Dual-purpose wheat grain and animal production under different grazing periods

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Abstract – The objective of this work was to evaluate the influence of different grazing periods on beef animal production and on wheat forage and grain yield. The experiment was carried out in Pato Branco, PR, Brazil. Six grazing periods were evaluated (0, 21, 42, 63, 84, and 105 days) on dual-purpose wheat cultivar BRS Tarumã. Purunã steers, with average live weight of 162 kg and ten months of age, were kept under continuous grazing using a variable stocking rate, in order to maintain the established sward height of 25 cm. Greater increases in total animal gain (TAG) occurred with longer grazing periods. However, there was little increase after 63 days (490 kg ha^{-1}), and TAG decreased from 552 to 448 kg ha^{-1} between 84 and 105 days. Grain yield decreased from 2,830 to 610 kg ha^{-1} when the grazing period increased from 0 to 105 days, but there was little change after 63 days (750 kg ha^{-1}). Cultivar BRS Tarumã shows excellent animal production potential, and the decision on how long wheat pastures should be grazed must be based on relative prices of grain and livestock.

Index terms: *Triticum aestivum*, 'BRS Tarumã', forage mass, nutritive value, Purunã steers, weight gain.

Produção animal e de grãos de trigo duplo propósito em diferentes períodos de pastejo

Resumo – O objetivo deste trabalho foi avaliar a influência de diferentes períodos de pastejo na produção de carne bovina, de forragem e de grãos de trigo. O experimento foi conduzido em Pato Branco, PR. Foram avaliados seis períodos de pastejo (0, 21, 42, 63, 84 e 105 dias) com a cultivar de trigo de duplo propósito BRS Tarumã. Novilhos Purunã, com peso vivo médio de 162 kg e idade de dez meses, foram mantidos em pastejo contínuo, com taxa de lotação variável, para manter a altura de pastejo estabelecida de 25 cm. Maior ganho animal por área (GA) foi encontrado em períodos mais longos de pastejo. No entanto, houve pouca diferença após 63 dias (490 kg ha^{-1}), e o GA diminuiu de 552 para 448 kg ha^{-1}, entre 84 e 105 dias. A produtividade de grãos diminuiu de 2.830 para 610 kg ha^{-1} com o aumento do período de pastejo de 0 para 105 dias, mas mudou pouco após 63 dias (750 kg ha^{-1}). A cultivar BRS Tarumã apresenta excelente potencial para a produção animal, e a decisão quanto ao período de utilização do trigo para pastejo deve ser baseada nos preços relativos de grãos e dos animais.

Termos para indexação: *Triticum aestivum*, 'BRS Tarumã', massa de forragem, valor nutritivo, novilhos Purunã, ganho de peso.

Introduction

Wheat (*Triticum aestivum* L.) is an important winter crop in southern Brazil. However, there are problems associated with its culture, including high frost probability, production costs, and competition from imported Argentine wheat. In this region, wheat is used primarily as a grain crop instead of as a dual-purpose crop for both forage and grain.

Grazing winter wheat during its vegetative stage is a common practice in southern United States, Argentina, Australia, and Uruguay, with economic advantages for farmers (Fontaneli, 2007). According to Carver et al. (2001), in some years, more than 50% of the winter wheat acreage in the southern Great Plains of the United States is used for the dual-purpose of grazing stocker cattle and harvesting grain. However, in Brazil, less than 1% of the wheat production area is planted with dual-purpose cultivars (Companhia Nacional de Abastecimento, 2010).

Recently, research institutes in Brazil have developed dual-purpose wheat varieties to improve winter forage yield and to offer production alternatives for farmers. Dual-purpose wheat can provide animal gains of 450 kg ha^{-1} and grain yield of up to 4,500 kg ha^{-1}, besides enabling the use of integrated crop-livestock systems (Bortolini et al., 2004). Brazilian cultivars of dual-purpose wheat can contribute to grain production for the domestic and export market, as well as improve the nutrition of 30 million cattle in southern Brazil.

If winter wheat is properly grazed or if the animals are removed prior to first hollow stem development, wheat will mature and grain yield will not be adversely affected (Redmon et al., 1995; Dove et al., 2002; Holman et al., 2005). Grazing can contribute to higher grain production by increasing the number of fertile tillers and decreasing plant height, which prevent lodging in tall cultivars and extend the vegetative period, allowing plants to escape frost susceptibility (Del Duca et al., 2006; Harrison et al., 2008). However, grain production decreases as stocking rate or grazing period increases (Bortolini et al., 2004). Therefore, grazing intensity and grazing duration are critical factors, which influence grain yield and animal production (Mcrae, 2003).

