AGRONOMIC TRAITS OF DUAL-PURPOSE WHEAT WITH DIFFERENT PLANT ARCHITECTURES UNDER DEFOLIATION STRATEGIES

CARACTERÍSTICAS AGRONÔMICAS DE TRIGO DUPLO-PROPÓSITO COM DIFERENTES ARQUITETURAS DE PLANTAS SOB ESTRATÉGIAS DE DESFOLHAÇÃO

Giselle Regina RODOLFO[1]; Clovis Arruda SOUZA[2]; André Fischer SBRISSIA[2]; Deivid Luis Vieira STEFEN[1]
1. Doutores em Produção Vegetal, Universidade do Estado de Santa Catarina – UDESC, Lages, SC, Brasil;
2. Professores, Doutores, Universidade do Estado de Santa Catarina – UDESC, Lages, SC, Brasil. souza_clovis@yahoo.com.br

ABSTRACT: Crop-livestock system implies in the balance of appropriate animal foraging, minimizing effects on grain production on the same crop season. This study aims to assess canopy heights (20 and 30 cm) and cuts number (no cut, 1, 2 and 3 cuts) effects on wheat productivity and bromatological composition of forage, and grain yield of BRS Umbu and BRS Tarumã cultivars. Regardless cuts number and cultivars, 30 cm provided higher forage productivity (1032 and 1348 kg DM ha^{-1}) than 20 cm (554 and 909 kg DM ha^{-1}), for BRS Umbu and Tarumã, respectively, in average crop seasons. For both cultivars and crop seasons, mean values of 26% crude protein, 55% neutral detergent fiber and 26% acid detergent fiber were obtained. At 20 cm no difference in grain yield was observed as a function of cuts number with 3780 kg ha^{-1} for BRS Umbu, in average crop seasons and 4306 kg ha^{-1} in 2014, for BRS Tarumã. However, at 30 cm, the grain yield was penalized at least in 30% as a result only third cut. These results indicate that wheat as dual-purpose can be employed in southern Brazil in grazing systems in forage shortage times and then produce grains without yield penalties as a function to the management used.

KEYWORDS: *Triticum aestivum* L. Integrated crop livestock system. Management height. Cuts number. Grain yield.

INTRODUCTION

In southern Brazil one of the biggest limitations to livestock farming is forage lack in period from fall to early winter; a time when the summer forage species reduced productivity, and winter forage species are still not satisfactorily developed. In addition to traditionally alternatives used in critical period, such as annual ryegrass and oat pastures, silage and hay, dual-purpose cereals like wheat can provide forage to animals and grains in same crop (MARIANI et al., 2012). Moreover, wheat is considered a forage with good nutritional quality, when grazed on vegetative growth (HARRISON et al., 2011; HARRISON et al., 2014).

Wheat cultivars differ in some traits such as tiller emission number, plant architecture, cycle length and consequently the productive potential (SANGOI et al., 2007). Plant architecture with erect growth habit improves the light distribution, canopy light use efficiency, and biomass production, mainly reducing the self-shading among leaves to allow more radiation to penetrate into the lower parts of canopies (LI et al., 2016; SAKAMOTO et al., 2006). Among brazilian dual-purpose wheat cultivars (grains and animal fodder), stands out, with plant architecture very distinct, BRS Umbu which shows erect leaves habit and BRS Tarumã that presents prostrate leaves habit. BRS Umbu, potentially targets for cutting-hay and silage, large dry matter productivity, which reaches up 10 tons ha^{-1}. Further, the spike in this cultivar lack awns, and thus do not cause irritation for esophageal mucosa (LEHMEN et al., 2014). This cultivar also displays high grain yield, reaching 3.47 tons ha^{-1} (MEINERZ et al., 2011), which is of interest as this plant fraction has great energy content. Moreover, high crude protein (CP) concentrations (up 83 g kg^{-1} dry matter) have been reported in BRS Umbu silage (LEHMEN et al., 2014). BRS Tarumã cultivar with prostrate habit and smaller leaf blades, has a greater potential for direct grazing, with accumulated forage production (DM) of 7.42 tons ha^{-1} (TAFFAREL et al., 2017); grain yield of 3.54 tons.ha^{-1} (HENZ et al., 2016), presents a long vegetative cycle (ZANON et al., 2012) and forage crude protein around 195.6 g kg^{-1} DM. Further, the spikes in this cultivar is awneds. Due to awns presence, this cultivar is not recommended for silage production.

