

Morphogenesis in pastures of Coastcross-1 and Tifton 85 mixed with forage peanut, submitted to cutting management

Morfogênese em pastagens de Coastcross-1 e Tifton 85 consorciadas com amendoim forrageiro, submetidas ao manejo de corte

Magnos Fernando Ziech^{1*}; Clair Jorge Olivo²; Ana Regina Dahlem Ziech³; Thomas Newton Martin⁴

Abstract

The objective of this study was to evaluate the effect of the presence of forage peanut (*Arachis pintoi* Krap. and Greg.) on the morphogenesis characteristics of two cultivars of *Cynodon* (Tifton 85 and Coastcross-1). The experimental design was factorial (three factors), in randomized blocks, having as factors the cultivars (2), the occupancy area of forage peanut (4) and the seasons (3), with three replications, established in plots. There were three assessments during the study, in spring, summer and autumn, in which the total number of tillers, the culm and leaf elongation, the senescence rate and leaf emergence, the phyllochron, the leaf lifespan, the leaf number and the height of culm and canopy were evaluated. The number of green leaves, number of elongating leaves and senescence rate were similar among cultivars, but cv. Coastcross-1 showed higher number of expanded leaves and leaf emergence rate, and lower phyllochron and leaf lifespan. We observed lower rates of senescence and higher leaf emergence in spring, and lower rates of leaf elongation in autumn. The increasing participation of forage peanut in the pastures did not affect the calculated morphogenetic variables, but decreased the number of grass tillers. A lower average daily thermal accumulation decreased the development of both grasses in this study, with a more pronounced effect in cv. Tifton 85. The Coastcross-1 cultivar has higher elongation rate and leaf emergence, coupled with lower phyllochron and leaf lifespan, indicating a need for shorter rest periods when compared to cv. Tifton 85.

Key words: *Arachis pintoi*. *Cynodon dactylon*. Mixed swards. Structural characteristics.

Resumo

O objetivo deste trabalho foi avaliar a presença do amendoim forrageiro (*Arachis pintoi* Krap. e Greg.) sobre as características morfológicas de duas cv.es do gênero *Cynodon* (Tifton 85 e Coastcross-1). O delineamento experimental utilizado foi em fatorial distribuído em blocos ao acaso, apresentando como fatores as cultivares (2), a oportunidade de área para o amendoim forrageiro no plantio das pastagens (4) e as estações estudadas (3), com três repetições, sendo estabelecidas em parcelas. Realizaram-se três avaliações no decorrer do estudo, caracterizando as estações de primavera, verão e outono, sendo avaliado o número total de perfilhos, alongamento de colmo e folhas, taxa de senescência e

¹ Prof. Dr., Coordenação de Zootecnia, Universidade Tecnológica Federal do Paraná, UTFPR, Dois Vizinhos, PR, Brasil. E-mail: magnos@utfpr.edu.br

² Prof. Dr., Departamento de Zootecnia, Universidade Federal de Santa Maria, UFSM, Santa Maria, RS, Brasil. E-mail: clairolivo@yahoo.com.br

³ Prof. M.e, Coordenação do eixo tecnológico de recursos naturais, Instituto Federal do Mato Grosso do Sul, IFMS, Ponta Porã, MS, Brasil. E-mail: ana.ziech@ifms.edu.br

⁴ Prof. Dr., Departamento de Fitotecnia, UFSM, Santa Maria, RS, Brasil. E-mail: martin.ufsm@gmail.com

* Author for correspondence

aparecimento de folhas, filocrono, duração de vida da folha, número de folhas e altura de colmo e de dossel. O número de folhas verdes, folhas em crescimento e a taxa de senescência foram similares entre as cultivares estudadas, porém, a cv. Coastcross-1 apresentou maior número de folhas expandidas e taxa de aparecimento foliar e menor filocrono e tempo de vida de folha. Na estação da primavera verificaram-se menores taxas de senescência e maiores de aparecimento de folha, enquanto no outono foram observadas menores taxas de alongamento foliar. A participação crescente de amendoim forrageiro nas pastagens não alterou as variáveis morfológicas calculadas, no entanto diminuiu o número de perfilhos das gramíneas. Menor média de acúmulo térmico diário diminuiu o desenvolvimento das gramíneas estudadas, porém de forma mais acentuada na cv. Tifton 85. A cv. Coastcross-1 apresenta maiores taxas de alongamento e de aparecimento foliar, aliada ao menor filocrono e tempo de vida de folha, indicando a necessidade de períodos de descanso menores quando comparada à cv. Tifton 85.

Palavras-chave: *Arachis pintoi*. Características estruturais. *Cynodon dactylon*. Pastagens consorciadas.

