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Article

Nutritional Value of Marandú Palisade Grass According to Increasing Coexistence Periods with Weeds

Valor Nutricional de Braquiarão em Função de Períodos Crescentes de Convivência com Plantas Daninhas

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ABSTRACT - This research aimed at evaluating the effect of increasing coexistence periods with weeds on the nutritional components of the forage grass *Brachiaria brizantha* cv. Marandú under pasture renewal conditions. The experiment was arranged in randomized blocks with four replications, and treatments were represented by eight coexistence periods, namely: 0, 15, 30, 45, 60, 75, 90 and 120 days after seedling emergence. A phytosociologic evaluation was performed on the weed community at the end of the coexistence periods; later, weeds were eliminated by an herbicide formulated with aminopyralid+2,4-D (40+320 g L^{-1}) at 2.5 L ha^{-1}, applied in post-emergence. The fodder plants were evaluated at the end of the experimental period as for leaf-stem ratio, volumetric density of green leaf, volumetric density of total dry matter and main nutritional components, including: crude protein, neutral detergent fiber, ether extract, organic matter and mineral matter, and from this, the total carbohydrate content was calculated. The presence of weeds altered the pasture structure, since it affected negatively the leaf/stem ratio and the volumetric leaf density of *B. brizantha*. The coexistence also reduced the nutritional components of *B. brizantha* and determined that control measures should be adopted before reaching 30 days of coexistence between fodder plants and weeds.

Keywords: *Brachiaria brizantha*, leaf/stem ratio, volumetric density, bromatology, renewal, weed competition.

RESUMO - O presente trabalho avaliou o efeito de períodos crescentes de convivência com plantas daninhas sobre os componentes nutricionais da gramínea forrageira ***Brachiaria brizantha*** *cv. Marandu em condições de renovação de pastagem. O experimento foi instalado no delineamento experimental de blocos casualizados com quatro repetições, e os tratamentos foram representados por oito períodos de convivência com as plantas daninhas: 0, 15, 30, 45, 60, 75, 90 e 120 dias após a emergência. Foi realizada avaliação fitossociológica na comunidade infestante ao término de cada período de convivência; posteriormente, as plantas daninhas foram eliminadas com o auxílio de herbicida formulado à base de aminopyralid+2,4-D (40+320 g L^{-1}) em pós-emergência. As forrageiras foram avaliadas ao final do período experimental quanto à relação entre matéria seca de folha e colmo, densidade volumétrica de folha verde, densidade volumétrica de matéria seca total e quanto aos principais componentes nutricionais, a saber: teor de proteína bruta, fibra em detergente neutro, extrato etéreo, matéria orgânica e matéria mineral, sendo determinado o teor de carboidratos totais. A presença das plantas daninhas alterou a estrutura da pastagem, uma vez que interferiu negativamente na relação folha/colmo e na densidade volumétrica de folhas verdes*

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*de **B. brizantha**. A convivência com as plantas daninhas também reduziu proporcionalmente o valor nutricional de todos os componentes nutricionais de **B. brizantha** conforme aumentou o período de convivência e determinou que o controle deva ser adotado antes de 30 dias de convivência entre a forrageira e as plantas daninhas.*

Palavras-chave: *Brachiaria brizantha*, relação folha/colmo, densidade volumétrica, bromatologia, renovação, matocompetição.

INTRODUCTION

The exploitation model practiced in Brazil in areas cultivated with pastures during the 1960's and 1970's was idealized under a strong extractive aspect and without the concern of preserving or renewing natural resources. The lack of technical criteria in using natural resources and pastures led to an accelerated degradation of these areas, which were considered fertile for the production of meat and milk (Macedo, 2009).

According to Dias Filho (2014), it is estimated that 80% of the pastures grown in the hot climate regions of South America are in degradation. This affects directly the sustainability of cattle breeding. This author also states that, considering only the fattening stage of cattle, the productivity of meat from a degraded pasture can be six times lower than the one coming from a pasture in a good maintenance state.

Pasture degradation may be explained as a dynamic process of degeneration or relative productivity fall. Among the most important factors related to pasture degradation, there are the inadequate management of animals and fodder plants, the decline of soil fertility, the formation of compaction layers and erosion grooves in the soil and the incidence of pests and diseases on the plants (Peron and Evangelista, 2004; Macedo, 2009; Costa et al., 2010). In addition to this, the selective herbivory process practiced by cattle helps the establishment of volunteer species, which causes a gradual replacement of fodder species by others that are considered weed.

The direct renewal of pastures has been the practice adopted to reestablish the economic levels of productivity in areas where the degradation degree reached economically unsustainable levels. Direct renovation is based mainly on costly activities to correct soil fertility and acidity, the implementation of a soil conservation system, the adoption of more appropriate animal management techniques and, mainly, the replacement of degraded fodder plants by a species that might be more adapted to the local conditions (Zimmer et al., 2012).

Brachiaria brizantha (palisade grass) is one of the most cultivated fodder species in the cerrado regions of South America, and has shown high adaptation capacity; it is responsible for much of the feed of cattle herds raised on pastures. It can be recommended as an alternative for cerrado with medium to good fertility, due to its high forage production, persistence, good regrowth capacity and relative tolerance to leafhopper attacks (*Deois* sp.) (Benett et al., 2008).

It is an excellent source for animal feed, with good quality, provided that the nutritional requirement of the plant is satisfied, with proper fertilization and management. Otherwise, it loses its nutritive value rapidly, especially after flowering (Valle et al., 2009).

