

# Steers performance in dwarf elephant grass pastures alone or mixed with *Arachis pinto*

Steben Crestani ·  
Henrique Mendonça Nunes Ribeiro Filho ·  
Marcolino Frederico Miguel · Edison Xavier de Almeida ·  
Flávio Augusto Portela Santos

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**Abstract** The inclusion of legumes in pasture reduces the need for mineral nitrogen applications and the pollution of groundwater; however, the agronomic and animal husbandry advantages with tropical legumes are still little known. The objective of this study was to quantify the effect of the use of forage peanut (*Arachis pinto* cv. Amarillo) in dwarf elephant grass pastures (*Pennisetum purpureum* cv. BRS Kurumi) on forage intake and animal performance. The experimental treatments were dwarf elephant grass fertilized with 200 kgN/ha, and dwarf elephant grass mixed with forage peanut without mineral fertilizers. The animals used for the experiment were 12 Charolais steers (body weight (BW)=288±5.2 kg) divided into four lots (two per treatment). Pastures were managed under intermittent stocking with an herbage allowance of 5.4 kg dry matter of green leaves/100 kg BW. Dry matter intake (mean=2.44 % BW), the average daily gain (mean=0.76 kg), and the stocking rate (mean=3.8 AU/ha) were similar between the studied pastures, but decreased drastically in last grazing cycle with the same herbage allowance. The presence of peanut in dwarf elephant grass pastures was enough to sustain the stocking rate, but did not allow increasing forage intake and animal performance.

**Keywords** Legumes · Herbage intake · Average daily gain · Stocking rate · *Pennisetum purpureum*

## Introduction

The effects of the inclusion of legumes in grass pastures are relatively well known and typically result in improved animal performance and reduced environmental impact (Peyraud et al. 2009; Steinshamn 2010). However, the advantages that might be obtained with the inclusion of forage peanut in elephant grass pastures are still unknown.

Among tropical legumes, forage peanut (*Arachis pinto*) has received attention mainly for its productivity, nutritional value, intercropping potential, and persistence in soil of medium fertility (Lascano 1994). Its potential for intercropping is due to the fact that it has protected growing points, indeterminate flowering and prostrate growth habit, rooting ability, and soil seed reserves (Jones 1993). Under shade conditions, it shows low reduction in the accumulation of forage with increased vertical growth of the stolon and lower leaves density. In addition, there is evidence of high capacity for biological nitrogen fixation on this forage species (Miranda et al. 2003).

Among grasses, dwarf elephant grass (*Pennisetum purpureum*) has shown to be adaptable to grazing because of lower elevation of its stem and higher proportion of leaves throughout its growing season. Regarding the potential for animal performance, Almeida et al. (2000) using cv. Mott observed average daily gain over 1 kg/day of steers without any kind of energy or protein supplementation. However, the agronomic and animal husbandries advantages are likely to be obtained with the inclusion of a forage legume in this type of pasture are still unknown.

S. Crestani · H. M. N. R. Filho (✉) · M. F. Miguel  
Universidade do Estado de Santa Catarina, Av. Luiz de Camões,  
2090, 885520-000, Lages, SC, Brazil  
e-mail: a2hrf@cav.udesc.br

E. X. de Almeida  
Empresa de Pesquisa Agropecuária do Estado de Santa Catarina,  
Ituporanga, SC, Brazil

F. A. P. Santos  
ESALQ-USP, Piracicaba, SP, Brazil

The objective of this study was to quantify the effects of the inclusion of *A. pintoi* in dwarf elephant grass pastures on the forage intake and animal performance. We tested the hypothesis that the inclusion of *Arachis* allows the maintenance of stocking rate and increases animal performance without the need of mineral fertilizer application.

## Material and methods

The experiment was conducted at the Experimental Station of EPAGRI, located in the municipality of Ituporanga, state of Santa Catarina, Brazil, which approximate geographic coordinates are 27°38'S and 49°60'W at 475 m of altitude. The climate is humid subtropical with average annual temperature of 17.0 °C. The mean annual rainfall is 2,190 mm. The soil of the experimental area was classified as a Cambisol Allico and this area was subjected to five grazing cycles; the first started on November 7, 2009 and the last ended on May 22, 2010. However, to describe responses in two seasons of the year (summer and autumn), the trial focused on the second, third, and fifth grazing cycles (January, February, and May).

