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A.B. Kröning
https://orcid.org/0000-0001-5902-6270
O.A.D. Costa
https://orcid.org/0000-0001-5201-2618
P.P. Farias
https://orcid.org/0000-0003-4587-2868
L.A. Martins
https://orcid.org/0000-0001-9256-090X
O.G. Ott
https://orcid.org/0000-0002-2863-3673
S. Macari
https://orcid.org/0000-0003-2746-2101
O.G.L. Ferreira
https://orcid.org/0000-0003-0302-8482

Grazing criteria for perennial peanut (*Arachis pintoi* cv. Amarillo) consumed by sheep in rotational stocking

[*Critérios de pastejo para amendoim forrageiro* (Arachis pintoi *cv. Amarillo*) *consumido por ovelhas em sistema rotacionado*]

A.B. *Kröning*[1], O.A.D. *Costa*[1], P.P. *Farias*[1], L.A. *Martins*[1], O.G. *Ott*[2],
S. *Macari*[3], O.G.L. *Ferreira*[3]

[1]Aluno de pós-graduação - Faculdade de Agronomia Eliseu Maciel – Universidade Federal de Pelotas - Pelotas, RS
[2]Aluno de graduação - Faculdade de Agronomia Eliseu Maciel - Universidade Federal de Pelotas - Pelotas, RS
[3]Faculdade de Agronomia Eliseu Maciel - Universidade Federal de Pelotas - Pelotas, RS

ABSTRACT

The objective of work was to study the productive profile of perennial peanut in a rotational stocking environment under different criteria. The treatments corresponded to pre-grazing height of 14 and 18cm or 95% of light interception (LI) distributed in a completely randomized design. The studied variables were forage mass, percentage of structural components, forage mass and the structural components in the lower and upper canopy strata. The entrance criterion of 18cm in height, despite having higher forage mass, presented lower percentage of leaves and higher percentage of stems and forage losses. The criteria of 14cm and 95% light interception presented similar production between them and the highest rate of forage accumulation. In all criteria, in the upper strata of pasture a higher percentage of leaves were found. The criteria of 95% LI and 14cm in height presented the best productive performances. The entry criterion of 18cm presented a higher mass of pre-grazing forage with lower percentage of dead material, but with higher forage losses, resulting from senescent leaves. Due to changes in the structural components, as grazing cycles increase, the interception of 95% of the incident light by the perennial peanut occurs at lower heights.

Keywords: forage mass, light interception, lower stratum, upper stratum

RESUMO

O objetivo do presente trabalho foi estudar o perfil produtivo do amendoim forrageiro em um ambiente rotacionado, sob diferentes critérios. Os tratamentos corresponderam à altura de pré-pastejo de 14 e 18cm ou 95% de intercepção de luz (LI), distribuídos em delineamento inteiramente ao acaso. As variáveis estudadas foram massa forrageira, porcentagem de componentes estruturais, densidade da massa forrageira e densidade dos componentes estruturais nos estratos do dossel inferior e superior. O critério de entrada de 18cm de altura, apesar de ter maior massa forrageira, apresentou menor porcentagem de folhas e maior porcentagem de hastes e perdas de forragem. Os critérios de interceptação de luz de 14cm e 95% apresentaram produção similar entre eles e a maior taxa de acumulação de forragem. Em todos os critérios, no estrato superior de pastagem, foi encontrada maior porcentagem de folhas. Os critérios de 95% LI e 14cm de altura apresentaram os melhores desempenhos produtivos. O critério de entrada de 18cm apresentou maior massa de forragem pré-pastagem com menor porcentagem de material morto, mas com maiores perdas de forragem, resultantes de folhas senescentes. Devido às mudanças nos componentes estruturais, à medida que os ciclos de pastagem aumentam, a intercepção de 95% da luz incidente pelo amendoim forrageiro ocorre em alturas mais baixas.

Palavras-chave: estrato inferior, estrato superior, interceptação luminosa, massa de forragem

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E-mail: alexsandro@zootecnista.com.br

INTRODUCTION

Summer pastures, despite their fast growth and high forage production, normally have lower quality grass than winter pastures, so that animal performance falls below its potential. The use of forage legumes introduces nitrogen into the pastoral ecosystem, resulting in improved forage quality being offered to the animal, and this is recognized as an important forage planning practice.

