soybeans > rice > maize, meaning that the wheat crop requires more B for the development of the system root (Fageria, 2000), in this way, the application in the soil may have provided greater amount of nutrient near the root, justifying the results obtained.

The lack of B is very common in tropical soils, which has caused great productivity losses in different crops (Mantovani et al., 2013). In addition, the amounts of B required for seed formation are generally greater than those required for vegetative growth (Marschner, 1995). For this reason, even in situations where the crop is in soil with good B reserves, increases in grain yield can be obtained with borated fertilization. Besides the B content in the soil is below the adequate range according to Raij et al. (1997) (0.17 mg dm^{-3} B in soil, while the content stipulated as the average is above 0.20 mg dm^{-3}), Brazilian Cerrado soil have low O.M. content, which is the main source of B for the crops (21 g dm^{-3} in the present study) and the high requirement of this nutrient for the wheat crop, demonstrate that the management of borated fertilization can be beneficial and positive in grain yield, as verified in this study.

Boron is an essential element to plant growth, participating in several processes, such as sugar transport, lignification, cell wall structure, carbohydrate metabolism, RNA metabolism, respiration, indole acetic acid (IAA) metabolism, phenolic metabolism, ascorbate metabolism, besides have function in cell wall synthesis and plasma membrane integrity (Calonego et al., 2010), influences the germination of the pollen grain and pollen tube growth, increases flower glue and granulation and causes less male sterility and less grain puffiness (Metwally et al., 2017). In addition to the better fertilization of flowers and grain formation, B interferes with the retention of spikes, besides acting on meristem growth, cell differentiation, maturation, cell division and plant growth (Tahir et al., 2009; Muhmood et al., 2014). These innumerable functions of the B mentioned probably increased the number of spikelets per spike, together with the greater absorption of this nutrient, increase B in the leaf, grains and aerial part, that influenced in a positive way the grain yield.

According to Mantovani et al. (2013), B enhances the fixation of flower and grain formation in different cultures, and provides less male sterility and lower pith grains, which possibly influenced the grain yield in this study. The nutritional requirement of the cultivated plants generally becomes more intense with the beginning of the reproductive phase, because the crops are in full vegetative development, added to the strong demand for nutrients for the formation of the reproductive structures, the relatively low quantities of B required by the crop in general can be met by foliar fertilization. However, the low mobility of B in plant tissues may constitute an impediment to plant nutrition, being necessary many applications. On the other hand, unlike micronutrients fertilization in soil, foliar fertilization allows more uniform applications per unit area and relatively faster responses, when the crops are in advanced stages of development, and it is possible to correct any deficiencies in the short term (Nomura et al., 2011, Lemiska et al., 2014). Therefore, it was expected that the application of B in the foliar tissue, being a fertilization closer to the reproductive stage could influence positively the grain yield, however, it was inferior to the application in the soil.

Similar results were obtained by Souza et al. (2011), working with 0, 0.6, 1.2, 1.8 and 2.4 kg ha^{-1} of B in common bean crop that obtained maximum grain yield at the dose of 1.8 kg ha^{-1} of B. Muhmood et al. (2014), researching borated fertilization on wheat, obtained higher grain yield at the dose of 2 kg ha^{-1} and Debnath et al. (2011), which found a higher yield of wheat grain at a dose of 1.9 kg ha^{-1} B.

Brunes et al. (2015) verified that borated fertilization, applied at sowing or tillering, in doses between 2.5 and 3.0 kg ha^{-1} caused an increase in the number of seeds and spikes produced per plant, but with a reduction of seed yield per plant, mass of 1000 seeds and the hectoliter mass, but a drastic reduction of grain yield was observed above the dose of 2.8 kg ha^{-1} of B. However, for Brazilian Cerrado conditions, Gomes et al. (2017) verified higher grain yield of soybeans with the application of 3.51 kg ha^{-1} of B, which can be explained mainly by the conditions of low organic matter of the soil. Factors that affect soil boron availability to plants include soil moisture, texture, temperature and organic matter content. Boron availability increases with increasing soil moisture, clay content, and organic matter content (Gomes et al., 2017).

