



Forage systems mixed with forage legumes grazed by lactating COWS

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ABSTRACT. Current research evaluates productivity, stocking and nutritional rates of three forage systems with Elephant Grass (EG) + Italian Ryegrass (IR) + Spontaneous Growth Species (SGS), without forage legumes; EG + IR + SGS + Forage Peanut (FP), mixed with FP; and EG + IR + SGS + Red Clover (RC), mixed with RC, in rotational grazing method by lactating cows. IR developed between rows of EG. FP was maintained, whilst RC was sown to respective forage systems. The experimental design was completely randomized, with three treatments and two replication, subdivided into parcels over time. Mean rate for forage yield and average stocking rate were 10.6, 11.6 and 14.4 t ha⁻¹; 3.0, 2.8 and 3.1 animal unit ha⁻¹ day⁻¹, for the respective systems. Levels of crude protein and total digestible nutrients were 17.8, 18.7 and 17.5%; 66.5, 66.8 and 64.8%, for the respective forage systems. The presence of RC results in better and higher forage yield in the mixture, whilst FP results in greater control of SGS. The inclusion of forage legumes in pasture systems provides better nutritional rates.

Keywords: *Arachis pintoi*, *Lolium multiflorum*, *Pennisetum purpureum*, rotational grazing, *Trifolium pratense*.

Sistemas forrageiros consorciados com leguminosas sob pastejo com vacas em lactação

RESUMO. O objetivo nesta pesquisa foi avaliar a produtividade, a taxa de lotação e o valor nutritivo de três sistemas forrageiros: capim elefante (CE) + aveia (AZ) + espécies de crescimento espontâneo (ECE), sem leguminosa; CE + AZ + ECE + amendoim forrageiro (AM), consórcio com AM; e CE + AZ + ECE + trevo vermelho (TV), consórcio com TV, em pastejo com lotação rotacionada utilizando vacas em lactação. Possibilitou-se o desenvolvimento do AZ entre as touceiras de CE. O AM foi preservado na área e o TV foi semeado, respectivamente para os sistemas forrageiros. O delineamento experimental foi inteiramente casualizado, com três tratamentos, duas repetições e parcelas subdivididas no tempo. Os valores médios de produção e das taxas de lotação foram de 10,6; 11,6 e 14,4 t ha⁻¹; 3,0; 2,8; e 3,1 unidades animal ha⁻¹ dia⁻¹, para os respectivos sistemas. Os teores de proteína bruta e de nutrientes digestíveis totais foram de 17,77; 18,70 e 17,45%; 66,47; 66,77 e 64,76% para os respectivos sistemas. O consórcio com TV resulta em melhor e maior produção de forragem, enquanto o consórcio com AM resulta em melhor controle de ECE. A inclusão de leguminosas forrageiras implica em melhor valor nutritivo do pasto.

Palavras-chave: *Arachis pintoi*, *Lolium multiflorum*, lotação rotacionada, *Pennisetum purpureum*, *Trifolium pratense*.

Introduction

Pastures constitute the main component of the animal's diet in dairy livestock systems, especially in subtropical climate regions, where soil and climate conditions favor several forage species to grow at different times of the year (Moreira, Prado, Cecato, Wada, & Mizubuti, 2004; Silva et al., 2011). Among forage plants, Elephant grass stands out for its high forage accumulation potential, particularly for its longevity (Azevedo Junior et al., 2012a). In subtropical regions, its high productivity in the summer period and growth decrease during the winter period due to low temperatures causes great

variations in forage yield and nutritional value, limiting animal performance.

Consequently, the use of more sustainable techniques, such as intercropping with legumes and mixing with other grasses, may balance forage supply and quality of forage during the agricultural year and minimize the environmental impact due to less use of nitrogen fertilizers (Olivo et al., 2012). Several research studies have shown that the use of legumes in intercropping with grasses may reduce direct spending on fertilizers, increase the quality and diversification of the diet consumed by the animals, improve forage availability by nitrogen supply to the system through recycling and transfer

to the grass companion and extend the period of pastures usage (Assmann et al., 2007; Diehl et al., 2014). Despite its several advantages, the above mixture is still limited in rural properties due to a considerable lack of scientific studies on forage legumes subjected to grazing conditions (Steinwandter et al., 2009).

Current study investigates forage systems composed of Elephant grass, Italian ryegrass, spontaneous growing species and legumes; Forage peanut or Red clover subjected to rotational stocking grazing throughout the growing season, with regard to forage mass, dry matter yield, stocking rate and nutritional rates.

Material and methods

All techniques and procedures in current study were approved by the Committee for Ethics in Animal Experimentation of the Federal University of Santa Maria, Santa Maria RS Brazil (Protocol 23081016073 / 2011-27, Process 113/2011).