Among summer legumes, the perennial peanuts (*Arachis pintoi* Krapov & W.C. Greg) stand out for the quality of forage and improvement of the pasture ecosystem by the biological fixation of nitrogen. These peanuts can be used in the production of forage in isolated or consortium crops with grasses, and they provide high amount of protein for ruminants, with the potential to intensify animal production systems based on grass in a sustainable manner.

The productivity and longevity of perennial peanut derive from characteristics such as the continuous emission of leaves and ramifications that guarantee a reconstitution of the leaf area of the field under grazing, and these characteristics are strongly influenced by management (Alonzo *et al.,* 2017). In a rotational stocking environment, adequate pre- and post-grazing heights are fundamental to obtain a good yield of high-quality biomass and, consequently, efficient animal production. The perennial peanut can grow tall, even exceeding the optimum point of light interception (95% of the incident light), increasing the proportion of stems and dead material. According to Carvalho (2014) the interception of 95% of incident light occurs between management heights of 10 and 15cm. For post-grazing, Alonzo *et al.* (2017) conclude that severe grazing intensities compromise forage accumulation. Therefore, the objective of this work was to study the productive profile of perennial peanut (*Arachis pintoi* cv. Amarillo) in a rotational stocking environment under different criteria for grazing by sheep.

MATERIALS AND METHODS

The experiment was conducted in the Palma Agricultural Center, county of Capão do Leão, Rio Grande do Sul state, Brazil, geographical coordinates 31º 52' S and 52º 21' W; altitude 13.24m. The climate of the region is Cfa according to the Köppen classification (Mota, 1953).

The soil classification of the experimental area is a typical Red Argisol - Yellow eutrophic, Camaquã mapping unit (Streck *et al.,* 2008). The chemical analysis of this soil presents the following characteristics: pH_{H2O}= 5.2; OM= 1.9 (%); P= 4.5 ($mg.dm^{-3}$); K= 32 ($mg.dm^{-3}$); Ca= 1.7 ($cmol_c.dm^{-3}$); Mg= 0.5 ($cmol_c.dm^{-3}$); Al= 0.2 ($cmol_c.dm^{-3}$); CTC_{pH7}= 5.4 ($cmol_c.dm^{-3}$) and base saturation of 70%. The recommended fertilization and liming was carried out using the software CADUB (Gubiani *et al.,* 2009). For soil correction, dolomitic lime (PRNT 76%) was applied as a cover dressing at the proportion of 1.8ton/ha on 19 November 2015. The fertilizer was applied as a cover dressing on 26 October 2015 using 366kg/ha NPK formula (4-23-18).

The experiment was carried out in a pasture of Perennial peanut (*Arachis pintoi* cv. Amarillo) that had been established in November 2001. The experimental area of $2880m^2$ was divided into 32 paddocks (experimental plots) each with an area of $90m^2$, of which 14 were for the adaptation of sheep and 18 were distributed randomly among the treatments.

The treatments corresponded to three criteria for animals to enter the pastureland: heights of 14 and 18cm and light interception of 95% of incident radiation. Because of the homogeneous conditions in the experimental area, a completely randomized design was used with six replications. The stocking rate varied from 12 to 18 animals, and was adjusted so that each paddock was occupied for one day (±6 horas), lowering the pasture to the height of 7cm (Alonzo *et al.,* 2017). The interval between grazing efforts was variable, since the animals entered the pasture based on the plant height or level of light interception that was intended for the relevant treatment.

In order to have pre-experimental standardization in the paddocks, from 14 to 21 December 2015 grazing took place with a high stocking rate of sheep, so that the pasture plants would quickly reach a mean height of 10cm. The experimental period was from 11 January 2016 to 01 April 2016, corresponding to the summer season in the study site.

To lower the pasture, 33 lambs (male and female) of a Texel x Corriedale cross were used, weighing 26.3±4.2kg. The animals were weighed at the beginning and at the end of the experimental period, and monitored bi-weekly for health status by the Famacha© method according to the methodology described by Molento *et al.*, 2004. They had access to clean fresh water and artificial shade in an area corresponding to 10% of the paddock.

