Multi-character nutraceutical selection aiming for the ideal wheat genotype

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Abstract – Wheat consumption represents a large part of human diet. The quality of wheat grains and derived products depends on the genotype and its interaction with the environment. This work aimed to identify the effects of different wheat genotypes grown in different environments, performing nutraceutical multitrait selection, seeking the wheat ideotype based on wheat quality indicators. In total, 16 wheat genotypes were evaluated in five environments, using two sowing times. The contents of proteins, lipids, fibers, mineral material, and carbohydrates were evaluated. The residual or restricted maximum likelihood/best linear unbiased prediction (REML/BLUP) methodology was used to estimate variance components and genetic parameters. Moreover, the multi-trait genotype-ideotype distance index (MGIDI) was used to select the genotypes that demonstrated superiority. Except for the lipid content, high values of genotypic variance were identified. FPS Certero, ORS 1403, LG Prisma, and Tbio Iguaçú genotypes, conducted in São Gabriel and Cachoeira do Sul, met the sought ideotype during the first sowing time. FPS Certero, Tbio Tibagi, and LG Supra genotypes were superior when conducted in the Santo Augusto environment during the second sowing time.

Index terms: *Triticum aestivum* L., ideotype, different environments, quality indicators.

Seleção multicaráter nutracêutica visando o genótipo ideal de trigo

Resumo – O consumo de trigo e derivados representa uma grande parte da dieta humana. A qualidade dos grãos de trigo e dos produtos derivados depende do genótipo e da sua interação com o ambiente. Este estudo teve o objetivo de identificar os efeitos de diferentes genótipos de trigo cultivados em ambientes, associando a seleção multicarácter nutracêutica buscando o ideótipo de trigo com base em indicadores de qualidade do trigo. Foram avaliados 16 genótipos de trigo em 5 ambientes, utilizando duas épocas de semeadura. O conteúdo de proteínas, lipídios, fibras, material mineral e carboidratos foram avaliados. O método REML/BLUP foi utilizado para estimar os componentes de variância e os parâmetros genéticos. Além disso, O índice MGIDI foi utilizado para selecionar os genótipos que demonstraram superioridade. Exceto para o teor de lipídios, altos valores de variância genotípica foram identificados. Os genótipos FPS Certero, ORS 1403, LG Prisma e Tbio Iguaçú, conduzidos em São Gabriel e Cachoeira do Sul, foram de encontro ao ideótipo para a primeira época de semeadura. Os genótipos FPS Certero, Tbio Tibagi e LG Supra também foram superiores, considerando o ambiente de Santo Augusto, para a segunda época de semeadura.

Termos de Indexação: *Triticum aestivum* L.; ideótipo; diferentes ambientes; indicadores de qualidade.

Introduction

The consumption of wheat grains represents more than 40% of the global human diet (SHEWRY, 2009). Grains are composed of three distinct parts: bran (outer layer), endosperm (part that contains most food reserves), and germ (embryo) (ASHRAF, 2014). Starch is the main constituent of the endosperm, varying from 60 to 75% based on dry weight (SHEWRY et al., 2013), whereas the protein content of wheat grains varies from 8 to 20% (DUPONT & ALTENBACH, 2003). The lipid and mineral content are around 1.5% (ASHRAF, 2014). In this sense, the quality of wheat grains is defined by the concentrations and compositions of protein and starch (JERNIGAN et al., 2017).

However, the quality of wheat grains depends on the genotype (MOURA et al., 2022) and its interaction with the

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environment (SEGATTO et al., 2022), so that environments in unfavorable conditions lead to a reduction in levels of various compounds in grains (ZAHRA et al., 2022). Singh et al. (2012) report that low water availability decreases the protein content of wheat grains by 7.4%. High temperatures, on the other hand, decrease carbohydrate (SATTAR et al., 2020) and amino acid (AIQING et al., 2018) contents, being accentuated when these stresses occur in the reproductive stage (ASHRAF, 2014). In addition, such conditions significantly decrease crop productivity (ZAHRA et al., 2022).

Previous studies indicate that traits such as crude protein and mineral material show low magnitudes of heritability, that is, such factors are strongly influenced by the cultivation environment (CARVALHO et al., 2019). In this context, understanding the magnitude of genetic and environmental effects on the nutritional composition of grains is a key element to acquire the necessary information to promote advances in genetic improvement by defining favorable environments (SZARESKI et al., 2017). In addition, there is a growing demand for products with higher protein, fiber, and mineral content.

In this context, this work aimed to identify the effects of various wheat genotypes grown in different environments, performing nutraceutical multi-trait selection to determine the wheat ideotype based on quality indicators.

