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Agronomic performance of wheat cultivars in different sowing dates under high temperature conditions in Brazil

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ABSTRACT. Wheat is considered a basic cereal for civilization with great economic importance for world agriculture. Currently, wheat is planted in the south, southeast and midwest regions of Brazil. Brazilian consumption of wheat will grow in the coming years due to population increase, which will require developing new cultivars for non-tradtional regions. We investigated commercial wheat genotypes grown at various sowing dates in a region with high temperature conditions. The experiment was conducted during the two summer and two autumn seasons. Sowings were March 10, March 20, April 1 and April 10. The agronomic traits (grain yield, plant height, spike size, total spikelets per spike and fertile spikelets per spike) for four commercial genotypes were evaluated. The experimental design was randomized blocks in a factorial scheme, corresponding to four genotypes, four sowing seasons and two years of cultivation. The second sowing year gave the best performance for the genotypes. Genotypes BR 18 and BRS 404 gave superior agronomic performance, standing out in the third and fourth sowing dates, under these culture conditions.

Key words: *Triticum aestivum*; Heat; Agronomic traits; Sowing dates; Plant breeding; Plant yield

INTRODUCTION

Wheat (*Triticum aestivum*) is considered a basic cereal for civilization, and is one of the first domesticated plant species. The crop is adapted to latitudes 30º-60º N and 27º-40º S; however, it can be cultivated outside of these limits, for example close to the equator (Börner et al., 2005).

Identified as the “king of cereals”, wheat provides about 20% of calories from food consumed by humans (Silva et al., 1996). In Brazil, it is considered one of the main raw material foods because of the large-scale consumption of several industrial products derived from this raw material (Madeira, 2014).

Wheat production worldwide is estimated to be approximately 777 million tons (USDA, 2021). The cultivated area of Brazil was around 2.70 million hectares in 2020/2021. The predominant area of cultivation is in the south, southeast and midwest regions (MAPA, 2018). The south is the main wheat growing region in Brazil with 3.08 $ton.ha^{-1}$ grain yield. The southeast region has an average of 2.68 $ton.ha^{-1}$ of grain yield with emphasis on the state of São Paulo, which has 2.96 $ton.ha^{-1}$ (Soares, 2021).

Domestic consumption of wheat in Brazil is projected to grow by an average of 1.2% per year between 2017/2018 and 2027/2028. Wheat importation was six million tons in 2021 (Soares, 2021).

To reduce external dependence and spending on wheat imports, it is important to look for alternatives in producing areas. In this case, the central Brazil region (Minas Gerais State, part of São Paulo State, Mato Grosso State, Federal District, part of Bahia and Mato Grosso do Sul State) are appropriate alternatives for expanding the Brazilian wheat area (Condé et al., 2013).

Wheat is a temperate species and can be stressed in regions with high temperatures, due to the influence of temperature on the development of the crop. (Asseng et al., 2011; Asseng et al., 2017; Mishra et al., 2017). In general, high temperatures accelerate phenological development, which results in a shorter growth period. (Asseng et al., 2011).

The optimal temperature range for the crop's growth is between 15 and 20°C (Doorenbos and Kassam, 1980) and 20 and 25°C (Fischer, 1985). Mota (1989) defined 20 to 25°C for leaf development and 15 to 20°C for tillering. However, Doorenbos and Kassam (1980) and Mota (1989) indicate a minimum daytime temperature of up to 5°C, while Fischer (1985) indicates a minimum temperature of 2°C in the early stage of development and 9°C near the development stage.

Pimentel (2013) indicated 20°C in the germination stage, 8°C in the vegetative stage, 15°C in the reproductive stage and 18°C from flowering to the physiological maturation of the grains. Condé et al. (2013) says that in the initial stage of the cycle, the requirement is for high humidity and medium temperatures (20-25ºC), which help to terminate the vegetative cycle and in the flowering and graining stage the preference is for mild temperatures (10-20ºC).

The need to enable wheat production in different regions of the Brazil country is an incentive to study new genotypes in other regions (Cargnin et al., 2006). Additional experiments are certainly needed, but alternative approaches can also be help understand crop responses to extreme temperatures and high frequency of heat events in plausible future scenarios (Lobell et al., 2012).

