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SOWING DENSITY AND CLIPPING MANAGEMENT: EFFECTS ON THE ARCHITECTURE AND YIELD OF DUAL-PURPOSE WHEAT

DENSIDADE DE SEMEADURA E MANEJOS DE CORTE: EFEITOS NA ARQUITETURA E RENDIMENTO DO TRIGO DE DUPLICAÇÃO

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ABSTRACT: The dual-purpose wheat stands out as a complementary alternative for forage supply during the winter period. Therefore, this work had the objective of evaluate the performance characteristics in five genotypes of dual-purpose wheat submitted to different sowing densities and different clipping managements. The experiment was carried out during the 2016 and 2017 harvests. The experimental design was a randomized block design, organized in a factorial scheme, with five dual-purpose wheat genotypes (BRS Tarumã, BRS Umbu, BRS Figueira, BRS Guatambu and BRS 277) x five sowing densities (75, 150, 225, 300 and 375 seeds m²) x four clipping operations (zero, one, two and three clippings), arranged in three replicates. The measuring of characters were number of fertile tillers, seeds yield, angle of flag leaf, chlorophyll content and flowering. The genotype BRS Tarumã is superior in number of fertile tillers and chlorophyll index for all the sowing densities, as well, the flowering is influenced direct by clipping managements. The sowing density of 75 seeds m^{-2} is not indicated for dual-purpose wheat independent of the clipping management. The seeds yield is amplified thought the increase in sowing density, however, advancing in clipping levels there is a decrease in forage yield.

KEYWORDS: *Triticum aestivum* L. Phenotypic plasticity. Intra-specific competition. Canopy adjustment of plants.

INTRODUCTION

The wheat *(Triticum aestivum* L.) crop is among the most produced cereals worldwide. Some genotypes may exhibit dual-purpose, thus, the capacity to produce forage and grains in quantities that are sufficiently economical and simultaneous during its cultivation (Koch et al., 2017). The Brazilian domestic consumption of wheat was around 11 million tons of grain in 2018, though the production only reached 5.2 million tons of grain produced (CONAB, 2018). Among the States that stand out in the production of this cereal, Paraná and Rio Grande do Sul account for 86% of national production (JESUS JUNIOR et al., 2011; SZARESKI, 2018).

The tolerance to clipping managements, as well as high tillering ability propitiated the dual-purpose to certain genotypes of wheat. Providing it as an alternative for forage source to remedy problems arising the lack of fodder during the period between the fall and early winter, since the early seeding can benefit the production chain of

dairy and beef (MEINERZ, 2012). In these cases, the establishment of dual-purpose crops allow the farmer to postpone his decision or then reconcile the production of grain and forage production (CARVALHO et al., 2017; HASTENPFLUG, 2009). Wheat cultivars with dual-purpose characteristics can contribute to the intensification of the use of agricultural areas in the winter, allowing the supplying of forage, production of straw for no-till sowing system and reduce dependence of Brazil on importing wheat.

The dual-purpose wheat stands out as a complementary alternative for forage supply during the winter period, mainly in properties that adopt the management system with the integration crop-livestock (FONTANELI, 2000). Genotypes with dual-purpose present high green mass yield, long vegetative stage, shorter reproductive period, tolerance to trampling and clipping management, high tillering potential and fast establishment of the culture (MARTIN et al., 2010).

It reveals some care needs regarding the management of the plants, when these are rationally

followed, the activity results in success in the productive and economic scope. The well-employed management techniques allow increasing the number of clippings, maximize forage extraction and re-growth capacity (CARVALHO et al., 2017). Among the practices used to increase productivity, the arrangement less spaced between the sowing lines allows the increase of the equidistance between the plants, constituting an important alternative to improve the results. However, there is a maximum limit of plants in one given space due to the natural intraspecific competition for nutrients and light (VON PINHO et al., 2008). Therefore, this work had the objective of evaluating the performance characteristics in five genotypes of dual-purpose wheat submitted to different sowing densities and different clipping managements.

