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Article

WEED INTERFERENCE IN THE ESTABLISHMENT OF *Urochloa ruziziensis*

Interferência de Plantas Daninhas no Estabelecimento de ***Urochloa ruziziensis***

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ABSTRACT - This research aimed to study weed interference relationship on morphogenesis, yield, and greenhouse gas production potential of *Urochloa ruziziensis* under pasture renovation conditions. The experimental design was a randomized block design with four replications. Treatments consisted of seven coexistence periods: 0, 15, 30, 45, 60, 75, and 90 days after emergence (DAE). The following morphological parameters were analyzed: number of tillers, number of leaves, photosynthetically active leaf blade biomass, fresh stem biomass, dead material biomass, and total dry biomass. In vitro analyses of methane (CH_4) and carbon dioxide (CO_2) production were also carried out. The results were submitted to analysis of variance by the F-test, and the test of means was carried out by the Scott-Knott test at 5%. Biomass, CH_4, and CO_2 production of *U. ruziziensis* were modified with only 15 days of weed coexistence, with an effect even higher from 45 DAE. Therefore, weeds interfere with all morphological parameters, yield, and greenhouse gas production in the pasture establishment with the forage grass *U. ruziziensis*.

Keywords: pasture renovation, weed competition, morphogenesis, carbon dioxide, methane.

RESUMO - Objetivou-se neste trabalho estudar a relação de interferência de plantas daninhas sobre a morfogênese, produtividade e potencial de produção de gases de efeito estufa de ***Urochloa ruziziensis*** *em condições de renovação de pastagem. O delineamento experimental foi em blocos ao acaso, com os tratamentos constando de sete períodos de convivência (0, 15, 30, 45, 60, 75 e 90 dias após a emergência - DAE), com quatro repetições. Foram realizadas análises dos parâmetros morfológicos: número de perfilho, número de folhas, biomassa de lâmina foliar fotossinteticamente ativa, biomassa de caule verde, biomassa de matéria morta e biomassa seca total. Também foram realizadas análises in vitro de produção dos gases metano (*CH_4*) e dióxido de carbono (*CO_2*). Os resultados foram submetidos à análise de variância pelo teste F, e para os testes de média utilizou-se Scott-Knott a 5%. A produção de biomassa, de* CH_4 *e* CO_2 *de* ***U. ruziziensis*** *foi alterada logo aos 15 dias de convivência com as plantas daninhas, havendo efeito ainda maior a partir de 45 DAE. Conclui-se que as plantas daninhas interferem em todos os parâmetros morfológicos, na produtividade e na produção de gases de efeito estufa na implantação de pastagem com a gramínea forrageira* ***Urochloa ruziziensis****.*

Palavras-chave: renovação de pastagem, matocompetição, morfogênese, dióxido de carbono, metano.

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INTRODUCTION

Grasses of the genus *Urochloa* are widely adapted to climate and soil conditions characteristic of the Cerrado region, being used for pasture-fed cattle (Silva and Ferrari, 2012). In agriculture, the genus *Urochloa* has been used as soil cover plants after harvesting summer crops. This genus presents a good capacity of plant biomass production even under periods of water scarcity (Machado and Assis, 2010).

Despite the ability to grow in the dry season, the genus *Urochloa* may present a low production due to weed competition. Weed-infested pastures are commonly found due to the lack of management at an appropriate time or weed reinfestation after control (Dias Filho, 2011).

Ineffective weed control has a negative influence on *Urochloa* pasture production because the production of tillers, biomass, and other forage components are modified, resulting in a low nutritional quality of forage (Marchi et al., 2017).

The decrease in nutritional quality results in an increase in greenhouse gas (GHG) production by cattle that consume it. According to the Food and Agriculture Organization of the United Nations - FAO (2013), GHG production by cattle is closely related to the nutritional quality of ingested feed.

The decrease in nutritional quality not only leads to an increase in gas production but also influences the time the animal remains at grazing. According to Zotti and Paulino (2009), ruminants lose 4.0 to 12% of the ingested crude energy in the synthesis and emission of methane. In other words, the energy that should be used for meat production is lost and thus the animal takes longer to reach the slaughter weight.

Considering this problem, this research aimed to study the weed interference relationships on pasture renovation, quantifying the effect of increasing coexistence periods with the weed community on the morphogenesis, greenhouse gases production, and yield of *Urochloa ruziziensis*.

MATERIAL AND METHODS

The experimental phase was conducted in Barra do Garças, MT, Brazil, whose geographical coordinates are 15°52´29" S and 52°18´37" W, average altitude of 350 meters, Aw climate according to Köppen and Geiger classification (1928). The experiment was carried out from November 2015 to February 2016. The accumulated precipitation in this period was 1,140.6 mm, and the mean maximum and minimum temperatures of 34 and 23 °C, respectively (Figure 1).

