AGRONOMY SCIENCE AND BIOTECHNOLOGY

RESEARCH ARTICLE

Agronomic performance of wheat genotypes and the use of nitrogen doses

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ABSTRACT

This work aimed to evaluate the agronomic performance of wheat cultivars and to evaluate the use of nitrogen doses. Two experiments took place at Centro de Pesquisas e Resultados Agronômicos das Missões (CEPRAM), in the municipality of Entre-Ijuís, Rio Grande do Sul, Brazil. Experiment I took place in a randomized block experimental design, evaluating 22 wheat genotypes in four replications. Experiment II took place in a randomized block experimental design, organized in a factorial arrangement of 7 nitrogen doses x 2 wheat genotypes. The doses of nitrogen were 0, 25, 50, 75, 100, 125, 150 kg ha^{-1} and two wheat cultivars ORS Senna and TBIO Audaz, with 4 replications. In 10 plants, randomly collected, in each experimental unit were evaluated the morphological and productive variables. Performing Analysis of variance and Tukey's mean comparison test in both experiments. Applying principal component analysis and genetic dissimilarity in experiment I. The cultivar TBIO Noble showed productive and morphological characteristics that maximize the agronomic performance of wheat. There is genetic divergence between wheat genotypes for productive and morphological traits. Cultivar ORS Senna enhanced ear length and number of tillers at doses of 44 kg of N ha^{-1} and 48 kg of N ha^{-1}, respectively.

Keywords: *Triticum aestivum*, principal component, Dendrogram, time of application, fertilization management, method of application.

INTRODUCTION

The wheat crop (*Triticum aestivum*) is of great importance and is included in cropping systems, being one of the alternatives most used by farmers in the winter period, especially in the south of the country. In addition to the traditional areas for wheat cultivation, other areas are currently suitable for wheat cultivation in Brazil, including the Midwest, Southeast and South, in addition to the *cerrado* region in Bahia (Orso et al., 2014; Casagrande et al., 2022; Demari et al., 2022). In 2021, the wheat crop occupied a cultivation area of 2.73 million hectares, and a significant increase in production compared to 2020, this increase being 2.6%, resulting in 7.87 million tons and a productivity of 2.876 kg ha^{-1} (Companhia Nacional de Abastecimento [CONAB], 2022).

Just like other plants of the *Poacea* family, wheat comprises about 2.9% of nitrogen (N) in the plant and 2% in the grains (Orso et al., 2014). The wheat crop is demanding in terms of N, and it is essential for better development and higher productivity of the crop. This nutrient is of great importance for all its collaboration in the development of substances that will determine better quality and essential metabolic functions, such as protein synthesis.

Nitrogen is one of the nutrients most required by this crop and its yield is a direct function of the amount of nutrients accumulated by the plant (Megda, Buzetti, Andreotti, Teixeira Filho, & Vieira, 2009). In view of this, nitrogen has a great impact on the development of wheat, enhancing the development of the crop, some factors such as the dose, the time of application and the method of application have a direct effect on the productivity of the crop. Topdressing nitrogen fertilization provides greater accumulation of crude and soluble proteins in the seeds (Gomes Júnior & Sá, 2010). The amount of nitrogen application will depend and vary according to the area to be cultivated, mainly by the level of organic matter in the soil, predecessor crop and expected grain yield (ITTT, 2020). At sowing, the amount indicated varies between 15 kg ha^{-1} and 20 kg ha^{-1}, and the remainder in coverage between the tillering and stalk elongation phases (ITTT, 2020).

In order to reach a high production ceiling, enhancing productivity and thus being able to meet the demand in Brazil, there are some techniques to take place, such as management, choice of environment, adequate genotype and quality seeds (Abati, Brzezinski, Zucareli, Foloni, & Henning, 2018). However, the chosen sowing density is also of great importance, and therefore it is one of the key points for the highest grain yield, and along with it comes the fertilization management. Because it is a crop that allows for different management situations, presenting a relatively constant productive behavior (Fioreze & Rodrigues, 2012; Fioreze & Rodrigues, 2014). Thus, this work aimed to evaluate the agronomic performance of wheat cultivars and to evaluate the use of nitrogen doses.