The study was carried out between May 2012 and May 2013, in an area owned by the Laboratório de Bovinocultura de Leite of the Universidade Federal de Santa Maria, in the central region of the state of Rio Grande do Sul, Brazil (29° 43'S and 53° 43'W). The study was carried out on Typic Hapludalf soil belonging to the São Pedro mapping unit (EMBRAPA, 2006); pH 5.5; 3% organic materials matter; 14 mg dm⁻³ phosphorus. Average monthly temperature and accumulated rainfall during the experimental period were 19.3°C and 1601 mm (Figure 1) respectively, with climate averages at 19.6° C and 1686 mm, respectively, for the past 30 years.

The experimental area comprised 0.78 ha, divided into six paddocks of 0.13 ha each. Evaluated forage systems were Italian ryegrass (*Lolium multiflorum* Lam., IR), cv. Common in winter; Elephant grass (*Pennisetum purpureum* Schum., EG), cv. Merckeron Pinda, in summer. In the case of the legume grass system in two paddocks, the Forage peanut cv. Amarillo (*Arachis pintoi* Krap. and Greg., FP), established in 2006 was maintained; and in two other paddocks inoculated and scarified seeds of Red clover (*Trifolium pratense* L., RC), cv. Estanzuela 116, with 86% germination were sown in May 2011, at a rate of 6 kg ha⁻¹. The Italian ryegrass grew by natural reseeding between the clumps of Elephant grass established since 2004 in rows 4 m apart, throughout the entire trial area. Treatments consisted of IR + EG without legumes; IR + EG + FP, mixed with Forage peanut; IR + EG + RC, mixed with Red clover.

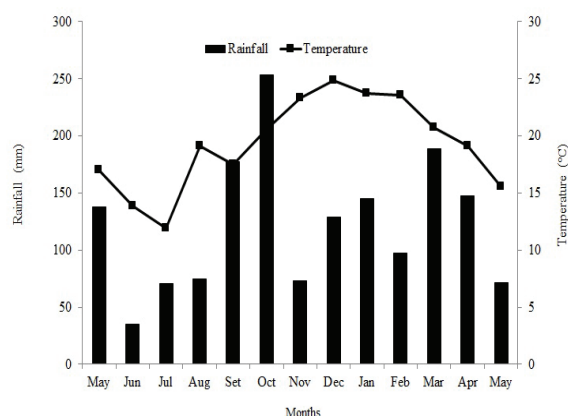


Figure 1. Cumulative rainfall and average monthly air temperature between May 2012 and May 2013, Santa Maria, Brazil.

Evaluated parameters comprised pre-grazing forage mass, botanical and structural composition, accumulation rate and forage yield, stocking rate and apparent forage intake. Crude protein (CP), neutral detergent fiber (NDF), and *in situ* digestibility of organic matter (ISOMD) were also assessed.

Acidity comprised corrected limestone, potassium and phosphorus fertilization, were carried out according to soil analysis. The urea-based nitrogen fertilizer rate was 93 kg ha⁻¹ of N, divided into four applications, with the first application 30 days after the emergence of Italian ryegrass in June and the remaining applications in August, December and March.

The criteria for the use of pastures were sward height with approximately 20 cm for Italian ryegrass in winter and 100-120 cm for Elephant grass in summer. Herbage samples were collected prior to the animal's access to the pastures. Samples were dried in a ventilated oven at 55°C to constant weight and ground in a 2 – 1 mm Willey mill sieve. Dry matter (DM) contents were determined by drying at 105° C for 8 hours. Ash contents were determined by combustion at 600°C for 4 hours and organic matter (OM) by their difference (adapted from AOAC (2005).

Pre-grazing forage mass was determined by visual estimation technique with double sampling. This was done on alignment formed by clumps of Elephant grass and also between Elephant grass rows. Structural composition of Elephant grass was also determined by the manual separation of the leaf, stem and senescent material. The samples of Elephant grass was harvested at a height of 50 cm, and the samples in the areas between the rows were harvested close to the ground. Forage mass estimation was based on the occupied area, or rather, 30% for Elephant grass and 70% for the species

present between the rows formed by clumps of Elephant grass.

Selected grazing method was rotational stocking with 1-day occupation by lactating Holstein cows, with body weight (BW) and average yield of 573 kg and 17 kg of milk day⁻¹, respectively. Cows were milked twice a day, at 7:30 and 16:00, remaining on the pastures from 9:00 to 15:30 and from 18:00 to 7:00. Each animal received a daily 0.9% BW of concentrate as diet supplement, comprising 16-18% crude protein (CP) and 65% total digestible nutrients (TDN). The concentrate was made with maize grain, wheat bran, soybean meal, vitamin and mineral premix.

