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Interference of weeds in ruziziensis grass pastures

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ABSTRACT. The aim of this study was to assess the effect of increasing periods of coexistence of weed plants with *Urochloa ruziziensis* on the canopy structure and productivity of a pasture already established with this forage species. The experiment was a randomized blocks design with four replications, and treatments consisted of seven increasing periods of coexistence of forage grass with weed plants: 0 (control), 15, 30, 45, 60, 75 and 90 days after regrowth (DAR). The main morpho-structural and productive characteristics of the forage plants were determined at the end of the experimental period (90 DAR). The ratio of the first green leaf height to the tiller height increases, while the leaf to stem ratio diminishes as the period of interaction with the infesting community increases. The number of green leaves per tiller and the tiller height diminishes as the period of coexistence with weed plants increases. The presence of weed plants interferes negatively with all parameters of the grass canopy structure and productivity of a grazing land already established with *Urochloa ruziziensis,* suggesting that measures of control of the infesting community should be adopted up to 17 days of regrowth of the forage plant.

Keywords: *Urochloa ruziziensis*; weed competition; productivity; leaf to stem ratio; morphogenic structure.

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Introduction

The expansion of cultivated pasture lands in Brazil has occurred mainly with the establishment of forage plants of the genus *Urochloa,* due to their high adaptability to acidic and low fertility soils (Bauer, Pacheco, Chichorro, Vasconcelos, & Pereira, 2011; Derré, Custódio, Agostini, & Guerra, 2013). Although *Urochloa ruziziensis* Germain and Evrard (sin. *Brachiaria ruziziensis*) is not the most cultivated species of the genus, this forage grass has good tolerance to cold weather and moderate tolerance to drought as well as high recovery speed after the first rains at the end of the dry season (Masetto, Ribeiro, & Rezende, 2013).

It should be noted that the use of grassland for livestock production is the most economic form of feeding cattle herds, which also provides all necessary nutrients for the good performance of the animal (Euclides, Montagner, Barbosa, & Nantes, 2014). However, pasture-based livestock production systems in Brazil traditionally use the continuous stocking method because of its operational ease, among other factors, but without a concern with protecting and renewing natural resources (Santos, Gomes, & Fonseca, 2014). As a consequence, there is an escalating degradation of pasture lands, characterized by a low capacity of production, support, maintenance and recovery of forage grasses (Carvalho et al., 2017; Marchi, Bellé, Foz, Ferri, & Martins, 2017; Marques et al., 2019).

Pasture degradation is one of the major problems in Brazilian livestock production, and it is estimated that in central Brazilian regions there are at least 32 million hectares of cultivated pastures undergoing a process of degradation (Marques et al., 2019). One of the main consequences of this process are empty spaces being formed among the forage plants, conducive to the growth of weed plants and directly affecting the pasture's floristic diversity (Inoue et al., 2012; Silva Neto et al., 2015).

When competing for growth factors such as space, light, water and nutrients, weed plants, especially the broadleaf species, can reduce drastically the physiological reserves of forages, increase the time of formation and recovery of pastures and even cause injuries and/or poisoning to animals (Carvalho et al., 2017; Marchi, Silva, Ferreira, Marques, & Moraes, 2019a). Because of this, the extractive aspects of exploration and the consequent presence of weed plants force animals to feed on low nutritional plants (Bellé, Marchi, Martins, Sousa, & Pinheiro, 2018). If one considers only the beef cattle fattening stage, meat yields in degraded pasture can be up to six times lower than those achieved in a well-preserved pasture (Dias-filho, 2011).

It is noteworthy that knowledge on the structural variables and morphogenesis of forage plants coexisting with weed plants has been a key instrument for determining appropriate pasture areas and, consequently, ensure good animal production (Araújo, Marques, Pinheiro, Souza, & Marchi, 2020). However, the few studies found in the literature about the management of weed plants in grazing lands do not focus on the study of the interference of weeds with forage grasses, especially with respect to productivity and pasture support capacity (Meurer, Brito, Marchi, Pinheiro, & Martins, 2020).