MATERIAL AND METHODS

Two experiments took place at Centro de Pesquisas e Resultados Agronômicos das Missões (CEPRAM), in the municipality of Entre-Ijuís, Rio Grande do Sul, Brazil, latitude and longitude of 28º 23'17.82" S and 54º 19'13.74 " W, altitude of 215 meters. Soil classified as typical dystrophic Red Latosol (STRECK et al., 2008) and climate characterized by humid subtropical Cfa according to Koeppen.

Experiment I

The experiment took place in a randomized block experimental design, with four replications. There were evaluated 22 wheat genotypes: TSZ Dominadore, TBIO Capricho, BRS Reponte, BRS Bela Joia, ORS Agile, ORS Feroz, TBIO Astro, TBIO Ello, TBIO Sinuelo, TSZ Chiaro, TBIO Duque, TBIO Ponteiro, ORS 1403, ORS Senna, TBIO Calibre, TBIO Trunfo, ORS Guardião, TBIO Noble, ORS Destak, TBIO Audaz, ORS Absoluto and ORS Madre Perola.

Experiment II

The experiment took place in a randomized block experimental design, organized in a factorial scheme 7 nitrogen doses x 2 wheat genotypes. The doses were 0, 25, 50, 75, 100, 125, 150 kg ha^{-1} and two wheat cultivars ORS Senna and TBIO Audaz, with 4 replications.

In both experiments (Experiment I and II), sowing was carried out in the second half of May 2021, with base fertilization of 320 kg ha^{-1} of formula 11-30-20 (N-P2O5-K2O). The experimental units were 30 m² with row spacing of 0.17 m. For disease control, two fungicide applications were used, the first of Azoxystrobin + Flutriafol (0.25 L ha^{-1}) in the elongation stages and the second of Tebuconazole (0.35 L ha^{-1}) in full flowering. The insecticide management took place with two applications of Imidacloprid + Bifenthrin (0.20 L ha^{-1}) along the fungicides.

At full physiological maturation, 10 plants per experimental unit, were randomly collected to measure the following characters: plant height (PH, cm), number of tillers. (TL, unit), ear length (EL, cm), ear weight (EW, g), number of grains per ear (NGE, unit), grain weight per ear (GWE, g) and grain yield (GY, kg ha^{-1}).

The individual data, obtained in the two experiments, were submitted to the assumptions of the statistical model of normality of errors and homogeneity of residual variances. Analysis of variance performance was at 5% probability using the F test and Tukey's mean comparison test applied at the 5% probability level in both experiments for qualitative factors. In experiment 1, using Biplot principal component analysis in order to determine the associations between the analyzed traits and wheat genotypes. In order to develop the genetic dissimilarity dendrogram, the Euclidean distance matrix used the UPGMA algorithm for calculation and grouping. In experiment 2, the variables that showed a significant effect for interaction were broken down to simple effects through polynomial regression with adjustment of the degree of the polynomial based on the t test at 5% probability. All analyzes were performed using the R software version 4.1.3 (R Core Team, 2022).

RESULTS AND DISCUSSION

Experiment I: Agronomic performance of wheat cultivars

There was a significant effect of cultivars for all evaluated variables. This indicates that the genotypes performed differently for these variables (Table 1). The CV ranged from 3.68 (PH) to 19.04% (GY), indicating that there is experimental precision.

