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Article

INTERCROPPING BETWEEN CORN AND *Urochloa brizantha* MANAGED WITH MESOTRIONE UNDERDOSES

*Consórcio entre Milho e **Urochloa brizantha** Manejada com Subdoses de Mesotrione*

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ABSTRACT - Corn and forage intercropping system has been commonly used for pasture establishment or renewal. In addition, the use of reduced doses of herbicides selective to corn has facilitated coexistence by reducing competitiveness against forage species. This study aimed to evaluate the effects of mesotrione underdoses in a corn and *Urochloa brizantha* intercropping on weed population dynamics, corn yield, and forage performance and nutritional quality. For this purpose, five mesotrione doses were tested (0.0, 9.6, 19.2, 38.4, and 57.6 g ha^{-1}) in corn and forage intercropping and monocultures. Individual density and weed dry matter were influenced by mesotrione doses, intercropping, and precipitation distribution over the evaluated period in the intercropping and pasture. In intercropping, *Alternanthera tenella* and *Commelina benghalensis* were the most important species because they could not be controlled by the herbicide. After intercropping, *A. tenella* and *C. benghalensis* presented higher relative importance (RI) in the formed pasture during the rainy season, while *Conyza bonariensis* and *A. tenella* presented the highest RI during the dry season. Corn grain yield was not affected by the presence of grass, but forage yield was affected by the competition with corn. Mesotrione doses did not affect the yield and nutritional quality of the forage. The effects on mineral matter, crude protein, and acid detergent fiber in the forage were due to the coexistence with corn when compared to the control grown in monoculture.

Keywords: *Zea mays* L., competition, herbicide, crop-livestock integration, weeds.

*RESUMO - Consórcios entre a cultura do milho e espécies forrageiras são comumente utilizados para a implantação ou renovação de pastagens. O uso de doses reduzidas de herbicidas seletivos ao milho tem facilitado a convivência pela redução da competitividade das espécies forrageiras. Objetivou-se avaliar nesta pesquisa os efeitos de subdoses de mesotrione no consórcio entre milho e **U. brizantha** sobre a dinâmica populacional de plantas daninhas, rendimento do milho e desempenho e qualidade nutricional da forrageira. Utilizaram-se cinco doses de mesotrione (0; 9,6; 19,2; 38,4; e 57,6 g ha^{-1}), mais o milho e a forrageira cultivados solteiros. A densidade de indivíduos e a massa seca de plantas daninhas foram influenciadas pelas doses de mesotrione, pelo cultivo consorciado e pela distribuição de chuvas ao longo do período avaliado no consórcio e na pastagem formada. Em consórcio, **Alternanthera tenella** e **Commelina benghalensis** foram as espécies de maior importância relativa, por não terem sido controladas pelo herbicida. Após o consórcio, na pastagem formada, **A. tenella** e **C. benghalensis** apresentaram maior importância relativa (IR) no período chuvoso, e **Conyza bonariensis** e **A. tenella**, maior IR no período seco. O rendimento de grãos de milho não foi afetado pela presença do capim, porém o rendimento forrageiro do*

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capim foi afetado pela competição com o milho. As doses de mesotrione não afetaram o rendimento e a qualidade nutricional da forrageira. Os efeitos nos teores de material mineral, proteína bruta e fibra em detergente ácido na forragem foram provenientes da convivência promovida com o milho, quando comparado à testemunha cultivada solteira.

Palavras-chave: *Zea mays* L., competição, herbicida, integração lavoura-pecuária, plantas daninhas.

INTRODUCTION

Areas cultivated in the integrated crop-livestock system (ICL) have increased in Brazil especially in the Cerrado region in the form of intercropping, rotation or succession of crops between forage species and food crops, mainly soybean and corn. The adoption of ICL is observed in areas where the substitution of natural vegetation by cultivated pastures promoted significant environmental changes in the agrosystem, which resulted in degradation of soil properties and weed infestation (Quintino et al., 2016).

The introduction of forage species in the grain production system or vice versa, mainly via intercropping, has as additional benefits grain production, formation of quality straw for the no-tillage system or recovery of degraded pastures, thus intensifying the use of monoculture areas (Ceccon et al., 2013). The establishment of intercropped forage with corn occurs under conditions of interference between them, especially if simultaneously planted, and several techniques can be adopted to minimize this condition (Freitas, 2013). Among them, it is necessary the use of underdoses of herbicides selective to corn in order to avoid the forage to stand out in the competition with the crop, preventing losses in grain yield or quality of the harvested product (Ceccon et al., 2010).

Chemical control is the most used method for weed control and forage suppression when intercropped with corn. The herbicide mesotrione belongs to the chemical group of tricetones and inhibits the biosynthesis of carotenoids by interfering with the activity of the HPPD (4-hydroxyphenylpyruvate dioxygenase) enzyme, located in chloroplasts, disrupting carotenoid biosynthesis, leading to leaf bleaching of treated plants and death of sensitive plants (Dayan et al., 2007; Rodrigues and Almeida, 2011).

