Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v36i1.20463

Initial height of pasture deferred and utilized in winter and tillering dynamics of signal grass during the following spring

Sabrina Saraiva Santana[1], Dilermando Miranda da Fonseca[2*], Manoel Eduardo Rozalino Santos[3], Braulio Maia de Lana Sousa[4], Virgílio Mesquita Gomes[5] and Domicio do Nascimento Júnior[2]

*[1]Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal, São Paulo, Brazil. [2]Departamento de Zootecnia, Universidade Federal de Viçosa, Av. P.H. Rolfs, s/n, 36570-000, Viçosa, Minas Gerais, Brazil. [3]Faculdade de Medicina Veterinária, Universidade Federal de Uberlândia, Uberlândia, Minas Gerais, Brazil. [4]Departamento de Zootecnia, Universidade Federal de Sergipe, São Cristóvão, Sergipe, Brazil. [5]Departamento de Ciências Agrárias, Universidade Estadual de Monte Carlos, Janaúba, São Paulo, Brazil. *Author for correspondence. E-mail: dfonseca@ufv.br*

ABSTRACT. Tillering dynamics during regrowth in the spring (September to December 2009) on signal grass (*Brachiaria decumbens* cv. Basilisk) pastures deferred in the beginning of April 2009 is evaluated. Four pasture heights were evaluated at the beginning of deferment (10, 20, 30 and 40 cm). The experimental design consisted of completely randomized blocks with two replications. Rise in pasture height at the beginning of deferment decreased the appearance rate, increased the mortality rate and reduced the survival rate, the balance between appearance and mortality and the stability index of the tiller population at the beginning of the spring. Pastures deferred at initial height of 30 and 40 cm presented relatively stable tiller appearance rate between the beginning and end of spring. However, these pastures presented greater mortality rate, lower survival rate, lower balance between appearance and mortality and lower stability index of the tiller population at the beginning of spring when compared to rates at the end of spring. Pastures managed with shorter initial heights (10 and 20 cm) provided more tissue renewal in the subsequent growth season after their utilization in the winter.

Keywords: *Brachiaria decumbens*, pasture deferment, plant ecophysiology, seasonality.

Altura inicial do pasto diferido e utilizado no inverno e dinâmica do perfilhamento do capim-braquiária durante a primavera subsequente

RESUMO. O trabalho foi realizado para avaliar a dinâmica do perfilhamento durante a rebrotação na primavera (setembro a dezembro de 2009) em pastos de capim-braquiária (*Brachiaria decumbens* cv. Basilisk) diferidos no início de abril de 2009. Foram avaliadas quatro alturas do pasto no início do diferimento (10, 20, 30 e 40 cm). O delineamento experimental utilizado foi o de blocos completos casualizados com duas repetições. A elevação na altura do pasto no início do diferimento diminuiu a taxa de aparecimento, aumentou a taxa de mortalidade e reduziu a taxa de sobrevivência, o balanço entre aparecimento e mortalidade e o índice de estabilidade da população de perfilhos no início da primavera. Pastos diferidos com altura inicial de 30 e 40 cm apresentaram taxa de aparecimento de perfilhos relativamente estáveis entre o início e final da primavera. Contudo, esses pastos apresentaram maior taxa de mortalidade, menor taxa de sobrevivência, menor balanço entre aparecimento e mortalidade e menor índice de estabilidade da população de perfilhos no início da primavera em relação ao final da primavera. Pastos manejados com menor altura inicial (10 e 20 cm) apresentam maior renovação de tecidos na estação de crescimento subsequente após utilização dos mesmos no inverno.

Palavras-chave: *Brachiaria decumbens*, diferimento da pastagem, ecofisiologia vegetal, estacionalidade.

Introduction

The equilibrium between demand and supply for feed throughout the year is the basic principle which underlies decisions in pasture production systems. However, the alternation between periods of vigorous growth of forage plants and periods in which growth diminishes or is paralyzed causes the seasonality of forage production. So that a balance between forage demand and supply could be achieved, management strategies have to be employed to provide cattle with feed during the scarcity period (winter). Among the possible alternatives, the simple and relatively low cost pasture deferment stands out as a management strategy (SOUSA et al., 2012).