Introduction

To maintain stability of perennial pastures with time, it is important to understand the characteristics of the implanted forage, especially with regard to environmental factors and pasture management. Awareness of morphologies of forage plants at distinct points in time may ensure better management practices for pasture use, increasing the production quality and the sustainability of the system.

The emergence pattern of leaves and culms and their growth dynamics characterize each pasture structure and are critical for the production of dry matter (SILVA et al., 2012). Proper pasture management allows the collection of the maximum amount of green matter as dry matter. As leaf tissues grow, they suffer senescence, decreasing mass accumulation and increasing the qualitative losses of the forage (CUTRIM JUNIOR et al., 2014). Growth rates are high at the beginning of regrowth, gradually decreasing with mass accumulation. In tropical pastures, daily thermal accumulation, together with the high doses of nitrogen fertilization and hydric efficiency, also promote higher growth rates in tropical grasses (MOTA et al., 2012), although resulting in short periods of productive and qualitative peaks of the pasture.

The use of legumes, such as the stoloniferous forage peanut, together with tropical grasses, especially those of genus *Cynodon*, could minimize the use of nitrogen fertilizers, and improve the

quality of the diet of forage animals. However, research on the morphogenetic characteristics of grasses planted together with legumes are sparse.

Therefore, the goal of this work was to evaluate the contribution of forage peanut, established together with pastures of Coastcross-1 or Tifton 85, to the main morphogenetic variables measured and calculated in three seasons of a year.

Materials and Methods

This study was conducted in an experimental area next to the Dairy Farming Teaching and Research Unit (UNEPE) of the Universidade Tecnológica Federal do Paraná - Dois Vizinhos campus (Dois Vizinhos, PR, Brazil), located at 25° 42' 52" S, 53° 03' 94" W, at 520 m above sea level. Local soil is Red dystroferic nitisol (BHERING; SANTOS, 2008). Local climate is classified as Cfa (humid subtropical, Köppen climate classification), without a well-defined dry season, with average temperature of the hottest month of 22°C.

The area used for the experiments was approximately 400 m², with two cultivars of genus *Cynodon* (Tifton 85 and Coastcross-1), considered as factor A (qualitative). At the time of planting, we allocated to a legume of the genus *Arachis* (stoloniferous forage peanut, cv. Amarillo) increasing percentages of occupied area (0%, 25%, 50% and 75%) which is treated as factor B (quantitative). The planted pastures were

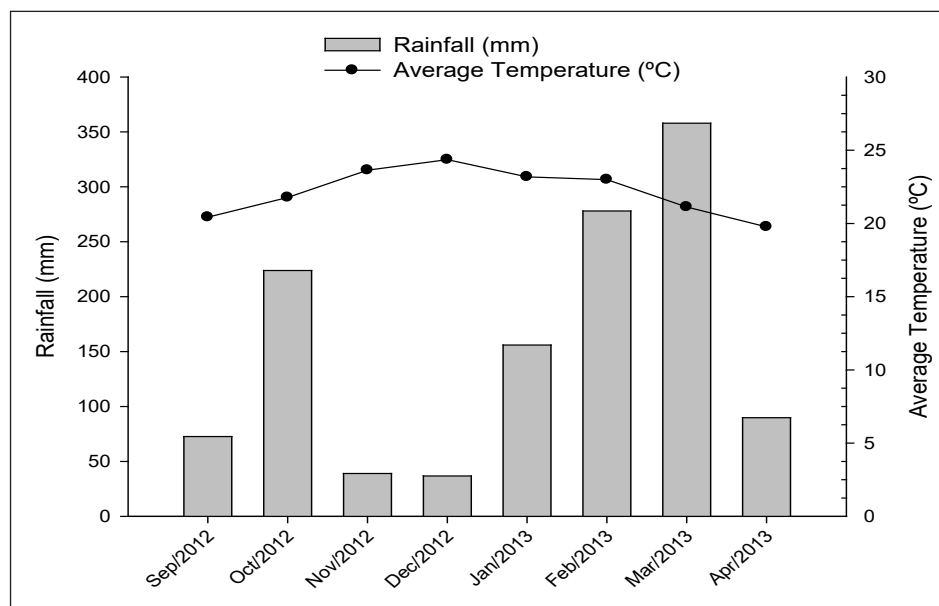
distributed in 2 x 6 m parcels. Planting was from seedlings, spaced 33 cm, linearly, in rows 50 cm apart, distributed in 3 iterations as follows: Tifton 85 planted alone; Tifton 85 and forage peanut planted in 3 successive rows for grass and one for legume, allowing 25% of the area for the legume; Tifton 85 and forage peanut with 2 successive rows for the grass and 2 for the legume, allowing 50% of the area for the legume; and Tifton 85 and forage peanut with one row for the grass and 3 successive rows for the legume, allowing 75% of the area for legume development; Coast Cross-1 planted alone; Coastcross-1 combined, in the same manner as Tifton 85.