Corn plants are considered tolerant to mesotrione as they can rapidly metabolize the herbicide, producing metabolites that do not have phytotoxic activity (Ogliari et al., 2009). The choice of herbicides for application in post-emergence, selective to corn, and that contribute to the management of intercropped forage grasses is essential in the ICL expansion (Dan et al., 2011).

Thus, the aim of this study was to evaluate the effects of mesotrione underdoses applied to corn intercropped with *Urochloa brizantha* on corn yield, weed population dynamics, grass yield, and bromatological characteristics of *U. brizantha* pasture.

MATERIAL AND METHODS

This research was carried out in Rio Verde, Goiás, at the geographical coordinates of 17º48'67" S and 50º54'18" W and altitude of 754 m. The soil of the area is classified as a typical Dystrophic Red Latosol (Embrapa, 2013) and presented as physicochemical characteristics at a depth of 0-20 cm a pH ($CaCl_2$) of 5.2, P of 11 mg dm^{-3}, K of 246 mg dm^{-3}, Ca of 5.77 $cmol_c$ dm^{-3}, Mg of 1.63 $cmol_c$ dm^{-3}, Al of 0.03 $cmol_c$ dm^{-3}, V of 64.6%, OM of 3.20 g dm^{-1}, and particle size of 46, 10, and 44 dag kg^{-1} of clay, silt, and sand, respectively. Climate data on precipitation, relative humidity, and temperature recorded during the experimental period are shown in Figure 1.

The experimental area was previously cultivated with sorghum. Chemical desiccation of the remaining vegetation was carried out with glyphosate (2,400 g a.e. ha^{-1}) and soil tillage was performed after 15 days with a disk plowing and two leveling harrows. Corn and forage were sown on November 7, 2014. The forage *U. brizantha* of the cultivar MG-5 Vitória was sown in the corn rows using 5 kg ha^{-1} of viable pure seeds, with 76% of crop value.

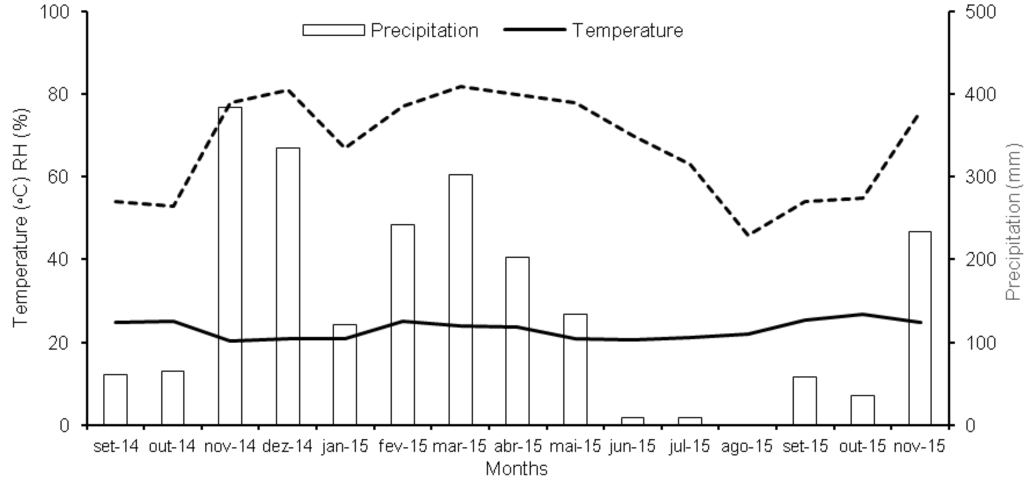

Figure 1 - Precipitation, average temperature, and relative humidity (RH) during the experimental period.

The simple corn hybrid 30A95HX (Agromen), with a population of 65,000 plants ha^{-1}, was used in rows spaced 0.50 m from each other. Corn seeds were treated with the fungicides carbendazim + thiram at doses of 30 + 70 g 100 kg^{-1} of seeds and sown at a depth of 4 cm. Sowing fertilization consisted of 350 kg ha^{-1} of the formulation 2-20-18 (N-P_2O_5-K_2O).

Each experimental unit had 20 m^2 consisting of eight rows of corn plants with 5 m long and useful area of four central rows. The experimental design was a randomized block design with seven treatments and four replications. Treatments consisted of five doses of the herbicide mesotrione (0.0, 9.6, 19.2, 38.4, and 57.6 g ha^{-1} of the commercial formulation of 480 g L^{-1} of Callisto®) applied in the intercropping and two control treatments represented by corn and forage cultivated in monoculture.

Mesotrione application was carried out at 18 days after emergence (DAE) of the corn crop with a CO_2-pressurized backpack sprayer equipped with a 2 m aluminum boom and four spray tips model TT11002, pulverized at a constant pressure of 2.5 bar and spray solution volume of 150 L ha^{-1}. Climate conditions and soil temperature were measured at application time by means of a thermo-hygro-anemometer and a skewer thermometer. A relative air humidity of 75.8%, wind speed of 3.7 km h^{-1}, and 26 and 25 °C of air and soil temperature, respectively, was obtained.

