Anais da Academia Brasileira de Ciências (2019) 91(2): e20180011
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
http://dx.doi.org/10.1590/0001-3765201920180011
www.scielo.br/aabc | www.fb.com/aabcjournal

Productivity and nutritive value of elephant grass pastures under organic and conventional production systems

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Manuscript received on January 16, 2018; accepted for publication on August 29, 2018

How to cite: SIMONETTI GD, OLIVO CJ, SEIBT DC, BRATZ VF, SAUTHIER JC AND ADAMS CB. 2019. Productivity and nutritive value of elephant grass pastures under organic and conventional production systems. An Acad Bras Cienc 91: e20180011. DOI 10.1590/0001-3765201920180011.

Abstract: Elephant grass (EG) (*Pennisetum purpureum* Schum.) have great importance in tropical and subtropical climates, especially on dairy farms. Normally, EG is established alone under high fertilization levels. EG in organic production system can improve low production costs and environmental issues, are still little known. The aim of this research was to evaluate the performance of herbage yield, nutritive value, extraction/ export nutrient and forage yield and animal responses. Three production systems of EG were analyzed: (i) EG mixed spontaneous-growing species (SGE) in warm-season and ryegrass (R) in cool-season under organic production; (ii) EG mixed SGE + R under conventional system (positive control); and (iii) EG based under conventional production (control). Holstein cows were used in a rotational stocking. Forage samples were collected to evaluate the pasture and animal responses. Seven grazing cycles were performed during the experimental period (312 days). Herbage yield, forage intake, and stocking rate were 12548; 10270; 19168 kg ha^{-1} and 2.5; 2.6; 2.7% and 3.3; 2.1; 4.5 AU ha^{-1} day^{-1}, respectively. Crude protein of EG was 17.9; 15.4; 16.4%, respectively. Mixed pastures, in conventional and organic production, had a better forage distribution throughout the seasons. Highest forage yield and extraction/ export nutrient was reported in pure EG within the conventional system.

Key words: crude protein, dairy cows, *Pennisetum purpureum* Schum, production of forage, stocking rate.

INTRODUCTION

Milk production is one of the predominating alternatives for small- and medium- sized farms in different regions of Brazil. Pasture, the main roughage source, is comprised of grass established in monoculture and with mineral fertilizers (Olivo et al. 2006).

Perennial pasture, such as elephant grass (*Pennisetum purpureum* Schum.), are highly relevant due to their capacity in forage production and to their easy adaptation in tropical and subtropical regions, especially when used with rotational stocking (Pegoraro et al. 2009). Their establishment in spaced rows in organic or conventional system favors the inclusion of annual winter crops, such as oats and ryegrass, forming an important strategy due to the usage of the same area throughout the year (Diehl et al. 2014).

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It is important to underscore that such pasture composition, featuring perennial and annual grasses, produces a great conservation of naturally based resources.

The predominant use of elephant grass is in monoculture under conventional production system. In these conditions, the forage yield is concentrated in the summer (Seibt et al. 2018), with dependence of commercial nitrogen and involves high production costs and environmental issues. Elephant grass under organic production can more sustainable, but few studies have investigated this production system (Olivo et al. 2017). The aim of this research was to evaluate elephant grass-based pasture under organic and conventional production systems on the botanical and morphological compositions, herbage yield, nutritive value, grazing efficiency, forage intake, extraction/ export nutrient (N) and forage yield, and stocking rate.

MATERIALS AND METHODS

The Committee for Ethics in Experiments with Animals of the Universidade Federal de Santa Maria, Santa Maria, RS, Brazil (Protocol 23081016073/2011-27, Process 113/2011) approved all techniques and procedures employed in current analysis.

The study was performed in Laboratory of Dairy Cattle of the Department of Animal Science of the Universidade Federal de Santa Maria (UFSM), Santa Maria, Brazil, of between May 2015 and April 2016, with a total of 312 days. The soil is classified as Hapludalf Paleudult (Smith 2014) and region´s climate is Cfa (humid subtropical climate), following Köppen´s classification (Kuinchtner and Buriol 2001). The 30-yr average annual rainfall and monthly temperature were 140.5 mm and 19.6 C, respectively. The experimental period was from May 2015 to April 2016 the average monthly precipitation and daily temperature were 172.7 mm and 20.0 C, respectively (INMET 2016).