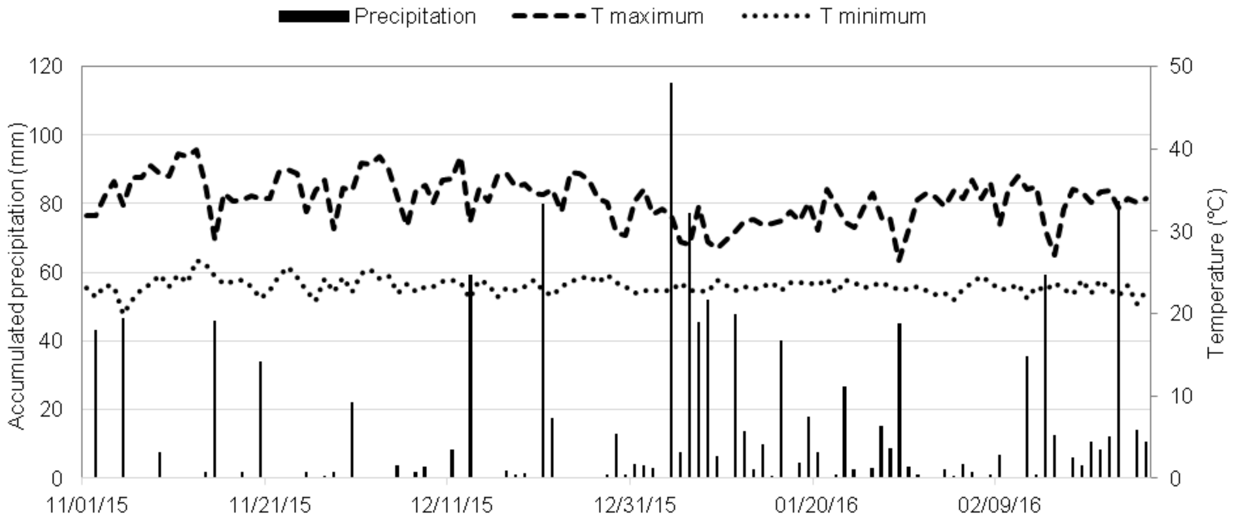


Figure 1 **-** Minimum and maximum temperature (°C) and precipitation (mm) during the period from November 2015 to February 2016 in Barra do Garças, MT, 2015/2016.

The research was conducted in a renovation area with a history of high infestation of broadleaf weeds, where the existing vegetation was eliminated with glyphosate application at a dose of 3.0 L ha^{-1} and subsequent harrowing for the total elimination of plant remains.

Composite samples of Red-Yellow Latosol were collected and sent for laboratory analyses, and their chemical and physical characteristics are presented as follows: pH in $CaCl_2$ of 4.3; organic matter of 22.0 g dm^{-3}; P resin of 3.8 mg dm^{-3}; V of 23.50%; K, Ca, Mg, and H+Al of 0.15, 0.66, 0.42, and 4.0 $cmol_c$ dm^{-3}, respectively; and sand, silt, and clay of 692, 97, and 211 g kg^{-1}, respectively, which characterizes it as sandy texture.

Correction of soil acidity and fertility was performed according to recommendations of Vilela et al. (2003), consisting of 2,000 kg ha^{-1} of limestone, with subsequent harrowing for its incorporation, aiming at raising base saturation to 50%, and 250 kg ha^{-1} of the formulation 5-25-15 (N-P_2O_5-K_2O), distributed manually on the soil surface.

Sowing of *U. ruziziensis* was performed at the beginning of the rainy season with a knapsack granule distribution machine adjusted to apply the equivalent of 8.0 kg ha^{-1} of seeds. After that, seeds were manually incorporated into the soil at a mean depth of 2.0 cm with rakes. Seeds with germinative vigor and purity of 60% were used.

The experimental design was a randomized block design with four replications. Treatments consisted of seven coexistence periods between the weed community and forage grass (0, 15, 30, 45, 60, 75, and 90 days after plant emergence - DAE). The period equivalent to 0 DAE was considered as absolute control, in which there was a total absence of coexistence between weeds and forages during the entire experimental period. At the end of each coexistence period, weed community was removed from the plot by applying 1.5 L ha^{-1} of an herbicide formulated with 40 g a.e. L^{-1} of aminopyralid acid + 320 g a.e. L^{-1} of 2,4-D applied in plant post-emergence. Sprayings were carried out whenever necessary with a CO_2-pressurized research sprayer containing a boom with four flat spray tips XR 11002 calibrated for a spray solution volume equivalent to 200 L ha^{-1}.

The characterization of the weed population was performed in plots characterized by the end of the coexistence period. The species of the weed community inside the randomly placed squares were identified, numerically quantified, and taken to the laboratory, where they were washed, individually packaged, and dried in a forced air circulation oven at 65 ^oC until reaching constant weight. After this procedure, the shoot dry biomass of the species collected was weighed on a 0.01 g precision scale.

The relative importance of each species was obtained from the number of individuals and dry biomass, as proposed by Mueller-Dombois and Ellemberg (1974).

The effect of coexistence periods was evaluated at the end of the experimental period, i.e., at 90 DAE. At that time, the mean canopy height and the number of tillers per plant were obtained. After that, samples were collected by cutting the forage at the height of 10 cm above the soil and within the area delimited by a 0.5 x 0.5 m polyethylene square, which was randomly placed in the experimental unit. These samples were sent to the laboratory and fractionated into the fresh leaf blade, fresh stem, and dead material. Inflorescences eventually present were considered as the fresh stem. Dry biomass of each fraction was also obtained according to the methodology previously described for weeds.

The results of dry biomass of fractions were used to estimate the yield parameters of the forage grass, namely: fresh leaf dry biomass (FLDB), fresh stem dry biomass (FSDB), dead material dry biomass (DMDB), and total dry biomass (TDB), all expressed in t ha^{-1}. The values of FLDB and mean forage canopy height were used as the basis to estimate the fresh leaf volumetric density (FLVD) (in g m^{-3}), which is considered an indication of nutritional quality of forage grasses.

Also at 90 DAE, 20 tillers from each plot were randomly collected to measure the influence of weeds on tiller height, first leaf height, tiller diameter, and the number of fresh leaves. These tillers were fractionated into fresh leaf and stem, being washed, packaged, dried in a forced air circulation oven, and weighed, according to the methodology above. The results of the first fresh leaf height and total stem height were used to determine the relationship between the first leaf height and stem height, while the results of fresh leaf dry biomass and stem biomass were used to determine the leaf to stem ratio.