Pasture evaluations were conducted pre- and post-grazing. The height of the forage canopy was measured with a rising meter plate in 15 random points in each paddock. For the evaluation of forage mass and separation of the morphological component of the pasture {leaf, stem (stem + petioles + petiolule) dead material and other species} a representative sample was collected of the average height of pasture using a ring with the same area of disc (1017.8cm^2). In the pre-grazing, the sample was collected in two strata, corresponding each to 50% of the profile of the pasture (comprising the upper and lower strata of pasture, while in the post-grazing the sample was collected in a single stratum, including the whole profile. The accumulation index of forage was calculated by the difference for the two consecutive samplings (pre-grazing – post-grazing from the previous period).

The forage losses were determined according to (Hillesheim, 1998). After grazing for standardization had taken place, four sampling points were demarcated in each paddock, using aluminum rods buried in the ground, with approximately 20cm above ground. The area was cleared, removing all the dead material and any damaged by grazing. After each grazing, at each of these points, a square area of 400cm^2 was cleared of the forage considered not suitable for use by the animals (senescent material, dead or damaged by trampling and droppings). In order to obtain the dry matter of all the forage samples, they were dried in a forced circulation oven at 55ºC until constant weight.

The photosynthetically active radiation (PAR) and leaf area index (LAI) of the canopy were evaluated using the *SunScan Canopy Analysis System*® canopy analyzer, and measurements were taken on the diagonal of each plot. For PAR, three measurements were performed above the canopy and three measurements were taken at the ground level, alternately. The percentage of light interception was calculated as the amount of PAR intercepted (PAR above the canopy minus that at the canopy base) divided by the PAR above the canopy, and multiplying the result by 100 (Gobbi *et al.*, 2011). For evaluating the leaf area index, three-point assessments were made at the soil level, and the value of IAF was obtained instantaneously (Webb *et al.*, 2016).

The results were submitted for analysis of variance and means were compared by Duncan at 5% probability. All analyses were performed using the statistical package SAS® (Statistical Analysis System), version 9.0 for Windows®.

RESULTS AND DISCUSSION

The pre-grazing height presented small variation during the grazing cycles, with the same values for the treatments of 95% LI and 14cm ($P< 0.0001$) in the first and second cycles and in the mean grazing (Table 1). The treatment with entrance height of 18cm differed from the others, a result that was expected, due to the imposition of the treatments.

In the treatment with 95% LI entry there was a reduction in the pre-grazing height with the addition of grazing cycles, so that in the third cycle 95% light interception occurred at 10.9cm.

Table 1. Height obtained in the pre-grazing of perennial peanuts under different entry criteria, grazed by sheep

Treatments	1º Grazing	2º Grazing	3º Grazing	Average
95% LI	15.6±0.55^B	13.0±0.58^B	10.9±0.39^B	13.4±0.59^B
14cm	15.1±0.38^B	14.0±0.39^B	14.7±0.34^A	14.8±0.28^B
18cm	19.3±0.34^A	17.5±0.32^A	-	18.4±0.35^A

*Means followed by the same letter in the column do not differ statistically from each other by the Duncan test at 5% probability.

When analyzing the interception of solar radiation and leaf area index in pre-grazing, no significant differences (P> 0.05) were found between treatments (Figure 1), agreeing with the results of Carvalho (2014) and Alonzo *et al*. (2017), who observed interception of 95% of incident light and optimal LAI reached when the perennial peanut reached a height of 14cm.