3.2 Economic Analysis: Total Operating Costs, Gross Revenue, Operating Profit, Profitability Index, Equilibrium Price and Equilibrium Yield

Table 2 shows the structure of the total operating costs (TOC) of the wheat crop in the municipality of Selvíria, describing the treatment with application in straw and boron dose of 0 kg ha^{-1}. This TOC structure model was used in all treatments. As can be seen in Table 2, the expenses with fertilizers, followed by mechanized operations, were the highest, corresponding to 47.5 and 33.6% of the TOC, respectively. It should point out that with the elevation of B doses, the percentage of expenses in relation to the TOC of the fertilizers tends to increase. The costs with boron fertilization, as a function of the increasing B doses, ranged from 0.99 to 3.85% of the TOC.

Table 2. Total operating costs structure model of wheat for the treatment zero kg ha^{-1} B in applied in the straw, per hectare. Selvíria, MS, 2016

Description	Specification[1]	Times	Coefficient	Unitary Value (R$)	Total Value (R$)
A. OPERATIONS					
Desiccation	HM	1.00	0.50	85.00	42.50
Hoeing (triton)	HM	1.00	0.50	85.00	42.50
Seeding	HM	1.00	0.60	150.00	90.00
Pulverization	HM	1.00	0.60	85.00	51.00
Topdressing	HM	1.00	0.40	150.00	60.00
Harvest	HM	1.00	1.00	118.00	118.00
Irrigation (pivot)	mm	1.00	150.00	2.50	375.00
Subtotal A					779.00
B. AGRICULTURAL INPUTS					
Fertilizer 08-28-16	t	1.00	0.28	1,998.00	549.45
Urea	t	1.00	0.31	1,780.00	553.76
Boric acid fertilizer	t	1.00	0.00	3,960.00	0.00
Wheat seed CD 1104	sc 50 kg	1.00	2.90	60.00	174.00
Glyphosate	L	1.00	4.00	14.51	58.04
2,4-D	L	1.00	1.00	13.24	13.24
Metsulfuron methyl	g ha^{-1}	1.00	3.00	1.02	3.05
Seed treatment pyraclostrobin + thiophanate-methyl + fipronil	L	1	0.04	350.00	14.00
Subtotal B					1,365.54
Effective operating costs (EOC)					2,144.54
Other expenses					107.23
Interest cost					69.70
Total operating cost (TOC)					2,321.47

Note. HM = Hour machine; sc = sack; 2016 and 2017 average exchange rate: R$2,97 = U$1,00.

As regards the TOC and yield of the treatments (Table 3), the highest value was found in the treatment with B dose of 4 kg ha^{-1} irrespective of the form of boron application. The lowest TOC corresponded to the treatments without B fertilization (0 kg ha^{-1}). However, it is noteworthy that if B is not replenished in the soil, the soil reserves deplete as the nutrient is extracted, which compromises the productivity of crops over time. For grain yield, the highest values were found in the treatment with boron application in soil at the dose of 1 kg ha^{-1}, with average yields of 73.96 sacks of 60 kg.

Table 3. Total operating cost (TOC), grain yield, gross revenue (GR), operating profit (OP), profitability index (PI), equilibrium price (EP) and equilibrium yield (EY) of wheat affected by boron doses and forms of application. Selvíria MS, 2016

Doses	TOC	YIELD	GR	OP	PI	EP	EY
	R$	60 kg ha^{-1} sc	R$		%	R$ sc^{-1}	60 kg ha^{-1} sc
Straw							
0	2321.47	52.34	2128.67	-192.80	-9.08	44.35	57.08
1	2346.68	58.07	2362.11	15.43	0.65	40.40	57.70
2	2371.90	69.69	2834.29	462.39	16.31	34.04	58.32
4	2422.33	66.24	2693.98	271.65	10.08	36.57	59.56
Mean	2365.60	61.59	2504.76	139.17	4.49	38.84	58.17
Soil							
0	2321.47	69.71	2835.00	513.53	18.11	33.30	57.08
1	2346.68	73.96	3007.84	661.16	21.98	31.73	57.70
2	2371.90	73.33	2582.47	610.57	20.47	32.34	58.32
4	2422.33	70.39	2862.85	440.52	15.39	34.41	59.56
Mean	2365.60	71.85	2822.04	556.45	18.99	32.95	58.17
Leaf Tissue							
0	2321.47	59.90	2435.97	114.50	4.70	38.76	57.08
1	2346.68	72.69	2956.18	609.50	20.62	32.28	57.70
2	2371.90	68.15	2771.48	399.58	14.42	34.81	58.32
4	2422.33	57.53	2339.74	-82.59	-3.53	42.11	59.56
Mean	2365.60	64.57	2625.84	260.25	9.05	36.99	58.17

Note. * Average wheat trading price R$ 40.67 per 60-kg sack according to IEA (2017).