Given the above, this study aimed to examine the interference of weed plants with the morpho-structural and productive components of *Urochloa ruziziensis* forage as a function of increasing periods of coexistence of this grass species with weeds.

Material and methods

The experimental stage of the present research was represented by a field study conducted in an already established pasture, under maintenance conditions, located at coordinates 15°52'29" S and 52°18'37" W GR, mean altitude of 350 m above sea level. Climate in the region is Aw according to Köppen's classification, characterized by mean temperatures over 27°C in the warmest months (November to February), and over 18°C in the coldest months (June to August). Mean annual precipitation is between 1000 and 1500 mm distributed in two well-defined periods: a rainy season from October to March, and a clear drought period from April to September (Alvares, Stape, Sentelhas, Gonçalves, & Sparovek, 2013).

The soil in the experimental area was characterized by dystrophic Red Yellow Latosol, with average texture. The physicochemical characteristics of the soil for the 0-20 cm layer were: pH 4.4 in $CaCl_2$; 17.0 g dm^{-3} of organic matter; Resin P not significant; V of 20.20%; and K, Ca, Mg and H+AL contents of 0.19, 0.61, 0.25 and 4.2 $cmol_c$ dm^{-3}, respectively; 700 g dm^{-3} of sand, 75 g dm^{-3} of silt and 225 g dm^{-3} of clay.

The experimental area consisted of a four-year-old degraded pasture, where maintenance activities were performed. Land preparation consisted of mechanical mowing of *U. ruziziensis* plants and possible weed plants present in the area, which were cut to an approximate height of 10 cm. All cut plant material was immediately removed from the experimental units using a rake to prevent that plant clippings left on the ground would form a barrier that might hinder the regrowth of the forage or spontaneous plant propagules present in the soil seed bank. No soil fertility corrections were performed.

The experiment was carried out in a randomized complete blocks design with four replications, and the treatments consisted of seven increasing periods of coexistence of the *U. ruziziensis* grass with weed plants (0, 15, 30, 45, 60, 75, 90 days after forage regrowth - DAR). The treatment at day 0 (zero) was considered as absolute control, when there was total absence of interaction of weed plants with forage plants during the entire experimental period. Each experimental plot had a total area of 12 m^2 (4.0 x 3.0 m), and the net area used consisted of the central 6 m^2 of the plots.

At the end of each period of coexistence, the plant population was examined to determine the characteristics of the infesting community. The evaluations were conducted using a 0.25-m^2 plastic quadrat (0.50 x 0.50 m) thrown at random onto the plots' net area. The individuals present within the quadrat were grouped according to species, quantified and taken to a laboratory, where they were placed into paper bags and dried in forced circulation oven at 65°C to constant weight. Afterwards, total dry matter of the aboveground plant material of each group of collected species was determined using a 0.01 g precision scale.

The entire infesting community was removed from the experimental units as soon as it was assessed, and the development of any emerging weed, after this period, was interrupted with an application of 2.0 L ha^{-1} of herbicide based on aminopyralid + 2,4-D (40 + 320 g ae L^{-1}) at post-emergence. Herbicide sprayings were performed as needed using a CO_2-pressurized backpack sprayer with spraying boom equipped with four fan-type tips XR 11002 and set to dispense the equivalent of 200 L ha^{-1} of spray liquid.

Based on the data relating to the number of individuals and accumulated dry matter, it was possible to determine the relative importance (RI) that simultaneously comprises the relationship between dominance, density and frequency that a given plant species has in relation to others, as proposed by Monquero, Hirata, and Pitelli (2014). Thus, the results of the phytosociological parameters of the main species of weed plants present in the experimental area were obtained.