Success in the use of deferred pastures mainly depends on the structure of deferred pastures, which may be modified by pasture height at the beginning of deferment. The height of the pasture at the start of deferment influences its leaf area, which has a direct connection to the plant capacity of intercepting light radiation, one of the basic premises for maintenance of photosynthesis at maximum level (PARSONS et al., 1983). In fact, initial deferment height affects pasture growth rate which, in turn, modifies the pasture's morphological and structure differentiation (VILELA et al., 2012).

Since pastures deferred at elevated heights in the beginning of the fall usually have a greater number of tillers with a remaining apical meristem, in such conditions photo assimilates are preferentially reallocated for the development and maintenance of the existing tillers (ROBSON et al., 1988). The larger leaf area of high-deferred pastures causes more shading at the foot of plants and inhibition for the appearance of new tillers (SANTOS et al., 2009a). At the end of the deferment period, the above may determine a tiller population mainly comprised of older tillers and may result in a response pattern contrary to the one that normally occurs on pastures deferred at lower initial height.

The effect of these management actions, such as pasture height at the beginning of deferment on the regrowth of pastures in the following growth season (spring), is still unknown. Consequently, studies on the tillering pattern of the forage plant after deferment periods and periods of utilization of the deferred pastures are of paramount importance since tillering is the main source of perennation of forage grasses.

Knowledge on the regrowth of the previously-utilized pasture under deferred grazing may help in the development of effective and rational management strategies of the pasture deferred. Current study evaluates the effect of the pasture height of signal grass (*Brachiaria decumbens* cv. Basilisk) at the beginning of the deferment period during regrowth in the spring.

Material and methods

The experiment was conducted between September and December 2009 in the Forage Sector of the Department of Animal Science of the Universidade Federal de Viçosa, in Viçosa, Minas Gerais State, Brazil (20º45'S; 42º51'W; 651 m altitude).

According to Köppen classification, the regional climate Viçosa is Cwa, with well defined dry (May to October) and rainy (November to April) seasons. Average annual rainfall is 1,340 mm; average air relative humidity reaches 80%; and an annual average temperature 19ºC. The climatic information during the experimental period was obtained from the meteorological station of the Federal University of Viçosa, approximately 500 meters distance from the experiment site (Table 1).

Table 1. Average daily temperature, insolation and rainfall during the experimental period (September to December 2009).

Month	Average daily temperature (°C)	Insolation (hour day^{-1})	Rainfall (mm)
September	21.1	4.9	72.2
October	21.7	3.8	127.9
November	23.1	5.6	131.5
December	22.4	3.2	333.1

The signal grass (*Brachiaria decumbens* cv. Basilisk) pasture, established in 1997, was utilized in the experiment. The experimental area was composed of eight paddocks with areas varying from 0.25 to 0.40 ha. The soil of the experimental area consisted of Red-Yellow Latosol of clayey texture in a moderately undulating relief (EMBRAPA, 2006). Results of the chemical analysis performed at the beginning of the experimental phase showed that the 0-20 cm layer presented the following characteristics: pH in H_2O = 5.1; P = 2.9 (Mehlich-1) and K = 85 mg dm^{-3}; Ca^{+2} = 2.05; Mg^{+2} = 0.45; Al^{+3}= 0.19 cmol$_c$ dm^{-3}.

The effect of four pasture heights (10, 20, 30 and 40 cm) on the regrowth of pastures at the beginning (September to October 2009) and end of spring (November to December 2009) was evaluated at the beginning of the deferment period, in April 2009. The experimental design consisted of completely randomized blocks, with two replications, in subdivided plots over a time period.

Before the setting of the initial pasture heights between December 2008 and February 2009, the signal grass was managed under continuous stocking and at a variable stocking rate to maintain the sward height at 25 cm. In the beginning of March 2009, animals were placed or removed from pastures so that the intended sward heights would be achieved (10, 20, 30 or 40 cm). When the above heights were reached, the pastures were then again managed under continuous stocking and at variable stocking rate to maintain the heights desired.