The objective of this work was to evaluate the influence of different grazing periods on beef animal production and on wheat forage and grain yield.

Materials and Methods

The experiment was carried out at the experimental area of Instituto Agronômico do Paraná, in Pato Branco, PA, Brazil, located at 26º07'S and 52º39'W, at an average altitude of 700 m. The experiment was established on 4/30/2007, by sowing the wheat cultivar BRS-Tarumã, classified as a bread wheat for baking and pasta, recently released by Embrapa Trigo, and ended on 11/11/2007, with grain harvest.

The climate of the region is classified as subtropical humid, according to Köppen (Moreno, 1961), and the soil is a clayey Latossolo Vermelho (Red Latosol) (Santos et al., 2006). The meteorological conditions during the experiment are described in Table 1 (Instituto Agronômico do Paraná, 2008).

No-tillage cropping has been used in the area since 1995, and soybean has been grown in rotation with corn in the summer and with cereals in the winter. The system of ley farming started in 2003 with grazing of winter oat. Soil samples were collected at a depth of 0–20 cm before planting oat, and the results of soil analysis indicated: pH ($CaCl_2$) 5.0; 66.6 g dm^{-3} of organic matter; 9.06 mg dm^{-3} of P; 0.88 $cmol_c$ dm^{-3} of K; 0.00 $cmol_c$ dm^{-3} of Al; 7.28 $cmol_c$ dm^{-3} of Ca; 3.38 $cmol_c$ dm^{-3} of Mg; 16.55 $cmol_c$ dm^{-3} of CTC; and base saturation of 67.7%. Fertilization practices were guided by soil chemical analyses and based on the recommendation of the Brazilian commission for chemical and soil fertility (Manual de adubação e de calagem para os Estados do Rio Grande do Sul e Santa Catarina, 2004). A fertilizer with 20 kg ha^{-1} of N, 70 kg ha^{-1} of P_2O_5, and 40 kg ha^{-1} of K_2O was applied at the sowing date. Three N topdressing fertilization applications were done according to the wheat vegetative growth stage and weather conditions on: May 5 (45 kg ha^{-1}), June 25 (22 kg ha^{-1}), and August 8 (18 kg ha^{-1}), which totaled 85 kg ha^{-1} of N applied after the application at sowing, using urea as N source.

Treatments consisted of six grazing periods: 0, 21, 42, 63, 84, and 105 days, represented by T0, T21, T42, T63, T84, and T105, respectively. A randomized complete block design, with two replicates, was used. The plots were grazed until July 10, August 1, August 22, September 12, and October 3.

Ten-month-old steers of the Brazilian race Purunã (¼ Aberdeen Angus, ¼ Canchim, ¼ Caracu, ¼ Charolais) were used. Two tester steers with initial live weight of 162 kg were assigned to each pasture. Pastures were managed by continuous stocking rate, using the put-and-take technique, with animals of similar age and weight used as controls when necessary in order to maintain the target forage sward height (Mott & Lucas, 1952). Grazing management followed the recommendations of Del Duca et al. (2000), by maintaining a sward height of 25 cm. Sward height was measured weekly using a sward stick. The distance from soil level to the height where the stick marker touched the first leaf (Bircham, 1981) was measured at 50 places in each pasture.

Table 1. Meteorological data during the experimental period.

Month	Average temperature (ºC)		Total rainfall (mm)	
	1979–2006	2007	1979–2006	2007
April	19.1	21.4	173	375
May	15.7	15.6	202	280
June	14.5	16.8	166	24
July	14.2	14.0	145	145
August	16.1	17.5	116	24
September	16.9	18.1	178	105
October	19.4	21.4	253	172
November	20.9	21.0	191	8
Total period	-	-	1,425	1,135

It was used an area of 4.5 ha divided into ten experimental units of 0.38 ha where was assigned a grazing period by replicate combination. In addition to the grazed plots, ungrazed control plots measuring 12 m^2 each where also evaluated to determine production of wheat, making a total of twelve experimental units. The animals entered the plots 71 days after the wheat sowing (7/10/2007).

Forage mass production was evaluated every 21 days at the grazed areas to determine ponctual of forage mass. From each plot, six forage samples of 0.25 m^2 were cut at soil level. Samples were dried in a forced-air oven (55ºC) until constant weight to determine forage mass in kg ha^{-1} of dry matter (DM).

Forage allowance was calculated according to the methodology proposed by Sollenberger et al. (2005), with a slight modification. In the present study, initial forage mass was added to the final forage mass of each period, divided by two, and then divided by the mean animal live weight on the pasture during the period.