A 0.8 ha area, subdivided into nine paddocks, was used for the study, featuring three forage systems (treatments), with elephant grass, cv. Merckeron Pinda. The organic production system was comprised of pasture with mixed forages. Elephant grass-based was planted in rows, 3m apart. Ryegrass (*Lolium multiflorum* Lam.), cv. Ponteio, was sown in May between elephant grass rows at 40 kg ha^{-1} during the winter; and spontaneous-growing species developed during the warm-season. Two systems were evaluated in conventional production: (1) a mixed system with the same species and the establishment of an organic production system (control); (2) a system with elephant grass was cultivated alone. In the three systems, elephant grass was mowed to a 20-cm stubble, in August 2015. In systems with mixed forages, within the in-between rows, two harvests were undertaken close to the ground, in May and December 2015.

Basic fertilization was applied, following soil analysis and based on the recommendation obtained in the Comissão de Química e Fertlidade do Solo RS/SC (2004), based on recommendation for perennial grasses, with 60 kg P_2O_5 ha^{-1}yr^{-1} and 60 kg ha^{-1}yr^{-1}. 100 kg N ha^{-1}yr^{-1} was employed for all systems. For organic production, fertilization comprised cattle manure (23.8 m^3 ha^{-1}; 36% DM) and swine slurry (41 m^3 ha^{-1}; 5% DM), distributed into three applications (July, November, February). DM-based chemical composition of cattle manure and swine slurry respectively comprised 0.63; 1.44; 0.41% and 0.25; 0.31; 0.076% of N, P_2O_5 and K_2O. To conventional production system, basic fertilization contained mineral fertilizers; urea was distributed in four applications (October, November, December and February) for nitrogen fertilization.

In the case of forage mixture systems, the height of ryegrass at 20-cm was the criterion for the start of grazing during the cool-season; in the summer, canopy height of elephant grass had to be between

100 and 110 cm (Voltolini et al. 2010). The same criterion was employed in the conventional system (elephant grass in monoculture). Grazing method consisted of rotational stocking with one-day occupation. Before and after each grazing event, the paddocks were sampled to determine pre-and post-grazing herbage mass using a double sampling technique, with five cuts close to the ground and 20 visual estimates. The above procedure was undertaken within the alignment formed by elephant grass tufts and within the in-between rows. Elephant grass, cut 50-cm stubble height (1m linear), plus the width of the tufts, revealed a 30.7% occupied area in mixed pastures. Between elephant grass rows 0.25-m^2 quadrats were used. In the paddocks of elephant grass established alone 1.0-m^2 were used for sampling.

Forage from the cut samples per paddock was homogenized and a sub-sample was retrieved to determine the botanic composition of the pasture and the structural composition of the elephant grass. Later were oven dried with forced air circulation at 55 ºC for 72 hours to determine dry matter rates (Silva and Queiroz 2006). Mean data of pastures were grouped according to the season.

The stocking density of one-day occupation was calculated based on the herbage allowance of 4 kg DM per 100 kg BW for biomass of leaf blades of elephant grass and 10 kg of DM per 100 kg BW for mass in the in-between rows of the two systems made up of forage mixtures and based on pre-grazing forage mass. Holstein lactating cows, 522 kg LW and 17.3 kg milk day^{-1}, were used. Feed supplementation, based on corn, soybean meal, rice meal, wheat meal and premix mineral, was provided at 0.9% BW. When the animals were not in the experimental areas, they were maintained under a similar management on seasonal pasture.

Grazing efficiency was calculated as the ratio between the amount of forage removed by the difference to pre- and post-grazing forage mass (Hodgson 1979). Herbage accumulation in the first grazing cycle was assumed as the pre-grazing forage mass. For subsequent grazing cycles, forage accumulation was calculated by subtracting the pre-grazing forage mass of the following cycle from the post-grazing forage mass of the previous cycle. The herbage accumulation rate was obtained from the relation between the herbage yield and number of days between grazing cycles. Forage yield was estimated by adding daily herbage accumulation. Stocking rate was calculated by dividing stocking density by the number of days of the grazing cycle, and by 450 kg to calculate animal unit (AU). Apparent forage intake was estimated by the agronomic difference (Burns et al. 1994) where the difference between forage masses (pre- and post-grazing) was divided by stocking density and multiplied by 100.