The milling industries are distributed throughout almost the entire Brazilian territory. Therefore, it is important to develop new cultivars in order to increase the production and quality of the wheat in each region to supply the demand for the product.

The high frequency of heat events in plausible future scenarios underscores the importance of understanding crop responses to extreme temperatures. Climate change, therefore, is a considerable challenge for increasinf world food production. New wheat cultivars better adapted for future climatic conditions will therefore be required (Semenov et al., 2014).

The association between plant breeding and basic genetic principles has been important for the great advances in the plant adaptation to new environments, as well as in the increase in yield and in the quality of the commercial product (Federizzi et al., 1999).

Improvements in yield are essential to keep pace with population growth and increased demand, yet long-term climate trends threaten to reduce wheat yields, or at least slow yield growth, in many regions (Gourdji et al., 2013).

Due to the need for expansion of the cultivate wheat, the aim of the present study was to investigate the development between different commercial wheat genotypes in different sowing dates on high temperature conditions.

MATERIAL AND METHODS

The research was conducted in 2017 and 2018 at the Teaching, Research and Extension Farm in the Faculty of Agrarian and Veterinary Sciences, São Paulo State University, UNESP/FCAV, Jaboticabal, São Paulo at 21°14'05" S, 48°17'09" W (southeast) and approximately 605 m altitude. The soil classification in the experimental area is Eutrophic Red Latosol, with a gently undulating relief. According to Köppen's classification, the climate of the Jaboticabal region is subtropical type (Cwa) with a dry winter and a hot and wet summer (Vianna et al., 2013).

The climatic data had been recorded with precipitation value and maximum and minimum temperatures by the Agroclimatological Station of the São Paulo State University, located approximately 1500 m from the experimental area. After, the mean temperature was calculated during the development crop (Figure 1).

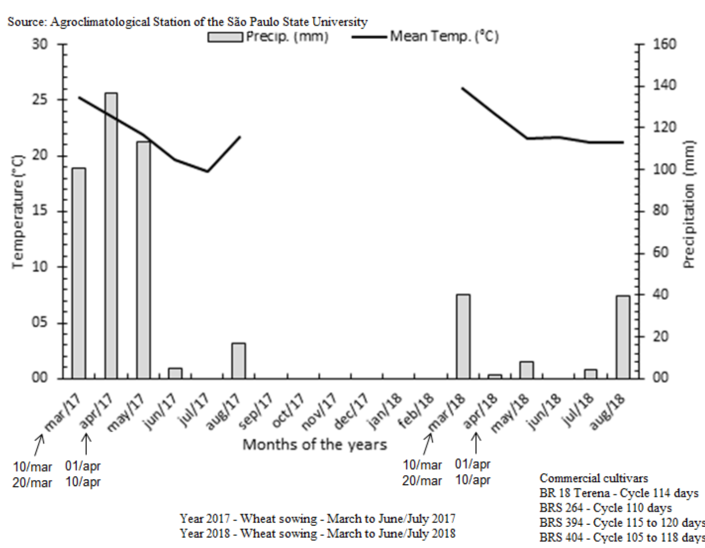

Figure 1. Precipitation (mm), mean temperature (°C), sowing wheat dates, cycle of the cultivars.

The temperature averages during the months crop cycle in 2017 were 25.21°C (March), 23.54°C (April), 21.87°C (May), 19.68°C (June), 18.58°C (July) and 21.63°C (August). In 2018, the temperature averages were 26.01°C (March), 23.75°C (April), 21.53°C (May), 21.71°C (June), 21.14°C (July) and 21.21°C (August).

The annual medium temperatures for the south Brazilian region where the wheat is the most cultivated range from 14 to 22°C and in places with altitudes above 1100 m drops to approximately 10°C. The annual medium pluviosity oscillates from 1250 to 2000 mm. The maximum pluviometric indexes was in the winter and the minimum in the summer throughout almost the whole region (Alvares, 2013).

The soil analysis of the experiment before sowing was carried out (Table 1) in the depth layer from 0 to 20 cm to understand about the soil fertility of the experimental area.

Table 1. Chemical soil analysis of the experimental areas before wheat sowing.

