Revista Brasileira de Ciências Agrárias
ISSN (on line) 1981-0997
v.13, n.2, e5528, 2018
Recife, PE, UFRPE. www.agraria.pro.br
DOI:10.5039/agraria.v13i2a5528
Protocolo 5528 - 23/10/2017 • Aprovado em 23/03/2018

Management of the consortium between maize and *Urochloa brizantha* with tembotrione subdoses

Deborah Amorim Martins[1], Cassio Jardim Tavares[2], Adriano Jakelaitis[1], Jackellyne Bruna Sousa[3], Viniccius Matheus da Silveira Maia[1], Renan Jesus de Sousa[1], Alana Cristina Ferreira Araújo[1]

[1] Instituto Federal Goiano, Campus Rio Verde. Rio Verde, GO, Brasil. E-mail: deborahamartins@gmail.com (ORCID: 0000-0002-1782-2380); ajakelaitis@yahoo.com.br (ORCID: 0000-0003-0093-9846); viniccius.mm@gmail.com (ORCID: 0000-0003-4594-0306); renan_js15@hotmail.com (ORCID: 0000-0003-1079-0694); alanashego@hotmail.com (ORCID: 0000-0003-1333-212X)

[2] Instituto Federal Goiano, Campus Posse. Posse, GO, Brasil. E-mail: cassiojardimtavares@hotmail.com (ORCID: 0000-0003-2813-8442)

[3] Universidade de São Paulo, Escola Superior de Agricultura "Luiz de Queiroz", Departamento de Fitotecnia. Piracicaba, SP, Brasil. E-mail: jackellyne_bruna@hotmail.com (ORCID: 0000-0002-7561-0984)

ABSTRACT: Consortium between maize crop and forage species managed with herbicide reduce doses have been widely used in the crop integration system for pasture formation. However, answers to this management in both maize and forage have presented different responses. In this research, evaluated the corn productivity, weed population dynamics, and yield and quality characteristics of pasture the *Urochloa brizantha* in three cuts when it was formed after the harvest of corn treated with tembotrione subdoses. The subdoses tested were: 0; 3.78; 7.56; 15.12 e 22.68 g ha^{-1}. Corn and forage were also tested in monocultures. In a consortium, weed species *Alternanthera tenella*, *Commelina benghalensis* and *Galinsoga parviflora* were of relative importance (IR) and were not controlled by the herbicide. Yield of maize grains was not affected by forage, but forage yield (YF) of grass was reduced by maize. The tembotrione subdoses affected YF both in maize intercropped pastures and in pasture formed during the rainy season. The values of ethereal extract and crude protein in the pasture formed were influenced by the herbicide management.

Key words: competition; herbicide; crop-livestock integration; weed; *Zea mays* L.

Manejo do Consórcio entre milho e *Urochloa brizantha* com subdoses de tembotrione

RESUMO: Consórcios entre o milho e espécies forrageiras manejadas com subdoses de herbicidas têm sido utilizados no sistema de integração lavoura pecuária para formação de pastagens. Todavia, as respostas a este manejo tanto no milho quanto na forrageira têm apresentado respostas diferenciadas. Nesta pesquisa, avaliou-se a produtividade do milho, a dinâmica populacional de plantas daninhas, as características de rendimento e de qualidade da pastagem de *Urochloa brizantha* em três cortes quando esta foi formada após a colheita do milho tratado com subdoses de tembotrione. As subdoses foram: 0; 3,78; 7,56; 15,12 e 22,68 g ha^{-1}. Testaram-se também o milho e a forrageira em monocultivos. Em consórcio, as espécies de plantas daninhas *Alternanthera tenella*, *Commelina benghalensis* e *Galinsoga parviflora* foram de maior importância relativa (IR) e não foram controladas pelo herbicida. O rendimento de grãos de milho não foi afetado pela forrageira, mas o rendimento de forragem (RF) do capim foi reduzido pelo milho. As subdoses de tembotrione afetaram o RF tanto na forrageira consorciada com milho quanto na pastagem formada no período chuvoso. Os valores de extrato etéreo e de proteína bruta na pastagem formada foram influenciados pelo manejo com herbicida.