The cultivars TBIO Calibre, TBIO Astro, TBIO Trunfo, ORS Guardião, TBIO Noble, ORS Destak, TBIO Audaz, ORS Absoluto and ORS Madre Perola had the lowest plant

height (68 to 70 cm) (Table 2). Wheat genotypes with lower plant height generally have the lowest tendency to lodging (Meleto et al., 2013; Prando, Zucareli, Fronza, Oliveira, & Oliveira Júnior, 2013). Thus, more nutrients may be provided for the plant to develop with less energy expenditure. The ORS Guardião genotype showed the highest ear length (8.84 cm).

Table 1. Summary of analysis of variance for wheat cultivar effects.

		MS[1]							
SV[2]	DF[3]	PH[4] (cm)	EL[5] (cm)	EW[6] (g)	NGE[7] (units)	TGE[8] (g)	TL[9] (units)	GY[10] (kg ha^{-1})	TGW[11] (g)
CULTIVARS	21	0.001*[12]	0.001*	0.018*	0.001*	0.001*	0.003*	0.00081*	0.001*
BLOCKS	3	0.307	0.989	0.742	0.91	0.867	0.843	0.725	0.882
ERROR	61	7.929	0.250	0.013	9.204	0.008	0.102	338895	4.073
TOTAL	85								
CV%		3.68	6.8	11.58	11.7	13.03	14.16	19.04	7.37

Mean square (MS[1]), Source of Variation (SV[2]), Degree of Freedom (DF[3]), Plant height (PH[4]), ear length (EL[5]), ear weight (EW[6]), number of grains per ear (NGE[7]), grain weight per ear (TGE[8]), number of tillers (TL[9]), grain yield (GY[10]) and thousand grain weight (TGW[11]). [12]Significant by the F test at 5% probability.

Table 2. Means of the variables measured for the different evaluated wheat cultivars.

CULTIVARS	PH[1] (cm)	EL (cm)	EW (g)	NGE (units)
TSZ Dominadore	86.41a[2]	7.79abcde	0.991ab	28.2a
TBIO Capricho	85.55a	7.32bcde	1.088ab	28.3a
BRS Reponte	84.16a	7.19bcde	0.965ab	27.5a
BRS Bela Joia	84.00a	7.07cde	0.848b	22.3ab
ORS Agile	83.91a	6.88de	0.914ab	25.8a
ORS Feroz	82.71a	6.86de	0.989ab	28.8a
TBIO Ello	82.23a	7.44bcde	0.992ab	28.8a
TBIO Sinuelo	81.70a	6.70e	0.995ab	24.2ab
TSZ Chiaro	79.92ab	7.04cde	0.934ab	24.6ab
TBIO Duque	79.70ab	7.10cde	1.088ab	26.1a
TBIO Ponteiro	78.80ab	6.51e	0.948ab	22.8ab
ORS 1403	73.37bc	6.94cde	0.971ab	25.4a
ORS SENNA	72.32bc	6.77de	1.058ab	25.9a
TBIO Calibre	70.78c	6.73e	0.951ab	28.9a
TBIO Astro	70.75c	6.57e	0.965ab	25.6a
TBIO Trunfo	70.61c	7.42bcde	1.065ab	30.4a
ORS Guardião	69.98c	8.84a	1.119ab	23.9ab
TBIO Noble	69.80c	8.52ab	1.218a	24.9ab
ORS Destak	69.62c	7.24bcde	0.992ab	23.3ab
TBIO Audaz	69.48c	8.13abcd	1.160ab	27.6a
ORS Absoluto	68.72c	7.86abcde	0.988ab	17.1b
ORS Madre Perola	68.47c	8.28abc	1.002ab	27.5a

[1]Plant height (PH), ear length (EL), ear weight (EW), number of grains per ear (NGE). [2]Means followed by the same lowercase letter in the column do not differ statistically at 5% probability by Tukey's test.