Two areas of approximately 1 ha each were used. One of them was planted with dwarf elephant grass (*P. purpureum* cv. BRS Kurumi) in monoculture (PG) and the other one with dwarf elephant grass intercropped with forage peanut (*A. pintoi*; PAG) in 2004. Each area was subdivided into 16 paddocks, forming two replicates with eight paddocks of approximately 600 m<sup>2</sup>.

After chemical analysis of the soil (dwarf elephant grass area: pH=5.6, P=1.3 mg/dm<sup>3</sup>, K=97 mg/dm<sup>3</sup>, Mg=3.7 mg/dm<sup>3</sup>, Ca=5.0 Cmol<sub>c</sub>/dm<sup>3</sup>, Al=0.2 Cmol<sub>c</sub>/dm<sup>3</sup>, organic matter=39 g/kg; dwarf elephant grass+*A. pintoi* area: pH=5.7, P=1.5 mg/dm<sup>3</sup>, K=121 mg/dm<sup>3</sup>, Mg=3.4 mg/dm<sup>3</sup>, Ca=6.3 Cmol<sub>c</sub>/dm<sup>3</sup>, Al=0.3 Cmol<sub>c</sub>/dm<sup>3</sup>, organic matter=38 g/kg) both areas received fertilization in April 2009. The area intercropped with forage peanut did not receive any mineral fertilizer, but 7.5 t of turkey litter bedding, totaling 180 kg of phosphorus (P), 225 kg of potassium (K), and 140 kg nitrogen (N). The pure stands with elephant grass received fertilization with 180 kg of P in the form of triple superphosphate and 225 kg of K in the form of potassium chloride. In September 2009, the areas were mowed to become uniform. In the dwarf elephant grass pastures, 200 kg of N as ammonium nitrate was applied and fractionated into five times (one after mowing and one after each of the first four grazing cycles). For mixed pastures, there was no additional application of N.

Twelve steers with average weight of 288±5.2 kg were divided into four uniform groups, constituting two replicates with three animals per experimental treatment. The

animals were managed under intermittent stocking with an herbage allowance of 6.0 kg of green leaf blades dry matter per 100 kg body weight (BW)/day. Only green leaves of dwarf elephant grass were considered to define the herbage allowance for PG treatment. Leaves of dwarf elephant grass and forage peanut 5 cm above the soil were considered for PAG treatment. For the forage allowance to be constant, the number of days of occupancy of paddocks was variable. The average occupancy per paddock was 2.5 days with intervals of 36.5 days. In the intervals between grazing cycles, the animals were all gathered in an elephant grass pasture.

The dry matter of green leaves (DMGL) was estimated before and after grazing by comparative yield method (Haydock and Shaw 1975). For this, in each grazing cycle, four squares of 1 m<sup>2</sup> were used to construct a standard range of four values. For each standard allocated, an area with similar biomass of green leaves was sampled and dried in an oven at 60 °C with forced ventilation. Regression equations for estimating DMGL per hectares, depending on the patterns (1–4), were built and in each paddock DMGL was estimated from 20 points mark given by three trained evaluators. The pregrazing forage mass was represented only by living leaf blades and for the after grazing forage mass, leaf blades accumulated on the ground, during the occupancy of paddock, were also counted.

Sward height and its botanical, morphological, and bromatological compositions were determined in the last three paddocks of each grazing cycle. The average height of pastures was obtained from 30 measurements before and after grazing using a graduated scale and considering the first touch on a leaf. The botanical and morphological compositions were determined in samples representative of the area obtained by cutting two samples of 1 m<sup>2</sup>, 5 cm above ground level per paddock. The forage cut was separated into dwarf elephant grass (leaf blades and stem plus sheaths), forage peanut (stolon and leaflet plus petiole), dead material, and other species. The different fractions were dried in an oven with forced ventilation at 60 °C for 72 h. The chemical–bromatological composition of forage intake was determined from samples obtained by simulated grazing. These samples were obtained from a sample composed of collections conducted by two samplers, two times per day, over the period of animal occupation in the paddocks. After collection, the samples were dried in a forced air ventilation oven, ground into a 1-mm sieve and stored for later analysis.