Elephant grass and of other species in the in-between elephant grass rows were sampled to estimate nutritive value, using hand-plucked technique (Euclides et al. 1992). This occurred after observing the animals' ingestion behavior during 15 min, at the start and end of each grazing period. Samples were dried in a forced-air buffer at 55 ºC during 72 hours and stored for the later formation of compounded samples. Samples from each grazing cycle, retrieved at the beginning and end at the grazing, were mixed. Grazing samples were later mixed according to the seasons. Compounded samples were analyzed by the Laboratory of Animal Nutrition/ Federal University of Santa Maria (LABRUMEN/ UFSM) with regard to crude protein (CP) by Kjeldahl method (AOAC 1995) and *in situ* digestibility of the organic matter (ISDOM) (Mehrez and Orskov 1977). Total digestible nutrients (TDN) were estimated by the product of organic matter (%) and ISDOM, divided by 100 (Barber et al. 1984). Extraction/ export dry matter rate was calculated by multiplied forage yield by grazing efficiency. Extraction/ export of CP as the product of forage yield by CP tenor. Extraction/ export N was calculated by dividing CP yield by

6.25. The Extraction/ export of TDN was estimated by multiplied forage yield by TDN rate.

Spittlebugs (*Deois flavopicta*) were detected in September 2015, controlled by METARRIL®, a biological pesticide with spore of fungus *Metarhizium anisopliae* as its active ingredients.

Statistical analysis comprised mean data of grazing cycles in each season. Experimental design was completely randomized with three treatments (forage systems), three replications of the area (paddocks), with repeated measurement over time (seasons). The seasons' mean data underwent analysis of variance. When there was a significant interaction effect between forage system and season, means were compared by Student's t test at 5% probability, by MIXED procedure. When no interaction existed, the significant effect of the forage system was tested. Covariance matrix was chosen by the lowest AIC (Akaike's Information Criteria) rate, with Variance Components (SAS 2016). Pearson's correlation coefficient analysis was performed so that the association between variables could be verified. The statistical model used was: $Y_{ijk} = m + F_i + R_j(F_i) + S_k + (FS)_{ik} + \varepsilon_{ijk}$, where Y_{ijk} represents dependent variables; m is the mean of all data; F_i is the effect of the forage system; $R_j(F_i)$ is the effect of replication (paddocks) within the forage system (error a); S_k is the effect of the season; $(FS)_{ik}$ is the interaction between the forage system and the season; ε_{ijk} is the residual effect (error b).

RESULTS AND DISCUSSION

Seven grazing cycles (one, two, three and one, during winter, spring, summer and autumn, respectively) were conducted during the experimental 312 days. Grazing cycles had a mean 27 days each when the period of greatest development of elephant grass is taken into account, between spring and autumn. Short grazed and rest periods (approximately 30 days) on elephant grass pasture are associated with the best forage quality (Soares et al. 2004) and to the performance of lactating cows (Deresz 2001).

To pre-grazing herbage mass (Table I) grazing during the winter revealed similarity between organic and conventional pastures made up of elephant grass alone. Results were due to favorable meteorological conditions throughout the season, with high participation of elephant grass in pasture composition. The highest rate ($p \leq 0.05$), detected in mixed pasture with organic production system, may be associated with the employment of organic manure which resets micronutrients, organic matter, N, P_2O_5 and K_2O and improves soil fertility (Menezes et al. 2004). High response of elephant grass to organic manure is also added (Oliveira et al. 2011). There was no difference in the participation of the other botanic components of pasture when the two mixed systems (organic and conventional) were compared.

Pre-grazing herbage mass was greater ($p \leq 0.05$) in organic production pasture during spring. This was especially due to a greater participation of ryegrass, probably due to a better response in mineral fertilization. In fact, during spring, the great participation of other grasses of the summer cycle could be underscored in mixed systems, mainly *Paspalum conjugatum*, *Cynodon dactylon*, *Paspalum urvillei* Steud., *Setaria* spp. and *Dichanthelium* spp. The high contribution of dead material in the forage mass during spring was due to the effect of frosts and the maturation of ryegrass.

Pre-grazing elephant grass herbage mass was greater ($p \leq 0.05$) during the summer within the conventional production system, with elephant grass cultivated alone. This occurred due to the area occupied and the highest yield of elephant grass cultivated alone, when compared to the species of spontaneous-growth present in the in-between rows of the other systems (Diehl et al. 2013).

When the mixed pastures were compared, there was a better response in the autumn with

TABLE I
Pre-grazing herbage mass and botanic composition of pastures in three forage systems (FS). Santa Maria, Brazil, 2015-2016.