Material and Methods

The experiments were conducted during the 2019 agricultural season in five different locations, each representing a different wheat region, in the following municipalities: Cachoeira do Sul – RS, Cruz Alta – RS, Santo Augusto – RS, São Gabriel – RS, and Vacaria – RS (Table 1). In total, 16 wheat genotypes were sown, namely: BRS 327, BRS Parrudo, Celebra, Esporão, Estrela Atria, FPS Certero, Jadeite 11, Marfim, Mirante, ORS 1403, ORS 1405, Quartzo, Tbio Iguaçú, Tbio Tibagi, LG Prisma, and LG Supra. The experimental design employed was randomized blocks, with a 10×16 factorial scheme (10 environments × 16 genotypes), with three replications. Each experimental

Table 1. Description of sowing environments and genotypes employed.
Tabela 1. Descrição dos ambientes de semeadura e genótipos utilizados.

Environment ID	Sowing environment[1]		Coordinate	Altitude (m)	Soil [2]
	Municipality of RS	Sowing time (2019)			
E1	Cachoeira do Sul	1st half of May	30°17'52"S, 52°57'54"W	113	Eutrophic Haplic Planosol (Alfisol)
E2	Cruz Alta	1st half of May	28°38'19"S, 53°36'23"W	452	Dystrophic Red Latosol (Oxisol)
E3	Santo Augusto	1st half of May	27°54'47"S, 53°49'04"W	503	Dystrophic Red Latosol (Oxisol)
E4	São Gabriel	1st half of May	30°20'09"S, 54°10'21"W	159	Eutrophic Haplic Planosol (Alfisol)
E5	Vacaria	1st half of May	28°30'44"S, 50°56'02"W	971	Bruno Latosol (Oxisol)
E6	Cachoeira do Sul	2nd half of June	30°17'52"S, 52°57'54"W	113	Eutrophic Haplic Planosol (Alfisol)
E7	Cruz Alta	2nd half of June	28°38'19"S, 53°36'23"W	452	Dystrophic Red Latosol (Oxisol)
E8	Santo Augusto	2nd half of June	27°54'47"S, 53°49'04"W	503	Dystrophic Red Latosol (Oxisol)
E9	São Gabriel	2nd half of June	30°20'09"S, 54°10'21"W	159	Eutrophic Haplic Planosol (Alfisol)
E10	Vacaria	2nd half of June	28°30'44"S, 50°56'02"W	971	Bruno Latosol (Oxisol)

[1]RS, state of Rio Grande do Sul, Brazil. [2] Source: Santos *et al*. (2013) and Streck *et al*. (2008).

unit consisted of 5 spaced sowing rows, 20cm and 5m long. Sowing was conducted simultaneously for all genotypes within each environment, adhering to the agricultural zoning recommended for each region and considering two evaluated sowing times. Nutritional management consisted of applying 250kg ha^{-1} of NPK 08-25-20 at the base of sowing, and 50kg ha^{-1} of nitrogen per cover in the form of urea (46% of N) as a single application during the full tillering stage. Crops were managed agronomically to avoid damage from weeds, insect pests and diseases. Management was standardized for all environments and genotypes.

The contents of proteins (PTN, %), lipids (LIP, %), fibers (FIB, %), mineral material (MM, %), and carbohydrates (CHO, %) were evaluated. In addition, meteorological variables, including mean air temperature (T2M, °C), minimum air temperature (TMIN, °C), maximum air temperature (T2MAX, °C), precipitation (PREC, mm), relative humidity at 2m (RH2M, %), and altitude (ALT, m) were obtained using the NASAPOWER data package (NASA POWER, 2022) for the crop cycle to provide further context for the obtained results.

To meet the assumptions of the model, additivity, homogeneity, and normality of the residual variances were assessed using the Shapiro-Wilk and Bartlett tests to make errors independent. Subsequently, a descriptive analysis was performed using heat maps to explain the performance of each genotype in each environment, stratifying the results for each of analyzed variable.

A deviance test was performed using the chi-square test at a 5% error probability to identify the most adjusted linear model for the study. Variance components and genetic parameters were obtained using the residual or restricted maximum likelihood/best linear unbiased prediction (REML/BLUP) methodology, following the model proposed by Olivoto *et al*. (2019). The model proposed is represented as $y_{ijk} = \mu + \alpha_i + \tau_j + (\alpha t)_{ij}$, where y_{ijk} represents the response variable of the k-th block of the i-th genotype in the j-th environment; μ denotes the overall mean; α_i represents the main effect of the i-th genotype; τ_j represents the main effect of the j-th environment; and $(\alpha t)_{ij}$ represents the interaction effect of the i-th genotype with the j-th environment. The multi-trait genotype-ideotype distance index (MGIDI) was used to select the genotypes that demonstrated superiority, considering the multiple characteristics evaluated (OLIVOTO & NARDINO, 2020). The sought ideotype was wheat plants with grains exhibiting low levels of fiber and mineral material, and high levels of proteins, lipids, and carbohydrates. To assess dissimilarity between genotypes, a dissimilarity test was conducted, considering the Euclidean distance between individuals. Moreover, to estimate the association between the studied variables, a correlation analysis was performed. All analyses were conducted using the R software (R CORE TEAM, 2022).

