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CORRELATION AND PATH ANALYSIS IN WHEAT CULTIVARS IN THE INITIAL PERIOD OF DEVELOPMENT

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ABSTRACT - The cultivation of soybeans in the central region of the state of Rio Grande do Sul, has increased the interest of farmers for winter crops in the region. However, information related to crop development in a low-latitude environment is limited and necessary to improve crop management. The objectives of this article were to evaluate the linear relation between traits of spring wheat cultivars in the initial period of development in a low-altitude site. The experiments were conducted in two years in Santa Maria - RS. The experimental design used was randomized blocks, with ten wheat cultivars. The evaluations were carried out at the end of the tillering, where 300 plants were selected per year, obtaining a total sample number of 600 plants. After selecting, the character's plant height (PH), the number of leaves of the main stem (NLMS), the number of leaves per plant (NLP), the number of tillers (NT), and the dry matter (DM) were measured. Pearson's correlation coefficient matrices were estimated, and the path analysis of the main variable DM was performed as a function of PH, NLMS, NLP, NT, and DM. The cultivars TBIO Mestre and TBIO Sinuelo have a higher number of tillers. The NLP has a greater direct effect on DM, in field conditions it is recommended to count the NT, as it has a direct relationship with DM and NLP, associated with this, the character is fast to count and has agronomic value for the wheat crop. In a low-altitude cultivation site, the number of tillers depends on cultivation and environmental conditions. The cultivars TBIO Mestre and TBIO Sinuelo have high tillering capacity. Based on linear relationships, through the non-destructive selection of wheat plants with a greater number of leaves per plant and a greater number of tillers, plants with a higher dry matter mass are indirectly selected. However, the number of tillers is recommended because it is quick to measure.
Keywords: *Triticum aestivum* L., number of tillers, low-altitude cultivation.

CORRELAÇÃO E ANÁLISE DE TRILHA EM CULTIVARES DE TRIGO NO PERÍODO INICIAL DE DESENVOLVIMENTO

RESUMO - O cultivo de soja na região central do estado do Rio Grande do Sul, vêm aumentando o interesse de agricultores por cultivos de inverno na região. No entanto, informações relacionadas ao desenvolvimento da cultura em ambiente de baixa latitude são limitadas e necessárias para o aprimoramento do manejo da cultura. O objetivo deste trabalho foi avaliar as relações lineares entre caracteres de cultivares de trigo de primavera no período inicial de desenvolvimento em local de baixa altitude. Os experimentos foram conduzidos em dois anos em Santa Maria - RS. O delineamento experimental utilizado foi blocos ao acaso, com dez cultivares de trigo. As avaliações foram realizadas ao final do afilhamento, onde foram selecionadas 300 plantas em cada ano, obtendo um número amostral total de 600 plantas. Depois de selecionadas realizou-se a mensuração dos caracteres altura de planta (AP), número de folhas do colmo principal (NFCP), número de folhas por planta (NFP), número de afilhos (NA) e matéria seca (MS). Foram estimadas as matrizes de coeficientes de correlação de Pearson e realizada análise de trilha da variável principal MS em função da AP, NFCP, NFP, NA e MS. As cultivares TBIO Mestre e TBIO Sinuelo apresentam maior número de afilhos. O NFP apresenta maior efeito direto sobre MS, em condições de campo é recomendado contar o NA, pois o mesmo tem relação direta com MS e NFP, associado a isso, o caractere é de rápida contagem e apresenta valor agronômico para a cultura do trigo. Em um local de cultivo de baixa altitude, o número de afilhos depende do cultivo e das condições ambientais. As cultivares TBIO Mestre e TBIO Sinuelo apresentam alta capacidade de afilhamento. Com base em relações lineares, por meio da seleção não destrutiva de plantas de trigo com maior número de folhas por planta e maior número de afilhos, indiretamente são selecionadas plantas com maior massa de matéria seca. No entanto, o número de afilhos é recomendado porque é rápido de medir.
Palavras-chave: *Triticum aestivum* L., número de afilhos, cultivo em baixa altitude.

INTRODUCTION

The southern region of Brazil is responsible for 89.4% of wheat production (*Triticum aestivum* L.), in the country and the state of Rio Grande do Sul is the second-largest producer (CONAB, 2019). Despite being prominent in wheat production, Brazil is the largest cereal

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importer, providing evasion of national financial resources (SILVEIRA et al., 2009).