FS	Season				Mean	CV (%)
	Winter	Spring	Summer	Autumn		
	Pasture forage mass (kg DM ha^{-1})					
Org[1]	2714[a]	2776[a]	3879[b]	3374[a]	3186	4.4
Conv1[2]	1903[b]	2138[b]	2657[c]	2278[c]	2244	6.3
Conv2[3]	2460[a]	1268[c]	5111[a]	2612[b]	2863	4.9
CV (%)	6.9	7.9	4.2	5.9		
	Botanical composition					
	Elephant grass (%)					
Org	27.4[b]	10.7[b]	37.6[b]	30.3[b]	26.5	11.5
Conv1	21.7[c]	15.6[b]	25.8[c]	20.4[c]	20.9	15.8
Conv2	86.0[a]	93.0[a]	94.1[a]	91.2[a]	91.1	2.8
CV (%)	7.4	9.3	5.8	6.7		
	Ryegrass (%)					
Org	27.3[a]	21.8[a]	---	---	24.5	12.2
Conv1	32.4[a]	10.7[b]	---	---	21.5	15.7
CV (%)	12.2	15.7				
	Other warm grasses (%)					
Org	25.8	44.9	39.7	46.7	39.7[b]	7.1
Conv1	27.5	49.2	53.5	59.5	46.9[a]	8.5
CV (%)	20.9	11.2	8.7	8.8		
	Other species (%)					
Org	5.4	5.6	6.1	10.5	6.2	21.0
Conv1	7.1	4.1	7.1	10.0	7.1	24.3
CV (%)	28.9	26.1	18.4	15.8		
	Dead material (%)					
Org	14.8[a]	16.9[b]	16.5[a]	12.4[a]	15.1	8.7
Conv1	13.2[a]	20.4[a]	13.6[a]	10.1[a]	14.3	10.5
Conv2	13.9[a]	5.1[c]	5.0[b]	8.8[a]	8.2	11.3
CV (%)	15.2	11.3	12.9	15.1		
	Relation leaf blade: stem + sheath elephant grass					
Org	1.3	16.6	3.0	2.7	5.9[b]	7.2
Conv1	1.4	18.2	3.2	3.1	6.5[b]	7.8
Conv2	1.6	22.7	3.5	3.3	7.7[a]	6.4
CV (%)	5.0	5.4	3.8	11.3		

[1]Organic production system, with mixed pastures. [2]Conventional production system, with mixed pastures. [3]Conventional production system, with elephant grass cultivated alone. Different letters in the column differ by Student's t test ($p \leq 0.05$). DM=dry matter. CV=coefficient of variation.

regard to pasture with organic production, with greater participation of elephant grass.

With relation regard to the ratio leaf blade: stem + sheath elephant grass, rates were high during spring. They averaged higher ($p \leq 0.05$) for pasture with an elephant grass alone, perhaps due to closeness with tufts, since this implied a greater participation of leaf blades in the plants' upper stratum.

To post-grazing herbage mass (Table II) rates reveal a low association with pre-grazing herbage mass, mainly due to the greater preference of cows to elephant grass and ryegrass when compared to tropical spontaneous-growth species (Azevedo Junior et al. 2012).

There was an increase in the participation of dead material due to animal trampling. Since rates for leaf blade: stem + sheath elephant grass were similar, the biomass of leaf blades provided adequate intake. Even during the winter, the percentage of leaf blades in the residual forage mass was close to 50% and thus sufficient for the plants' recovery (Rodolfo et al. 2014). In fact, it provided a new grazing in about 33 days (De Bem et al. 2015). There was no difference ($p \leq 0.05$) for daily herbage accumulation during the winter for the pasture´s productive variables (Table III). Result was due to high participation rate of elephant grass during this season (Table I) since it is tropical species. Mild weather conditions in the winter contributed towards such a performance with high yield participation when compared to response of the elephant grass in normal climate conditions (Steinwandter et al. 2009). The performance of elephant grass provided conditions so that the same number of grazing events could be undertaken.

In the other seasons, the forage accumulation rate was predominant in the conventional production system with singular elephant grass. Results were due to the yield forage's greater production potential with regard to the other species in systems formed by mixed pastures. Accumulation rates obtained during the summer and autumn are similar to those in the same region, between January and March, featuring cv. Taiwan elephant grass under cultivated alone and fertilized with 90 kg N ha^{-1} (Míssio et al. 2006).

