Communications in PLANT SCIENCES

http://cpsjournal.org
e-ISSN 2237-4027
Volume 10 (2020)

RESEARCH ARTICLE

Guinea grass yield under interference of monocotyledon weeds

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Submitted on May 26, 2020
Accepted on October 23, 2020
Early View on November 03, 2020
Final Publication on November 03, 2020

Author declares no conflict of interest

KEYWORDS:
Volumetric density
Weed competition
Panicum maximum Jacq. cv Guinea
Leaf:Stem ratio

ABSTRACT

Pastures are the main source of food for herds; thus, it is essential to understand the interference relationships between forage species and weeds to use management strategies properly and to obtain forage production with satisfactory nutritional value. The objective of this study was to evaluate the effect of different periods of coexistence with major monocotyledonous weeds on the alteration of the canopy structure and the productive components of *Panicum maximum* Jacq. cv. Guinea under pasture reform condition. The experiment was set up in a randomized block design, with four replications, and the treatments were represented by increasing periods of coexistence, namely: 0, 15, 30, 45, 60, 75 and 90 days after seedling emergence. Forage plants were evaluated at 90 days after emergence for their main structural and productive characteristics. The findings show that the presence of monocotyledon weeds negatively interferes in the structural and productive aspects of *P. maximum* Jacq. cv Guinea. Therefore, control measures should be adopted using a period before interference (PBI) less than sixteen days of coexistence with the monocotyledon weed community.

Highlighted Conclusions

1. Increased period of coexistence with weeds affects the Guinea grass leaf:stem ratio.
2. Guinea grass leaf volumetric density is negatively affected by an increased period of coexistence with weeds.

INTRODUCTION

Pastures are the mainstay of ruminant production in Brazil, and using them is the most economical way to feed cattle. Tropical forage grasses of the genus *Panicum* stand out for their high potential for dry mass production and great acceptability by animals (Dutra et al. 2015).

The species *Panicum maximum* Jacq. cv. Guinea is a promising cultivar that has a great size, strong tillers, drought tolerance and satisfactory results in pasture fields, especially on farms with intensive animal farming. It is considered as the most productive among the cultivars of this species. In addition, it is one of the most used forages in pasture areas grown in Brazil owing to its good adaptation to tropical and subtropical climates and its high nutritional quality (Jank et al. 2010, Gomes et al. 2011).

Knowledge of the ecophysiology of forage plants is of paramount importance to define management strategies compatible with the productive capacity of pastures. Therefore, efficient use of the forage species and proper management of pastures are needed to optimize forage use and animal performance (Difante et al. 2011, Amorim et al. 2017).

However, the extractive form of exploitation of pastures leads to progressive degradation, which is characterized by the dynamic process of degeneration with decreases in stocking capacity and animal weight gain. The relevant factors that cause this degradation are lack of fertilization, inconsistent choice of forage species, occurrence of invasive pests and plants, use of fire, and overcrowding of animals (Carvalho et al. 2017).

In Brazilian pastures, the presence of weeds is a common problem whose major cause is inadequate management. Infestation occurs because weeds easily adapt to the environment and have high capacity for competition for essential components such as water, light and nutrients, which can make the development of forage unfeasible and increase operating costs (Carvalho et al. 2016).

DOI: 10.26814/cps2020013 | 8 pages

The concern with the infestation of monocotyledonous species has increased considerably owing to the expansion of razor grass (*Paspalum virgatum* L.) and smut grass (*Sporobolus indicus* (L.) R. Br.), species that have high multiplication capacity and are difficult to control, thus posing challenges to weed management in pastures cultivated with tropical forages (Herrera 2015, Marques et al. 2019b).

The potential productive increase of pastures is supported by the recovery of degraded areas. Some strategies can be adopted; for example, renovation or reform of pasture fields. These strategies are linked to factors such as degree of degradation and size of the area to be recovered, percentage of infestation, stage of weed development and financial capacity of farmers (Dias-Filho 2011).

The starting point for the adoption of weed control measures is knowledge of both the appropriate period for weed management, and the morphophysiological characteristics and competitive ability of weed species (Mascarenhas et al. 2009). However, studies on the interference of monocotyledon weeds in forage production are scarce in the literature, because research is mostly focused on the effects of herbicides in the control of invasive plants (Marques et al. 2019a).