Forage intake was estimated by the difference between DMGL present before and after grazing. The average daily weight gain (ADG, kilogram per day) was calculated by the difference between the weights after a 12 h fast for liquid and solid, held at the beginning and end of each experimental

**Table 1** Pregrazing characteristics of dwarf elephant grass in PG or intercropped with PAG in different grazing cycles (GC)

Parameter	GC I		GC II		GC III		s.e.d	Significance		
	PG	PAG	PG	PAG	PG	PAG		Sward	Cycle	Int
Herbage mass (kg DM/ha)	3,014	3,178	2,603	2,572	1,405	1,323	94.7	—*	—**	—*
Sward height (cm)	94.2	87.3	91.2	84.2	66.4	62.3	3.08	—*	—***	—*
Chemical composition (g/kg DM)										
Dry matter (g/kg fresh weight)	165	192	153	179	134	155	1.4	—**	—**	—*
Organic matter	884	891	875	890	868	873	7.3	—****	—****	—*
Crude protein	121	127	175	158	197	180	6.5	—*	—***	—*
Neutral detergent fiber	645	627	585	568	569	550	5.6	—****	—**	—*
Acid detergent fiber	353	347	317	328	316	321	4.5	—*	—**	—*
Morphological composition (g/kg of total DM)										
Leaf blade (grass)	436	351	423	355	282	266	2.6	—***	—***	—*
Stem (grass)	444	367	394	346	510	340	2.8	—***	—*	—****
Foliolate+Petiole (Arachis)	—	76	—	42	—	35	11.0	—	0.07	—
Stolon (Arachis)	—	60	—	59	—	44	8.9	—	—*	—
Dead material (grass+Arachis)	98	67	162	147	205	259	1.2	—*	—**	—****
Other species	22	79	22	50	6.0	57	1.7	—***	—*	—*
<i>A. pintoii</i> content										
g/kg of DM arachis+leaf blade	—	316	—	248	—	244	26.7	—	—*	—
g/kg of total DM	—	162	—	117	—	86	12.5	—	—****	—

\* $P>0.10$ , \*\* $P<0.001$ , \*\*\* $P<0.01$ , \*\*\*\* $P<0.05$

period. The stocking rate (SR) was expressed as animal unit/ha (AU/ha):

$$SR(\text{AU/ha}) = [(\text{BW}/A)/450 \times d/\text{cycle length}] :$$

BW=average BW of the lot between the beginning and end of period (kilogram); A=area occupied by lot (hectare); d=days

occupancy during the period; cycle length=grazing days+days open.

The dry matter content in samples of forage were determined by drying it at 105 °C in an oven for at least 12 h and the ash content was determined by burning it in a muffle furnace at 550 °C for 4 h. The content of crude protein was

**Table 2** Herbage allowance (HA) and post-grazing characteristics of dwarf elephant grass in PG or intercropped with PAG in different grazing cycles (GC)

Parameter	GC I		GC II		GC III		s.e.d	Significance		
	PG	PAG	PG	PAG	PG	PAG		Sward	Cycle	Int
HA (kg DMGL/100 kg BW)	5.5	5.7	5.1	5.1	5.5	5.5	0.15	—*	—**	—*
Postgrazing DMGL (kg/ha)	1,620	1,789	1,226	1,125	815	777	36.1	—*	—****	—****
Postgrazing sward height (cm)	61	60	56	52	55	48	1.7	—****	—****	—*
Morphological composition (g/kg of total DM)										
Leaf blade (grass)	229	222	248 a	148 b	208 a	154 b	17.3	—**	—****	—****
Stem (grass)	535	436	517	477	541	409	48.5	—****	—*	—*
Dead material (grass+arachis)	232	127	211	206	248	299	45.8	—*	0.07	—*
Other species	6	58	48	39	7	54	31.7	—*	—*	—*
Postgrazing <i>A. pintoii</i> content										
g/kg of DM arachis+leaf blade	—	461	—	488	—	374	155.1	—	—*	—
g/kg of total DM	—	208	—	166	—	172	91.4	—	—*	—

Means within each period followed by dissimilar letters differ significantly by Student's test  $t$  ( $P<0.05$ )

BW body weight, DMGL dry matter of green leaves

\* $P>0.05$ , \*\* $P<0.01$ , \*\*\* $P<0.001$ , \*\*\*\* $P<0.05$

determined using Kjeldahl method (AOAC 1995; method no. 984.13). The acid detergent fiber (ADF) and lignin soluble in 72 % sulfuric acid were quantified according to Roberston and Van Soest (1981) and the content of neutral detergent fiber (NDF) according to Van Soest et al. (1991), using polyester bags as proposed by Komarek (1993). NDF was determined using heat-stable amylase, but without sodium sulphite, and the concentrations of NDF and ADF were expressed with residual ash. Analyses were performed as repeated measurements in the paddocks (pasture variables) or animals (animal variables).