The highest ear weight was by the TBIO Noble genotype. This character is one of the components of wheat grain yield, consequently, greater ear weight enhances the productive performance of wheat (Carvalho, Szareski, Nardino, Villela, & Souza, 2018). The highest averages of the number of grains per ear were by the cultivars TSZ Dominadore, TBIO Capricho, BRS Reponte, ORS Agile, ORS Feroz, TBIO Ello, TBIO Duque, ORS 1403, ORS Senna, TBIO Calibre, TBIO Astro, TBIO Trunfo, TBIO Audaz and ORS Madre Perola.

The cultivar TBIO Noble expressed the highest average of ear grain weight (Table 3). The ability to maintain productive tillers is associated with the supply of N to the plant, and this character contributes to an increase in the number of fertile ears, especially at low sowing densities (Fioreze & Rodrigues, 2012; Fioreze & Rodrigues, 2014; Ferrari et al., 2016). Therefore, the TBIO Ponteiro cultivar had the highest average number of tillers, while the lowest average was for the ORS 1403 cultivar. This indicates that the TBIO Ponteiro cultivar has a greater compensation capacity when subjected to low density conditions of plants.

Table 3. Means of the variables measured for the different evaluated wheat cultivars.

CULTIVARS	GWE[1] (g)	TL (units)	GY (kg ha $^{-1}$)	TGW (g)
TSZ Dominadore	0.695abcde[2]	2.55ab	3426.181a	24.479de
TBIO Capricho	0.750abcd	2.47ab	3559.715a	26.505bcde
BRS Reponte	0.695abcde	2.03ab	2718.190ab	25.385cde
BRS Bela Joia	0.539de	2.52ab	2579200ab	23.966de
ORS Agile	0.661bcde	2.19ab	2783.101ab	25.590cde
ORS Feroz	0.706abcde	2.17ab	2961.380ab	24.403de
TBIO Ello	0.675abcde	2.53ab	3292.816ab	23.565e
TBIO Sinuelo	0.652bcde	2.65ab	3310.699ab	27.018bcde
TSZ Chiaro	0.651bcde	2.10ab	2621.498ab	26.500bcde
TBIO Duque	0.744abcd	2.20ab	3135.734ab	28.685bcde
TBIO Ponteiro	0.621cde	2.70a	3203.276ab	27.269bcde
ORS 1403	0.741abcde	1.80b	2545.515ab	29.169bcd
ORS SENNA	0.787abcd	2.20ab	3311.473ab	30.388bc
TBIO Calibre	0.760abcd	2.48ab	3639.020a	26.180cde
TBIO Astro	0.685abcde	2.11ab	2786.820ab	26.829bcde
TBIO Trunfo	0.844abc	2.53ab	4091.011a	27.733bcde
ORS Guardião	0.687abcde	2.39ab	3021.685ab	29.035bcde
TBIO Noble	0.919a	1.87ab	3304.935ab	36.832a
ORS Destak	0.660bcde	2.18ab	2763.273ab	28.285bcde
TBIO Audaz	0.880ab	2.13ab	3551.863a	31.732ab
ORS Absoluto	0.488e	1.87ab	1757.189b	28.588bcde
ORS Madre Perola	0.671abcde	2.30ab	2959.364ab	24.428de

[1]Grain weight per ear (GWE), number of tillers (TL), grain yield (GY) and thousand grain weight (TGW). [2]Means followed by the same lowercase letter in the column do not differ statistically at 5% probability by Tukey's test

The highest grain yield average was by the cultivar TBIO Trunfo. The cultivar TBIO Noble potentiated the expression of thousand grain weight. The cultivar TBIO Noble did not differ statistically from the best averages of the evaluated traits. For

example, characterized by a cultivar with low plant height, with a high expression of productive traits.

The first two principal components explained 42.56 and 31.33% of the total data variability (PC1 + PC2 = 73.89) (Figure 1). Cultivar TBIO Noble showed the highest magnitude of expression of thousand grain weight, ear length and ear weight. However, it had the lowest plant height and number of tillers. The cultivars TBIO Trunfo and TBIO Audaz showed the highest means of grain yield and grain weight per ear, respectively.