However, pasture-cattle production systems should be improved to make beef cattle production more profitable by avoiding degradation. Therefore, the objective of the present research was to understand the effect of interference from monocotyledonous weeds on Guinea grass under pasture reform conditions, and also to determine when control activities should be adopted.

MATERIAL AND METHODS

The experiment was conducted in a degraded pasture area with a history of high monocotyledonous weed infestation, located at the geographical coordinates of 15º 52' 29"S and 52º 18" 37 "W Gr, average altitude of 350 meters above sea level, with Aw climate according to the Köppen classification, i.e., average temperatures above 27 ºC in the hottest months (November to February), average temperatures above 18 ºC in the coldest months (June to August), and average annual precipitation between 1,000 and 1,500 mm, distributed in two well-defined periods in terms of precipitation: a period of intense rain between the months of October and March and a clear period of drought between the months of April and September (Alvares et al. 2014).

The soil in the area was characterized as a dystrophic Red-Yellow Latosol whose physical and chemical characteristics are shown below: pH in CaCl2 of 4.3; 22.0 g dm^{-3} of organic matter; 2.7 mg dm^{-3} of Mehlich-extractable P ; V of 23.50%; and contents of K, Ca, Mg and H + AL of 0.15; 0.66; 0.42 and 4.0 cmolc dm^{-3}, respectively; 692 g kg^{-1} of sand, 97 g kg^{-1} of silt and 211 g kg^{-1} of clay, which characterizes it as having medium texture.

To prepare the area, the existing vegetation in the degraded pasture was eliminated by post-emergence application of the herbicide glyphosate in the dose of 3.0 L ha^{-1}. Afterwards, soil acidity was corrected according to the recommendations of Vilela et al. (2004). The equivalent to 2,000 kg ha^{-1} of limestone was applied to increase the base saturation to 50% and harrowing was subsequently performed to incorporate the limestone and eliminate vegetable remains. Fertilization at sowing consisted of 250 kg ha^{-1} 5-25-15 of the (NP_2O_5-K_2O) formulation, broadcast on the soil surface.

Sowing was carried out with inter-row spacing of 40 cm. The seeds of the species *Panicum maximum* Jacq. cv. Guinea were manually dropped into the planting furrows. Seeds with high vigor and purity acquired from a suitable company were used and, based on their power of germination, the equivalent of 10.0 kg ha^{-1} was sown.

The experiment was conducted in a randomized block design with four replications. The treatments consisted of seven growth periods of coexistence between the forage grass and weeds, namely: 0, 15, 30, 45, 60, 75 and 90 days after seedling emergence (DAE). Each experimental plot had a total area of 12.0 m^2 (4.0 x 3.0 m), and the usable area consisted of 6 m^2 of the central area of the plots.

A 90-day period was established, based on the time needed to obtain adequate conditions for grazing Guinea grass (Jank et al. 2010). The treatment equivalent to 0 (zero) days was considered as absolute control, in which there was a total absence of coexistence between weeds and forage grass throughout the whole experiment.

The weed population was surveyed at the end of each coexistence period to characterize the entire existing weed community. The evaluations were carried out in the usable area of each experimental unit with the aid of a 0.25 m^2 (0.50 x 0.50 m) plastic quadrat randomly thrown inside the plots.

The species of the infesting community present inside the plastic quadrat were identified, quantified numerically and taken to the laboratory, where they were dried in a forced air circulation oven at 65 ºC for three days. Shoot dry matter accumulation of the collected species was determined with the aid of a 0.01 g precision scale. After collection, at the end of each coexistence period, the entire weed community was removed from each plot by manual weeding and thinning.

Based on the evaluation data on number of specimens and dry matter accumulated by different weed species, the relative importance (RI) of each weed species could be determined during the different study periods of coexistence, as proposed by Monquero et al. (2014).

The form and structure of Guinea grass were evaluated at the end of the period of conduction of the experiment, that is, at 90 days after seedling emergence (DAE), the following parameters were determined in twenty tillers collected randomly within each plot: tiller height (cm), tiller diameter (mm), first green leaf height (cm), number of green leaves and number of dry leaves. The tillers were then divided into leaves and stems, and the dry matter values of the respective fractions were determined according to the method mentioned above. The ratio of green leaf dry matter to green stem dry matter (leaf/stem) was determined using the data on dry matter while the ratio between first green leaf height and tiller height (FGLH/TH) was determined with the data on height.