This fact underscores the importance of inserting culture into new productive areas associated with strategies aimed at increasing productivity, and this involves the greater use of resources from the cultivation environment (VALÉRIO et al., 2009). One of the strategies to increase grain yield is by increasing the number of fertile tillers per plant (HARTWIG et al., 2007). This allows the increase in the number of ears per area, which is a yield component with a direct effect on the determination of grain yield (OZTURK et al., 2006). Besides, Lauer and Simmons (1988), consider the tillers a source of photoassimilates for the main stem.

Evaluating the tillering capacity in cultivars is important because it measures the compensatory effect on ear density, that is, genotypes with reduced tillering potential are more dependent on sowing density to maintain grain yield potential (VALÉRIO et al., 2008). Cultivars that need a greater amount of seeds due to the lower tillering increase the production cost of the crop, a fact that is not interesting for the crop in Brazil, due to the low financial profitability that the triticola has been presenting in recent years.

In addition to evaluating the traits of plants at the beginning of development, verifying their linear relation helps in the positioning of cultivars and the selection of genotypes with higher initial growth. One way to evaluate the linear relationships between the characters is by using Pearson's linear correlation coefficient. Cargnelutti Filho et al. (2015) point out that it can be used as a measure of the degree of relationship between two characters, but when there are more than two characters understudy, the path analysis is appropriate because it allows measure the influence of one variable on the other, regardless of the others (CRUZ; CARNEIRO, 2003). Furthermore, the path analysis provides detailed knowledge of the influences of the characters involved in a previously established diagram and justifies the existence of positive and negative correlations of high and low magnitudes between the studied characters (SILVA et al., 2005).

Studies on agronomic performance in the initial period of development are important to evaluate the tillering and growth capacity of wheat cultivars in a period that is defined as the productive potential of the crop. Associated with this, linear relationships in the initial period of development help to understand the associations between morphological characters, assisting in the selection of cultivars with better adaptation to certain environments. In this sense, it is assumed that wheat cultivars present differences concerning initial development and that there is a linear relationship between these traits. As frequent failures in plant density occur, either due to lack of seeds or biotic and abiotic stresses, the greater tillering capacity of the cultivar may be determinant to ensure the maintenance of the productive potential of wheat crops. Thus, the objectives of this article were to evaluate the linear relationships between traits of wheat cultivars in the initial period of development in a low-altitude site.

MATERIALS AND METHODS

Experiments were carried out in the years 2018 and 2019 with the cultivation of wheat crop (*Triticum aestivum* L.), at the Santa Maria (latitude 29º71'S, longitude 53º70'W and 90 m altitude) state of Rio Grande do Sul, Brazil. The region's climate is humid subtropical *Cfa* type, according to Köppen's classification, with hot summers and no dry season (ALVARES et al., 2013).

For the 2018 and 2019 experiment periods, rainfall, global solar radiation, and average daily air temperature were quantified, whose mean values for each month (Figure 1). The soil of the site is classified as ARGISSOLO VERMELHO Distrófico Arênico (SANTOS et al., 2018). The conduction site of the experiment presents good drainage, in the Coxilha area. After the analysis, the pH correction was performed with the application of lime, two months before the sowing of the first experiment.

In both experiments, ten wheat cultivars were evaluated TBIO Audaz, TBIO Sintonia, TBIO Mestre, TBIO Sonic, TBIO Iguaçu, TBIO Toruk, TBIO Sinuelo, BRS Marcante, BRS Reponte, BRS Parrudo. These cultivars represent a large area of wheat cultivation in Brazil, representing in the state of Rio Grande do Sul more than 40% of the area cultivated with wheat (APASSUL, 2018). The experimental design used was complete blocks at random (STORCK et al., 2016), with three repetitions and sampling of ten plants per plot. In both experiments, the plot was composed of nine rows of 5m long, spaced 0.20m between rows and 1m between blocks, totaling 9 m² per plot.

The sowing of the experiments was carried out with the aid of a plot seeder on May 28, 2018, and on June 5, 2019, in the no-tillage system, the base fertilization was performed according to liming manual and fertilization for yield expectation of 4 ton ha^{-1}. The sowing density considered the cultural value of each cultivar, being adjusted to 300 plants m^{-2}. For nitrogen fertilization in cover, urea (45% N) was used at a dose of 120 kg ha^{-1} of N, fractionated into two applications, the first when the plants were starting the tillering (three leaves fully expanded in most cultivars) and the second when the plants were at the beginning of stretching.