Topdressing nitrogen fertilization was carried out in all plots at 20 and 30 DAE of corn at doses of 60 + 60 kg ha^{-1} of N, respectively. The insecticides deltamethrin (Decis 25 EC®) at a dose of 7.5 g ha^{-1} and chlorfenapyr (Pirate®) at a dose of 187.5 g ha^{-1} were applied at 10 and 25 DAE, respectively.

In corn, plant height (PH), first ear height (EH), and stem diameter (SD) were measured in five random plants from the useful area of the plots at harvest time at 109 days after application (DAA) of the herbicide mesotrione. All plants were also harvested from the useful area to determine grain yield (GY). Five ears from the useful area were used to determine the number of rows per ear (NRE), number of grains per row (NGR), ear diameter (ED), ear length (EL), and one hundred-grain weight (HGW). Grain yield per hectare and one hundred-grain weight were corrected to 13% moisture.

Forage was harvested at 109 DAA at the useful area of the plot. Forage was cut with a cutlass from 2 m^2 of the useful area at a height of 20 cm from the soil surface. To determine the forage yield (FY), the collected material was weighed and then a sample of approximately 500 g was taken, packed in paper bags, dried in a forced air ventilation oven (60 ± 5 °C for 72 hours), and weighed, with values converted to kg ha^{-1}. The bromatological analysis was carried out with another sample of approximately 500 g, which was dried in a forced air ventilation oven (60 ± 5 °C for 72 hours) and ground in a Willey type mill with 1 mm screen sieves. The contents of dry matter (DM), mineral matter (MM), ethereal extract (EE), lignin (LIG), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) was determined according to methodology described by Silva and Queiroz (2002) and AOAC (1990).

After the forage was harvested, a uniform cut of the entire experimental area was carried out with a cutlass at 20 cm from the soil and the residual from this cut was removed from the area. After harvesting corn and forage, two other cuts were carried out in the pasture formed at 178 DAA (May 25, 2015) and 344 DAA (November 9, 2015), with a 69 day interval between the first and second cut and a 166 day interval between the second and third cut. Similar to the first cut, the same procedures were performed for the evaluated variables and cuts of standardization of the area.

At 178 and 344 DAA of mesotrione, the percentage of coverage (PC) of plots by the forage was determined by assigning visual scores between zero and 100%, being zero the uncovered plot and 100% the fully covered plot by the forage (Rizzardi and Fleck, 2004).

Weed community evaluations were carried out at 43, 109 (corn harvest and first forage cutting), 178 (second forage cutting), and 344 DAA (third forage cutting). Four samples were taken per plot by placing at random a 0.25 m^2 square, being the plants inside the square identified, separated by species, and quantified. The plants were then cut close to the soil and the shoot was conditioned in paper bags and taken to dry in a forced air ventilation oven at 65 ± 5 ^oC until constant weight, being later weighed.

The results obtained for corn and forage variables and weed density and dry matter were submitted to analysis of variance (pd"0.05) and regression equations were adjusted according to the obtained significance. Models were chosen considering their simplicity, biological meaning, and coefficient of determination. Statistical analyses were performed using the statistical software Assistat (version 7.7 beta 2014) and Sigmaplot V.12 (SPSS Inc., USA). Weed community description was carried out by the relative importance (RI) of the species, which characterizes a weighted percentage measure of frequency, density, and dry matter accumulation of weed species, according to a methodology described by Pitelli (2000).

RESULTS AND DISCUSSION

Considering the evaluations performed at 43 and 109 DAA of mesotrione (Table 1), the occurrence of 20 weed species was observed in the intercropping distributed into nine botanical families. The species found were southern sandbur (*Cenchrus echinatus* - CENEC), Jamaican

Table 1 - Relative importance of weed species evaluated at 43 days after application (DAA) of the herbicide mesotrione in the intercropping between corn and *Urochloa brizantha* and 109 DAA (corn harvest).

Dose ($g\ ha^{-1}$)	Specie							
	ALTTE*	BIDPI	COMBE	DESTO	DIGHO	GALPA	RICCO	Other**
				43 DAA				
0	25.93	24.94	16.64	10.77	5.66	4.41	2.77	8.88
9.6	35.47	0.00	22.21	4.24	7.40	3.63	12.67	14.37
19.2	38.17	2.89	33.25	2.13	2.47	5.36	3.65	12.09
38.4	29.32	0.00	26.67	0.00	13.49	16.16	0.00	14.35
57.6	28.74	0.00	25.21	0.00	1.95	8.68	10.77	24.64
Mean	31.53	5.57	24.80	3.43	6.19	7.65	5.97	14.87
				109 DAA - Corn harvest				
0	25.64	24.82	16.40	10.65	6.61	4.38	2.74	8.76
9.6	35.15	0.00	22.02	4.97	7.50	3.65	12.86	13.85
19.2	37.49	2.85	32.71	2.09	3.76	5.27	3.94	11.89
38.4	29.04	0.00	25.05	0.00	13.33	18.48	0.00	14.10
57.6	29.42	0.00	24.00	0.00	2.04	8.60	11.65	24.28
Mean	31.35	5.53	24.04	3.54	6.65	8.08	6.24	14.58