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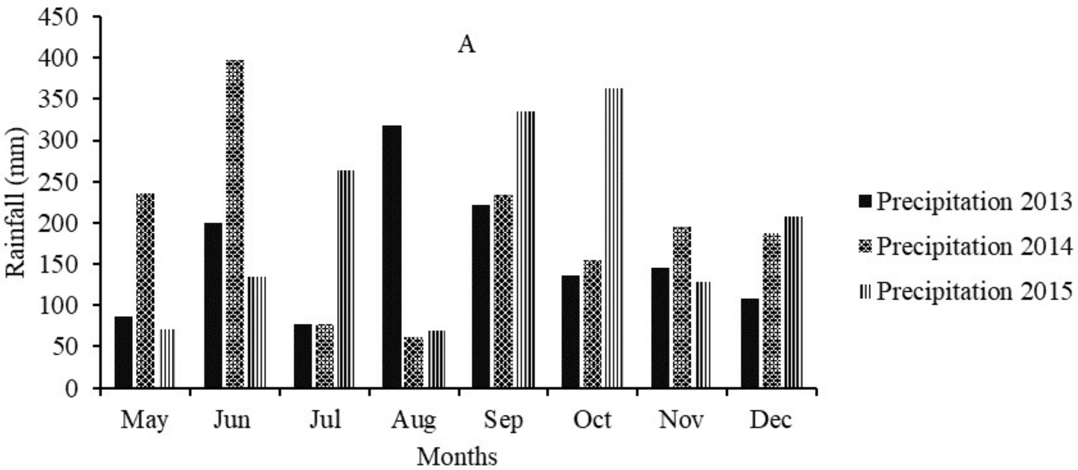
Management strategies in wheat cultivars with different growth habits and development cycle influence canopy structure, forage, and grains (BUTCHEE; EDWARDS, 2013). In most international works carried out with dual-purpose winter cereals, phenological stage predominates as a management tool, suggesting that cuts should be made up to when the stem starts to elongate, until growth stage code 30 (GS 30) (ZADOKS et al., 1974). However, there are some recommendations that these crops can be grazed or cut when plants reach 30 cm height (FONTANELI et al., 2009; HASTENPFLUG et al., 2011a; MARTIN et al., 2013; MEINERZ et al., 2012). Control of defoliation intensity avoids damage to apical meristem, and keep source-sink relationship equilibrium by shoot remove, enabling grain production (MARTIN et al., 2010; PEREIRA et al., 2012). Thus, it is important to consider the intensity and cuts number in dual-purpose cereal production system.

Dual-purpose cultivars used in southern Brazil is mainly concentrated in some research projects in Rio Grande do Sul, Paraná and recently in Santa Catarina states. Due to lack of information and management tools complexity, it is necessary a refinement of management recommendations for dual-purpose wheat cultivars with different growth habits, highlighting the use of more practical management tools, such as plant height. This study aims to assess canopy heights and cuts number effects on wheat agronomic characteristics such as forage productivity, bromatological composition, and grain yield of BRS Umbu and BRS Tarumã cultivars.

MATERIALS AND METHODS

Experiments were conducted in Lages, Santa Catarina state, southern Brazil, from May (seeding day 5) to November (harvest day 26) in 2013 and 2014 with wheat BRS Umbu cultivar; and same period in 2014 and 2015 with BRS Tarumã cultivar. Wheat cultivars have different characters: BRS Umbu has medium late cycle and cespitose-erect growth habit and BRS Tarumã has late cycle and cespitose-prostrate habit.

Experimental area soil was classified as loamy Haplumbrept (EMBRAPA, 2013), and according to analysis, (0 to 20 cm layer) soil $pH_{(water)}$, organic matter, Mehlich-1 P, Mehlich-1 K, Ca, Mg, Al and H+Al were, respectively, 5.6, 33 g kg^{-1}, 8.3 mg dm^{-3}, 0.47 $cmol_c$ dm^{-3}, 4.5 $cmol_c$ dm^{-3}, 2.4 $cmol_c$ dm^{-3}, 0.7 $cmol_c$ dm^{-3} and 9.9 $cmol_c$ dm^{-3}. Weather data for experimental period were obtained and provided by Weather Station from Rural Extension and Agricultural Research of Santa Catarina (INMET / EPAGRI / CIRAM) (Figure 1).



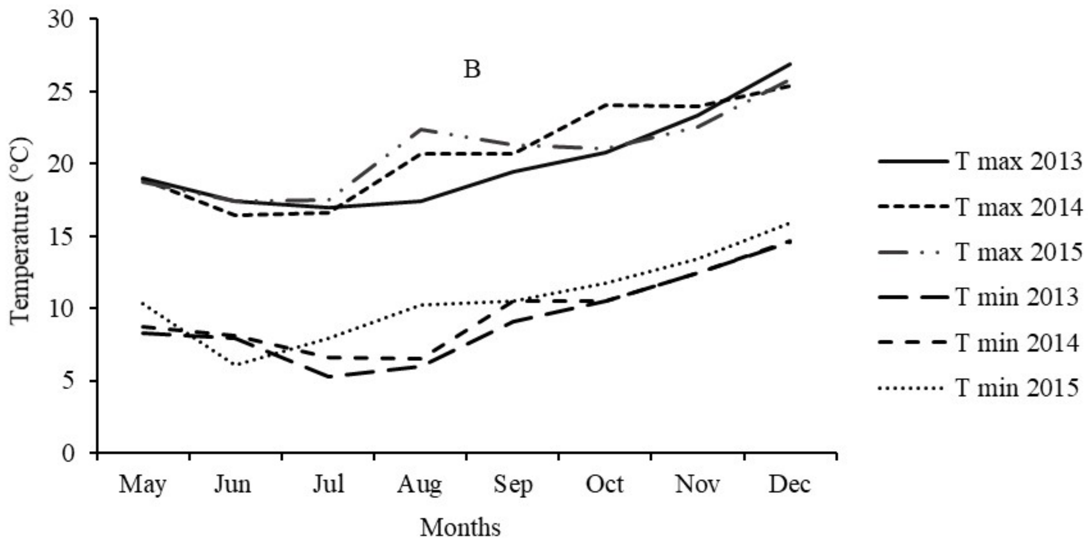


Figure 1. Climatic data of accumulated monthly precipitation (A) and average monthly temperatures (B) in the experimental period, in Lages, SC.