In the stretching stage, ten plants from the useful area of each plot were randomly selected. In each plant, plant height (PH, in cm), number of leaves in the main stem (NLMS), number of leaves per plant (NLP), number of tillers (NT), and dry matter mass (DM, in g plant $^{-1}$) were measured. After, in each experiment, for the characters, PH, NLMS, NLP, NT, and DM, the variance analysis and F tests were performed for block and cultivar effects at 5% significance. The averages of the cultivars were grouped using the Scott-Knott test.

For the study of linear relationships, in each experiment, Pearson (r) and partial (rp) correlation coefficients were estimated between the five characters with the 300 observations (10 cultivars × 3 replicates × 10 plants per plot). The significance of these coefficients was verified by the student's t-test, at 5% probability, with n-2 = 298 degrees of freedom, in which n is equal to 300 wheat plants. Pearson's linear correlation coefficient matrix (r), with the characters PH, NLMS, NLP, and NT, was diagnosed with multicollinearity (CRUZ, 2016) and interpreted according to the Montgomery and Peck criterion (1982). After that, path analysis of the main variable MS was performed as a function of the explanatory variables PH, NLMS, NLP, and NT. These same procedures were repeated by joining the data of the two experiments, that is, with 600 wheat plants.

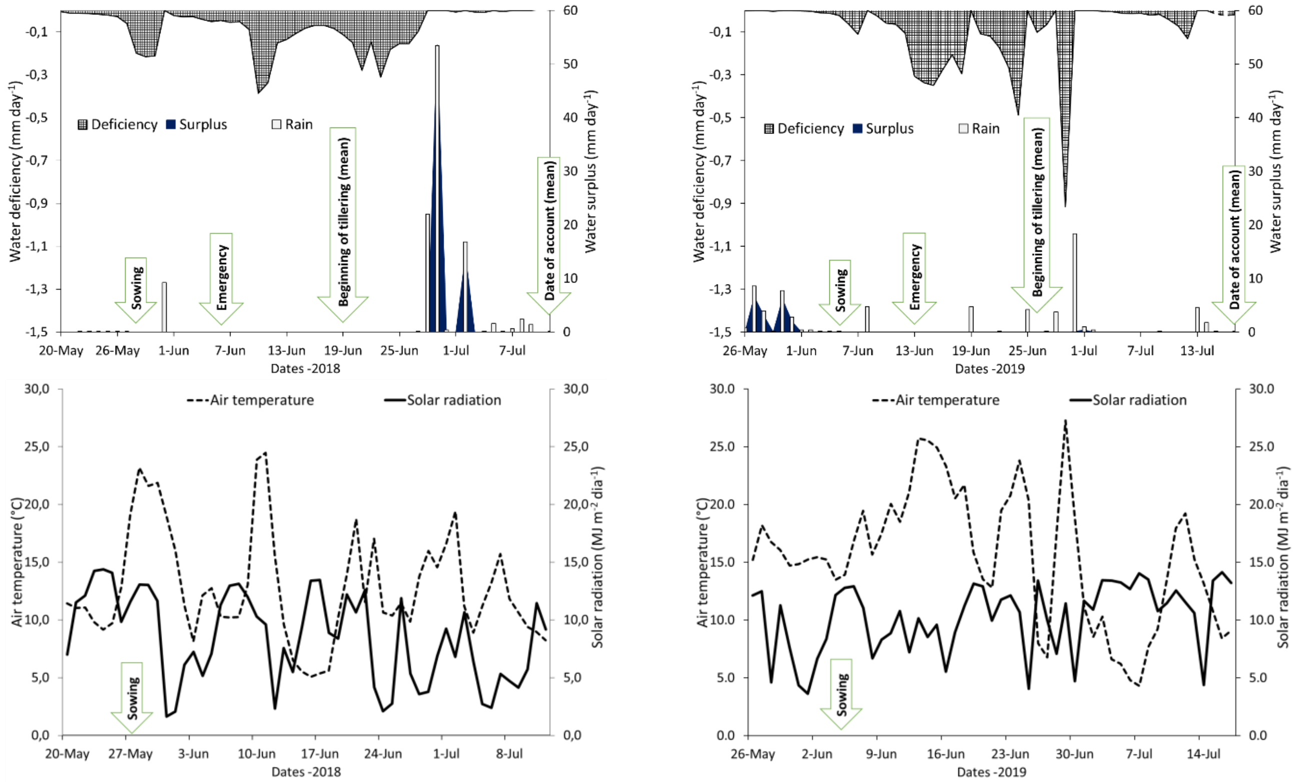

FIGURE 1 - Excess and daily water deficiency of sequential water balance for grassy surface (CAD = 75 mm), rainfall, global solar radiation, and average daily air temperature in 2018 and 2019 in Santa Maria-RS.

