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Forage mass and nutritive value of bermuda grass mixed to forage peanut or common vetch

Clair Jorge Olivo*, Juliano Costa dos Santos, Maurício Pase Quatrin, Gabriela Descovi Simonetti, Daiane Cristine Seibt and Michelle Schalemberg Diehl

*Universidade Federal de Santa Maria, Avenida Roraima, 1000, 97105-900, Santa Maria, Rio Grande do Sul, Brazil. *Author for correspondence. E-mail: clairo@smail.ufsm.br*

ABSTRACT. Three pasture-based systems (PS) with bermuda grass (BG) + forage peanut + 75 kg of N ha^{-1}; BG + common vetch + 75 kg of N ha^{-1} and BG + 150 kg of N ha^{-1} were evaluated. Lactating Holstein cows were used for evaluation and the experimental design was completely randomized. Forage mass, botanical and structural composition, daily dry matter accumulation rate and stocking rate were evaluated. Samples were collected by hand-plucking method to analyze crude protein (CP), neutral detergent fiber (NDF), (ISDMD), *in situ* organic matter digestibility (ISOMD) and total digestible nutrients (TDN). Average forage production and stocking rate were 13.8; 15.3 and 16.1 t ha^{-1} and 5.6; 6.4 and 5.5 UA ha^{-1} day^{-1} for PS respectively. Average CP and NDF were 16.4; 22.2 and 15.3%; 68.3; 65.7 and 66.3%; for ISDMD, ISOMD and TDN were 68.5; 70.3 and 66.4%; 64.3; 63.2 and 65.3%; 57.3; 58.3 and 57.5%, for PS respectively. Best results were reported on bermuda grass mixed with common vetch.

Keywords: *Arachis pintoi*, *Cynodon dactylon*, Coastcross-1, *Vicia sativa*.

Massa de forragem e valor nutritivo de pastagens de capim bermuda consorciadas com amendoim forrageiro ou ervilhaca

RESUMO. O objetivo da pesquisa foi avaliar três sistemas forrageiros (SF), constituídos por capim bermuda (CB) + amendoim forrageiro + 75 kg de N ha^{-1}; CB + ervilhaca + 75 kg de N ha^{-1} e CB + 150 kg de N ha^{-1}. Para a avaliação foram usadas vacas em lactação da raça Holandesa. O delineamento experimental utilizado foi o inteiramente casualizado. Avaliaram-se a massa de forragem, as composições botânica e estrutural, a taxa de acúmulo de matéria seca e a taxa de lotação. Foram coletadas amostras pelo método de simulação de pastejo para analisar proteína bruta (PB), fibra em detergente neutro (FDN), digestibilidade *in situ* da matéria seca (DISMS), digestibilidade *in situ* da matéria orgânica (DISMO) e nutrientes digestíveis totais (NDT). Os valores médios de produção de forragem e taxa de lotação foram de 13,8; 15,3 e 16,1 t ha^{-1} e 5,6; 6,4 e 5,5 UA ha^{-1}dia^{-1}, para os respectivos SF. Os valores médios para PB e FDN foram de 16,4; 22,2 e 15,3%; 68,3; 65,7 e 66,3%; para DISMS, DISMO e NDT foram de 68,5; 70,3 e 66,4%; 64,3; 63,2 e 65,3%; 57,3; 58,3 e 57,5%, para os respectivos SF. Melhores resultados foram obtidos no consórcio de capim bermuda com ervilhaca.

Palavras-chave: *Arachis pintoi*, *Cynodon dactylon*, Coastcross-1, *Vicia sativa*.

Introduction

Milk production is one of the most relevant livestock activities in Brazil especially on small and medium-sized farms (Lopes, Santos, Resende, Carvalho, & Cardoso, 2011). An increase in forages of the genus *Cynodon* has been reported on most farms, due to their high nutrition rates and high forage production per area unit (Campos, Saglietti, Campos, & Bueno, 2005) for grazing and for hay silage.