Area	**Depth**	**pH(CaCl2)**	**O.M**	**P(resin)**	**S**	**Ca**	**Mg**	**Na**	**K**	**H+Al**	**B.S**	**CEC**	**V**
	----- cm -----		$g \cdot dm^{-3}$	-- $mg \cdot dm^{-3}$ --			--------- mmolc $\cdot dm^{-3}$ ---------						(%)
Year 2017	0 - 20	5.3	25	33	-	30	10	-	4.6	30	44.8	74.6	60
Year 2018	0 - 20	5.2	29	34	-	32	13	-	4.7	20	49.2	68.8	72

Legends: bases sum (B.S = Ca+Mg+Na+K) | Ref. IAC 2001, cation exchange capacity (CEC = B.S+H+Al), base saturation (V% = (B.S/CEC)*100) | Ref. IAC 2001, organic matter (O.M) by spectrophotometry | Ref. IAC 2001, P (fósforo) on resin by spectrophotometry | Ref. IAC 2001, pH in $CaCl_2$ by potentiometry | Ref. IAC 2001, H+Al – in buffer SMP by potentiometry | Ref. IAC 2001, S (sulfur) by turbidimetry | Ref. IAC 2001, Ca (cálcio) by spectrophotometry of atomic absorption | Ref. IAC 2001, Mg (magnesium) by spectrophotometry of atomic absorption | Ref. IAC 2001, Na (sódio) by spectrophotometry of atomic absorption | Ref. IAC 2001, K (potassium) by spectrophotometry of atomic absorption | Ref. IAC 2001, Al (aluminum) on KCl by titration | Ref. IAC 2001.

A sowing fertilization of 292 $kg.ha^{-1}$ (00-20-12 NPK formula) has used in according to the wheat yield needs. It was also a nitrogen topdressing fertilization after 25-30 days of sowing, in the proportion of 40 $kg.ha^{-1}$ (Rcbptt, 2015).

Insects and diseases were managed throughout the crop cycle by applying insecticide and fungicide. Weed control was performed by herbicide and hand weeding. Additionally, sprinkler irrigation as necessary was performed in the initial stages of development.

Four commercial cultivars (BRS 394, BR 18 Terena, BRS 264 and BRS 404) from the Embrapa-Trigo Germplasm Bank were used in the evaluation. The BRS 394 cultivar has traits of wide adaptation, high yield potential, early cycle (period from emergence to heading is 55-60 days; period from emergence to maturation is 115-120 days) and lodging classified as moderately resistant. This cultivar is indicated for cultivation in the states of Goiás, Minas Gerais and Distrito Federal. (Albrecht et al., 2016). The BR 18 Terena cultivar has traits such as an early cycle of 62 days until heading and 114 days until maturation, and moderate lodging. It is recommended for cultivation in the states of Mato Grosso, Mato Grosso do Sul, Paraná, São Paulo, Minas Gerais, Distrito Federal and Goiás. (Sousa, 2002). The cultivar BRS 264 has super early cycle trait, allowing its harvest about ten days earlier. It is recommended for cultivation in the states of Minas Gerais, Mato Grosso, Distrito Federal and Goiás. (Albrecht et al., 2006). The cultivar BRS 404 is an early/medium cycle cultivar (77 days is the period from emergence to heading; 105 to 118 days is the period from emergence to maturation), drought resistant and highly productive. It is recommended for the Central Brazil region, such as Goiás, Minas Gerais and Distrito Federal (Só et al., 2015). All these cultivars were adapted in hot and dry conditions.

The experimental design was randomized blocks in a 4x4 factorial scheme, corresponding to four genotypes (BRS 394, BR 18 Terena, BRS 264 and BRS 404) and four sowing dates (March 10, March 20, April 1 and April 10). In these four sowing dates, two were in the summer season (considered outside of the sowing season in Brazil) and the other two were considered the autumn season, considered normal growing seasons.

Each plot had five rows of 8 m of the length, with 0.225 m apart, with 60 seeds of density per linear meter, and each sowing had 16 total plots. The total experimental area was 648 m^2. The wheat seeds were manual sowing under no-tillage system. Soybean was the last crop in the experimental area.