Stocking rate was based on forage mass (pre-grazing) so that herbage allowance was approximately 4 kg DM 100 kg BW⁻¹ for leaf blade mass of Elephant grass and of 6 kg DM 100 kg BW⁻¹ for the forage mass between Elephant grass rows. When animals were removed from pasture, the sampling procedure was repeated to calculate forage mass (post-grazing). Grazing was repeated when forage again reached the recommended height.

Initial forage mass (pre-grazing) was subtracted from the residual forage mass (post-grazing) of the previous grazing to determine forage accumulation. Daily accumulation rate was determined by dividing forage accumulation by the number of days between grazing cycles. Forage yield was calculated by adding forage accumulation in each grazing range. Forage intake was estimated by the method of agronomic difference, or rather, by subtracting the mass of residual forage (post-grazing) from the initial forage mass (pre-grazing), divided by stocking density.

Samples were collected by hand plucking technique, at the beginning and end of each grazing period to determine the forage variables of nutritional rates. The material was mixed in proportional amounts and a subsample extracted for analysis. The results of nutritional value analyses were grouped according to season, with two grazing cycles for each. Total nitrogen (N) was determined by the Kjeldahl method (Method 984.13; AOAC (2005) and a correction factor of 6.25 was used for the conversion of N into CP. NDF (Van Soest, Robertson, & Lewis, 1991) and *in situ* organic matter digestibility (ISOMD) were also determined (Mehrez & Orskov, 1977), whilst estimated NDT was obtained by organic matter percentage times ISOMD and divided by 100 (NRC, 2000).

The experimental design was completely randomized, with three treatments (forage systems), two replications (paddocks) and split plots (grazing periods). Data were subjected to analysis of variance

and means were compared by Tukey's test at 5% error probability, using the MIXED procedure (SAS, 2004). Statistical model for the analysis of the studied variables was represented by: $Y_{ijk} = m + T_i + R_j(T_i) + G_k + (TG)_{ik} + E_{ijk}$, where: Y_{ijk} is the dependent variables; i treatment index (forage systems); j repetition indexes (paddocks); k grazing cycle index; m average of all observations; T_i effect of treatments; $R_j(T_i)$ = effect of repetition in treatments (error a); G_k = effect of grazing cycles; $(TG)_{ik}$ = interaction between treatments and the grazing cycles; E_{ijk} the residual experimental error (error b).

Results and discussion

Eight grazing cycles were carried out during the 364-days experimental period (Table 1), with a mean interval of 38 days (± 12), and two grazing cycles in each season. In the case of forage mass (pre-grazing), difference ($p \leq 0.05$) occurred only in grazing during May with a higher rate for mixtures, indicating a possible residual effect of the legumes (Table 1). The mixture's improved performance in the autumn is important since it is a critical period in southern Brazil with its usual shortage of pasture. Among the grazing cycles, the lowest herbage mass rate occurred in July, due to Elephant grass seasonality, and in October as a result of mowing done in August. The average forage mass was 2.5 t ha⁻¹, which was lower than that reported by Azevedo Junior et al. (2012b), or rather, 3.5 t ha⁻¹, in similar systems with Elephant grass, Italian ryegrass and mixture with Forage peanut or Red clover, but with higher amounts of nitrogen fertilizer.

As expected, rates of Elephant grass structural components were low during the winter period. Differences in leaf blades occurred in three grazing periods, with higher rates for the mixture with Red clover, probably associated to the presence of this legume and contributing positively to the companion grass (Carvalho & Pires, 2008). The only difference in the case of Elephant grass stem + sheath occurred for grazing in March with higher rates for the system without legumes; among grazing periods, rates were similar among systems, particularly low rate of this fraction in grazing during February due to low rainfall during the period (Figure 1). It should be underscored that, in the case of the dead material fraction of Elephant grass, the high rate ($p \leq 0.05$) in July occurred in the system without legume.

Italian ryegrass was similar and was not affected by legumes, possibly due to their minor

involvement in grazing during August and October. A comparison between mean rates points to a difference ($p \leq 0.05$), with higher availability for forage peanut. The average participation of legumes on the mass of the total forage reached 47% for Forage peanut and 16% for Red clover, which were adequate for the sustainability of the forage systems (Diehl et al., 2013).

In the case of spontaneous growth species, especially for Bahia grass (*Paspalum notatum*), Alexander grass (*Urochloa plantaginea*) and *Paspalum conjugatum*, the observed differences ($p \leq 0.05$) between systems for all grazing cycles indicate that legume contributed towards the control of these species (Olivo et al., 2008). It should be underscored that these species present high participation particularly during summer and early fall. For the dead material fraction of forage between Elephant grass clumps, the high rates were reported in July

due to the cumulative action of frost on the spontaneous growing species, and in December due to the senescent Italian ryegrass material.