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

Introduction

Cultivation conditions of maize (*Zea mays*) in Brazil are diversified, ranging from highly technified to typical subsistence agriculture. This is one of the justifications for the low average productivity found in Brazil. The increase of corn grain yield is complex and depends on the interactions between genetic and environmental factors and adequate phytosanitary management (Sangoi et al., 2010). Due to the importance of maize, the benefits that crop-livestock integration (CLI) systems can provide for crops and pastures, and the possibility of favoring the recovery of degraded areas (Macedo, 2009), there is a need for further studies involving maize/forage grasses intercropping for improvement of the system.

In these intercrops, cultivars of the genus *Urochloa* (synonymy *Brachiaria*) have been the most used and studied (Dan et al., 2011; Gimenes, 2011). Among these are the cultivars 'Marandu' of *U. brizantha* (synonymy *B. brizantha*) and Basilisk of *U. decumbens* (synonymy *B. decumbens*); the Cv MG-5 Vitória (*U. brizantha*) has a great potential of use in integrated systems.

When there are two crops that will germinate at the same time, interspecific competition is expected, leading to reduced yield of the main crop (Vidal, 2010). In order to avoid competition between main crop and forage grass, it is necessary to apply herbicide in low doses to prevent the later to override the maize and obtain a good maize grain yield without eliminating the grass (Ferreira et al., 2007). Several studies have been conducted aiming at suppressing the competition of forage plants in intercrops with minimal herbicide dose and at the same time evaluating weed management (Dan et al., 2012; Ceccon et al., 2015).

Among the herbicides used in post-emergence control in maize crops that present graminicidal and latifolicide action, carotenoid inhibitors stand out, mainly those that inhibit the enzyme 4-hydroxyphenyl pyruvate dioxygenase (HPPD) (Felix & Doohan, 2005). In the absence of these compounds, whose function is to protect the chlorophyll from excess radiation, oxidation of chlorophyll occurs, with consequent bleaching of leaves from the oxidative degradation of chlorophyll and plasma membrane causing leakage of cellular content and consequent necrosis of tissues (Grossmann & Ehrhardt, 2007).

Launched in Brazil for post-emergence use in maize crops, Tembotrione has shown a satisfactory performance in weed control, especially of grasses (Dan et al., 2010). However, there are few studies on the potential use of this herbicide in intercropping systems.

Studies evaluating the effect of tembotrione on weed suppression in maize/forage grasses intercrops are scarce, as well as surveys of weed species that can cause interference in these intercrops. The objective of this study was to evaluate the effects of minimal doses of tembotrione applied to maize intercropped with *Urochloa brizantha* on the yield of maize crop, yield and quality of *U. brizantha* forage intercropping and on the pasture formed, as well as on the weed community.

Material and Methods

The research was carried out in Rio Verde, Goiás, in the coordinates 17º48'67'' S and 50º54'18'' W and at an elevation of 754 m. The soil of the area, classified as Dystrophic Red Latosol, has the following physical-chemical characteristics at 0-20 cm depth: pH ($CaCl_2$) 5.2; 11 mg dm^{-3} of P; 246 mg dm^{-3} of K; 5.77cmolc dm^{-3} of Ca; 1.63 cmolc dm^{-3} of Mg; 0.03 cmolc dm^{-3} of Al; V% of 64.6; and grain size of 46, 10 and 44 dag kg^{-1} of clay, silt and sand, respectively. As for climatological data, the rainfall, relative humidity and temperature recorded during the research period are presented in Figure 1.