The cultivation of grasses is normally undertaken individually with great amounts of chemical fertilizers. Although the strategy increases forage production, especially due to the high response of forager to nitrogenated fertilization, increase in production costs, loss of nutrients due to leeching, percolation and volatilization, soil acidity occur coupled to environmental problems (Primavesi, Primavesi, Corrêa, Silva, & Cantarella, 2006; Teixeira, Natale, Neto, & Martins, 2007).

The mixture of legumes to sward pastures may be a benefit for the formation of more sustainable forage systems due to amounts of N in the system and grasses, with the consequent improvement of diet for the animals (Diehl et al., 2014). Increase in grazing usage period and animal production should also be taken into account (Assmann et al., 2004), besides preventing the degradation of pasture by pests and disease (Silva & Saliba, 2007).

The common vetch (*Vica sativa* L.), a legume selected for mixture owing to its high forage production and its ability in N fixing (Pinnow et al., 2013), and the forage peanut (*Arachis pintoi* Krap. & Greg.), a perennial forage with nutrition rates higher than other tropical legumes and high forage mass production (Ribeiro et al., 2008), are underscored for forage mixture.

Current research assesses the production and nutrition rates of forage comprising Coastcross-1 and several legumes in pastures for the grazing of dairy cattle.

Material and methods

Research was conducted in the Laboratory of Dairy Livestock of the Department of Animal Science of the Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul State, Brazil. According to the 2010 soil analysis, soil, classified as sandy dystrophic red argisol, has the following mean rates: pH-H_2O = 5.4; SMP index = 5.9; clay = 20%; P = 16.32; K = 102 mg dm^{-3}; MO = 2.65%; Al = 0.4; Ca = 4.9; Mg = 2.2 cmolc dm^{-3}; saturation of bases = 58.6 and saturation by Al = 5.6%. Climate is humid subtropical climate (Cfa), following Köppen´s classification. Meteorological data were retrieved from the Meteorological Station of UFSM, distant 500 m from the experimental area. Rainfall and temperatures during the experimental period between May 2010 and May 2011 (360 days) were respectively 141.8 mm $month^{-1}$ and 18.4ºC, similar to normal climate rates for the period, namely, 140.5 mm $month^{-1}$ and 19.2ºC (Figure 1).

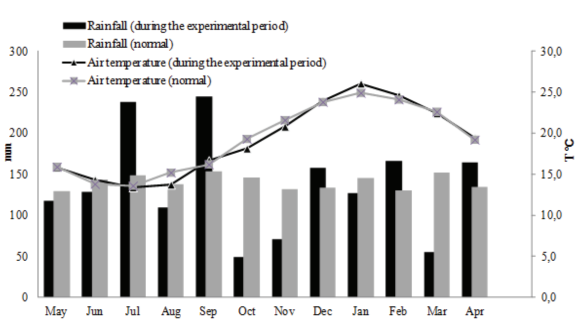

Figure 1. Accumulated monthly rainfall; mean monthly temperature and climate normal features between May 2010 and April 2011. Meteorological Station of Santa Maria, Rio Grande do Sul State, Brazil.

The 4760 m^2 experimental area was subdivided into six plots. Treatments comprised the following pasture swards: bermuda grass (cv. Coastcross-1) + stoloniferous forage peanut (cv. Amarillo) + 75 kg N ha^{-1}; Coastcross-1 + vetch, cv. Comum + 75 kg N ha^{-1} and Coastcross-1 + 150 kg N ha^{-1}. Bermuda grass from seedlings derived from tussocks division was planted manually throughout the experimental area. Vetch mixed with Coastcross-1 was planted in two plots on May 25, by multiple seeding for tillage, with 17 cm space between the rows and seedling density of 60 kg ha^{-1}. Forage peanut was introduced manually in the other two plots, with approximately three rooted seedlings per m², planted in approximately 10 cm-deep holes. Basic fertilization, respectively with 50 and 45 kg ha^{-1} of P_2O_5 and K_2O, occurred in September following recommendations for grass and legume mixture. Five urea applications, respectively with 15 and 30 kg N, were conducted after 1st, 3rd, 5th, 7th and 9th grazing, for nitrogenated fertilization corresponding to 75 and 150 kg N of treatments.

