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Response of elephant grass to grazing under an organic production system[1]

Resposta do capim elefante sob pastejo em sistema de produção orgânica

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ABSTRACT - The aim of this research was to evaluate elephant grass under an organic and a conventional system. Under the organic system, species with complementary growth periods were combined; elephant grass was planted in rows 3.0 m apart and ryegrass was sown between the rows of elephant grass during the winter period, with spontaneous species being allowed to develop during the summer period. For the conventional production, two types of pasture were studied: one using the same strategy as for the organic production, and the other with a monocrop of elephant grass. Under the conventional and organic systems, 120 kg of N ha^{-1} were applied as chemical and organic fertiliser (cattle manure and pig slurry) respectively. Holstein cows were used in the evaluation. The experimental design was completely randomised, with three treatments (forage systems), three replications (paddocks) and measurements repeated over time (season). During the experimental period (370 days), nine grazing cycles were carried out under the organic and conventional systems (elephant grass in association with other forages) and eight grazing cycles under the conventional system (a monocrop of elephant grass). Forage production was 31.6, 32.8 and 24.2 t ha^{-1}, and the stocking rate was 3.4, 2.1 and 4.6 AU ha^{-1} day^{-1} under the respective systems. Better results for forage production and distribution were found under the organic and conventional systems including a mixture of forages. The best results for leaf to stem ratio in the elephant grass and for stocking rate were seen under the monocrop system.

Key words: Apparent forage intake. Grazing efficiency. Rotational stocking. *Pennisetum purpureum*. Forage production systems.

RESUMO - O objetivo desta pesquisa foi avaliar o capim elefante nos sistemas orgânico e convencional. No sistema orgânico, combinaram-se espécies com períodos de crescimento complementares; o capim elefante foi plantado em linhas com 3,0 m de distância entrelinhas; entre as fileiras de capim elefante, durante o período hibernal, foi semeando o azevém e no período estival permitiu-se o desenvolvimento de espécies de crescimento espontâneo. Na produção convencional duas pastagens foram estudadas: uma com a mesma estratégia da produção orgânica, e outra com capim elefante sob cultivo solteiro. Aplicou-se 120 kg de N ha^{-1} com adubação química e orgânica (esterco bovino e dejetos de suínos) nos sistemas convencionais e orgânico, respectivamente. Vacas da raça Holandesa foram utilizadas na avaliação. O delineamento experimental foi inteiramente casualizado com três tratamentos (sistemas forrageiros), três repetições (piquetes) com medidas repetidas no tempo (estação do ano). Durante o período experimental (370 dias), nove ciclos de pastejo foram realizados nos sistemas orgânico e convencional (capim elefante em associação com outras forrageiras) e oito ciclos de pastejo no sistema convencional (capim elefante sob cultivo solteiro). A produção de forragem foi de 31,6; 32,8; 24,2 t ha^{-1}; e a taxa de lotação foi de 3,4; 2,1; 4,6 UA ha^{-1} dia^{-1}, para os respectivos sistemas. Melhores resultados quanto à produção e distribuição de forragem foram encontrados nos sistemas orgânico e convencional, com misturas forrageiras. Na relação folha:colmo do capim elefante e a taxa de lotação, os melhores resultados foram observados no sistema de capim sob cultivo solteiro.

Palavras-chave: Consumo aparente. Eficiência de pastejo. Lotação rotacionada. *Pennisetum purpureum*. Sistemas de produção forrageira.

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INTRODUCTION

The production and consumption of organic food has increased in recent decades. This includes public concern over the production process, seeking a process that does not pollute the environment or exert undue pressure on natural resources, but that takes into account aspects related to social equity (CASTRO NETO *et al*., 2010). In organic production with ruminants, legislation requires that most of the feed be bulky (BRAZIL, 2011).

Among the pasture that best fits this type of agriculture, elephant grass (*Pennisetum purpureum* Schum.) is important due to its high capacity for forage production (PEGORARO *et al*., 2009) and for the ways it can be used, for cutting and grazing, and for hay and silage. Despite its versatility, research conducted with this forage is based on a conventional strategy of pasture management (OLIVO *et al*., 2009), and there are few studies on the response of the crop to organic production systems, which use a mixture of forage species (AZEVEDO JÚNIOR *et al*., 2012).