Results and discussion

During the first sowing time, from May 15 to September 30, precipitation totaled 467.38 mm in the Cachoeira do Sul municipality, being recorded at 358.69mm in Cruz Alta, 407.32 mm in Vacaria, 288.93mm in Santo Augusto, and 358.69 mm in São Gabriel (Figure 1). Conversely, during the second sowing time, from June 15 to October 31, Cachoeira do Sul recorded 467.38mm of accumulated precipitation, Cruz Alta 554.1mm, Vacaria 432.49mm, Santo Augusto 356.72mm, and São Gabriel 455.29mm (Figure 1). Thus, considering that the adequate water requirement for the wheat crop ranges from 450 to 600mm (DOORENBOS & KASSAM, 1979), only the Cachoeira do Sul environment, during the first sowing time, met this criterion. However, during the second sowing time, only the Vacaria and Santa Augusto environments failed to reach the minimum requirement of 450mm (Figure 1).

Wheat exhibits an ideal temperature range for its development of 12 to 15°C (GUARIENTI et al., 2004). Elevated temperatures have been found to negatively affect plant growth, reducing productivity (DJANAGUIRAMAN et al., 2020) and quality of wheat grains (LIU et al., 2017). Among the evaluated environments during the first growing season, only Santo Augusto recorded a mean temperature above the ideal range (15.9°C), whereas Vacaria exhibited the lowest mean temperature at 12.7°C.

In the second growing season, all environments recorded higher mean temperatures compared to the first season (Figure 1). Only the Vacaria environment showed an ideal mean temperature for wheat development. The highest mean temperatures were found in the Santo Augusto (17.12°C) and São Gabriel (17.83°C) environments. Research has shown that a 1°C increase in minimum or maximum temperatures during the wheat harvest can decrease global wheat production by 5.6% (LOBELL & FIELD, 2007). Likewise, other studies have indicated that a 1°C increase in temperature during the reproductive stages can decrease wheat grain yield by 21% (BARKLEY et al., 2011).

The variance components and estimated genetic parameters for wheat genotypes (Supplementary Table 1; Supplementary Figure 1) show high genotypic correlation (σG) values, mainly for protein, mineral material, and carbohydrate contents.