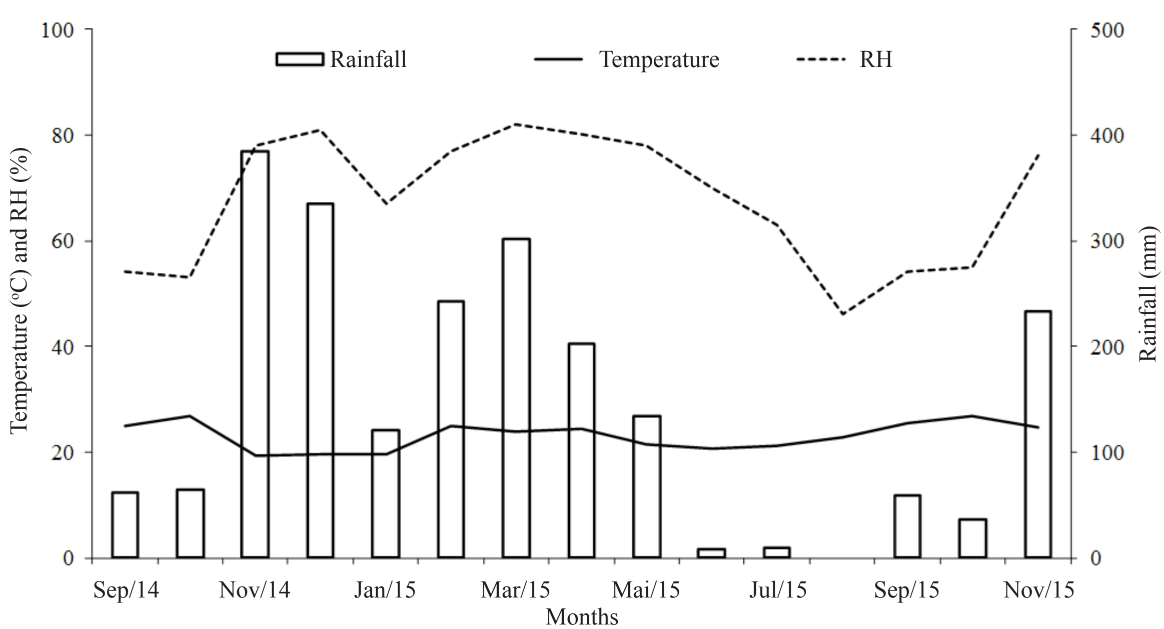

Figure 1. Rainfall, mean temperature and relative humidity (RH) during the experiment.

The experimental area was previously cultivated with sorghum. Chemical desiccation of the remaining vegetation was done with glyphosate (2,400 g e.a. ha^{-1}) and 15 days afterwards the soil was prepared with disc plowing using a disc plow and two disk harrowing with a leveling harrow. Seeding of maize and the forage grass was carried out on November 7, 2014. The forage *Urochloa brizantha* Cv MG-5 Vitória was sown in the rows of maize using 5 kg ha^{-1} of viable pure seeds, with 76% of cultural value.

The simple maize hybrid 30A95HX (Agromem) with a population of 65 thousand plants per ha was used in rows spaced 0.50 m apart. Maize seeds were treated with carbendazim + fungicides at rates of 30 + 70 g, respectively, for 100 kg of seeds, and were seeded at 4 cm depth. Sowing fertilization consisted of 350 kg ha^{-1} of a 2:20:18 formulation of N, P_2O_5, K_2O.

Each 20 m² experimental unit consisted of eight rows of maize with five meters in length and a useful area of four central lines. A completely randomized block design with seven treatments and four replications was adopted. The treatments corresponded to five doses of tembotrione: 0; 3.78; 7.56; 15.12 and 22.68 g i.a. ha^{-1} of the commercial formulation of 420 g L^{-1} from Soberan® applied in the intercrop and two further controls represented by single cultures of maize and forage grass.

The application of tembotrione occurred 18 days after emergence (DAE) of maize with carbon dioxide-pressurized backpack sprayer composed of a 2 m aluminum bar containing four spray tips model TT110°02, pulverized at a constant pressure of 2.5 bar and a volume of 150 liters of poison preparation ha^{-1}. At the moment of applications, the climatic conditions and the soil temperature were measured with an instrument that measures the temperature and the relative humidity of the air and the wind speed named *termohigroanemometer* and a spike type thermometer. The measures were: relative humidity of 75.8%, wind speed of 3.7 km $hour^{-1}$, and 26°C and 25°C of air and soil temperature, respectively.