The height of the plant was measured during physiological maturation in centimeters (cm) inside the plot and classified as dwarf (under 60 cm), semi-dwarf (61 to 99 cm) and tall (over 100 cm) size. For the wheat spike size collected spikes in 1.0 m of the plot in the bulk grain stage and then measured from the first node to the terminal spikelet. For the total number of spikelets per spike and for the total number of fertile spikelets per spike had been collected spikes in 1.0 m of the plot in the mass grain stage and the total and fertile spikelets were counted. For the grain yield, the plants had been harvested in 4.0 m length in three central lines of each plot. After the trail system and cleaning of them, the grains were weighed and transformed into $kg.ha^{-1}$ to estimate the yield of each cultivar. The Scale of Zadoks (1974) was used to evaluate the traits.

An individual analysis for each trait evaluated in two years of cultivation had been used to detect cultivars effects on different sowing dates. The program used for statistical analysis was SAS (Statistical Analysis System) version 9.4 software (Sas, 2013).

The Guided Data Analysis Procedure was used for the data statistical analysis. First of all, it was used to identify eventual outliers and required transformations, and then it was used the MIXED (Mixed Models) procedure of the statistical package in the same SAS Program (Littell et al., 1996).

Data normality and homogeneity of variance were tested using the procedure mentioned above. The prerequisites of variance analysis showed homoscedasticity, normally distributed data and error independence. After it, the data were submitted to analysis of variance. In case of significance of the F test, the "LSMEANS" was used by the same program, to compare means between treatments, adopting the Tukey test at a 5% probability level of significance. Data normality and homogeneity of variance were tested using the procedure mentioned above. The prerequisites of variance analysis showed homoscedasticity, normally distributed data and error independence. After it, the data were submitted to analysis of variance. In case of significance of the F test, the "LSMEANS" was used by the same program, to compare means between treatments, adopting the Tukey test at a 5% probability level of significance.

RESULTS AND DISCUSSION

In 2017, the total rainfall was 394.4 mm during the total crop cycle with a mean temperature of 21.8°C. In 2018, the total rainfall and mean temperature were 94 mm and 22.6°C respectively. The development of wheat crop in the experiment during the years 2017 and 2018 was within the optimal temperature range proposed by Condé and Coelho (2009).

Table 2 shows the analysis of variance obtained for the data analyzed. In 2017, there was a significant difference between genotypes in almost all evaluated traits, except for fertile spikelet number (FSN). For sowing dates was observed significant difference only for grain yield (GY). There also were significant differences for GY and FSN in the interaction of genotype factors and sowing dates.

Table 2. Mean squares of variance analysis, degree of freedom (DF), means and coefficients of variation (CV) for the traits: grain yield (GY), plant height (HEI), spike size (SS), total spikelet number per spike (TSN), fertile spikelet number (FSN) performed by proc MIXED.

Variation Source	DF	Means Square				
		HEI	SS	TSN	FSN	GY
Year - 2017		(cm)	(cm)	(n°)	(n°)	(kg.ha^{-1})
Blocks	3	1.35 NS	36.41 NS	0.6 NS	1.47 NS	96580.65 NS
Dates	3	17.06 NS	37.68 NS	0.44 NS	2.85 NS	663901.18 **
Genotypes	3	372.27 **	412.65 **	3.94 **	2.39 NS	422751.20 **
Date x Gen.	9	48.13 NS	28.51 NS	1.15 NS	2.39 *	102549.25 *
Residue	45	25.65	23.15	0.87	1.13	43108.31
Overall Average	-	71.30	67.39	13.66	11.27	1242.01
CV (%)		7.10	7.14	6.83	9.44	16.72
Year - 2018						
Blocks	3	130.79 *	25.13 NS	1.31 NS	1.29 NS	296247.85 NS
Dates	3	60.29 NS	435.72 **	25.02 **	16.88 **	1032463.90 *
Genotypes	3	334.71 **	44.48 NS	3.64 *	6.17 *	783048.91 *
Date x Gen.	9	65.19 NS	33.14 NS	2.79 **	4.21 **	496072.43 NS
Residue	45	44.84	24.18	0.96	1.47	254289.30
Overall Average	-	75.81	74.33	15.20	12.88	2070.60
CV (%)		8.83	6.62	6.45	9.41	24.35

* significant at 5% probability by the F test, ** significant at 1% probability by the F test, NS not significant by the F test.