The number of plants studied (600 plants), give credibility in the observed information because a low sample size can generate non-assertive information. Grain yield per plant could not be measured, due to the evaluation of DM being a destructive variable, however, there are studies in the literature that associate the largest number of tillers at the end of the tillering stage.

From the 600 plants, measures of central tendency and variability were calculated. This allowed the construction of frequency histograms and scatter plots between the five characters. Meteorological data were collected at the automatic and conventional stations of the National Institute of Meteorology installed 500 m from the experiment site. To characterize the water condition, the daily sequential water balance was performed for the grassy surface (reference evapotranspiration calculated by Penman-Monteith) considering a water capacity available in the soil (CAD) of 75 mm. Statistical analyses were performed with the help of the Microsoft Office Excel application® and the Genes program (CRUZ, 2016).

RESULTS AND DISCUSSION

The F test of the variance analysis revealed that there was a significant effect of cultivars concerning the characters PH, NLP, and NT in both experiments. The characters NLMS and DM showed a relevant difference between cultivars only for the year 2019 (Table 1). This may have resulted from better thermal availability and solar radiation in 2019 compared to 2018. The absolute values of the averages of the number of tillers and dry mass of the plants were 15 and 46% higher in 2019 when compared to 2018, respectively. This may be associated with the increased availability of solar radiation in the tillering period.

For the variable NT, the cultivars TBIO Mestre (mean of 2.97 tillers in 2018 and 2.83 tillers in 2019) and TBIO Sinuelo (mean of 2.87 tillers in 2018 and 3.03 tillers in 2019) were in the group of the best averages in both years. Emphasizing that regardless of year and environmental conditions, these cultivars obtained high tillering capacity. On the other hand, the cultivars BRS Reponte (mean of 1.77 tillers in 2018 and 2.07 tillers in 2019) and BRS Parrudo (mean of 1.97 tillers in 2018 and 2.27 tillers in 2019), were present in the group with the lowest averages in both years. According to Kavalco et al.

(2014), the number of tillers is highly influenced by genotypic characteristics and environmental conditions, also, the same author emphasizes that the selection of plants with a higher number of tillers will result in more productive genotypes.

The cultivars TBIO Sintonia (average of 2.03 tillers in 2018 and 2.83 tillers in 2019), TBIO Iguaçu (average of 2.23 tillers in 2018 and 2.70 tillers in 2019), TBIO Toruk (average of 2.40 tillers in 2018 and 2.93 tillers in 2019) and BRS Marcante (average of 2.47 tillers in 2018 and 3.03 tillers in 2019) had the highest averages in 2019. Ferrari et al. (2016) observed an average of 2.15 tillers per plant in five wheat cultivars in the municipality of Frederico Westphalen (Rio Grande do Sul State), mean values intermediate to those found in the present experiment, corroborated by the good tillering capacity of the cultivars in the environmental conditions of Santa Maria, in a low-altitude location.

TABLE 1 - Analysis of variance and significance of the mean square of the sources of variation of five characters of ten wheat cultivars (*Triticum aestivum* L.), evaluated in two years (2018 and 2019).