* ALTTE - *Alternanthera tenella*, BIDPI - *Bidens pilosa*, COMBE - *Commelina benghalensis*, DESTO - *Desmodium tortuosum*, DIGHO - *Digitaria horizontalis*, GALPA - *Galinsoga parviflora*, RICCO - *Ricinus communis*. ** Other species include *Cenchrus echinatus*, *Eleusine indica*, *Leptochloa panicea*, *Panicum maximum*, *Pennisetum setosum*, *Urochloa plantaginea*, *Melampodium paniculatum*, *Tridax procumbens*, *Glycine max*, *Phyllanthus tenellus*, *Nicandra physalodes*, *Ipomoea triloba*, and *Sida cordifolia*.

crabgrass (*Digitaria horizontalis* - DIGHO), goosegrass (*Eleusine indica* - ELEIN), red sprangletop (*Leptochloa panicea* - LEPPA), guineagrass (*Panicum maximum* - PANMA), mission grass (*Pennisetum setosum* - PENSE), and alexandergrass (*Urochloa plantaginea* - UROPL), belonging to the Poaceae family; hairy beggarticks (*Bidens pilosa* - BIDPI), smallflower galinsoga (*Galinsoga parviflora* - GALPA), blackfoot (*Melampodium paniculatum* - MELPA), and coat buttons (*Tridax procumbens* - TRIPR), belonging to the Asteraceae family; Florida beggarweed (*Desmodium tortuosum* - DESTO) and soybean (*Glycine max* - GLYMA), belonging to the Fabaceae family; long-stalked Phyllanthus (*Phyllanthus tenellus* - PHYTE) and castorbean (*Ricinus communis* - RICCO), belonging to the Euphorbiaceae family; calicoplant (*Alternanthera tenella* - ALTTE), belonging to the Amaranthaceae family; Benghal dayflower (*Commelina benghalensis* - COMBE), belonging to the Commelinaceae family; apple of Peru (*Nicandra physalodes* - NICPH), belonging to the Solanaceae family; threelobe morningglory (*Ipomoea triloba* - IPOTR), belonging to the Convolvulaceae family; and heartleaf sida (*Sida cordifolia* - SIDCO), belonging to the Malvaceae family.

Higher RI values were observed for ALTTE, COMBE, GALPA, and DIGHO at 43 and 109 DAA regardless of the mesotrione dose, and higher RI values were observed for BIDPI and DESTO in plots without mesotrione application, showing the susceptibility of both species to herbicide underdoses (Table 1). The other species, in the different treatments, presented very low RI values, except for RICCO at doses of 9.6 and 57.6 g ha^{-1} (Table 1).

At 178 DAA of mesotrione, the weed community in the pasture formed after corn harvest consisted of 23 weed species distributed into eight botanical families (Table 2). The species found were CENEC, DIGHO, ELEIN, PANMA, PENSE, UROPL, natalgrass (*Rhynchelytrum repens* - RYNRE), spreading liverseed grass (*Urochloa decumbens* - URODE), and Congo grass (*Urochloa ruziziensis* - URORU), belonging to the Poaceae family; BIDPI, GALPA, tropic ageratum (*Ageratum conyzoides* - AGECO), and hairy fleabane (*Conyza bonariensis* - CONBO), belonging to the Asteraceae family; DESTO, belonging to the Fabaceae family; RICCO and garden spurge (*Chamaesyce hirta* - CHAHI), belonging to the Euphorbiaceae family; ALTTE and low amaranth (*Amaranthus deflexus* - AMADE), belonging to the Amaranthaceae family; COMBE, belonging to the Commelinaceae family; IPOTR, belonging to the Convolvulaceae family; and SIDCO, arrowleaf sida (*Sida rhombifolia* - SIDRO), and moth fanpetals (*Sida santaremnensis* - SIDSA), belonging to the Malvaceae family. After corn harvest, the species AGECO and CONBO stood out among those that emerged exclusively in this evaluation, showing RI values in most treatments (Table 2). However, the highest RI values were observed for ALTTE and COMBE.

Table 2 **-** Relative importance of weed species evaluated at 178 and 344 days after application (DAA) of the herbicide mesotrione in the pasture formed after intercropping between *Urochloa brizantha* and corn

178 DAA								
Dose ($g\ ha^{-1}$)	Species							
	AGECO*	ALTTE	COMBE	CONBO	DIGHO	GALPA	PENSE	Other**
0	0.00	41.56	17.45	6.60	6.13	0.00	2.61	25.65
9.6	5.52	60.30	9.37	2.45	6.43	1.51	3.11	11.30
19.2	4.23	61.86	12.74	1.98	3.33	10.81	0.00	5.07
38.4	10.81	53.85	9.50	6.03	4.22	0.00	5.93	9.67
57.6	4.42	49.21	13.16	5.46	2.90	0.00	4.06	20.80
Mean	5.00	53.36	12.44	4.50	4.60	2.46	3.14	14.50