Usage and assessment of pasture started when forage mass reached between 2.0 and 2.5 t of DM ha^{-1}. First grazing occurred in October (spring) and the last in May (autumn). A supply of 5% of dry forage for every 100 kg of BW was calculated for animal load, at one-day occupation period.

Holstein dairy cows, mean weight 565 kg and mean production of 17.4 kg milk day^{-1}, were used in the experiment. Dairy cows were supplemented with 0.9% of BW after milking, plus mineral salt and water. When the animals were not on the experimental areas, they were kept in pastures with oats and ryegrass during winter and spring and in pastures with elephant grass and spontaneous-growing species during the summer and fall. In any case, they were supplemented with the same feed.

Forage mass was calculated by double sampling technique with 20 visual estimates and five cuts close to the ground. The process was repeated after the animals were removed from the plots. A sample of the cut forage was weighed and a sub-sample was removed to determine the botanic and structural composition of the Coastcross -1 pasture. It was later placed in a forced air oven at 60ºC till constant weight, to determine partial dry matter. Accumulated daily forage mass rate was calculated by subtracting the initial forage mass from the residue of the previous grazing and dividing the result by the number of days of the grazing cycle.

Pasture samples were removed, as sham grazing, at the entrance and exit of the animals from each plot to determine variables of forage nutrition rates. Samples were dried, ground (2 and 1 mm) in a Willey mill and conditioned as a compounded sample. Entrance and exit samples of each grazing per plot were first mixed to obtain the period´s compounded sample and then the mixtures of the samples corresponding to the grazing cycles of each season were prepared. Total N rates were determined by Kjeldahl´s method (Association of Official Analytical Chemists [AOAC], 1995); neutral detergent fiber was calculated according to Van Soest, Robertson, and Lewis (1991) and the *in situ* digestibility of organic matter was determined by technique described by Mehrez and Orskov (1977). Estimates of total digestible nutrient rates were calculated by the product of percentage of organic matter (OM) and the *in situ* digestibility of OM divided by 100 (Barber, Adamson, & Altman, 1984).

Experimental design was totally randomized, with three treatments (forage system), two replications (plots) and independent evaluations (seasons). Results were submitted to variance analysis and means compared by Tukey´s test at 5% probability; co-relation was calculated by Pearson´s coefficient (Statistical Analysis System [SAS], 2004). The following statistical model was used to Equation 1:

$$Y_{ijk} = m + T_i + \varepsilon_{ijk}, \quad (1)$$

where:
Y_{ijk} represents dependent variables;
m is the means of all data;
T_i is the effect of treatments (forage systems);
j is the index of repetitions (plots);
k is the index of the seasons;
ε_{ijk} is the residual effect.

Techniques and procedures in current research were approved by the Committee in Ethics for Experiments with animals of the Universidade Federal de Santa Maria (protocol 23081016073/2011-27; authorization 113/2011).

Results and discussion

Eleven grazing cycles were conducted during the period in which pasture was used (244 days), namely, three in the spring, five in the summer and three in the winter. Occupation time for each grazing cycle in each plot varies between one and three days; rest period varies between 21 and 23 days.

There were no differences in forage mass between forage systems (Table 1) and mean rates are close to 2.5 t of DM ha^{-1}, which were adequate to this type of forage (Paris, Cecato, Branco, Barbero, & Galbeiro, 2009).

As expected, pasture components in spring had a lower participation rate of Coastcross-1 ($p \leq 0.05$) in the mixture due to legumes. In the summer, higher participation rate of Coastcross-1 occurred in mixed pasture with vetch due to the absence of the legume and the stimulus caused by the degradation of its residual mass through the availability of N to the system (Pinnow et al., 2013). In the fall, there was a greater participation in the mixture by vetch with a prolonged activity on mixed grass and on the pasture without legumes due to the high level of nitrogenated fertilization.