In April 2009, all pastures received, on the top, 70 kg ha^{-1} nitrogen with urea, during the late evening. The animals were removed from the pastures on this occasion for the start of the deferment period. Pastures remained deferred for approximately 70 days. On July 6, pastures were then again utilized by animals, managed under continuous stocking and at a fixed stocking rate of 3 AU ha^{-1} until September 20, 2009.

In September 2009, after the employment of previously deferred pastures, the evaluation of pasture regrowth during the spring began. During the experimental period between September and December 2009, the pastures were managed under continuous stocking, with 25 cm mean height and by crossbreed steers with initial weight 190 kg. Animals were respectively removed from or placed on pastures when the sward height was below or above the intended height (25 cm). The monitoring of pasture heights was done twice a week, at five points per experimental unit. Measurement criterion of the pasture height corresponded to the distance from the soil surface to the leaves located at the upper part of the sward.

Evaluations of the tillering pattern were performed in three (0.25 sided) squares per experimental unit, placed at representative points of the mean pasture height. At the beginning of the experimental period (September), all tillers within the squares were counted and tagged with plastic-coated wire of a certain color. Every 30 days all tagged tillers were counted once more; new tillers were tagged with a different color from the previous tagging; the wires of dead tillers were removed. The tiller was considered dead when it disappeared, dried out or was at an advanced senescence stage. It was thus possible to estimate the tiller population of all generations and to calculate the rates of appearance [(flowered tillers/total live tillers at the previous tagging) × 100], mortality [(dead tillers/total live tillers at the previous tagging) × 100], survival (100 - tiller mortality rate) and tiller flowering [(flowered tillers/total live tillers at the previous tagging) × 100], the balance between tiller appearance and mortality (tiller appearance - mortality rates) and the tiller population stability index [tiller survival rate × (1 + tiller appearance rate)].

In the case of data analysis, a descriptive comparison of the means of the response variables was first conducted by graphs to identify the months when the variations of patterns were similar. Based on the above, data were clustered at two periods of the year (beginning of spring - September and October; end of spring - November and December) and analyzed with SAEG (Statistics and Genetics Analyses System 8.1). In the case of quantitative factor (pasture height), the models were chosen due to the significance of the regression coefficients, utilizing the t test up to 10% probability of the coefficient of variation (r^2 = SQRegression/SQTreatment). Regardless of whether the interaction was significant or not, current authors decided on its unfolding.

No statistical analysis was conducted for the variable tiller flowering since a large number of rates equal to zero were recorded in this evaluation.

Results and discussion

The pastures deferred at initial height of 10 and 20 cm had ($p < 0.05$) higher leaf appearance rate at the beginning of spring when compared to that at the end (Table 2). However, there was no difference in rates between the beginning and end of spring on pastures deferred at initial height of 30 and 40 cm ($p > 0.05$). The elevation in pasture height at the beginning of deferment reduced tiller appearance rate linearly ($p < 0.10$) at the beginning of spring (Table 2).

Signal grass deferred at 20, 30 and 40 cm high presented ($p < 0.05$) higher tiller mortality at the beginning when compared to that at the end of spring (Table 2). There was no difference between the beginning and end of spring for tiller mortality rates on pastures deferred at 10 cm ($p > 0.05$). Highest tiller mortality rates featured an average 39.3% (beginning of spring) and the lowest 11.8% (end of spring). In spite of the absence of statistical difference ($p > 0.05$) for seasonal effect on pastures deferred at mean height 10 cm, the tiller mortality rate was almost three times higher at the beginning when compared to that at the end of spring. Since tiller mortality rate was affected by pasture height at the beginning of deferment ($p < 0.10$), the elevation in pasture height at the beginning of deferment increased linearly tiller mortality rate, regardless of the season evaluated (Table 2).

The pastures deferred at 20, 30 and 40 cm presented ($p < 0.05$) greater tiller survival rates at the end of spring when compared to those at the beginning of spring (Table 2). There was no difference in the tiller survival rate of the pasture deferred at 10 cm ($p > 0.05$) between the beginning and end of spring. Rise in pasture height at the beginning of deferment decreased linearly tiller survival rate ($p < 0.10$), regardless of the time of the year evaluated (Table 2).