Forage grass yield was also measured at 90 DAE to determine average canopy height and number of tillers. After that, samples of forage were collected by cutting the plants at 10 cm above the ground within an area delimited by a 0.50 x 0.50 m plastic quadrat randomly thrown into the usable area of the plot. The collected samples were taken to the laboratory and sectioned into green leaf, green stem and dead material. When there were inflorescences, they were considered as green stem.

All the samples were packed in paper bags and kept in a forced air circulation oven at 65 ºC for three days, at which time they were weighed on a 0.01 g precision scale to determine the dry matter of the fractions produced by the forage grass (gm^{-2}). Guinea grass yield was characterized by the volumetric density values of green leaf (GLVD), green stem (GSVD) and dead material (DMatVD) (gm^{-3}) calculated by multiplying dry biomass production (gm^{-2}) by forage canopy height (m). Total volumetric density (TVD, in gm^{-3}) is represented by the sum of GLVD, GSVD and DMatVD.

The values were analyzed by the F-test, and the effects of treatments were compared by the Scott-Knott test at 5% of probability using the statistical program AgroEstat (Barbosa and Maldonado Jr. 2015).

The results for leaf:stem and FGLH/TH ratios underwent regression analysis and the degrees of freedom of the evaluated factor were further analyzed for the linear and quadratic effect by the Origin 8.5.1 SR1 program. The regression model was selected on the basis of the highest value of the determination coefficient (R^2) after ≤ 0.05 according to the F-test, while respecting the biological response.

The average values of TVD produced by the forage species were adjusted according to Boltzmann's sigmoidal model to determine the period before interference (PBI), as suggested by the equation for weed interference studies proposed by Kuva et al. (2001):

$$Y = \frac{(A_1-A_2)}{1+e^{(x-x_0)/d_x}} + A_2 \frac{(A_1-A_2)}{1+e^{(x-x_0)/d_x}} + A_2$$

where: Y is forage production depending on the periods of control or coexistence; X is the upper limit of the control or coexistence period; A_1 is the maximum production obtained in the weeded plots throughout the cycle; A_2 is the minimum production obtained in the non-weeded plots throughout the cycle; (A_1-A_2) is yield loss; X_0 it is the upper limit of the control or coexistence period, which corresponds to the intermediate value between maximum and minimum yield; and dx is the parameter indicating the speed of loss or gain of yield (tg α at point X_0).

The Period Before Interference (PBI) was determined by estimating losses of 5% in comparison to the IVOMD values of the control.

RESULTS AND DISCUSSION

In the evaluations of the weed community carried out during the experimental period of this research, there were six monocot weed species belonging to two distinct botanical families: one Cyperaceae and five Poaceae (Table 1).

Table 1. Scientific and common names, international codes and families of weeds present in the experimental area.

Name		International code	Families
Scientific	Common		
Cyperus diformis L.	Tiririca	CYPDI	Cyperaceae
Digitaria horizontalis Willd.	Capim-colchão	DIGHO	Poaceae
Eleusine indica (L.)	Capim-pé-de-galinha	ELEIN	Poaceae
Hyparrhenya bracteata	Hyparrhenya	HYRBR	Poaceae
Urochloa decumbens (Stapf) R. D. Webster	Braquiária	BRADC	Poaceae
Pennisetum setosum (Sw.) Rich.	Capim-avião	PESSE	Poaceae

Total dry matter (gm^{-2}) accumulated by weeds during the period of coexistence increased during the experiment; however, there was variable accumulation by the most representative species, namely HYRBR, PESSE and BRADC (Figure 1).

