http://dx.doi.org/10.1590/1678-4162-11885

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Arq. Bras. Med. Vet. Zootec., **v.73, n.1, p.247-255, 2021**

Dry matter productivity and bromatological quality of ryegrass genotypes cultivated in southern Brazil

[*Produtividade de matéria seca e qualidade bromatológica de genótipos de azevém cultivados no Sul do Brasil*]

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ABSTRACT

The goal of this work was to assess the biomass production and bromatological quality of ryegrass genotypes in ten municipalities of the Western and North Plateau regions of the State of Santa Catarina, Brazil. The cultivars La Estanzuela 284 (diploid), Bar HQ, Barjumbo, INIA Escorpio, Potro, and Winter Star (tetraploids) were compared, distributed in a randomized block design, in which the municipalities constituted the blocks, with three replications. The cuts were performed when the plants reached 30cm, leaving a residue of 10cm. In three cuts, the cultivars Barjumbo and Bar HQ were the most productive, exceeding 4.6 t ha^{-1} of dry matter. In the places in which five cuts were performed, the production of these cultivars exceeded 7.3 t ha^{-1}, placing them again ahead of the others. The average crude protein content in three cuts was greater than 25% in all cultivars. There was no difference between the genotypes in the content of neutral detergent fiber and total digestible nutrients. There was a significant correlation between quantitative and qualitative productive variables. The assessed cultivars represented good options for composing short-term or long-term winter-feeding systems, adjusted to the integration with annual crops or warm-season pastures.

Keywords: cultivars, diploid, *Lolium multiflorum*, tetraploid, nutritional value

RESUMO

O objetivo deste trabalho foi avaliar a produção de biomassa e qualidade bromatológica de genótipos de azevém, em dez municípios das regiões Oeste e Planalto Norte Catarinense, Estado de Santa Catarina, Brasil. Foram comparados os cultivares La Estanzuela 284 (diploide), Bar HQ, Barjumbo, INIA Escorpio, Potro e Winter Star (tetraploides), distribuídos em um delineamento blocos casualizados, em que os municípios constituíram os blocos, com três repetições. Os cortes foram realizados quando as plantas atingiram 30cm, deixando um resíduo de 10cm. Sob três cortes, os cultivares Barjumbo e Bar HQ foram os mais produtivos, ultrapassando 4,6 t ha^{-1} de matéria seca. Nos locais em que ocorreram cinco cortes, a produção destes cultivares superou 7,3 t ha^{-1}, posicionando-os novamente à frente dos demais. O teor médio de proteína bruta em três cortes foi superior a 25% em todos os cultivares. Não houve diferença entre os genótipos no teor de fibra detergente neutro e de nutrientes digestíveis totais. Verificou-se correlação significativa entre variáveis produtivas quantitativas e qualitativas. Os cultivares testados representam boas opções para compor sistemas forrageiros hiberno-primaveris de curta ou longa duração, ajustando-se à integração com lavouras ou pastagens anuais de estação quente.

Palavras-chave: cultivares, diploide, Lolium multiflorum, *tetraploide, valor nutritivo*

INTRODUCTION

Due to its numerous positive characteristics, ryegrass (*Lolium multiflorum* Lam.) is classified by Carvalho *et al*. (2013) as "the most important forage for the agricultural context of southern Brazil" (p.495). It is used both for grazing and for production of conserved forage, isolated or in intercrop cultivation. Ryegrass also composes crop-livestock integration systems and can be sowed over perennial warm-season grasses (Hahn *et al*., 2015). With a production cycle that extends

Recebido em 20 de março de 2020
Aceito em 4 de julho de 2020
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between winter and spring, it provides forage of excellent bromatological quality for a long period. Ryegrass genotypes are divided into diploid and tetraploid materials. The later have fast initial production, longer vegetative cycle, higher mass production and greater relationship between content and cell wall, which determines higher levels of soluble carbohydrates and proteins, as well as greater digestibility (Oliveira *et al*., 2014, 2015; Marchesan *et al*., 2016).