Variation source	PH	NLMS	NLP	NT	DM
			Year = 2018		
Block (GL = 2)	18.881^{ns}	3.453^{ns}	4.423^{ns}	0.010^{ns}	0.038*
Cultivate (GL = 9)	200.075*	0.524^{ns}	10.601*	4.268*	0.020^{ns}
Experimental error (GL = 18)	11.944	1.331	2.383	0.403	0.009
Sampling error (GL = 270)	10.908	0.364	2.852	0.702	0.008
Average	29.02	4.31	8.05	2.32	0.26
CV (%)	3.77	8.47	6.06	8.65	11.30
			Year = 2019		
Block (GL = 2)	0.996^{ns}	4.480*	13.563^{ns}	2.440*	0.037^{ns}
Cultivate (GL = 9)	459.758*	1.606*	23.211*	3.270*	0.063*
Experimental error (GL = 18)	14.380	0.361	5.115	0651	0.017
Sampling error (GL = 270)	9.511	0.243	2.812	0.431	0.016
Average	26.51	3.96	8.36	2.67	0.38
CV (%)	4.52	4.80	8.55	9.56	10.93
Cultivars	PH	NLMS	NLP	NT	DM
			Year = 2018		
TBIO Audaz	30.22b	4.23a	8.57a	2.30b	0.27a
TBIO Sintonia	30.17b	4.07a	7.63b	2.03c	0.24b
TBIO Mestre	25.54d	4.20a	9.13a	2.97a	0.29a
TBIO Sonic	30.95b	4.53a	8.40a	2.20b	0.30a
TBIO Iguaçu	29.22b	4.33a	8.17a	2.23b	0.25b
TBIO Toruk	26.17d	4.27a	7.67b	2.40b	0.23b
TBIO Sinuelo	26.00d	4.30a	8.37a	2.87a	0.25b
BRS Marcante	30.22b	4.37a	8.00b	2.47b	0.24b
BRS Reponte	33.68a	4.47a	7.47b	1.77c	0.29a
BRS Parrudo	28.05c	4.30a	7.13b	1.97c	0.26b
			Year = 2019		
TBIO Audaz	27.53b	4.17a	8.90a	2.57b	0.35a
TBIO Sintonia	30.80a	4.20a	9.03a	2.83a	0.42a
TBIO Mestre	25.59c	4.00a	8.60a	2.83a	0.39a
TBIO Sonic	31.42a	4.13a	8.23a	2.43b	0.42a
TBIO Iguaçu	24.84c	3.93a	8.70a	2.70a	0.40a
TBIO Toruk	24.48c	4.13a	9.03a	2.93a	0.41a
TBIO Sinuelo	21.72d	3.80b	8.77a	3.03a	0.35a
BRS Marcante	26.05c	3.83b	8.80a	3.03a	0.38a
BRS Reponte	31.99a	3.97a	7.13b	2.07b	0.38a
BRS Parrudo	20.73d	3.43c	6.43b	2.27b	0.27b

PH = plant height (cm), NLMS = number of leaves in the main stem, NLP = number of leaves per plant, NT = number of tillers, DM = dry matter mass (g plant^{-1}), GL = degrees of freedom, * = significant effect by the F-test at a 5% significance level, ^{ns} = not significant. Means not followed by the same letter in the column differ by the Scott-Knott test, at 5% significance. Mean and experimental coefficient of variation (CV). Average cultivars and number of groups formed through the Scott-Knott test.

Given the difference in rainfall, in 2018 and 2019 the average air temperature of June was 12 and 18ºC, respectively (Figure 1). According to Valério et al. (2009), the effects of the environment related to the emission and development of tillers can be highlighted by several aspects, including temperature and water availability. In the 2018 experimental period, the average daily air temperature was 14.2°C, and rainfall accumulated was 102.3 mm. In 2019, there was an average daily air temperature of 14.9°C, 4.9% higher than in 2018, and rainfall of 33.7 mm. The largest difference in air temperature occurred in the subperiod of emergence at the beginning of tillering, being 84.6% higher in 2019 than in 2018.

Besides, solar radiation was on average 10.5% higher in 2019 than in 2018. The greatest difference in the availability of solar radiation occurred in the subperiod at the beginning of the tillering until the date of data collection, being 22.0% higher in 2019 when compared in 2018. Although such differences occurred, the condition of water deficiency related to the need for evapotranspiration in both years was very similar, with a 9.75% deficiency in 2018 and 9.56% in 2019. The subperiod of greatest relative water deficiency occurred in both years from emergence to the onset of tillering, with a 13.90% deficiency in 2018 and 13.41% in 2019.

The cultivar TBIO Mestre was positioned in the group with the highest average for NLMS, NLP, NT, and DM in both years, being associated with low PH. This behavior was also observed for cultivars TBIO Sintonia, TBIO Iguaçu, and TBIO Toruk in 2019, highlighting that environmental differences are associated with the initial performance of these cultivars. Moreover, the lower plant height in 2019 compared to 2018 may be due to the same conditions that favored the highest number of tillers (Figure 1), since both characters are negatively correlated (Table 2; Table 3). When the comparison between the years was performed, evaluating 600 plants, some correlations remained linearly positive in both. Pearson's correlations (r) between the characters NLP × NT, NLP × DM, and NT × DM were significant at a 5% probability by the student's t-test (Table 2).