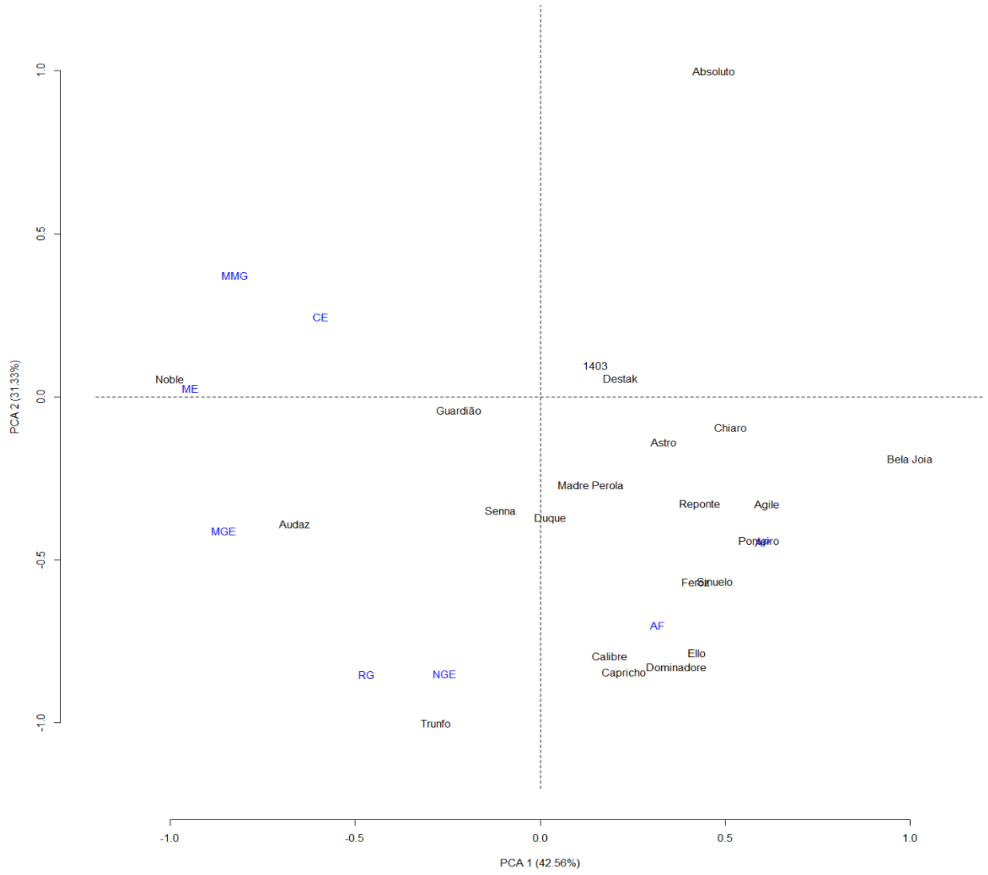

Figure 1. Total data variability represented by two principal components. Plant height (PH, cm), number of tillers (TL, unit), ear length (EL, cm), ear weight (EW, g), number of grains per ear (NGE, unit), grain weight per ear (GWE, g) and grain yield (GY, kg ha^{-1}).

Variables plotted close on the biplot show a positive correlation, while variables in opposite directions a negative one. Therefore, thousand grain weight, ear length and ear weight have positive correlation with each other. These correlate negatively with plant height and number of tillers. Grain yield and the number of grains per ear correlated positivily

The genetic dissimilarity dendrogram formed two large groups (Group I: 9 cultivars and Group II: 13 cultivars) dissimilar to each other (Figure 2). Group I was formed by the genotypes TBIO Trunfo (22), TBIO Calibre (7), TBIO Astro (5), TBIO Capricho (8), TSZ Dominadore (11), TBIO Ello (13), TBIO Sinuelo (21), TBIO Noble (17) and ORS Senna (20). These cultivars stood out for the highest averages of plant height (PH), ear weighy, number of tillers, a thousand grain weight and grain yield.