The morphogenic structure of *U. ruziziensis* was assessed at the end of the period of plant coexistence (90 DAR), when 20 tillers were collected at random from the net area of each plot in order to measure the tiller height (cm), height of the first green leaf (cm), tiller diameter (mm) and number of green leaves per tiller. Then, the tillers were fractionated into leaf and stem, and the dry matter of the respective fractions was obtained according to the methodology mentioned above for weed plants. Based on the dry matter data, the ratio of the dry matter of green leaf to the dry matter of green stem (leaf:stem ratio) was determined, and based on the plant height data, the ratio of the first green leaf height to the tiller height (FGLH:TH) was also determined.

The productivity of the forage plants was also assessed at 90 DAR, which was determined by the mean canopy height and the number of tillers per plant. Subsequently, forage samples were collected by cutting the plants at a height of 10 cm from the ground in the area limited by the 0.25 m^2 quadrat that was placed on the plot's net area. After being taken to the laboratory, the samples were fractionated into green leaf, green stem and dead matter. Inflorescences that eventually were present were considered as green stem.

The samples were individually placed into paper bags and maintained in forced circulation oven at 65°C to constant weight. Then, a 0.01-g precision scale was used for determination of dry matter of green leaf (g m^{-2}), green stem (g m^{-2}), dead matter (g m^{-2}) and, consequently, the total dry matter (g m^{-2}) produced by *U. ruziziensis*.

The values obtained were subjected to analysis of variance by the F test and, when significant, the effects of the treatments were compared by the Scott-Knott test at the level of 5% probability, using the AgroEstat statistical program (Barbosa & Maldonado Júnior, 2015).

The mean yields of total dry matter produced by the forage plants were adjusted according to Boltzmann' sigmoidal model for determination of the period prior to interference (PPI), based on the suggested equation for studies of weed plants' interference proposed by Kuva, Gravena, Pitelli, Christoffoleti, and Alves (2001):

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

where: Y is the forage grass production as a function of the periods of control or plant coexistence; X in the upper limit of the period of control or coexistence; A_1 is the maximum production obtained in the plots that were maintained cleared of weeds during the entire cycle; A_2 is the minimum production obtained in the plots that were maintained with weed plants during the entire cycle; (A_1-A_2) is the production loss; X_0 is the upper limit of the period of control or coexistence, corresponding to the intermediate value between maximum and minimum production; and d_x is the parameter that indicates the velocity of production loss or gain (tg α at point X_0).

The period prior to interference (PPI) was determined by estimating 5% losses in relation to the productivity of the control.

Results and discussion

In the evaluations of the infesting community carried out during the experimental period, ten dicotyledon weed species distributed in seven families were found. The family Malvaceae was the most representative, with three species, followed by the family Euphorbiaceae, with two species (Table 1).

Table 1. Species, common name, international code and family of weed plants present in the experimental area.

Species	Common name	International code	Family
Chamaesyce hirta (L.) Mill sp.	Asthma plant, pillpod sandmat	EPHHI	Euphorbiaceae
Croton glandulosus L.	Tooth-leaved croton	CVNGL	
Hyptis suaveolens (L.) Kuntze	Wild sparknard, bush tea	HYPSU	Lamiaceae
Mimosa debilis L.	Shy plant	MINDE	Mimosaceae
Senna obtusifolia (L.) H.S. Irvin & Barneby	Coffeeweed, sickepod	CASOB	Fabaceae
Spermacoce latifolia Aubl.	Oval-leaf false buttonweed	BOILF	Rubiaceae
Sida acuta Burm. f.	Common wireweed, teaweed, ironweed	SIDAC	Malvaceae
Sida santaremnensis Monteiro	Fanpetals	SIDSN	
Waltheria americana L.	Sleepy morning	WALAM	
Triumfetta bartramia L.	Burr bush	TIUBA	Tiliaceae

These weeds are native to the American continent with large distribution in South America, especially in Brazil, and often infest annual, perennial crop areas and pastures (Inoue et al., 2012).