The NLP × NT correlation showed a higher degree of linear association in 2018 (r=0.7575), and remained in 2019 (r=0.7068), highlighting that the higher the number of tillers that the plant generates, the greater the number of leaves. Similar results were found by Cargnelutti Filho et al. (2015), evaluating the correlation between these characters in black oats, obtaining correlations from 0.70 to 0.91.

TABLE 2 - Pearson correlation coefficient (above diagonal) and partial (below diagonal) correlation coefficients between traits of ten wheat cultivars (*Triticuma estivum* L.), evaluated in 300 plants (30 plants per cultivar) in each year (2018 and 2019).

Year = 2018; n = 300 plants					
Characters	PH	NLMS	NLP	NT	DM
PH	-	0.1722*	0.1026^{ns}	-0.1215*	0.4435*
NLMS	0.1750*	-	0.2401*	0.0144ns	0.0835^{ns}
NLP	-0.0943^{ns}	0.3639*	-	0.7575*	0.7094*
NT	-0.3812*	-0.1657*	0.5482*	-	0.5811*
DM	0.6023*	-0.1887*	0.4611*	0.2771*	-
Year = 2019; n = 300 plants					
Characters	PH	NLMS	NLP	NT	DM
PH	-	0.3464*	0.1605*	-0.0558^{ns}	0.4579*
NLMS	0.2589*	-	0.5069*	0.2332*	0.4225*
NLP	-0.1829*	0.4078*	-	0.7068*	0.7350*
NT	-0.3026*	-0.1211*	0.4574*	-	0.5722*
DM	0.5482*	-0.0522^{ns}	0.4963*	0.2701*	-
Years 2018 and 2019; n = 600 plants					
Characters	PH	NLMS	NLP	NT	DM
PH	-	0.3099*	0.1067*	-0.1392*	0.2659*
NLMS	0.2811*	-	0.3274*	0.0418^{ns}	0.1019*
NLP	-0.0012^{ns}	0.4216*	-	0.7258*	0.6776*
NT	-0.3152*	-0.1660*	0.5707*	-	0.5801*
DM	0.3829*	-0.2209*	0.4292*	0.2351*	-

Characters: PH = plant height (cm), NLMS = number of leaves in the main stem, NLP = number of leaves per plant, NT = number of tillers, DM = dry matter mass (g plant^{-1}). * = significant at 5% probability by student's t-test, with 298 degrees of freedom for the years 2018 and 2019 analyzed separately and 598 degrees of freedom for the years 2018 and 2019 analyzed together. ^{ns} = non-significant.

TABLE 3 - Direct and indirect effects on path analysis, from Pearson's correlation matrix between traits of ten wheat cultivars (*Triticum aestivum* L.), evaluated in 300 plants (30 plants per cultivar) in each year (2018 and 2019). Coefficient of determination, the effect of a residual variable, and the number of conditions.

	Year = 2018; n = 300 plants			
Effects	PH	NLMS	NLP	NT
Direct effect on DM	0.4452	-0.1146	0.4901	0.2656
Indirect effect via PH	-	0.0767	0.0457	-0.0541
Indirect effect via NLMS	-0.0197	-	-0.0275	-0.0017
Indirect effect via NLP	0.0503	0.1177	-	0.3712
Indirect effect via NT	-0.0323	0.0038	0.2012	-
Total (Pearson Correlation)	0.4435*	0.0835^{ns}	0.7094*	0.5811*
Coefficient of determinations	0.6899			
Effect of residual variable	0.3101			
Condition number	13.94			
	Year = 2019; n = 300 plants			
Effects	PH	NLMS	NLP	NT
Direct effect on DM	0.3989	-0.0361	0.5258	0.2313
Indirect effect via PH	-	0.1382	0.0640	-0.0223
Indirect effect via NLMS	-0.0125	-	-0.0183	-0.0084
Indirect effect via NLP	0.0844	0.2665	-	0.3717
Indirect effect via NT	-0.0129	0.0539	0.1635	-
Sum (Pearson's correlation)	0.4579*	0.4225*	0.7350*	0.5722*
Coefficient of determinations	0.6862			
Effect of residual variable	0.3138			
Condition number	15.55			
	Years 2018 and 2019; n = 600 plants			
Effects	PH	NLMS	NLP	NT
Direct effect on DM	0.2988	-0.1709	0.5182	0.2528
Indirect effect via PH	-	0.0926	0.0319	-0.0416
Indirect effect via NLMS	-0.0530	-	-0.0559	-0.0071
Indirect effect via NLP	0.0553	0.1697	-	0.3761
Indirect effect via NT	-0.0352	0.0106	0.1834	-
Sum (Pearson's correlation)	0.2659*	0.1019*	0.6776*	0.5801*
Coefficient of determinations	0.5598			
Effect of residual variable	0.4402			
Condition number	12.26			