The large group II is composed by the genotypes ORS Absoluto (2), BRS Reponte (19), ORS Destak (10), ORS Agile (3), TBIO Astro (4), TSZ Chiaro (9), ORS 1403 (1), BRS Bela Joia (6), ORS Guardião (15), ORS Feroz (14), ORS Madre Perola (16), TBIO Duque (12) and TBIO Ponteiro (18). This group characterized the highest mean magnitudes of ear length and ear grain weight. Therefore, there is genetic diversity among the evaluated wheat genotypes. This indicates that group I cultivars may be used in crosses with group II cultivars to guarantee the generation of genetic variability in genetic improvement programs.

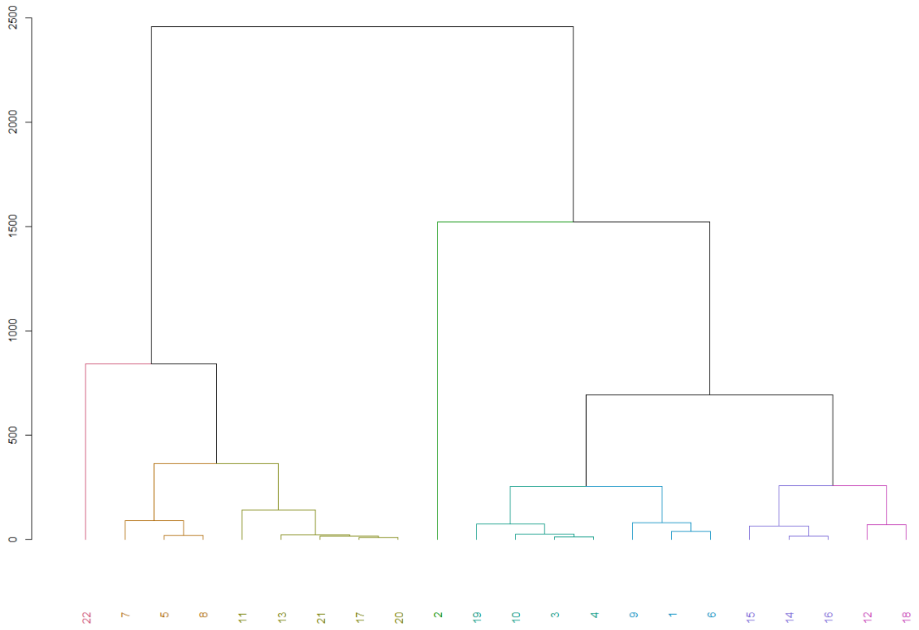

Figure 2. Dendrogram obtained by the UPGMA grouping method, from the dissimilarity measures between 22 wheat cultivars, based on the Euclidean distance. 1- TSZ Dominadore; 2- TBIO Capricho; 3- BRS Reponte; 4- BRS Bela Joia; 5- ORS Agile; 6- BRS Feroz; 7- TBIO Ello; 8- TBIO Sinuelo; 9- TSZ Chiaro; 10- TBIO Duque; 11- TBIO Ponteiro; 12- ORS 1403; 13- ORS Senna; 14- TBIO Calibre; 15- TBIO Astro; 16- TBIO Trunfo; 17- ORS Guardião; 18- TBIO Noble; 19- ORS Destak; 20- TBIO Audaz; 21- ORS Absoluto; and 22- ORS Madre Perola.

Experiment II: Nitrogen doses

Analysis of variance revealed a significant effect of the cultivar x nitrogen dose interaction for the variables ear length and number of tillers (Table 4). For the effect of cultivars, a significant effect was observed for the variables plant height, ear weight, thousand grain weight, number of grains per ear and grain weight per ear. CV ranged from 3.75 to 34.70% for plant height and grain yield, respectively.