On the other hand, there is a substantial difference in the cost of pasture production, particularly with regard to the price of seeds, which is much higher in tetraploid cultivars. It is worth mentioning that comparative assessments between ryegrass cultivars have been performed for over twenty years (Tcacenco, 1995), and intensified in recent years, given the wide variety of genotypes in the market (Tonetto *et al*., 2011; Kroning *et al*., 2014; Mioto *et al*., 2014; Oliveira *et al*., 2014; 2015; Hahn *et al*., 2015).The extensive use of ryegrass in milk production systems has promoted obtaining more information about genotypes with higher production and biomass quality. This fact has helped reduce production costs and enhance productivity by areas. This is extremely important in the State of Santa Catarina, Brazil, where 89% of farms have up to 50 ha (Censo…, 2018), which requires high efficiency in the use of available space. In view of the context above described, the goal of the present study was to assess the biomass production and bromatological quality of ryegrass genotypes submitted to different number of cuts in southern Brazil.

MATERIAL AND METHODS

The experiment that resulted in the present work was approved by the Animal Ethics and Experimentation Committee of the University of the State of Santa Catarina (UDESC), Brazil, under protocol CEUA nº 7354280716. The research was conducted in ten rural properties of the West and North Plateau regions of the State of Santa Catarina, Brazil, located in the following municipalities, geographical coordinates, and altitude of the experiment sites: Abelardo Luz (26°35’51”S, 52°07’54”W, 1,007 m), Chapecó (27°05’30”S, 53°00’40”W, 600 m), Guaraciaba (26°35’31”S, 53°33’32”W, 570 m), Porto União (26°20’53”S, 50°51’04”W, 763 m), Quilombo (26°44’14”S, 52°42’05”W, 425 m), São Bernardino (26°29’04”S, 52°58’51”W, 806 m), São Lourenço do Oeste (26°39’59”S, 52°53’40”W, 809 m), São Miguel do Oeste (26°42’05”S, 53°36’23”W, 535 m), Xanxerê (26°53’08”S, 52°25’08”W, 801 m) and Xaxim (26°59’43”S, 52°32’25”W, 757 m). According to Köppen classification (Alvares *et al*., 2013), Chapecó, Guaraciaba, Quilombo, São Bernardino, São Miguel do Oeste, and Xaxim are located in regions of Cfa climate (humid temperate climate with hot summer), whereas Abelardo Luz, Porto União, São Lourenço do Oeste, and Xanxerê are under Cfb climate (humid temperate climate with mild summer).

The assessments were performed from May to October 2016. Five tetraploid genotypes (Bar HQ, Barjumbo, INIA Escorpio, Potro, and Winter Star), and one diploid (La Estanzuela 284 or LE 284) were assessed. The parameters of soil fertility in the areas are illustrated in Table 1. Fertilization management was carried out following the recommendations provided by the Brazilian Society for Soil Science (Manual…, 2016) for cold season grasses, with an expected yield of 6t ha^{-1} of dry matter (DM). Before sowing, four properties (three in Cfa climate and one in Cfb) proceeded with organic fertilization. All properties carried out basic fertilization at sowing, as well as nitrogen cover fertilization after the first and/or second cut, using urea.

Sowing was carried out in May, between days 1 and 5 (Guaraciaba, Quilombo, and São Bernardino), day 19 (Abelardo Luz and Chapecó), days 22 to 25 (São Miguel do Oeste, Xanxerê and Xaxim), or in June (Porto União and São Lourenço do Oeste). Plots ranging from 1,000 to 2,000 m^2 were used depending on the rural properties, cultivated by means of a seeder-fertilizer, with 17cm row spacing. The sowing rate was 30kg ha^{-1} for the tetraploid genotypes (cultural value= 95.7%) and 40kg ha^{-1} for LE 284 (cultural value= 68.3%).

Before each grazing, when the plants reached 30cm in height, samples were collected in order to assess forage production and nutritive value. In each sampling, 12 sub-samples of 1.5 linear meters were collected, with forage cut at 10cm from to the ground. The heights were determined using a graduated stick. The samples from the area under grazing were weighed and conditioned in a forced air oven at 55ºC for 72 hours, to determine the DM content. The dry samples were sent to the

Labtron, laboratory of Cargill/Nutron, São Paulo, SP, Brazil, for bromatological analysis using near infrared reflectance spectroscopy. The contents of crude protein (slope = 1.008, r^2 = 0.975), neutral detergent fiber (NDF) (slope = 1.000, r^2 = 0.957) and total digestible nutrients (TDN) were determined, using net energy for lactation NEL = (2.2*(1.044-(0.0119*ADF)), with ADF being the acid detergent fiber (r^2 = 0.934). The result was applied in the formula TDN = (89.796*NEL/2.2)+4.898).