Variables were analyzed taking into account factors as pasture type, grazing cycle, and pasture type  $\times$  grazing cycle interaction, using PROC MIXED (Statistical Analysis System; Littell et al. 1998). Pasture type and grazing cycle were considered as fixed variables, whereas paddock or animals was considered as a random variable. Akaike's information criterion was used to choose the variance-covariance matrix (Wolfinger 1993). Means were compared using a probability level of 5 %.

## Results

There was no effect of treatment  $\times$  grazing cycle interaction on the pregrazing herbage mass, pregrazing sward height and chemical composition of forage (Table 1). The pregrazing dry matter of green leaf mass (mean=2,350 kg DM/ha) and pregrazing sward height (mean=81 cm) were similar in both types of pasture, but decreased 1,730 kg DM/ha ( $P<0.001$ ) and 26 cm ( $P<0.01$ ) from the first to the third evaluation period. The crude protein content was similar between pasture types (mean=160 g/kg DM) and rose by 65 g/kg DM ( $P<0.01$ ) from the first to the third evaluation period, while the NDF content was lower (−18 g/kg DM,  $P<0.05$ ) in grass–legume pastures compared to grass-alone pastures, and decreased 77 g/kg DM ( $P<0.001$ ) from the

first to the third evaluation period. In both types of pasture, leaf/stem ratio was around 1.0 in the first and second periods before grazing. However, in the third period, this value decreased to 0.65, with significant increase of dead material in the fractions, mainly in PAG pastures (interaction treatment  $\times$  grazing cycle,  $P<0.01$ ).

The herbage allowance of DMGL (mean=5.4 kg DM/100 kg BW) were similar in both pasture types and lower ( $P<0.01$ ) on the second cycle, compared to the first and third cycles (Table 2). The postgrazing dry matter of green leaf mass was similar in both pasture types (mean=1,225 kg DM/ha) and decreased from the first to the third evaluation period with a more pronounced effect on the grass–legume pastures (interaction treatment  $\times$  grazing cycle,  $P<0.01$ ). The postgrazing sward height was 3.8 cm lower ( $P<0.05$ ) in mixed pastures compared to pure grass and 10 cm lower ( $P<0.05$ ) in the last grazing cycle compared to the first grazing cycle. The proportion of leaves after grazing was reduced by approximately 50 % compared to the proportion existing before grazing, regardless of the experimental treatment. In the grass–legume pastures, the proportion of forage peanut after grazing increased by approximately 170 g/kg of DMGL.

The dry matter intake (mean=2.44 % BW) and average daily gain (mean=0.75 kg/day) were similar in both types of pasture (Table 3). However, in the first and second periods, forage intake was around 2.58 % BW and decreased to 2.16 % BW in the third period (period effect:  $P<0.05$ ). Similarly, average daily gain was around 1.0 kg/day in the first two periods (December 2009 and February 2010) and fell to less than 0.5 kg/day in April 2010 (period effect,  $P<0.05$ ). The stocking rate was around 4.0 AU/ha in both pasture types in the first two periods. However, in the third period, the stocking rate decreased by 0.6 AU/ha in the grass–legume pasture compared to the grass alone pasture (effect of the iteration treatment  $\times$  time,  $P<0.05$ ).

**Table 3** Forage intake and animal performance of cattle grazing on dwarf elephant grass in PG or intercropped with PAG in different grazing cycles (GC)

Parameter	GC I		GC II		GC III		s.e.d	Significance		
	PG	PAG	PG	PAG	PG	PAG		Sward	Cycle	Int
DM intake (% BW)	2.44	2.49	2.74	2.65	2.16	2.18	0.078	—*	—**	—*
DM intake (g/kg BW <sup>0.75</sup> )	100	102	115	111	93	95	2.9	—*	—***	—*
OM intake (g/kg de BW <sup>0.75</sup> )	89	91	100	99	81	83	2.7	—*	—**	—*
Average daily gain (kg)	0.79	0.97	1.05	0.99	0.31	0.42	0.113	—*	—**	—*
Stocking rate (UA/haday)	3.99	4.10	3.75	3.80	2.20 a	1.58 b	0.088	—**	—***	—**