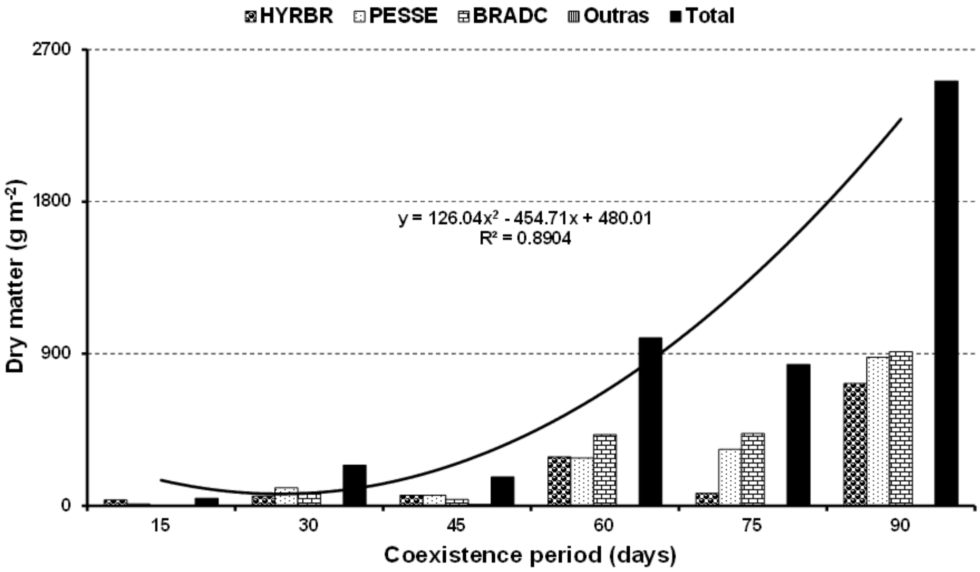

Figure 1. Accumulated dry matter (g m^{-2}) by weeds during the coexistence period.

The peak of development and accumulation of dry matter of all the study species occurred at 90 days of coexistence (Figure 1), indicating that the weeds had rapid vegetative growth and were able to compete with the forage species in search of resources of the shared environment, such as water, light and nutrients.

The BRADC species showed the highest dry matter accumulation at 90 days of coexistence: 911.8 gm^{-2} (Figure 1). This specie belonging to the genus *Urochloa*, which is from the same botanical family as Guinea grass, has highly competitive ability due to the similarity of morphological characteristics. However, this grass has low dry mass production, lower nutritional value and high sensitivity to spittlebugs (Martins et al. 2007).

The relative importance index (%RI) simultaneously involves the ratio between density, dominance and frequency of a given species in comparison to all other species present in the weed community. Thus, this index needs to be evaluated to better identify the weed species that are individually benefited or jeopardized by the changes made to the agro-ecosystem (Figure 2).

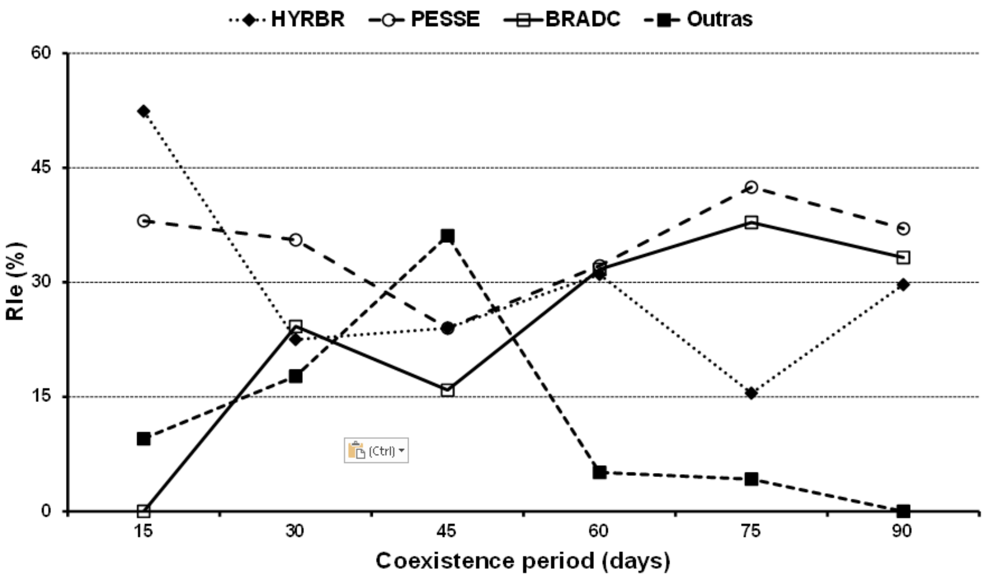

Figure 2. Relative importance (%) evolution of weed community in the respective coexistence period.