Table 1. Classification and parameters of soil fertility, according to analysis of the soils of the assessed areas with ryegrass genotypes, located in Abelardo Luz (AL), Chapecó (CH), Guaraciaba (GUA), Porto União (PU), Quilombo (QUI), São Bernardino (SB), São Lourenço do Oeste (SLO), São Miguel do Oeste (SMO), Xanxerê (XAN), and Xaxim (XAX)

Local	AL	CH	GUA	PU	QUI	SB	SLO	SMO	XAN	XAX
Soil classification[1]	DL	EC	EC	DC	EC	EC	EN	EC	DL	DL
Clay (%)	36.0	46.0	63.0	26.0	30.0	33.0	40.0	68.0	45.0	28.0
pH in water	5.7	5.3	5.0	5.0	5.9	5.6	5.4	5.5	5.7	5.7
P (mg dm^{-3})	2.9	22.0	7.8	8.2	32.0	18.8	8.6	4.3	9.9	5.2
K (mg dm^{-3})	84.0	212.0	168.0	128.0	200.0	132.0	120.0	110.0	204.0	391.0
OM m/v (%)	5.5	3.9	3.5	5.1	2.9	2.6	3.3	2.5	4.6	2.8
Al ($cmol_c$ dm^{-3})	0.0	1.3	2.7	2.0	0.0	0.0	0.0	0.3	0.0	0.0
CEC pH 7.0 (cmol dm^{-3})	13.3	15.8	11.7	21.5	21.0	16.6	14.7	14.7	12.0	23.0
Base Saturation (%)	79.3	76.0	67.8	66.3	76.7	82.7	84.5	66.8	75.4	78.7

[1]DL – Dystrophic Brown Latosol, EC – Haplic Ta Eutrophic Cambisol, DC – Dystrophic Humic Cambisol, EN – Eutrophic Litolic Neosol. Source: (Censo…, 2001); Sistema…, (2006).
P – phosphorus; K – potassium; OM – Organic Matter: Al – aluminum; CEC – cation exchange capacity.

Following the field sampling, the animal stocking rate necessary for the consumption of the forage available in the assessed area was estimated using, as a criterion, a forage offer of 3.5% of the animals' live weight (LW). The lactating cows remained in the area until the total consumption of the produced and sampled forage, limited to one day in the paddock. In addition to ryegrass forage, the animals received supplementation (corn silage and/or grass hay) and concentrate. The present study did not measure milk production, and the animals were used only as a factor causing changes in the grazing environment, as "harvesters" of the forage produced. The day after grazing, the heights of residue were assessed in twelve points at random. In each point, where a height greater than 10cm was found, this sample was cut to be subtracted from the weight of the forage produced. If a large unevenness of residue was found, the plots were levelled off with a mechanical mowing at 10cm from the ground.

Sampling was carried out until the areas were destined for summer cultivation, promoting ryegrass desiccation in August or September for sowing corn silage, or desiccation in October or November, when the subsequent cultivation was annual summer pasture. In this way, the system used was the usual for the regions where the present study was conducted. Therefore, the number of cuts/grazing varied according to the assessed property. In four of them, three cuts were performed (Abelardo Luz, São Lourenço do Oeste, Porto União, and São Miguel do Oeste), in four properties there were four cuts (Chapecó, Quilombo, Xanxerê, and Xaxim), and in the others (Guaraciaba and São Bernardino) there were five cuts.

The experimental design was completely randomized blocks with six ryegrass genotypes as treatments, and considering the areas (municipalities) as blocks, with three repetitions. The mathematical model used was: $Y_{ij} = \mu + G_i + B_j + \varepsilon_{ij}$, where, μ is a constant common to all observations, G_i is the effect of the i-th genotype, B_j is the effect of the j-th block, and ε_{ij} is a non-observable random error assigned to Y_{ij} observations. The dependent variables analyzed were DM produced by grazing cycle (cut), total DM production (total of cuts), average plant height with respect to the ground, forage accumulation rate per day or ARF (calculated by the total DM produced divided by the number of days between one cut and another), and bromatological quality for CP, NDF, and TDN. The normality of residues was determined, and the analysis of variance was subsequently performed.