Table 2. Tiller appearance, mortality and survival rate (%) during the spring on signal grass pastures deferred at four initial heights (H).

Season	Initial heights (cm)				Regression equation	r^2
	10	20	30	40		
Tiller appearance rate (%)						
BS	62.04a	59.97a	8.24a	43.85a	$\hat{Y} = 70.0964 - 0.66283^{*}H$	0.93
ES	38.27b	32.52b	39.39a	37.16a	$\bar{Y} = 36.84$	-
Tiller mortality rate (%)						
BS	25.31a	42.84a	42.94a	46.00a	$\hat{Y} = 23.729 + 0.621818^{*}H$	0.73
ES	9.43a	11.09b	11.53b	14.74b	$\hat{Y} = 7.60679 + 0.16356^{*}H$	0.91
Tiller survival rate (%)						
BS	74.69a	57.16b	57.06b	53.99b	$\hat{Y} = 76.271 - 0.621818^{*}H$	0.73
ES	90.57a	88.92a	88.4a	85.26a	$\hat{Y} = 92.3932 - 0.16356^{*}H$	0.91

BS - beginning of spring; ES - end of spring; *Significant by t test ($p < 0.10$); means followed by the same letter on the column do not differ by Tukey's test ($p > 0.05$).

The persistence of one species on pasture is associated to the maintenance of the plant population and to its production over time

(MATTHEW et al., 2000), which is linked to the dynamic and harmonious balance of the processes of appearance and dying, as a form to keep the tiller population stable at a specific environment and management condition (DA SILVA et al., 2008). Thus, due to the relatively more stable tiller appearance rates during the end of the spring, mortality rates decreased and tiller survival rates increased (Table 2) which contributed to keep the tiller population density of the signal grass relatively stable in the season of the year (SBRISSIA et al., 2010).

It is known that during the deferment period, the total number of tillers of the pasture decreases concomitantly with a decrease in vegetative tiller population density and elevation of those in the reproductive stage and dead ones (SANTOS et al., 2009b, 2010a), in response to the greater intraspecies competition for light in the sward (DA SILVA; NASCIMENTO JÚNIOR, 2007). During the period of utilization of deferred pastures in the winter, however, pasture height and forage mass in the pasture decrease (SANTOS et al., 2009c), which probably reduces the intraspecies competition for light in the sward. However, in spite of a lower competition for light, plant tillering is reduced due to bad environmental conditions in the winter (July to September) (SBRISSIA et al., 2010), a time characterized by low mean temperatures, short photoperiod and reduced rainfall, when compared to the months of spring and summer.

In the spring subsequent to the employment of deferred pastures, environmental conditions favorable to pasture growth (temperature, rainfall, photoperiod) are reestablished, stimulating plant tillering (SANTOS et al., 2011). Consequently, pastures deferred at initial height of 10 and 20 cm presented greater tiller appearance rate at the beginning of the spring when compared to that at the end. Despite managing pasture at 25 cm at the end of the deferred pastures duration, pastures at heights 30 and 40 cm were not affected by the times on the tiller appearance rate, probably because of the high mass of available forage on the grassland after the utilization of these pastures deferred in the winter which decreased the light incidence on the base of the plants of the sward, Consequently, tillering (regrowth) was not stimulated.

In fact, when compared to pasture deferred at initial height of 10 cm, the pastures deferred at 30 and 40 cm had greater masses of forage (5,240 vs. 7,753 and 7,463 kg ha^{-1} DM) and dead tissues (2,944 vs. 4,276 and 4,640 kg ha^{-1} DM), superior leaf area index (2.0 vs. 2.6 and 2.5) and falling rate (1.4 vs. 1.5 and 2.0) at the end of the winter, respectively. Response pattern probably determined decrease in tiller appearance rate at the beginning of spring with elevation of pasture height at the beginning of the deferment period (Table 2). The greater forage mass, falling rate and leaf area index on pastures deferred at higher initial height might have reduced the amount and quality of the incoming light at the lower section of the sward, which decreased bud activation and production of new tillers (CASAL et al., 1985). Decrease in the tiller appearance rate with the heights of the pastures at the beginning of the spring, with values varying from 63.47% in the pasture deferred with 10 cm to 43.58% at the height of 40 cm, indicated that lower pasture at the start of the deferment period provided a better regrowth condition in the next season. Higher rates of tiller appearance in low deferred pastures probably occurred because of higher light incidence on the base of the plants which stimulated the tillering, caused by the lower dead forage mass (leaves and stems) found at the end of the deferred pasture utilization and allowing greater regrowth at the beginning of the spring.