The phytosociological study of the weed community points out that the HYRBR species had the highest RI index (52.41%) at 15 DAE. After this period of coexistence, the BRADC species started to allocate considerable

DOI: 10.26814/cps2020013 | 8 pages

amounts of resources, which makes it the major part of the interference relationships that were established between monocotyledonous weeds and Guinea grass, with possible effects on the productive potential of this forage species (Figure 2).

Knowledge of weed behavior provides further insights into interference relationships and indicates which plants are more adapted to the environment, on the basis of diversity indexes, wide distribution in the area, high density and rapid initial growth, contributing to the suppression of neighboring species (Concenço et al. 2013).

Marchi et al. (2019) analyzed the weed community present in pasture fields cultivated with Guinea grass and underscored that at least one weed species was present throughout the experimental period. Together, all species were able to establish a competitive relationship, causing changes in the morphogenesis of Guinea grass on the first days after seedling emergence.

Table 2 shows that all the structural variables were significantly influenced by the increase in the period of coexistence of the forage grass with the weeds. There was a drastic reduction in canopy height after 15 days of coexistence with the weed community, with no recovery when the weeds were removed.

Table 2. Canopy height, stem diameter, first green leaf height, number of tillers and number of green leaves per tiller (NGLT) of Guinea grass according to coexistence period.

Coexistence (days)	Height (cm)	Diameter (mm)	1st green leaf height (cm)	Number of tillers	NGLT
0	33.7 a	5.65 a	13.6 a	4.3 a	5.6 a
15	21.2 b	4.49 b	11.4 b	4.0 a	5.7 a
30	19.0 b	3.97 c	10.5 c	3.0 b	5.4 a
45	16.0 c	3.58 c	6.0 d	3.0 b	5.0 b
60	11.8 d	2.44 d	7.9 d	2.2 c	4.9 b
75	13.0 d	1.97 d	9.3 c	1.8 c	4.9 b
90	16.4 c	2.06 d	13.0 a	1.0 d	4.2 c
F Coexistence	62.58**	59.08**	17.46**	46.20**	4.93**
F Blocks	1.99^{NS}	0.93^{NS}	1.23^{NS}	0.30^{NS}	1.43^{NS}
C.V. (%)	9.9	10.4	9.8	12.5	9.1

NS– Not significant. ** Significant at 1% probability. Means followed by the same letter in the column do not differ statistically by the Scott-Knott test (p<0.05).

Forage canopy height is a structural feature that affects the feed intake behavior of cattle and is used as a practical parameter for defoliation management (Macedo et al. 2010). Thus, the management conditions applied to forage species affect their morphological characteristics, as reported in this study; on the first days of coexistence with weeds, there was interference that limited the development of forage grass.

There was a gradual reduction in stem diameter up to the period of 60 days of coexistence; thereafter, diameter values were 50% lower up to 90 days when compared to the period when there was no coexistence with the weeds (Table 2).

Variation in first green leaf height values over the 90 days of coexistence with weeds has an influence on leaf architecture and leaf elongation rate, causing changes in defoliation management, and showing that competition can jeopardize grazing and reduce the amount of forage offered to cattle (Alexandrino et al. 2011).

Importantly, increased coexistence led to a gradual decrease in the number of tillers and the number of green leaves per tiller, which were 1.0 and 4.2, respectively, at the end of the period (90 days) (Table 2). The success of a productive pasture field is due to good tillering; therefore, a decrease in the number of tillers can reduce leaf production and, consequently, reduce photosynthesis and carbohydrate synthesis in the plant, causing losses to forage productivity (Vilela 2011).

Notably, the ratio between first green leaf height and tiller height (FGLH:TH) increased linearly during the period of coexistence with weeds, and the highest ratio was found at 90 days (Figure 3). This result shows that pasture structure can be negatively altered owing to tiller elongation, stimulated by interference of the weed community. Thus, an uneven spatial arrangement of shoot components compromises grazing efficiency (Santos et al. 2011).

Figure 4 shows the leaf:stem ratio of Guinea grass, in which the forage plants presented a greater ratio on the first 15 days of coexistence, but there was a decline in this ratio throughout the rest of the period. This fact demonstrates that there was competition for light and space with weeds, which causes changes in dry matter production by the forage.