When a significant difference was detected, the Tukey test (5%) was used to compare the treatment averages. Pearson's correlation coefficient was calculated to determine and estimate the existence of a relationship between the quantitative and qualitative productive variables. The statistical analyses were performed using the Statistical Analysis System software version 9.4.

RESULTS AND DISCUSSION

In 2016, the Western and Northern Plateau regions of the State of Santa Catarina, Brazil, were subject to a typical winter (i.e., within the normal climactic conditions), with a reasonable frequency of low temperatures. Data from meteorological stations located in the area addressed by the present study indicated that, in May and June, the average of average temperatures in Cfa climate ranged from 0.3 to 0.9ºC higher than the average of Cfb locations. On the other hand, from July to September, months in which the cuts were concentrated, this difference ranged from 1.6 to 3.1ºC. With respect to the minimum temperatures, the variation was even greater, and the monthly average from July to September in Cfa locations was 10.9, 12.7, and 11.8ºC vs. 8.0, 8.6, and 9.1ºC in Cfb locations.

The average interval between sowing and the first cut was 54.5 ± 7.6 days (Cfa) and 62.8 ± 9.7 days (Cfb). In Cfa climate, Mioto *et al*. (2014) and Oliveira *et al*. (2014) had found a longer period (65 days and 75 days, respectively) whereas Tonetto *et al*. (2011) observed a similar interval (56 days), in all cases with a shorter cut height (20cm), which demonstrates the precocity of the genotypes in the present study. Between the first cut (performed at the end of June or in July) and second cut (in August, in most places), the intervals were 29.2 ± 2.3 and 29.0 ± 6.3 days, whereas between the second and third cut (second half of August or September), they were 25.5 ± 1.9 and 30.5 ± 6.3 days, respectively for Cfa and Cfb climate locations. The first and the third cuts were performed, on average, eight and five days before in Cfa condition, a fact associated with the minimum and average temperatures observed in each period.

The highest average DM accumulation rates, considering the entire period, were exhibited by the cultivars Barjumbo and Bar HQ, which exceeded INIA Escorpio, Potro, and Winter Star ($P<0.05$). Costa *et al*. (2013) recorded a higher DM accumulation rate in INIA Escorpio (43.02kg ha^{-1} day^{-1}); however, the DM accumulation rate observed in Barjumbo was similar to that observed by Marchesan *et al*. (2016). Barjumbo exhibited the highest production of DM in each cut and in the total of the three cuts, exceeding 4.8 t ha^{-1}, though without difference with respect to Bar HQ. In all assessments, INIA Escorpio produced significantly less DM than Barjumbo ($P<0.05$). The tetraploid materials Potro and Winter Star, as well as the diploid LE 284, exhibited intermediate productions.

The total DM production of Barjumbo, INIA Escorpio, Potro, and Winter Star were 10 to 18% lower than those observed by Hahn *et al*. (2015), also in three cuts. On the other hand, they surpassed by 37 to 138% those obtained by Flores *et al*. (2008) and Mioto *et al*. (2014) with LE 284, Barjumbo, and INIA Escorpio, also with three cuts. In absolute values, DM production increased over the period. In the first cut, the genotypes produced, on average, 1,024kg ha^{-1}. This productivity was increased by 40% in the second cut, and by 14% in the third cut, compared to the second. This variation had also been observed by Hahn *et al*. (2015) in four cuts, demonstrating that the production cycle of ryegrass is concentrated at the end of winter and spring.

However, it was found that the difference in production between the most and least productive genotypes decreased, varying from 58% to 31% from the first to the third cut, with 38% in the total of the three cuts. It is worth mentioning that the results of the present study were obtained in ten rural properties, which were subject to the most diverse edaphoclimatic conditions. Therefore, they were significantly representative of the average reality of the regions assessed. Table 2 illustrates the productive performance of the genotypes in three cuts, assessed in the ten properties in which the present study was conducted.

In two locations (Guaraciaba and São Bernardino), it was possible to assess the fourth cut (September) and fifth cut (second half of September or first half of October) (Table 3). Bar HQ and Barjumbo (tetraploid) cultivars showed higher DM production, both exceeding 7 t ha^{-1}, and higher daily rates of accumulation ($P<0.05$).