In 2018, a significant difference between genotypes was observed for all traits, except for spike size (SS). There was significant difference for sowing dates for all traits, except for height (HEI) trait. There was significant difference for total spikelets number (TSN) and FSN in the interaction of genotype factors and sowing dates.

These results showed the possibility of identifying the best sowing date, being mainly used the grain yield. Moreover, it was possible to identify the genotypes ability to respond individually for the evaluated trait. According to Cruz and Regazzi (2001), the individual analyzes are very important because they allow to evaluate the existence or not of the genetic variability and also to observe the differences between the residual variances obtained in each source of variation tested.

The coefficients of variation (CV) for the evaluated traits ranged from 7.40% (TSN) to 24.60% (GY), within the limits recommended by Pimentel-Gomes (1985). The CV is associated with mean and the residual variance. It is an appropriate statistic for the classification of the accuracy of experiments (Cargnelutti Filho et al., 2007).

Significant effects of genotype interaction with another source of variation have also been found by several authors such as Lobato (2006), Biudes (2007), Camargo et al. (2008), Silva (2009) and Corrêa (2018) where they observed different behavior in the evaluation of wheat genotypes because there were alterations in the adopted environments.

The general averages found for the grain yield trait in the two years (2017 and 2018) were 1242.01 and 2070.60 kg.ha^{-1}, respectively. These values are still considered below the national average that have done 2225.00 kg.ha^{-1} in 2017 and 2438.00 kg.ha^{-1} in

2018 (Conab, 2018). This is relatively expected because the experiments were in high temperature environmental conditions during experimental evaluation in the two years of cultivation. The differences between the years can be explained by the environmental conditions found. In 2017 had a high rainfall and a low rainfall. In 2018 had an important periods of the crop (early flowering and physiological maturation) that affected the good development of the crop. For the other averages, the year 2018 presented higher values to the evaluated traits, demonstrating that the genotypes could better express their genetic potential under those conditions of crop development. The evaluated genotypes were developed for the Central Brazilian Region of cultivation and the differences in their behavior between the years studied were already expected.

The different responses of wheat genotypes to different years is related to the concepts of genotype x environment interaction cited by some authors (Ramalho et al., 1993; Borém, 1997; Cruz and Regazzi, 2001), where they report the importance of this interaction in the genetic crop breeding because there are possibilities of the genotypes show us different behaviors in certain situations which makes difficult the selection and/or recommendation of genotypes under wide cultivation conditions, since they depend on predictable and unpredictable environmental factors.

Therefore, in water deficiency environments where there are unpredictable factors involved it is necessary to use secondary production characters to assist in the selection of more productive genotypes because the selection through these characteristics results in selection of superior genotypes which may enable greater gains in productivity than the direct selection is made on the grain yield trait (Bänzinger et al., 2000).

The results showed that the behavior of the evaluated genotypes between the years were different. Bevilaqua et al. (2003), Cargnin et al. (2006), and Corrêa (2018) also observed different responses in wheat genotypes when subjected to different environmental conditions.

Table 3 shows the interaction between genotypes and sowing date in 2017. The best sowing dates for genotype BR 18 are on third and fourth dates. The best sowing dates for genotypes BRS 264 and BRS 394 are on second to forth dates. The best dates for the BRS 404 genotype was first and third. The best performing genotypes were BR 18 (1395.37 kg.ha-¹) and BRS 404 (1368.98 kg.ha-¹). This fact can be explained due to the genotype cycle being the first of the early cycle and the last of the middle cycle. In general, genotypes had a better response on third (1468.98 kg.ha-¹) and fourth (1350.46 kg.ha-¹) sowing dates.

Table 3. Average values for grain wheat yield (GY) trait in the 2017 year.