The aim of this research therefore, was to evaluate elephant grass used for grazing under organic production as to plant response and plant-animal interaction, compared to conventional production.

MATERIAL AND METHODS

The experiment was conducted in an area of the Dairy Cattle Laboratory of the Animal Science Department at the Federal University of Santa Maria (UFSM), in the State of Rio Grande do Sul, Brazil, between May 2014 and May 2015, totalling 370 days. The soil is classified as a dystrophic arenic Red Argisol, of the São Pedro mapping unit (STRECK *et al*., 2008). According to the Köppen classification the climate in the region is type Cfa (subtropical humid) (MORENO, 1961). The annual mean values for daily air temperature and monthly rainfall were 19.2 °C and 140.5 mm respectively. For the experimental period (Figure 1), the mean values were 19.7 °C and 179.5 mm month^{-1}. During July and August of 2014, three frosts were recorded (INMET, 2015).

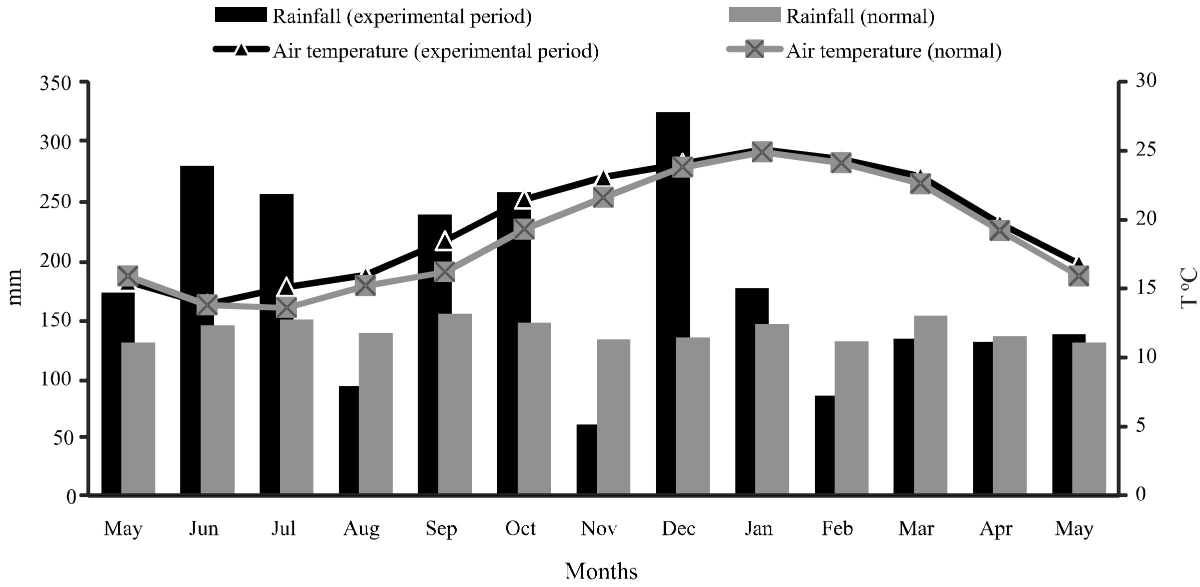
For the experimental evaluation, an area of 0.8 ha was used, divided into nine paddocks. Three forage systems (treatments) were set up, based on elephant grass (*Pennisetum purpureum* Schum.) ‘Merckeron Pinda’. Under the organic production system, the pasture comprised a mixture of forages. The elephant grass was established in rows 3.0 m apart. During the winter period, ryegrass (*Lolium multiflorum* Lam.),‘Ponteio’ was sown at a seed rate of 35 kg ha^{-1} between the rows; during the summer period, spontaneous species were allowed to develop, in particular *Paspalum conjugatum*, *Cynodon dactylon* L. Pers., *Paspalum urvillei* Steud., and less frequently, setaria grass (*Setaria* spp.) e *Dichanthelium* spp. For the conventional production, two systems were evaluated; one having the same strategy as the organic system (with elephant grass established in rows 3.0 m apart - control treatment) and another with a monocrop of elephant grass (treatment representing the real world, where the grass is used on farms). In the areas comprising clumps of elephant grass, and under the system with elephant grass as a monocrop, the pasture was cut to a height of 20 cm in August 2014. In the systems composed of a mixture of forages, the pasture between the rows were cut level with the ground in May, December and March of 2014.