Means within each period followed by dissimilar letters differ significantly by Student's *t* test ( $P<0.05$ )

BW body weight, UA unit animal 450 kg

\* $P>0.05$ , \*\* $P<0.01$ , \*\*\* $P<0.001$ , \*\*\*\*= $P<0.05$

## Discussion

### Effect of pasture types on the pasture characteristics and animal performance

The similar animal performance between animals grazing both types of pasture was a consequence of similar chemical–bromatological composition of forage intake and herbage allowance of DMGL in both pasture types. The similarity of chemical composition of forage can be partially explained by the low proportion of forage peanut in the DM harvested. This could be detected because average DM disappearance from leaves of dwarf elephant grass was 1,125 kg/ha (pregrazing DM of leaves of dwarf elephant grass–postgrazing DM of leaves of dwarf elephant grass) and the average DM disappearance of *A. pintoi* was only 94 kg/ha (pregrazing DM of *A. pintoi*–postgrazing DM of *A. pintoi*). Thus, the disappearance of legume proportion in DMGL was lower than 8 % DM. The lack of effect of *A. pintoi* added in forage intake and the average daily gain in beef cattle grazing tropical grass pastures (*Cynodon dactylon*) was also observed by Paris et al. (2009) when the proportion of legume was less than 10 % of total DM.

On the other hand, the similarity in the stocking rates observed between treatments shows that the introduction of forage peanut in dwarf elephant grass pastures, as well as others grass–legume pastures (Peyraud et al. 2009) can contribute to reducing nitrogen mineral fertilizer use in production systems (Steinshamn 2010). Moreover, considering that in this type of pasture *A. pintoi* is overlapped by the leaves of elephant grass, future work should be conducted to test spatial distributions that facilitate the legume grazing. This proposition is in accordance with a recent paper published by Solomon et al. (2011), which suggest that spatially separated monoculture of grasses and legumes within the same paddock may be an option to enhance adoption of legumes in temperate pastures.

### Effect of the grazing cycle on the pasture characteristics and animals' performance

The animals' performance observed in May 2010 was lower than in previous periods (January and February 2010) and this result cannot be associated to herbage quality. Contrary to the average daily gain observed, the content of NDF was higher and content of CP was lower in the first period. This can be explained by the fact that in the first cycle, pastures were in more advanced stages of regrowth, compared to later periods. On the other hand, considering that DMGL allowance was the same in all evaluation periods, lower animal performance at last grazing cycle seems to be a consequence of sparse aerial distribution of dwarf elephant grass leaves. This fact can be explained by the reduction in

the amount of DMGL (in kilogram per hectare) present in the canopy in both types of pasture. Thus, even with the offer of similar DMGL, bigger spatial dispersion of the preferred fractions of plants seems to have influenced the process of harvesting forage with the impact on consumption and animals' performance (Ratray and Clark 1984). Considering the reduction of DMGL of more than 2,500 kg/ha in the first two periods to less than 1,500 kg/ha in the third period, it can be said that these data agree with the work of Almeida et al. (2000), who reported that steers achieved ADG above 1 kg/day when the amount of DMGL was above 2,000 kg/ha. Allden and Whittaker (1970) also found increases in grazing time and reductions in intake speed as herbage mass in tropical pastures was reduced.

Finally, the average daily gain observed in the first two evaluation periods (January and February 2010) were obtained when forage intake was close to 2.5 % BW. These results confirm the observation that dwarf elephant grass may support DM intake above 2.5 % BW (Morenz et al. 2006) and gains around 1 kg/day (Sollenberger and Jones 1989; Almeida et al. 2000). However, the inclusion of *A. pintoi* had no effect on animal performance, probably due to the low proportion of *A. pintoi* in the forage consumed. This, in turn, might be related to the spatial distribution and low proportion of *A. pintoi* in the sward. Future studies should evaluate the effect of spatially separated monocultures of *A. pintoi* and *P. purpureum* on animal performance.

## Conclusions

The spatial distribution of *A. pintoi* in dwarf elephant grass pastures is not enough to provide increases in animal's performance and spatially separated monoculture of tropical grasses and legumes need to be studied.

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