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Forage bromatology is affected by sowing density and cutting management in dual purpose wheat

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ABSTRACT. We evaluated the effects on the nutritional value of the forage of five genotypes of wheat with dual purpose submitted to different sowing densities, as well as different cutting managements. The experiments were carried out in the agricultural crop years of 2013 and 2014 in Frederico Westphalen, RS. The experimental design was a randomized block, organized in a factorial scheme with five genotypes of dual purpose wheat (BRS Tarumã, BRS Umbu, BRS Figueira, BRS Guatambu and BRS 277) x five sowing densities (75, 150, 225, 300 and 375 seeds per square meter) x three cutting managements (one, two and three cuttings), arranged in three replicates. The attributes of interest were obtained through the collection of all plants per experimental unit. These included percentage of crude protein, lipids, neutral detergent fiber and non-fibrous carbohydrates. The bromatological quality of forage from wheat with dual purpose depends on cutting management, genotype and sowing density. The maximum protein fraction and non-fibrous carbohydrates in the forage was obtained at intermediate sowing densities of 300 and 375 seeds per square meter, independent of the genotype for the largest number of cuts.

Key words: Forage wheat; Dual purpose wheat; Cutting management

INTRODUCTION

Wheat is one of the most widely cultivated cereals in the world; some genotypes have the capacity to produce both forage and grain (Szareski et al., 2016a; Koch et al., 2017). Brazil consumed 11 million tons of wheat grain in 2017 (Conab, 2018). It is traditionally produced in the Southern Region of Brazil due to the climate conditions (Jesus Junior et al., 2011; Ferrari et al., 2016a; Szareski et al., 2018). According to Meinerz (2012), the main limitations of livestock activity are the lack of forage in the cool parts of the year, which results in the reduction of milk and meat production; dual-purpose wheat can minimize the negative effects of forage scarcity (Bartmeyer, 2006; Carvalho et al., 2017), and is considered a good alternative for crop-livestock integration (Fontaneli, 2000; Szareski et al., 2016b).

Wheat intended for dual purpose requires that the management techniques be well employed and that they provide various cuttings, high forage yield and regrowth capacity (Carvalho et al., 2016a, Ferrari et al., 2016b; Gehlling et al., 2018). In order to maximize the use of the available resources in the environment, it is possible to increase the forage and grain yield, in the then optimal adjustment of the magnitude of plants in a given physical space, cutting height and mechanized management (Martin et al., 2010; Pelegrin et al., 2016). Del Duca et al. (1999) showed that winter cereals increase protein proportions due to plant arrangement and cutting management. In view of the importance and lack of information on the correct management and arrangement to be applied in dual purpose wheat genotypes, this study aimed to evaluate the effects on the nutritional value of the forage of five genotypes of wheat with dual purpose submitted to different sowing densities, as well as, cutting managements.

MATERIAL AND METHODS

The experiments were carried out in the agricultural crop years of 2013 and 2014 in Frederico Westphalen - RS, at the coordinates: Latitude 27^{o}39'56" S and Longitude 53^{o}42'94" W, with an altitude of 490 m. The soil is classified as Ferric Alumino Red Latosol (Oxisol) and the climate is characterized by Köppen as subtropical Cfa (Moreno, 1961). The experimental design was a randomized block, organized in a factorial scheme with five genotypes of dual purpose wheat (BRS Tarumã, BRS Umbu, BRS Figueira, BRS Guatambu and BRS 277) x five sowing densities (75, 150, 225, 300 and 375 seeds per square meter) x three cutting managements (one, two and three cuts), arranged in three replicates.

The experimental units were composed of 12 lines with two meters in length, spaced 17 centimeters, with a useful area of 4.08 m^2. In both harvests the direct seeding system was applied with 250 kg.ha^{-1} of NPK 10-20-20 for base fertilizer, and 90 kg.ha^{-1} of nitrogen in urea (45% N) for top dressing, with application performed in full tillering stage. The control of insect pests and diseases was carried out in a preventive way.

The cutting managements consisted of: one cut, two cuts, three cuts and the criterion used for the accomplishment of the cuts corresponds to 75% of the plants of the experimental unit presented average height of 30 cm, the cuts were performed manually with 10 cm of stubble. The attributes of interest were obtained through the collection of all plants per experimental unit. The evaluated characters were:

Crude protein (PTN): Measured through the methodology proposed by Nogueira and Souza (2005).

Lipids (LIP): determined by the technique proposed by Bligh and Dyer (1959).

Neutral detergent fiber (NDF): the samples were subjected to autoclaving with neutral detergent at 110°C for 40 min, followed the methodology of Senger et al. (2008).

Non-fibrous carbohydrates (NFC): following the methodology proposed by Carvalho (2015).

The data obtained were submitted to the assumptions based on the homogeneity and normality of the residual variances, after being submitted to analysis of variance at 5% probability by the F test, in order to examine the interaction between wheat genotypes with dual purpose x sowing density x cutting management. The characters that showed significant interaction were dismembered to the simple effects for the qualitative factors (dual purpose wheat genotypes and cutting managements), as well as, the quantitative factor (sowing density) was submitted to linear regression where the highest significance degree of the polynomial by the t test at 5% probability for each level of the qualitative factors. Statistical analyses were performed using the Genes software (Cruz, 2013).

RESULTSAND DISCUSSION

The analysis of variance revealed significance at 5% probability for the interaction of dual purpose wheat genotypes x sowing density x cutting management for crude protein, lipids, neutral detergent fiber and non-fibrous carbohydrates (Table 1). The PTN was expressed for the five genotypes tested (Figure 1; Table 2e; Table 6), being genotype BRS 277 submitted to one and two cuts responsible for the greater magnitudes of this character when the plants are cultivated in the density of 375 seeds/m^2, however, for three cuts the proportion of crude protein was increased in the density 300 seeds m^2.

Table 1. Summary of variance analysis for variables related to bromatology for five dual-purpose wheat genotypes under different sowing densities and cutting managements.

FV	DF	Medium Squares			
		PTN	LIP	NDF	NFC
Genotypes (G)	4	2.9446169*	12.8635897*	70.94854*	30.97544*
Density (D)	4	4.7128124*	2.3463562*	12.46992*	40.57138*
G x D	16	12.2793660*	2.9094635*	21.75466*	72.89365*
Cutting management (C)	2	2.5734627	54.7224088*	7759.17866*	5119.60828*
G x C	8	1.0135663*	4.6210465*	77.48841	72.14724*
D x C	8	4.5186863*	3.8231411*	8.41616*	40.69268*
G x D x C	32	5.8843464*	2.6066296*	20.76672*	43.72490*
Block	2	1.5407339^{ns}	0.2700472^{ns}	0.43469^{ns}	0.19283^{ns}
Residue	148	0.7574066	0.4949281	2.66339	5.05567
CV (%)		14.04	16.73	2.99	8.40

* and ^{ns}, significant at 5% probability and not significant, respectively. PTN = protein; NDF = neutral detergent fiber; NFC = non-fibrous carbohydrates.