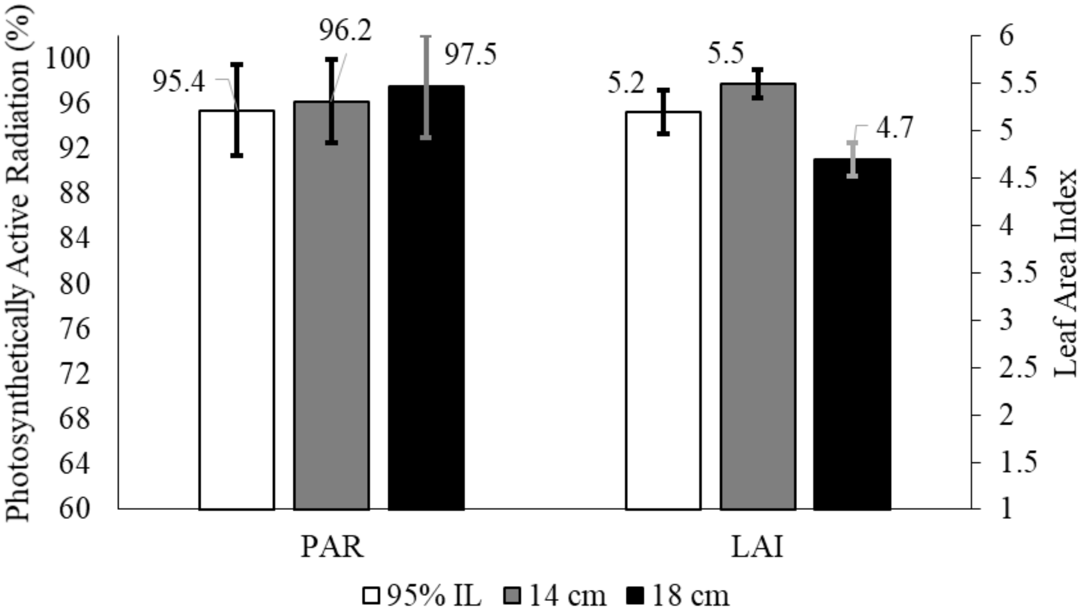

Figure 1. Photosynthetically active radiation (PAR) and leaf area index (LAI) with mean standard error in perennial peanut pre-grazing under different entry criteria grazed by sheep.

When perennial peanut was managed at 18cm height, with light interception reaching 97.5%, there was an increase in senescence and death of leaves in the lower forage canopy because they did not receive adequate light.

Regarding leaf area index (LAI), despite the absence of differences between treatments, the values found in the present study are in the range reported by Carvalho (2014). This author, evaluating the LAI of perennial peanut, did not find significant differences in grazing land managed at 5, 10 and 15cm in the summer, with values of 4.03, 4.05 and 5.05 respectively, obtaining a higher value (6.94) when the pasture was maintained at 20cm. In the present study, when taller plants were used as the entry criterion for the animals in the pasture, a reduction of LAI was observed due to leaf senescence.

The treatments provided different levels of pasture exploitation (Table 2). The 95% LI and 14cm criteria provided three grazing intervals of 28 and 30 days, respectively. In turn, with the 18cm criteria only two grazing intervals of 47 days were performed. A shorter period brings benefits to the management of rotational stocking due to the need for a smaller area to fit the grazing cycle. On the other hand, increasing the unstocked period may lead to a loss of forage quality. According to Pedreira; Pedreira; Silva, (2009), the prolongation of the interval between grazing results in greater mass of forage, but is often a result of greater participation of stems and dead material. Brunetti *et al.* (2016) also observed this fact in perennial peanuts, and they attributed the increase in forage mass available at 18cm height to the greater proportion of stems.

Table 2. Number of grazing periods, Rest (unstocked) Period (in days and day degrees), dry matter accumulation rate and forage losses in perennial peanut pre-grazing under different grazing criteria, grazed by sheep

Treat.	N° of grazing periods	Rest period (Days)	Rate of accumulation (Kg/ha/day)	Forage losses (Kg/ha)
95% LI	3	28.6±1.3^{A}	60.0±3.8^{A}	335±32.8^{B}
14cm	3	30.0±1.8^{A}	56.2±5.5^{AB}	383±68.5^{B}
18cm	2	46.9±5.5^{B}	41.2±3.2^{B}	660±71.5^{A}

Tb=15 ºC (Fialho, 2015). Means followed by the same letter in the column do not differ statistically from each other by the Duncan test at 5% probability.

The forage accumulation rate was higher in treatments 95% LI and 14cm. Considering the trend of the observed data, there was no fall in forage accumulation among grazing cycles in the treatment of 9.5% IL. When the pasture reached a height of 18cm, light interception approached 100%, a high value, in which there is shading of the leaves of the lower portion of the forage canopy, and senescence and death occur. This has a negative impact on the pasture, reducing its daily dry matter accumulation rate.

Forage losses, corresponding to damaged or dead forage that was not used by the animal, were significantly higher in the treatment of 18cm (Table 2). To reach the intended height, in this treatment a longer rest period of pasture was required, which probably exceeded the leaf's life-span. This, according to Fialho (2015), is not yet known; there was an increase in senescence rate and death of leaves, which were detached from the plant.