Significant differences ($p \leq 0.05$) for herbage disappearance rate of forage (Table 2) were registered in four grazing cycles, with high mixture rates. It may be observed that there was better performance in the structural composition of Elephant grass during the early crop development in October, with a higher disappearance rate for leaf blade and a lower one for stem + sheath, in the mixture. The above indicated a possible synergistic effect of forage legumes to the companion crop, improving the nutritional rate and grass intake accordingly. Similar result occurred in the early use of Italian ryegrass. Azevedo Junior et al. (2012b), in similar research, obtained lower performance in Italian ryegrass disappearance rate, with average of 44.2%.

Table 1. Forage mass, structural and botanical composition (kg of DM ha⁻¹) of three forage systems (FS).

FS	Grazing cycles								Means	MSE
	1 st Jul.12	2 nd Aug.12	3 rd Oct.12	4 th Dec.12	5 th Jan.13	6 th Feb.13	7 th Mar.13	8 th May.13		
Forage mass (Pre-grazing)										
WL ¹	1213 ^D	3121 ^A	1739 ^C	2125 ^B	2778 ^A	2641 ^A	2811 ^{Ab}	2651 ^{Ac}	2385	149
FP ²	1307 ^C	2806 ^A	1980 ^C	2241 ^B	2337 ^B	2345 ^B	2868 ^{Ab}	3094 ^{Ab}	2372	133
RC ³	1474 ^C	3043 ^{AB}	1905 ^C	2425 ^B	2757 ^B	2572 ^B	4052 ^{Aa}	3978 ^{Aa}	2776	212
MSE	44.1	54.7	41.1	50.4	82.9	51.6	234	225		
Elephant grass leaf blade										
WL	-	195 ^D	53 ^{Eb}	1176 ^B	1537 ^{Aa}	1409 ^A	721 ^C	688 ^{Cb}	826	142
FP	-	162 ^C	101 ^{Cab}	1109 ^A	586 ^{Bb}	664 ^B	598 ^B	665 ^{Bb}	555	86.8
RC	-	206 ^C	131 ^{Ca}	1105 ^A	979 ^{Ab}	771 ^B	661 ^B	1140 ^{Aa}	713	107
MSE	-	7.6	13.1	13.3	159	134	20.5	89.3		
Elephant grass stem + sheath										
WL	-	23 ^E	8 ^F	396 ^B	210 ^C	67 ^D	318 ^{Ba}	772 ^A	256	62.6
FP	-	12 ^E	14 ^E	374 ^B	147 ^C	62 ^D	194 ^{Cb}	674 ^A	211	55.8
RC	-	24 ^E	7 ^F	372 ^B	122 ^C	58 ^D	178 ^{Cb}	513 ^A	182	44.1
MSE	-	2.2	1.3	4.4	15.1	1.5	25.5	43.6		
Dead material of Elephant grass										
WL	944 ^{Aa}	789 ^A	108 ^B	-	-	-	-	-	613	92.8
FP	588 ^{Ab}	796 ^A	206 ^B	-	-	-	-	-	530	74.3
RC	560 ^{Ab}	837 ^A	286 ^B	-	-	-	-	-	561	76.1
MSE	71.4	8.6	29.7							
Italian ryegrass										
WL	965 ^C	2729 ^A	1585 ^B	-	-	-	-	-	1766	241
FP	1156 ^C	2177 ^A	1577 ^B	-	-	-	-	-	1636	208
RC	997 ^C	2478 ^A	1329 ^B	-	-	-	-	-	1601	217
MSE	34.1	92.1	48.5							
Legumes										
FP	-	176 ^{Db}	242 ^C	733 ^{Ba}	438 ^C	1296 ^{Aa}	1720 ^{Aa}	1422 ^{Aa}	861	152
RC	178 ^C	220 ^{Ca}	239 ^C	431 ^{Bb}	472 ^B	194 ^{Cb}	624 ^{Ab}	277 ^{Bb}	329	37.7
MSE	-	11.0	0.8	75.5	8.5	276	274	286		
Spontaneous growth species										
WL	62 ^D	-	-	654 ^{Ca}	1241 ^{Bb}	1232 ^{Ba}	2089 ^{Ab}	1964 ^{Ab}	1207	201
FP	-	108 ^{Ea}	28 ^{Bb}	198 ^{Eb}	1752 ^{Aa}	385 ^{Bb}	550 ^{Cb}	1007 ^{Bc}	575	142
RC	-	68 ^{Eb}	116 ^{Da}	632 ^{Ca}	1307 ^{Bb}	1608 ^{Ba}	2768 ^{Aa}	2562 ^{Aa}	1294	264
MSE	-	-	-	85.7	92.6	209	379	261		
Dead material between rows of Elephant grass										
WL	188 ^{Bab}	392 ^A	82 ^C	294 ^{Aa}	-	-	-	-	239	36.2
FP	152 ^{Bb}	348 ^A	34 ^C	202 ^{Ab}	-	-	-	-	184	30.4
RC	299 ^{Aa}	278 ^A	152 ^B	258 ^{Aab}	-	-	-	-	247	32.4
MSE	25.5	19.2	19.8	19.5	-	-	-	-		

¹WL (without legumes) = Elephant grass (EG)+Italian ryegrass (IR)+spontaneous growth species (SGS); ² FP (mixture with Forage peanut) = EG+IR+SGS+FP; ³ RC (mixture with Red clover) = EG+IR+SGS+RC. MSE = means standard error. Means followed by different low case letters (column) and by upper case letters (rows) differ significantly by Tukey's test ($p \leq 0.05$).