Base fertilisation was carried out based on the soil analysis, as recommended by the Brazilian Society for Soil Science, Southern Regional Centre (2004) for hot-season grasses, using 80 and 60 kg ha^{-1} yr^{-1} P_2O_5 and K_2O, with 120 kg ha^{-1} yr^{-1} being used as nitrogen fertiliser. Under the organic production system, fertilisation consisted of cattle manure and pig slurry distributed in four applications, in July, September, January and February. Based on the DM, the chemical composition of the cattle manure (36% DM) was 0.63, 1.44 and 0.41% N, P and K respectively, and of the pig slurry (5% DM), it was 0.25, 0.31, and 0.076% N, P and K respectively. For the system under conventional production, basic fertilisation was carried out using mineral fertilisers and nitrogen fertiliser (as cover), urea was distributed in four applications during July and December of 2014, and January and February of 2015.

For the systems comprising a mixture of forages, the criterion adopted for using the grass during the winter period was a height of approximately 20 cm for the ryegrass; during the summer period, this height was between 100 and 110 cm for the canopy of elephant grass. This criterion was also used under the conventional system (with elephant grass as a monocrop). The rotational stocking method, with one day of occupation, was used for grazing. Before the animals entered each pasture and paddock, the mass of the forage was estimated by a double-sampling technique adapted from T’Mannetje (2000), carrying out 20 visual estimates and 5 destructive cuts (0.5 X 0.5 m) in the rows for the monocrop of elephant grass, and between rows in the systems including a mixture of forages. The cuts were made 50 cm from the ground for the elephant grass, and close to the ground between the rows. After the animals were removed, the same sampling protocol was repeated to obtain the residual weight of the forage.

The forage from the cut samples was homogenised, and a sub-sample removed for each paddock, which was used to determine the botanical composition of the pasture

Figure 1 - Monthly accumulated rainfall, mean monthly air temperature and climate normals from May 2014 to May 2015. Data obtained from the Weather Station of the Federal University of Santa Maria, in Santa Maria, Rio Grande do Sul



and the structural composition of the elephant grass; these were later oven-dried to determine the dry matter content as per Silva and Queiroz (2006). The mean data of the pastures were grouped by season.

The length and width of the rows of elephant grass were measured to obtain the occupied area in the systems including a mixture of forages. The area occupied by elephant grass under each system was approximately 33%.

In order to determine the animal load to be used, the supply of forage was kept at 4.0 kg DM per 100 kg body weight for the leaf-blade biomass of the elephant grass, and 10 kg DM per 100 kg body weight for the biomass present between the rows in the two systems consisting of a mixture of forages. Lactating Holstein cows were used in the evaluation, with a mean body weight of 555 kg and a mean production of 16.6 kg milk day^{-1}, receiving feed supplement at a rate of 0.9% of body weight, based on maize, soybean meal and a mineral premix. When they were not in the experimental areas, the animals were kept under similar management, in pastures reflecting the season.

Grazing efficiency was estimated from the difference between the pre- and post-grazing mass of the forage, transformed into a percentage (HODGSON, 1979). The pasture accumulation rate was determined from the difference between the initial forage mass and the residual forage mass of the previous grazing, dividing the result by the number of days included in the grazing cycles being considered. Forage production was calculated by summing the daily forage accumulation for each grazing cycle. To calculate the stocking rate, the value of the instantaneous animal load was divided by the number of days in the grazing cycle, and then by 450 kg to obtain the value in animal units (AU). Apparent forage intake was estimated by the method of agronomic difference (BURNS *et al*., 1994), in which the difference between forage mass (pre and post-grazing) is divided by the animal load and then multiplied by 100.

In November 2014, the presence of the spittlebug (*Deois flavopicta*) was seen. This was controlled by applications of a biological product (METARRIL® - a biological agent whose active ingredients are spores of the fungus *Metarhizium anisopliae*).