Total accumulated dry matter of the infesting community increased during the experimental period, reaching 1235.0 g m^{-2} at 90 DAR, approximately four times over that found at 15 DAR. This demonstrates the rapid initial development of weeds and may indicate possible competition with forage plants for common resources such as water, sunlight and nutrients (Figure 1).

The HYPSU species exhibited the highest amount of dry matter and rapid development at 30 DAR, achieving a DM accumulation over 1000.0 g m^{-2} at 90 DAR (Figure 1). This species is an excellent competitor in areas with minor disturbance such as pastures, as it can reach two meters in height, form dense clusters and be a dominant plant over other neighboring species, which can be attributed to its rapid vegetative growth and high survivability in the early stages of development (Inoue et al., 2013; Islam, Ohno, Suenaga, & Kato-Noguchi, 2014).

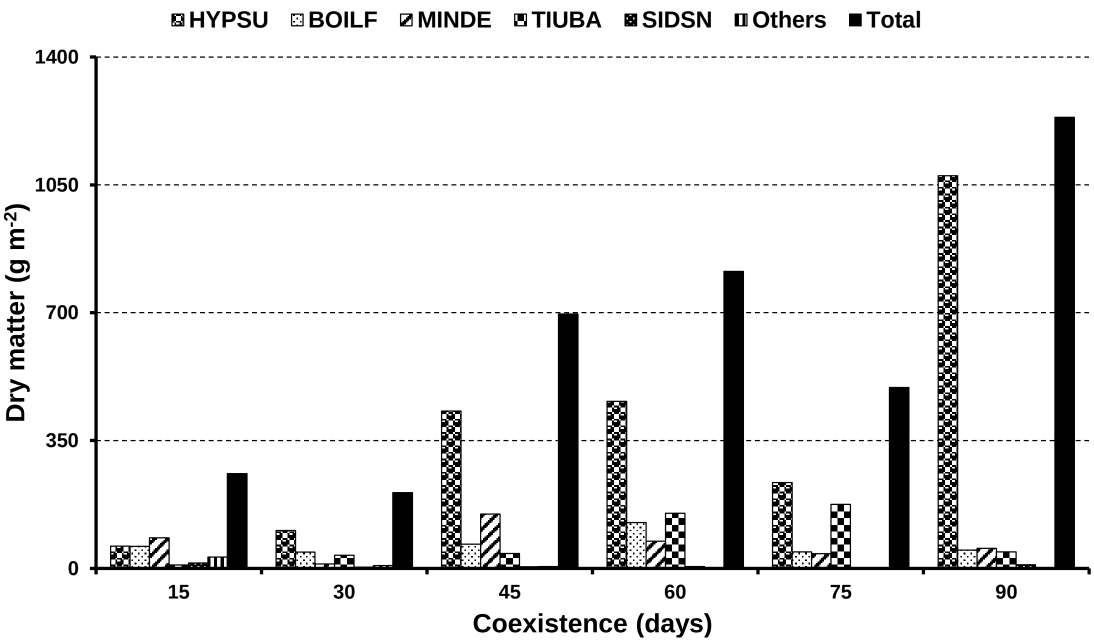

Figure 1. Accumulated dry matter (g m^{-2}) of weed plants during the experimental period. HYPSU - *Hyptis suaveolens*. BOILF - *Spermacoce latifolia*. MINDE - *Mimosa debilis*. TIUBA - *Triumfetta bartramia*. SIDSN - *Sida santaremnensis*.

The phytosociological study indicated that the species BOILF achieved the highest percentages of relative importance (28.2 – 33.0%) until 30 DAR. The species HYPSU exhibited increasing rates of relative importance (16.8 – 53.3%) surpassing the species BOILF in terms of importance at 45 DAR (Figure 2). These results are similar to the ones found in phytosociological studies conducted by Marchi et al. (2017), Marques et al. (2019) and Meurer et al. (2020), in which the species HYPSU and BOILF were among the main species found in the infesting community, achieving high rates of relative importance.