Table 2. Herbage disappearance rate (%) of three forage systems (FS).

FS	Grazing cycles								Means	MSE
	1 st Jul.12	2 nd Aug.12	3 rd Oct.12	4 th Dec.12	5 th Jan.13	6 th Feb.13	7 th Mar.13	8 th May.13		
	Forage									
WL ¹	31 ^{BCb}	68 ^A	42 ^C	33 ^{Cb}	64 ^A	55 ^B	44 ^{Cc}	35 ^{BCc}	46	3.3
FP ²	55 ^{Aa}	61 ^A	40 ^A	56 ^{Aa}	68 ^A	58 ^A	62 ^{Aa}	55 ^{Ab}	57	1.9
RC ³	60 ^{Ba}	73 ^A	49 ^C	57 ^{Ba}	61 ^B	62 ^B	69 ^{Aa}	70 ^{Aa}	63	1.8
MSE	5.2	2.0	1.6	4.5	1.2	1.2	4.3	5.9		
	Elephant grass leaf blade									
WL	-	-	19 ^{Cb}	37 ^C	87 ^A	72 ^B	67 ^B	26 ^C	51	7.8
FP	-	-	40 ^{Ba}	54 ^B	85 ^A	56 ^B	62 ^B	66 ^B	61	7.2
RC	-	-	44 ^{Ca}	57 ^B	86 ^A	49 ^B	62 ^B	70 ^B	61	7.3
MSE	-	-	4.5	3.6	0.3	3.9	1.0	8.1		
	Elephant grass stem + sheath									
WL	-	-	50 ^{Ba}	68 ^A	65 ^A	77 ^A	20 ^{Cb}	26 ^C	48	7.2
FP	-	-	44 ^{Bb}	78 ^A	80 ^A	86 ^A	29 ^{Bb}	36 ^B	59	8.1
RC	-	-	41 ^{Cb}	79 ^B	61 ^B	83 ^A	82 ^{Aa}	70 ^B	69	8.2
MSE	-	-	1.5	2.0	3.3	1.5	11.2	7.7		
	Italian ryegrass									
WL	33 ^{Cb}	87 ^A	49 ^B	-	-	-	-	-	56	7.6
FP	60 ^{Ba}	83 ^A	38 ^C	-	-	-	-	-	60	7.8
RC	52 ^{Ba}	89 ^A	47 ^B	-	-	-	-	-	63	8.1
MSE	4.6	1.0	20.	-	-	-	-	-		
	Legumes									
FP	-	25 ^C	39 ^B	36 ^B	39 ^B	77 ^A	78 ^A	70 ^{Ab}	52	6.4
RC	68 ^A	25 ^D	47 ^C	31 ^C	35 ^C	62 ^B	77 ^A	78 ^{Aa}	53	4.9
MSE	-	0	2.0	1.3	1.0	3.8	0.3	2.0		
	Spontaneous growth species									
WL	17 ^C	-	-	34 ^{Bb}	54 ^{Ac}	54 ^A	36 ^{Bb}	53 ^{Ab}	42	5.4
FP	-	12 ^D	73 ^B	42 ^{Cb}	90 ^{Aa}	34 ^C	56 ^{Cb}	70 ^{Ba}	54	7.3
RC	-	41 ^C	28 ^B	85 ^{Aa}	71 ^{ABb}	78 ^A	86 ^{Aa}	78 ^{ABa}	63	7.4
MSE	-	-	-	9.1	6.0	7.3	8.4	4.3		

¹WL (without legumes) = Elephant grass (EG)+Italian ryegrass (IR)+spontaneous growth species (SGS); ² FP (mixture with Forage peanut)= EG+IR+SGS+FP; ³ RC (mixture with Red clover)= EG+IR+SGS+RC. MSE= means standard error. BW=body weight. Means followed by different lower case letters (column) and upper case letters (rows) differ significantly by Tukey's test ($p \leq 0.05$).