Forage nutritive value was assessed in samples collected every 21 days by the hand-plucking method, according to the methodology described by Johnson (1978). The samples were analyzed by the NIRS technique described by Marten et al. (1985) in order to determine crude protein (CP), total digestible nutrients (TDN), neutral digestible fiber (NDF), and acid digestible fiber (ADF).

To determine the average stocking rate (kg ha^{-1} per day of live weight) and the average daily gain (ADG) of the testers, the animals were weighed every 21 days after a food and water fast of 14 hours. The mean weight of the testers and the put-and-take animals was used to calculate average stocking rate during each period. ADG was calculated based on the two tester animals per pasture. Total animal gain (TAG) per hectare was calculated for each period by multiplying the average stocking rate during each period by the ADG of the tester. Total live weight gain for the entire season was obtained by the sum of the production of each period.

Grain yield was measured by harvesting a 30x20 m area from the grazed treatments and the entire plot of the ungrazed control. The control plots were bordered by wheat, and yields were adjusted to 13% moisture. Grain harvests were done at two different dates, depending on the treatment. Ungrazed plots were harvested 173 days after the sowing date (10/19/2007), and grazed treatments were harvested 208 days after (11/13/2007). A small-plot combine was used to harvest the grains.

Data were analyzed using analysis of variance. Forage mass production was assessed for each treatment during each period to test the interactions between the treatment and the grazing period. Forage nutritive value and animal responses were evaluated when animals were grazing a particular treatment in order to compare treatments within periods. When the F test was significant, means were compared using the Tukey test, at 5% probability. For grain and animal production, polynomial contrasts were used.

Results and Discussion

Mean forage mass allowance at the beginning of the experiment was of 1,930 kg ha^{-1}. Within grazing treatments, wheat forage mass allowance differed among grazing periods and forage mass increased as the season progressed (Table 2), which is in accordance with Del Duca et al. (2006) who observed regrowth ability of wheat after grazing. Differences in forage mass were greater between T105 and treatments T0 and T21.

Table 2. Average forage dry matter mass and forage allowance of dual-purpose wheat cultivar BRS Tarumã pastures subjected to grazing for 21 (T21), 42 (T42), 63 (T63), 84 (T84), and 105 (T105) days[(1)].

Treatment	Evaluation period					Mean
	July 10–31	Aug. 1–21	Aug. 22 to Sep. 11	Sep.12 to Oct. 2	Oct. 3–23	
	Forage dry matter mass (kg ha^{-1})					
T21	2,080	-	-	-	-	2,080a
T42	2,310	2,970	-	-	-	2,640a
T63	2,000	3,120	4,170	-	-	3,100a
T84	2,330	3,170	3,530	4,170	-	3,300a
T105	2,040	2,910	4,060	4,020	5,050	3,610a
Mean	2,150C	3,040BC	3,920AB	4,092AB	5,048A	-
CV (%)	10.9	7.3	8.2	9.2	-	-
	Forage allowance [forage dry matter mass (kg)/ animal live weight (kg)]					
T21	2.6	-	-	-	-	2.6a
T42	2.6	2.2	-	-	-	3.1a
T63	2.3	1.8	2.3	-	-	2.7a
T84	2.7	1.8	2.4	3.3	-	2.8a
T105	2.1	1.8	2.6	3.0	3.8	2.7a
Mean	2.4BC	1.9C	2.5ABC	3.2AB	3.9A	-
CV (%)	9.4	10.9	23.1	11.02	-	-

[(1)]Means followed by equal letters, lowercase in the columns and uppercase in the rows, do not differ by Tukey's test, at 5% probability.

The increase in forage mass over time for the grazing treatments may be explained in part by the increase in forage DM concentration below the target stubble height, which was associated with increased forage maturity and a greater proportion of structural tissue in the stubble. Average DM concentration was 22.9, 24.2, 44.04, and 49.1% for T21, T42, T63, and T105, respectively. Seasonal changes in tiller density and plant part proportion can also lead to DM accumulation in the ungrazed portion of the sward, especially when grazing is managed based on sward height and not on forage mass (Sollenberger and Burns, 2001).

There were no significant differences among treatments regarding forage mass within a given time period (p>0.05), indicating that similar levels of forage mass were maintained among treatments. According to Hodgson (1990), forage mass should be greater than 1,500 kg ha^{-1} of DM in order to not limit forage intake of temperate grasses. In the present study, mean forage mass was greater than that typically found for winter crop species (Soares & Restle, 2002), which could be explained by the prostrate growth habit and high tiller density of this cultivar. There were also no significant differences in forage allowance among treatments within each period of evaluation (Table 2), although there were differences among periods within a grazing treatment.