Characters: PH = plant height (cm), NLMS = number of leaves in the main stem, NLP = number of leaves per plant, NT = number of tillers, DM = dry matter mass (g plant^{-1}). * = significant at 5% probability by student's t-test, with 298 degrees of freedom for the years 2018 and 2019 analyzed separately and 598 degrees of freedom for the years 2018 and 2019 analyzed together. ^{ns} = non-significant.

The NLP × DM correlation was significant and positive in 2018 (r=0.7094) and in 2019 (r=0.7350) (Figure 2), which represents an increase in DM when the NLP is higher. In this context, Cruz et al. (2007) point out that the maintenance of leaf area, maintained by adequate nitrogen supply, is also important to promote greater interception of the incident solar energy and, consequently, determine greater carbon assimilation, which can contribute significantly to increase the accumulation of dry matter by plants, especially the central region of the state of Rio Grande do Sul, which presents low levels of radiation in the winter period due to high cloudiness in the first hours of the day.

Analyzing the NT and DM, which also had positive linear relationships (r=0.5811 in 2018 and r=0.5722 in 2019), and considering the previous characters, the highest NT is associated with the increase in NLP and, consequently, the greater accumulation of DM. Fioreze & Rodrigues (2014), studying plant density and the use of regulators, found that the emission of tillers resulted in greater accumulation of individual dry matter of plants, acting as a compensation mechanism for the smallest number of plants per unit area. The PH × NLMS, PH × NLP, NLMS × NLP, NLMS × NT, and NLMS × DM correlations were positive, but with a smaller magnitude (Table 2). Therefore, it is verified that the NLMS has low linear relations with the other characteristics. In both years, the PH × NT ratio was negative, but with low magnitude.