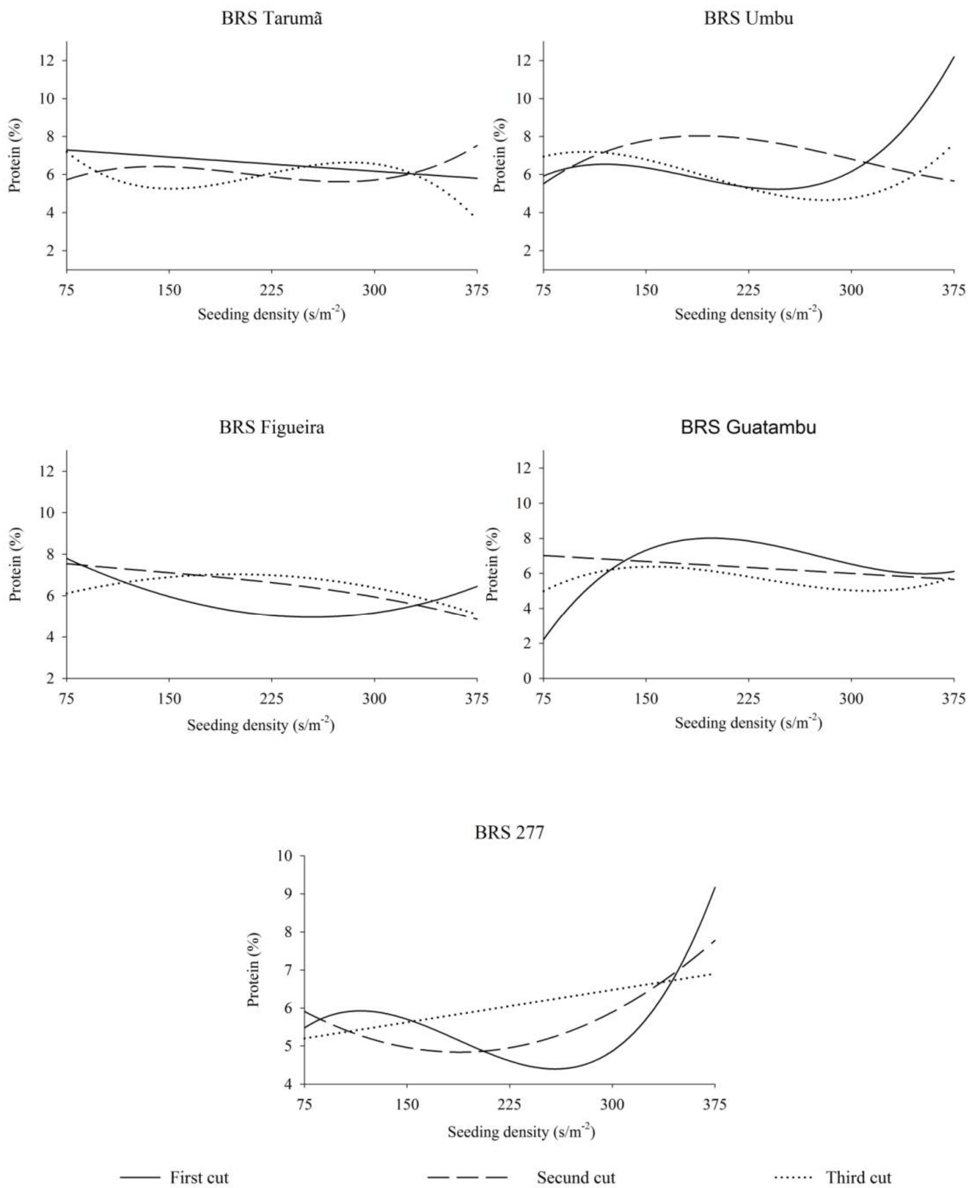

Figure 1. Crude protein at different sowing densities and under cutting managements for five dual-purpose wheat genotypes.