However, the requirement for better edaphic conditions may represent an ecological disadvantage for *B. brizantha*, especially when submitted to the biological relation of competition. This fact occurs frequently during pasture renewal processes, when, after sowing and the emergence of fodder plant seedlings, there are also other seedlings coming from propagules that were left by weeds in previous years.

In most cases, weeds are native species and have greater adaptability to the environment than cultivated plants; this gives plant development adequacy and adjusted allocation capacity of resources from the environment (Erasmo et al., 1997; Bianco et al., 2014).

Researches on weed interference effects on grasses such as maize (Campos et al., 2016) and sorghum (Rodrigues et al., 2010) have shown that weeds may represent an hazard for the establishment, growth and biomass production of these fodder plants, especially if the biological competition relation is established at early stages of their development. However, no research was conducted on the nutritional aspects of these species.

Thus, this work had the purpose of studying interference relations among weeds and their effects on the nutritional quality of *B. brizantha* cv. Marandu in pasture renewal conditions.

MATERIAL AND METHODS

The experimental phase of this work was conducted in the pasture renewal area located in the municipality of Itaúba, Mato Grosso state - Brazil, whose geographic coordinates are 11°11'29" S and 55°15'13" W, in relation to the Greenwich meridian. The climate of the region, according to Köppen's classification, is Aw-type; data about rainfall and average, minimum and maximum temperature during the period of the experiment, are presented in Figure 1.

The experimental area corresponded to a degraded pasture where renovation activities were carried out, starting with desiccation, using the herbicide glyphosate at the dose of 3.0 L ha^{-1}, and harvesting for the total elimination of plant remains.

The soil of the area was analyzed and its chemical characteristics were presented in Table 1. In the physical analysis, 866 g kg^{-1} of sand, 39 g kg^{-1} of silt and 91 g kg^{-1} of clay were obtained, characterizing the soil as a sandy texture one. Soil fertility correction followed the recommendations for pasture (Vilela et al., 2003), applying the equivalent of 2,000 kg ha^{-1} of limestone, which is enough to raise base saturation by 50%. A new harrowing procedure was carried out in order to incorporate the limestone. Sowing fertilization consisted of 250 kg ha^{-1} of the formula 5-25-15 (N-P_2O_5-K_2O), distributed on the soil surface.

B. brizantha cv. Marandu was sown by mechanized seed distribution in the proportion of 10 kg ha^{-1}. The experimental area was closed to grazing during the conduction of the experiment.

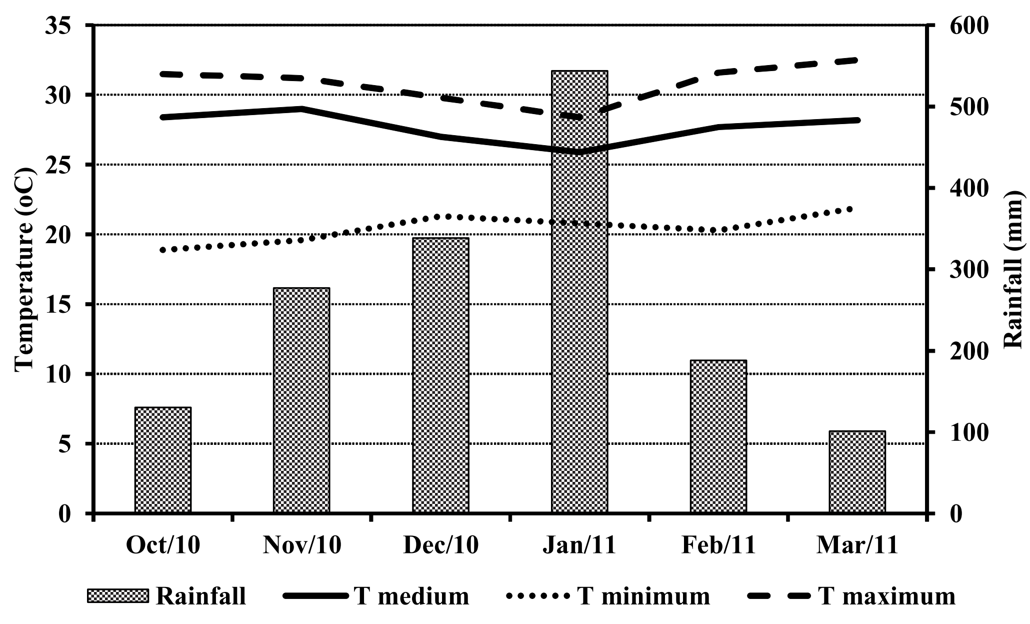


Figure 1 - Monthly rainfall and temperatures (T) means during the coexistence period of *B. brizantha* cv. Marandu and weeds.

Table 1 - Attributes for the chemical characterization of soil in the experimental area, in the 0-200 mm layer

pH $CaCl_2$	C org.	P	Ca	Mg	K	Al	H+Al	S	V
(0.01 mol L^{-1})	(g dm^{-3})		($cmol_c$ dm^{-3})						(%)
3.88	18.45	0.04	0.09	0.03	0.04	0.3	4.79	0.16	21

The experiment was conducted in a randomized complete block design with four replications, and the treatments were represented by eight coexistence periods between fodder plants and weed species: 0, 15, 30, 45, 60, 75, 90 and 120 days after emergence (DAE). Each experimental unit had a total area of 16 m^2 (4 x 4 m); the central 9 m^2 were used as the usable area of the plot.