During the experimental period, nine grazing cycles were carried out under the organic and conventional systems, consisting of a mixture of forages, with three grazing periods during the winter, two in the spring, three during the summer and one cycle in the autumn, with a mean interval of 33 and 40 days for the respective systems. Under the conventional system, with a monocrop of elephant grass, eight grazing cycles were conducted, with two during the winter; during the remaining seasons the same number of cycles were carried out as under the other systems. The mean length of each grazing cycle was 41 days.

The mean grazing data for each season were used in the statistical analysis. The experimental design was completely randomised, with three treatments (forage systems) and three replications by area (paddocks); the measurements were repeated over time (grazing cycles grouped by season). The mean data for each season were submitted to analysis of variance, using the MIXED procedure. The covariance matrix was chosen from the lowest value for the AIC (Akaike's Information Criteria), using the Banded Main Diagonal (SAS INSTITUTE, 2001). The mean values were compared by Student's t-test at a level of 5%. Pearson's correlation analysis was used to verify the association between variables. The following statistical model was used: $Y_{ijk} = m + S_i + R_j (S_i) + E_k + (SE)_{ik} + \varepsilon_{ijk}$, where Y_{ijk} represents the dependent variables, m is the mean of all the observations, S_i is the effect of the forage system, $R_j(S_i)$ is the repetition effect within the forage system (error a), E_k is the effect of the season, $(SE)_{ik}$ represents the interaction between forage system and season, ε_{ijk} is the residual effect (error b).

The experimental project was approved by the Ethics and Biosafety Committee of UFSM in decision 113/2011 under control no 23081016073/2011.

RESULTS AND DISCUSSION

When analysing the length of the grazing cycles for warm-season species such as elephant grass, short periods of occupation and of resting of around 30 days are considered as being associated with better quality forage and animal performance (SOARES *et al*., 2004). Similar time for grazing cycles were seen under the organic system. It should be emphasised that in the present study the occupation time was one day, a situation that is more appropriate to animal performance.

There was interaction between the seasons and forage systems ($p \leq 0.05$) for initial forage mass, elephant grass forage mass, other grasses, dead matter and the leaf to stem ratio (Table 1). This result is due to the varied composition of the forage systems, with the presence of species of both winter and summer cycles.

The elephant grass, the largest constituent of the forage mass, displayed a distinct response pattern to the seasons ($p \leq 0.05$). This result is associated with the characteristics of the species, which in subtropical climates displays higher production during the summer and lower production during the other seasons (OLIVO *et al*., 2017). Furthermore, the fraction of other grasses comprising species with a summer cycle, such as *P. conjugatum*, *Cynodon dactylon* L. Pers and *Paspalum urvillei* Steud, contributed to a greater ($p \leq 0.05$) value for forage mass during those seasons of the year with a higher mean temperature. This result is confirmed by the correlation ($r = 0.67$, $p < 0.0001$) seen between mean daily temperature and initial forage mass.

For initial forage mass, differences ($p \leq 0.05$) were seen between systems for all seasons (Table 1), with the organic system superior during the winter, summer and autumn, in relation to the other systems. During spring, there was a similarity between the organic and conventional systems composed of a mixture of forages. Under the conventional monocrop system, a smaller ($p \leq 0.05$) initial forage mass was found in all seasons. The mean values for initial forage mass under the different systems are higher than those found by De Bem *et al*. (2015) and Olivo *et al*. (2014b), conducting similar work in the same region. The greater initial forage mass under the organic system is probably due to the residue being employed in improving the physical, chemical and biological properties of the soil (MELO *et al*., 2011; OLIVEIRA *et al*., 2013), which positively influenced the organic matter dynamics, increasing cation exchange capacity, allowing nutrient retention and making the nutrients available to the plants (SCOTTI *et al*., 2015). Organic fertiliser also increases the rainwater retention capacity, solubilises various toxic or essential metals for the plants, such as Iron, Zinc, Magnesium, Copper and Cobalt (NCIIZAH; WAKINDIKI, 2012; OURIVES; SOUZA; TIRITAN, 2010), and increases the organic carbon content of the soil, reducing gas emissions to the atmosphere (LOSS *et al*., 2011).