Table 1. Botanic and structural components of forage mass (pre-grazing), daily accumulation rate of forage and stocking rate of the forage systems (FS) made up of Coastcross-1(C) + forage peanut + 75 kg N (C + AF + 75 N); C + vetch + 75 kg N (C + ER + 75 N) and C + 150 kg N (C + 150 N).

FS	Seasons			Means
	Spring	Summer	Fall	
Forage mass (kg of DM ha^{-1})				
C + AF + 75 N	2231	2558	2845	2545
C + ER + 75 N	2431	2748	2813	2664
C + 150 N	1962	2721	2901	2528
CV (%)	14.2	9.7	12.0	9.0
Coastcross-1 (%)				
C + AF + 75 N	42.2^{b}	50.3^{b}	50.0^{b}	47.5
C + ER + 75 N	40.1^{b}	63.1^{a}	74.0^{a}	59.0
C + 150 N	51.0^{a}	55.2^{b}	60.0^{a}	55.4
CV (%)	14.1	14.4	12.0	12.5
Leaf blade of Coastcross-1 (%)				
C + AF + 75 N	48.5^{b}	41.5^{b}	38.7^{b}	43.9^{b}
C + ER + 75 N	55.2^{a}	53.7^{a}	52.5^{a}	53.8^{a}
C + 150 N	50.5^{b}	38.4^{b}	42.8^{b}	42.9^{b}
CV (%)	3.5	2.4	2.4	8.1
Stem + sheath of Coastcross-1 (%)				
C + AF + 75 N	50.1^{a}	57.8^{a}	60.5^{a}	56.1
C + ER + 75 N	44.0^{a}	45.8^{b}	44.7^{c}	44.9
C + 150 N	48.0^{a}	60.6^{a}	54.0^{b}	54.3
CV (%)	3.3	2.6	2.2	3.0
Other species (%)				
C + AF + 75 N	29.7^{b}	28.2^{a}	24.2^{a}	27.4
C + ER + 75 N	23.3^{b}	23.1^{a}	14.3^{b}	20.2
C + 150 N	34.0^{a}	29.4^{a}	24.2^{a}	29.2
CV (%)	11.2	13.5	11.7	12.7
Legumes (%)				
C + AF + 75 N	5.6	9.5	13.8	9.6
C + ER + 75 N	25.0	---	---	25.0
Dead material (%)				
C + AF + 75 N	22.2^{a}	13.2^{a}	11.2^{b}	15.5
C + ER + 75 N	13.2^{b}	14.7^{a}	11.2^{b}	13.0
C + 150 N	14.8^{b}	15.0^{a}	15.7^{a}	15.1
CV (%)	13.4	14.2	11.5	14.2
Daily accumulation rate (kg of DM ha^{-1} day^{-1})				
C + AF + 75 N	37.0^{b}	55.4^{c}	81.0^{a}	57.8
C + ER + 75 N	42.5^{ab}	77.2^{b}	72.6^{a}	64.1
C + 150 N	42.0^{a}	86.8^{a}	73.0^{a}	67.3
CV (%)	7.1	10.0	9.2	10.4
Stocking rate (AU ha^{-1} day^{-1})				
C + AF + 75 N	2.8^{b}	7.1^{c}	6.7^{a}	5.6
C + ER + 75 N	5.7^{a}	8.0^{a}	6.7^{a}	6.4
C + 150 N	2.9^{b}	7.7^{b}	7.0^{a}	5.5
CV (%)	7.1	10.0	12.6	10.4

$^{a, b, c}$ - Means followed by different letters on the column differ by Tukey´s test ($p \leq 0.05$). DM = dry matter; CV = coefficient of variation; AU = animal unit, 450 kg.