Pastures were managed by cutting every time the grasses reached 20 to 25 cm of height. Cuts were performed 7 cm above soil (1 m²), to determine

the available forage mass, and from the crown to a height of 7 cm (0.25 m²) to characterize the residual forage mass. The sum of both measures yielded the total forage mass of the pastures. Data were collected in spring, summer, and autumn of the second agricultural year (after establishment), for a total of three periods of evaluation. Nitrogen fertilization was applied every two cuttings, at a ratio of 20 kg ha⁻¹ N, for a total of 60 kg ha⁻¹ N during the whole period of the study. Data were always collected in the forage production cycle preceding nitrogen fertilization.

During the study period, climatic data (rainfall and average air temperature) were collected by the weather station of the Instituto Nacional de Meteorologia (National Meteorology Institute), in the campus' Annual Crops UNEPE (Figure 1).

Figure 1. Rainfall (mm) and monthly average temperature during the study period. Dois Vizinhos, PR, Brazil, 2013.



Source: Instituto Nacional de Meteorologia automated weather station - Dois Vizinhos, PR, Brazil.

To determine the morphogenetic variables, the marked tiller technique (CARRÈRE et al., 1997) was employed. In each parcel, 10 tillers were marked with colored phone wires, 1 mm thick, to represent

the grass, regardless of the established combination, spaced 50 cm. In each season, evaluations were performed every 3 to 4 days (twice a week). Data was recorded during the rest period, starting 3 to 4

days after cutting. After the uniformization cutting, in the next season, new tillers were marked, in order to maintain population representativeness.

At each assessment, we measured, with a ruler, the length of the green fraction of the completely expanded leaf blades (ligule apparent), expanding blades (without visible ligule), senescent blades (only the green portion of each leaf blade), height of the culm (using as lower limit the insertion point of the tiller and, as upper limit, the sheath of the topmost, completely expanded leaf), the height of the canopy (taking the soil as the lower limit and the curve of the topmost leaf blades). We also manually measured the number of tillers, with three counts per parcel, using a 10 x 5 cm rectangle, before cutting the pasture. Thus we generated the variables: average size of leaf blades, total number of green leaves (including expanding leaves), and average number of dead, expanding and expanded leaves.

The rate of leaf appearance was determined by dividing the number of leaves appearing during the study period by the number of days in that period. The inverse value of the slope of the regression of number leaves by tiller vs. accumulated thermal sum in the corresponding period was considered the phyllochron. The product of the phyllochron by the total number of green leaves per tiller was the leaf lifetime. Elongation and senescence rates of leaf blades and culm elongation were calculated as the ratio of average elongation (or senescence) of the tiller in two consecutive assessments, and the number of days in that period.

To calculate the daily heat accumulation, we used the equation $[(T^{\circ}Mx + T^{\circ}Mn)/2] - 10$, where $T^{\circ}Mx$ = maximum temperature, $T^{\circ}Mn$ = minimum temperature, and 10 = minimum temperature for growth of tropical species (WESTPHALEN, 1975).

Experimental design was random blocks with three blocks, factorially distributed, with qualitative factors being the *Cynodon* cultivars (2) and the seasons (3), and quantitative factors being the levels

of inclusion of forage peanut (4).

Data were subjected to polynomial regression analysis of variance, with a significance level of 5% of likelihood of error. Analyses were performed with the statistical package Genes (CRUZ, 2006), in which averages were compared by the Tukey test. The variable senescence time did not obey error normality requirements, and thus this data was transformed as the square root of X.

The statistical model referring to the analyses of the variables studied in the pasture was represented by $Y_{ijkl} = \mu + T_i + D_j + P_k + T_iD_j + T_iP_k + D_jP_k + T_iD_jP_k + B_l + \epsilon_{ijkl}$, where, Y_{ijkl} are the dependent variables; i , is the A treatment index, qualitative (cultivars); j , is the B treatment index (quantitative); k , is the cutting index (seasons); l , the repetition index; μ is the mean of all observations; T_i represents the cultivar effect; D_j represents the effect of including the forage peanut; P_k is the effect of the seasons; T_iD_j is the interaction between cultivars and forage peanut; T_iP_k is the interaction between cultivars and seasons; D_jP_k is the interaction between forage peanut inclusion and seasons; $T_iD_jP_k$ is the interaction among cultivars, forage peanut introduction, and seasons; B_l is the blocks effect; and ϵ_{ijkl} corresponds to the residual experimental error.