According to Baroni et al. (2010), the leaf:stem ratio is an important indicator of the nutritional value and management of forage species; as plants grow in search of light, the internodes are elongated and, as a result, there is a higher leaf:stem ratio, generating a low-digestibility material which affects the quality of forage.

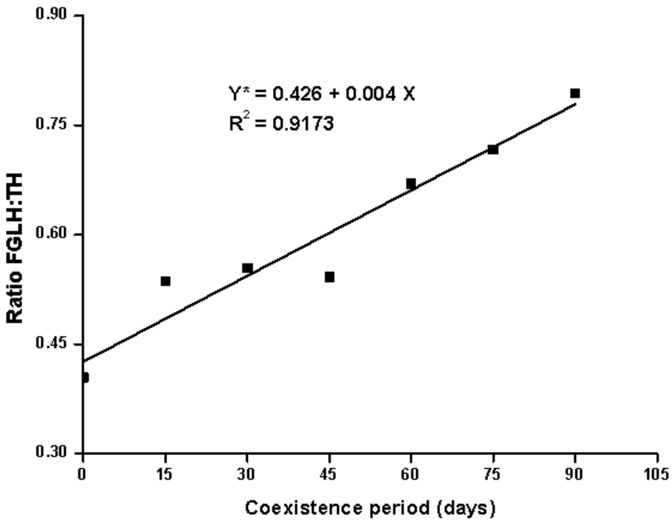

Figure 3. Ratio between first green leaf height and tiller height of Guinea grass obtained as a function of coexistence period. (* p<0,05).

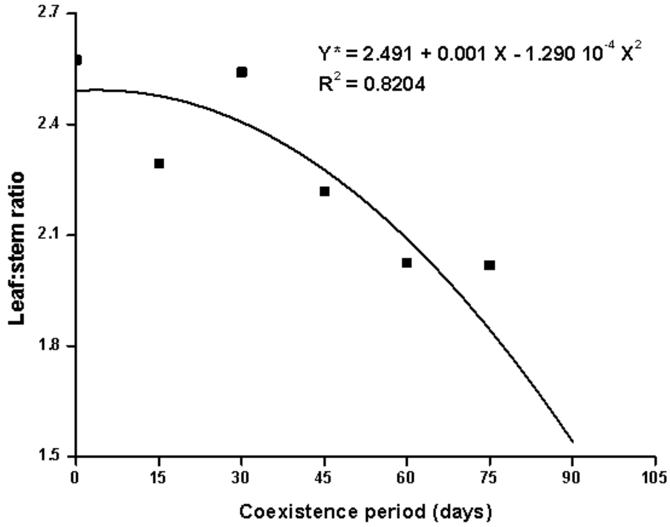

Figure 4. Leaf:stem ratio of Guinea grass obtained as a function of coexistence period. (* p<0,05).

The productive components of Guinea grass were negatively affected by coexistence with weeds on the first 15 days, and this may have limited the consumption of forage by cattle. There was a marked decrease in total volumetric density (TVD) of approximately 475 gm^{-3} of forage canopy between 30 and 45 days of coexistence. After the 45th day of coexistence, dead material volumetric density (DMatVD) values did not differ statistically until the end of the evaluation period at 90 days DAE (Table 3).

It appears that at 15 DAE, there were significant changes in the production of leaves and stems of Guinea grass, represented by reductions of 190.84 gm^{-3} for green leaf volumetric density (GLVD) and 193.54 gm^{-3} for green stem volumetric density (GSVD). In the absence of coexistence, GLVD was approximately 90% higher when compared to the period of 90 days of coexistence with weeds (Table 3).

Table 3. Green leaf volumetric density (GLVD); green stem volumetric density (GSVD); dead material volumetric density (DMatVD) and total volumetric density (TVD) of Guinea grass canopy according to the coexistence periods.