Before first trial year, in 2013, the area was made up by rangeland. Preparation was made with application of 7 tons of dolomitic limestone accompanied by plowing and harrowing. In 2014 and 2015 wheat was sown under no-tillage in common bean and soybean straw, respectively. Was used mineral fertilizer N-P_2O_5-K_2O in formulation 5-20-10(%) at a rate of 400 kg ha^{-1}, per crop season. Nitrogen topdressing from urea was applied with 50 kg ha^{-1} N, at tillering stage (GS 21), at first visible node (GS 31), and after each cut as a replacement harvested nitrogen removal. When replacement fertilization coincided with the fertilization of GS 31 stage, N fertilization was the same, that is, performed only once.

Seeds were treated with fungicide and insecticide suitable for culture: carbendazim (Methyl benzimidazol-2-ylcarbamate), imidacloprid [1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-yilideneamine] and, tiodicarb (3,7,9,13-tetramethyl-5,11-dioxa-2,8,14-trithia-4,7,9,12-tetra-azapentadeca-3,12-diene-6,10-dione) and sowings were made with a plot seeder, where each plot was made up of five rows spaced 20 cm and seeds deposited at 2-5 cm depth. Density of seeding was 350 seeds per square meter (FONTANELI et al., 2012). Size of each plot was 6 m^2 and experiment was composed by 32 plots of each cultivar. For insecticide and fungicide applications the same recommendations of traditional grain production were followed.

Wheat plant height before the defoliation was the criterion for cuts, thus two contrasting canopy heights were stubble residual height (FONTANELI et al., 2009; HASTENPFLUG et al., 2011a; MARTIN et al., 2013; MEINERZ et al., 2012). For defoliation intensity, was used 50% of canopy height, based on intensities used by Mezzalira et al. (2014) for black oat (*Avena strigosa* Schreb.). Similar to Carletto et al. (2015) and Meinerz et al. (2012), three successive cuts were made in plants regrowth.

Treatments consisted in a combination of canopy heights (20 and 30 cm) and cuts number (no cut, 1, 2, and 3), resulting in treatments: 20/1, 20/2, 20/3, 30/1, 30/2, 30/3 and uncut control. A randomized complete block design was used and treatments were distributed in a 2 x 4 factorial arrangement (heights and cuts number), with four replications. Each cultivar was considered an independent experiment, analyzed separately.

Canopy height was monitored weekly, using a graduated sward stick (BARTHRAM, 1985) at 30 random points per plot and plants phenologic stage subjected to each treatment, was evaluated using the Zadoks scale (ZADOKS et al., 1974). When plants achieved 20 or 30 cm, before each cut, tiller population density (TPD) was evaluated by tillers counting contained within a 50 cm x 50 cm frame placed in three central lines of plot. In uncut plots, tillers counting were performed at GS 31, thus ensuring that tillering had ceased. Growth stage code 31 was recognized when first plant node at basal region was visible.

Upon achieving 20 and 30 cm, plants were cut using scissors to 50% of canopy height, corresponding to 10 and 15 cm stubble height. A 0.5 m edge was discarded from each end of plot. All shoot material from three central lines was cut and collected. Then, shoot material was dried in forced air at 60 ºC to constant weight, from which the forage production was calculated.

Plant materials were ground to pass for analyses of crude protein (CP) according to AOAC (1990), neutral detergent fiber (NDF) and acid detergent fiber (ADF) according to Van Soest et al. (1991). Crude protein was determined by micro Kjeldahl method, multiplying the nitrogen concentration value by 6.25. Neutral detergent fiber and ADF analyzes were performed sequentially with adaptations for using Fiber Analyzer device (ANKOM). Crude protein, NDF and, ADF levels were expressed in relation to dry matter (DM) (%).

With plants regrowth and grain production, before harvest, spikes were collected in 1 linear meter of central line of each plot and later estimated the spikes number per square meter. Plants height (H) was determined with a rule graduated in centimeters. Grain was harvested when plants reached harvest maturity, with a combine plot (Wintersteiger).

After harvest, spikelets per spike number were quantified (NSS) and grains per spike number (NGS) from the spikes collected from each plot. Thousand grain weight (TGW) was determined by counting one thousand grains from each experimental plot, with an automatic grain counter (Sanick model ESC 2011) and subsequent weighing. Grain yield (GY) was determined from production of plots useful area, corrected at 13% standard moisture.