Results and Discussion

This study shows the effect of including the forage peanut in the structural variables of *Cynodon* cultivars. Available forage mass varied from 4.2 to 6.0 t.ha⁻¹ of dry matter, with forage peanut contributing an amount proportional to the area planted with it (0%, 25%, 50%, and 75% of implanted area) (Table 1). The contribution of the legume to available forage mass was the same regardless of the grass planted with it, and proportional to its share in the pasture area. However, this contribution only reached a level

considered adequate for the combination, that is, where 75% of the area was set aside for the legume close to 25% of the forage mass, in the pastures (CADISH et al., 1994).

Table 1. Average total forage mass and forged peanut share in pastures of Coastcross-1 and Tifton 85 established with increasing participation of foreign subpoenaed planted area along three productive seasons in the second year of evaluation. Dois Vizinhos, PR, Brazil, 2013.

AAF (%)	Forage mass (kg ha ⁻¹ de DM)					
	Coastcross-1			Tifton 85		
	Spring	Summer	Autumn	Spring	Summer	Autumn
0	4.442	5.304	4.651	5.930	5.867	4.796
25	4.393	5.028	5.319	5.069	5.803	5.357
50	4.922	5.232	4.961	5.872	6.046	5.000
75	5.133	5.095	5.709	6.052	6.174	5.905
	Forage peanut (%)					
	0	0.00	0.00	0.00	0.00	0.00
	25	5.23	6.72	7.26	7.56	6.40
	50	9.94	13.23	15.52	10.89	14.84
	75	29.96	24.54	28.56	24.49	24.62

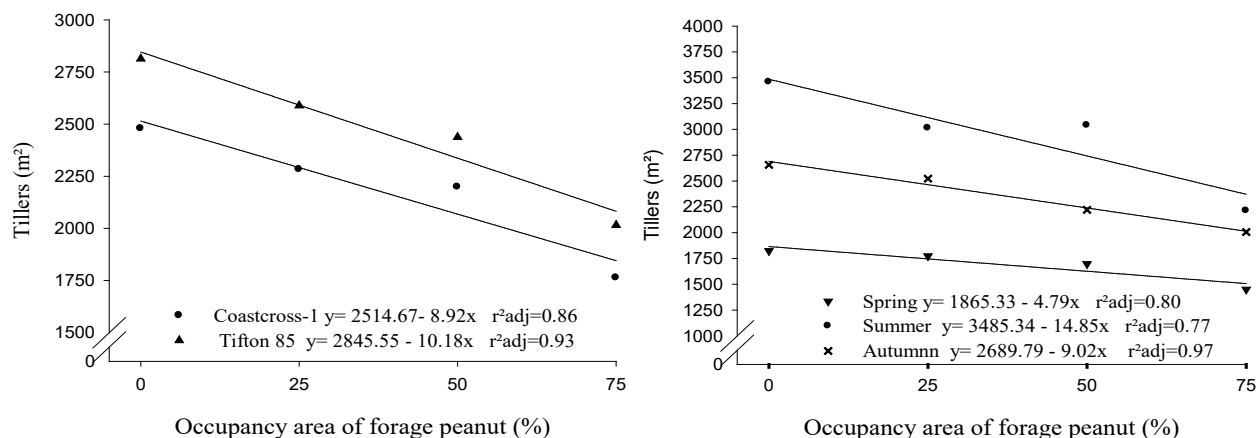
Data not statistically tested. AAF = area available for forage peanut planting.

Daily heat accumulation, measured in degrees-day, was 14.9, 15.6, and 10.6, for spring, summer, and fall, respectively, taking 10°C as basal temperature for the appearance of a new leaf.

Increasing participation of forage peanuts in the pastures implied a linear reduction in the number of tillers. Moreover, there was interaction ($P < 0.05$) between choice of cultivar and proportion of forage peanut regarding number of tillers (Figure 2). Cultivar Tifton 85 displayed the most tillering compared to cv. Coastcross-1, when established alone; and while each 1% area increase set aside for forage peanut resulted in a decrease of 10.2 tillers (m²)⁻¹, it still performed better than Coastcross-1 for similar proportions of grass - to forage peanut - planted area. It is possible that the space taken by the legume prevented optimal development of the grasses. We also observed interaction between proportion of legume planted and season of the year (Figure 2): the decrease in the number of tillers with

increasing legume proportion was least in summer and most in spring (14.85 and 4.79 tillers for each 1% increase in the area set aside for the legume, respectively). Possibly, in periods with higher temperatures there was a better development of the forage peanut, directly affecting tillering in the grass. Indeed, Vilela et al. (2005) observed that the number of tillers, in pastures exclusively planted with Coastcross-1, did not vary with the seasons, reporting a value of 2770 tillers (m²)⁻¹. We obtained a similar value, 2514 tillers (m²)⁻¹, for Coastcross-1 in single planting. Moreover, in spring there was less tillering overall; this could be due the fact that spring counting was at the first cut after the cold season, and this period showed high rates of elongation of leaf and culm. According to Sbrissia et al. (2001), Coastcross-1 pastures show a compensation mechanism for size and density, in which high population densities associate with small tillers and vice versa.