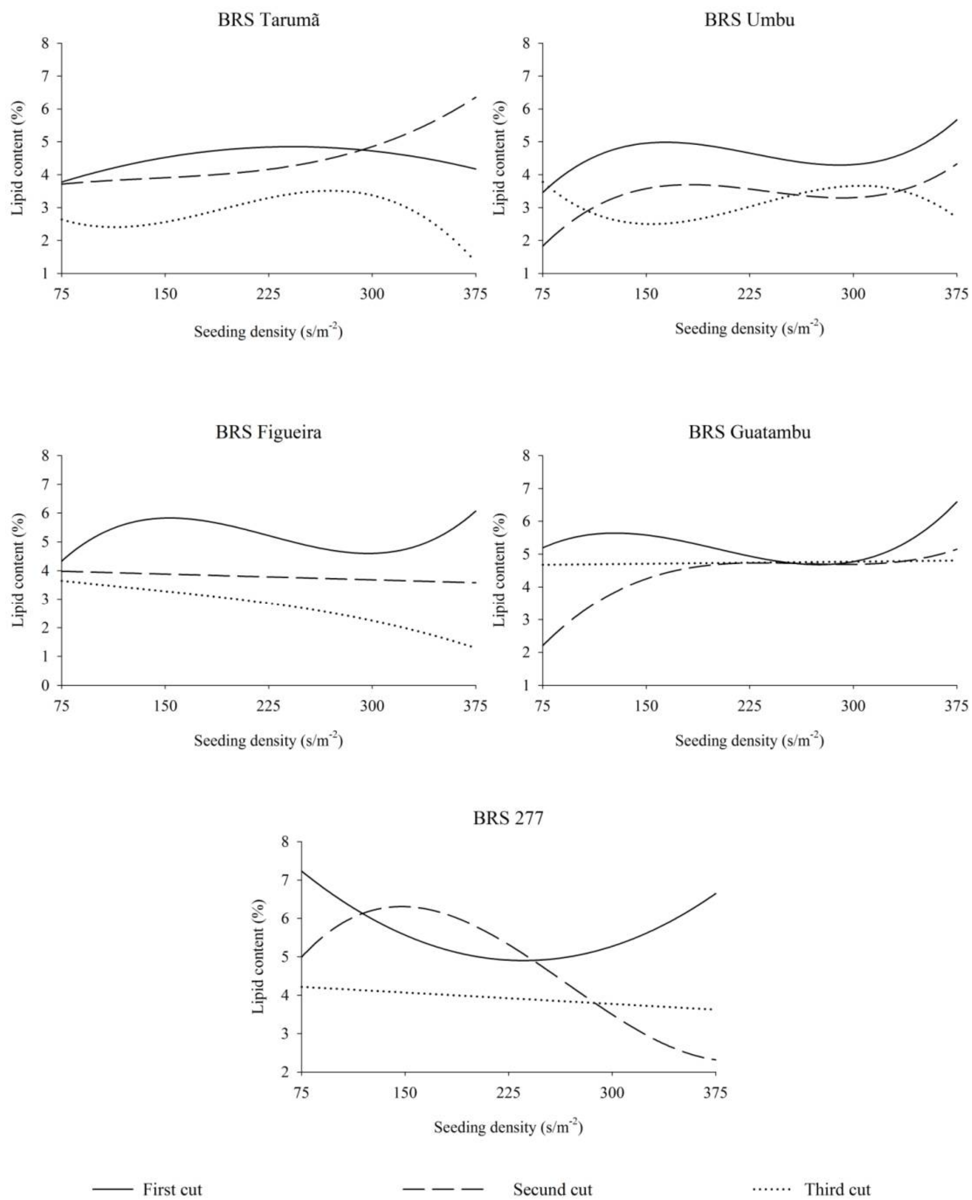

Figure 2. Lipids at different sowing densities and cutting managements for five dual-purpose wheat genotypes.

Table 2. Percentage of crude protein (PTN)for five dual-purpose wheat genotypes under different sowing densities and cutting managements.

PTN			
Sowing density	BRS 277		
	1	2	3
75	5.25 Aβ[1]	5.83 Aαβ	4.58 Aβ
150	6.61 Aα	5.05 Bγ	6.55 Aβ
225	3.25 Bγ	5.14 Aγδ	5.55 Aβ
300	5.78 Bα	5.55 ABβ	7.14 Aα
375	8.94 Aβ	7.92 Aα	6.42 Bαβ
Sowing density	BRS FIGUEIRA		
	1	2	3
75	7.63 Aα	7.18 ABα	5.95 Bβ
150	6.62 Bα	8.53 Aα	7.42 ABαβ
225	4.04 Bγ	4.49 Bδ	6.39 Aαβ
300	5.83 Bα	7.36 Aα	6.67 ABα
375	6.29 Aγ	4.49 Bγ	5.04 Abβ
Sowing density	BRS GUATAMBU		
	1	2	3
75	2.37 Bγ	6.42 Aαβ	5.29 Aβ
150	6.63 Aα	7.18 Aαβ	5.16 Bβγ
225	8.88 Aα	7.29 ABβ	7.63 Aα
300	5.84 Aα	4.94 ABβ	3.82 Bβ
375	6.29 Aγ	5.84 Aβγ	6.11 Aβ
Sowing density	BRS TARUMÃ		
	1	2	3
75	8.19 Aα	5.69 Bβ	7.22 Aα
150	5.97 Aα	6.53 Aβ	5.14 Aγ
225	5.97 Aβ	6.53 Aγ	5.14 Aαβ
300	5.97 Aα	5.83 Aαβ	6.44 Aα
375	6.33 Aγ	7.50 Aα	3.67 Bβ
Sowing density	BRS UMBU		
	1	2	3
75	6.11 Aβ	5.97 Aαβ	6.94 Aαβ
150	5.61 Aα	5.97 Aβγ	6.78 Aαβ
225	6.44 Bβ	10.58 Aα	5.28 Bαβ
300	5.42 Aα	5.00 Aβ	4.75 Aβ
375	12.34 Aα	6.11 Cβ	7.63 α

(1) First cut, (2) Second cut, (3) Third cut.[1] Means followed by the same capital letter in the row at each sowing density for each cultivar and the same Greek letter in the columns at each sowing density for each cut do not differ from each other by the t test at the 5% probability level.

For the LIP character genotype BRS 277 expressed the highest magnitudes when grown in the density of 150 seeds/m^2, as well, submitted to management with two and three cuts, when this genotype is submitted to one cut management, arrangements are obtained with 75 seeds/m^2 (Table 3, Figure 2e, Table 6). BRS Figueira showed that management with a cut in density of 375 seeds/m^2, management with two cuts in density of 225 seeds/m^2 and three cuts in the density of 75 seeds/m^2 (Table 3, Figure 2c, Table 6), expressed superiority for the accumulation of lipids in the forage produced.

BRS Guatambu submitted to management with two and three cuts was specific for the cultivation in the density of 225 seeds/m^2, but when it is only a cut, it is recommended to use 375 seeds/m^2 (Table 3, Figure 2d, Table 6). BRS Tarumã genotype grown at the density of 300 and 375 seeds/m^2 (Table 3, Figure 2a, Table 6) potentiates the magnitude in the cutting managements. Studies by Thacker and Widyaratne (2007), determined that the lipid fraction of the forage can be 1.4%.