For statistical analysis, crop seasons and cultivars were not considered as factors. This because are different habits and growth cycles and the intention was obtaining results by different plants conditions. Crop seasons are used for data confiability, and no comparisons in time. Thus, data were submitted to analysis of variance (ANOVA) and when a significant *F*-test was observed, means were compared by Tukey test at 5% probability using the statistical SAS® program version 9.0.

RESULTS AND DISCUSSION

Tables 1 and 2 refers to dates and days after sowing at which cuts were performed, plant phenological stage at time of cuts and anthesis dates. This data helps explain the results obtained.

Table 1. Days of cuts, days after sowing (DAS) and respectives phenological stages of dual-purpose wheat BRS Umbu and BRS Tarumã cultivars, in two crop seasons.

	20 cm			30 cm		
	Date	DAS	Stage	Date	DAS	Stage
Cuts	BRS Umbu					
Year 2013						
First	July, 2	57	23	July, 15	70	25
Second	July, 15	70	25	August, 5	91	31
Third	July, 29	84	31	August, 19	105	33
Year 2014						
First	July, 8	50	23	July, 21	63	25
Second	July, 21	63	25	August, 4	77	31
Third	July, 28	70	27	August, 12	85	32
	BRS Tarumã					
Year 2014						
First	July, 14	56	23	August, 18	91	28
Second	August, 5	78	25	September, 1	104	32
Third	August, 12	85	27	September, 8	111	33
Year 2015						
First	July, 19	73	25	August, 4	89	28
Second	August, 3	88	28	August, 15	100	31
Third	August, 11	96	31	August, 24	109	33

Table 2. Dates of dual-purpose anthesis of BRS Umbu and BRS Tarumã cultivars as a funtion of pre-cut height and cuts number, in two crop seasons.

	Anthesis dates			
Treatment	BRS Umbu - 2013	BRS Umbu - 2014	BRS Tarumã - 2014	BRS Tarumã - 2015
Control	September, 9	September, 16	September, 22	September, 20
20 cm / 1 cut	September, 9	September, 16	September, 22	September, 20
20 cm / 2 cuts	September, 16	September, 19	September, 26	September, 25
20 cm / 3 cuts	September, 16	September, 19	September, 26	September, 28
30 cm / 1 cut	September, 9	September, 16	September, 22	September, 20
30 cm / 2 cuts	September, 24	September, 22	October, 2	October, 15
30 cm / 3 cuts	September, 30	September, 29	October, 9	October, 12

Productivity and bromatological composition of forage

Regardless the canopy height, for two cultivars and in two crop season, accumulated forage productivity (FP) increased with increase in cuts number. For FP obtained, in same cut, at different canopy heights, a higher value was obtained in plants managed in 30 cm (Table 3). Similar behavior was obtained in other studies such as Tonetto et al. (2011) who observed that in ryegrass, the increase in cuts number resulted in increased dry matter production. Ramella et al. (2015) found that in dual-purpose wheat BRS cultivar Tarumã, FP was higher in two cuts compared to single cut. Hastenpflug et al. (2011a) working with four dual-purpose wheat cultivars, managed in two cuts, obtained that in second cut, the FP practically doubled. Tian et al. (2012) in an experiment conducted with dual-purpose wheat, managed in three cuts according to plant phenological stage (before and after GS 30), verified increases in FP, because the crop was in vegetative growth stage, which can also be verified in this work.

Table 3. Accumulated forage productivity (DM) and tiller population density of dual-purpose wheat BRS Umbu and BRS Tarumã cultivars, submitted to two canopy heights and cuts number, in two crop seasons.

	Canopy heights (cm)					
	20	30		20	30	
	------------- Accumulated forage productivity BRS Umbu (kg DM ha^{-1}) -----------------					
Cuts number	2013		Mean	2014		Mean
1	192.2 c B	392.9 c A	292.5	175.0 c B	391.6 c A	283.3
2	565.4 b B	1217.3 b A	891.3	529.1 b B	1004.1 b A	766.6
3	1044.5 a B	1866.1 a A	1455.3	825.0 a B	1320.0 a A	1072.5
Mean	600.8	1158.7	879.7	509.7	905.2	707.5
CV (%)		14.2			15.1	
Source of variation						
H		<0.001			<0.001	
C		<0.001			<0.001	
H x C		<0.001			0.035	
	----------- Accumulated forage productivity BRS Tarumã (kg DM ha^{-1}) ---------------					
Cuts number	2014		Mean	2015		Mean
1	191.6 c B	687.5 c A	439.5	491.7 b B	1041.7 b A	766.7
2	758.3 b B	1162.5 b A	960.4	1333.3 a A	1220.8 b A	1277.1
3	1041.6 a B	1895.8 a A	1468.7	1637.5 a B	2079.2 a A	1858.3
Mean	663.8	1248.6	956.2	1154.1	1447.2	1300.7
CV (%)		9.4			18.3	
Source of variation						
H		<0.001			0.008	
C		<0.001			<0.001	
H x C		<0.001			0.030	
	-------------------Tiller population density BRS Umbu (tillers m^{-2})-------------------					