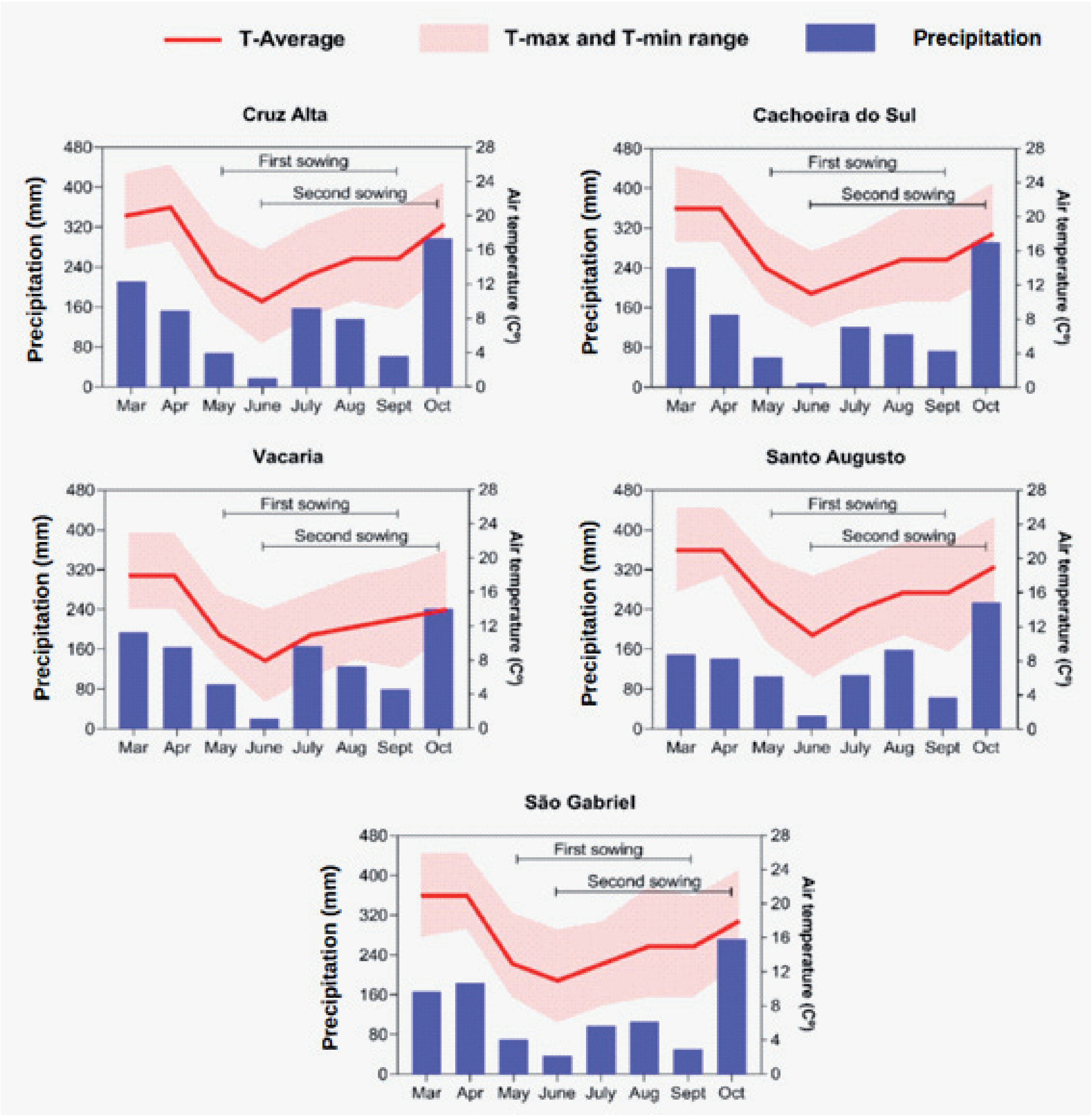


Figure 1. Precipitation (mm), minimum (°C), mean (°C), and maximum (°C) air temperature during the first (May 15 to September 30/2019) and second (June 15 to October 31/2019) wheat sowing times in Cruz Alta, Cachoeira do Sul, Vacaria, Santo Augusto, and São Gabriel environments

Figura 1. Precipitação (mm), temperatura mínima (°C), média (°C) e máxima (°C) durante o primeiro (15 de maio a 30 de setembro/2019) e segundo (15 de junho a 31 de outubro/2019) período de semeadura de trigo nos ambientes Cruz Alta, Cachoeira do Sul, Vacaria, Santo Augusto e São Gabriel

Slightly higher environmental variance values (σA) were observed for lipid and fiber contents. The estimated heritability values reinforce these variance components, with narrow-sense heritability values exceeding 0.95 for protein, mineral material, and carbohydrate contents, in addition to values exceeding 0.90 for lipid and fiber contents. According to Resende (2021), individual heritabilities can be classified as low ($0.01<h^2<0.15$), medium ($0.15<h^2<0.50$), and high ($h^2>50$).

Figure 2 illustrates the BLUP for the evaluated nutraceutical traits across 16 wheat genotypes grown in different environments and two sowing dates. Protein concentration in wheat grains is an important factor in determining the price of grains (BARNEIX, 2007). Consequently, breeders have aimed to enhance protein concentration in wheat grains for several decades (MOORE et al., 2015), as it is a genotype-dependent trait. The highest protein concentrations (PTN) were found in BRS 327, BRS Parrudo, and Marfim cultivars (Figure 2A). In addition, this characteristic is highly influenced by the environment (FILIP et al., 2023). Particularly, fertilizers and temperature affect protein amount, composition, and/or polymerization (DUPONT & ALTENBACH, 2003). The environments with the highest levels of PTN were Santa Augusto (second sowing time) and Cruz Alta (first sowing time), both showing temperatures above appropriate levels (Figure 1). However, this response can be explained by adequate nitrogen fertilization and water availability, as these factors can attenuate the negative effects of increasing temperature on PTN concentration in wheat. For example, DuPont et al. (1998) reported no decrease in PTN in wheat plants grown under temperature regimes of 24/17°C or 37/17°C when post-anthesis fertilizers were applied and plants were well-hydrated. Conversely, without post-anthesis fertilizer application, a decrease in PTN content and composition changes were observed under conditions of increased temperature (DUPONT et al., 2000).

For lipid contents (LIP), significant genotypic variation was identified for lipid concentrations among cultivars (Figure 2B), with emphasis on the Tbio Iguaçú, ORS 1403, and Mirante genotypes, while the BRS 327 and BRS Parrudo genotypes exhibited the lowest levels of LIP. These results corroborate the study by Moore et al. (2015), suggesting the potential for developing wheat varieties with high oil content, and the repeatability of genotypic differences with a wide genetic diversity that allows for development and selection of populations. Increasing lipid content may be important for food nutrition, as it holds potential for increasing glycolipid compositions and reducing the need for milling additives such as emulsifiers (CHUNG et al., 2009). Moreover, elevated lipid levels present an opportunity for developing animal feeds with higher caloric value (MOORE et al., 2015).