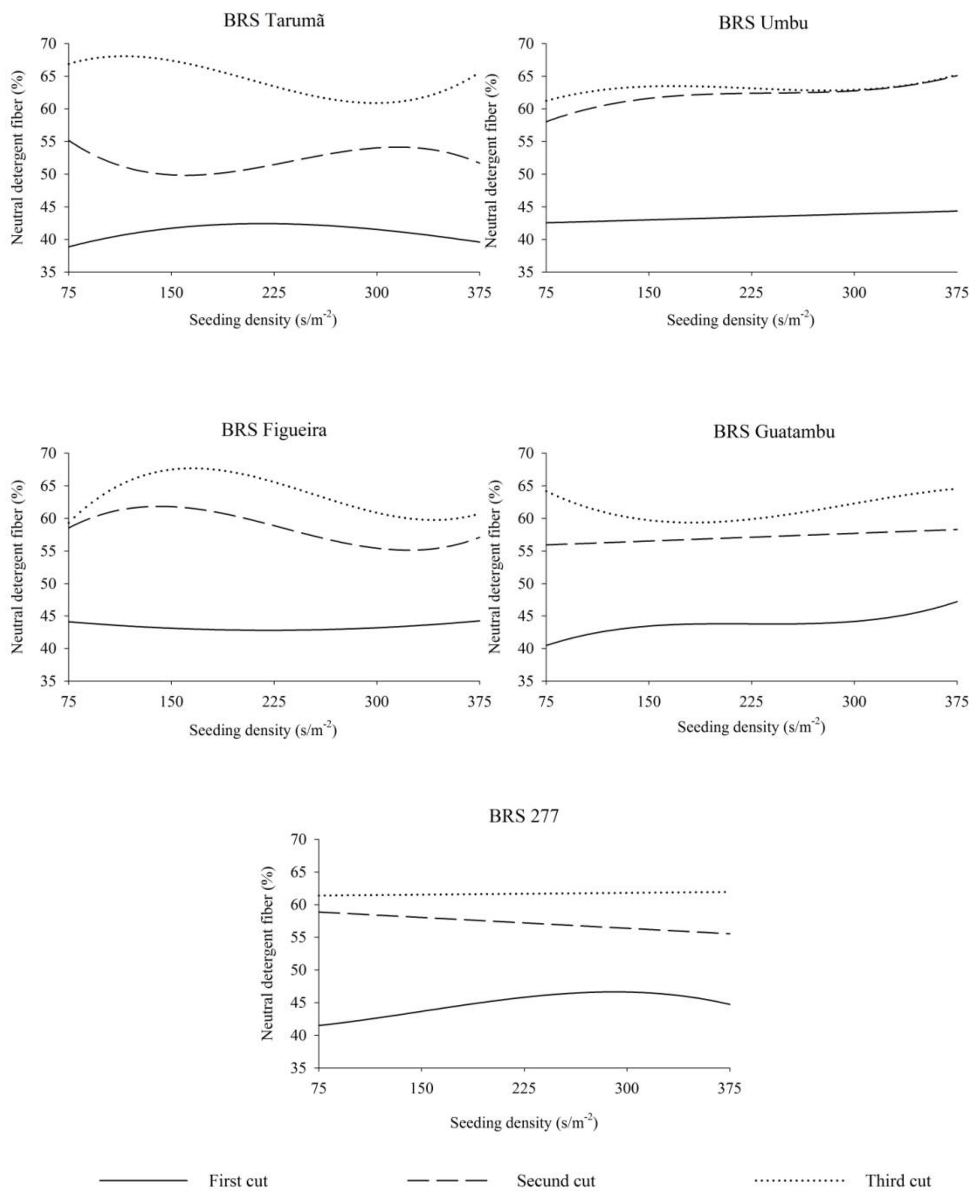

Figure 3. Neutral detergent fiber at different sowing densities under cutting managements for five dual-purpose wheat genotypes.

The NDF showed that the genotype BRS 277 submitted to the management of a cut potentiated this character in the density of 225 seeds/m^2, for the management with two cuts this was specific for the density of 75 seeds/m2 and with three cuts greater effects were expressed in the 375 m^2 seed arrangements (Table 4, Figure 3e, Table 6). The fibrous proportions in forage are constituted of slow digestive structural carbohydrates, being necessary to weigh the food ingested, chewing, salivation and rumination (Branco et al., 2011; Carvalho et al., 2016b).

Table 3. Percentage of lipids (LIP) for five dual-purpose wheat genotypes under different sowing densities and cutting managements.

	LIP		
Sowing density	BRS 277		
	1	2	3
75	7.29 Bα[1]	4.82 Aα	4.04 Aα
150	5.43 Bαβ	6.99 Aα	4.32 Bαβ
225	4.97 Aα	4.29 ABβ	3.68 Bβ
300	5.33 Aα	4.18 Bαβ	4.21 ABαβ
375	6.61 Aα	2.14 Cγ	3.35 Bαβ
Sowing density	BRS FIGUEIRA		
	1	2	3
75	4.33 Aβγ	4.04 Aαβ	3.57 Aα
150	5.82 Aα	3.58 Bβ	3.55 Bβ
225	5.22 Aα	4.15 Aβ	2.44 Bγ
300	4.59 Aα	3.53 ABβ	2.52 Bβ
375	6.07 Aα	3.57 Bβ	1.22 Cγ
Sowing density	BRS GUATAMBU		
	1	2	3
75	5.11 Aβ	2.33 Cγ	3.63 Bα
150	5.89 Aα	3.75 Bβ	5.12 Aα
225	4.47 Bαβ	5.48 ABα	6.43 Aα
300	5.08 Aα	4.19 Aαβ	4.35 Aα
375	6.51 Aα	5.27 Bαβ	4.17 Bα
Sowing density	BRS TARUMÃ		
	1	2	3
75	3.89 Aγ	3.62 ABβ	2.54 Bβ
150	4.39 Aβ	4.29 Aβ	2.95 Bβγ
225	4.55 Aα	3.58 ABβ	2.70 Bβγ
300	5.24 Aα	5.24 Aα	3.76 Bαβ
375	3.96 Bβ	6.26 Aα	1.24 Cγ
Sowing density	BRS UMBU		
	1	2	3
75	3.29 Aγ	1.77 Bγ	3.88 Aα
150	5.64 Aα	3.81 Bβ	2.11 Cγ
225	3.63 Aβ	3.20 Aβ	3.61 Aβ
300	4.99 Aα	3.54 Bβ	3.27 Bβ
375	5.49 Aα	4.27 Bβ	2.79 Cβ

(1) First cut, (2) Second cut, (3) Third cut.[1] Means followed by the same capital letter in the row at each sowing density for each cultivar and the same Greek letter in the columns at each sowing density for each cut do not differ from each other by the t test at the 5% probability level.

BRS Figueira genotype with a cut obtained higher magnitude for the NDF content when grown at 75 seeds/m^2 and submitted to two-cut management (Table 4, Figure 3c, Table 6). The excess of neutral detergent fiber in the forage chemical composition may interfere with forage intake by ruminants, thus limiting the consumption and growth of the animal (Branco et al., 2011). For BRS Guatambu genotype with one and three cuts greater accumulations of fiber occur in crops using 375 m^2 seeds, however, it is possible to reduce sowing density to 300 seeds/m^2 (Table 4, Figure 3d, Table 6) when the recommended management is two cuts.

The genotype BRS Tarumã presented different ideal sowing densities for each cut management. With a cut, the highest magnitude in the density of 225 seeds/m^2, with two cuts the greatest magnitude for the character of NDF was revealed using the density of 300 seeds/m^2 and for the management with three cuts, in the density of 75 seeds/m^2, it was obtained the greater magnitude (Table 4, Figure 3a, Table 6). The increase of the fibers in the second and third cuttings in relation to the first one confirms the statements of Blaser (1964), where the advancement of the phenological stages of development of the plant potentiate the accumulation of fibers, cellulose and lignin. Research by Henz et al. (2016), when evaluating the bromatological performance of dual-purpose wheat, stated that the increase in crude protein results in the decrease of non-fibrous carbohydrates, where the neutral detergent fibers are fundamental for animal consumption and performance.

Table 4. Percentage of neutral detergent fiber (NDF) for five dual-purpose wheat genotypes at different sowing densities and cutting managements.