In case of legumes, the difference obtained in May indicated that there was better use of the winter species, an expected outcome when compared to that of the summer species (Carvalho & Pires, 2008). In other grazing cycles, there was similarity in herbage disappearance rate was similar among legumes. Similar studies by Diehl et al. (2013) with Forage peanut and Red clover under mixture had lower disappearance rates. Performance for spontaneous growth species was better when in the mixture, especially during grazing cycles in autumn. The difference observed between the pastures' components indicated that the presence of forage legumes improve the herbage disappearance rate.

Difference ($p \leq 0.05$) in forage accumulation rate (Table 3) for grazing in January, with a higher rate for the mixture with Red clover, may have been caused by the effect of the legume on the forage system (Carvalho & Pires, 2008). The same synergistic action is also observed for grazing in May, recorded by the high accumulation rate of the Red clover mixture. There was a similar behavior at the end of May in the case of the mixture with Forage peanut, with

rates similar to the system without the legume. Lowest rate between the seasons occurred in July due to the seasonality of Elephant grass. In fact, assessments in autumn indicated a better performance for the pasture mixture.

Forage yield tally is reflected by accumulation rates. When considering forage yield (Table 3), the rate was higher ($p \leq 0.05$) for the mixed system with Red clover, 14 t ha⁻¹, also reported by Azevedo Junior et al. (2012b) and Diehl et al. (2013), with 12.0% and 19.4% higher value, respectively, when evaluating mixtures with Red clover. The higher herbage yield probably is caused by the contribution of the forage legume on spontaneous growth species and the Elephant grass (Table 2).

A difference ($p \leq 0.05$) occurred in stocking rates in the grazing cycles carried out in October and May, with best results for mixture with Red clover, at an average rate of 3 animal units (AU) ha⁻¹, similar to that registered by M.S. Diehl et al. (2013). Ribeiro et al. (2008) evaluated the stocking rate in Elephant grass pastures during the rainy and dry seasons respectively 5.1 and 3.9 AU ha⁻¹.

Table 3. Accumulation rate, forage yield, forage allowance real and apparent intake of three forage systems (FS).

FS	Grazing cycles								Means	MSE
	1 st Jul.12	2 nd Aug.12	3 rd Oct.12	4 th Dec.12	5 th Jan.13	6 th Feb.13	7 th Mar.13	8 th May.13		
Accumulation rate (%)										
WL ¹	17 ^C	39 ^B	27 ^C	17 ^C	38 ^{Bb}	57 ^A	38 ^B	23 ^{Cb}	32	3.2
FP ²	19 ^B	36 ^A	32 ^B	17 ^B	33 ^{Bb}	53 ^{AB}	43 ^{AB}	42 ^{ABab}	34	2.8
RC ³	20 ^C	43 ^B	36 ^B	23 ^C	52 ^{Aa}	51 ^A	53 ^A	62 ^{Aa}	42	3.5
MSE	0.5	1.2	1.5	1.2	3.3	1.0	2.5	6.5		
Forage yield (kg of DM ha ⁻¹)*										
WL	1186 ^{AB}	2284 ^A	746 ^B	1056 ^B	1268 ^{ABab}	1593 ^{ABa}	1556 ^{AB}	1052 ^{Bb}	1342	110
FP	1307 ^A	2039 ^A	894 ^B	1052 ^B	1089 ^{Bb}	1475 ^{Ab}	1796 ^A	1943 ^{Ab}	1449	102
RC	1389 ^{BC}	2431 ^{AB}	1002 ^C	1415 ^{BC}	1723 ^{ABCa}	1420 ^{BCb}	2152 ^{ABC}	2860 ^{Aa}	1799	147
MSE	34	66	43	69	109	29	100	301		
Stocking rate (AU ha ⁻¹)										
WL	0.6 ^E	4.6 ^A	3.4 ^{ABCDb}	1.8 ^{DE}	4.1 ^{ABC}	4.5 ^{AB}	2.7 ^{BCD}	2.6 ^{DCb}	3.0	0.3
FP	0.7 ^C	4.1 ^A	3.8 ^{Ab}	1.7 ^{BC}	3.4 ^A	3.4 ^A	2.6 ^{AB}	3.1 ^{ABab}	2.8	0.3
RC	0.8 ^E	4.5 ^A	4.2 ^{ABa}	1.8 ^{DE}	3.9 ^{AB}	3.8 ^{AB}	2 ^{CD}	3.4 ^{BCa}	3.1	0.3
MSE	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1		
Real forage allowance (kg DM 100 kg BW ⁻¹)										
WL	6.0 ^A	6.0 ^A	4.0 ^C	4.3 ^C	4.4 ^C	4.7 ^B	5.5 ^A	5.0 ^B	5.0	0.2
0.2FP	6.1 ^A	6.0 ^A	4.8 ^C	4.8 ^B	4.6 ^B	5.3 ^B	5.7 ^A	4.8 ^A	5.3	0.1
RC	5.7 ^A	6.0 ^A	4.9 ^C	4.9 ^B	4.8 ^B	5.2 ^B	7.0 ^A	5.3 ^B	5.5	0.2
MSE	0.1	0	0.2	0.1	0.1	0.1	0.3	0.1		
Apparent forage intake (% of BW)										
WL	1.8 ^{BC}	4.1 ^A	1.7 ^{BC}	1.3 ^C	2.7 ^B	2.6 ^B	2.3 ^{BC}	1.7 ^{BC}	2.3 ^b	0.2
FP	2.8 ^A	3.6 ^A	1.7 ^A	2.1 ^A	2.9 ^A	3.0 ^A	3.4 ^A	2.7 ^A	2.8 ^{ab}	0.1
RC	3.4 ^{AB}	4.3 ^{AB}	1.7 ^B	2.8 ^{AB}	3.0 ^{AB}	3.2 ^{AB}	5.1 ^A	3.7 ^{AB}	3.4 ^a	0.2
MSE	0.3	0.1	0	0.3	0.1	0.1	0.5	0.3		