The LIP contents were significantly influenced by the cultivation environment (Figure 2B), with the highest contents found in the São Gabriel environment during both sowing times. This observation can be explained by the higher temperatures in these environments during both periods, as high temperatures increase LIP levels (IMPA et al., 2020;2021). Conversely, the lowest LIP contents were found in Cruz Alta and Vacaria during the first sowing time.

Regarding fiber content (FIB), variation between genotypes was evident, with the highest values found for FPS Certero and ORS 1405 (Figure 2C). The environments that contributed the most to the increase in FIB contents were Santo Augusto during the first cultivation period and São Gabriel during both periods. On the other hand, the environments of Cruz Alta and Santo Augusto during the second sowing time showed minimal contribution to the increase in FIB contents in wheat grains.

The highest mineral material (MM) contents were found in the BRS 237 and BRS Parrudo genotypes, whereas the lowest levels were found in ORS 1405, Mirante, Tbio Iguaçu, and Quartzo (Figure 2D). Moreover, Cruz Alta and Santo Augusto environments, during the second sowing date, contributed to an increase in MM contents (Figure 2D). Conversely, São Gabriel (second sowing time) and Cachoeira do Sul (first cultivation period) environments negatively impacted the accumulation of MM contents in wheat grains.

Carbohydrates serve as the main source of energy for maintenance and are essential in human and animal nutrition (BIEL et al., 2020). Therefore, maintaining high levels of carbohydrate in grains is necessary to maintain a high nutritional value (da SILVA et al., 2020). However, stress conditions during plant cultivation can decrease carbohydrate levels (de SANTIS et al., 2021). Low water availability is one of the main factors that result in the reduction of starch contents in grains (THITISAKSAKUL et al., 2012). In this study, one of the environments that most contributed to the increase in carbohydrate (CHO) levels was Cachoeira do Sul during both sowing times (Figure 2E), mainly due to its water conditions being close to ideal for wheat cultivation (Figure 1). In addition, the São Gabriel environment also contributed to the increase in CHO levels in wheat grains. Both environments have lower altitudes compared to the others evaluated (Table 1), which may have influenced the increase in CHO levels, as a negative correlation was found between the increase in altitude and the CHO content. Conversely, the environment that least contributed to the increase in CHO levels was Cruz Alta during both sowing times (Figure 2E). This result is in line with those found by Do Nascimento et al. (2020) and Mohammadzadeh et al. (2011), which suggested that an increase in protein content in wheat grains may be associated with a decrease in CHO content. Regarding the cultivars, Tbio Iguaçú, ORS 1405, and Mirante stood out, showing the highest CHO contents.

Figure 3 shows the strengths and weaknesses of the selected genotypes, based on the prediction of genetic gains by FA 1 and FA 2 factors (OLIVOTO & NARDINO, 2020). In this sense, it is observed that some of the genotypes