344 DAA							
Dose ($g\ ha^{-1}$)	Species						
	ALTTE	CENEC	CONBO	DIGHO	ELEIN	PENSE	SIDCO
0	19.18	0.00	63.86	0.00	0.00	6.26	10.70
9.6	68.19	0.00	8.64	8.56	0.00	0.00	14.62
19.2	33.71	0.00	48.29	0.00	18.00	0.00	0.00
38.4	23.21	0.00	64.56	0.00	7.06	0.00	5.17
57.6	15.70	9.21	57.48	4.65	0.00	4.83	8.13
Mean	32.00	1.84	48.57	2.64	5.01	2.22	7.72

* AGECO - *Ageratum conyzoides*, ALTTE - *Alternanthera tenella*, COMBE - *Commelina benghalensis*, CONBO - *Conyza bonariensis*, DIGHO - *Digitaria horizontalis*, GALPA - *Galinsoga parviflora*, PENSE - *Pennisetum setosum*, CENEC - *Cenchrus echinatus*, ELEIN - *Eleusine indica*, SIDCO - *Sida cordifolia*. ** Other species include *Panicum maximum, Urochloa plantaginea, Rhynchelytrum repens, Urochloa decumbens, Urochloa ruziziensis, Bidens pilosa, Desmodium tortuosum, Ricinus communis, Chamaesyce hirta, Amaranthus deflexus, Ipomoea triloba, Sida rhombifolia*, and *Sida santaremnensis*.

In the evaluation performed at 344 DAA of mesotrione, a lower number of species were observed when compared to the other evaluated seasons, regardless of the treatments (Table 2), evidencing that the species richness is related to the precipitation distribution (Figure 1). Seven species (ALTTE, CENEC, CONBO, DIGHO, ELEIN, PENSE, and SIDCO) were found in this evaluation, with CONBO and ALTTE presenting the highest RI values (Table 2). Considering the entire weed evaluation period (43, 109, 178, and 344 DAA), ALTTE response to mesotrione underdoses is supported by the results obtained by Timossi (2009), who did not observe control of this species when tested mesotrione associated with atrazine.

According to Shaner et al. (2012), the residual activity of mesotrione in the soil is short, with a half-life between 3 and 26 days, and its dissipation is highly dependent on the microbial activity. Thus, for the variables density (2A) and dry matter (2B) of weeds, the effects on the weed community are associated with those of the evaluation periods and weed performance (intercropped or not), in addition to the effect of the mesotrione herbicide. Thus, a high density of individuals was observed at 43 and 109 DAA (Figure 2A), but with little dry matter accumulation (Figure 2B).