Cuts number	2013		Mean	2014		Mean
0	841 a A	860 a A	851	903 a A	960 a A	931
1	866 a A	827 a A	847	964 a A	905 a A	935
2	860 a A	802 a B	831	879 ab A	790 b B	835
3	785 b A	719 b B	752	798 b A	701 c B	749
Mean	838	802	820	886	839	862
CV (%)	3.4			4.7		
Source of variation						
H	0.001			0.003		
C	<0.001			<0.001		
H x C	0.029			0.003		
	--------------------Tiller population density BRS Tarumã (tillers m^{-2})--------------------					
Cuts number	2014		Mean	2015		Mean
0	1136 b A	1155 a A	1145	2194 b A	2172 a A	2183
1	1175 b A	1254 a A	1214	2229 b A	2177 a A	2203
2	1428 a A	1268 a B	1348	2511 a A	2218 a B	2364
3	1347 a A	950 b B	1148	2482 a A	1876 b B	2180
Mean	1272	1156	1214	2354	2111	2232
CV (%)	5.8			2.4		
Source of variation						
H	<0.001			<0.001		
C	<0.001			<0.001		
H x C	<0.001			<0.001		

CV: Coefficient of variation; H: canopy height; C: cuts number; *Means followed by the same letter, lowercase within column and uppercase within row, do not differ by Tukey test at 5% probability.

Different from results described, possibly due to the occurrence of higher temperatures in vegetative growth period, in BRS Tarumã cultivar 2015 crop season, the PF of plants managed at 20 cm in second cut was substantially similar to third cutting. Following the same trend, due to climatic conditions, PF in second cut between two canopy heights were similar (Table 3).

Since tiller is the grasses basic vegetative unit (HODGSON, 1990), TPD exploration, which is a pasture structural characteristic, helps define management strategies for forage plants (ARAÚJO et al., 2015). According to Bortolini et al. (2004), increase in DM associated at multiple cuts can be explained by high regrowth capacity and new tillers formation. Corroborating with these authors, it was observed that FP increase may be related to a general TPD stability, for BRS Umbu cultivar. For BRS Tarumã cultivar, it was observed that TPD in plants managed at 20 cm increased from second cut, where the late cycle of this cultivar is related to results obtained (Table 3).

However, TPD decreased prominently in third cut, allied to 30 cm (Table 3). This reduction may be associated to tillering stage closure (beyond GS 30), a possible tiller death associated with apical meristems removal (plants do not emit new tillers sufficiently to compensate the population) and due to leaf area reductions, that causes stress and less tiller regrowth (TIAN et al., 2012; NAVEED et al., 2014).

In this way, it can be observed that FP is related to TPD, especially in plants managed at 30 cm, since FP increase with cuts number increase can be maintained due to a compensatory mechanism of tiller size/ density and self-thinning promoted by light limitation (YODA et al., 1963; MATTHEW et al., 1995). Thus, it was observed that plants managed at 20 cm showed more tillers than 30 cm, but a FP was higher in this last height, because tillers were in smaller number, but which a higher density (Table 3).

Wheat forage bromatological composition is high, rich in protein and low fiber, and plants nutritional levels vary throughout developmental stages, decreasing the CP and raising the fibers percentage (Naveed et al., 2015). Based on this assertion, it can be observed that in this work, forage bromatological composition levels of two wheat cultivars behaved according to plant phenology in cut moments (Table 4).

Table 4. Crude protein, neutral detergent fiber and acid detergent fiber of dual-purpose wheat BRS Umbu and BRS Tarumã cultivars, submitted to two canopy heights and cuts number, in two crop seasons.

	Canopy heights (cm)					
	20	30		20	30	
	-------Crude protein BRS Umbu (%)-------					
Cuts number	2013		Mean	2014		Mean
1	29.0 a A[†]	23.4 a B	26.2	30.0 a A	27.2 a B	28.6
2	28.5 a A	20.5 b B	24.5	29.9 a A	25.5 b B	27.7
3	26.0 b A	18.5 c B	22.2	27.9 a A	25.4 b B	26.7
Mean	27.8	20.8	24.3	29.2	26.1	27.6
CV (%)		3.0			2.8	
Source of variation						
H		<0.001			<0.001	
C		<0.001			0.007	
H x C		0.009			0.043	
	-------Crude protein BRS Tarumã (%)-------					
Cuts number	2014		Mean	2015		Mean
1	29.4 b A	18.1 b B	23.7	26.0 b A	20.1 b B	23.0
2	28.6 b A	26.3 a B	27.4	26.6 b A	24.9 a B	25.7
3	32.2 a A	26.2 a B	29.2	28.9 a A	25.8 a B	27.4
Mean	30.0	23.5	26.8	27.2	23.6	25.4
CV (%)		3.7			4.8	
Source of variation						
H		<0.001			<0.001	
C		<0.001			<0.001	
H x C		<0.001			<0.001	
	-------Neutral detergent fiber BRS Umbu (%)-------					
Cuts number	2013		Mean	2014		Mean
1	39.6 b A	41.1 c A	40.4	34.3 a B	38.8 c A	36.6
2	43.6 a B	49.3 b A	46.5	34.9 a B	46.1 b A	40.5
3	41.0 ab B	58.3 a A	49.6	35.6 a B	50.3 a A	42.9
Mean	41.4	49.6	45.5	34.9	45.1	40.0
CV (%)		4.7			3.5	
Source of variation						
H		<0.001			<0.001	
C		<0.001			<0.001	
H x C		<0.001			<0.001	
	-------Neutral detergent fiber BRS Tarumã (%)-------					
Cuts number	2014		Mean	2015		Mean
1	33.1 b B	45.6 b A	39.3	48.9 a A	50.3 c A	49.6
2	44.2 a B	47.0 b A	45.6	50.2 a B	54.4 b A	52.3
3	44.4 a B	53.2 a A	48.8	48.9 a B	58.9 a A	53.9
Mean	40.5	48.6	44.6	49.4	54.5	51.9
CV (%)		3.4			1.9	
Source of variation						
H		<0.001			<0.001	
C		<0.001			<0.001	
H x C		<0.001			<0.01	
	-------Acid detergent fiber BRS Umbu (%)-------					
Cuts number	2013		Mean	2014		Mean
1	17.5 c B	20.7 c A	19.1	15.7 b B	18.8 c A	17.4
2	20.7 b B	24.0 b A	23.5	18.0 a B	22.8 b A	19.2
3	23.1 a B	28.8 a A	24.7	18.9 a B	25.9 a A	22.4
Mean	20.4	24.5	22.5	17.5	21.9	19.7