During the end of spring, there was no difference in tiller appearance rate due to the pasture height at the beginning of the deferment period ($p > 0.05$). After the reestablishment of the better pasture growth conditions and the beginning of regrowth, the effects of the height at the beginning of deferment disappeared. Further, during all spring, pastures were managed at an average of 25 cm height, which was an adequate goal for the management of signal grass under continuous stocking (SANTOS et al., 2011). It also contributed towards the lack of effect of pasture height at the beginning of the deferment period on the tiller appearance rate at the end of the spring.

The higher tiller mortality rate at the beginning of the spring coincided with greater tiller appearance rate at the same evaluation period (Table 2), which indicated high tiller renewal on the signal grass pasture. Pastures deferred at initial height of 20, 30 and 40 cm presented greater tiller mortality and lower survival rates at the beginning of spring when compared to those at the end of spring.

Moreover, rise in pasture height at the beginning of the deferment period increased tiller mortality rate and reduced survival rate at the beginning and end of spring. Pastures deferred with higher initial height presented greater forage mass, great foliage area index, great stem and dead forage mass at the end of the deferment period (SOUSA et al., 2012; VILELA et al., 2012). The above occurred because of a greater foliage area of the pastures at the start of deferment, a remarkable factor to the light interception used for the synthesis of assimilates during the initial regrowth stage. Indeed, signal grass with higher initial height had greater forage and dead tissue masses, greater foliage area and falling indexes even after the period of utilization during the winter. The above situation might be the result of the greater shadowing on the sward´s inferior section with a reduction of the quantity and quality of the light which penetrated inside the pasture, inhibiting the activation of auxiliary buds and, consequently, inhibiting the tillering of the pasture (SANTOS et al., 2009a).

Further, increase in mortality rate and decrease in the tiller survival rate in pastures deferred with higher heights may be a result of the existence of older vegetative and reproductive tiller and/or, at a more developed stage. Under this condition, the photo assimilates were preferably allocated for the development and maintenance of the existent tillers over the new ones (ROBSON et al., 1988). It is possible that these tillers have been kept alive during the utilization of the deferred pastures. However, they completed their life cycle and died at the beginning of the spring. So that the effect of significant variations on tiller appearance and mortality rates could be better analyzed, it was important to evaluate the combined effect of both (DIFANTE et al., 2008) by the balance between tiller appearance and mortality and by the index of population stability (BAHMANI et al., 2003).

Pastures deferred at initial height of 30 and 40 cm presented ($p < 0.05$) greater balance between tiller appearance and mortality at the end of the spring when compared to that at the beginning of spring (Table 3). There was no difference between the beginning and end of spring with regard to the balance between tiller appearance and mortality on pastures deferred at 10 and 20 cm ($p > 0.05$). The elevation in pastures at the start of deferment reduced the balance between tiller appearance and mortality in the beginning of the spring (Table 3). The positive balance between tiller appearance and mortality rates at the end of spring, regardless of the heights in which pastures were deferred, was associated to the reestablishment of the more favorable environmental conditions (Table 1) to growth and production of the species under analysis.

Pastures deferred at initial height of 30 and 40 cm presented lower rates of balance between tiller appearance and mortality at the beginning than at the end of spring. It may be underscored that pasture deferred at 40 cm had a negative balance at the beginning of spring. A negative balance indicated lower tiller renewal on pasture and consequently determined an older tiller population. Old tillers, in relation to young ones, presented worse morphologic composition and nutritional value (SANTOS et al., 2010a, 2010b) and caused less nitrogen fertilization, which minimized the benefits of agronomical practices and the use of inputs (DA SILVA et al., 2008). Moreover, evidence existed that tiller identity had an influence on the morphogenetic and structural characteristics, causing progressive loss of vigor with advance in tiller age (MONTAGNER et al., 2011; PAIVA et al., 2011).