With two more assessment cycles, DM production increased from 2,747kg ha^{-1} (INIA Escorpio) to 4,264kg ha^{-1} (Bar HQ). Hahn *et al*. (2015), also with five cuts, did not find differences in production between Barjumbo, INIA Escorpio, Potro, and Winter Star. On the other hand, Mioto *et al*. (2014) assessed nine cuts and observed the superiority of Barjumbo and INIA Escorpio in comparison to LE 284.

Table 2. Daily rate of dry matter productivity and accumulation in the first three cuts, and total of three cuts of ryegrass genotypes in ten municipalities in the Western and Northern Plateau regions of the State of Santa Catarina, Brazil

C	Bar HQ	Barjumbo	INIA Escorpio	LE 284	Potro	Winter Star	p-value
			Daily dry matter accumulation rate (kg ha^{-1} day^{-1})				
1	22.14^{A}±9.94	22.65^{A}±9.73	15.05^{B}±6.54	17.53^{B}±8.96	14.85^{B}±6.82	14.51^{B}±5.34	<0.0001
2	53.89^{AB}±30.45	56.65^{A}±33.67	39.27^{C}±18.53	46.08^{BC}±27.67	46.31^{BC}±24.73	46.57^{BC}±24.52	<0.0001
3	67.92^{AB}±35.02	71.39^{A}±33.44	55.84^{B}±25.26	65.20^{AB}±36.84	54.17^{B}±19.24	58.82^{AB}±21.27	0.0205
A	47.99^{AB}±15.22	50.23^{A}±14.90	36.72^{C}±13.52	42.94^{BC}±17.52	38.44^{C}±10.51	39.97^{C}±12.94	<0.0001
			Dry matter productivity (kg ha^{-1})				
1	1297.8^{A}±663.7	1305.6^{A}±667.9	866.6^{B}±439.5	992.4^{B}±561.5	858.5^{B}±437.3	826.6^{B}±346.4	<0.0001
2	1587.1^{A}± 991.2	1667.3^{A}±1052.9	1185.4^{B}±579.3	1393.3^{AB}±905.6	1333.9^{AB}±715.4	1452.9^{AB}±790.6	0.0015
3	1771.6^{AB}±809.5	1874.6^{A}±780.3	1482.5^{B}±662.7	1718.8^{AB}±906.1	1429.4^{AB}±485.9	1566.2^{AB}±602.5	0.0206
T	4654.5^{A}±1572.5	4877.7^{A}±1493.6	3534.7^{C}±1345.5	4095.5^{B}±1627.0	3632.9^{BC}±1085.1	3788.9^{BC}±1298.5	<0.0001

C: Cut (number); A: Average of three cuts; T: Total of three cuts.
Means followed by different letters in the line differ significantly by Tukey Test ($P<0.05$).

Table 3. Rate of daily dry matter productivity and accumulation in the fourth and fifth cuts, and the total of five cuts, in Guaraciaba and São Bernardino, Santa Catarina, Brazil

C	Bar HQ	Barjumbo	INIA Escorpio	LE 284	Potro	Winter Star	p-value
			Daily dry matter accumulation rate (kg ha^{-1} day^{-1})				
4	109.15^{A}±78.50	97.01^{AB}±48.45	75.89^{B}±38.82	87.75^{AB}±57.60	88.39^{AB}±58.55	77.56^{AB}±38.99	0.0162
5	95.32^{A}±51.24	102.53^{A}±58.74	53.43^{C}±14.91	67.08^{BC}±32.28	90.08^{AB}±48.85	57.28^{C}±17.85	<0.0001
A	62.53^{AB}±24.63	65.68^{A}±27.21	36.07^{C}±8.40	42.07^{C}±9.22	47.90^{BC}±13.91	44.30^{C}±5.46	<0.0001
			Dry matter productivity (kg ha^{-1})				
4	2383.0^{A}±1476.0	2062.8^{AB}±638.4	1699.1^{B}±706.1	1910.1^{AB}±1033.5	2045.0^{AB}±1216.4	1718.2^{AB}±675.6	0.0162
5	1881.4^{A}±1051.1	2026.0^{A}±1201.5	1048.3^{C}±319.3	1322.4^{BC}±666.1	1778.9^{AB}±1001.1	1123.9^{C}±374.9	<0.0001
T	7318.9^{A}±2384.7	7853.3^{A}±2678.1	4297.4^{B}±854.8	5070.1^{B}±831.2	5681.4^{B}±1434.2	5408.5^{B}±424.8	<0.0001

C: Cut (number); A: Average of five cuts; T: Total of five cuts.
Means followed by different letters in the line differ significantly by Tukey Test ($P<0.05$).