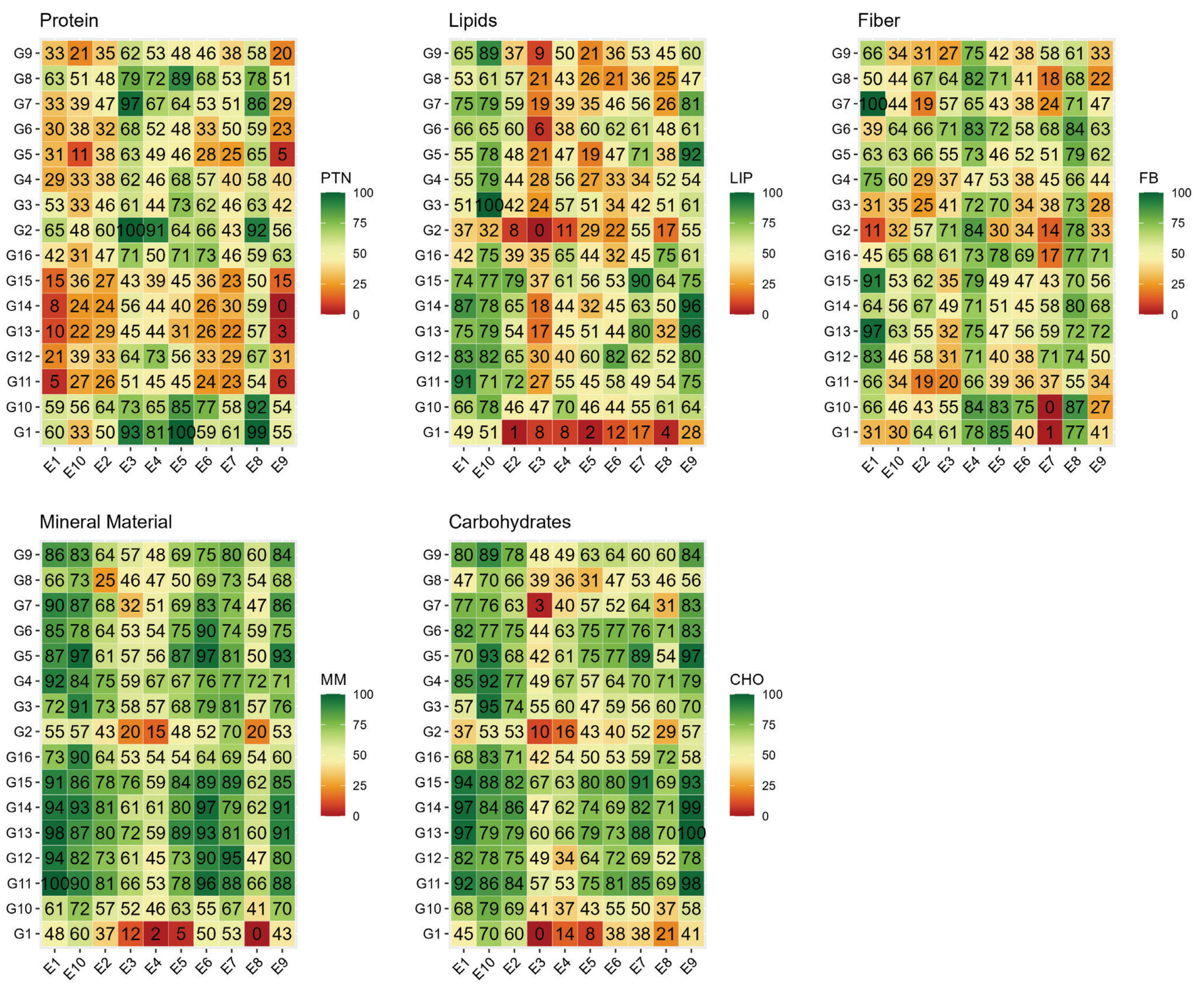


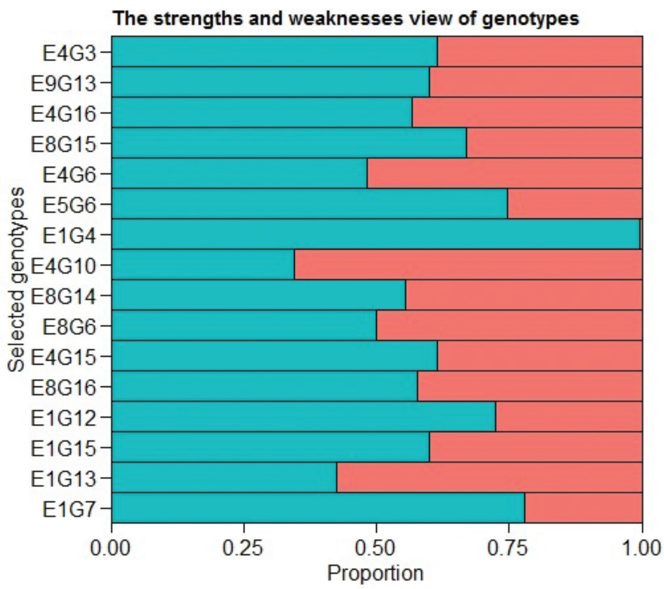
Figure 2. Heatmap for best linear unbiased prediction (BLUP) for protein (PTN), lipid (LIP), fiber (FIB), mineral material (MM), and carbohydrates (CHO) traits for wheat genotypes grown in different environments and sowing times. Each wheat genotype is represented by a designated ID, being G1: BRS 327, G2: BRS Parrudo, G3: Celebra, G4: Esporão, G5: Estrela Atria, G6: FPS Certero, G7: Jadeite 11, G8: Marfim, G9: Mirante, G10: ORS 1403, G11: ORS 1405, G12: Quartzo, G13: Tbio Iguaçú, G14: Tbio Tibagi, G15: LG Prisma and G16: LG Supra. E1: Cachoeira do Sul (1); E2: Cruz Alta (1); E3: Santo Augusto (1); E4: São Gabriel (1); E5: Vacaria (1); E6: Cachoeira do Sul (2); E7: Cruz Alta (2); E8: Santo Augusto (2); E9: São Gabriel (2); and E10: Vacaria (2)