Figure 2. Linear regression graphs of number of tillers (m²) vs. area available for forage peanut (%), showing interactions with cultivar employed in the combination (left), and with seasons (right), in pastures of forage peanut combined with Coastcross-1 or Tifton 85. Dois Vizinhos, PR, Brazil, 2013.



The number of green leaves (in expansion + expanded) was similar between the cultivars, 7.1 leaves, and did not vary significantly with the presence of forage peanut in the pastures (Table 2). A smaller average result, 6.66 green leaves per till, was reported by Costa et al. (2015), for

the cv. Vaquero, in greenhouse, with nitrogen fertilization between 80 and 160 mg kg⁻¹ soil. We observed number of green leaves in spring and autumn, compared to summer, possibly due to the water deficit that happened in that season (Figure 1).

Table 2. Number of green leaves (NGL), number of completely expanded leaves (NCEL), number of leaves in expansion (NLE), number of dead leaves (NDL) and average size of whole leaf (ASWL) in pastures of Coastcross-1 and Tifton 85 established with increasing inclusion levels of forage peanut along three productive seasons in the 2nd year of evaluation. Dois Vizinhos, PR, Brazil 2013.

Cultivars	Variables				
	NGL	NCEL	NLE	NDL	ASWL (cm)
Coastcross-1	7.20ns	5.92a	1.96ns	0.57ns	8.00a
Tifton 85	6.99	5.58b	1.97	0.55	6.99b
Forage peanut inclusion level (%)					
0	7.07ns	5.81ns	1.95ns	0.68*	7.38ns
25	6.82	5.61	1.91	0.58	7.22
50	7.25	5.94	1.97	0.55	7.70
75	7.24	5.64	2.02	0.41	7.66
Seasons					
Spring	7.28a	5.32b	2.28a	0.37b	8.15a
Summer	6.72b	5.59ab	1.81b	0.53ab	6.88b
Autumn	7.29a	6.33a	1.80b	0.78a	7.45ab
CV %	7.96	8.27	6.32	28.40	10.95

Different letters in the columns indicate difference according to the Tukey test, at 5% significance ($P < 0.05$). Ns= not significant.

Expanded leaves, however, appeared in higher numbers in the pastures established with cv. Coastcross-1, with the proportion of forage peanut planted having no effect on this parameter (average of 5.7 expanded leaves). Season also had an effect on number of expanded leaves, with the best results observed in autumn, which correlated with the longer time (in days) needed, in the season, for pastures to become ready for harvest (20 to 25 cm of height).

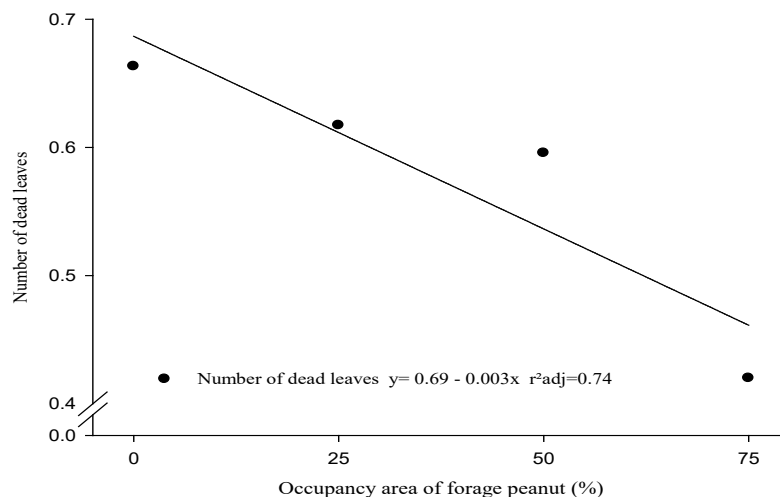
Neither cultivar choice, nor by inclusion level of legume significantly affected the number of expanding leaves, with an average of 2.0 expanding leaves per tiller. However, significant difference was observed between the seasons, with the highest number of expanding leaves observed in spring (2.3 leaves), indicating a higher rate of elongation and leaf emergence after the cold season, which supports the compensation mechanism described by Sbrissia et al. (2001).