MATERIALS AND METHODS

The experiment was conducted during the 2016 and 2017 harvests in Frederico Westphalen, RS, Brazil, in the coordinates of latitude 27° 39' 56" S and longitude of 53° 42' 94" W, with altitude of 490 meters. The soil is classified as Clayey Hapludox and the climate is characterized by Köppen as subtropical *Cfa* (MORENO, 1961).

The experimental design was a randomized block design, organized in a factorial scheme, with five wheat genotypes (BRS Tarumã, BRS Umbu, BRS Figueira, BRS Guatambu and BRS 277) x five sowing densities (75, 150, 225, 300 and 375 seeds m²) x four clipping operations (zero, one, two and three clippings), arranged in three replicates. The experimental units were comprised of 12 rows of 2.0 meters in length, spaced 17 cm, with a utile area of 4,08m^2. In both cropping season analyzed, we used no-till with basic fertilizing of 250 kg ha^{-1} NPK (10-20-20), and 90 kg ha $^{-1}$ of nitrogen coverage in the form of urea (45 % of N), with application in full tillering stage. The criterion used for realizing the clippings was when more than 75% of the plants of experimental unit showed height of 30 centimeters, the sections were manually performed leaving 10 cm of height (CARVALHO, 2015). The control of pests, weeds and diseases were preventively perfomed.

The measuring of characters were performed in ten random plants in the working area of the experimental unit, according to the methodology of Martin et al. (2013). The measured characters were: number of fertile tillers (NT) - number of tillers present in the plant that have productive potential of seeds, expressed in units; seeds yield (SY) – productivity per hectare,

expressed in kg ha^{-1}; angle of flag leaf (AF) - the angle at which the last leaf is located in the stem, expressed in degrees; chlorophyll content (CI) - were determined by a chlorophyll meter, results are expressed in index and flowering (F) – days until flowering.

The data obtained was submitted to the assumptions of the statistical model aiming to identify the normality of the residues and the homogeneity of the variances residues. Afterwards, it was submitted to analysis of variance at 5% of probability by the F test, in order to diagnose the interaction between the dual-purpose wheat genotypes x seeding density x clipping management. For the characters that revealed significant interaction were simplified to the simple effects for the qualitative factors (dual-purpose wheat genotypes and clipping management). For the quantitative effects (sowing density), linear regression was performed, where the largest significant degree of the polynomial was tested by the *t* test at 5% of probability.

RESULTS AND DISCUSSION

The variance analysis revealed significance of 5% of probability for the interaction of dual-purpose wheat genotypes x seeding density for the characters NT, CI, SY and AF; wheat genotypes x clipping management for characters F, NT and SY; seeding density x clipping system for the character NT.

The NT was expressed for five studied genotypes (Figure 1a, Table 1), the genotypes BRS Tarumã and BRS Figueira were responsible for the greatest magnitude of this character when plants were grown in the evaluated density, with the exception of the BRS Figueira genotype at the density of 150 seeds m^{-2}. The BRS 277 genotype presented the smallest magnitudes for NT in relation to the other genotypes. For this character, the best performances of the genotypes were presented when using the density of 75 seeds m^2.

For the CI variable, the BRS Umbu genotype showed higher magnitudes for the densities 75, 150, 225 and 300 seeds m^{-2} (Figure 1b, Table 1), in contrast, in the density of 375 seeds m^{-2} the BRS Tarumã genotype proved superior to the others. The genotype BRS 277 obtained high performance in all studied seeding densities. For BRS Figueira, increased density leads to decrease in the magnitude of CI. Better arrangements for the studied genotypes are obtained with densities of 75 and 225 seeds m^{-2}.

Table 1. Averages for number of fertile tillers (NT), chlorophyll index (CI), seed yield (SY) and angulation of the flag leaf (AF) for five dual-purpose wheat genotypes under different seeding densities.