The participation of elephant grass in all seasons implied higher ($p \leq 0.05$) forage yield for the conventional production system with elephant grass singular cultivation. Lower rates forage yield were detected in the region of Lages, SC, Brazil. During the first assessment year, under monoculture, among January and May, mean productions featured between 12 and 14 t DM ha^{-1} in elephant grass cultivars (Dall'agnol et al. 2005). In the case of mixed pasture, similarity existed during the spring, whereas higher rates occurred in organic production systems during the other seasons. This condition was attributed to a better response to organic fertilization due to the gradual release of macro- and micro-nutrients for soil solution, proportional to the chemical fertilization (Menezes et al. 2004). It should be underscored that, in these systems, there was less variability in herbage yield between the seasons. There was a greater ($p \leq 0.05$) production in the winter and in the autumn within the mixed organic production system than to the conventional production system. In fact, there was less availability of forage during these seasons, not only in subtropical but also in tropical climates.

The system's effect ($p \leq 0.05$) on grazing efficiency occurred in three out of the four seasons of the year, with lower rates for mixed systems, perhaps due to a smaller preference for spontaneous-growth species by the animals. Mean rate of grazing efficiency in these systems reached 38.7%. The highest grazing efficiency in elephant grass cultivate alone pasture has been associated with the ratio leaf blade: stem + sheath elephant grass and also to greater stocking rate ($r = 0.83$; $p = < 0.0001$); the grazing efficiency rates in the summer and autumn, albeit high, in these system

TABLE II
Post-grazing herbage mass and botanic composition of pasture in three forage systems (FS). Santa Maria, Brazil, 2015-2016.

FS	Season				Mean	CV (%)
	Winter	Spring	Summer	Autumn		
	Pasture forage mass (kg DM ha^{-1})					
Org1[1]	1513[a]	1997[a]	1841[a]	2089[a]	1860	6.4
Conv1[2]	1248[a]	1456[b]	1323[b]	1577[b]	1401	8.5
Conv2[3]	1554[a]	513[c]	885[c]	959[c]	978	12.2
CV (%)	9.9	6.2	5.3	7.9		
	Botanical composition					
	Elephant grass (%)					
Org	21.7[b]	5.9[b]	17.9[b]	15.1[b]	15.1	8.6
Conv1	13.9[c]	10.2[b]	11.9[c]	7.1[c]	10.7	11.6
Conv2	75.9[a]	97.5[a]	85.4[a]	87.3[a]	86.5	4.9
CV (%)	6.8	6.6	3.4	14.3		
	Ryegrass (%)					
Org	18.4	15.3	---	---	16.8[a]	8.4
Conv1	16.6	9.2	---	---	12.9[b]	11.1
CV (%)	9.3	9.9				
	Other warm grasses (%)					
Org	28.8[a]	51.2[a]	54.3[b]	56.9[b]	47.8	8.9
Conv1	30.1[a]	50.0[a]	61.5[a]	63.1[a]	51.2	10.6
CV (%)	6.2	10.1	8.5	16.0		
	Other species (%)					
Org	3.4	8.5	10.7	15.1	9.4	31.6
Conv1	3.5	8.4	13.9	16.6	10.6	37.6
CV (%)	56.1	39.0	21.7	21.8		
	Dead material (%)					
Org	27.4[b]	18.7[b]	17.0[b]	12.9[a]	19.0	8.6
Conv1	35.6[a]	22.2[a]	14.9[a]	13.0[a]	21.4	9.3
Conv2	24.1[b]	23.5[a]	14.5[a]	12.6[a]	18.8	8.3
CV (%)	11.2	11.2	14.4	14.5		
	Relation leaf blade: stem + sheath elephant grass					
Org	0.4	4.5	2.1	1.5	2.1	12.2
Conv1	0.6	4.0	1.4	1.1	1.8	11.4
Conv2	0.7	5.4	2.2	1.0	2.3	11.7
CV (%)	8.4	14.2	5.1	13.1		

[1]Organic production system, with mixed pastures. [2]Conventional production system, with mixed pastures. [3]Conventional production system, with elephant grass cultivated alone. Different letters in the column differ by Student´s t test ($p \leq 0.05$). DM=dry matter. CV=coefficient of variation.

TABLE III
Forage productivity and animal response in three forage systems (FS). Santa Maria, Brazil, 2015-2016.