The species MINDE and TIUBA exhibited intermediate relative importance, with values ranging from 4.6 to 25.5% and 3.3 to 32.6%, respectively (Figure 2). Marchi et al. (2019) highlight the importance of the presence of weeds with structures that cause animal discomfort, such as MINDE, which has a great number of thorns on their branches, preventing animals to graze in close proximity to these plants and/or causing injuries.

The other species exhibited RI values below 10% in all periods studied (Figure 2). However, this does not mean that these species have not competed for common resources in the area, seeing that they participated in the plant community as a whole.

In the absence of interspecific competition, *U. ruziziensis* exhibited a statistically higher tiller height. There was a 26% reduction if we compare the periods of 0 and 90 days of coexistence with the infesting community (Table 2).

Controlling the forage canopy structure is vitally important in animal grazing systems because it influences and determines the partial efficiency standards of the system such as growth, utilization and conversion (Paula et al., 2012).

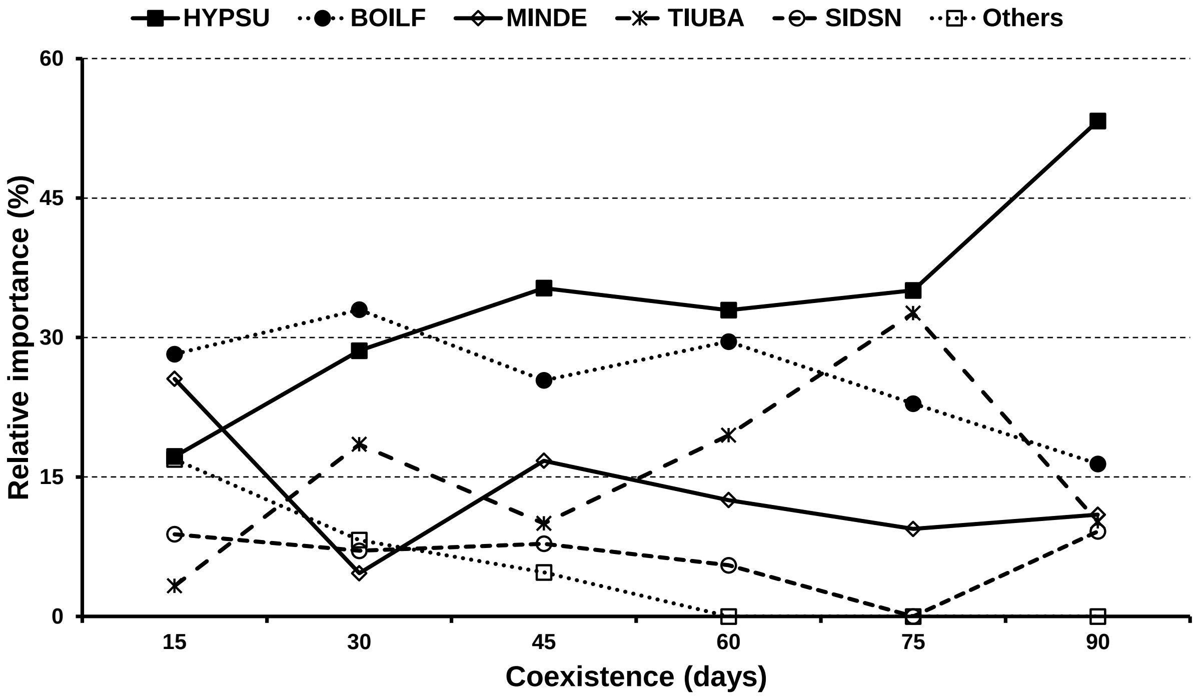

Figure 2. Relative importance (%) of the infesting community during the respective periods of coexistence. HYPSU - *Hyptis suaveolens*. BOILF - *Spermacoce latifolia*. MINDE - *Mimosa debilis*. TIUBA - *Triumfetta bartramia*. SIDSN - *Sida santaremnensis*.