Coexistence (days)	GLVD ($g\ m^{-3}$)	GSVD ($g\ m^{-3}$)	DMatVD ($g\ m^{-3}$)	TVD ($g\ m^{-3}$)
0	1927.08 a	756.38 a	102.22 a	2785.68 a
15	1736.24 b	562.84 b	69.83 b	2368.91 b
30	1004.76 c	418.66 c	69.79 b	1493.20 c
45	668.08 d	311.81 d	38.94 c	1018.84 d
60	536.36 e	319.52 d	42.63 c	898.51 d
75	405.04 e	203.70 e	32.62 c	645.10 e
90	181.91 f	131.13 e	45.43 c	358.47 f
F Coexistence	234.62**	40.52**	8.93**	372.98**
F Blocks	2.22^{NS}	1.96^{NS}	2.05^{NS}	1.00^{NS}
C.V. (%)	9.5	17.5	28.7	6.8

NS– Not significant. ** Significant at 1% probability. Means followed by the same letter in the column do not differ statistically by the Scott-Knott test (p<0.05).

Bellé et al. (2018) studied the effect of increasing periods of coexistence with weeds in pasture fields cultivated with palisade grass and found that forage yield was significantly affected by the presence of weeds, and this reduction was greater with increased period of coexistence. Thus, the present research corroborates these results and confirms that the decrease in forage production can limit daily consumption as well as affect the availability of food for cattle.

The analysis of the growth periods of coexistence between Guinea grass and monocotyledonous weeds showed that weed interference was established since the beginning of forage development (Figure 5).

The Period Before Interference (PBI) is the interval after emergence in which a crop can coexist with weeds without changing its characteristics permanently. Therefore, knowledge of the appropriate period for carrying out control measures is of paramount importance (Corrêa et al. 2015). In this case, the results are probably due to the high pressure and aggressiveness of weeds, especially species belonging to the same botanical families. Thus, control is performed from the first growth stages of Guinea grass, characterizing a PBI of sixteen days, considering five percent of acceptable loss in forage grass yield. Control measures should be adopted before 16 days of coexistence, which corresponds to the Period Before Interference (PBI), considering a tolerable loss of 5% in yield.

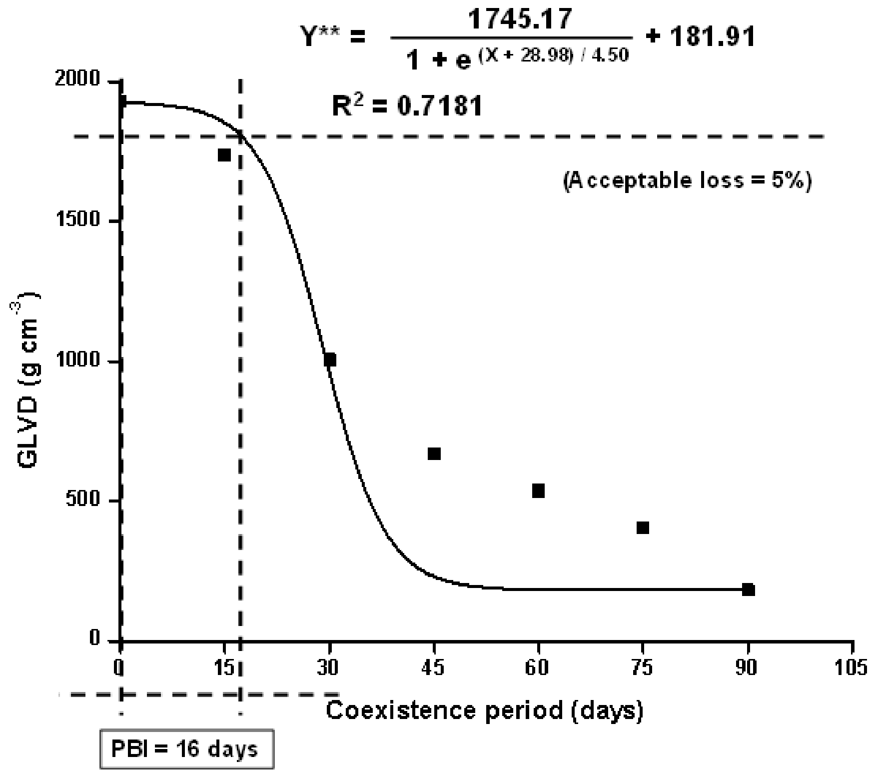

Figure 5. Period Before Interference (PBI) obtained as a function of coexistence period. (p<0,01).**

In summary, all structural and productive components decreased with increased coexistence weeds. The leaf:stem ratio decreased exponentially with increased coexistence with weed plants. Green leaf volumetric density of Guinea grass is negatively influenced by the presence of monocotyledonous weeds after 16 days of coexistence.

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