Seed density (s/m²)	BRS 277	BRS Figueira	BRS Guatambu	BRS Tarumã	BRS Umbu
number of fertile tillers (NT)					
75	4.5 [B]	6.1 [A]	4.8 [B]	5.7 [A]	4.4 [B]
150	2.1 [C]	3.0 [B]	2.4 [C]	3.9 [A]	2.7 [BC]
225	1.5 [B]	2.6 [A]	2.0 [BA]	2.4 [A]	2.2 [A]
300	1.2 [B]	1.9 [A]	1.3 [B]	2.0 [A]	1.7 [AB]
375	1.1 [B]	2.0 [A]	1.1 [B]	1.9 [A]	1.7 [B]
chlorophyll index (CI)					
75	15.5 [A]	15.6 [A]	16.1 [A]	15.6 [A]	15.8 [A]
150	14.7 [B]	15.2 [B]	14.6 [B]	15.7 [AB]	16.5 [A]
225	15.0 [A]	15.1 [A]	15.7 [A]	15.0 [A]	15.9 [A]
300	15.0 [B]	13.9 [C]	15.5 [AB]	13.8 [C]	16.4 [A]
375	14.4 [B]	13.8 [B]	14.8 [B]	16.0 [A]	14.4 [B]
seed yield (SY)					
75	921.1 [B]	2380.6 [A]	1419.0 [B]	1566.5 [B]	2504.1 [A]
150	575.3 [B]	2327.9 [A]	990.2 [B]	2260.7 [A]	2473.2 [A]
225	866.8 [BC]	2950.6 [A]	1594.3 [B]	2061.6 [B]	3053.9 [A]
300	729.02 [aD]	3331.4 [A]	1586.3 [C]	2639.4 [B]	2531.2 [B]
375	1002.5 [B]	3890.7 [A]	1852.0 [B]	3256.5 [A]	2633.8 [B]
angulation of the flag leaf (AF)					
75	37.6 [A]	35.1 [A]	34.1 [A]	36.2 [A]	36.5 [A]
150	34.8 [AB]	36.6 [A]	29.2 [B]	30.4 [AB]	33.0 [AB]
225	40.8 [AB]	44.6 [A]	35.4 [BC]	32.8 [C]	37.9 [B]
300	40.1 [A]	31.1 [B]	36.6 [AB]	29.4 [C]	30.4 [BC]
375	31.8 [B]	31.6 [B]	32.3 [B]	38.9 [A]	38.9 [A]

* Means followed by the same capital letter in the line do not differ by 5% of probability.
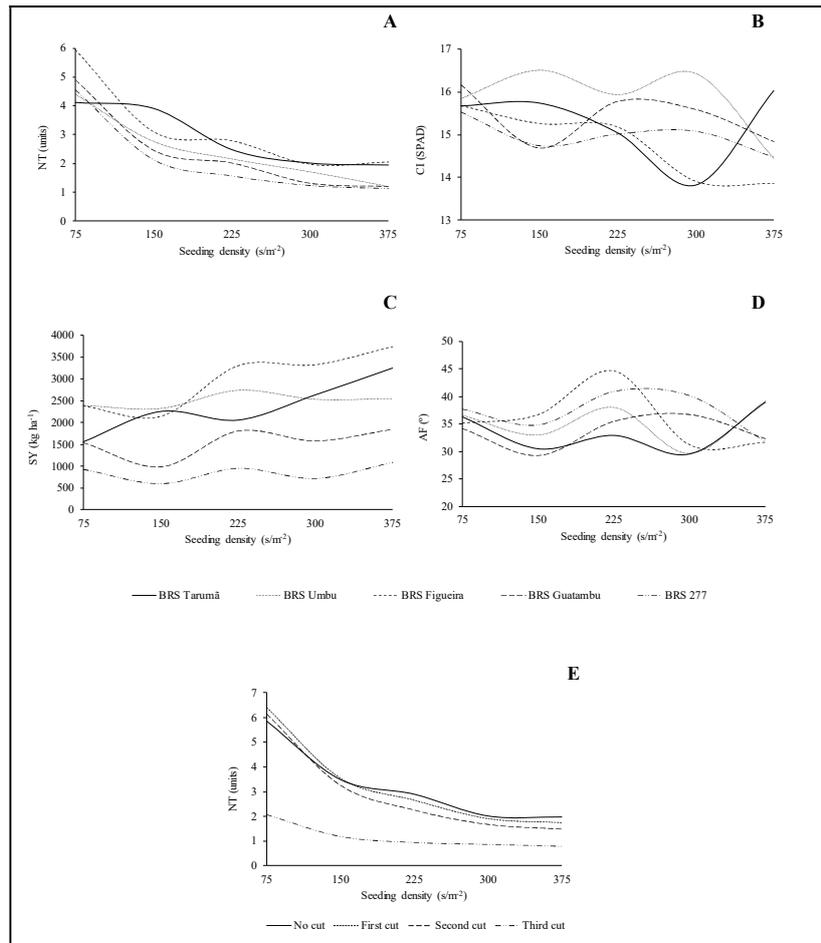
Figure 1. A: number of fertile tillers; B: chlorophyll index; C: seed yield; D: angulation of the flag leaf; E: number of fertile tillers.