Table 3. Balance between tiller appearance and mortality (%) during the spring on signal grass pastures deferred at four initial heights (H).

Season	Initial heights (cm)				Regression equation	r^2
	10	20	30	40		
BS	36.73a	17.13a	5.30b	-2.15b	$\hat{Y} = 46.3675 - 1.28465^{*}H$	0.96
ES	28.84a	21.44a	27.86a	22.42a	$\overline{Y} = 25.14$	-

BS - beginning of spring; ES - end of spring; *Significant by t test ($p < 0.10$); means followed by the same letter on the column do not differ by Tukey's test ($p > 0.05$).

Signal grass deferred at 40 cm presented ($p < 0.05$) a greater stability index at the end of the spring than at the beginning (Table 4). However, there was no difference between the beginning and end of the spring for the stability index on pastures deferred at initial heights of 10, 20 and 30 cm ($p > 0.05$). Moreover, the stability index of the tiller population was lower than 1 at the beginning of spring on pastures deferred at 20, 30 and 40 cm. As a rule, rates below 1.0 indicated that survival and appearance of new tillers were insufficient to compensate mortality rates and, therefore, the population would tend to decrease. Higher than 1.0 rates suggested the inverse situation, whereas rates close to 1.0 indicated a stable tiller population, in which the number of tillers practically did not vary, albeit the result of a dynamic balance (BAHMANI et al., 2003).

Table 4. Tiller population stability index during the spring on signal grass pastures deferred at four initial heights (H)

Season	Initial heights (cm)				Regression equation	r^2
	10	20	30	40		
BS	1.21a	0.94a	0.85a	0.78b	$\hat{Y} = 1.29176 - 0.0139227^{*}H$	0.90
ES	1.25a	1.18a	1.23a	1.17a	$\overline{Y} = 1.21$	-

BS - beginning of spring; ES - end of spring; *Significant by t test ($p < 0.10$); means followed by the same letter on the column do not differ by Tukey's test ($p > 0.05$).

Rise in pasture height at the beginning of deferment reduced linearly the tiller population stability index ($p < 0.05$) at the beginning of spring. These facts indicated that the tiller appearance rate was not high enough to compensate mortality rates, which might compromise pasture perenniality and productivity. However, since at the end of spring the stability index increased and remained above 1, the capacity of tillering and recovery of signal grass was demonstrated when temperature, luminosity and precipitation conditions were reestablished. Results demonstrated that, when well managed, tropical grasses increased the tiller population in the spring in spite of the detrimental effect of the deferment period over tillering (SANTOS et al., 2010a).

In the beginning of spring there was no flowering of signal grass, whereas at the end of spring, flowering averaged 0.34% (Table 5). During the spring, no effect of pasture heights at the beginning of deferment or of seasons of evaluation were observed on the signal grass flowering rate; the average flowering rate was 0.34%. In this context, in a study with signal grass under two management strategies and under continuous stocking, in the same experimental area, Santos et al. (2011) observed that the flowering of signal grass occurred mostly in the summer, albeit with little intensity. Similar results were reported by Morais et al. (2006), evaluating the same forage species under continuous stocking and fertilized with nitrogen. These authors reported a greater emission of reproductive tillers in the summer month when compared to that during the winter and spring.

Table 5. Tiller flowering rate during the spring on signal grass pastures deferred at four initial heights.

Season	Initial heights (cm)				Regression equation	r^2
	10	20	30	40		
BS	0.00	0.00	0.00	0.00	$\overline{Y} = 0.0$	-
ES	0.39	0.57	0.00	0.40	$\overline{Y} = 0.34$	-

BS - beginning of spring; ES - end of spring.

Conclusion

Pastures of signal grass deferred at lower initial height (10 and 20 cm) presented greater tiller renewal in the subsequent spring when compared with pastures deferred at superior initial heights (30 and 40 cm). It is recommended that deferment period of signal grass may start at 10 to 20 cm to stimulate pasture regrowth in the spring.