Forage samples were collected at 90 DAE for analyzing the in vitro production potential of methane and carbon dioxide. This collection was carried out randomly within each experimental unit using a 0.50 x 0.50 m polyethylene square. These samples were taken to the laboratory, packed, and dried in a forced air circulation oven at 65 °C until constant weight. Subsequently, the samples were ground to reach a particle size of 1.0 mm using a Willey knife mill. The samples were then packed, labeled, and sent to the Animal Unit for Digestive and Metabolic Studies and Laboratory of Analysis of Ingredients and Pollutant Gases (LIGAP), both belonging to the Department of Animal Science of the School of Agricultural and Veterinary Studies of the São Paulo State University - Jaboticabal campus.

Ruminal contents of four animals with a ruminal cannula fed a basal diet of corn silage (80%), ground corn, and soybean meal (20%) were used.

Ruminal content samples (200 mL from each animal) were collected three hours after feeding. The contents were filtered and ruminal fluids were mixed and added to the McDougall buffer solution at a 1:2 ratio. A sample of 0.2 g (1.0 mm) from each diet was weighed into glass vials with a 50 mL capacity, being added 30 mL of buffer solution + ruminal fluid. The vials were purged with hydrogen, sealed with a septum cap, and incubated in a Shaker bench equipment at 39 °C and stirring for 24 hours.

The in vitro gas production potential was measured using a digital pressure meter coupled to a needle. At the end of the test, the vials were placed on ice to stop the microbial activity, and samples of the produced gas were collected and analyzed for CH_4 and CO_2 concentrations on a gas chromatograph (Trace GC UltraTM, Thermo Scientific) equipped with a Porapak column and molecular sieve. The oven temperature was set to 70 °C and an injector temperature of 110 °C. Argon was used as a carrier circulation flow of 25 mL min^{-1}. The conversion of pressure into gas volume was performed using the following equation:

$$Vx = Vj \times Ppsi \times 0.068$$

where Vx is the gas volume at 39 °C (mL), Vj is the space between the solution and the cap of each vial (mL), and $Ppsi$ is the cumulative pressure observed after incubation.

The total gas production (CH_4 and CO_2) was estimated in mL per gram of incubated sample.

All the obtained data were submitted to analysis of variance by the F-test using the statistical program AgroEstat (Barbosa and Maldonado Júnior, 2015). The effects of treatments were compared by the Scott-Knott test at 5% probability. The first fresh height to stem height and leaf to stem ratios were used for polynomial regression analysis. The period before interference (PBI) was determined as a function of biomass production and methane production potential, according to the methodology proposed by Kuva et al. (2001).

RESULTS AND DISCUSSION

Ten weed species were found during the experimental period, all of them from the botanical class eudicotyledonous (Table 1). The most important species oval-leaf false buttonweed (*Spermacoce latifolia* Aubl.), caesarweed (*Urena lobata* L.), and uhaloa (*Waltheria americana* L.).

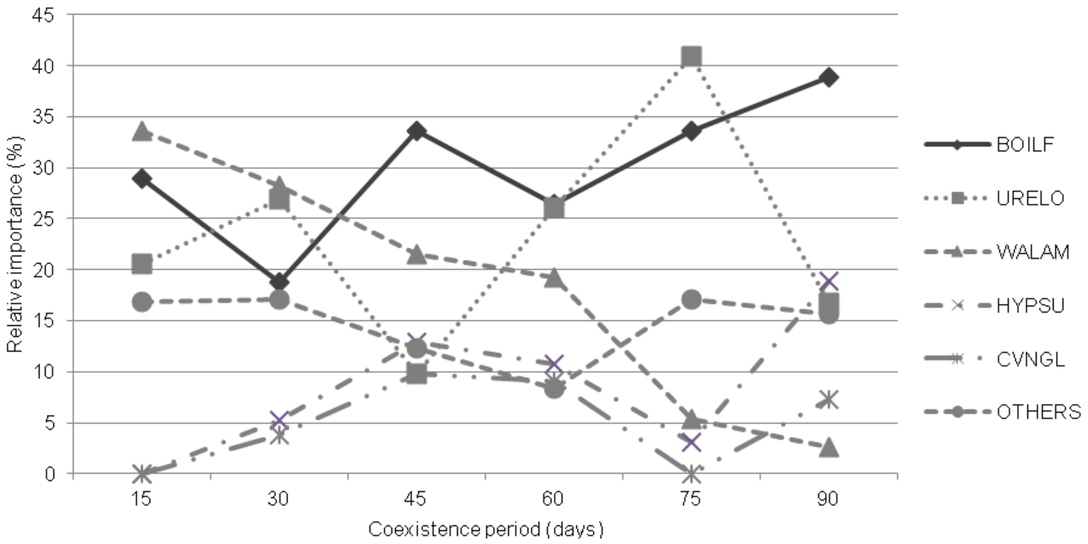
Regarding the relative importance (Figure 2), oval-leaf false buttonweed (BOILF), uhaloa (WALAM), and caesarweed (URELO) stood out. Oval-leaf false buttonweed presented the highest RI at 45 and 90 DAE, with values of 34 and 39%, respectively. At 15 and 30 DAE, uhaloa had a RI of 34 and 28%, respectively. At 75 DAE, the highest RI was observed for caesarweed, with a value of 41%.