FS	Season				Mean	CV (%)
	Winter	Spring	Summer	Autumn		
	Herbage accumulation rate (kg ha^{-1} day^{-1})					
Org1[1]	27.8^{a}	18.4^{b}	83.5^{b}	37.3^{b}	41.8	4.9
Conv1[2]	18.7^{a}	26.7^{ab}	60.3^{c}	21.4^{c}	31.8	5.5
Conv2[3]	25.2^{a}	30.6^{a}	143.1^{a}	53.8^{a}	63.1	4.0
CV (%)	7.0	6.9	3.5	5.7		
	Forage yield (kg ha^{-1})					
Org	2363^{a}	2061^{bc}	6930^{b}	1194^{b}	3137	3.9
Conv1	1590^{b}	2990^{b}	5005^{c}	685^{c}	2567	4.6
Conv2	2142^{ab}	3427^{a}	11877^{a}	1722^{a}	4792	3.3
CV (%)	5.2	5.2	2.7	6.9		
	Grazing efficiency (%)					
Org	44.2^{a}	28.1^{b}	52.5^{b}	38.1^{b}	40.7	8.3
Conv1	34.4^{b}	31.9^{b}	50.2^{b}	30.7^{b}	36.8	8.8
Conv2	36.8^{b}	59.4^{a}	82.7^{a}	63.3^{a}	60.5	5.6
CV (%)	9.5	12.2	2.2	10.3		
	Apparent forage intake (% BW)					
Org	2.1	2.0	2.5	3.2	2.5	5.7
Conv1	2.3	2.5	2.9	2.6	2.6	5.5
Conv2	2.8	1.8	3.5	2.5	2.7	5.4
CV (%)	5.7	7.2	2.6	8.7		
	Stocking rate (AU ha^{-1} dia^{-1})					
Org	1.4^{a}	2.1^{b}	6.8^{b}	2.9^{b}	3.3	4.5
Conv1	0.7^{b}	2.0^{b}	3.8^{c}	1.9^{c}	2.1	5.7
Conv2	0.8^{b}	3.2^{a}	9.5^{a}	4.4^{a}	4.5	4.0
CV (%)	5.6	9.7	2.4	3.7		

[1]Organic production system, with mixed pastures. [2]Conventional production system, with mixed pastures. [3] Conventional production system, with elephant grass cultivated alone. Different letters in the column differ by Student´s t test ($p \leq 0.05$). BW=body weight. AU=animal unit, 450kg. CV=coefficient of variation. Grazing cycles: winter (1) – from sowing of ryegrass, 15/05, to 1st grazing, 09/08 (85 days); spring (2) – end of 1st, 17/08, to start of 3rd grazing, 08/12 (112 days); summer (3) – end of 3rd grazing, 17/12, to start of 6th grazing, 09/03 (83 days); autumn (1) – end of 6th grazing, 16/03, to the start of 7th grazing cycle, 17/04 (32 days).

were adequate, even though they could constraint forage intake (Delagarde et al. 2001).

There was no difference in forge intake between the forage systems. Total animal intake is 3.5% when mean rate 2.6% (pasture) is added to feed supplementation (0.9%). The former percentage is above that expected for lactating cows according to body weight and milk yield (NRC 2001).

There was a difference with regard to stocking rates between the systems. Pasture at organic production was higher during the winter when compared to the other seasons due to a greater production of ryegrass. This amount also occurred in conventional pasture with elephant grass cultivate alone during the other seasons. It should be underscored that, between the similarly established mixed systems, higher results occurred in the organic system ($r = 0.76$; $p = 0.0048$) due to a greater participation of elephant grass in pasture composition (Table I).

In the case of variables for the nutritive value of elephant grass forage mass (Table IV), there was no interaction between seasons and systems, or rather, the period did not affect results. Organic matter rates for elephant grass were lower than those for the species when associated with forage groundnut or red clover, with mean 89% (Diehl et al. 2014). Perhaps due to organic fertilization, the system affected CP rate, with a greater rate ($p \leq 0.05$) in forage under organic production. The application of manure raised the rate of organic matter in the soil and improved the chemical composition of elephant grass (Oliveira et al. 2013). It must be underscored that during the winter the CP tenor of elephant grass is low, probably due to mild weather and, thus, pasture growth. CP rates in a normal climate tend to be higher in the winter, already verified in the same region, with 17.7% and 13.7% for winter and summer, respectively (Olivo et al. 2007). Above results are due to a greater development of the plant in hotter periods, with a subsequent rise in rates for cell wall, lignin, fiber and cellulose which usually have an inverse relationship with CP concentration (Macedo Júnior et al. 2007).