In comparison to the results of the present study, Mioto *et al*. (2014) recorded a higher DM production for INIA Escorpio, but lower in Barjumbo and LE 284 after five cuts. LE 284 had also produced less (about 4.6 t ha^{-1}) according to the results found by Flores *et al*. (2008) and Tonetto *et al*. (2011), but Rocha *et al*. (2007) indicated a production 40% higher than those observed, and with a cut less. Hahn *et al*. (2015) found that, in five cuts, Barjumbo produced less (7.48 t/ha) than in the present study, but INIA Escorpio, Potro, and Winter Star exhibited greater production rates than those observed here.

Even though Tables 2 and 3 illustrate data from different locations (ten and two properties, respectively), in absolute values they indicate that DM production increased in all cultivars until the fourth cut, with a greater decrease (38.3%, INIA Escorpio) or lower decrease (1.8%, Barjumbo) from the fourth to the fifth cut. The slowest decline in forage production over the pasture cycle (i.e., the greater productive persistence) is a characteristic whose importance is comparable to that of phytomass production (Malcolm *et al*., 2014). In addition, the average production of the fifth cut (greater than 1,500kg ha^{-1}) indicated that it would be possible to perform more cuts, if this were the option, enabling an even greater production.

The data referring to the bromatological composition of the forage are presented in Table 4, considering the first three cuts, i.e., the assessments performed in the ten locations. With regard to CP, there was a significant effect on the second cut. On the average of the cuts, the CP content of Potro exceeded that of Bar HQ, with no difference between them and the other cultivars. The average content among all materials was 27.4, 27.1 and 25.5%, respectively, from the first to the third cut, and never lower than 24.5%. These values can be considered expressive when grass is the subject of study. Rocha *et al*. (2007), Marchesan *et al*. (2015) and Costa *et al*. (2018) found lower levels of CP in LE 284, Barjumbo and INIA Escorpio, respectively.

Table 4. Content of crude protein, neutral detergent fiber, and total digestible nutrients of ryegrass genotypes in the first three cuts, in ten municipalities of the Western and Northern Plateau regions of the State of Santa Catarina, Brazil

C	Bar HQ	Barjumbo	INIA Escorpio	LE 284	Potro	Winter Star	p-value
				Crude Protein (%)			
1	26.13±4.88	27.02±3.32	28.36±4.85	27.73±5.80	29.09±4.89	26.12±5.26	0.1028
2	25.17^{B}±5.52	25.24^{B}±6.18	27.49^{AB}±5.08	28.20^{AB}±4.10	29.52^{A}±2.84	26.68^{AB}±5.45	0.0091
3	25.24±7.67	25.38±5.98	26.23±5.39	26.13±5.77	25.61±5.95	24.55±7.12	0.6670
A	25.51^{B}±4.39	25.87^{AB}±4.62	27.37^{AB}±4.56	27.35^{AB}±3.96	28.08^{A}±3.20	25.78^{AB}±4.60	0.0116
				Neutral Detergent Fiber (%)			
1	38.37±9.84	35.47±5.99	37.12±7.05	38.35±9.34	39.51±9.17	38.90±9.26	0.3838
2	41.06^{A}±6.53	39.38^{AB}±5.33	37.69^{B}±8.77	38.62^{AB}±7.69	40.30^{AB}±7.22	40.10^{AB}±6.22	0.0297
3	43.02^{AB}±8.30	46.27^{A}±7.96	41.31^{B}±7.25	46.20^{A}±9.43	42.11^{AB}±7.74	45.15^{AB}±6.96	0.0095
A	40.83±6.42	40.36±5.25	38.71±6.46	41.04±4.88	40.64±5.81	41.38±5.36	0.0609
				Total Digestible Nutrients (%)			
1	68.88±6.56	71.17±4.53	70.07±5.51	70.61±7.07	69.78±7.26	69.07±7.46	0.3536
2	67.52±6.05	69.28±3.32	69.66±4.40	70.04±4.39	68.08±4.16	68.02±4.59	0.3477
3	63.48±3.24	65.47±5.45	65.39±5.72	64.80±4.40	65.39±4.97	65.26±4.15	0.6553
A	66.62±4.11	68.63±4.05	68.39±4.62	68.49±4.27	67.73±4.62	67.27±4.02	0.2895

C: Cut (number); A: Average of three cuts.
Means followed by different letters in the line differ significantly by Tukey Test (P<0.05).