The genotype BRS Figueira showed superiority and genotype BRS 277 obtained the smallest magnitudes for the SY character, at the studied densities (Figure 1c, Table 1). It was observed that the highest yields were obtained in the density of 375 seeds m^{-2}, except for BRS Umbu genotype that obtained higher seed yield using 225 seed m^{-2}. Research by Zilio et al. (2017), affirm that the seeding density influences the seed production of the dual-purpose genotypes, in agreement with the results it is evident that the genotypes show similar behavior, however, a general recommendation for the density is not obtained, but there is a need for stratification of the recommendation for genotypes.

For the AF character, the genotype BRS 277 showed to be superior to the others, however with the density of 375 seeds m^{-2} the genotype BRS Umbu obtained greater magnitude (Figure 1d, Table 1). For BRS Guatambu there were smaller magnitudes in relation to the other genotypes. The reduction of the angle between the stem and the flag leaf can provide better utilization of the incident solar radiation on the crop canopy, provoking reduction of leaves overlapping.

The deployment of the interaction of dual-purpose wheat genotypes x clipping management (Table 2) revealed significance for the variables NT, F and SY. For the NT variable in the clipping management, with one and three clippings, the BRS Tarumã was superior (Table 2). The BRS Guatambu and BRS Umbu obtained better performances for this character in the management without clipping. As management is employed with a greater number of clippings, the NT for genotypes decreased. However, there was increment for the character BRS Figueira with on clipping and BRS Tarumã with the second clipping.

Table 2. Averages for number of fertile tillers (NT), flowering (F) and seed yield (SY) for five dual-purpose wheat genotypes under management of clippings.

Cut	BRS 277	BRS Figueira	BRS Guatambu	BRS Tarumã	BRS Umbu
number of fertile tillers (NT)					
Non cut	2.7 B *	3.5 A	3.0 B	3.8 A	3.0 B
First cut	2.7 B	4.0 A	2.9 B	3.7 A	2.9 B
Second cut	2.5 C	3.3 B	2.6 C	4.0 A	2.3 C
Third cut	0.4 B	1.7 A	0.8 BC	1.2 AC	1.5 A
flowering (F)					
Non cut	119.6 B	110.4 C	117.3 C	150.0 A	111.6 C
First cut	143.0 A	115.0 C	126.6 B	150.0 A	119.6 BC
Second cut	150.0 A	131.3 B	150.0 A	150.0 A	144.2 A
Third cut	150.0 A	143.0 A	150.0 A	150.0 A	147.6 A
seed yield (SY)					
Non cut	1129.0 E	4804.3 AB	2427.1 D	3292.6 C	5195.2 A
First cut	1232.1 D	4325.7 A	2068.0 C	3161.0 B	3570.7 B
Second cut	855.2 B	2246.7 A	1270.2 B	2690.4 A	1441.3 B
Third cut	59.5 A	528.3 A	188.3 A	283.8 A	349.8 A

* Means followed by the same capital letter in the line do not differ by 5% of probability.