There were no significant differences in nutritive value among treatments within periods of evaluation, which allowed data to be presented by periods (Table 3). From the first to the fourth period, there was a decrease in handplucked CP and TDN concentrations, and an increase in NDF and ADF. These results are related to changes in the forage sward as the length of the grazing season increased, including the decrease of the leaf:stem ratio and more lignified cell walls. Similar changes were reported by Hastenpflug et al. (2011).

Forage protein concentration increased on the fifth period due to changes in sward botanical composition. Alexandergrass (*Urochloa plantaginea* (Link) R.D. Webster), which has good forage nutritive value, became more prevalent at the time, and by T105, 52% of the forage mass was composed of alexandergrass.

Stocking rate differed among periods (Table 4), increasing from the beginning to the middle of the experiment, then decreasing and increasing again, at the end of grazing, as a consequence of alexandergrass forage growth. These results are similar to those obtained by Bartmeyer et al. (2006) who found stocking rates of 1,800 and 1,620 kg ha^{-1} per day of live weight, while evaluating the dual-purpose wheat 'BRS 176' with grazing periods of 30 and 45 days, respectively.

Table 3. Average concentration of crude protein (CP), total digestible nutrients (TDN), neutral digestible fiber (NDF), and acid digestible fiber (ADF) of dual-purpose wheat cultivar BRS Tarumã pastures, during five grazing periods[(1)].

Period	CP	TDN	NDF	ADF
	(%)			
July 10–31	24.2a	73.4a	42.4c	20.6b
Aug. 1–21	21.2b	73.5a	48.8c	20.5b
Aug. 22 to Sep. 11	17.9c	71.3a	55.2b	23.7b
Sep. 12 to Oct. 2	14.3d	67.4b	59.5a	29.2a
Oct. 3–23	15.3c	68.6b	58.4a	27.5a
Mean	18.6	70.8	52.8	24.3

[(1)]Means followed by equal letters do not differ by Tukey's test, at 5% probability.

Table 4. Stocking rate daily gain and total animal live weight gain of Purunã steers grazing dual-purpose wheat cultivar BRS Tarumã pastures during different grazing periods: 21 (T21), 42 (T42), 63 (T63), 84 (T84), and 105 (T105) days.

Treatment	July 10–31	Aug. 1–21	Aug. 22 to Sep. 11	Sep.12 to Oct. 2	Oct. 3–23	Mean
	Stocking rate (kg ha^{-1} of live weight)					
T21	930	-	-	-	-	930d
T42	870	1,330	-	-	-	1,100c
T63	870	1,670	1,870	-	-	1,470a
T84	870	1,720	1,500	1,270	-	1,340b
T105	960	1,570	1,540	1,320	1,300	1,340b
Mean	900D	1,570AB	1,640A	1,290C	1,300BC	-
CV (%)	5.1	14.9	18.1	3.4	-	-
	Average daily gain (kg per animal per day)					
T21	0.82	-	-	-	-	0.82bc
T42	0.73	0.69	-	-	-	0.70cd
T63	1.03	0.93	1.23	-	-	1.06a
T84	1.02	1.25	1.16	0.62	-	1.01ab
T105	0.88	0.95	1.35	0.57	-0.33	0.68d
Mean	0.90AB	0.96AB	1.25A	0.60B	-0.33C	-
CV (%)	19.7	18.9	7.3	43.9	-	-
	Total animal gain (kg ha^{-1})					
T21	87	-	-	-	-	87b
T42	77	102	-	-	-	179b
T63	109	167	213	-	-	490a
T84	106	223	152	69	-	552a
T105	93	149	180	62	-37	448a
Mean	94BC	160AB	182A	66C	-37D	-
CV (%)	18.8	22.8	12.6	41.4	-	-

[(1)]Means followed by equal letters, lowercase in the columns and uppercase in the rows, do not differ by Tukey's test, at 5% probability.

The stocking rate values observed in the present study indicate high carrying capacity of the wheat cultivar BRS Tarumã. Differences in forage growth and changes in sward structure resulted in variability in the stocking rate, which was adjusted along the grazing period to keep forage at the target height. According to Heringer & Carvalho (2002), this technique is considered effective, since forage species with high growth rates lose forage by senescence if not readily consumed by animals, especially under conditions of high forage allowance.