Assessments in the weed community were made at the end of each coexistence period, with the help of a metal square having an area of 1.0 m^2, randomly released within the useful area of the plot. The species inside the metal square were identified, numerically quantified and taken to the laboratory, where they were separately packed in properly labeled paper bags for later drying in a forced air circulation oven at 60-63 ^oC for 72 hours. After this procedure, the shoot dry matter of the collected species was determined, using an electronic scale with 0.01 g precision.

With data about the evaluation of numbers of individuals and dry matter accumulated by different species of weeds, it was possible to determine the importance value index (IVI) of each weed species found in the weed population during the different studied coexistence periods, as proposed by Mueller-Dombois and Ellemberg (1974).

All weeds were removed from the respective plots at the end of each coexistence period, and from that moment on, the development of any emerging weed was interrupted by applying 1.5 L ha^{-1} of herbicide formulated with aminopyralid + 2,4-D (40 + 320 g L^{-1}) during post-emergence.

Fodder plants were evaluated only at the end of the experiment, corresponding to 120 days after the emergence of seedlings. At that time, the height of the forage canopy was evaluated, and two samples were collected by cutting plants at 10 cm from the soil surface, within the area delimited by the 1.0 m^2 metal square, randomly chosen in the useful area of the experimental unit.

One of the samples was sent to the laboratory and fractionated in green leaves, green shoots and dead matter. The green inflorescences that were eventually present were considered as stem. The different fractions were packed in properly labeled paper bags, for later drying in a forced air circulation oven at 60-63 ^oC for 72 hours. Dry matter determination of the different fractions was carried out in an electronic scale with 0.01 g accuracy, and allowed calculating the relation between leaf and stem (leaf/stem). The green leaf and total forage yield volumetric density, expressed as g m^{-2} cm^{-1}, was calculated by dividing, respectively, the green leaf dry matter and total dry mass of the fodder plant by the canopy height in each plot.

The other sample was sent to the laboratory and placed in properly labeled paper bags, where it was dried until constant weight in a forced air circulation oven at 60-63 ^oC for 72 hours, and then milled until reaching a 1.0 mm granulometry, in order to carry out the nutritional analyses. Crude protein (CP), organic matter (OM), ethereal extract (EE), mineral matter (MM) by "wet method", neutral detergent fiber (NDF), and non-fiber carbohydrate (NFC) analysis were conducted according to Silva and Queiroz (2002). The total carbohydrate content (TCC) was obtained by the formula TCC = 100 - (CP% + EE% + MM%), described by Sniffen et al. (1992). The values of all nutritional components were estimated in relation to the percentage of forage dry matter.

The values of leaf/stem ratio and volumetric density were adjusted by regression analysis, according to the curve model that best represents the data variation. The forage nutrient components were submitted to analysis of variance by F test, and the effects of the treatments were compared by Scott-Knott test (p>0.05).

RESULTS AND DISCUSSION

Only three weed species were found during the experiment period: *Hyptis suaveolens*, *Senna obtusifolia* and *Sida rhombifolia*. The importance value index, which expresses simultaneously density, dominance and frequency of the individuals, shows that the three species at issue were always found in practically equal proportions, indicating that they all exerted an equal interference on palisade grass (Figure 2).

S. rhombifolia had the highest importance value index (128.4%), 15 days after emergence (DAE). This value remained stable up to 30 DAE and decreased to values close to 100% in subsequent evaluations. *S. obtusifolia* had in importance value index of 87.4% at 15 DAE and

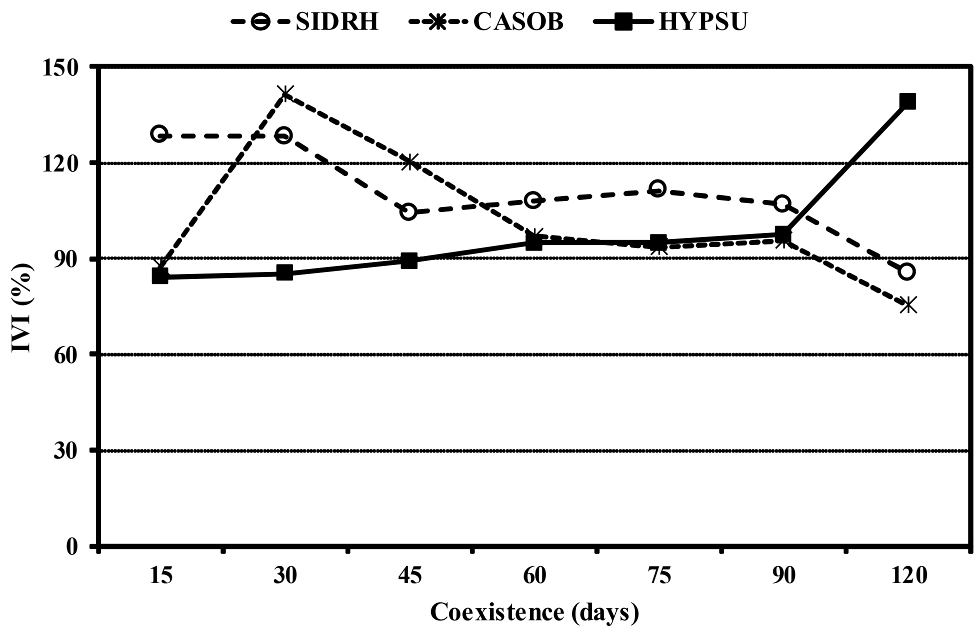


Figure 2 - Relative importance value index (IVI) of the weeds *Senna obtusifolia* (CASOB), *Hyptis suaveolens* (HYPSU) and *Sida rhombifolia* (SIDRH) during the coexistence periods with *B. brizantha* cv. Marandu.

progressed to 141.3% at 30 DAE; this index fell to levels below 100% in the evaluations conducted on the following dates. On the other hand, *H. suaveolens* presented increasing importance during the experimental period; it was the species showing the highest importance value index (138.9%) at 120 DAE.