For the initial forage mass of the elephant grass (Table 1), it was seen that even during the winter, this summer-cycle forage played a large contribution, due to the milder temperatures and the low number of frosts, the first occurring only in July. There was a difference ($p \leq 0.05$) for the initial forage mass of the elephant grass, with a higher value during the winter under the monocrop. This result was expected because of the larger area occupied by the grass, which has greater production potential in relation to winter-cycle species like ryegrass. However, the same did not occur during the other seasons, when a better or similar performance was seen under the systems (organic and conventional) consisting of a mixture of forages. This result demonstrates that elephant grass established in rows 3.0 m apart, occupying on average 33% of the area, displays better performance than the monocrop. This can be attributed to better exposure of the clumps to sunlight, considering that the companion species are smaller. For the senescent-matter fraction of the elephant grass, the values are low and there was no difference between forage systems; it should be considered that cuts were made 50 cm from the ground.

Differences ($p \leq 0.05$) were found in the different species that made up the botanical composition of the pastures under the organic and conventional systems including a mixture of forages (Table 1), with a greater participation of ryegrass under the organic system.

For the fraction composed of other grasses, the presence of *P. conjugatum*, *Cynodon dactylon* L. Pers., *Paspalum urvillei* Steud., setaria grass and *Dichanthelium* spp. should be noted. The highest ($p \leq 0.05$) value found during the summer is due to the characteristics of these species, which have a summer cycle. The presence of other species was small, consisting mainly of *Sida* spp., *Polygonum hydropiperoides* Michx., *Cyperaceae* spp. and *Urochola plantaginea* Link Hitch.

Differences ($p \leq 0.05$) were seen between forage systems regarding the leaf to stem ratio of the elephant grass, with a higher value under the conventional monocrop system and no difference between the systems

Table 1 - Initial forage mass and botanical composition of the pastures under three forage systems. Santa Maria, 2014-2015

FS	Season				Mean	CV (%)
	Winter	Spring	Summer	Autumn		
			Pasture forage mass (t DM ha^{-1})			
Org[1]	3.7 a	6.0 a	11.2 a	9.2 a	7.5	5.1
Conv1[2]	3.0 b	5.6 a	9.0 b	7.4 b	6.2	6.2
Conv2[3]	2.5 c	2.7 b	6.1 c	4.8 c	4.9	9.6
Mean	3.0 D	4.8 C	8.8 A	7.1 B		
CV (%)	2.8	6.1	7.2	7.6		
			Elephant grass (t DM ha^{-1})			
Org	1.8 b	2.9 ab	6.5 a	5.5 a	4.1	6,8
Conv1	1.7 b	3.2 a	6.0 a	4.4 a	3.8	7,4
Conv2	2.3 a	2.7 b	6.1 a	4.5 a	3.9	7,3
Mean	1.9 D	2.9 C	6.2 A	4.8 B		
CV (%)	6.4	4.4	7.6	8.7		
			Elephant grass senescent matter (t DM ha^{-1})			
Org	0.4	0.3	0.2	0.2	0.3	13.3
Conv1	0.5	0.4	0.2	0.3	0.3	16.3
Conv2	0.2	0.0	0.5	0.3	0.2	27.4
Mean	0.3	0.1	0.1	0.3		
CV (%)	12.4	23.8	28.1	14.5		
			Ryegrass (t DM ha^{-1})			
Org	0.4	0.3	-	-	0.4 a	13.5
Conv1	0.2	0.1	-	-	0.2 b	20.6
Mean	0.3	0.2				
CV (%)	14.8	18.2			16.3	
			Other grasses (t DM ha^{-1})			
Org	0.7	1.9	3.8	2.5	2.2	12.3
Conv1	0.4	1.8	2.3	2.2	1.7	14.3
Mean	0.5 C	1.9 B	3.1 A	2.3 B		
CV (%)	23.3	12.3	9.7	11.2		
			Other species (t DM ha^{-1})			
Org	0.2	0.4	0.3	0.1	0.3	14.0
Conv1	0.1	0.2	0.2	0.2	0.2	20.9
Mean	0.2	0.3	0.3	0.1		
CV (%)	30.7	19.3	20.1	30.5		