ADG did not differ between treatments within any evaluation period (Table 4), although there were period differences within treatments. These gains were directly influenced by forage nutritive values. Forage TDN (>73%) and CP (>21%) were greater in the first two periods, while NDF was lower (<49 %). High levels of forage mass and forage allowance later in the season (September 11 and onwards) did not support greater ADG, since nutritive value decreased significantly at the time.

Lower gains and weight loss during the fourth and fifth periods, respectively, may also be linked to the bimodal sward structure formed in the pasture at the end of the grazing period. This structure was represented by ungrazed areas with taller height and lower nutrient concentrations and by overgrazed areas with very low forage mass. The overgrazed areas may have had a structural limitation to animal intake (Sollenberger & Burns, 2001) associated with low bite weight and inability of animals to graze the pasture due to its low height. Gonçalves et al. (2009) found that animals recognize taller patches as opportunities for greater intake, but may reject them because of their high fiber concentrations. The bimodal sward structure observed in the last grazing periods was probably influenced by the awns of the wheat spikes which caused avoidance, resulting in decreasing forage nutritive value and increasing time spent searching for alexandergrass in the swards. Moreover, animal weight losses late in the grazing season were not higher due to alexandergrass growth, which contributed to the animal diet, explaining the increase in the CP and TDN concentrations and the decrease in NDF and ADF, in October (Table 3).

The values of ADG obtained in this study are similar to those reported by Bortolini et al. (2004), of 0.95 and 0.88 kg. However, Bartmeyer et al. (2011) observed ADG of 1.69 and 1.65 kg during 30 and 45 days of grazing, which is considerably greater than the ADG found in the present study.

TAG was affected by grazing periods (Table 4). Gains increased from 94 to 160 and 182 for the first and third periods, but decreased to 66 and -37 kg ha^{-1} for the fourth and fifth periods, respectively. TAG differed significantly among treatments, increasing from 87 in T21 to 448 in T105. The higher gain in the second and third periods can be attributed to the higher stocking rate needed to consume the increasing forage mass during these periods. Structural constraints from the fourth period onwards explain the lower TAG in the last periods of evaluation.

The hypothesis that animal gain would increase as the length of the grazing period increased was confirmed for the first four grazing periods (84 days). However, keeping the animals on the pasture for an additional 21 days did not result in greater animal production due to sward structural changes and decreases in forage nutritive value. Low grazing efficiency also occurred late in the grazing season because of the presence of awns on the wheat spikes, which reduced forage consumption.

Wheat grain production was affected by the length of the grazing period, showing a quadratic response ($y = 2939 - 40.5x + 0.1606x^2$; $R^2 = 0.92$). These results indicate that grain production was negatively affected by short grazing periods. Grain production was 2,830, 2,210, 1,880, 750, 490, and 610 kg ha^{-1} for T0, T21, T42, T63, T84, and T105, respectively.

Treatment T0 showed greater production than the mean of 2,110 kg ha^{-1} from Paraná State, in South Brazil (Governo do Paraná, 2007). According to Redmon et al. (1995), the decrease in wheat grain production increases as the length of the grazing period increases, especially under heavy grazing pressure, since there is a positive correlation between leaf area index at anthesis and grain yield of grazed wheat (Winter & Musick, 1991). Del Duca et al. (2000), while evaluating wheat under cutting, reported grain production of 3,480 and 2,100 kg ha^{-1} and forage dry mass of 1,470 and 2,510 kg ha^{-1}, for treatments with one and two cuts, respectively. In addition, when grazing occurs after stem elongation, the apical meristem can be grazed or injured. The plant produces new tillers, which produce spikes with lower production potential and uneven maturity, complicating harvest management and compromising grain quality. This could explain the large reduction in wheat grain yield as the length of the grazing period increased.

Similar effects were observed by Bortolini et al. (2004) and Bartmeyer et al. (2011). The latter authors found that the size of the spikes decreased as the grazing period increased, which reflected in lower grain yield. According to Henrique (2006), the negative effect of defolation on grain yield occurs before spike emergence, even if the apical meristem is not injured. Defoliation until stem elongation, when the crop shows the first hollow internodes, increased forage production but decreased grain production by half.

Conclusions

1. Wheat cultivar BRS Tarumã shows excellent animal production potential and is well adapted for grazing, except near the end of its growth cycle when morphological and structural traits provide low gain per animal.
2. Grazing significantly reduces wheat grain yield as the length of the grazing period increases.
3. Livestock production on 'BRS Tarumã' can be achieved efficiently during a period of 88 days of grazing.
4. The ideal length of the grazing period varies in different situations and should be based on yield goals and relative prices of grain and livestock.

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