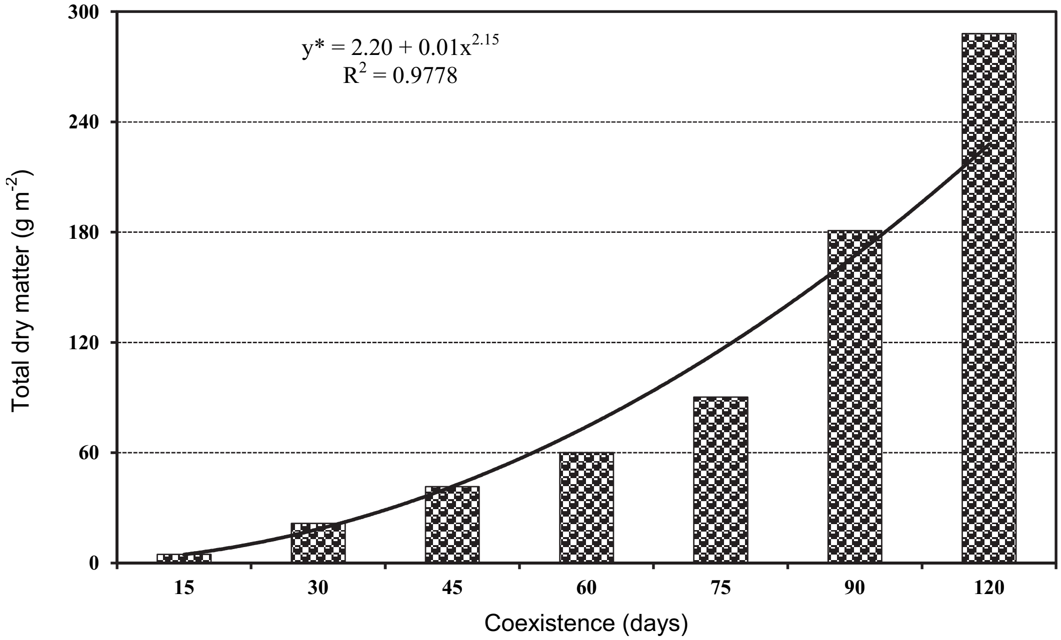
It is worth mentioning that the observed accumulation of dry matter mass increased throughout the experimental period; at 120 DAE, the total dry matter produced by weeds was more than 280 g m^{-2}, indicating that these species were able to recruit the resources from the environment (Figure 3).

The highest value of the leaf/stem ratio (1.88) of palisade grass was obtained when the plant had no weed coexistence during the whole period, while the lowest value (0.98) was obtained when the coexistence was 120 DAE (Figure 4). The negative effect of weeds on the leaf/stem ratio was linearly proportional to the coexistence period, where the increase in the period promoted a decrease in the leaf/stem ratio (Figure 4).

The decrease in leaf/stem ratio values is probably due to the reduction in leaf production by *B. brizantha* cv. Marandu, since the volumetric density of green leaves also decreased proportionally with the increase in the coexistence period with weeds (Figure 5A). Fifteen coexistence days were enough to provide a 21.1% reduction in the green leaf volume density, while the coexistence for 120 days reduced the volumetric density by more than 40% when compared to the condition under which plants remained for 120 days without the presence of weeds (Figure 5A).

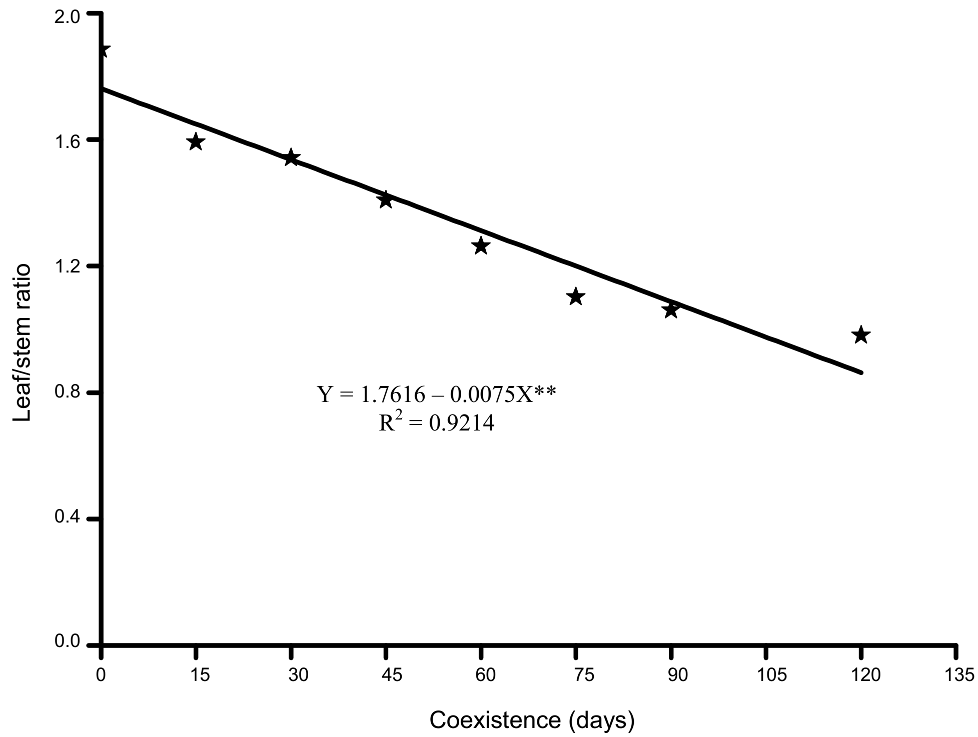
Weeds also had a negative influence on the volumetric density of the total dry matter density of plants, since the decrease was proportional to the increase in the coexistence period, causing a reduction of approximately 50% when palisade grass coexisted for 120 days with the weed community (Figure 5B).