	NDF		
Sowing density	BRS 277		
	1	2	3
75	41.70 Bβ[1]	59.73 Aα	61.57 Aβγ
150	42.80 Cβ	57.99 Bβγ	61.72 Aγ
225	47.09Cα	56.02 Bβ	60.96 Aβ
300	45.77 Cα	55.36 Bγ	61.94 Aα
375	44.94 Cαβ	56.89 Bβ	62.14 Aβ
Sowing density	BRS FIGUEIRA		
	1	2	3
75	44.19 Bαβ	59.12 Aα	59.12 Aγ
150	43.00 Cβ	59.41 Bβ	68.23 Aα
225	42.55 Bβ	62.45 Aα	64.41 Aαβ
300	43.61 Cα	53.03 Bγ	61.61 Aαβ
375	44.06 Cβ	57.69 Bβ	60.53 Aβ
Sowing density	BRS GUATAMBU		
	1	2	3
75	40.50 Cβ	55.74 Bβ	63.84 Aβγ
150	43.21 Cβ	55.99 Bγ	60.98 Aγ
225	44.09 Bβ	57.97 Aβ	57.97 Aγ
300	43.93 Cα	58.40 Bβ	63.54 Aα
375	47.24 Cα	57.48 Bβ	64.22 Aαβ
Sowing density	BRS TARUMÃ		
	1	2	3
75	39.62 Cβ	54.84 Bβ	67.33 Aα
150	38.71 Cγ	51.13 Bδ	65.51 Aβ
225	46.93 Cα	49.58 Bγ	66.24 Aα
300	38.52 Cβ	55.27 Bγ	59.01 Aβ
375	40.35 Cγ	51.34 Bγ	66.05 Aα
Sowing density	BRS UMBU		
	1	2	3
75	42.26 Cαβ	57.83 Bα	61.17 Aγ
150	46.05 Bα	62.38 Aα	63.60 Aβγ
225	39.10 Bγ	61.22 Aα	62.88 Aβ
300	44.55 Bα	63.54 Aα	63.06 Aα
375	45.27 Bαβ	64.89 Aα	65.17 Aα

(1) First cut, (2) Second cut, (3) Third cut.[1] Means followed by the same capital letter in the row at each sowing density for each cultivar and the same Greek letter in the columns at each sowing density for each cut do not differ from each other by the t test at the 5% probability level.

The NFC show that the genotype BRS 277 when submitted to a cut, potentiate the magnitude of this character in the arrangement of 150 seeds/m^2, for two cuttings better results are obtained through the density of 225 seeds/m^2, for three cuts this bromatological aspect may be maximized by growing at the density of 75 seeds/m^2 (Table 5, Figure 4e, Table 6).

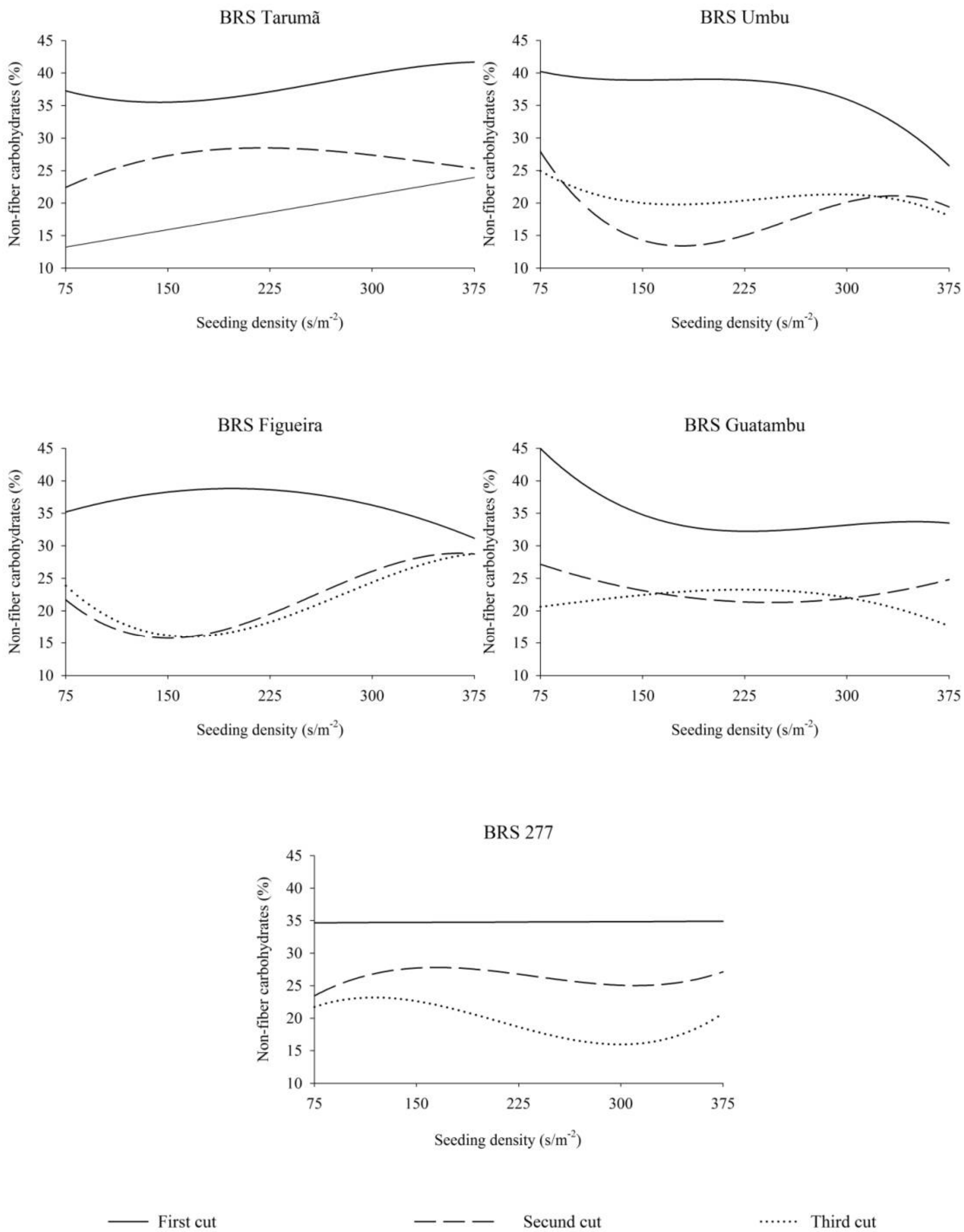

Figure 4. Non-fibrous carbohydrates at different sowing densities and under cutting managements for five dual-purpose wheat genotypes.

The genotype BRS Figueira submitted to the two and three cut management obtained the highest magnitudes in the density of 375 seeds m^2, but for a cut the optimal density was 225 seeds/m^2 (Table 5, Figure 4c, Table 6). Research indicates that high proportions of non-fibrous carbohydrates confer good forage quality and rapid digestibility by ruminants (Mertens, 1987).

Table 5. Percentage of non-fibrous carbohydrates (NFC) for five dual-purpose wheat genotypes under different sowing densities and cutting managements.