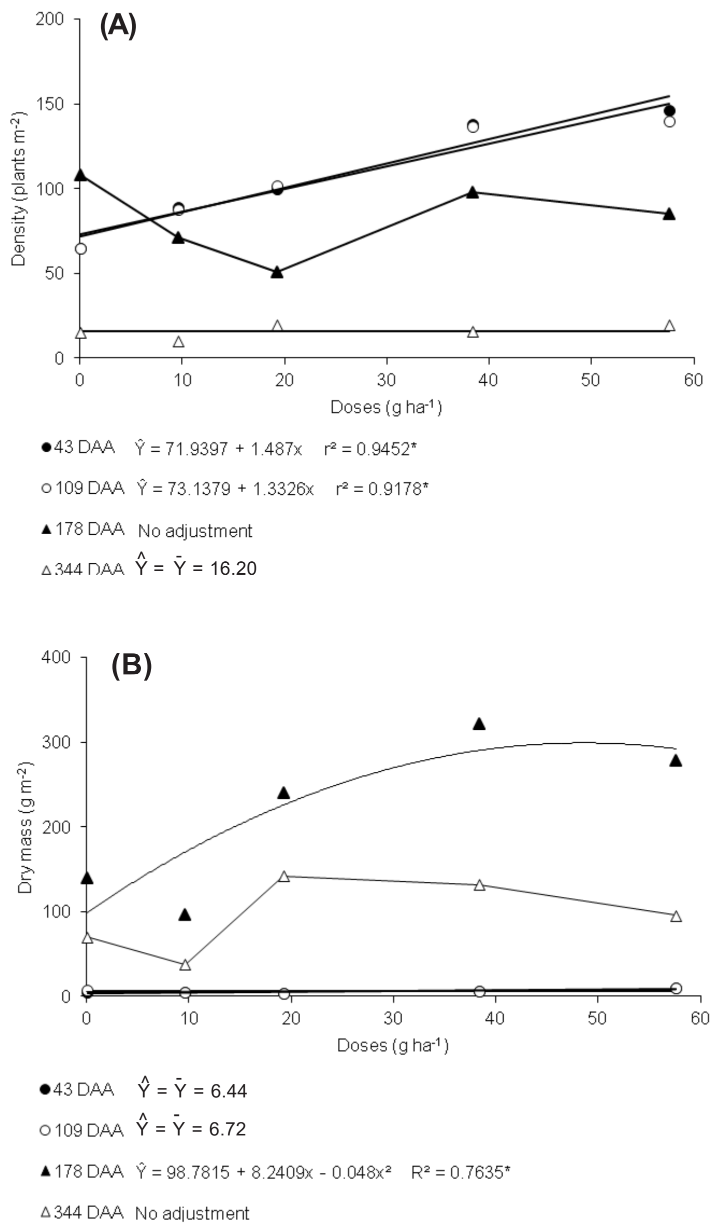

Figure 2 - Density (A) and dry matter (B) of weed evaluated at 43 days after application (DAA) of the herbicide mesotrione in the intercropping between corn and *Urochloa brizantha*, at 109 DAA (corn harvest), and at 178 and 344 DAA in the pasture formed after intercropping between forage and corn.

The increase in weed density due to the increased herbicide underdoses may be associated with the effect of interspecific competition in the weed community. No effects of mesotrione doses were observed on ALTTE and COMBE, which had combined participation of 56.33 and 55.39% in the weed community at 43 and 109 DAA of mesotrione, respectively (Table 1). However, an effect of underdoses was observed on other species, such as BIDPI and DESTO, which presented expressive RI values in the absence of the herbicide, which may have led to a lower interspecific competition of these species and favored the others. In intercropping, the inexpressive dry matter accumulation of the weed community was also due to the competition and shading exerted by the corn and intercropped forage.

In the evaluation carried out at 178 DAA of mesotrione, a high weed density was observed in the weed community associated with a higher dry matter accumulation (Figure 2A, B). However, it was not possible to fit a model that explained the response pattern for the density of individuals. Weed density associated with the highest dry matter accumulated by the weed community in this evaluation when compared to the previous ones may be associated with the removal of the corn crop and precipitation during the sampled period, considered as sufficient for the establishment of the weed community (Figure 1). In addition, a growing dry matter accumulation was observed as a function of the lack of efficiency of the treatments on the density of ALTTE and COMBE individuals during the intercropping, which contributed to an RI value of 65.79% for both species in the weed community (Table 2).

On the contrary, a water deficit at 344 DAA of mesotrione (Figure 1) contributed to the low density of individuals of weed species, with no effect between treatments (Figure 2A). Among the few species present, CONBO (48.57%) and ALTTE (32%) had a total participation of 80.57% in the RI value of the weed community (Table 2), being non-significant for dry matter accumulation (Figure 2B). In addition, the low soil water availability, although affecting CONBO seed germination, did not affect its establishment since this species is tolerant and continues to grow and produce seeds under conditions considered stressful for the establishment of crops (Santos et al., 2013).

Significant effects were observed in corn for SD and GY considering the contrasts between the mesotrione underdoses used in the intercropping with the forage and corn in monoculture (Table 3). For the other corn variables, no effects were observed between corn intercropped with mesotrione underdoses and corn in monoculture (Table 3). The increase in mesotrione doses promoted an increasing linear response in the SD of corn intercropped with *U. brizantha*.

Considering only the response of GY as a function of herbicide underdoses, no significant effects were observed (Table 3). The obtained responses indicate that corn yield was not affected by the intercropping with forage nor herbicide use. Several studies have shown that the intercropping between corn and forage managed with herbicide underdoses is a viable technology for grain and straw production in no-tillage systems due to the lack of significance between the yield of intercropped corn and that in monoculture (Ceccon et al., 2010; Silva et al., 2014).

Forage quality is directly and indirectly related to its bromatological composition, which expresses its nutritional value (Geron et al., 2014). Regarding the forage variables, the evaluations carried out at 109 DAA (corn harvest and first grass cutting) and 178 DAA (second grass cutting) in the established pasture showed statistical differences in PH and FY of *U. brizantha* conducted intercropped and in monoculture (Table 4). The highest values of PH and FY were observed for the forage cultivated in monoculture, demonstrating that corn exerted a competitive effect with the associated forage and that this reflected in the cut carried out after harvest for both variables (Table 4).

However, mesotrione underdoses used to manage the coexistence between forage and corn showed to be of low phytotoxicity to the forage, which was demonstrated by the lack of significance between the tested doses (Table 4). These results are in accordance with those observed by Dan et al. (2011), who studied corn intercropped with *U. brizantha* and found that forage yield was not affected at doses below 96 g ha^{-1} of mesotrione.