As to the gross revenues per hectare obtained in the combination of treatments (Table 3), the price of wheat being constant, the gross revenues of the treatments followed the same trend as the yields (Table 3); that is, the accruals in revenue are due to the increases in grain yield. This result is in agreement with and Duete et al. (2009), according to whom the yield is a primordial factor to ensure good profitability to the producer. As asserted by Duete et al. (2009), even in regions where producers obtain good grain prices, if their productivity is low, profitability is compromised. Thus, investment in management practices, like balanced B fertilization, elevates the grain yield and the gross margin of the crops, regardless of the location.

For the values referring to operating profit (Table 3), the OP was positive for the majority studied treatments, irrespective of dose or application form, except at the dose of 0 kg ha^{-1} of B in straw and 4 kg ha^{-1} in foliar tissue, respectively.

The highest OP was obtained with soil application at the dose of 1 kg ha^{-1} (R$661.16). Even with boron fertilization in high doses, until 4 kg ha^{-1}, irrespective of the form of boron application, which would increase costs, with the possibility of reducing the OP, wheat growing would be viable, given mainly the high yield obtained; this reinforces the importance of micronutrients fertilization management like boron so as to achieve high yields and consequently high financial return.

With respect of profitability index, the highest value was obtained again with soil application at the dose of 1 kg ha^{-1} providing a PI of 21.98%. In the analysis of equilibrium yield (minimum yield to cover the costs), for the price of R$40.67 per sack of 60 kg of wheat (Table 3), when boron was used at the dose of 4 kg ha^{-1}, irrespective of the form of boron application, the equilibrium yield was higher (59.56 sacks ha^{-1}), while the lowest equilibrium yields were observed without application of B fertilizer: 57.08 sacks ha^{-1}, to cover the costs of production. Although the lowest equilibrium yield was obtained in absence of B fertilization, it is noteworthy that a lack of B supply in a cultivated soil will reduce its concentration in the soil, thus compromising the success of the activity over time, in case the nutrient is not replenished.

A little variation was observed between non-fertilized and treatments with 4 kg ha^{-1} of boron applied, regard to equilibrium yield, at the same application form, which is due to the low cost of the boron fertilization (R$ 23.29 per ha), which is one of the main advantages of this micronutrient management application.

The values (in R$) of the 60-kg wheat sack for the equilibrium price (minimum price to cover the TOC) are shown in Table 3. The grains produced with application in soil had a lower equilibrium price as compared with those produced with application in foliar tissue and straw (average of R$32.95 for soil application, R$36.99 for foliar tissue, and R$38.84 for straw, respectively). Concerning the B doses, the application of 1 kg ha^{-1} provided lower equilibrium prices when the application was in soil and foliar tissue: R$31.73 and R$32.28, respectively, and with application of 2 kg ha^{-1} when the application was in straw: R$34.04. Individually, the highest equilibrium price was obtained with straw application and without borated fertilization, while the lowest value was verified at the dose of 1 kg ha^{-1} of B applied in the soil.

The results obtained demonstrate benefits in wheat grain yield, elucidating the need for new research related to the beneficial effects of boron fertilization associated with forms of application and calling attention to the possibility of wide use of this technology in the field due to low economic cost, non-toxic and with high potential of response of wheat crop. For this reason, this technique is likely increasingly adopted by rural farmers.

Brazil is an essential importing country of wheat, becoming dependent on countries like Argentina, Canada and the United States, selling the cereal in dollars, in this way, buying wheat over R$ 50.00 per sack of 60 kg, which is much higher than that paid to wheat produced in the country, which is around R$ 40.00 per sack. Thus, the need for the Government to provide incentive to the national wheat producers is evident, not only to stimulate production, but also to invest more in technology and in the reduction of the use of foreign currency for the acquisition of the product, since the value of the dollar is on the upward trend.

4. Conclusions

At the dose of 2 kg ha^{-1} of B, the boron fertilization resulted in higher grain yields, regardless of forms of application.

Boron application in soil makes wheat increase more profitable, irrespective of the B dose.

The B dose of 2 kg ha^{-1} provides greater grain yields, but the highest economic return is obtained at the dose of 1 kg ha^{-1}, with application in soil, ensuring profitability from production of irrigated wheat in the Cerrado.

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