The average size of the whole leaf followed the same trend as the number of expanded leaves, with a 14.5% larger size, on average, found in pastures established with cv. Coastcross-1, compared to Tifton 85 grass, which suggests a cultivar characteristic. The inclusion level of the legume

had no significant effect on this parameter, with an average of 7.5 cm.leaf⁻¹. This value is rather smaller than what was reported by Vilela et al. (2005), using cv. Coastcross-1, subjected to grazing with rotating occupancy, in Coronel Pacheco, MG, Brazil, for the same seasons as in this study (average size of leaf blades 9.3 cm). Analyzing the variable as a function of time, we observed the largest whole leaf size in spring, followed by autumn, with the lowest value in summer (which again could be justified by the low rainfall during that period - Figure 1). In the Vilela et al. (2005) study, the smallest average size observed was 7.4 cm, in spring, and the largest was 10.5 cm, in summer and autumn, in Coastcross-1 pastures with single cultivation.

The number of dead leaves was similar for both cultivars (0.56 dead leaves.tiller⁻¹), but increasing the area planted with forage peanut had a significant ($P < 0.05$), negative linear effect (Figure 3), with an average reduction in the number of dead leaves of 65% for the highest level of inclusion of legume to the pasture. Season of the year also had an effect, with the largest numbers of dead leaves found in autumn, followed by summer. That may be explained by the larger intervals between cuttings, which were 17, 21, and 24 days for spring, summer, and autumn, respectively.

Figure 3. Number of dead leaves in pastures of Coastcross-1 and Tifton 85 established with increasing areas for inclusion of forage peanut along three productive seasons. Dois Vizinhos, PR, Brazil, 2013.



For the rate of senescence, we observed similar results for both cultivars, with an average of 1.8 mm tiller⁻¹.day⁻¹; furthermore, we detected no significant effect of the presence of forage peanut in the pastures (Table 3). This contrasts with reports by Pereira et al. (2011), who studied the effect of increasing doses of nitrogen on Tifton 85 grass. They observed senescence rates of 8.1 and 1.1 mm tiller⁻¹.day⁻¹ for pastures with no fertilizer and with 133 kg ha⁻¹ nitrogen, respectively. Seasons, however, did affect senescence, which was lowest

in spring. That is related to the greater leaf and culm elongation in this period, that resulted in pastures reached cutting size (20 to 25 cm) early, compared to summer and autumn. According to Pereira et al. (2011), the increase in leaf senescence rate relates to the loss of forage and nutrient value. Managing the pasture with a lower canopy may decrease those effects. Additionally, the grater shading of older leaf blades by newer ones may cause an increase in leaf senescence rate of taller tropical grasses (HODGSON, 1990).

Table 3. Senescence rate (cm.tiller⁻¹.day⁻¹) and leaf appearance rate (leaf.tiller⁻¹.day⁻¹) in pastures of Coastcross-1 and Tifton 85 established with increasing areas available for planting of forage peanut along three productive seasons in the second year of evaluation. Dois Vizinhos, PR, Brazil, 2013.

Cultivars	Senescence rate	Leaf appearance rate
Coastcross-1	0.20ns	0.34a
Tifton 85	0.17	0.28b
Inclusion level of forage peanut (%)		
0	0.19ns	0.32ns
25	0.20	0.29
50	0.18	0.32
75	0.18	0.32
Seasons		
Spring	0.14b	0.39a
Summer	0.20a	0.27b
Autumn	0.21a	0.27b
CV %	22.53	12.52

Different letters in the columns indicate difference according to the Tukey test, at 5% significance ($P < 0.05$). Ns= not significant.

The rate of leaf emergence (leaf.tiller⁻¹.day⁻¹) was, on average, 21.4% higher for cv. Coastcross-1 than for cv. Tifton 85, characterizing Coastcross-1 as a more precocious variety. The presence of forage peanuts did not interfere with leaf emergence, but the seasons did: we recorded the highest rates in spring, in direct relation to the leaf elongation rate and with the availability of reserve nutrients in the plant. Premazzi et al. (2011), looking at nitrogen levels in Tifton 85 grass, in greenhouse, reported leaf emergence rates growing linearly with nitrogen

up to 80 mg kilogram⁻¹ of soil, again contrasting with the lack of effect of legume inclusion that we observed in this study. On the other hand, Vilela et al. (2005), in a study with Coastcross-1, observed values similar to those reported here: 0.33, 0.27, and 0.24 leaves day⁻¹ for spring, summer and autumn, respectively.

Forage peanut inclusion in the pasture had no effect on rates of leaf and culm elongation, or on canopy and culm heights. Seasons, however, did interact with all of those parameters ($P < 0.05$,

Table 4). Leaf elongation rates were highest in spring, and were similar for both cultivars; while in autumn leaf elongation rates were on average 51.5% lower than in spring, with cv. Tifton 85 having the lowest values observed. Those responses contrast with Vilela et al. (2005), who reported the most elongation in summer. The reason for the difference may be due to the water deficit suffered by our pastures in the summer (Figure 1), as, according to Pinto et al. (2001), a reduction in the availability of water in the soil correlates to a lower leaf area. Based on our data, we may conclude that cv. Coastcross-1 decreased its rate of leaf elongation along the seasons, but less than cv.