Year - 2017	GY (kg.ha^{-1})				Means
	BRS 18	**BRS 264**	**BRS 394**	**BRS 404**	
1st Date	1044.44 abC	833.33 bB	909.26 bB	1311.11 aAB	1024.54 B
2nd Date	1231.48 aBC	970.37 aAB	970.37 aAB	1324.07 aAB	1124.07 B
3rd Date	1698.15 aA	1351.85 baA	1148.15 bAB	1677.78 aA	1468.98 A
4th Date	1607.41 aAB	1303.7 baA	1327.78 abA	1162.96 bB	1350.46 A
Means	1395.37 a	1114.81 b	1088.89 b	1368.98 a	-

Means followed by the same upper-case letters between dates (vertical) and averages followed by the same lower case letters (horizontal) between genotypes do not differ from each other by the 5% significance Tukey test.

In the plant height trait, the Table 4 indicates that the genotypes that stood out with higher averages are the BR 18 and BRS 404 genotypes. The averages presented for the plant height characteristics of the cited genotypes were 72.81 cm and 77.06 cm (semi-dwarf wheat size) respectively. It may have a relationship with grain yield where plants with higher heights showed higher yields. Height differences in wheat genotypes were also observed by Fornasieri Filho (2008), Silva (2011) and Corrêa (2018).

Table 4. Average values for wheat plant height trait (HEI) in 2017.

Year - 2017	HEI (cm)			
	BRS 18	**BRS 264**	**BRS 394**	**BRS 404**
Means	72.81 ab	69.62 bc	65.69 c	77.06 a

Means followed by the same lower-case letters between genotypes do not differ from each other by the 5% Tukey significance test.

Table 5, the BRS 394 genotype showed the highest mean (73.80 mm) for the spike size characteristic in relation to the others. Studies involving plant breeding and spike size were also carried out by Hartwig et al. (2007) and Rivera-Amado et al. (2019).

Table 5. Average values for the wheat spike size (SS) trait in 2017.

Year - 2017	SS (cm)			
	BRS 18	**BRS 264**	**BRS 394**	**BRS 404**
Means	67.86 b	61.46 c	73.80 a	66.43 b

Means followed by the same lower-case letters between genotypes do not differ from each other by the 5% Tukey significance test.

For the total spikelets number trait (Table 6), the averages from the crops BRS 18 and BRS 404 showed were 14.00 and 14.12 respectively, demonstrating low abortion and better self-fertilization when compared to the other genotypes.

Table 6. Average values for the total wheat spikelet number per spike (TSN) trait in 2017.

Year - 2017	TSN (n°)			
	BRS 18	**BRS 264**	**BRS 394**	**BRS 404**
Means	14.00 a	13.06 b	13.43 ab	14.12 a

Means followed by the same lower case letters between genotypes do not differ from each other by the 5% Tukey significance test.

For fertile spikelet number (Table 7), the BR 18 genotype presented a lower number of spikelets on the fourth date compared to the others genotypes (9.50). Aude et al. (1994), worked with the number of flowers per spikelet and the number of spikelets per spike in wheat, concluding that they do not depend on environmental factors, but mainly on inherent factors to the genotypes themselves.

Table 7. Average values for the fertile wheat spikelet numbers (FSN) trait in 2017.

Year - 2017	FSN (n°)			
	BRS 18	**BRS 264**	**BRS 394**	**BRS 404**
1st Date	12.00 aA	11.75 aA	10.50 aA	12.25 aA
2nd Date	11.75 aA	11.75 aA	10.75 aA	12.25 aA
3rd Date	11.50 aAB	10.75 aA	10.50 aA	10.50 aA
4th Date	9.50 bB	11.00 abA	11.50 abA	12.00 aA

Means followed by the same upper case letters between dates (vertical) and averages followed by the same lower case letters (horizontal) between genotypes do not differ from each other by the 5% Tukey significance test.

Table 7 shows that the BR 18 genotype for fertile spikelets number presented the lower number (9.50) of spikelets compared to the others genotypes on the fourth date. Aude et al. (1994) worked with flowers number per spikelet and spikelets number per spike in wheat, concluding that they do not depend on environmental factors but mainly on inherent factors to the genotypes themselves.

The Table 8 shows the averages obtained in the Tukey Test (5%) for the characteristic grain yield (GY) for the experiment in 2018 to identify the genotype and/or the date that is relevant.

Table 8. Average values for the wheat grain yield (GY) trait in 2018.