Continuation Table 1

Dead matter between rows (t DM ha^{-1})						
Org	0.3	0.3	0.5	1.0	0.5	11.3
Conv1	0.2	0.2	0.3	0.4	0.3	14.6
Mean	0.2 B	0.3 B	0.4 A	0.7 A		
CV (%)	10.4	9.3	6.1	25.3		
Elephant grass leaf to stem ratio						
Org	2.0	4.3	4.0	1.8	3.0 b	17.8
Conv1	0.8	5.0	3.5	1.4	2.7 b	26.1
Conv2	3.1	8.5	7.5	2.1	5.3 a	12.3
Mean	2.0 B	5.9 A	5.0 A	1.8 B		
CV (%)	24.8	8.0	19.4	29.2	17.0	

[1]Organic production system with a mixture of forages; [2]Conventional production system with a mixture of forages; [3]Conventional production system with a monocrop of elephant grass. Lowercase letters in a column and uppercase letters on a row differ by Student's t-test ($p \leq 0.05$); DM = dry matter; CV = coefficient of variation

including a mixture of forages. This result agrees with Machado (2012), working with mixtures of annual and perennial forage species. The higher values ($p \leq 0.05$) found during the spring and summer are associated with the longer growth period of the elephant grass.

In relation to residual forage mass (Table 2), there was an interaction ($p \leq 0.05$) between the forage system and season for the values of forage mass, elephant grass forage mass, elephant grass senescent matter, other grasses and dead matter.

Values for residual forage mass are related to those for initial forage mass, considering the different systems. However, when considering the pasture components, there was greater variability, especially for the elephant grass when compared to initial forage mass. It was seen that 70.5% of this forage disappeared under the conventional system involving a mixture of forages, while under the organic system it was 48%. This result is probably due to the presence of other grasses, which are less grazed by the cows (OLIVO *et al*., 2007).

For the senescent matter of the elephant grass, the highest ($p \leq 0.05$) value between seasons was found during the winter; this is due to the action of the cold and frost burning the leaves. For the fraction of other grasses, as they are summer-cycle species, the value was lower ($p \leq 0.05$) during the winter.

For the dead matter present in the residual mass between the rows, the values are similar to those of initial forage mass, showing that losses from grazing were low, a condition not seen by Meinerz *et al*. (2011), who found greater losses due to grazing by animals in smaller forage species that suffer greater impact compared to the more erect structure of elephant grass.

In relation to the production variables for pasture and to the plant-animal interaction (Table 3), there was an interaction ($p \leq 0.05$) between forage system and season for accumulation rate, forage production, grazing efficiency and stocking rate. The influence of the mean daily air temperature should be noted, and is confirmed by the correlations with the rate of accumulation ($r = 0.67$, $p < 0.0001$) and forage production ($r = 0.73$, $p < 0.0001$). It can be seen that during the winter, the temperature was higher when compared to the climate normals. Rainfall distribution was however more irregular, despite the larger volume during the experimental period (Figure 1).

A difference ($p \leq 0.05$) was seen for the daily accumulation rate of the forage, which was superior under systems including a mixture of forages. During the summer, the rates were higher ($p \leq 0.05$) due to a peak in the production of elephant grass and the grasses present between the rows in the systems that included a mixture of forages. The mean values are high considering the moderate level of fertiliser used. Part of this result can be attributed to environmental conditions, since the temperatures were mild during the winter, and there was more rainfall compared to the climate normals throughout the agricultural year. Lower values than those of the present study were found by Azevedo Júnior *et al*. (2012) and Diehl *et al*. (2013), of 53 kg ha^{-1} day^{-1}, when evaluating elephant grass intercropped with different legumes in the same region.