At 178 DAA, PC of plots by the forage was not affected by treatments. Similarly, at 344 DAA, no statistical differences were observed between treatments in the pasture formed from the intercropping managed with herbicide and in monoculture for PH, PC, and FY (Table 4). These

Table 3 - Plant height (PH), first ear height (EH), stem diameter (SD), ear length (EL), ear diameter (ED), number of rows per ear (NRE), number of grains per row (NGR), one hundred-grain weight (HGW), and grain yield (GY) of corn intercropped with *Urochloa brizantha* cv. MG-5 Vitória as a function of mesotrione dose application

Variable	Dose (g ha^{-1})					Regression	MM	$F_{5\%}$	CV%
	0	9.6	19.2	38.4	57.6				
PH (m)	2.03	2.02	2.04	2.01	2.05	$\hat{Y} = \bar{Y} = 2.031$	1.965	0.66^{ns}	3.68
EH (m)	1.11	1.07	1.11	1.06	1.14	$\hat{Y} = \bar{Y} = 1.1045$	1.045	1.77^{ns}	5.35
SD (mm)	17.99	19.05	18.68	19.24	19.86	$\hat{Y} = 18.2936 + 0.027\ x,\ r^2 = 0.811^*$	20.265	3.56*	4.49
EL (cm)	17.07	16.90	16.27	16.51	16.82	$\hat{Y} = \bar{Y} = 16.714$	17.25	0.68^{ns}	5.17
ED (mm)	51.21	52.78	52.22	51.16	52.01	$\hat{Y} = \bar{Y} = 51.879$	50.43	1.10^{ns}	3.14
NRE	18.70	19.00	19.00	18.07	18.90	$\hat{Y} = \bar{Y} = 18.735$	17.80	1.80^{ns}	4.14
NGR	32.91	33.98	29.95	32.33	33.63	$\hat{Y} = \bar{Y} = 32.565$	34.685	1.55^{ns}	8.12
HGW (g)	30.56	33.28	31.23	32.31	32.69	$\hat{Y} = \bar{Y} = 32.01$	34.37	1.39^{ns}	7.20
GY (kg ha^{-1})	6911.62	6110.70	7742.25	8255.52	7814.00	$\hat{Y} = \bar{Y} = 7366.81$	7376.00	3.96*	10.42

CM - corn in monoculture. ns not significant.

Table 4 - Plant height (PH), forage yield (FY), and percentage of soil coverage (PC) by the forage *Urochloa brizantha* cv. MG-5 Vitória as a function of the treatments evaluated at 109, 178, and 344 DAA

Variable	Dose (g ha^{-1})					Regression	MF	$F_{5\%}$	CV%
	0	9.6	19.2	38.4	57.6				
	109 DAA - Corn and forage harvest								
PH (cm)	49.40	62.80	57.46	61.93	51.23	$\hat{Y} = \bar{Y} = 56.56$	132.26	7.54**	28.60
FY (kg ha^{-1})	1031.25	1142.25	1111.50	798.00	798.75	$\hat{Y} = \bar{Y} = 976.35$	3213.00	10.93**	41.48
	178 DAA - Second grass cutting								
PH (cm)	57.16	63.21	62.71	56.13	60.73	$\hat{Y} = \bar{Y} = 59.98$	83.00	34.45*	8.12
PC (%)	62.91	71.25	64.58	50.00	61.25	$\hat{Y} = \bar{Y} = 61.99$	71.25	2.54^{ns}	15.51
FY (kg ha^{-1})	1654.43	2377.92	1544.11	11167.44	1598.70	$\hat{Y} = \bar{Y} = 1668.52$	2510.36	3.91*	29.21
	344 DAA - Third grass cutting								
PH (cm)	56.30	59.20	50.25	57.80	54.00	$\hat{Y} = \bar{Y} = 55.51$	55.70	0.73^{ns}	13.23
PC (%)	82.50	85.83	81.66	77.91	81.25	$\hat{Y} = \bar{Y} = 81.83$	79.167	1.39^{ns}	5.75
FY (kg ha^{-1})	3177.12	3041.06	2899.95	2900.00	2873.81	$\hat{Y} = 2978.39$	3028.47	0.11^{ns}	23.24

FM - forage in monoculture. ns not significant, * significant by the F-test at 5% probability.

similarities can be attributed to climate conditions during the evaluated period (Figure 1), which did not allow adequate forage growth due to water deficiency.

Regarding the nutritional characteristics of the grass, significant differences were observed in the first forage cutting at the 109 DAA (corn harvest) for the mean contents of MM, CP, and ADF in the intercropped forage managed with mesotrione underdoses and the control grown in monoculture (Table 5). The intercropping with corn presented higher mean contents of MM and CP in relation to monoculture, which can be justified by the higher FY produced by the control (Table 4). Probably, the factor dilution would be an explanation for this increase in CP and MM content since a lower FY leads to higher CP and MM contents. Another explanation for the increased CP content is reported by Leonel et al. (2009), who observed higher CP contents in brachiaria grass intercropped with corn when compared to the monoculture cultivation. According to these authors, the moisture is higher in shaded soils, contributing to organic matter decomposition and nitrogen mineralization, making it more available for absorption.

On the contrary, lower mean contents of ADF were observed in the intercropped forage when compared to monoculture (Table 5). Shading caused by corn can modify the growth pattern and morphogenesis of the forage under its canopy, and these variations in morphogenesis modify tillering, height, and leaf expansion, affecting the bromatological variables, such as fiber content (Leonel et al., 2009). The other bromatological variables were not affected by treatments at 109 DAA of mesotrione (Table 5).