Mean estimates ISDOM and TDN reached 74.0% and 61.4% respectively, or rather, close to those for elephant grass with different forage legumes (Diehl et al. 2014). The similarity of the components of the elephant grass's nutritive value between the seasons may be associated with meteorological conditions in which elephant grass grew throughout the whole year (Table I). Normal climatic conditions affect the nutritive value variables of elephant grass (Meinerz et al. 2008).

In the case of variables of the nutritive value of forage in the in-between rows, there was an interaction between seasons and systems for organic matter and CP rates. During the summer, highest rate ($p \leq 0.05$) for organic matter in the conventional system is due to a lower participation of the pasture´s dead material (Tables I and II). Higher rates in CP during the winter and in the spring are due to a greater participation of ryegrass (Table I) and a smaller participation of dead material (Table II). High rates during the summer indicate that spontaneous-growth species, such as *Paspalum conjugatum*, *Paspalum urvillei* Steud., *Setaria* spp. and *Dichanthelium* spp. have significant CP concentration. However, CP rates decrease during the autumn and indicate that species are more sensitive to fall in temperature when compared to elephant grass under analysis (Tables III and IV). There was neither interaction nor system effect on ISDOM and TDN. When the variables of forage's nutritive value in the in-between rows are taken into account, rates are high (Diehl et al. 2014), even though there is a greater variability between the seasons, when compared to elephant grass.

The extraction/ export forage yield by cows (Table V) had a higher rate ($p \leq 0.05$) in the conventional system with elephant grass cultivate alone, followed by the organic system, demonstrating a relationship ($r = 0.99$; $p = <0.0001$) with the herbage yield. To extraction/ export of CP, there is equilibrium between the conventional system under monoculture with elephant grass and the organic system. Similarity in three out of the four seasons in these systems demonstrated that a greater performance in CP export was registered. Similar results were obtained for the extraction/ export of N, especially during the winter and spring. There was a relationship ($r = 0.97$; $p = <0.0001$) with regard to energy between the export of dry matter and TDN, due to the similarity in the digestibility (Table IV) of forage mass between pastures. The energy removal was greater ($p \leq 0.05$) compared with conventional system with mixed pastures.

TABLE IV
Nutritive value of elephant grass and the forage in the in-between rows, in three forage systems (FS). Santa Maria, Brazil, 2015-2016.

FS	Season				Mean	CV (%)
	Winter	Spring	Summer	Autumn		
			Elephant grass			
			Organic matter (%)			
Org1[1]	81.8	80.8	84.5	81.7	82.2	0.6
Conv1[2]	82.6	82.1	84.4	81.4	82.6	0.6
Conv2[3]	83.6	83.8	84.7	82.9	83.8	0.6
CV (%)	0.5	0.8	0.6	0.5		
			Crude protein (%)			
Org	17.3	19.1	16.4	18.7	17.9[a]	3.0
Conv1	14.3	14.4	16.5	16.6	15.4[b]	3.5
Conv2	14.8	15.6	17.7	17.4	16.4[b]	3.3
CV (%)	1.6	4.2	5.2	2.5		
			In situ digestibility of organic matter (%)			
Org	71.0	76.3	74.5	75.6	74.3	3.1
Conv1	75.6	76.1	76.2	69.6	74.4	3.1
Conv2	73.9	75.3	73.4	71.3	73.5	3.1
CV (%)	1.6	3.0	2.4	3.8		
			Total digestible nutrients (%)			
Org	58.1	61.6	62.9	61.8	61.1	2.5
Conv1	62.5	62.5	64.3	56.6	61.5	2.5
Conv2	61.8	63.2	62.2	59.1	61.6	2.5
CV (%)	3.0	2.9	2.8	3.0		
			Forage in the in-between rows			
			Organic matter (%)			
Org	84.1[a]	86.0[a]	84.0[b]	83.8[a]	84.5	0.3
Conv1	85.3[a]	86.5[a]	86.1[a]	84.0[a]	85.5	0.3
CV (%)	0.5	0.8	0.1	0.3		
			Crude protein (%)			
Org	14.9[a]	13.7[a]	22.6[a]	13.1[a]	16.0	2.9
Conv1	11.6[b]	10.7[b]	20.5[a]	12.1[a]	13.7	3.1
CV (%)	4.9	5.2	2.9	5.1		
			In situ digestibility of organic matter (%)			
Org	77.4	59.2	71.4	61.5	67.4	2.5
Conv1	73.3	61.5	66.6	62.4	66.0	2.5
CV (%)	3.1	3.9	3.4	3.8		
			Total digestible nutrients (%)			
Org	65.1	50.9	60.0	51.6	56.9	2.6
Conv1	62.5	53.3	57.4	52.5	56.4	2.6
CV (%)	3.3	4.1	3.6	4.1		

[1]Organic production system, with mixed pastures. [2]Conventional production system, with mixed pastures. [3]Conventional production system, with elephant grass cultivated alone. Different letters in the column differ by Student's t test (p≤0.05). CV=coefficient of variation.