The BRS Tarumã genotype showed superiority and uniformity for all clipping managements (Table 2). The largest magnitude for this character was reached in the third clipping management for the genotypes presented in this study. The SY character is negatively influenced by the presence of clipping management and the number of times it is used, and this technique should be reviewed in order to improve this character for dual-purpose wheat genotypes. The BRS Umbu presented superiority when not clipped, although not differing from BRS Figueira, which had superior performance for the first and third clipping management. For Martin et al. (2010), clippings management revealed BRS Figueira genotype superior for this character, where there was a decrease in yield of all genotypes. In the use of the two-clipping system, the genotype BRS Tarumã showed the highest seed yield in relation to genotypes BRS 277, BRS Figueira, BRS Guatambu and BRS Umbu.

Table 3. Number of fertile tillers (NT) for five dual-purpose wheat genotypes under different sowing densities and management of clippings.

Seed Density (s/m²)	No clipping	First clipping	Second clipping	Third clipping
75	5.8 B *	6.5 A	6.1 AB	2.0 C
150	3.4 A	3.5 A	3.2 A	1.1 B
225	2.8 A	2.6 AB	2.2 B	0.9 C
300	2.0 A	1.9 A	1.7 A	0.8 B
375	1.9 A	1.7 A	1.4 A	0.8 B

* Means followed by the same capital letter in the line do not differ at 5% of probability.

Table 4. Equations for architecture components and productivity of five genotypes of dual-purpose wheat under different seeding densities and management of clippings.

Genotypes	Equations
	number of fertile tillers (NT)
BRS 277	$\hat{Y} = 6.87 - 0.03x + 0.00006x^2$ R^2: 0.50
BRS Figueira	$\hat{Y} = 8.44 - 0.04x + 0.00006x^2$ R^2: 0.53
BRS Guatambu	$\hat{Y} = 7.13 - 0.03x + 0.00005x^2$ R^2: 0.50
BRS Tarumã	$\hat{Y} = 8.33 - 0.03x + 0.00005x^2$ R^2: 0.54
BRS Umbu	$\hat{Y} = 5.85 - 0.02x + 0.00002x^2$ R^2: 0.54
	chlorophyll index (CI)
BRS 277	$\hat{Y} = 15.49$ R^2: 0.02
BRS Figueira	$\hat{Y} = 16.26 - 0.006x$ R^2: 0.28
BRS Guatambu	$\hat{Y} = 20.37 - 0.08x + 0.0004x^2 - 0.0000006x^3$ R^2: 0.16
BRS Tarumã	$\hat{Y} = 11.63 + 0.08x - 0.0005x^2 + 0.0000008x^3$ R^2: 0.21
BRS Umbu	$\hat{Y} = 5.76 + 0.25x - 0.002x^2 + 0.000006x^3 - 0.000000008x^4$ R^2: 0.29
	seed yield (SŶ)
BRS 277	$\hat{Y} = 749.80$ R^2: 0.00
BRS Figueira	$\hat{Y} = 1812.44$ R^2: 0.06
BRS Guatambu	$\hat{Y} = 1169.20$ R^2: 0.02
BRS Tarumã	$\hat{Y} = 1229.33 + 5.01x$ R^2: 0.11
BRS Umbu	$\hat{Y} = 2349.23$ R^2: 0.00
	angulation of the flag leaf (AF)
BRS 277	$\hat{Y} = 53.18 - 0.33x + 0.001x^2 - 0.000003x^3$ R^2: 0.14
BRS Figueira	$\hat{Y} = 131.10 - 2.54x + 0.02x^2 - 0.00007x^3 + 0.0000001x^4$ R^2: 0.32
BRS Guatambu	$\hat{Y} = 53.84 - 0.41x + 0.002x^2 - 0.000003x^3$ R^2: 0.11
BRS Tarumã	$\hat{Y} = 44.60 - 0.13x + 0.0003x^2$ R^2: 0.11
BRS Umbu	$\hat{Y} = 123.32 - 2.21x + 0.01x^2 - 0.00006x^3 - 0.0000001x^4$ R^2: 0.11
	number of fertile tillers (NT)
No clipping	$\hat{Y} = 8.07 - 0.03x + 0.00005x^2$ R^2: 0.77
First clipping	$\hat{Y} = 9.38 - 0.04x + 0.00007x^2$ R^2: 0.79
Second clipping	$\hat{Y} = 11.46 - 0.09x + 0.0002x^2 - 0.0000003x^3$ R^2: 0.72
Third clipping	$\hat{Y} = 3.92 - 0.03x + 0.0001x^2 - 0.0000002x^3 + 0.000000000x^4$ R^2: 0.29