There was a difference ($p \leq 0.05$) relative to forage production (t DM ha^{-1}), with a greater value under the organic and conventional systems comprising a mixture of forages. Results from work with similar forage systems carried out in the same region displayed lower production, between 14.6, Diehl *et al*. (2013),

Table 2 - Residual forage mass and botanical composition of the pastures under three forage systems. Santa Maria, 2014-2015

FS	Season				Mean	CV (%)
	Winter	Spring	Summer	Autumn		
Pasture forage mass (t DM ha^{-1})						
Org[1]	3.0 a	5.0 a	6.0 a	5.2 a	4.8	4.8
Conv1[2]	2.1 b	3.0 b	2.9 b	2.8 b	2.7	8.3
Conv2[3]	1.5 c	1.3 c	1.6 c	1.5 c	1.5	15.5
Mean	2.4 B	3.1 A	3.5 A	3.2 A		
CV (%)	5.4	6.4	6.9	12.8		
Elephant grass (t DM ha^{-1})						
Org	1.2 a	2.3 a	2.7 a	2.5 a	2.2	6.2
Conv1	1.0 b	1.3 b	1.2 b	1.0 b	1.1	12.0
Conv2	1.1 ab	1.2 b	1.4 b	1.2 b	1.2	11.1
Mean	1.2 B	1.6 A	1.8 A	1.6 A		
CV (%)	4.5	14.2	7.6	10.3		
Elephant grass senescent matter (t DM ha^{-1})						
Org	0.5 a	0.3 a	0.5 a	0.3 a	0.4	12.6
Conv1	0.6 a	0.2 b	0.2 b	0.2 a	0.3	18.5
Conv2	0.4 a	0.1 b	0.2 b	0.3 a	0.3	18.4
Mean	0.5 A	0.2 B	0.3 B	0.3 B		
CV (%)	11.7	26.2	20.7	22.1		
Ryegrass (t DM ha^{-1})						
Org	0.2	0.2			0.2 a	11.1
Conv1	0.1	0.1			0.1 b	16.2
Mean	0.2	0.1				
CV (%)	12.9	13.4			13.2	
Other grasses (t DM ha^{-1})						
Org	0.6 a	1.4 a	2.2 a	1.9 a	1.5	7.1
Conv1	0.4 a	1.2 a	1.3 b	1.3 a	1.0	8.7
Mean	0.5 C	1.3 B	1.7 A	1.6 AB		
CV (%)	13.9	7.7	4.3	15.6		
Other species (t DM ha^{-1})						
Org	0.2	0.3	0.2	0.2	0.2 a	12.6
Conv1	0.1	0.1	0.1	0.1	0.1 b	25.1
Mean	0.1	0.2	0.1	0.1		
CV (%)	26.6	23.1	22.6	25.0	20.1	
Dead matter between rows (t de MS ha^{-1})						
Org	0.3	0.5	0.4	0.4	0.4	15.6
Conv1	0.2	0.3	0.3	0.3	0.3	22.2
Mean	0.2 B	0.4 C	0.3 AB	0.4 A		
CV (%)	23.7	13.8	22.6	6.2		

[1]Organic production system with a mixture of forages; [2]Conventional production system with a mixture of forages; [3]Conventional production system with a monocrop of elephant grass. Lowercase letters in a column and uppercase letters on a row differ by Student's t-test ($p \leq 0.05$); DM = dry matter; CV = coefficient of variation

Table 3 - Response of elephant grass under three forage systems. Santa Maria, 2014-2015

FS	Season				Mean or Production	CV (%)
	Winter	Spring	Summer	Autumn		
Rate of forage accumulation (kg DM ha^{-1}dia^{-1})						
Org[1]	51.7	52.4	187.6	54.8	86.6 ab	11.9
Conv1[2]	61.3	70.8	199.5	73.0	101.2 a	11.6
Conv2[3]	42.6	34.9	149.6	54.3	70.3 b	13.4
Mean	51.9 B	52.7 B	178.9 A	60.7 B		
CV (%)	5.2	10.2	9.5	20.1	10.5	
Accumulated forage prodution (t DM ha^{-1})						
Org	5.6 a	5.4 a	17.8 a	2.8 a	31.6 a	10.8
Conv1	4.5 b	6.7 a	17.5 a	4.1 a	32.8 a	9.9
Conv2	3.4 b	3.5 b	14.3 a	3.0 a	24.2 b	13.0
Mean	4.3 B	5.2 B	16.7 A	3.3 C		
CV (%)	7.2	11.7	9.5	17.0		
Grazing efficiency (%)						
Org	33.0 c	34.0 b	46.0 b	43.5 b	39.0	12.8
Conv1	35.0 b	44.7 a	66.4 a	61.6 a	52.0	8.3
Conv2	39.3 a	49.6 a	73.7 a	68.4 a	57.8	7.3
Mean	35.8 C	42.8 B	62.0 A	57.8 A		
CV (%)	5.5	7.2	3.5	8.3		
Apparent forage intake (% BW)						
Org	2.6	2.1	2.4	3.2	2.6	18.0
Conv1	2.5	2.9	3.7	3.6	3.1	13.3
Conv2	3.0	2.2	3.3	3.4	2.9	15.8
Mean	2.7 AB	2.4 B	3.1 AB	3.4 A		
CV (%)	15.5	14.5	3.7	24.1		
Stocking rate (AU ha^{-1} day^{-1})						
Org	2.2 a	2.0 b	7.0 b	2.2 b	3.4	6.8
Conv1	1.7 b	1.8 b	3.5 c	1.2 c	2.1	12.3
Conv2	1.7 b	2.9 a	9.8 a	3.9 a	4.6	5.1
Mean	1.8 C	2.3 B	6.8 A	2.4 B		
CV (%)	4.1	8.5	6.6	9.3		