NFC			
Sowing density	BRS 277		
	1.0	2.0	3.0
75.0	32.97 Aδ[1]	24.04 Bβ	22.22 Bαβ
150.0	36.92 Aα	25.35 Bα	20.57 Cαβ
225.0	34.55 Aγ	30.30 Bα	21.69 Cβ
300.0	35.55 Aβ	22.69 Bαβ	13.93 Cβ
375.0	33.94 Aβ	27.72 Bαβ	21.25 Cβγ
Sowing density	BRS FIGUEIRA		
	1.0	2.0	3.0
75.0	35.34 Aγδ	21.89 Bβ	24.21 Bαβ
150.0	37.69 Aα	15.00 Bβ	14.82 Bγ
225.0	39.49 Aβ	20.68 Bβ	20.31 Bβ
300.0	35.67 Aβ	25.30 Bα	23.02 Bα
375.0	31.31 Aβ	28.93 Aα	29.13 Aα
Sowing density	BRS GUATAMBU		
	1.0	2.0	3.0
75.0	44.63 Aα	27.22 Bαβ	20.96 Cβ
150.0	36.12 Aα	23.57 Bα	21.04 Bαβ
225.0	30.25 Aδ	19.54 Cβ	25.36 Bα
300.0	34.51 Aβ	23.90 Bαβ	20.63 Bα
375.0	33.17 Aβ	24.13 Bβ	17.99 Cγ
Sowing density	BRS TARUMÃ		
	1.0	2.0	3.0
75.0	36.74 Aγ	22.99 Aβ	12.58 Cγ
150.0	37.66 Aα	24.99 Bα	16.42 Cγ
225.0	33.92 Aγ	31.95 Aα	18.53 Bβ
300.0	42.06 Aα	25.06 Bα	22.54 Bα
375.0	41.16 Aα	25.91 Bαβ	22.89 Bβ
Sowing density	BRS UMBU		
	1.0	2.0	3.0
75.0	40.99 Aβ	27.85 Bα	25.04 Bα
150.0	35.80 Aα	14.54 Cβ	19.59 Bβ
225.0	43.52 Aα	14.60 Cγ	20.97 Bβ
300.0	32.87 Aβ	20.41 Bβ	20.91 Bα
375.0	26.51 Aγ	19.30 Bγ	18.11 Bγ

(1) First cut, (2) Second cut, (3) Third cut.[1] Means followed by the same capital letter in the row at each sowing density for each cultivar and the same Greek letter in the columns at each sowing density for each cut do not differ from each other by the t test at the 5% probability level.

The genotype BRS Guatambu submitted to one and two cuts showed that the density of 75 seeds/m^2 increased this character, for three cuts this genotype obtained greater magnitude when grown with 225 seeds/m^2 (Table 5, Figure 4a, Table 6). BRS Tarumã intended for a cut can maximize this character through the density of 300 seeds m^2, in two cuts it indicates 225 seeds/m^2 and three cuts should increase this item to 375 seeds/m^2 (Table 5, Figure 4a, Table 6). This study is essential for the maximization of the bromatological quality of the forage obtained through dual purpose wheat genotypes, since the genetic specificity of the characteristics of the genotypes reflects in the peculiarities of the adjustment of the optimum sowing density and the number of cuts to be used so that the forage production system is sustainable.

Table 6. Equations for nutritional values of five dual-purpose wheat genotypes at different sowing densities and cutting managements.