This variation in relative importance may be related to the precipitation, i.e., the amount of water available in the environment favored plant development, which changed the number of times the species occurred and increased dry biomass accumulation. Therefore, periodic monitoring during the rainy periods is necessary for effective weed control.

Weed dry biomass (Figure 3) increased according to the coexistence period with *U. ruziziensis*. The highest biomass accumulation at 15, 30, 60, and 75 DAE was observed for caesarweed (URELO), with values of 20, 87, 168, and 310 g m^{-2}, respectively, and for pignut (HYPSU) at 45 and 90 DAE,

Table 1 **-** Scientific, common names and international weed codes present in the experimental area. Barra do Garças/MT, 2016

Scientific name	Common name	International code	Family
	Eudicotyledonous		
Croton glandulosus L.	Vente conmigo	CVNGL	Euphorbiaceae
Senna obtusifolia (L.) H.S. Irvin & Barneby	Sicklepod	CASOB	Fabaceae
Glycine wightii (Wight & Arn.) Verdc.	Wight's neonotonia	GLIWI	
Mimosa debilis L.	Mimosa	MINDE	Mimosoideae
Hyptis suaveolens (L.)	Pignut	HYPSU	Lamiaceae
Diodella teres (Walter) Small	Poorjoe	DIQTE	Rubiaceae
Spermacoce latifolia Aubl.	Oval-leaf false buttonweed	BOILF	
Sida santaremnensis Monteiro	Sida	SIDSN	Malvaceae
Waltheria americana L.	Uhaloa	WALAM	
Urena lobata L.	Caesarweed	URELO	



SIDSN - *Sida santaremnensis*. CASOB - *Senna obtusifolia*. BOILF - *Spermacoce latifolia*. URELO - *Urena lobata*. WALAM - *Waltheria americana*. HYPSU - *Hyptis suaveolens*. MINDE - *Mimosa debilis*. DIQTE - *Diodella teres*. CVNG - *Croton glandulosus*.

Figure 2 **-** Relative Importance (%) of weed community in the respective coexistence periods (days). Barra do Garças, MT, 2015/2016.

with values of 66 and 338 g m^{-2}, respectively. Oval-leaf false buttonweed (BOILF) presented a DM of 14, 54, 71 and 183 g m^{-2} at 15, 45, 75 and 90 DAE, respectively. Uhaloa (WALAM) had the second highest DM accumulation at 30 DAE, with a value of 42 g m^{-2}, which was reduced as the coexistence period increased. The species vente conmigo (CVNGL), wight's neonotonia (GLIWI), sida (SIDSN), and sicklepod (CASOB) had the highest dry biomass accumulation at 90 DAE, with values of 76.26, 35.11, 14.32, and 3.64 g m^{-2}, respectively. However, mimosa (MINDE) and poorjoe (DIQTE) had a higher DM accumulation at 75 DAE, with values of 8.80 and 7.70 g m^{-2}, respectively.

The species URELO, BOILF, and HYPSU are annual weeds that tend to grow faster when compared to the forage *U. ruziziensis* and the perennial species WALAM. According to Awan et al. (2014), URELO is a negative photoblastic species and presents slow germination, which are important characteristics. It may explain its expression only from 45 DAE and its highest RI at 75 DAE, competing for environmental resources even under the suppression of other species. Parreira et al. (2011) verified that BOILF has a high germination rate at a temperature range between 25 and 35 ^{o}C, i.e., the medium range found during the experimental period (Figure 1). It corroborates the obtained results, in which this species had the highest RI at 45 and 90 DAE and a relatively high biomass accumulation at 90 DAE even with a reduced size in relation to the other weeds, indicating a large number of specimens.

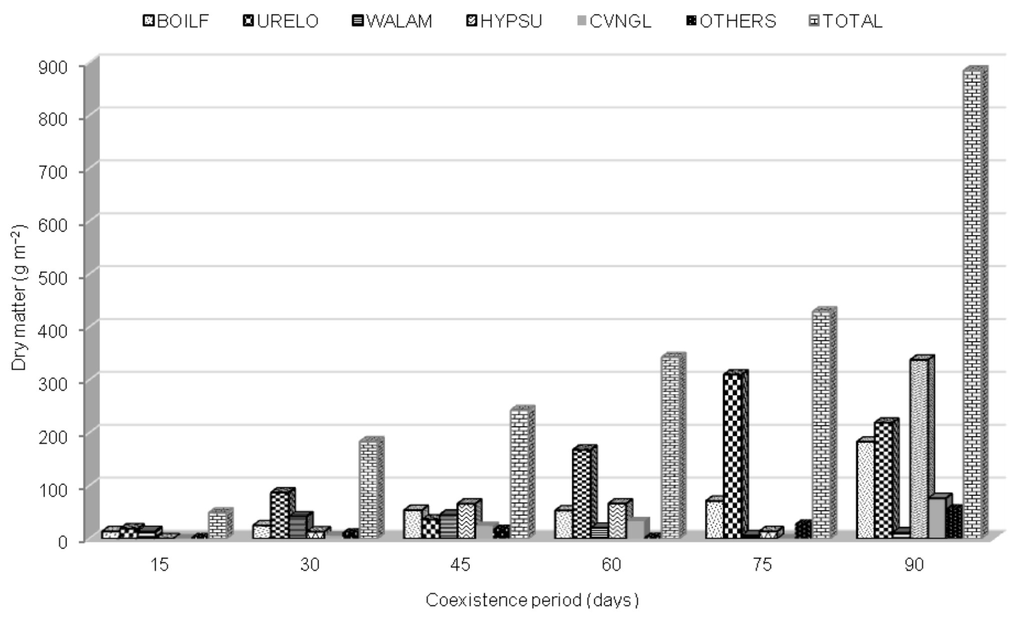


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Figure 3 **-** Dry matter (g m^{-2}) of weed community in the respective coexistence periods (days). Barra do Garças, MT, 2015/2016.