The morphogenic characteristics and environmental conditions are the main factors that modify the amount of leaf area that will catch the solar radiation (Sousa et al., 2011). Through these characteristics, it is possible to obtain the structural parameters of the pasture (leaf size, number of leaves per tiller and tiller population density), which will result in the formation of the leaf area index, that is, the leaf area available to intercept light per soil unit area and, consequently, the green material that will be consumed by grazing animals (Cruz and Boval, 2000; Martuscello et al., 2009).



* Significant (p>0.05).

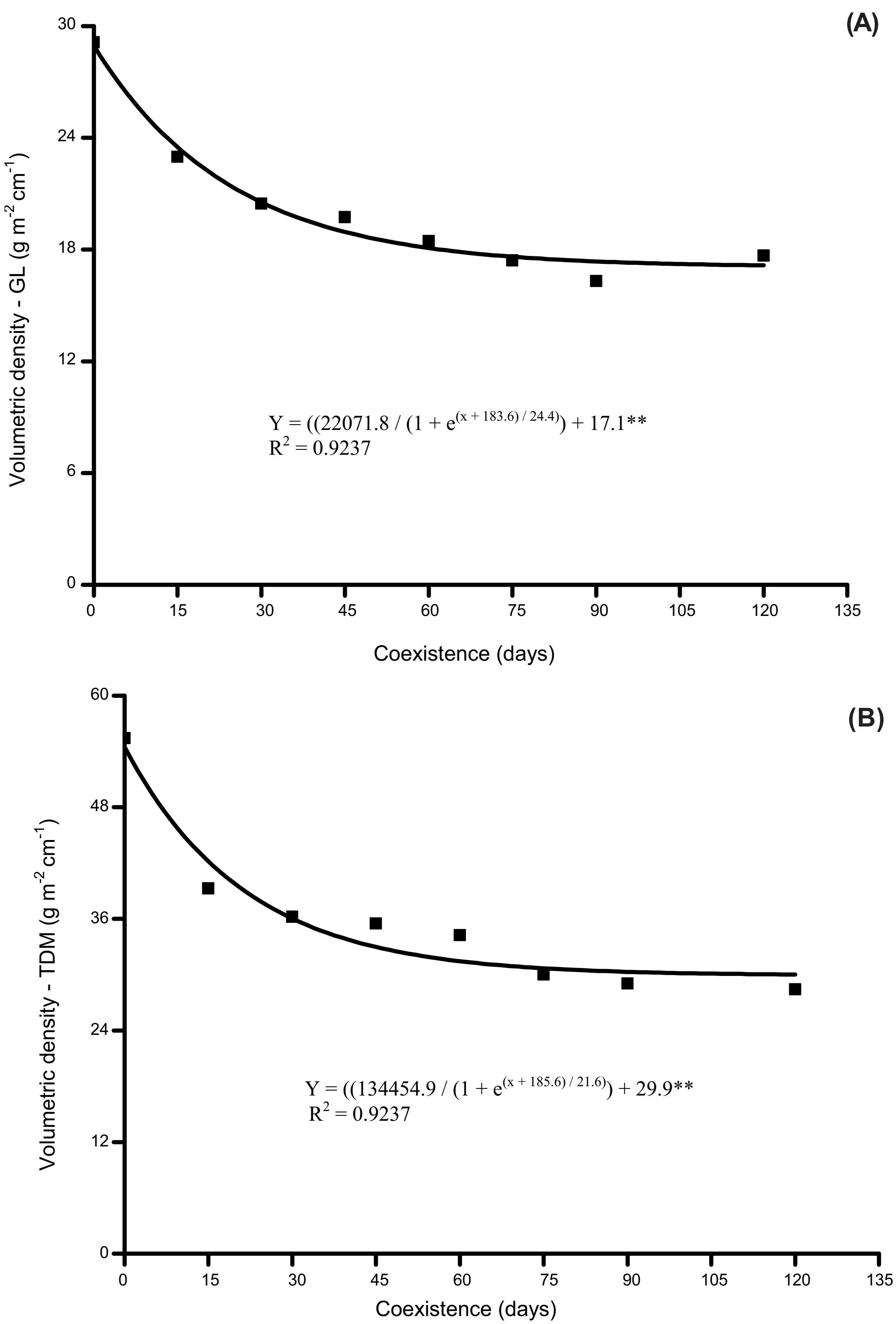
Figure 3 - Total dry matter (g m^{-2}) accumulated by weeds in the respective coexistence periods.