[1]Organic production system with a mixture of forages; [2]Conventional production system with a mixture of forages; [3]Conventional production system,with a monocrop of elephant grass. Lowercase letters in a column and uppercase letters in a row differ by Student's t-test ($p \leq 0.05$); BW=body weight; DM=dry matter; AU=animal unit, 450kg; CV=coeficiente de variação. Period of evaluation=365, 325 and 345 days for the respective treatments

and 18 t ha^{-1} yr^{-1} by Azevedo Júnior *et al.* (2012), when intercropping elephant grass with red clover. In work with the same cultivar, Dall'Agnol *et al*. (2005) obtained a production of 17 t DM ha^{-1} year^{-1} with six cuts.

A difference ($p \leq 0.05$) was found for grazing efficiency between forage systems, with higher mean values under the conventional monocrop system. This result is due to the composition of the pasture, which consisted of elephant grass only. Part of this performance is attributed to the greatest ($p \leq 0.05$) value for the leaf to stem ratio in elephant grass found under the monocrop system. Under the other systems, the values for grazing efficiency are lower, which is due to the presence of spontaneous summer-cycle species, usually less grazed than the elephant grass. This result is confirmed by the low consumption of other grasses and species, considering the high values for the residual forage mass of these fractions when compared to the initial forage mass (Table 2).

No differences were seen between the forage systems for apparent forage intake. Among the seasons, the highest ($p \leq 0.05$) value was seen during the autumn; this was possibly due to the smaller growth of the elephant grass, which resulted in an improvement in the nutritive value of the forage (MEINERZ *et al*., 2008). The mean value for apparent forage intake under all systems was approximately 3%. Considering the feed supplement that the animals received, and the loss of forage due to trampling and the accumulation of waste, the values are as expected, and approach the consumption of lactating cows found by Diehl *et al*. (2014) of 2.99 kg of DM per 100 kg of body weight in pastures with a predominance of summer-cycle species.

Differences ($p \leq 0.05$) were seen among forage systems for stocking rate, with greater values in the monocrop pasture, due to the greater contribution of forage mass and the leaf to stem ratio of the elephant grass. This result is confirmed by the correlation found between the stocking rate and leaf to stem ratio of the elephant grass ($r = 0.41$, $p = 0.0128$). The mean value of the three forage systems, of 3.66 AU ha^{-1} day^{-1}, is higher than that obtained by Olivo *et al*. (2014a) in pastures composed of elephant grass intercropped with forage peanuts or red clover, with a mean value of 2.32 AU ha^{-1} day^{-1}.

CONCLUSION

The results show that elephant grass can be used in association with other species under both organic and conventional production. Elephant grass in association with other species shows higher productivity when compared to the monocrop. Systems comprising a mixture of forages provide a better distribution of pasture, a greater number of grazing cycles, greater forage production, and more balanced stocking rates between seasons. The system composed only of elephant grass results in a higher leaf to stem ratio, with forage production concentrated during the summer and autumn. Elephant grass as a monocrop is more efficient for stocking rate.

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