The species HYPSU presented the highest dry biomass accumulation and the second highest RI only at 90 DAE, which is similar to that found by Gravena et al. (2002). These authors stated that this species could be considered a late growth plant in the cycle of annual crops due to its slow initial growth and high dry biomass accumulation at the end of its cycle. Because WALAM is a perennial weed species, it presented a low DM accumulation throughout the experimental period, but the highest RI was observed at 15 and 30 DAE, indicating that this weed showed a higher and faster germination rate in relation to the other species, being suppressed during the period.

Tiller height of *U. ruziziensis* varied from 39 to 72 cm. Tiller height from 0 to 90 DAE for each coexistence period was 70, 67, 48, 44, 39, 65, and 72 cm ($p<0.05$) (Table 2), showing intra- and interspecific competition for light and space (Lorenzi, 2014).

Table 2 **-** Height and diameter of tillers, first leaf height, and number of fresh leaves obtained at 90 DAE as a function of coexistence periods with weed community. Mean of 20 tillers. Barra do Garças, MT, 2016

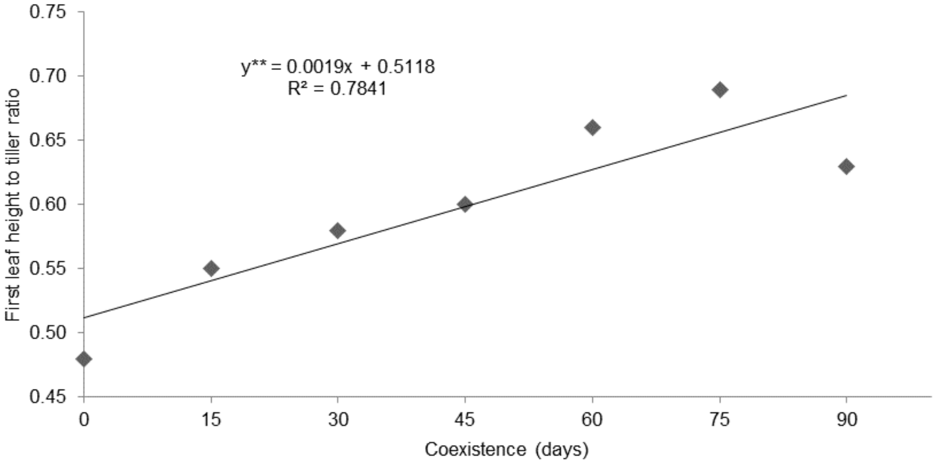
Coexistence period (DAE)	Tiller height (cm)	First leaf height (cm)	Tiller diameter (mm)	Number of fresh leaves
0	70.00 a	34.00 b	3.30 a	6.68 a
15	67.00 a	37.00 a	2.29 b	6.70 a
30	48.00 b	28.00 b	2.08 b	5.64 b
45	44.00 b	27.00 b	1.72 c	5.23 b
60	39.00 b	26.00 b	1.90 c	4.76 b
75	65.00 a	45.00 a	1.75 c	5.13 b
90	72.00 a	46.00 a	1.79 c	5.83 b
F Treatment	8.03**	6.60**	16.36**	2.73*
F Block	3.32*	3.94*	0.71^{ns}	0.53^{ns}
CV (%)	16.61	18.76	13.08	15.98
P	0.0003	0.0008	<0.0001	0.0459

** Significant at 1%; * significant at 5%; ^{ns} not significant. Means followed by the same letter in the column do not differ from each other by the Scott-Knott test at 5% probability.

The first leaf height in the tiller (Table 2) followed tiller height, i.e., it also showed a difference between coexistence periods of *U. ruziziensis* with weeds. The highest heights (37, 45, and 46 cm) were found at 15, 75, and 90 DAE, while the lowest heights (34, 28, 27, and 26 cm) were observed at 0, 30, 45, and 60 DAE.

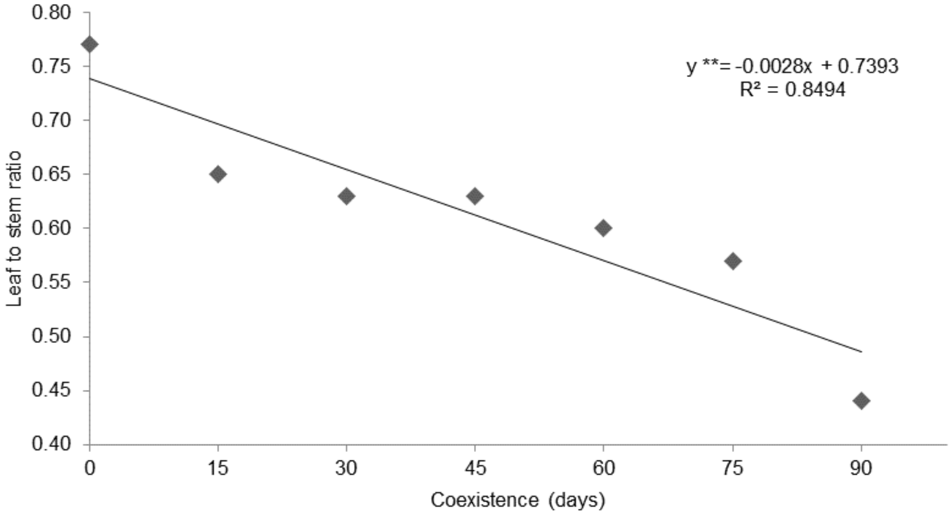
A statistical difference ($p<0.05$) was also observed for tiller diameter (Table 2). The diameter decreased as the coexistence period increased. Tiller diameter was 3.30 mm at 0 DAE, with values of 2.29, 2.08, 1.72, 1.90, 1.75, and 1.79 mm at 15, 30, 60, 75, and 90 DAE, respectively.