Highest participation ($p \leq 0.05$) rate of leaf blades and a lower participation of stems in the structural composition of Coastcross-1 occurred in the mixture with vetch. The above indicated influence of the legume on the grass during spring, summer and fall, corroborated by Azevedo Júnior et al. (2012). In the fall, a high rate was also verified in the forage system without legumes when a double rate of nitrogenated fertilization was employed.

The fraction made up of other species was chiefly composed of ryegrass (*Lolium multiflorum* Lam.) with natural re-seeding, in the spring, and by spontaneous growth species, such as papuã (*Urocloa plantaginea* [Link] Hictch), *Paspalum conjugatun* and guanxuma (*Sida* spp.), during the other seasons of the year. Moreover, one may note that these species are inversely associated to legumes. Mean rates of dead material in the different systems were lower than 15%, considered to be adequate when losses by animal trampling and the high number of grazing cycles were taken into account.

Highest rates in the forage mass accumulation rate were reported in the mixture with vetch and in pasture without legumes. Result for mixed pasture with vetch is due to a higher participation of legumes in the botanic composition of the pasture during spring and to residual effect during summer, with more availability of N in the system due to degradation of nodules, roots and components of the plants´ aerial parts. There were lower rates in the mixture with forage peanut when compared to the others, due to low participation of the legume in all the seasons. Rates were higher ($p \leq 0.05$) in the case of legume-less system, probably due to higher levels of nitrogenated fertilization. Higher rates in accumulation rates were reported in Maringá, Paraná State, Brazil, with Coastcross-1 in mixed cultivations and alone, employing higher rates of nitrogenated fertilization (Ribeiro et al., 2008).

When daily accumulation rates were taken into account, forage productions in the experimental period were 13.8; 15.3 and 16.1 t of DM ha^{-1}, for mixtures with peanut and vetch and legume-less pasture. In their research with Coastcross-1 mixed with winter legumes (arrowleaf clover and vetch) plus 100 kg N ha^{-1} and pure pasture plus 200 kg N ha^{-1}, Aguirre et al. (2014) obtained a production of 21.0; 20.3 and 24.3 t DM ha^{-1}, respectively.

High vetch participation produced a stocking rate during spring ($p \leq 0.05$) when compared to the other systems, which was also reported in the summer. Fall rates were similar among the systems due to similar accumulation rate among the pastures. In their work with Coastcross-1 plus forage peanut, with different N levels, in the northwestern region of the state of Paraná, Brazil, Paris et al. (2008) reported a mean stocking rate of 3.45 dairy cows ha^{-1} day^{-1}, or rather, lower than that in current assay.

There was a higher CP rate of forage (Table 2) in the spring ($p \leq 0.05$) for the bermuda grass and vetch system, due to the high participation of the legume in the pasture composition (Table 1), with a subsequent rise in the protein rate of forage (Olivo et al., 2013).

Table 2. Variables of nutrition rates, crude protein (CP), neutral detergent fiber (NDF), *in situ* dry matter digestibility (ISDMD), *in situ* organic matter digestibility (ISOMD) and total digestible nutrients (TDN) in forage systems of Coastcross-1 (C) + forage peanut + 75 kg N (C + AF + 75 N); C + vetch + 75 kg N (C + ER + 75 N) and C + 150 kg of N (C + 150 N).