The period between sowing and flowering is the period for the vegetative development, this period is extremely important for crops with dual-purpose and required for clipping managements in order to provide the supply of forage during the crop growth. The reduction of seed yield, according to the number of clippings performed, refers to the reconciling of forage supply managements and seed production occurring jointly, where, there is an exploitation of the characteristics of the genotype as a source of feed and grains. The NT character for the five dual-purpose wheat genotypes analyzed under clipping regimes and different sowing densities showed that, for the increment of this character, better magnitudes were obtained using the density of 75 seeds m^{-2}, independent of the adopted clipping regime (Figure 1e, Table 3). Considering the sowing densities studied, the management system with one clipping was superior, evidencing that for the best performance it is recommended the use of this management system.

CONCLUSIONS

The genotype BRS Tarumã is superior in number of fertile tillers and chlorophyll index for all the sowing densities, as well, the flowering is influenced direct by clipping managements.

The sowing density of 75 seeds m^{-2} is not indicated for dual-purpose wheat independent of the clipping management.

The seeds yield is amplified thought the increase in sowing density, however, advancing in clipping levels there is a decrease in forage yield.

RESUMO: O trigo de duplo propósito se destaca como uma alternativa complementar para o fornecimento de forragem durante o período de inverno. Portanto, este trabalho teve como objetivo avaliar as características de desempenho de cinco genótipos de trigo de duplo propósito submetidos a diferentes densidades de semeadura e diferentes manejos de corte. O experimento foi realizado durante as safras de 2016 e 2017. O delineamento experimental foi em blocos ao acaso, organizado em esquema fatorial, com cinco genótipos de trigo de duplo propósito (BRS Tarumã, BRS Umbu, BRS Figueira, BRS Guatambu e BRS 277) x cinco densidades de semeadura (75, 150, 225, 300 e 375 m² de sementes) x quatro operações de clipagem (zero, um, dois e três recortes), dispostos em três repetições. As medidas dos caracteres foram número de perfilhos férteis, rendimento de sementes, ângulo de folha de bandeira, teor de clorofila e floração. O genótipo BRS Tarumã é superior em número de perfilhos férteis e índice de clorofila para todas as densidades de semeadura, assim como o florescimento é influenciado diretamente pelos manejos de corte. A densidade de semeadura de 75 sementes m-2 não é indicada para trigo de dupla finalidade independente do manejo de corte. O rendimento das sementes é amplificado pelo aumento da densidade de semeadura, entretanto, avançando nos níveis de recorte, há uma diminuição no rendimento de forragem.

PALAVRAS-CHAVE: Ajuste de copa das plantas. Competição intraespecífica. Plasticidade fenotípica. Triticum aestivum L.

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