Figura 2. Heatmap para o BLUP dos caracteres proteínas (PTN), lipídeos (LIP), fibras (FIB), material mineral (MM) e carboidratos (CHO) para genótipos de trigo conduzidos em diferentes ambientes e épocas de semeadura. G1: BRS 327, G2: BRS Parrudo, G3: Celebra, G4: Esporão, G5: Estrela Atria, G6: FPS Certero, G7: Jadeite 11, G8: Marfim, G9: Mirante, G10: ORS 1403, G11: ORS 1405, G12: Quartzo, G13: Tbio Iguaçú, G14: Tbio Tibagi, G15: LG Prisma e G16: LG Supra. E1: Cachoeira do Sul (1); E2: Cruz Alta (1); E3: Santo Augusto (1); E4: São Gabriel (1); E5: Vacaria (1); E6: Cachoeira do Sul (2); E7: Cruz Alta (2); E8: Santo Augusto (2); E9: São Gabriel (2); E10: Vacaria (2)

showed characteristics that were against the sought ideotype in the study, which consists of wheat genotypes with high levels of proteins, lipids, and carbohydrates and low levels of fiber and mineral material. This was the case with the FPS Certero and ORS 1403 genotypes, conducted in São Gabriel, and the LG Prisma and Tbio Iguaçú genotypes conducted in Cachoeira do Sul during the first sowing time.

The FPS Certero, Tbio Tibagi, and LG Supra genotypes also showed characteristics of interest (Figure 3) when cultivated in the Santo Augusto environment during the second sowing date. On the other hand, considering the first sowing date, the genotypes Esporão, Quartzo, and Jadeite 11 cultivated in Cachoeira do Sul, and the genotype FPS Certero cultivated in Vacaria, did not meet the desired agronomic ideotype due to their high fiber content.

Figure 4 shows the dendrogram formed from the contents found for the nutritional trait contents of 16 wheat



Traits	Factor	Xo	Xs	Sd	h²	Sense
MM	FA 1	1.710	1.680	-0.031	0.985	decrease
PTN	FA 1	14.400	13.900	-0.551	0.991	increase
LIP	FA 1	1.480	1.640	0.165	0.965	increase
CHO	FA 1	58.200	59.000	0.842	0.992	increase
FB	FA 2	2.660	2.460	-0.199	0.965	decrease

Figure 3. Strengths and weaknesses of selected genotypes for proteins (PTN), lipids (LIP), fibers (FIB), mineral material (MM), and carbohydrates (CHO) traits of 16 wheat genotypes grown in 10 different environments

Figura 3. Pontos fortes e fracos dos genótipos selecionados para os caracteres de proteínas (PTN), lipídeos (LIP), fibras (FIB), material mineral (MM) e carboidratos (CHO) de 16 genótipos de trigo cultivados em 10 diferentes ambientes

genotypes, using the Euclidean distance between the genotypes to delineate two distinct groups and two subgroups. It can be observed that the genotypes of group 1 (Tbio Iguaçu, Quartzo, Mirante, ORS 1405, Estrela, LG Supra, QRS 1403, Certeiro, and Esporão) stood out in terms of lipids and carbohydrates, while presenting lower levels of mineral material. Conversely, the genotypes in group 2 (BRS 327, BRS Parrudo, LG Prisma, Marfim, Jadeite 11, Celebra, and Tbio Tibagi) showed elevated levels of protein and mineral material, with lower levels of lipids and carbohydrates.

Correlations can be positive, indicating that both variables vary in the same direction, or negative, indicating that one variable increases while the other decreases. The correlation coefficients are classified according to the value of r, representing their magnitude. A null correlation corresponds to r=0.00, a weak correlation ranges from r=0.00 to r=0.30, mean correlation from r=0.31 to r=0.60, a strong correlation from r=0.61 to r=0.90, a very strong correlation from r=0.91 to r=0.99, and a perfect correlation when r=1.0 (CARVALHO et al., 2004).

In the study, a very strong positive correlation was observed between the variables minimum temperature and mean temperature, in addition to a very strong negative correlation between protein and carbohydrate contents (Table 2). Furthermore, a strong positive correlation was identified between the levels of protein and mineral material, as well as between the levels of lipids and mineral material. Moreover, strong negative correlations were observed between the levels of proteins and lipids, lipids and mineral material, carbohydrates and mineral material, precipitation and maximum temperature, radiation and maximum temperature, and altitude and minimum temperature.

Conclusions

- Except for the lipid content, high genotypic variance was identified for all characters studied;
- The FPS Certero and ORS 1403 genotypes, conducted in São Gabriel, and the LG Prisma and Tbio Iguaçú genotypes, conducted in Cachoeira do Sul during the first sowing time, met the sought ideotype;
- During the second sowing time, the FPS Certero, Tbio Tibagi, and LG Supra genotypes also showed characteristics of interest when grown in the Santo Augusto environment.