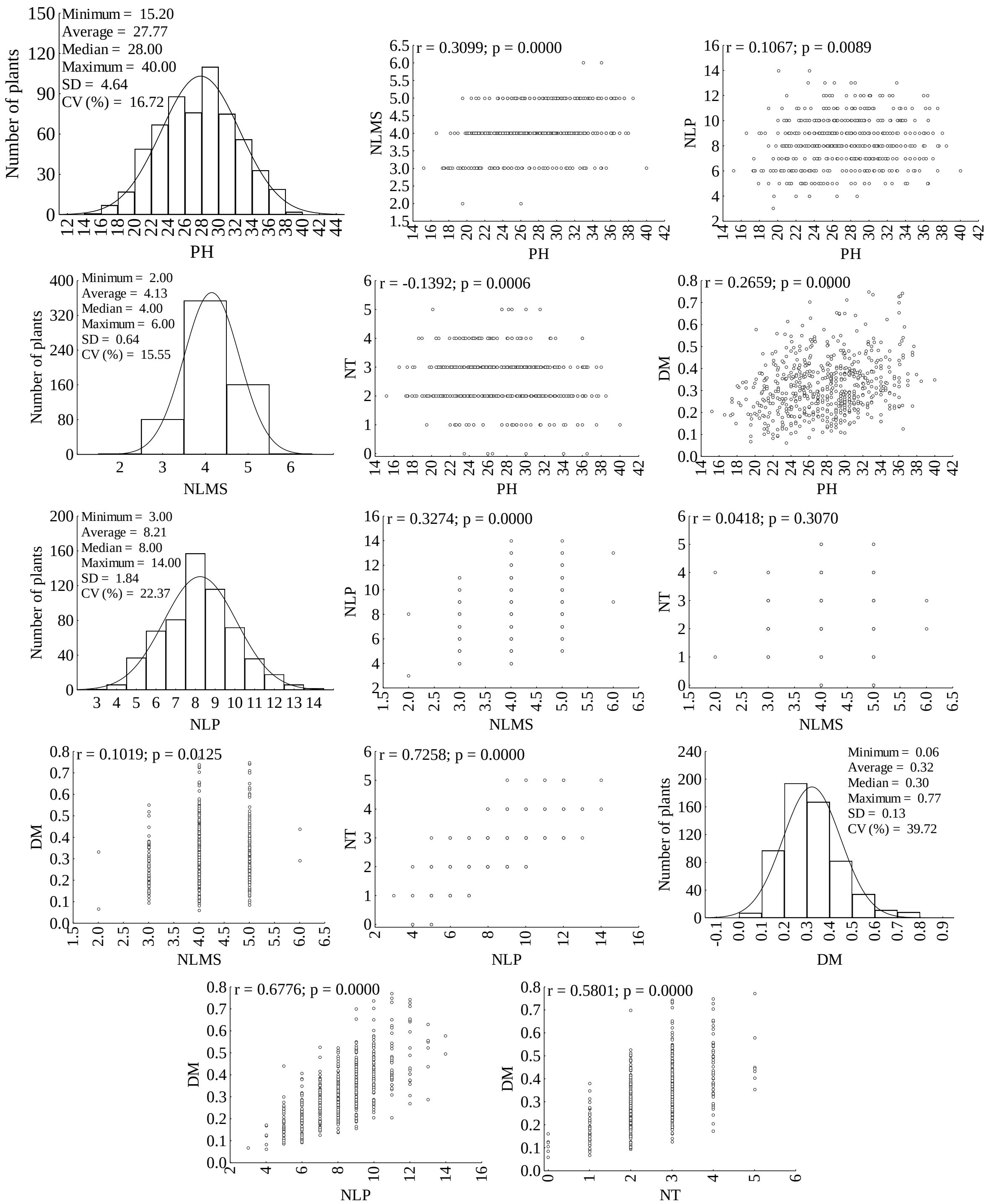

FIGURE 2 - First column on the left - five-character frequency histograms of ten wheat cultivars (*Triticuma estivum* L.), evaluated in 600 plants (60 plants per cultivar). In histograms, the line represents the normal distribution curve. SD = standard deviation and CV = coefficient of variation. Second and third columns - scatter plots between the five characters, Pearson correlation coefficient (r) and p-value (p) of student's t-test, with 598 degrees of freedom. Characters: PH = plant height (cm), NLMS = number of leaves in the main stem, NLP = number of leaves per plant, NT = number of tillers, DM = dry matter mass (g plant^{-1}).

With the aid of path analysis, it was possible to identify the direct and indirect effects of the characters PH, NLMS, NLP, and NT on DM (Table 3). DM is an important character and can be considered as an indicator of initial performance, because the higher its value, the greater the vigor of the plant and, consequently, increases the reserves of photoassimilates in the stem that can be translocated to grain filling (HEINEMANN et al., 2006). The NLP for both years was the character that presented the highest linear association with DM (r=0.6776). This high value can be explained by the high direct effect that NLP has with DM. The NLP character contributes to the increase of leaf area, which exerts great importance as active photosynthesizer tissue, providing greater partition of those assimilated in grain filling (SILVA et al., 2003).

The NT presented, in the two years of the experiment, a direct effect of medium magnitude with DM, mainly due to the high indirect effect with NLP (Table 3). If plants with higher NT are selected there is an indirect gain in NLP, consequently, it will have a gain in DM.

According to Espindula et al. (2010), the higher the NT, the greater the number of leaves and, consequently, the intraspecific competition for photoassimilates is accentuated inside the plants. However, the NLMS expressed negligible direct effect and a negative relationship, demonstrating that the higher the NLMS, the lower the DM. Thus, to select wheat plants in a nondestructive way, with better initial development in a low-altitude location in the central region of the state of Rio Grande do Sul, that is, plants with higher DM in the initial period, cultivars and genotypes should be selected (for selection purposes in wheat breeding programs) with higher NLP and NT.

CONCLUSIONS

In a low-altitude cultivation site, the number of tillers is dependent on the cultivar and environmental conditions. The cultivars TBIO Mestre and TBIO Sinuelo have a high tillering capacity.

Based on linear relationships, by nondestructively selecting wheat plants with a higher number of leaves per plant and a greater number of tillers, indirectly plants with higher dry matter mass are selected. However, the number character of tillers is recommended because it is quick to measure.

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