Coexisting with the infesting community diminished significantly the number of green leaves per tiller after 15 days of interaction, with an approximate reduction of 60% in the comparison of the periods of 0 and 90 days (Table 2). The number of green leaves per tiller represents one of the major morphogenic characteristics that change the leaf area index, i.e., the leaf area available for intercepting sunlight per unit of ground area and, consequently, the green material that will be consumed by animals when grazing (Casagrande et al., 2010).

The tiller stem diameter had a significant difference only for the 90-day treatment. Although the treatments did not exhibit a statistically significant difference for the first green leaf height (Table 2), the ratio of the first green leaf height to the tiller height (FGLH:TH) increased linearly as the coexistence periods increased (Figure 3).

The presence of weeds may cause shading of the forage plants, generating competition for light and causing a sharp stalk growth and senescence of the lower leaves. This is an adaptive response of shade-grown plants and a strategy to compensate for reduced sunlight (Paciullo et al., 2011; Faria, Morenz, Paciullo, Lopes, & Gomide, 2018). In grass plants, this mechanism is an attempt to provide a better distribution of sunlight over the canopy (Reis et al., 2013).

Changes in the morphogenic structure of *U. ruziziensis* can also be seen in the ratio of leaf dry matter to stem (leaf:stem), which in this study decreased following quadratic proportions as the period of coexistence with weeds increased (Figure 4).

Table 2. Tiller structural variables in *Urochloa ruziziensis* pasture based on increasing periods of coexistence.

Coexistence (days)	Tiller height (cm)	NGLT\1	Diameter (mm)	FGLH\2 (cm)
0	213.2 a	13.6 a	3.36 a	106.6
15	167.1 b	10.3 b	3.42 a	93.1
30	173.9 b	10.0 b	3.11 a	114.9
45	175.7 b	9.8 b	3.31 a	99.8
60	167.0 b	8.2 b	3.22 a	97.1
75	170.5 b	8.2 b	3.37 a	115.7
90	156.9 b	8.1 b	2.57 b	96.9
F Coexistence	4.14**	5.42**	6.67**	2.24^{NS}
F Blocks	0.44^{NS}	0.80^{NS}	1.36^{NS}	0.44^{NS}
C.V. (%)	11.2	17.1	7.2	11.7

\1 NGLT – Number of green leaves per tiller; \2 FGLH – First green leaf height; NS – Not significant; ** Significant at 1% probability level. Means followed by same letter in column do not differ statistically from each other by the Scott-Knott test at the level of 5% probability.

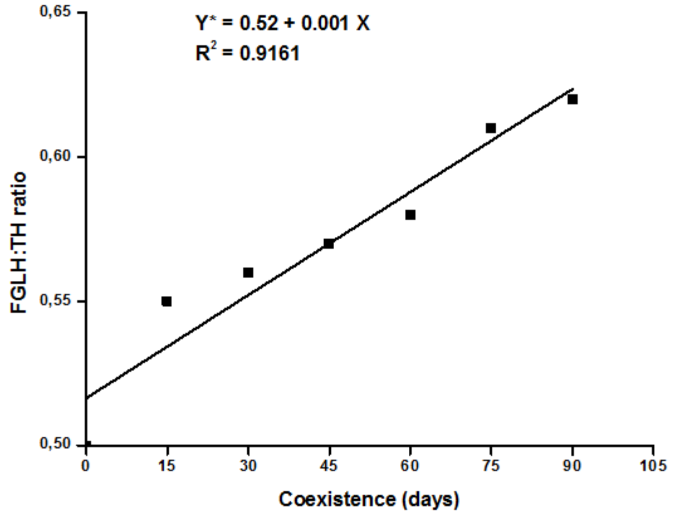

Figure 3. Ratio of first green leaf height (FGLH) to tiller height (TH) of *Urochloa ruziziensis* plants during the coexistence periods. *Significant at 5% probability.