The variable number of fresh leaves per tiller (Table 2) differed at 0 and 15 DAE ($p<0.05$) from 30, 45, 60, 75, and 90 DAE. The first leaf height (Figure 4) presented a linear increase with the coexistence periods, with values from 0.48 m in the control to 0.55, 0.58, 0.60, 0.66, 0.69, and 0.63 m at 15, 30, 45, 60, 75, and 90 DAE, respectively. This result shows that *U. ruziziensis* was under competition for light and space, which made it etiolate in an attempt to avoid the shading caused by weeds. This increase is detrimental to pasture since the leaf to stem dry matter ratio decreases (Figure 5), i.e., the availability of easily digestible fiber decreases. According to Santos et al. (2014), competition for light and space also has a negative effect on the structural components of grass, such as height, biomass production, number of tillers, and others.



** Significant at 1% probability.

Figure 4 **-** Relationship between first fresh leaf height and tiller height of *U. ruziziensis* obtained as a function of coexistence periods. Barra do Garças, MT, 2016.



** Significant at 1% probability.

Figure 5 **-** Relationship between leaf and stem dry matter (leaf/stem) of *U. ruziziensis* obtained as a function of coexistence periods. Barra do Garças, MT, 2016.

In studies conducted on the influence of degree of shading on grasses of the genus *Urochloa*, Martuscello et al. (2009) and Paciullo et al. (2008) reported that under shading of 50 and 70% and 18 and 50%, respectively, plants etiolate as a result of the search for light and, as a consequence, they reach higher height, changing the number of tillers and the percentage of leaves, but maintaining the values for each variable at higher levels at full sun (Paciullo et al., 2008).

Pinto et al. (1994) observed that the leaf to stem ratio directly influences the nutritional value of pastures. Furthermore, Brennecke et al. (2016) reported that stem elongation results in a decrease in the nutritional value of pasture. Thus, it is necessary to seek a high leaf to stem ratio since it ensures a high protein content, digestibility, and intake, better adaptation, and tolerance to grazing (Brennecke et al., 2016).

Weeds induced changes in the forage canopy height of *U. ruziziensis*. The coexistence periods of 15, 30, and 90 DAE did not differ from the control, but a difference was observed at 45, 60, and 75 DAE ($p<0.05$). There was, again, the reaffirmation of interspecific competition. The highest values of canopy height at 0, 15, and 30 DAE were due to the lack of competition or pasture recovery after weed elimination. A high precipitation index was observed from 45 to 75 DAE (Figure 1), which favored weed development and led to forage shading. Pasture canopy height at 90 DAE was the same as that of the control, as the stem etiolated in search of light.

In this sense, Paciullo et al. (2008) observed that shading caused leaf and stem elongation of *Brachiaria decumbens*. Martuscello et al. (2009) also verified that shading increased the height of *B. decumbens* and *B. brizantha* plants.

The variable number of tillers (Table 3) showed no difference ($p<0.05$) at 15 to 60 DAE when compared to the control. However, a difference was observed at 75 and 90 DAE in relation to all other periods. Shading of weeds in the pasture may be responsible for the decreased number of tillers in the last two coexistence periods (Paciullo et al., 2008; Martuscello et al., 2009). However, shading alone is not able to influence the number of tillers (Santos, 2014), thus being competition for space and nutrients (Lorenzi, 2014).

The production of the fresh leaf (FLDB) and stem (FSDB) dry biomass (Table 3) were negatively influenced by weeds from 45 days of coexistence. From 0 to 30 DAE, fresh leaf dry biomass was higher than 3.27 t ha^{-1}, with a maximum value of 4.55 t ha^{-1}. From 45 to 90 DAE, fresh leaf production was 2.50 and 1.68 t ha^{-1}, respectively. Similarly, stem dry matter production was higher in coexistence periods from 0 to 30 DAE, with the highest and lowest values of 5.95 t h^{-1} (control) and 5.22 t ha^{-1} (30 DAE), respectively. From 45 DAE, the values were 4.02, 3.84, 4.18, and 3.81 t h^{-1}, respectively, for the increasing periods.

Table 3 **-** Canopy height, number of tillers, fresh leaf dry biomass (FLDB), and fresh stem dry biomass (FSDB) obtained at 90 DAE as a function of weed coexistence periods. Barra do Garças, MT, 2016

Coexistence period (DAE)	Canopy height (m)	Number of tillers	FLDB (t ha^{-1})	FSDB (t ha^{-1})
0	0.72 a	4.00 a	4.55 a	5.95 a
15	0.67 a	4.50 a	4.14 a	6.40 a
30	0.69 a	5.50 a	3.27 a	5.22 a
45	0.58 b	4.50 a	2.50 b	4.02 b
60	0.60 b	4.25 a	2.27 b	3.84 b
75	0.60 b	3.00 b	2.39 b	4.18 b
90	0.77 a	2.75 b	1.68 b	3.81 b
F Treatment	4.13**	4.13**	7.40**	2.70*
F Block	1.81^{ns}	1.94^{ns}	0.24^{ns}	0.04^{ns}
CV (%)	10.53	22.79	26.07	27.41
P	0.0088	0.0088	0.0004	0.0478

** Significant at 1%; * significant at 5%; ^{ns} not significant. Means followed by the same letter in the column do not differ from each other by the Scott-Knott test at 5% probability.