CV (%)		4.2			3.5	
Source of variation						
H		<0.001			<0.001	
C		<0.001			<0.001	
H x C		<0.001			<0.001	
	--------------------------Acid detergent fiber BRS Tarumã (%)--------------------------					
Cuts number	2014		Mean	2015		Mean
1	15.4 c B	20.0 c A	17.7	19.5 c B	20.8 c A	20.2
2	18.6 b B	21.7 b A	20.1	21.6 b B	24.3 b A	22.9
3	20.9 a B	24.6 a A	22.7	23.6 a B	25.9 a A	24.7
Mean	18.3	22.1	20.2	21.6	23.7	22.6
CV (%)		2.3			1.8	
Source of variation						
H		<0.001			<0.001	
C		<0.001			<0.001	
H x C		0.021			0.011	

CV: Coefficient of variation; H: canopy height; C: cuts number; *Means followed by the same letter, lowercase within column and uppercase within row, do not differ by Tukey test at 5% probability.

Crude protein levels were elevated according to NRC requirements (2001), which address 18 to 20% of this fraction to animal nutrition. Nitrogen content excess may have been derived from replacement fertilization, ends up being excreted in urine and is not used in diet (VAN SOEST et al., 1991). Thus, reductions in CP levels found in forage from BRS Umbu cultivar, in third cut to 20 cm and second cut to 30 cm, may be nutritionally beneficial (Table 4). In contrast to present work, Tian et al. (2012) found that CP content was similar across cuts before GS 30 and after this stage there was a decrease of the same. Crude protein content increase with cuts number increase observed in BRS Tarumã cultivar (Table 4) may be related to the findings of MacKown and Carver (2005), that late maturing cultivars have a higher plant nitrogen concentration. Content above 60% NDF and 40% ADF are limiting to consumption and forage digestibility, respectively (VAN SOEST, 1965). It can be observed, as Meinerz et al. (2011), that for both cultivars, NDF and ADF levels increased with cuts number increase, following the plant development, but were below the limits cited above (Table 4).

Grain yield and yield components

Concerning grain yield, it was observed that for BRS Umbu cultivar in both crop seasons and BRS Tarumã 2014 crop season, the GY did not present a significant difference between the cuts numbers in plants managed at 20 cm. For BRS Umbu and BRS Tarumã 2014 crop season, the GY decreased in plants managed at 30 cm with three cuts (Table 5).

Table 5. Grain yield and plant height of dual-purpose wheat BRS Umbu and BRS Tarumã cultivars, submitted to two canopy heights and cuts number, in two crop seasons.

	Canopy heights (cm)					
	20	30		20	30	
	------------------------------Grain yield BRS Umbu (kg ha^{-1}) ------------------------------					
Cuts number	2013		Mean	2014		Mean
0	3164.1 a A[†]	2579.9 a A	2872.0	4874.6 a A	4664.5 a A	4769.6
1	2974.7 a A	2731.9 a A	2853.3	4327.0 a A	4439.1 a A	4383.0
2	2665.7 a A	2438.1 a A	2551.9	4661.4 a A	4425.3 a A	4543.3
3	3041.1 a A	1019.3 b B	2030.2	4525.5 a A	3244.3 b B	3884.9
Mean	2961.4	2192.3	2576.8	4597.1	4193.30	4395.2
CV (%)		20.3			8.9	
Source of variation						
H		0.004			0.008	
C		0.013			0.001	