The treatments of 14 and 18cm for the entry criteria of the animals were those that had the highest forage mass, with the same morphological composition in the upper stratum (Table 3). However, when managed at 14cm the perennial peanut showed less forage loss (Table 2). The forage masses obtained in the study are higher to those found by Bruyn (2003) and Silveira (2007), who obtained values of 2000 and 2191kg/ha respectively, and similar to those found by Alonzo *et al*. (2017) with values of 3776kg/ha in the same area as the present study. In the same region forage mass found by Machado *et al.* (2005); Affonso *et al.* (2007); Nascimento *et al.* (2010) are close to these obtained in this study with values among 3.142 and 7026kg/ha. Ferreira (2014), evaluating the production of different perennial peanut genotypes, found forage yield of 4900kg/ha for cv. Amarillo, 5000kg/ha for cv. Mandobi, 5200kg/ha for cv. Bushel and 8400kg/ha for cv. Belmonte.

The upper stratum of the pasture profile was responsible for approximately 34% the available forage grass. In this stratum, there were no significant differences between the treatments for forage mass and percentage of leaves and stems, demonstrating that none of the treatments affected this portion of the canopy (Table 3). In all treatments, the leaf portion was the component with the highest participation. This is desirable, since this stratum is the first portion to be grazed, which allows the ingestion of better quality food.

The percentages of dead material were higher in treatments with 95% LI and 14cm. In these, due to the smaller interval between grazing periods, senescent leaves remained attached to the plants, increasing the participation of this component in the forage mass. In the 18cm treatment the senescent leaves were detached from the plants, reducing the percentage of dead material and incorporating the forage losses found in this treatment. According to Pinto *et al.* (2001), the greater the forage mass, the greater the losses due to senescence, as a consequence of the low utilization of the forage produced.

The percentage of weeds was higher in the treatments with 95% LI and 14cm, and these weed species were composed, basically, of low-growing plants like *Cynodon dactilon*. Thus, as the strata corresponded to 50% of the height of the canopy, the lower the plant height when the animals entered (Table 1), the higher the participation of weeds in the forage mass of the upper stratum. In the 18cm management, the pasture provided soil cover for longer, leading to a reduction in the appearance of weeds due to competition for light. Agreeing with the results of the study, Brunetti *et al.* (2016) verified in perennial peanut pasture that when associated with less grazing frequency (higher pre-grazing height) and lower grazing intensity (higher post-grazing height), the result is a lower percentage of weeds. This author considers the lowest proportion of weeds to be the best growth condition that the perennial peanut possesses.

Table 3. Forage Mass (FM), Percentage of leaves, stems, dead material (D.M.) and weeds in the pre-grazing of perennial peanut under different entry criteria, grazed by sheep

Stratum	Treat.	FM (Kg/ha)	Leaves (%)	Stems (%)	D.M. (%)	Weeds (%)
			Pre-grazing			
Upper stratum	95% LI	1310±108	64.9±3.1	22.6±3.3	7.3±2.2^{A}	5.1±1.2^{A}
	14 cm	1519±172	65.2±2.9	28.4±3.1	3.2±1.0^{AB}	3.1±1.0^{AB}
	18 cm	1475±148	67.7±2.7	29.8±2.3	1.1±0.6^{B}	1.3±0.6^{B}
Lower stratum	95% LI	2645±105^{B}	24.6A±1.2^{A}	58.2±1.8^{B}	10.1±1.8	7.1±1.5^{A}
	14 cm	2649±301^{B}	18.2B±1.9^{B}	69.1±1.8^{A}	8.6±1.1	4.1±1.0^{B}
	18 cm	3127±244^{A}	25.6A±1.5^{A}	64.0±2.0^{A}	6.4±1.8	4.0±0.9^{B}
			Post-grazing			
Total	95% LI	2622±117	15.3±2.1	63.3±3.1	9.0±1.3	12.4±2.0
	14cm	2602±168	15.5±2.1	65.6±3.4	9.6±1.5	9.4±1.5
	18 cm	2892±231	15.7±3.7	61.3±3.8	10.9±1.7	12.0±2.7

* Means followed by the same letter in the column do not differ statistically from each other by the Duncan test at 5% probability.