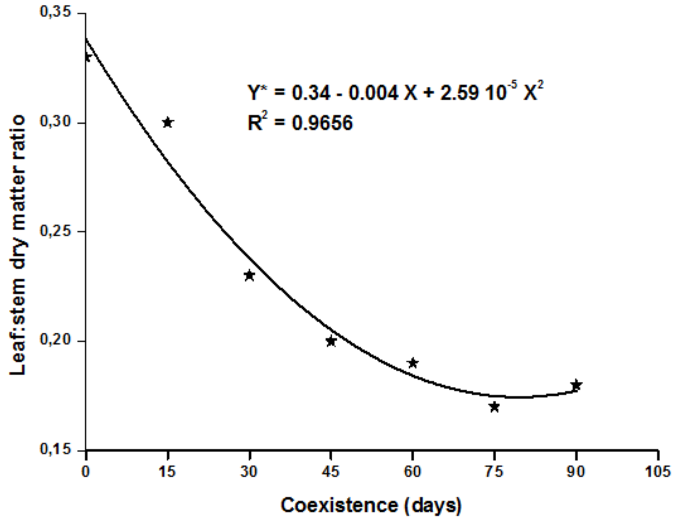

Figure 4. Dry matter ratio of leaf to stem (L:S) of *Urochloa ruziziensis* found during the periods of coexistence. * Significant at 5% probability level.

The leaf:stem ratio is a variable of great importance in animal nutrition and management of forage plants. The high leaf:stem ratio represents a higher content of crude protein, better digestibility, easier and stronger forage growth and, consequently, more consumption. In the opposite direction, the lower leaf:stem ratio results in higher levels of fibrous carbohydrates that are difficult to digest and, consequently, more losses of the energy consumed from food and a higher production of methane and carbon gas by the animals' digestive tract (Bellé et al., 2018; Meurer et al., 2020).

The changes in the morphogenic structure of *U. ruziziensis* caused by the coexistence with weed plants had an effect on the productive variables of this forage plant. The number of tillers per plant changed significantly after 30 days of coexistence, with a reduction of more than 64% when compared with the periods of 0 day (control) and 90 days of coexistence (Table 3). It should be noted that tillering is a predominant characteristic of most grass plants, and in pastures the success of production is associated with good tillering and consequent occupation of the spaces between plants, hindering the establishment of weed species (Bauer et al., 2011; Paula Neto et al., 2014; Santos et al., 2014).

Green leaf dry matter had a significant reduction after 30 days coexisting with weed plants, with a sharp drop in leaf production after 45 days (Table 3). Oliveira et al. (2016) state that green leaf is the morphological component that provides the best palatability to animals because of its good digestibility, accessibility, and lower resistance. Thus, a reduction in this component results in a smaller portion of the food in the the animal's mouth and may raise the grazing time (Carloto et al., 2011; Paula et al., 2012).

Green stem dry matter changed significantly after 15 days of coexistence, indicating 16% reduction compared to the control period. For dry matter of dead matter, the reduction observed between the control treatment and the 90-day treatment was around 75% (Table 3).

The weed plants also influenced negatively total dry matter production, as it decreased proportionally to the increasing coexistence periods. The longest interference period (90 days) yielded an accumulated dry matter of 1838.0 g m-2, a reduction of approximately 61% in relation to the control period (Table 3).

It is noteworthy that the main method of control of broadleaf weed plants in pastures is the application of specific selective herbicides. This represents a significant operational expense. But this study indicates a possible reduction in the quantity of pasture grass produced as a result of weed infestation, and this fact may aid farmers' decision to control weeds or let them grow.

However, it seems that if weed plants are not controlled as early as possible, it would not be advisable to control them to minimize effects on forage production in that season, because even if removed, weed competition would likely cause a depressive effect on maximum production (Marchi et al., 2017; Marques et al., 2019) and a reduction of the nutritional quality of forage plants (Bellé et al., 2018), in addition to contributing to the production of greenhouse gases (Lourenço, Mota, Sanches, Marques, & Marchi, 2019; Marchi et al., 2019b; Meurer et al., 2020).