So that a better understanding of the effects of the pasture heights at the beginning of deferment on grassland production during the spring may be obtained, it is important that other characteristics are evaluated, such as the forage production, stocking rate, animal performance and production per area unit.

Acknowledgements

The authors would like to thank Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) for the financial support and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the support on the given scholarships.

References

BAHMANI, I.; THOM, E. R.; MATTHEW, C.; HOOPER, J. R.; LEMAIRE, G. Tiller dynamics of perennial ryegrass cultivars derived from different New Zealand ecotypes: effects of cultivar, season, nitrogen fertilizer, and irrigation. **Australian Journal of Agricultural Research**, v. 54, n. 8, p. 803-817, 2003.

CASAL, J. J.; DEREGIBUS, V. A.; SANCHEZ, R. A. Variations in tiller dynamics and morphology in *Lolium multiflorum* Lam vegetative and reproductive plants as affected by differences in red far-red irradiation. **Annals of Botany**, v. 56, n. 4, p. 553-559, 1985.

DA SILVA, S. C.; NASCIMENTO JÚNIOR, D. Avanços na pesquisa com plantas forrageiras tropicais em pastagens: características morfofisiológicas e manejo do pastejo. **Revista Brasileira de Zootecnia**, v. 36, n. 4, p. 121-138, 2007. (Suplemento especial).

DA SILVA, S. C.; NASCIMENTO JÚNIOR, D.; EUCLIDES, V. B. P. **Pastagens**: conceitos básicos, produção e manejo. Viçosa: Suprema, 2008.

DIFANTE, G. S.; NASCIMENTO JÚNIOR, D.; DA SILVA, S. C.; EUCLIDES, V. P. B.; ZANINE, A. M.; ADESE, B. Dinâmica do perfilhamento do capim-marandu cultivado em duas alturas e três intervalos de corte. **Revista Brasileira de Zootecnia**, v. 37, n. 2, p. 189-196, 2008.

EMBRAPA-Empresa Brasileira de Pesquisa Agropecuária. Serviço nacional de levantamento e conservação de solos. **Sistema brasileiro de classificação de solos**. 2. ed. Rio de Janeiro: Embrapa Solos, 2006.

MATTHEW, C.; ASSUERO, S. G.; BLACK, C. K.; SACKVILLE HAMILTON, N. R. Tiller dynamics of grazed swards. In: LEMAIRE, G.; HODGSON, J.; MORAES, A.; NABINGER, C.; CARVALHO, P. C. F. (Ed.). **Grassland ecophysiology and grazing ecology**. Wallingford: CABI Publishing, 2000. p. 127-150.

MONTAGNER, D. B.; NASCIMENTO JÚNIOR, D.; SOUSA, B. M. L.; VILELA, H. H.; EUCLIDES, V. P. B.; DA SILVA, S. C.; SBRISSIA, A. F.; CARLOTO, M. N. Morphogenetic and structural characteristics of tillers of Guinea grass of different age and grazing severities. **Revista Brasileira de Zootecnia**, v. 40, n. 10, p. 2105-2110, 2011.

MORAIS, R. V.; FONSECA, D. M.; NASCIMENTO JÚNIOR, D.; RIBEIRO JÚNIOR, J. I.; FAGUNDES, J. L.; MOREIRA, L. M.; MISTURA, C.; MARTUSCELLO, J. A. Demografia de perfilhos basilares em pastagem de *Brachiaria decumbens* adubada com nitrogênio. **Revista Brasileira de Zootecnia**, v. 35, n. 2, p. 380-388, 2006.

PAIVA, A. J.; DA SILVA, S. C.; PEREIRA, L. E. T.; CAMINHA, F. O.; PEREIRA, P. M.; GUARDA, V. D. A. Morphogenesis on age categories of tillers in Marandu palisadegrass. **Scientia Agricola**, v. 68, n. 6, p. 626-631, 2011.