The lower pasture stratum presented higher forage mass when compared to the upper stratum, with stems the main component in all treatments (Table 3). Among these, a higher forage mass was observed in the 18cm criterion, where a higher percentage of leaves and stems were also observed. The leaves of the lower stratum of the pasture are those that remain after grazing and are responsible for the production of photosynthesized plants used in the regrowth of the plant. However, these leaves are older than the ones in the upper stratum and feature reduced photosynthetic capacity due to the lower exposure to light caused by the shade promoted by the leaves of the upper stratum (Lara e Pedreira, 2011). Despite this fact, they are responsible for a large part of the initial photosynthesis after grazing. In perennial peanuts, the presence of stems in the post-grazing forage mass is also important, because they shelter the growth points that will lead to new regrowth (Griffith *et al.*, 2015).

In the post-grazing, significant differences were observed between treatments only in the variable leaf area index LAI (Table 3 and Figure 2). Higher LAI values were observed in treatments with 95% LI and 14cm as input criteria (Figure 2). This probably results from similar alterations in the architecture of the plants in these treatments, since they present the same pre-grazing height (Table 1) and are both lowered to the same residue (Table 2).

The 18cm treatment, in having lower post-grazing LAI, presents unfavorable conditions for regrowth and needs to exceed the optimum level of interception (95% of incident light) to reach grazing height, which puts it at a disadvantage compared to other treatments. According to Martha Júnior *et al.* (2004), higher post-grazing LAI provides a favorable status of physiological reserves of the plant and less elimination of growth points, contributing to faster regrowth of pasture, reducing the interval between grazing periods. This corroborates the results obtained in the present study, where the highest leaf area post-grazing was associated with a higher rate of forage accumulation and number of grazing periods, and shorter intervals between grazing periods and forage losses.

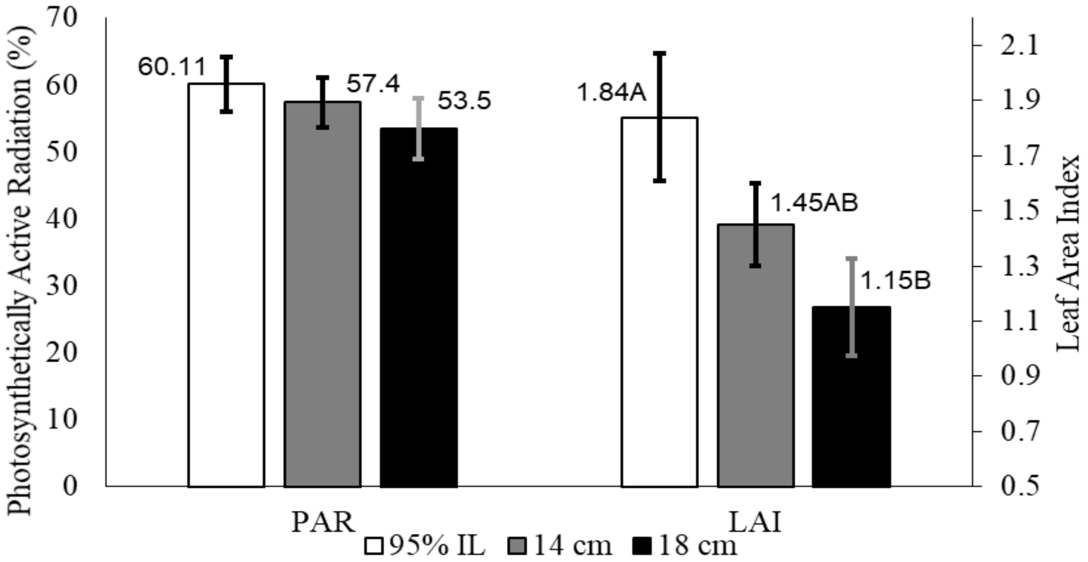

Figure 2. Active photosynthetic radiation (PAR) and leaf area index (LAI) with mean standard error in the post-grazing of perennial peanut under different grazing criteria, grazed by sheep. * Means followed by the same letter in the column do not differ statistically from each other by the Duncan test at 5% probability.

CONCLUSIONS

The criteria for the animals to enter pasture for grazing at 95% LI and 14cm of plant height presented the best productive performances, but with a lower proportion of weeds in the 14cm criterion. The entry criterion of 18 cm presented higher mass of pre-grazing forage with a lower percentage of dead material, but with higher forage losses, resulting from detachment of senescent leaves. Due to modification in the structural components, as grazing cycles increase, the interception of 95% of the incident light by the perennial peanut occurs at lower plant heights.

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