Tifton 85 (Table 4). Pereira et al. (2011) looking at nitrogen levels in Tifton 85 pastures, observed leaf elongation rates between 0.8 and 1.8 cm tiller⁻¹.day⁻¹, at different leaf insertion levels, with nitrogen fertilization of 66 kg.ha⁻¹, which is similar to this study. In contrast, Vilela et al. (2005), using 200 kg ha⁻¹ of nitrogen in Coastcross-1 pastures, observed much higher rates, 2.6 cm⁻¹.day⁻¹, for the average of three seasons. Those values are higher than what we observed in this study, possibly due to the high nitrogen fertilizer doses they used, which increase leaf elongation rate (OLIVEIRA et al., 2007; MARTUSCELLO et al., 2005; ANDRADE et al., 2005).

Table 4. Averages of interaction of leaf elongation rate and culm elongation rate (cm.tiller⁻¹.day⁻¹), culm and canopy height (cm) among *Cynodon* cultivars and seasons, in pastures established with increasing areas available for planting of forage peanut along three productive seasons in the second year of evaluation. Dois Vizinhos, PR, Brazil, 2013.

Cultivars	Leaf elongation		
	Spring	Summer	Autumn
Coastcross-1	1.40aA	1.21aAB	0.99aB
Tifton 85	1.49aA	0.95bB	0.71bB
Cultivars	Culm elongation		
	Spring	Summer	Autumn
Coastcross-1	0.76aA	0.21aB	0.23aB
Tifton 85	0.54bA	0.16aB	0.10bB
Cultivars	Culm height		
	Spring	Summer	Autumn
Coastcross-1	16.90aA	11.59aB	15.60aA
Tifton 85	14.27bA	10.39aB	10.89bB
Cultivars	Canopy height		
	Spring	Summer	Autumn
Coastcross-1	24.44aA	18.79aB	21.71aAB
Tifton 85	21.40bA	17.11bB	16.35bB

Different letters in the columns indicate difference according to the Tukey test, at 5% significance ($P < 0.05$). Ns= not significant.

Culm elongation rate was also highest in spring, with rates above 5.0 mm per day. During this time, we observed a result 40.0 % higher for cv. Coastcross-1 than for cv. Tifton 85. In summer and autumn culm elongation rates were similar, but, in the summer, there was no significant difference between the cultivars, while, in the autumn, culm elongation rates were lower for cv. Tifton 85. This result, together with the leaf expansion data,

indicates that this cultivar decreases its elongation rate when average daily temperatures are milder. The low rainfall in summer may explain the lack of difference observed between the cultivars during that season. Comparing average values among the seasons, culm elongation rates are similar to those observed for tropical grasses: between 0.2-0.4 cm tiller⁻¹ day⁻¹ (CÂNDIDO et al., 2005; MARCELINO et al., 2006).

Both cultivars had similar culm heights in summer, but cv. Coastcross-1 had larger culms ($P < 0.05$) in spring and autumn. We recorded the largest culm height values for both cultivars in spring, with similar values for autumn for cv. Coastcross-1. Likewise, in summer culm height was lower for both cultivars, being similar to autumn for cv. Tifton 85.

Regarding canopy height, the largest values ($P < 0.05$) were observed for cv. Coastcross-1 in all seasons, thus confirming it as a taller forage vegetation than Tifton 85 grass. Comparing seasons, the largest heights were observed in spring for both cultivars, with lower heights in summer and autumn for cv. Tifton 85. Cultivar Coastcross-1 heights, however, were intermediary in autumn and lowest in summer. Based on this interaction, together with the other variables (Table 4), we conclude that the water deficit impaired the growth of both cultivars, but with greater effect on cv. Coastcross-1. Canopy height should not be taken as a key variable for processes of growth and usage of forage in tropical pastures.

Phyllochron and leaf lifetime suffered no effects from mixing stoloniferous forage peanut in the pastures either (Table 5). However, pastures established with Tifton 85 displayed a 20.1% higher phyllochron ($P < 0.05$) than Coastcross-1 pastures, which had an average of 3.1 days/leaf (42 degrees-day), pointing to a greater thermal need