PARSONS, A. J.; LEAFE, E. L.; COLLET, B. The physiology of grass production under grazing. II. Photosynthesis, crop growth and animal intake of continuously-grazed swards. **Journal of Applied Ecology**, v. 20, n. 1, p. 127-139, 1983.

ROBSON, M. J.; RYLE, G. J. A.; WOLEDGE, J. The grass plant - its form and function. In: JONES, M. B.; LAZENBY, A. (Ed.). **The Grass crop**: the physiological basis of production. London: Chapman and Hall, 1988. p. 25-83.

SANTOS, M. E. R.; FONSECA, D. M.; EUCLIDES, V. P. B.; NASCIMENTO JÚNIOR, D.; QUEIROZ, A. C.; RIBEIRO JÚNIOR, J. I. Características estruturais e índice de tombamento de *Brachiaria decumbens* cv. Basilisk em pastagens diferidas. **Revista Brasileira de Zootecnia**, v. 38, n. 4, p. 626-634, 2009a.

SANTOS, M. E. R.; FONSECA, D. M.; BALBINO, E. M.; MONERAT, J. P. I. S.; SILVA, S. P. Caracterização dos perfilhos em pastos de capim-braquiária diferidos e adubados com nitrogênio. **Revista Brasileira de Zootecnia**, v. 38, n. 4, p. 643-649, 2009b.

SANTOS, M. E. R.; FONSECA, D. M.; EUCLIDES, V. P. B.; RIBEIRO JÚNIOR, J. I.; NASCIMENTO JÚNIOR, D.; MOREIRA, L. M. Produção de bovinos em pastagens de capim-braquiária diferidas. **Revista Brasileira de Zootecnia**, v. 38, n. 4, p. 635-642, 2009c.

SANTOS, M. E. R.; FONSECA, D. M.; GOMES, V. M.; BALBINO, E. M.; MAGALHÃES, M. A. Estrutura do capim-braquiária durante o diferimento da pastagem. **Acta Scientiarum. Animal Sciences**, v. 32, n. 2, p. 139-145, 2010a.

SANTOS, M. E. R.; FONSECA, D. M.; BALBINO, E. M.; SILVA, S. P.; MONERAT, J. P. I. S. Valor nutritivo de perfilhos e componentes morfológicos em pastos de capim-braquiária diferido e adubado com nitrogênio. **Revista Brasileira de Zootecnia**, v. 39, n. 9, p. 1919-1927, 2010b.

SANTOS, M. E. R.; FONSECA, D. M.; GOMES, V. M.; NASCIMENTO JÚNIOR, D.; GOMIDE, C. A. M.; SBRISSIA, A. F. Capim-braquiária sob lotação contínua e com altura única ou variável durante as estações do ano: dinâmica do perfilhamento. **Revista Brasileira de Zootecnia**, v. 40, n. 11, p. 2332-2339, 2011.

SBRISSIA, A. F.; DA SILVA, S. C.; SARMENTO, D. O. L.; MOLAN, L. K.; ANDRADE, F. M. E.; GONÇALVES, A. C.; LUPINACCI, A. V. Tillering dynamics in Marandu palisadegrass swards continuously stocked by cattle. **Plant Ecology**, v. 206, n. 2, p. 349-359, 2010.

SOUSA, B. M. L.; VILELA, H. H.; SANTOS, A. L.; SANTOS, M. E. R.; NASCIMENTO JÚNIOR, D.; ASSIS, C. Z.; FARIA, B. D.; ROCHA, G. O. Piata palisadegrass deferred in the fall: effects of initial height and nitrogen in the sward structure. **Revista Brasileira de Zootecnia**, v. 41, n. 5, p. 1134-1139, 2012.

VILELA, H. H.; SOUSA, B. M. L.; SANTOS, M. E. R.; SANTOS, A. L.; ASSIS, C. Z.; ROCHA, G. O.; FARIA, B. D.; NASCIMENTOS JÚNIOR, D. Forage mass and structure of piatã grass deferred at different heights and variable periods. **Revista Brasileira de Zootecnia**, v. 41, n. 7, p. 1625-1631, 2012.

Received on April 11, 2013.
Accepted on June 17, 2013.