TABLE V
Extraction/ export forage variables and nutrient (N) in three forage systems (FS). Santa Maria, Brazil, 2015-2016.

FS	Season				Total	CV (%)
	Winter	Spring	Summer	Autumn		
			Forage yield (kg DM ha^{-1})			
Org[1]	1201.7^{a}	777.7^{a}	1952.9^{b}	1284.8^{b}	5216.3^{b}	9.0
Conv1[2]	654.9^{b}	703.5^{a}	1281.5^{c}	700.8^{c}	3340.3^{c}	14.1
Conv2[3]	906.5^{c}	716.7^{a}	4188.2^{a}	1653.7^{a}	7465.0^{a}	6.3
CV (%)	14.7	18.5	5.5	11.2		
			Nitrogen (kg DM ha^{-1})			
Org	30.8^{a}	18.8^{a}	56.8^{b}	33.9^{b}	140.3^{b}	9.3
Conv1	13.0^{c}	13.7^{b}	42.6^{c}	16.8^{c}	86.1^{c}	15.1
Conv2	20.7^{b}	16.6^{ab}	111.2^{a}	43.9^{a}	192.4^{a}	6.7
CV (%)	17.9	22.8	5.3	11.8		
			Crude protein (kg DM ha^{-1})			
Org	189.3^{a}	117.7^{a}	352.4^{b}	208.7^{a}	868.4^{b}	9.3
Conv1	81.7^{b}	85.7^{b}	262.9^{c}	105.2^{b}	534.7^{c}	15.1
Conv2	129.2^{a}	102.9^{a}	693.9^{a}	274.4^{a}	1200.5^{a}	6.7
CV (%)	17.5	22.8a	5.3	11.9		
			Total digestible nutrients (kg DM ha^{-1})			
Org	748.5^{a}	419.5^{a}	1218.8^{b}	741.8^{b}	3128.7^{b}	8.6
Conv1	407.5^{c}	394.6^{a}	765.8^{c}	397.2^{c}	1963.7^{c}	13.7
Conv2	566.4^{b}	447.4^{a}	2693.1^{a}	937.2^{a}	4643.8^{a}	5.8
CV (%)	13.5	18.5	4.9	11.4		

[1]Organic production system, with mixed pastures. [2]Conventional production system, with mixed pastures. [3]Conventional production system, with elephant grass cultivated alone. Different letters in the column differ by Student's t test ($p \leq 0.05$). CV=coefficient of variation. Different letters in the column differ by Student's t test ($p \leq 0.05$).

CONCLUSIONS

Elephant grass mixed with other species adapts itself in organic and in conventional production. Mixed pastures, in conventional and organic production, had a better forage distribution throughout the seasons and herbage yield was greater in elephant grass cultivated alone. To mixed pastures, better nutritive value and greater productivity was found in organic production system. The extraction/ export dry mater, N, CP and TDN was greater in elephant grass system cultivated alone. There is a better grazing efficiency and a higher forage yield, mainly in the summer, to elephant grass cultivated alone under conventional production system.

AUTHOR CONTRIBUTIONS

Gabriela Descovi Simonetti: Participated in all stages of the research, from the planning, execution, writing and revision of the manuscript. Clair Jorge Olivo: Advised and supervised the research, from the planning to the finalization of the manuscript. Daiane Cristine Seibt: followed the activities of data collection and analysis, contributing to the scientific construction of the manuscript, considering the reading and revision stages. Vinicius Felipe Bratz: followed the activities of field data collection and contributed to the scientific construction of the manuscript, considering the reading and revision stages. Julio Clemente Sauthier: followed the activities of field data collection and contributed to the scientific construction of the manuscript, considering the reading and review stages. Carine Beatriz Adams: followed the activities of data collection in the laboratory and contributed to the scientific construction of the manuscript, considering the steps of reading and review.

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