FS	Seasons			Means
	Spring	Summer	Fall	
		CP (%)		
C + AF + 75 N	16.6[b]	15.0[a]	15.2[a]	16.4
C + ER + 75 N	28.1[a]	20.1[a]	17.8[a]	22.2
C + 150 N	16.4[b]	16.3[a]	14.2[a]	15.3
CV (%)	6.0	7.1	5.0	4.0
		NDF (%)		
C + AF + 75 N	70.1	66.2	68.2	68.3
C + ER + 75 N	64.0	66.5	66.7	65.7
C + 150 N	66.0	64.3	67.4	66.3
CV (%)	9.2	7.3	5.5	4.0
		ISDMD (%)		
C + AF + 75 N	70.3[a]	69.0[a]	65.0[a]	68.5
C + ER + 75 N	74.2[a]	71.5[a]	67.0[a]	70.3
C + 150 N	71.0[a]	69.3[a]	60.2[b]	66.4
CV (%)	6.3	7.3	5.1	4.4
		ISOMD (%)		
C + AF + 75 N	61.1[b]	65.0[a]	64.0[a]	64.3
C + ER + 75 N	66.2[a]	65.5[a]	63.1[a]	63.2
C + 150 N	63.7[b]	65.2[a]	63.0[a]	65.3
CV (%)	3.3	4.0	3.5	3.2
		TDN (%)		
C + AF + 75 N	56.6	57.2	57.3	57.0
C + ER + 75 N	60.0	58.9	59.1	58.3
C + 150 N	58.4	56.9	58.2	57.5
CV (%)	3.4	3.6	3.2	3.3

[a, b, c] - Means followed by different letters on the column differ by Tukey´s test ($p \leq 0.05$). CV = coefficient of variation.

There was no difference for the other systems due to the low participation of forage peanut. Relatively high CP rate in the system is due to the participation of ryegrass in the pasture composition which is also verified in the legume-less pasture (Table 1). Since systems were similar during summer and fall, there was a residual effect of vetch and forage peanut. Results reveal that mixed and pure pasture is equivalent in the pasture´s protein rate where double nitrogenated fertilization was employed. Mean rates in the legume-less system in the summer and fall had lower protein variability when compared with rates established by Moreira et al. (2012), who evaluated Tifton-85 in the summer (10,5%) and in the autumn (16,2%), albeit with a higher amount of fertilizers (200 kg N ha^{-1}). Protein rate in a relatively high forage in the summer and in the fall may be associated to high participation of the leaf blades of Coastcross-1 ($r = 0.62$; $p = 0.0034$).

There were no differences in NDF among the forage systems, with low variability of NDF in all seasons. Relatively high NDF in spring is associated to the high participation of Coastcross-1 during this period (Table1). Mean NDF rates are close to mean rate (67.09%) reported by Ribeiro et al. (2012) for leaf blade of mixed Coastcross-1 and at different levels of nitrogenated fertilization.

ISDMD was similar between the forage systems in the spring and summer. Rates were higher ($p \leq 0.05$) in the fall in forage derived from mixed pastures, perhaps due to the effects of the legumes. Mean rates are high when compared to those reported by Olivo et al. (2009), or rather, 59.6%, in Coastcross-1 pasture mixed with ryegrass. Similar rates were also registered by Ribeiro et al. (2012), with mean rates 73.3 and 63.6%, for leaf blade and stem plus Coastcross sheath, respectively.

ISOMD greatly differed ($p \leq 0.05$) when mixed with vetch due to the high participation of the legume during the season. The systems were similar in the summer and fall. However, lower ISOMD rates were reported by Hill, Gates, and Burton (1993) with varieties of bermuda grass, Tifton 85 and Tifton 44, fertilized with 196 kg N ha^{-1} $year^{-1}$, or rather, 60.3 and 55%, respectively. Usual co-relationships between ISDMD and NDF ($r = -0.71$; $p = 0.0009$); protein and NDF ($r = -0.47$; $p = 0.0496$); and ISDMD and CP ($r = 0.65$; $p = 0.0032$) were reported.

There was no difference in TND rates among the forage systems. Mean rate (58%) is close to that reported by Santos, Silva, and Chaves (2008), which was 63.6%, in their research with Tifton 85, with and without irrigation and fertilization with 150 kg N ha^{-1}.

Conclusion

The introduction of vetch caused a greater participation of leaf blades of the Coastcross-1 grass throughout the evaluation period. The system was similar to pasture alone in which double nitrogenated fertilization was employed, confirmed by forage accumulation and stocking rates. Mixture with Coastcross-1 and forage peanut had a lower performance rate and a similar nutrition rate to the Coastcross-1 system in its own cultivation.

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