** Significant (p>0.01).

Figure 4 - Graphical representation of the leaf/stem ratio obtained in *B. brizantha* cv. Marandu at 120 DAE, according to the coexistence periods with weeds.

The structure of the pasture consists in the spatial arrangement of aerial biomass in a pasture and can be characterized by variables such as forage mass and volumetric density, light interception by canopy and pasture height. This structure is relevant because it conditions the responses of plants and animals under grazing regime. In addition, the pasture structure is not static, since the morphogenic characteristics and the environmental conditions are the main factors that modify the horizontal and vertical structures of the pasture over time, even in those with a single species and managed with the same criterion (Santos et al., 2010; Sousa et al., 2011).



** Significant (p>0.01).

Figure 5 - Volumetric density of green leaf - GL (A) and total dry matter - TDM (B) of *B. brizantha* cv. Marandu at 120 DAE, according to the coexistence periods with weeds.

Deleterious effects on the structure of plants were observed by Santos et al. (2011), which verified that the volumetric density of green leaf and total dry matter produced by *B. decumbens* cv. Basilisk was lower in the plants located within a radius of 0.50 m from the weed *Solanum sisymbrifolium*, when compared to those located at greater distances.

Changes in the leaf/stem ratio, green leaf volume density and total dry matter volumetric density of the fodder plant found in this study demonstrate that weeds had an important effect on the biological relation established when coexisting with *B. brizantha* cv. Marandu. The continuous increase in dry matter allocation by spontaneous plants and the progressive reduction of the leaf/stem ratio and volumetric densities can be an indication that interspecies competition has been established and that weeds, because they are native, have obtained competitive advantages on the fodder grass.

The leaf/stem ratio and leaf volume density were also an important characteristic in the evaluation of the quality of forage materials (Pereira et al., 2000), since a higher proportion of leaves can show better degradability, due to the lower presence of indigestible hardly degradable structural tissues, being able to influence the degradation dynamics and speed of the dry matter by the rumen microorganisms (Pereira et al., 2000; Baroni et al., 2010).

All nutritional components of *B. brizantha* cv. Marandu were significantly altered by the coexistence with weeds. Crude protein levels were above 14.5% when the period was equal to or less than 45 DAE. From 60 coexistence days on, crude protein levels fell below 13.5%, all being statistically below the values obtained in previous coexistence periods (Table 2).

Serafim and Galbiatti (2012), while using swine wastewater in the fertilization of *B. brizantha* cv. Marandu, observed similar values to those obtained in this study when the pasture had no weed presence.

As for ethereal extract levels, significant differences were observed in the shortest coexistence periods; at 45 days, the content was represented by 1.54% and was statistically lower than those obtained in previous periods (Table 2).

The lipid fraction or ethereal extract of fodder plants can be altered by genes, plant age and growth rate. The levels obtained in this work are in accordance with values found by other authors (Santos et al., 2003, 2008) and with the percentage presented in the Brazilian tables of cattle feed composition (Valadares Filho et al., 2006).

Mineral matter contents decreased when the coexistence between fodder plants and weeds was equal to or greater than 75 DAE; the obtained MM values were lower than 5.2%. Non-fiber carbohydrate values were negatively affected when the coexistence was equal to or higher than

Table 2 **-** Crude protein (CP), neutral detergent fiber (NDF), ethereal extract (EE), mineral matter (MM), organic matter (OM), total carbohydrates (TC) and non-fiber carbohydrates (NFC), expressed as dry matter percentage, observed in palisade grass according to the coexistence periods with weeds

Coexistence (days)	CP (%)	EE (%)	MM (%)	OM (%)	TC (%)	NDF (%)	NFC (%)
0	14.51 a	1.86 a	5.95 a	94.05 b	77.69 b	62.84 c	14.85 a
15	15.61 a	1.72 a	6.08 a	93.92 b	76.60 b	63.24 c	13.35 a
30	14.86 a	1.70 a	5.77 a	94.23 b	77.67 b	64.85 c	12.81 a
45	15.88 a	1.54 b	5.40 a	94.60 b	77.17 b	66.85 c	10.84 b
60	13.50 b	1.53 b	5.33 a	94.67 b	79.64 b	69.48 b	10.15 b
75	10.60 b	1.50 b	5.02 b	94.97 a	82.87 a	72.72 a	10.16 b
90	9.72 b	1.47 b	4.78 b	95.22 a	84.03 a	73.53 a	10.50 b
120	10.35 b	1.37 b	4.39 b	95.61 a	83.89 a	74.56 a	9.33 b
F Days	16.92**	3.21*	5.25**	5.25**	16.76**	15.55**	2.50*
F Block	1.06^{NS}	0.13^{NS}	2.86^{NS}	2.86^{NS}	0.84^{NS}	0.18^{NS}	0.68^{NS}
VC (%)	9.34	11.26	9.57	0.54	1.93	3.52	21.25

NS – Non significant. ** Significant (p>0.01); * Significant (p>0.05). Means followed by the same letter in the column do not differ statistically from one another by Scott-Knott test at 5% probability.

45 DAE, and the values (10.84%) were statistically lower than those obtained during the lowest coexistence periods (Table 2).