of Tifton 85. Pereira et al. (2011) in Viçosa, MG, Brazil, studying nitrogen fertilization and cutting heights in Tifton 85 grass, observed, for a two-year average, between spring and summer, phyllochrons of 3.0, 2.1, and 1.3 days leaf⁻¹ for nitrogen levels of 0, 66, and 133 kg ha⁻¹, respectively, in canopies with 30 cm height. In this study, results were the same, between cultivars, both for phyllochron expressed in days or in degrees-day; however, when we compared seasons, we observed differences depending on how we measured phyllochron. In order to standardize results from different sites we recommend using thermal time (MARTUSCELLO et al., 2005). Along the study period, phyllochron, in days, was longer ($P < 0.05$) in summer and autumn, and lower in spring (2.6 days leaf⁻¹). However, when the variable is measured in degrees-day, the largest value was observed in summer (59.0); thus, even with a greater average daily heat accumulation (15.6 degrees-day), phyllochron did not decrease in summer - this may have been due to the low rainfall during that time (Figure 1). Pinto et al. (2001), in a study in Piracicaba, SP, Brazil, with Tifton 85 grass, along tree seasons, fertilized with 135 kg ha⁻¹ nitrogen, observed phyllochrons of 3.9, 4.5, and 5.0 days leaf⁻¹ for spring, summer, and autumn, with 48.5, 58.4, and 64.1 degrees-day, respectively. This is similar, for spring and summer, to our results, demonstrating the importance of describing data as heat accumulation.

Table 5. Phyllochron and leaf lifetime (LLT) in degrees-day (DD) and days, in pastures of Coastcross-1 and Tifton 85 established with increasing areas available for planting of forage peanut along three productive seasons in the second year of evaluation. Dois Vizinhos, PR, Brazil, 2013.

Cultivars	Variables			
	Phyllochron (days)	Phyllochron (DD)	LLT (days)	LLT (DD)
Coastcross-1	3.09b	42.00b	21.95b	296.35b
Tifton 85	3.71a	50.26a	25.80a	348.32a
Inclusion level of forage peanut (%)				
0	3.33ns	44.88ns	23.31ns	313.02ns
25	3.56	48.85	23.98	325.64
50	3.37	45.44	24.09	324.68
75	3.34	45.34	24.11	325.99
Seasons				
Spring	2.63b	39.14b	18.97b	282.13b
Summer	3.79a	59.02a	25.27a	393.46a
Autumn	3.78a	40.23b	27.38a	291.40b
CV %	12.59	13.02	10.92	10.53

Different letters in the columns indicate difference according to the Tukey test, at 5% significance ($P < 0.05$). Ns= not significant.

Leaf lifetime is important for pasture management, as it indicates the maximum potential of the species (LEMAIRE; CHAPMAN, 1996), making it possible, in some cases, to determine an appropriate resting time between grazings or cuttings. Oliveira et al. (2007), working with pots in a greenhouse with controlled environment, observed an average leaf lifetime of 23.6 days for Tanzania grass (*Panicum maximum* L.) with canopy height between 20 and 30 cm. Martuscello et al. (2005), also working in greenhouse, observed leaf lifetimes of 41.5 and 36.1 days; and 496 degrees-day and 487 degrees-day, for nitrogen fertilization of 0 and 120 $[\text{mg} (\text{dm}^3)^{-1}]$, respectively. Garcez Neto et al. (2002) observed leaf lifetime of 38 days (386 degrees-day), for cv. Mombaça. In this study, leaf lifetimes (degrees-day or days) behaved similarly to phyllochron, with the largest values ($P < 0.05$) for the Tifton 85 pastures, in which an expanded leaf persisted 25.8 days (348.3 degrees-days), while, for cv. Coastcross-1, the average leaf lifetime was 21.9 days (296.3 degrees-day). This difference of 51.20 degrees-day (3.8 days) relates directly to the higher leaf appearance rate of Coastcross-1 grass.

Thus, this cultivar requires shorter rest periods. Comparing seasons, the results differed depending on how we measured leaf lifetime. Using thermal time, the pasture had a maximum amount of green material without senescence during a longer time (393.5 degrees-day) in summer; but, if we measured leaf lifetime in days, we observed the longest leaf lifetime in autumn (27.4 days). This difference is due to the lower daily heat accumulation during this season. We observed the shortest leaf lifetime, for both cultivars, during spring. Therefore, we recommend, for appropriate usage of the pasture, rest periods no longer than 282.1 degrees-day, equivalent to 19 days for the southwestern region of the state of Paraná.

Conclusions

Mixing grasses of genus *Cynodon* and stoloniferous forage peanut does not change the morphogenetic variables of pastures, except for the number of tillers and dead leaves, which decrease as the share of the legume in the pasture increases.

Thus, this combination sward is a good alternative for forage production in the South West of Paraná.

Cultivar Coastcross-1 displays larger leaf elongation and appearance rates, together with a shorter phyllochron and leaf lifetime, pointing to a need for shorter resting periods compared to cv. Tifton 85.

Further studies on mixed swards of grass and forage peanut, especially with tropical grasses of genus *Cynodon*, for pasture use will be required, particularly to understand the interactions with cattle, such as selectivity and the effect of trampling.

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