H x C	0.007			0.010		
	--------------------------Grain yield BRS Tarumã (kg ha^{-1}) --------------------------					
Cuts number	2014		Mean	2015		Mean
0	4392.3 a A	4054.4 ab A	4223.3	371.0 a A	467.0 ab A	419.0
1	4500.0 a A	4367.5 a A	4433.7	450.7 a A	499.0 a A	474.9
2	4167.2 a A	3628.6 bc B	3897.9	440.2 a A	373.4 b A	406.8
3	4167.7 a A	2991.5 c B	3579.6	280.7 b B	363.8 b A	322.2
Mean	4306.8	3760.5	4033.63	385.6	425.8	405.7
CV (%)	7.5			12.2		
Source of variation						
H	<0.001			0.024		
C	<0.001			<0.001		
H x C	0.013			0.031		
	-----------------------------Plant height BRS Umbu (cm) -----------------------------					
Cuts number	2013		Mean	2014		Mean
0	88.0 a A	87.5 a A	87.7	85.5 ab A	86.0 a A	85.7
1	83.1 ab A	81.8 a A	82.4	88.6 a A	85.4 a A	87.0
2	80.0 b A	70.7 b B	75.4	85.8 ab A	79.6 ab B	82.7
3	74.5 c A	65.3 b B	69.9	83.6 b A	75.4 b B	79.5
Mean	81.45	76.3	78.8	85.9	81.6	83.7
CV (%)	3.6			2.9		
Source of variation						
H	<0.001			<0.001		
C	<0.001			<0.001		
H x C	0.006			0.012		
	----------------------------Plant height BRS Tarumã (cm) ----------------------------					
Cuts number	2014		Mean	2015		Mean
0	76.6 a A	75.0 a A	75.8	59.3 a A	59.2 a A	59.6
1	77.0 a A	72.8 a B	74.9	56.3 ab A	55.0 ab A	55.6
2	73.8 b A	64.8 b B	69.3	52.3 b A	50.4 bc A	51.3
3	71.8 b A	54.3 c B	63.0	53.5 b A	44.2 c B	48.8
Mean	74.8	66.7	70.7	55.5	52.2	53.8
CV (%)	2.4			4.7		
Source of variation						
H	<0.001			0.001		
C	<0.0001			<0.001		
H x C	<0.001			0.008		

CV: Coefficient of variation; H: canopy height; C: cuts number; *Means followed by the same letter, lowercase within column and uppercase within row, do not differ by Tukey test at 5% probability.

It is possible to emphasize that plant nitrogen nutrition contributed to this results in GY, because the shoots that acted as source organs were satisfactory to supply the grains production, sink organs. With the cuts made throughout the plant cycle, apical meristems decapitation and height of plants decrease occurred, with consequent reduction in GY, mainly employing 30 cm management. Thus, the results showed that the cuts influenced the height of plants for both cultivars, from the second cut, contributing to GY reduce in the third cut (Table 5).

For BRS Tarumã cultivar in 2015 crop season, in plants managed at 20 cm was found a significant difference in GY, as a function of cuts ($p<0.05$). According to 2015 crop season meteorological data, shown in Figure 1, the precipitation amounts at time of anthesis and the freezing temperatures occurrence in this culture critical period, may have affected the GY (Table

5). Therefore, it can be observed that even in years with climatic adversities that contribute to GY reduction, it is possible to produce forage, so that it does not affect the production system as a whole.

Our results confirm that factors such as defoliation proportion influence on grain production. Conditions related to apical meristems removal by cutting or grazing, remaining leaf area proportion and the consequent reduction radiation interception and photoassimilates distribution, cuts or grazing beyond GS 30, delayed the maturation and shortened the grain filling period, resulting in grain yield decrease (BELL et al., 2015; HARRISON et al., 2011; HARRISON et al., 2014; SEYMOUR et al., 2015). Similar to this study, Hastenpflug et al. (2011b), Carletto et al. (2015), and Ramella et al. (2015) made two cuts in wheat and observed that the grain yield was reduced due to cuts. Tian et al. (2012) found that wheat defoliated after GS 30 resulted in reduction of more than 60% in grain yield, mainly due to meristems removal, subsequent tillers death and reduction of plant capacity to translocate resources for grain production and filling.

In this work, TGW was reduced from second cut for both cultivars and crop seasons, regardless of canopy height used (Table 6). In addition, the lower TGW of BRS Tarumã cultivar was due to this one having smaller grains and consequently lower mass (SANTOS et al., 2015). This decrease in TGW can be related to stress caused by defoliation, resulting in reduced grains photoassimilates distribution (NAVEED et al., 2014) and also by reduced grain filling period as a function of delayed anthesis dates compared to control (Table 2). Carletto et al. (2015) reported that cuts management influenced TGW and observed that in BRS Umbu cultivar this characteristic was significantly lower as a function of second cut performed. Islam et al. (2015) also found that TGW was reduced due to defoliation in dual-purpose wheat.

Table 6. Thousand grain weight, number of spikelets per spike and number of grains per spike of dual-purpose wheat BRS Umbu and BRS Tarumã cultivars, submitted to cuts number, in two crop seasons.