Trait	Cuts	Genotypes	Equations
NFC	1	BRS Tarumã	$\hat{Y}$= -22.8 + 1.54x - 0,01x^2 + 0.00004x^3 - 0.0000000x^4 R^2= 0.92
NFC	2	BRS Tarumã	$\hat{Y}$= 85.13 - 1.65x + 0.01x^2 - 0.00004x^3 + 0.00000005x^4 R^2= 0.62
NFC	3	BRS Tarumã	$\hat{Y}$= 10.5 + 0.03x R^2= 0.73
NFC	1	BRS Umbu	$\hat{Y}$= 143.9 - 2.58x + 0.02x^2 - 0.00006x^3 + 0.0000001x^4 R^2= 0.88
NFC	2	BRS Umbu	$\hat{Y}$= 66.1 - 0.71x + 0.003x^2 - 0.000009x^3 R^2= 0.82
NFC	3	BRS Umbu	$\hat{Y}$= 40.0 - 0.28x + 0.001x^2 - 0.000001x^3 R^2= 0.78
NFC	1	BRS Figueira	$\hat{Y}$= 29.4 + 0.09x - 0.0002x^2 R^2= 0.84
NFC	2	BRS Figueira	$\hat{Y}$= 44.0 - 0.43x + 0.0021x^2 - 0.000002x^3 R^2= 0.80
NFC	3	BRS Figueira	$\hat{Y}$= 89.9 - 1.51x + 0.01x^2 - 0.00003x^3 - 0.00000003x^4 R^2= 0.88
NFC	1	BRS Guatambu	$\hat{Y}$= 25.1 + 0.65x - 0.007x^2 + 0.00002x^3 - 0.00000003x^4 R^2= 0.97
NFC	2	BRS Guatambu	$\hat{Y}$= 33.5 - 0.10x + 0.0002x^2 R^2 = 0.45
NFC	3	BRS Guatambu	$\hat{Y}$= 62.7 - 1.08x + 0.009x^2 - 0.00002x^3 + 0.00000003x^4 R^2= 0.63
NFC	1	BRS 277	$\hat{Y}$= 34.6
NFC	2	BRS 277	$\hat{Y}$= 84.0 - 1.60x + 0.01x^2 - 0.00004x^3 + 0.00000005x^4 R^2= 0.55
NFC	3	BRS 277	$\hat{Y}$= 73.9 - 1.35x + 0.01x^2 - 0.00003x^3 + 0.00000005x^4 R^2= 0.67
FDN	1	BRS Tarumã	$\hat{Y}$= 128.1 - 2.28x + 0.01x^2 - 0.00006x^3 + 0.0000001x^4 R^2= 0.94
FDN	2	BRS Tarumã	$\hat{Y}$= 73.2 - 0.35x + 0.001x^2 - 0.000002x^3 R^2= 0.43
FDN	3	BRS Tarumã	$\hat{Y}$= 115.0 - 1.24x + 0.01x^2 - 0.00003x^3 + 0.0000000x^4 R^2= 0.82
FDN	1	BRS Umbu	$\hat{Y}$= -35.6 + 1.94x - 0.01x^2 + 0.00004x^3 + 0.00000005x^4 R^2= 0.56
FDN	2	BRS Umbu	$\hat{Y}$= 42.0
FDN	3	BRS Umbu	$\hat{Y}$= 53.9 + 0.14x - 0.0006x^2 + 0.000001x^3 R^2= 0.72
FDN	1	BRS Figueira	$\hat{Y}$= 45.7 - 0.02x + 0.0000006x^2 R^2= 0.35
FDN	2	BRS Figueira	$\hat{Y}$= 118.5 - 1.58x + 0.01x^2 - 0.00004x^3 + 0.0000001x^4 R^2= 0.87
FDN	3	BRS Figueira	$\hat{Y}$= 33.7 + 0.48x - 0.002x^2 + 0.000002x^3 R^2= 0.79
FDN	1	BRS Guatambu	$\hat{Y}$= 32.1 + 0.15x - 0.0007x^2 + 0.000001x^3 R^2= 0.91
FDN	2	BRS Guatambu	$\hat{Y}$= 55.3 + 0.007x R^2 = 0.27
FDN	3	BRS Guatambu	$\hat{Y}$= 35.5 + 0.79x - 0.007x^2 + 0.00002x^3 + 0.00000003x^4 R^2= 0.91
FDN	1	BRS 277	$\hat{Y}$= 67.4 - 0.67x + 0.005x^2 - 0.00001x^3 + 0.00000002x^4 R^2= 0.88
FDN	2	BRS 277	$\hat{Y}$= 59.6 - 0.01x R^2= 0.26
FDN	3	BRS 277	$\hat{Y}$= 61.2
LIP	1	BRS Tarumã	$\hat{Y}$= 2.5 + 0.01x - 0,00003x^2 R^2= 0.32
LIP	2	BRS Tarumã	$\hat{Y}$= -9.05 + 0.31x - 0.0025x^2 + 0.000008x^3 - 0.000000009x^4 R^2= 0.83
LIP	3	BRS Tarumã	$\hat{Y}$= -7.33 + 0.25x - 0.002x^2 + 0.000007x^3 - 0.000000009x^4 R^2= 0.81
LIP	1	BRS Umbu	$\hat{Y}$= -23.1 + 0.63x - 0.004x^2 + 0.00001x^3 - 0.00000002x^4 R^2= 0.87
LIP	2	BRS Umbu	$\hat{Y}$= -10.6 + 0.28x - 0.001x^2 + 0.000005x^3 -0.00000001x^4 R^2= 0.89
LIP	3	BRS Umbu	$\hat{Y}$= 8.5 - 0.09x + 0.0004x^2 - 0.0000006x^3 R^2= 0.36
LIP	1	BRS Figueira	$\hat{Y}$= -1.3 + 0.11x - 0.0005x^2 + 0.0000008x^3 R^2= 0.76
LIP	2	BRS Figueira	$\hat{Y}$= 4.07
LIP	3	BRS Figueira	$\hat{Y}$= -4.69 + 0.21x - 0.001x^2 + 0.000005x^3 - 0.000000006x^4 R^2= 0.86
LIP	1	BRS Guatambu	$\hat{Y}$= 2.25 + 0.06x - 0.0003x^2 + 0.0000005x^3 R^2= 0.50
LIP	2	BRS Guatambu	$\hat{Y}$= 13.2 - 0.31x + 0.0028x^2 - 0.000009x^3 + 0.00000001x^4 R^2 = 0.82
LIP	3	BRS Guatambu	$\hat{Y}$= 4.64
LIP	1	BRS 277	$\hat{Y}$= 9.9 - 0.04x + 0.00009x^2 R^2= 0.59
LIP	2	BRS 277	$\hat{Y}$= -21.5 + 0.63x - 0.004x^2 + 0.00001x^3 + 0.00000002x^4 R^2= 0.81
LIP	3	BRS 277	$\hat{Y}$= 4.36
PTN	1	BRS Tarumã	$\hat{Y}$= 7.66
PTN	2	BRS Tarumã	$\hat{Y}$= 2.2 + 0.07x - 0.0003x^2 + 0.0000006x^3 R^2= 0.66
PTN	3	BRS Tarumã	$\hat{Y}$= 14.9 - 0.15x + 0.0007x^2 - 0.00000x^3 R^2= 0.63
PTN	1	BRS Umbu	$\hat{Y}$= 24.1 - 0.47x + 0.004x^2 - 0.00001x^3 + 0.00000002x^4 R^2= 0.94
PTN	2	BRS Umbu	$\hat{Y}$= 57.0 - 1.33x + 0.01x^2 - 0.00003x^3 + 0.00000004x^4 R^2= 0.91
PTN	3	BRS Umbu	$\hat{Y}$= 3.36 + 0.08x - 0.0005x^2 + 0.0000009x^3 R^2= 0.73
PTN	1	BRS Figueira	$\hat{Y}$= -10.5 + 0.48x - 0.004x^2 + 0.00001x^3 - 0.00000002x^4 R^2= 0.76
PTN	2	BRS Figueira	$\hat{Y}$= -36.8 + 1.12x - 0.009x^2 + 0.00002x^3 - 0.00000003x^4 R^2= 0.80
PTN	3	BRS Figueira	$\hat{Y}$= 4.6 + 0.02x - 0.00006x^2 R^2= 0.43
PTN	1	BRS Guatambu	$\hat{Y}$= 11.4 - 0.31x + 0.0035x^2 - 0.00001x^3 + 0.00000002x^4 R^2= 0.91
PTN	2	BRS Guatambu	$\hat{Y}$= 7.35
PTN	3	BRS Guatambu	$\hat{Y}$= 38.1 - 0.86x + 0.007x^2 - 0.00002x^3 + 0.00000003x^4 R^2= 0.80
PTN	1	BRS 277	$\hat{Y}$= 1.24 + 0.09x - 0.0005x^2 + 0.000001x^3 R^2= 0.76
PTN	2	BRS 277	$\hat{Y}$= 7.8 - 0.03x + 0.00008x^2 R^2= 0.56
PTN	3	BRS 277	$\hat{Y}$= 4.77

NFC: Non-fibrous carbohydrates, NDF: Neutral detergent fiber, LIP: Lipids, PTN: Crude protein.

The genotype BRS Guatambu submitted to one and two cuts showed that the density of 75 seeds/m2 increased this character, for three cuts this genotype obtained greater magnitude when grown with 225 seeds/m2 (Table 5, Figure 4a, Table 6). BRS Tarumã intended for a cut can maximize this character through the density of 300 seeds m2, in two cuts it indicates 225 seeds/m2 and three cuts should increase this item to 375 seeds/m2 (Table 5, Figure 4a, Table 6). This study is essential for the maximization of the bromatological quality of the forage obtained through dual purpose wheat genotypes, since the genetic specificity of the characteristics of the genotypes reflects in the peculiarities of the adjustment of the optimum sowing density and the number of cuts to be used so that the forage production system is sustainable.

CONCLUSIONS

The bromatological quality of forage from wheat with dual purpose depends on cutting management, genotype and sowing densities. Maximization of protein fraction and non-fibrous carbohydrates in the forage is obtained at intermediate sowing densities of 300 and 375 seeds per square meter, independent of the genotype, for the largest number of cuttings.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Blaser RE (1964). Symposium on forage utilization: effects of fertility levels and stage of maturity on forage nutritive value. *J. Anim. Sci.* 23(2): 246-253.

Bligh EG and Dyer WJA (1959). Rapid method of total lipid extraction and purification. *Can. J. Physiol. Biochem.* 37(1): 911-917.