¹WL (without legumes) = Elephant grass (EG)+Italian ryegrass (IR)+spontaneous growth species (SGS); ² FP (mixture with Forage peanut) = EG+IR+SGS+FP; ³ RC (mixture with Red clover) = EG+IR+SGS+RC. MSE= means standard error. BW=body weight. *Total forage yield, WL= 10739b, FP= 11593b and RC= 14391a kg of DM ha⁻¹. Means followed by different lower case letters (column) and upper case letters (rows) differ significantly by Tukey's test (p ≤ 0.05).

Average rates of true forage supply were within the recommended estimate of 4 kg DM 100 kg BW⁻¹ for leaf blades mass of Elephant grass and 6 kg DM 100 kg BW⁻¹ for forage mass between rows. The use of different forages provided more balanced herbage allowance during the growing season. In high quality pastures (above 15% crude protein and about 50% NDF), animal performance may be basically explained by intake level, determined mainly by forage supply and pasture structure (Ribeiro Filho, Heydt, Baade, & Thaler Neto, 2009).

Since cows in current assay had an estimated intake of 3% BW, according to weight and milk yield, coupled to concentrate, there was no limitation to forage intake. This fact is confirmed by the apparent forage, or rather, 2.8% BW, considering the means of the systems. There were significant differences (p ≤ 0.05) between them, with a higher intake in mixture with Red clover and similar to the mixture with Forage peanut. Current result may be associated with the forage's better nutritional rate.

In the winter, the species between the rows of Elephant grass showed that crude protein levels were close to 23% due to high Italian ryegrass participation (Table 4). Rates were higher than those reported by Azevedo Junior et al. (2012b), or rather, 15% CP for forage systems of Elephant grass in mixture with Forage peanut and Red clover in the same period. A similar mean rate of 21% for Italian

ryegrass was registered by Olivo et al. (2012) when they evaluated different forage mixtures in the same region as that of current study. Pellegrini et al. (2010) reported mean rates of 21% when evaluating the effect of nitrogen fertilization on the yield and quality of herbage mass of annual ryegrass pastures with sheep.

On spring and summer there are no difference between the forage systems, and naturally decline the crude protein rates cause the presence of summer species. However, in the fall there are differences (p ≤ 0.05) with higher rates for the mixture, and confirmed that these forages legumes usually have higher protein content when compared to that of grasses. Rates obtained with Forage peanut are on an average higher than those reported by Azevedo Junior et al. (2012b), 16 and 14% respectively, in winter and summer. Concerning the crude protein of legumes, there is lower variability between seasons. The presence of forage legumes didn't affect the crude protein content of Elephant grass.

NDF rates for forage between rows were low during the winter period due to the presence of Italian ryegrass, and increased with the development of grasses and participation of spontaneous growth species (Table 2). During the autumn there is difference (p ≤ 0.05), with lower value to the pasture mixed with Red clover, due the contribution

Table 4. Crude protein, neutral detergent fiber, *in situ* digestibility of organic matter and total digestible nutrients of three forage systems (FS).