The reduction in mineral matter contents is probably a direct reflection of the competition for nutrients that are available in the environment (Rajcan and Swanton, 2001). Studies conducted by several authors have shown that weeds have a high nutrient uptake capacity and that the uptake rate was differentiated between species, resulting in different growth and dry matter accumulation patterns throughout the life cycle (Erasmo et al., 1997; Gravena et al., 2002; Bianco et al., 2014). However, the main point to be highlighted in this study was that there was always at least one weed species exerting competitive pressure on palisade grass, indicating that the coexistence between the fodder plant and the weed community would cause competitive disadvantages for some of the individuals involved in this coexistence as for the allocation of soil nutrients.

In contrast, organic matter and total carbohydrate contents increased as the coexistence period between fodder plants and weeds increased. Both nutritional components presented statistically higher values in a coexistence period of 75 DAE or more, since the percentages of organic matter and total carbohydrates were lower than 95% and 83%, respectively, in lower coexistence periods (Table 2).

Weed interference influenced the neutral detergent fiber content of *B. brizantha* cv. Marandu, especially over time (Table 2). Three distinct levels of fiber percentages were identified: the lowest, below 66% in coexistence periods equal to or lower than 45 DAE; the intermediate, of 69% at 60 DAE; and the highest, above 72% in coexistence equal to or greater than 75 DAE.

As the physiological age of the plant progresses, the percentages of cellulose, hemicellulose and lignin increase, reducing the proportion of potentially digestible nutrients (soluble carbohydrates, proteins, minerals and vitamins), which represent a significant drop in digestibility (Reis et al. 2005). In addition to the increased fiber concentration in stems and in most leaves, fiber concentration was also higher in the total forage due to the decrease in the leaf/stem ratio, deriving from plant maturity (Gomide et al., 2007). The increase in the coexistence period with weeds caused a similar effect to the mentioned one, due to the advancing in the physiological age of the plant, in relation to the contents of neutral detergent fiber and total carbohydrates.

The highest values of neutral detergent fiber and total carbohydrates were due to the fact that fodder plants probably allocated resources in the stem elongation process, at the expense of the production of leaf blades. The elongation of the main stem, called etiolation, represents a response to the search for light of the individuals that were shaded by neighboring individuals. Thus, the increased growth of the fodder plant implies an increase in the conversion of photoassimilates to structural carbohydrates. This happens to the detriment of organic molecules, nutrients or not, that actively participate in metabolic processes; with the deposition of non-nitrogenous organic molecules such as cellulose, hemicellulose and lignin, there is a reduction in the concentration of nitrogen compounds (Silva et al., 2010; Velasquez et al., 2010).

In addition, the elongation of the main stem and the non-production of leaf blades interfere negatively in the photosynthetic efficiency of plants, since the smaller amount of leaves will reduce the production of photoassimilates, sugars and plant dry matter (Taiz and Zeiger, 2004) . This event can be verified in this study, since non-fiber carbohydrate contents decreased as the coexistence period with weeds increased.

Thus, the change promoted by weeds in the leaf/stem ratio and volumetric density of leaves consequently influenced the nutritional quality of *B. brizantha* cv. Marandu, so that the decreases in crude protein and ethereal extract contents followed the decreasing trend of the leaf/stem ratio and volumetric density of leaves with the increase in the period of mutual coexistence. A high leaf/stem ratio means producing forage with a high crude protein content and higher animal weight gain, since the percentage of leaf blades has a remarkable importance in the nutritive value of forage (Magalhães et al., 2007; Rodrigues et al., 2008).

The results obtained in this work reveal that the presence of weeds provided changes in the structure of the pasture, being detrimental to leaf/stem ratio, leaf volumetric density and, especially, to the nutritional value of *B. brizantha* cv. Marandu cultivated under tropical climate conditions.

The results suggest that control measures should be adopted before reaching 30 days of weed-fodder plant coexistence in a pasture renewal situation, in order to avoid the establishment of the biological relationship of competition and in order to avoid damages to the development and nutritional value of *B. brizantha* cv. Marandu.

REFERENCES

Baroni C.E.S. et al. Levels of corn meal based supplement in Nellore steers finished on pasture in the dry season: performance, carcass characteristics and pasture evaluation. **Rev Bras Zootec.** 2010;39:175-82.

Benett C.G.S. et al. Produtividade e composição bromatológica do capim Marandú a fontes e doses de nitrogênio. **Cienc Agrotecnol.** 2008;32:1629-36.

Bianco S., Carvalho L.B., Bianco M.S. Crescimento e nutrição mineral de *Sida rhombifolia*. **Planta Daninha**. 2014;32:311-7.

Campos C.F. et al. Periods of weed interference in maize crops cultivated in the first and second cycles. **Semina: Ci Agr.** 2016;37:2867-80.

Costa K.A.P., Faquin V., Oliveira I.P. Nitrogen doses and sources on pasture recuperation of grass Marandú. **Rev Bras Med Veter Zootec.** 2010;62:192-9.

Cruz P., Boval M. Effect of nitrogen on some morphogenetic traits of temperate and tropical perennial forage grasses. In: Lemaire G. et al., editors. **Grassland ecophysiology and grazing ecology**. Wallingford: CABI Publishing, 2000. p.151-68.

Dias Filho M.B. **Diagnóstico das pastagens no Brasil**. Belém: Embrapa Amazônia Oriental, 2014. 36p. (Documentos 402)

Erasmo E.A.L., Bianco S., Pitelli R.A. Estudo sobre o crescimento de fedegoso. **Planta Daninha**. 1997;15:170-9.