Branco RH, Rodrigues MT, Silva MMC, Rodrigues CAF, et al. (2011). Desempenho de cabras em lactação alimentadas com dietas com diferentes níveis de fibra oriundas de forragem com maturidade avançada. *Rev. Bras. Zootec.* 40(5): 1061-1071. Doi: http://dx.doi.org/10.1590/S1516-35982011000500018

Carvalho IR (2015). Modelos biométricos aplicados ao melhoramento genético de trigo de duplo propósito. 75 f. Master's Thesis in Agronomy, Universidade Federal de Santa Maria, Santa Maria.

Carvalho IR, Nardino M, Demari GH, Szareski VJ, et al. (2016a). Biometry and Genetic Breeding of dual purpose wheat. *Inter. J. Curr. Res.* 8: 34539-34545.

Carvalho IR, Nardino M, Demari GH, Pelegrin AJ, et al. (2016b). Sowing date and multivariate analysis of yield and physiological components in elite wheat genotypes. *Inter. J. Curr. Res.* 8: 40828-40833.

Carvalho IR, Nardino M, Follmann DN, Demari GH, et al. (2017). Path analysis of grain yield associated characters in wheat (*Triticum aestivum* L.) Brasilians. *Aust. J. Crop Sci.* 11: 1406-1410. Doi: 10.21475/ajcs.17.11.11.pne484

Conab - Companhia Nacional de Abastecimento (2018) Safra 2017/18: Décimo segundo levantamento, Setembro 2018. Brasília, DF.

Cruz CD (2013). GENES a software package for analysis in experimental statistics and quantitative genetics. Acta Scien. 35(1): 271-276. Doi: http://dx.doi.org/10.4025/actasciagron.v35i3.21251

Del Duca LJA, Molin R and Sandini I (2000). Experimentação de genótipos de trigo para duplo propósito no Paraná, em 1999. Embrapa Trigo, Passo Fundo. Boletim de Pesquisa e Desenvolvimento 6.

Ferrari M, Szareski VJ, Nardino M, Pelegrin AJ, et al. (2016a). Effects of sources and split application of nitrogen fertilizer on wheat genotypes performance. *Aust. J. Crop Sci.* 10(12): 1669-1674. Doi: 10.21475/ajcs.2016.10.12.p7741

Ferrari M, Nardino M, Carvalho IR, Szareski VJ, et al. (2016b). Manejos e fontes de nitrogênio nos componentes de afilhamento de trigo. *Agrária.* 11(3): 178-185. Doi: 10.5039/agraria.v11i3a5379

Fontaneli RS, Ambrosi I, Santos HP, Ignaczak JC, et al. (2000). Análise econômica de sistemas de produção de grãos com pastagens anuais de inverno, em sistema de plantio direto. *Pesq. Agrop. Bras.* 35(11): 2129-2137.

Gehlling VM, Segalin SR, Troyjack C, Pimentel JR, et al. (2018). Temporal Waterlogging and Physiological Performance of Wheat (*Triticum aestivum* L.) seeds. *J. Agric. Sci* .10(6): 363. Doi:10.5539/jas.v10n6p363

Henz EL, Almeida PSG, Velho JP, Nörnberg JL, et al. (2016). Produção de trigo duplo propósito com diferentes doses de adubação nitrogenada em cobertura. *Semina. Ciênc. Agrar.* 37(2): 1091-1100.

Jesus Júnior C, Sidonio L and Moraes VEG (2011). Panorama das importações de trigo no Brasil. BNDES Setorial. Rio de Janeiro: Banco Nacional de Desenvolvimento Econômico e Social. *BNDES Setorial.* 34: 389-420.

Koch F, Carvalho IR, Szareski VJ, Demari GH, et al. (2017). Ecophysiological responses of dual-purpose wheat originating from different cutting management systems. *Semina. Cienc. Agrár.* 38(3): 1641-1650. Doi: http://dx.doi.org/10.5433/1679-0359.2017v38n3p1641

Martin TN, Simionatto CC, Bertoncelli P, Ortiz S et al. (2010). Fitomorfologia e produção de cultivares de trigo duplo propósito em diferentes manejos de corte e densidades de semeadura, *Cienc. Rural.* 40(8): 1695-1701. Doi: http://dx.doi.org/10.1590/S0103-84782010000800004.

Meinerz GR, Olivo CJ, Fontaneli RS, Agnolin CA, et al. (2012). Produtividade de cereais de inverno de duplo propósito na depressão central do Rio Grande do Sul. *Rev. Bras. Zootec.* 41(4): 873-882. Doi: http://dx.doi.org/10.1590/S1516-35982012000400007

Mertens DR (1987). Predicting intake and digestibility using mathematical models of ruminal function. *J. Anim. Sci.* 64(5): 1548-1558.

Moreno JA (1961). Clima do Rio Grande do Sul. Secretaria deAgricultura, Porto Alegre.

Pelegrin AJ, Carvalho IR, Ferrari M, Nardino M, et al. (2016). Evaluation of solvent retention capacity of wheat (*Triticum aestivum* L.) flour depending on genotype and different timing of nitrogenous fertilizer application. *Afri. J. Agri. Res.* 11(43): 4389-4394. Doi: 10.5897/AJAR2016.11610

Senger CCD, Kozloski GV, Sanchez LMB, Mesquita FR, et al. (2008). Evaluation of autoclave procedures for fibre analysis in forage and concentrate feedstuffs. *Anim. Feed Sci. Tech.* 146: 169-174.

Szareski VJ, Carvalho IR, Nardino M, Demari GH, et al. (2016a). Seeding rate and physiological quality of dual purpose wheat seeds. *Afri. J. Agri. Res.* 11(43): 4367-4374.

Szareski VJ, Carvalho IR, Nardino M, Demari GH, et al. (2016b). Ethyl Methane Sulfonate and its effects on morphological traits of dual - pourpose wheat. *Inter. J. Cur. Res.* 8(10): 39707-39713. Doi: http://dx.doi.org/10.1590/0103-8478cr20151582

Szareski VJ, Carvalho IR, Kehl K, Levien AM, et al. (2018). Phenotypic and predicted genetic approaches for genotype ranking of wheat seed yield in Brazil. *Genet. Mol. Res.* 17: GMR18026.

Thacker PA and Widyaratne GP (2007). Nutritional value of diets containing graded levels of wheat distillers grains with solubles fed to broiler chicks. *J. Sci. Food Agric.* 87(7): 1386-1390.

Zilio M, Peloso JA and Mantovani A (2017). Produção de forragem e de grãos de trigo de duplo propósito submetido a diferentes densidades de semeadura, adubação nitrogenada e manejos de corte. *Rev. Cien. Agrovet.* 16(4): 367-375. Doi: http://dx.doi.org/10.5965/22381171164201736