Variables	FS	Winter	Spring	Summer	Fall	Means	MSE
Crude Protein (%)							
BR ¹	WL ²	22.49 ^A	17.76 ^B	16.19 ^B	13.08 ^{Cc}	17.38	0.8
	FP ³	23.50 ^A	18.31 ^B	15.95 ^B	18.86 ^{Ba}	20.27	0.7
	RC ⁴	22.42 ^A	16.70 ^B	20.42 ^B	14.71 ^{Bb}	17.45	0.8
MSE		0.1	0.2	0.6	0.7		
LEG ⁵	FP	28.92 ^A	22.59 ^B	19.61 ^{Ba}	20.13 ^B	22.81	0.9
	RC	29.32 ^A	22.79 ^B	17.57 ^{Bb}	20.21 ^B	22.50	1.1
MSE		0.1	0.04	0.4	0.0		
EG ⁶	WL	-	18.73 ^A	16.94 ^A	17.65 ^A	17.77	1.9
	FP	-	19.06 ^A	17.95 ^A	19.11 ^A	18.70	2.0
	RC	-	18.33 ^A	16.24 ^A	17.78 ^A	17.45	1.9
MSE		-	0.1	0.2	0.2		
Neutral detergent fiber (%)							
BR	WL	35.95 ^B	46.86 ^B	56.40 ^A	61.51 ^{Aa}	50.18	2.4
	FP	36.74 ^B	44.23 ^B	39.62 ^B	60.51 ^{Ba}	40.82	2.3
	RC	34.46 ^B	54.00 ^A	50.94 ^A	42.69 ^{Bb}	49.97	1.9
MSE		0.3	1.2	2.0	2.5		
LEG	FP	-	35.89 ^A	39.83 ^A	38.81 ^A	38.18 ^a	4.1
	RC	-	27.60 ^B	31.82 ^A	35.56 ^A	31.66 ^b	3.5
MSE		-	1.5	1.4	0.6		
EG	WL	-	58.84 ^A	56.69 ^A	56.82 ^A	55.45	6.2
	FP	-	49.25 ^B	54.61 ^A	55.08 ^A	52.98	5.8
	RC	-	50.00 ^B	54.72 ^A	55.82 ^A	53.51	5.8
MSE		-	1.3	0.3	0.2		
<i>In situ</i> digestibility of organic matter (%)							
BR	WL	87.06 ^A	70.80 ^B	71.49 ^B	60.33 ^{Bb}	72.42	2.4
	FP	87.92 ^A	69.28 ^B	75.49 ^B	78.39 ^{Ba}	77.77	1.7
	RC	87.74 ^A	61.13 ^B	73.78 ^B	60.48 ^{Bb}	70.78	2.8
MSE		0.1	1.2	0.5	2.4		
LEG	FP	-	-	74 ^A	73.81 ^A	74.14	9.2
	RC	-	-	78.46	-	78.46	-
MSE		-	-	0.8	-		
EG	WL	-	72.35 ^A	76.81 ^A	74.41 ^A	74.41	8.1
	FP	-	74.39 ^A	77.00 ^A	77.64 ^A	76.34	8.3
	RC	-	64.72 ^B	75.86 ^A	77.66 ^A	72.75	8.0
MSE		-	1.2	0.1	0.4		
Total digestible nutrients (%)							
BR	WL	77.22 ^A	64.00 ^B	64.82 ^B	54.89 ^{Bb}	65.23	2.0
	FP	78.35 ^A	62.06 ^B	68.06 ^B	71.04 ^{Ba}	69.87	1.5
	RC	78.13 ^A	55.42 ^B	67.28 ^B	55.04 ^{Bb}	63.97	2.4
MSE		0.1	1.1	0.4	2.2		
LEG	FP	-	-	66.28 ^A	66.54 ^A	66.41 ^b	8.3
	RC	-	-	71.15	-	71.15 ^a	-
MSE		-	-	0.9	-		
EG	WL	-	64.44 ^A	68.75 ^A	66.23 ^A	66.47	7.2
	FP	-	62.38 ^B	68.38 ^A	69.54 ^A	66.77	7.3
	RC	-	57.52 ^B	67.15 ^A	69.62 ^A	64.76	7.1
MSE		-	0.8	0.2	0.5		

¹BR= between rows of Elephant grass; ²WL (without legumes)= Elephant grass (EG)+Italian ryegrass (IR)+spontaneous growth species (SGS); ³FP (mixture with Forage peanut)= EG+IR+SGS+FP; ⁴RC (mixture with Red clover)= EG+IR+SGS+RC. ⁵LEG= forage legumes. ⁶EG= Elephant grass. MSE= means standard error. Means followed by different lower case letters (column) and upper case letters (rows) differ significantly by Tukey's test ($p \leq 0.05$).

of the legume to the system. In the case of Elephant grass, there was no difference between pasture systems and seasons. However, it may be observed that Elephant grass's NDF mixtures in the spring are lower when compared to those of Elephant grass and legumes.

Significant differences ($p \leq 0.05$) in ISOMD and NDT contents were identified only in the autumn, with better values for species present between rows for the system where Forage peanut is present. Rates close to 78% for IOSMD were also observed by Azevedo Junior et al. (2012a).

Conclusion

The presence of Red clover in the pasture results in better and higher forage yield in the mixture,

whilst Forage peanut results in greater control of spontaneous growth species. Moreover, the inclusion of legumes in pasture systems provides better nutritional rates.

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Received on June, 15, 2016.

Accepted on July, 19, 2016.

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