The cultivar TBIO Audaz had the highest ear length (7.07 cm) at the dose of 50 kg ha^{-1} of nitrogen, while the cultivar TBIO Senna had the highest average (7.45 cm) at the dose of 75 kg ha^{-1} of nitrogen (Table 5). In the other nitrogen doses, the average length of the ear of the cultivars did not differ statistically. The cultivar TBIO Senna showed the highest mean number of tillers (1.94 tillers) at the dose of 25 kg ha^{-1} of nitrogen. At the other doses, there was no significant difference between cultivars for the number of tillers.

The cultivar TBIO Audaz had the highest plant height (66.73 cm), number

of grains per ear (28.97) and grain weight per ear (0.99 g) (Table 6). The cultivar ORS Senna, on the other hand, stood out for having the highest average weight of the ear (1.22 g) and thousand grain weight (34.54 g).

Table 4. Summary of analysis of variance for the effects of wheat cultivars x nitrogen doses.

SV[2]	DF[3]	MS[1]							
		EL[4]	PH[5]	TL[6]	EW[7]	TGW[8]	NGE[9]	GWE[10]	GY[11]
BLOCK	3	0.32	11.03	0,03	0,02	51,68	11,67	0,013	630543.66
CULTIVAR	1	0.44	561.26*[12]	0,91*	0,65*	581,32*	63,77*	0,80*	4055688.00
DOSES	6	0.52*	4.43	0,10*	0,025	51,89	21,17	0.018	1168695.67
CULTIVAR*DOSES	6	0.51*	3.5	0,19*	0,04	55,73	27,27	0.025	3264.44
RESIDUE	38	0.14	5.69	0,035	0,02	37,11	12,92	0.051	2211600.68
TOTAL	54	0.24	15,89	0,077	0,035	51,71	16,3	0.057	2159018.09
CV (%)		5.27	3.75	11.34	12.96	19.53	12.89	26.10	34.70

Mean square (MS[1]), Source of Variation (SV[2]), Degree of Freedom (DF[3]), Ear Length (EL[4]) Plant Height (PH[5]), number of tillers (TL[6]) ear weight (EW[7]), thousand grain weight (TGW[8]), number of grains per ear (NGE[9]), grain weight per ear (GWE[10]) and grain yield (GY[11]). [12]Significant by the F test at 5% probability.

Table 5. Average comparison test for the interaction between cultivars x nitrogen doses.

DOSES	CULTIVARS			
	AUDAZ	SENNA	AUDAZ	SENNA
	EL[1]		TL[2]	
0	7.20A[3]	7.45A	1.82A	1.57A
25	6.94A	7.43A	1.94A	1.42B
50	7.07A	6.10B	1.83A	1.76A
75	6.78B	7.45A	1.75A	1.60A
100	7.20A	7.52A	1.59A	1.75A
125	7.22A	7.23A	1.81A	1.71A
150	7.43A	7.60A	1.83A	1.02A

Ear Length (EL[1]), number of tillers (TL[2]). [3]Means followed by the same capital letter in the row do not differ statistically by Tukey's test at 5% probability of error.

Table 6. Mean comparison test for two wheat cultivars.

CULTIVARS	VARIABLES				
	PH[1] (cm)	EW[2] (g)	TGW[3] (g)	NGE[4] (units)	GWE[5] (g)
TBIO AUDAZ	66.73a[6]	1.00b	27.97b	28.97a	0.99a
ORS SENNA	60.34b	1.22a	34.54a	26.83b	0.75b

Plant Height (PH[1]), Ear Weight (EW[2]), Thousand Grain Weight (TGW[3]), Number of Grains per ear (NGE[4]), Grain Weight per ear (GWE[5]). [6]Means followed by the same lowercase letter in the column do not differ statistically with a 5% probability of error using the Tukey test.