Because of the influence of weeds on the production of fresh leaf and stem dry matter, the total dry biomass (TDB) and fresh leaf volumetric density (FLVD) were also decreased from 45 days of coexistence with weeds (Table 4).

Table 4 **-** Dead material dry biomass (DMDB), total dry biomass (TDB), fresh leaf volumetric density (FLVD) obtained at 90 DAE as a function of weed coexistence periods. Barra do Garças, MT, 2016

Coexistence period (DAE)	DMDB (t ha^{-1})	TDB (t ha^{-1})	FLVD (g m^{-3})
0	1.77	12.27 a	329.11 a
15	1.30	11.83 a	275.94 a
30	1.96	10.46 a	224.31 a
45	1.39	7.91 b	145.75 b
60	1.62	7.73 b	138.65 b
75	1.53	8.10 b	143.98 b
90	1.40	6.90 b	128.62 b
F Treatment	0.59^{ns}	3.01*	7.59**
F Block	0.42^{ns}	0.10^{ns}	0.56^{ns}
CV (%)	39.02	26.83	29.14
P	0.7352	0.0324	0.0004

** Significant at 1%; * significant at 5%; ^{ns} not significant. Means followed by the same letter in the column do not differ from each other by the Scott-Knott test at 5% probability.

The total dry matter production (TDB) decreased by 44% when compared to the control at 90 days of coexistence. At 0, 15 and 30 DAE, TDB was 12.27, 11.83, and 10.46 t ha^{-1}, respectively. At 45, 60, 75, and 90 DAE, TDB was 7.91, 7.73, 8.10, and 6.90 t ha^{-1}, respectively. In addition to a decrease in total dry matter production, most of the biomass can be conferred to the stem, which has a poor nutritional quality (Bottega et al., 2017). The difference in FLVD production between the control and 90 DAE was 61%, i.e., FLVD was 200 g m^{-3} lower than that found in the control at 90 DAE. At 0, 15 and 30 DAE, FLVD presented values of 329, 276, and 224 g m^{-3}, differing from the other periods ($p<0.05$). For the other periods, it reached values of 146, 139, 144, and 129 g m^{-3} at 45, 60, 75, and 90 DAE, respectively. These results are similar to other found by several authors, who reported that weeds compete for nutrients, space, and light that should be made available to crops, negatively influencing their respective production (Paciullo et al., 2008; Martuscello et al., 2009; Lorenzi, 2014).

The reduction in TDB and FLVD interferes with animal grazing, as they may limit animal intake, which occurs under high accessible leaf densities (Euclides et al., 1999). Similarly, changes in canopy structure influence forage intake by the animal (Nantes et al., 2013), modifying the bite rate, which has a linear increase with an increase in forage availability (Palhano et al., 2007).

Weed control in pastures is essential to obtain a satisfactory forage production, being also an alternative for the mitigation of GHG produced by cattle on pastures (Table 5). According to FAO (2013), forage quality influences the amount of gases produced by animals. This study found results that corroborate FAO (2013) since weed coexistence not only decreases forage production but also interferes with GEE production in the animal rumen (Table 5).

Table 5 shows an increase in the amount of total gases, methane (CH_4), and carbon dioxide (CO_2) produced with only 15 days of coexistence of *U. ruziziensis* with weeds, with an increase even higher after 45 DAE.

The control provided the lowest gas production, with values of 76, 8.7, and 64 mL g^{-1} incubated DM for total, methane, and carbon dioxide production, respectively. From 15 to 45 DAE, total gas production was 89, 92, and 88 mL g^{-1} incubated DM, methane production was 9.5, 10, and 10 mL g^{-1} incubated DM, and carbon dioxide production was 77, 74, and 75 mL g^{-1} incubated DM.

For 60, 75, and 90 DAE, the increased production of total gases, methane, and carbon dioxide was even higher. At 60 days of coexistence, the total gas, CH_4, and CO_2 production was 101, 11, and 85 mL g^{-1} incubated DM, respectively. At 75 days, it was 99.42, 11.27, and 82.5 mL g^{-1} incubated DM, respectively, while at 90 days, it was 101, 12 and 89 mL g^{-1} incubated DM.

Table 5 **-** Production potential of the greenhouse gases methane (CH_4) and carbon dioxide (CO_2) obtained at 90 DAE as a function of weed coexistence periods. Barra do Garças, MT, 2016

Coexistence period (DAE)	Total gas (mL g^{-1} incubated DM)	CH_4 (mL g^{-1} incubated DM)	CO_2 (mL g^{-1} incubated DM)
0	75.92 c	8.69 b	64.47 c
15	89.48 b	9.52 b	77.01 b
30	92.43 b	10.23 b	73.62 b
45	88.73 b	10.08 b	75.10 b
60	101.12 a	10.93 a	85.14 a
75	99.42 a	11.27 a	82.53 a
90	101.66 a	11.81 a	88.67 a
F Treatment	10.45**	7.69**	21.57**
F Block	1.77^{ns}	0.93^{ns}	2.76^{ns}
CV (%)	6.12	7.44	4.49
P	< 0.0001	0.0003	<0.0001

** Significant at 1%; * significant at 5%; ^{ns} not significant. Means followed by the same letter in the column do not differ from each other by the Scott-Knott test at 5% probability.