Year - 2018	GY (kg.ha^{-1})			
	BR 18	**BRS 264**	**BRS 394**	**BRS 404**
Means	2201.85 a	1989.81 b	2181.94 a	2158.80 a
	1st Date	**2nd Date**	**3rd Date**	**4th Date**
Means	2035.19 AB	2355.56 A	2145.83 AB	1745.83 B

Means followed by the same upper-case letters between dates and averages followed by the same lower case letters between genotypes do not differ from each other by the 5% Tukey significance test.

In the year 2018 for the grain yield, the genotypes in general had higher averages compared to the previous year, as already predicted. It is note that the genotypes had better means (2035.19, 2355.56 and 2145.83 kg.ha^{-1} respectively) on the first, second and third dates. It evidences that the BR 18, BRS 394 and BRS 404 genotypes stood out with values of 2201.85, 2181.96 and 2158.80 kg.ha^{-1} respectively, close to the value of the national average of 2438.00 kg.ha^{-1} in 2018 (Conab, 2018).

In the height trait, the means obtained by the Tukey test (Table 9) demonstrated that the genotype that stood out with the highest value was the BRS 404 with an average of 82.62 cm (semi-dwarf) like to the result presented in the previous year.

Table 9. Average values for wheat plant height (HEI) trait in 2018.

Year - 2018	HEI (cm)			
	BRS 18	**BRS 264**	**BRS 394**	**BRS 404**
Means	74.25 b	72.94 b	73.44 b	82.62 a

Means followed by the same lower-case letters between genotypes do not differ from each other by the 5% Tukey significance test.

The spike size trait (Table 10), the third and fourth dates had higher averages (76.44 mm and 80.69 mm) showing that spike size is not directly related to grain yield.

Table 10. Average values for the wheat spike size (SS) trait in 2018.

Year - 2018	SS (cm)			
	1st Date	**2nd Date**	**3rd Date**	**4th Date**
Means	69.46 B	70.71 B	76.44 A	80.69 A

Averages followed by the same capital letters between dates do not differ from each other by the 5% Tukey significance test.

For the total spikelet number (TSN) and fertile spikelet number (FSN) traits, the best averages were found (Table 11) on the third and fourth sowing dates. The BRS 404 genotype showed higher value compared to the others in the first date and in the fourth date for the total spikelet number trait. The BR 18 genotype had better performance on the second date and the BRS 394 genotype on the third date.

Table 11. Average values for the total wheat spikelet number (TSN) and fertile spikelet number (FSN) traits for wheat grown in 2018.

Year - 2018	BRS 18	BRS 264	BRS 394	BRS 404	Means
			TSN		
1st Date	14.75 abB	14.25 abB	13.25 bB	15.50 aAB	14.44 C
2nd Date	14.50 aB	14.25 aB	13.25 aB	13.75 aB	13.93 C
3rd Date	15.75 abAB	14.50 bB	16.75 aA	16.00 abA	15.75 B
4th Date	17.25 aA	17.00 abA	15.25 bA	17.25 aA	16.69 A
Means	15.56 A	15.00 BA	14.62 B	15.62 A	-
			FSN		
1st Date	12.00 abA	13.25 abAB	11.00 bB	13.75 aAB	12.50 BC
2nd Date	11.75 aA	11.50 aB	11.50 aB	12.25 aB	11.75 C
3rd Date	12.50 abA	11.50 bB	14.25 aA	14.00 aAB	13.06 BA
4th Date	13.75 abA	15.25 aA	12.75 bAB	15.00 abA	14.19 A
Means	12.50 b	12.87 ab	12.37 b	13.75 a	-

Means followed by the same uppercase letters (horizontal) between dates and averages followed by the same lowercase letters (vertical) between genotypes do not differ from each other by the 5% Tukey significance test.

In general, the BRS 404 genotype presented values greater than or close to the greatest for the fertile spikelets number trait in all dates when it was planted. Emphasizing that the BRS 394 genotype showed the best behavior on the third date and the BRS 264 genotype showed the best performance on the fourth date.

CONCLUSIONS

The genotypes that presented satisfactory agronomic performance for grain production over the two years of cultivation under tehese conditions were BR 18 and BRS 404. The sowing dates that stood out for these cultivars were the third and fourth dates (April 1 and April 10, respectively).

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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