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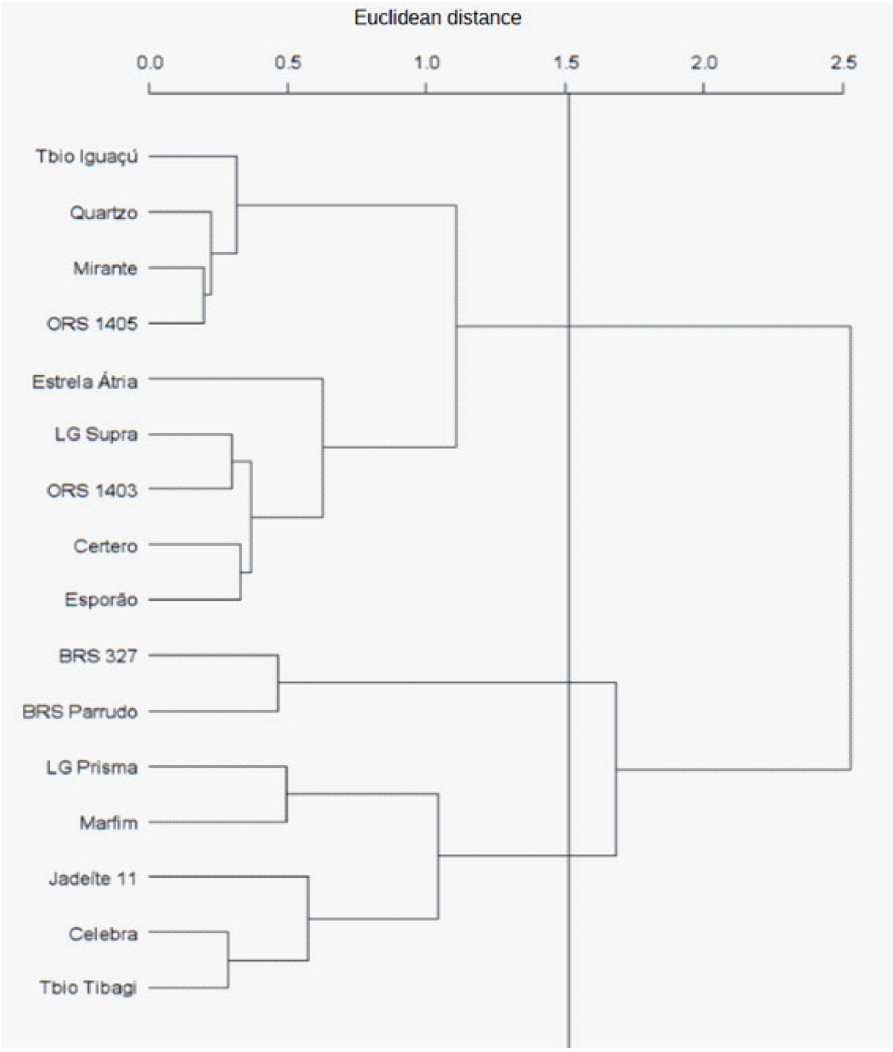

Figure 4. Dendrogram of genetic distances resulting from the cluster analysis of 16 wheat genotypes using the Euclidean distance method (based on nutritional trait contents) as a measure of genetic distance

Figura 4. Dendrograma das distâncias genéticas, resultante da análise do agrupamento de 16 genótipos de trigo, utilizando a distância Euclidiana (com base nos caracteres nutricionais) como medida de distância genética

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Table 2. Pearson's linear correlation for the variables proteins (PTN), lipids (LIP), fibers (FIB), mineral material (MM), carbohydrates (CHO), mean temperatures (T2M), maximum temperatures (T2MAX), minimum temperatures (TMIN), total precipitation (PREC), relative humidity (RH2M), and altitude (ALT), considering 16 wheat genotypes in different environments in Rio Grande do Sul; * = significant correlation
*Tabela 2. Correlação linear de Pearson para as variáveis proteínas (PTN), lipídeos (LIP), fibras (FIB), material mineral (MM), carboidratos (CHO), temperaturas médias (T2M), temperaturas máximas (T2MAX), temperaturas mínimas (TMIN), precipitação total (PREC), radiação total (RH2M) e altitude (ALT), considerando 16 genótipos de trigo em diferentes ambientes do Rio Grande do Sul; * = correlação significativa*

LIP	−0.72*									
FIB	−0.14	−0.072								
MM	0.84*	−0.68*	−0.23*							
CHO	−0.91*	0.77*	0.064	−0.85*						
T2M	−0.091	0.28*	−0.1	0.063	0.14					
T2MAX	0.075	0.16*	−0.12	0.0045	−0.055	0.55*				
TMIN	−0.15	0.33*	−0.077	0.012	0.19*	0.99*	0.5*			
PREC	−0.11	0.044	−0.15	0.089	0.095	0.039	−0.64*	0.085		
RH2M	−0.095	−0.13	0.1	−0.15	0.025	−0.86*	−0.75*	−0.79*	0.28*	
ALT	0.38*	−0.41*	−0.0072	0.11	−0.33*	−0.56*	0.022	−0.65*	−0.34*	0.15
	PTN	LIP	FIB	MM	CHO	T2M	T2MAX	TMIN	PREC	R2HM

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