There was no significant effect of nitrogen doses on the variables ear length and number of tillers in the cultivar TBIO Audaz. In the regression analysis of the ORS Senna cultivar (Figure 3), a quadratic response of ear length was observed as a function of nitrogen doses. The maximum technical efficiency of ear length occurred at the dose of 44 kg of N ha^{-1}.

Therefore, with the increase of 1 kg of N ha^{-1} above 44 kg of N ha^{-1}, there is a reduction of 0.0088 cm in ear length. The same behavior occurs with the variable number of tillers, in which it presented its maximum technical efficiency at the dose of 48 kg of N ha^{-1}, and there was a reduction of 0.0096 tillers for each kg of N above the dose of maximum technical efficiency.

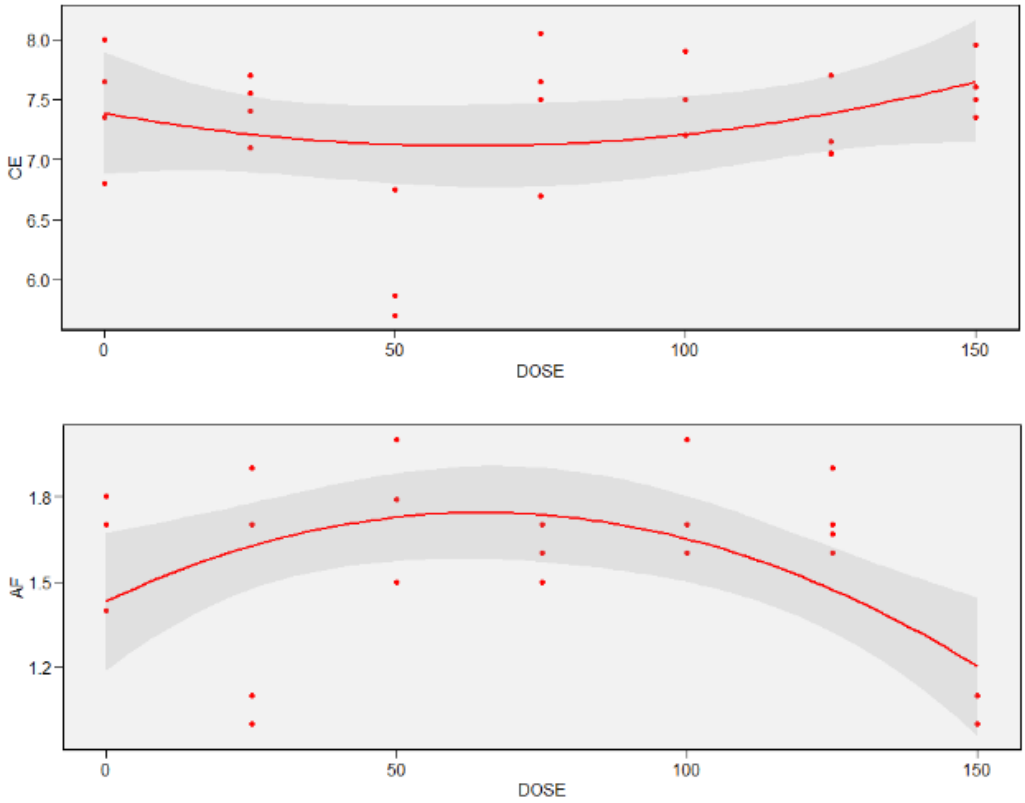

Figure 3. Regression analysis for the ORS Senna genotype with a significant effect for the ear length (EL) and number of tillers (TL) variables.

CONCLUSIONS

The cultivar TBIO Noble showed productive and morphological characteristics that maximize the agronomic performance of wheat.

There is genetic divergence between wheat genotypes for productive and morphological traits.

Cultivar ORS Senna enhanced ear length and number of tillers at doses of 44 kg of N ha^{-1} and 48 kg of N ha^{-1}, respectively.

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