With respect to NDF, INIA Escorpio exhibited lower content than Bar HQ in the second cut, and Barjumbo and LE 284 in the third cut (P<0.05). The other cultivars did not differ from those or between themselves. Likewise, there was no difference between the genotypes when the average of the three cuts was assessed. As the cuts were performed, there was a slight increase in the average NDF content (38 to 44%), which reached a level of 40.5% in the set of the three assessments. The contents observed in LE 284 were equivalent to those determined by Rocha *et al*. (2007). However, for INIA Escorpio and Barjumbo the values were below than those reported by Costa *et al*. (2018) and Marchesan *et al*. (2015), respectively.

There was no effect of the genotypes on TDN contents in any of the cuts and in the average of the three cuts. The average contents varied slightly (70% in the first cut to 65% in the third), coinciding with the contents of 65 to 71% levels observed by Kobayashi *et al*. (2008). The bromatological parameters indicated that this forage had very good nutritional value, with high potential for animal production.

Table 5 shows Pearson's correlations for the variables studied. The quantitative variables DM production, forage height when cutting, and daily DM accumulation rate correlated positively with each other and with NDF contents. On the other hand, they showed negative correlations with CP and TDN contents. Among the qualitative variables, NDF had a negative relationship with both CP and TDN contents. Only the relationship between CP and TDN was not significant (P>0.05).

Table 5. Pearson's correlation between quantitative and qualitative variables of the ryegrass genotypes production, in the first three cuts, in ten municipalities of the Western and Northern Plateau regions of the State of Santa Catarina, Brazil

	CH	DAR	CP	NDF	TDN
DMP	0.54975 <0.0001	0.85832 <0.0001	– 0.42460 <0.0001	0.29755 <0.0001	– 0.21430 0.0039
CH		0.54898 <0.0001	– 0.36269 <0.0001	0.31674 <0.0001	– 0.27206 0.0002
DAR			– 0.33211 <0.0001	0.34371 <0.0001	– 0.25021 0.0007
CP				– 0.20687 0.0053	0.12882 0.0848
NDF					– 0.61190 <0.0001

DMP: dry matter production; CH: cutting height; DAR: daily dry matter accumulation rate; CP: Crude Protein; NDF: Neutral Detergent Fiber; TDN: Total Digestible Nutrients.

The results found by other studies are in line with the results found in the present study, with a negative relationship between the amount of DM in ryegrass and the content of CP and NDF (Vandewalle *et al*., 2003; Müller *et al*., 2012), and between the levels of CP and NDF (Müller *et al*., 2012; Wang *et al*., 2015). A positive correlation between forage accumulation rate and canopy height was reported by Rosa *et al*. (2013).

CONCLUSION

The data obtained in two mesoregions of the State of Santa Catarina, Brazil, indicated that the tetraploid cultivars Barjumbo and Bar HQ were more productive than three other tetraploid genotypes and one diploid genotype, either considering three or five cuts. The production of 3.5 to 4.9 t ha^{-1} of DM reached until the third cut, performed in the second half of August or in September, indicated that all materials were good options for short-cycle systems, as in the case of models of integration with summer crops, very common in the south region of the country. On the other hand, it should be noted that ryegrass is mostly characterized by a spring growth cycle, and the productions of the fourth and fifth cuts were, on average, 43.5% higher than the sum of the first three cuts. With the fifth cut occurring in the first half of October, and in view of the slow production decline at this stage, it was concluded that the cultivars were fully adapted to long-term forage systems, with a period of use that extends until November. The productive advantage of Barjumbo and Bar HQ, regardless of the number of cuts, indicated that the eventual higher cost of seeds, typical of tetraploid cultivars, can be fully compensated by greater outcomes in animal performance. However, it should be noted that the diploid LE 284 cultivar was not inferior to the other tetraploid cultivars assessed. The bromatological composition of the forage produced until the third cut (CP above 25%, TDN above 66%, and NDF below 42%), with no difference between cultivars, ensures that they are materials of high nutritional value and, therefore, high potential for animal production. In this way, they are especially suitable for herds of great nutritional demand and recognized capacity to respond to the quality of the diet.

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