At the 178 DAA, the effects were attenuated on the bromatological variables of the forage, with significant effects only for ADF and DM, considering the contrasts between underdoses and

Table 5 **-** Mineral matter (MM), ethereal extract (EE), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (LIG), and dry matter (DM) of the forage *Urochloa brizantha* cv. MG-5 Vitória as a function of the treatments evaluated at 109, 178, and 344 DAA

Variable (%)	Dose (g ha^{-1})					Regression	MF	$F_{5\%}$	CV%
	0	9.6	19.2	38.4	57.6				
	109 DAA - Corn and forage harvest								
MM	11.68	12.79	12.65	13.33	12.64	$\hat{Y} = \bar{Y} = 12.61$	8.45	13.76**	8.05
EE	7.27	7.13	7.71	6.35	7.55	$\hat{Y} = \bar{Y} = 7.20$	5.32	1.97^{ns}	18.66
CP	13.03	12.98	13.81	13.45	13.23	$\hat{Y} = \bar{Y} = 13.30$	10.48	2.963*	10.76
NDF	64.67	53.72	64.63	58.10	63.85	$\hat{Y} = \bar{Y} = 60.99$	71.84	2.61^{ns}	12.30
ADF	36.34	35.19	35.73	33.43	35.37	$\hat{Y} = \bar{Y} = 35.21$	39.07	4.17*	5.06
LIG	11.21	12.81	10.63	11.76	10.62	$\hat{Y} = \bar{Y} = 11.40$	14.55	1.26^{ns}	22.76
DM	22.58	23.08	22.99	23.19	22.77	$\hat{Y} = \bar{Y} = 22.92$	22.74	1.07^{ns}	1.95
	178 DAA - Second grass cutting								
MM	11.11	10.81	10.72	10.19	10.78	$\hat{Y} = \bar{Y} = 10.72$	8.69	0.83^{ns}	16.15
EE	6.37	7.73	7.94	8.37	8.85	$\hat{Y} = \bar{Y} = 7.85$	7.95	0.47^{ns}	30.98
CP	14.04	14.52	13.97	14.64	15.86	$\hat{Y} = \bar{Y} = 14.60$	12.71	1.97^{ns}	10.27
NDF	68.33	73.06	69.27	67.55	66.90	$\hat{Y} = \bar{Y} = 69.02$	69.72	1.49^{ns}	5.19
ADF	31.49	42.41	35.28	36.15	35.74	$\hat{Y} = \bar{Y} = 36.21$	34.89	3.37*	10.76
LIG	5.91	7.01	6.78	7.15	7.48	$\hat{Y} = \bar{Y} = 6.86$	6.29	0.73^{ns}	20.10
DM	21.88	21.59	22.13	20.98	20.99	$\hat{Y} = \bar{Y} = 21.51$	22.92	4.54*	3.17
	344 DAA - Third grass cutting								
MM	7.79	8.90	7.69	7.69	8.95	$\hat{Y} = \bar{Y} = 8.20$	8.44	1.35^{ns}	12.50
EE	9.28	9.12	9.88	8.89	9.48	$\hat{Y} = \bar{Y} = 9.33$	9.47	0.23^{ns}	15.43
CP	9.65	10.69	10.20	11.82	10.36	$\hat{Y} = \bar{Y} = 9.33$	10.54	0.48^{ns}	20.32
NDF	72.51	70.15	71.00	68.68	72.98	$\hat{Y} = \bar{Y} = 71.06$	70.20	1.52^{ns}	3.67
ADF	32.74	32.48	33.37	31.66	31.20	$\hat{Y} = \bar{Y} = 32.29$	33.08	0.53^{ns}	7.08
LIG	6.30	6.64	7.03	5.34	6.77	$\hat{Y} = \bar{Y} = 6.41$	6.87	1.03^{ns}	18.66
DM	31.84	30.36	30.96	30.44	29.77	$\hat{Y} = \bar{Y} = 30.67$	30.00	0.59^{ns}	6.37

FM - forage in monoculture. ns not significant, * significant by the F-test at 5% probability.

forage in monoculture (Table 5). However, the effects were not significant for both variables among mesotrione underdoses. At 344 DAA of mesotrione, no effects were observed on the bromatological variables of the forage in the pasture from the intercropping managed with herbicide when compared to the pasture in monoculture.

Based on the above, mesotrione underdoses, intercropped crops, and precipitation distribution during the evaluated period affected the density of individuals and dry matter accumulation of the weed community, favoring the species *A. tenella*, *C. benghalensis*, and *C. bonariensis*.

The species *A. tenella* and *C. benghalensis* were not controlled by the herbicide, being the most important species in the intercropping between corn and *U. brizantha*. After harvesting corn, still in the rainy season at 178 DAA of mesotrione, *A. tenella* and *C. benghalensis* were the most important species, while in the period after rain at 344 DAA, *C. bonariensis* and *A. tenella* were the most important species.

The intercropped forage did not affect corn production capacity, but corn reduced the forage production of *U. brizantha*.

Mesotrione underdoses did not affect forage yield and bromatological quality of the grass. However, the effects on silage quality components related to CP, MM, and ADF contents came from the coexistence with corn when compared to the control treatment in monoculture.

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