Table 3. Productive components of the *Urochloa ruziziensis* canopy according to increasing coexistence periods.

Coexistence (days)	NTP\1	GLDM\2 (g m^{-2})	GSDM\3 (g m^{-2})	DMDM\4 (g m^{-2})	TDM\5 (g m^{-2})
0	24.5 a	495.0 a	1635.0 a	890.0 a	3020.0 a
15	26.5 a	465.0 a	1375.0 b	810.0 a	2650.0 b
30	16.0 b	321.0 b	1385.0 b	565.0 b	2271.0 c
45	14.0 b	237.0 c	1240.0 c	555.0 b	2032.0 d
60	14.5 b	220.0 c	1115.0 c	515.0 b	1850.0 d
75	13.0 b	218.0 c	1215.0 c	460.0 b	1893.0 d
90	8.8 b	207.0 c	750.0 d	225.0 c	1182.0 e
F Coexistence	11.26**	69.13**	24.28**	49.80**	86.33**
F Blocks	2.27^{NS}	2.79^{NS}	2.66^{NS}	0.13^{NS}	2.94^{NS}
C.V. (%)	22.8	9.6	8.9	10.9	6.0

\1 NTP – Number of tillers per plant; \2 GLDM Green leaf dry matter; \3 GSDM – Green stem dry matter; \4 DMDM – Dry matter of dead matter; \5 TDM – Total dry matter. ^{NS} – Not significant; ** Significant at 1% probability level. Means followed by same letter in column do not differ statistically from one another by the Scott-Knott test at 5% probability.

Thus, it is suggested to adopt control measures up to 17 days of coexistence, corresponding to the period prior to interference (PPI), considering a tolerable loss of 5% in the yield of green leaf dry biomass (Figure 5).

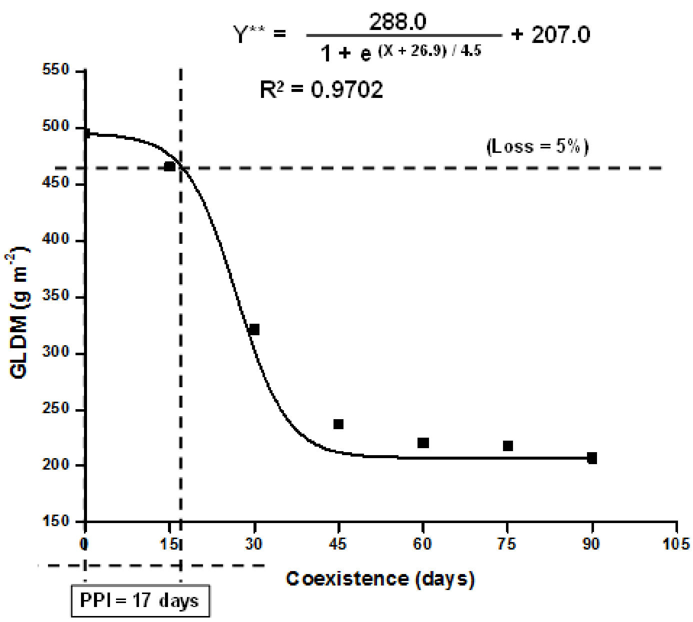

Figure 5. Period prior to interference (PPI) as a function of the increasing interaction periods, considering as acceptable losses 5% of yield of green leaf dry biomass compared to the control. ** Significant at 1% probability.

Conclusion

The number of green leaves per tiller and the tiller height diminish as the period of coexistence with weed plants increases.

All productive components of *Urochloa ruziziensis* diminish as the period of coexistence with weed plants increases.

The ratio of the first green leaf height to tiller height increases linearly, while the leaf to stem ratio diminishes quadratically as the coexistence period with the infesting community increases.

Green leaf dry matter of *Urochloa ruziziensis* is negatively affected after 17 days of coexistence with weeds.

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