Ribeiro (2014) studied the total gases emission (in vitro) in leaves of the grasses *U. brizantha* cv. Marandu, *U. brizantha* cv. Xaraés, and *U. hibrida* cv. Mulato and obtained values of 202.97, 202, 19 and 192.3 mL g^{-1} dry matter during 24 hours of incubation, respectively. It shows that the variation in GHG production may vary according to the species and cultivars and not only as a function of the presence or absence of weeds.

The mitigation of gas production by weed control, besides being positive in the environmental point of view, is also positive in the increase of animal production. According to Johnson and Ward (1996) and Johnson and Johnson (1995), methane production leads to a loss of 2 to 12% of gross energy intake. When the diet is composed exclusively by forage or forage is equivalent to 80% of the total ingested by the animal, this loss decreases to 8.1 and 2.1% of gross energy intake (Harper et al., 1999). Thus, the better the pasture quality is, the lower the loss of energy for methane production and, therefore, the better the production rates.

Energy losses for GHG synthesis directly influence the time the animal is at grazing because the energy spent would be used for meat production and not for CH_4 and CO_2 production. Also, due to the lower nutritional quality of forage, the animal bite rate increases (Brâncio et al., 2003), and consequently, the higher the energy expenditure and the lower the feed conversion.

Therefore, in order to avoid losses in biomass production, especially in *U. ruziziensis* quality, it is necessary to control weeds as early as the first days. The period before interference (PBI) is 22 days for biomass production and seven days for methane (forage quality), both considering a 5% loss of forage production (Figures 6 and 7).

In this case, there are two periods before interference (PAI) for *U. ruziziensis*: one for biomass and another for methane production, the latter an indicator of quality, as several authors have reported a link between GHG production and forage quality (Johnson and Johnson,1995; Johnson and Ward, 1996; Haper et al., 1999; Ribeiro, 2014).

Jakelaitis et al. (2010) found a similar result, in which the period before interference for *U. brizantha* was nine days, with a biomass reduction of 40% if the control is not carried out at an appropriate time. These authors also reported that this moment is the best to control weeds since they are still under development and, consequently, more susceptible to herbicides.

Controlling weeds is of paramount importance for pasture production in Brazil, which must be carried out at an appropriate time. It can avoid losses in forage yield (number of tillers, volumetric density, and better leaf, stem, and total biomass ratio), increase forage used by animals (lower loss of gross energy intake), and mitigate GHG emission by ruminants, significantly contributing to cattle production on pastures and hence economic returns to the producer.

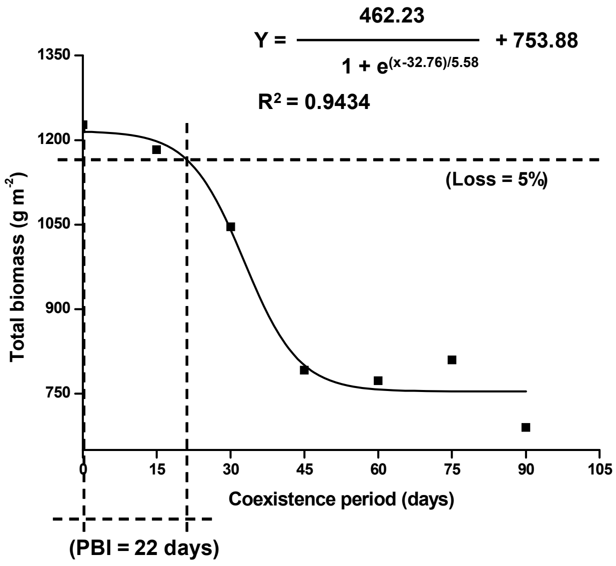


Figure 6 - Period before interference (PBI) for biomass production obtained as a function of increasing coexistence periods (days). Barra do Garças, MT, 2016.

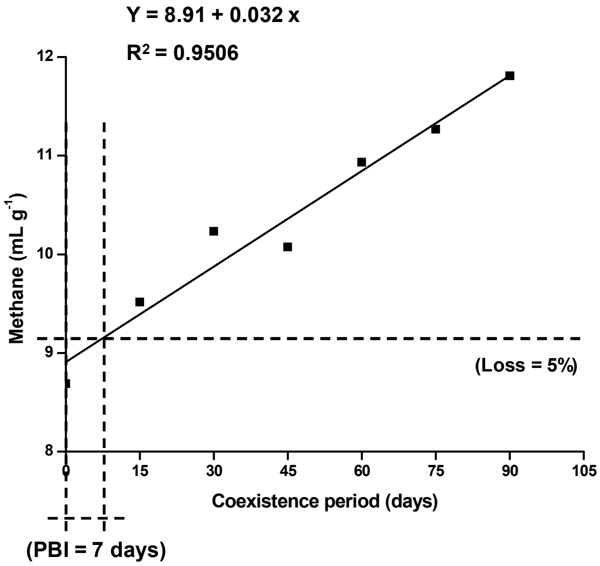


Figure 7 - Period before interference (PBI) for methane production obtained as a function of increasing coexistence periods (days). Barra do Garças, MT, 2016.

Under the conditions in which this study was conducted, we can conclude that:

- The coexistence of *U. ruziziensis* with weeds is detrimental to all morphological parameters and dry biomass production.
- The increase in the coexistence period leads to an increase in greenhouse gas production potential.
- The period before interference (PBI) for *U. ruziziensis* is 22 days for total biomass production.
- The period before interference (PAI) for *U. ruziziensis* is seven days for the potential production of the greenhouse gas methane (CH_4).

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