Gomide C.A.M., Gomide J.A., Alexandrino E. Características estruturais e produção de forragem em pastos de capim-Mombaça submetido a períodos de descanso. **Pesq Agropec Bras**. 2007;42:1487-94.

Gravena R. et al. Análise do crescimento de *Hyptis suaveolens*. **Planta Daninha**. 2002;20:189-96.

Macedo M.C.M. Crop and livestock integration: the state of the art and the near future. **Rev Bras Zootec.** 2009;38:133-46.

Magalhães A.F. et al. Influence of nitrogen and phosphorus on *Brachiaria decumbens* stapf. production. **Rev Bras Zootec.** 2007;36:1240-6.

Martuscello J.A. et al. Produção de gramíneas do gênero *Brachiaria* sob níveis de sombreamento. **Rev Bras Zootec.** 2009;38:1183-90.

Mello A.C.L. et al. Degradação ruminal da matéria seca de clones de capim-elefante em função da relação folha/colmo. **Rev Bras Zootec.** 2006;35:1316-22.

Mueller-Dombois D., Ellemberg H. **Aims and methods of vegetation ecology**. New York: John Wiley & Sons, 1974.

Pereira A.V. et al. Variação da qualidade de folhas em cultivares de capim-elefante (*Pennisetum purpureum*) e híbridos de capim-elefante x milheto (*P. purpureum* x *P. glaucum*), em função da idade da planta. **Cienc Agrotecnol.** 2000;24:490-9.

Peron A.J., Evangelista A.R. Degradação de pastagens em regiões de Cerrado. **Cienc Agrotecnol.** 2004;28:655-61.

Rajcan I., Swanton C. Understanding maize-weed competition: resource competition, light quality and the whole. **Field Crops Res.** 2001;71:139-50.

Reis R.A. et al. Otimização da utilização da forragem disponível através da suplementação estratégica. In: Reis R.A. et al., editores. **Volumosos na produção de ruminantes**. Jaboticabal: Funep, 2005. p.187-238.

Rodrigues A.C.P. et al. Períodos de interferência de plantas daninhas na cultura do sorgo. **Planta Daninha**. 2010;28:23-31.

Rodrigues R.C. et al. Produção de massa seca, relação folha/colmo e alguns índices de crescimento do Brachiaria brizantha cv. Xaraés cultivado com a combinação de doses de nitrogênio e potássio. **Rev Bras Zootec.** 2008;37:394-400.

Santos M.V.F. et al. Produtividade e composição química de gramíneas tropicais da zona da mata de Pernambuco. **Rev Bras Zootec.** 2003;32:821-7.

Santos N.L., Silva M.W.R., Chaves M.A. Efeito da irrigação suplementar sobre a produção dos capins Tifton 85, Tanzânia e Marandú no período de verão no sudeste Baiano. **Cienc An Bras.** 2008;9:911-22.

Santos M.E.R. et al. Estrutura do pasto de capim-braquiária com variação de alturas. **Rev Bras Zootec.** 2010;39:2125-31.

Santos M.E.R. et al. Estrutura do capim-braquiária em relação à planta daninha. **Acta Sci An Sci.** 2011;33233-39.

Serafim R.S., Galbiatti J.A. Efeito da aplicação de água residuária de suinocultura na *Brachiaria brizantha* cv. Marandú. **Rev Colomb Ci An.** 2012;4:185-203.

Silva D.J., Queiroz A.C. **Análise de alimentos:** métodos químicos e biológicos. 3ª.ed. Viçosa, MG: Universidade Federal de Viçosa, 2002. 235p.

Silva R.R. et al. Novilhos nelore suplementados em pastagens: consumo, desempenho e digestibilidade. **Arch Zootec.** 2010;59:549-60.

Sniffen C.J. et al. A net carbohydrate and protein system for evaluating cattle diets: carbohydrate and protein availability. **J An Sci.** 1992;70:3562-77.

Sousa B.M.L. et al. Morphogenetic and structural characteristics of xaraes palisadegrass submitted to cutting heights. **Rev Bras Zootec.** 2011;40:53-9.

Taiz L., Zeiger E. **Fisiologia vegetal**. 3ª.ed. Porto Alegre: Artmed, 2004. 719p.

Valadares Filho S.C., Paulino P.V.R., Magalhães K.A. Exigências nutricionais de zebuínos e tabelas de composição de alimentos BR-Corte**.** In: Valadares Filho S.C. et al. **Consumo de matéria seca de bovinos nelore e mestiços**. Viçosa, MG: Universidade Federal de Viçosa, 2006. 142p.

Valle C.B., Jank L., Resende R.M.S. O melhoramento de forrageiras tropicais no Brasil. **Rev Ceres**. 2009;56:460-72.

Velásquez P.A.T. et al. Composição química, fracionamento de carboidratos e proteínas e digestibilidade *in vitro* de forrageiras tropicais em diferentes idades de corte. **Rev Bras Zootec.** 2010;39:1206-13.

Vilela L. et al. Calagem e adubação para pastagens. In: Sousa D.M.G., Lobato E., editors. **Cerrado:** Correção do solo e adubação**.** Planaltina, DF: Embrapa Informação Tecnológica, 2003. p.367-84.

Zimmer A.H. et al. **Degradação, recuperação e renovação de pastagens.** Campo Grande: Embrapa de Gado e Corte, 2012. 42p. (Documentos, 189)