	2013	2014	2014	2015
Cuts number	Weight of one thousand grain BRS ----------------Umbu (g)-------------		Weight of one thousand grain BRS --------------Tarumã (g)-------------	
0	31.3 ab†	31.6 a	27.5 a	20.4 a
1	32.5 a	30.4 a	27.2 a	20.0 a
2	28.7 b	27.1 b	25.7 b	18.4 b
3	28.9 b	27.8 b	24.9 b	18.5 b
Mean	30.4	29.2	26.4	19.3
CV (%)	7.2	4.8	3.2	3.3
Source of variation				
H	0.116	0.765	0.101	0.372
C	0.005	<0.001	<0.001	<0.001
H x C	0.119	0.179	0.168	0.207
Cuts number	Number of spikelets per spike -------------BRS Umbu-----------		Number of spikelets per spike ------------BRS Tarumã-----------	
0	12.1 a	13.8 a	11.8 ab	14.1 a
1	11.6 ab	13.3 a	12.5 a	13.3 ab
2	11.5 ab	13.0 a	11.0 ab	12.6 b
3	10.8 b	11.0 b	10.3 b	11.5 c
Mean	11.5	12.8	11.4	12.9
CV (%)	6.0	8.9	10.6	5.9
Source of variation				
H	0.217	0.079	0.260	0.497
C	0.015	<0.001	0.0114	<0.001
H x C	0.126	0.903	0.387	0.079
Cuts number	Number of grains per spike -------------BRS Umbu-----------		Number of spikelets per spike -------BRS Tarumã Crop 2014-------	

0	22.7 a	24.8 a	18.2 ab
1	21.2 a	22.4 ab	18.4 a
2	18.0 ab	19.6 bc	16.5 ab
3	15.8 b	15.5 c	14.2 b
Mean	19.4	20.5	16.8
CV (%)	18.8	15.5	17.5
Source of variation			
H	0.761	0.115	0.532
C	0.004	<0.001	0.035
H x C	0.058	0.098	0.978

CV: Coefficient of variation; H: canopy height; C: cuts number; *Means followed by the same letter, lowercase within column and uppercase within row, do not differ by Tukey test at 5% probability.

According to Hendrickson et al. (2005), when the apical meristem is removed, the secondary tiller appearance is induced and plants produce smaller spikes with few grains. The yield components NSS and NGS were reduced in third cut in both cultivars and crop seasons, regardless of canopy height employed (Table 6), except for NGS of BRS Tarumã cultivar 2015 crop season, where no significant differences were found ($p<0.05$). For these components, Hastenpflug et al. (2011b) found that NSS decreased with cuts. Under two cuts management Ramella et al. (2015) too found that NSS and NGS decreased. Virgona et al. (2006) reported a decrease of 50-60% in NGS due to prolonged grazing periods and Tian et al. (2012) reported that cuts after GS 30 resulted in 55% NGS reduction compared to non-defoliated plants.

CONCLUSIONS

Results show that canopy heights and cuts number led to differences in productive characteristics of wheat BRS Umbu and BRS Tarumã cultivars in dual- purpose system. The trend of the results due treatments were similar for the two cultivars of different growth habits, except for the trait tillering. Therefore, management strategies can be selected according to the situation and farmer intended purpose in profiting more with either the forage harvest or grain. These two wheat cultivars can be employed for dual-purpose with forage production plus grain and may be an approach suited to southern Brazil cropping and grazing systems. In dual-purpose wheat managed at 20 cm, it is possible to obtain forage for animals, prioritizing grain yield. At 30 cm forage yield was prioritized and grain yield was penalized, as a result of the third cut for both cultivars.

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RESUMO: A integração lavoura-pecuária implica no equilíbrio do forrageamento adequado dos animais, minimizando os impactos nas áreas agrícolas graníferas. Os objetivos deste trabalho foram verificar, em trigo, os efeitos das alturas pré-corte (20 e 30 cm) e do número de cortes (sem corte, 1, 2 e 3 cortes) sobre a produtividade e composição bromatológica da forragem, e a produtividade de grãos dos cultivares BRS Umbu e BRS Tarumã. Independente do número de cortes, a altura de 30 cm proporcionou maior produtividade de forragem (1032 e 1348 kg MS ha^{-1}) do que 20 cm (554 e 909 kg MS ha^{-1}), para os cultivares BRS Umbu e BRS Tarumã, respectivamente, na média das safras. Para ambos cultivares e safras, obteve-se valores médios de 26% de proteína bruta, 55% de fibra em detergente neutro e 26% de fibra em detergente ácido. A 20 cm não foram encontradas diferenças na produtividade de grãos em função do número de cortes, com 3780 kg ha^{-1} para BRS Umbu na média das safras e 4306 kg ha^{-1} em 2014 para BRS Tarumã. Porém, para ambos os cultivares a 30 cm, o rendimento de grãos foi prejudicado em 30% no terceiro corte. Estes resultados indicam que o trigo duplo-propósito pode ser empregado no sul do Brasil em sistemas de pastejo em épocas de escassez de forragem e ainda produzir grãos sem penalidades, de acordo com o manejo empregado.

PALAVRAS-CHAVE: *Triticum aestivum* L. Sistema de integração lavoura pecuária. Altura de manejo. Número de cortes. Produção de grãos.

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