Nitrogen fertilization at planting was performed in all plots and was applied at 20 and 30 DAE of maize, at doses of 60 + 60 kg ha^{-1} of N, respectively. As phytosanitary treatment, the insecticides deltamethrin (Decis 25 EC®) at the dose of 7.5 g ha^{-1} and chlorfenapyr (Pirate®) at the dose of 187.5 g ha^{-1} were applied at 10 and 25 DAE, respectively.

In the maize crop, plant height, height of insertion of the first spike and stem diameter were measured in five random plants in the useful area of the plots at the time of harvest, at 109 days after application (DAA) of the herbicide tembotrione. All plants within the useful area were harvested to determine grain yield. Five spikes were taken from the plants of the useful area to determine the number of rows per spike, number of grains per rows, diameter and length of spike, and 100-grain mass. Grain yield per hectare and 100-grain mass were corrected to 13% of moisture.

The forage was also harvested in the useful area of the plot at 109 DAA of the herbicide. The forage was cut to the height of 20 cm in 2 m² with aid of a knife. For the determination of total dry mass of the forage, the collected material was weighed and a sample of approximately 500 g was subsequently collected, packed in paper bags and dried in a forced-air circulation oven (60 ± 5 °C for 72 h). Afterwards, the sample was weighed and the values converted into kg ha^{-1}. For bromatological analysis, another sample of approximately 500 g was obtained, dried in a forced-air circulation oven (60 ± 5 °C for 72 h) and milled in a Willey mill with 1-mm sieves. Dry matter (DM), mineral matter (MM), ethereal extract (EE), crude protein (CP), lignin (LIG), neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to the methodology described by Silva & Queiroz (2002).

After harvesting the forage, a leveling cut of the entire experimental area was done with a chopper at 20 cm from the ground and the resulting residues were removed from the area. After harvesting the maize and the forage, two further cuts were made in the pasture at 178 DAA (25/05/2015) and 344 DAA (09/11/2015), with a 69-day interval between the first and the second cut and a 166-day interval between the second and third cut. The same procedures of the first cut were performed, with respect to the variables evaluated and the leveling cuts in the area.

The results obtained for maize and forage variables were submitted to analysis of variance ($p < 0.05$) and, according to the significance obtained, regression equations were fitted. The models were chosen based on simplicity, biological significance and the coefficient of determination. Statistical analyses were performed using the Assistat statistical software (version 7.7 beta 2014) and Sigmaplot V.12 software (SPSS Inc., USA).

The evaluations of the weed community in the experiment occurred at 43 DAA, 109 DAA (maize harvest and first forage cut), 178 DAA (second forage cut) and 344 DAA (third forage cut). Four samples were taken per plot by random casting of a 0.25 m² hollow square, and the plants within the square were identified, sorted by species and counted. Then, they were cut at ground level and shoots were packed in paper bags and then dried in a greenhouse with forced air ventilation at 65°C ± 5 °C until reaching constant weight and then weighed.

The results of weed density and dry mass were submitted to analysis of variance ($p < 0.05$) and regression. The weed community was described based on the relative importance (RI) of species, which characterizes a percentage weighted measure of the frequency, density and dry matter accumulation of weed species according to the methodology described by Pitelli (2000).

Results and Discussions

The weed community consisted of 32 weed species: *Ageratum conyzoides* (AGECO), *Alternanthera tenella* (ALTTE), *Amaranthus deflexus* (AMADE), *Bidens pilosa* (BIDPI), *Cenchrus echinatus* (CENEH), *Chamaescy hirta* (CHAHI), *Commelina benghalensis* (COMBE), *Conyza bonariensis* (CONBO), *Desmodium tortuosum* (DESTO), *Digitaria horizontalis* (DIGHO), *Digitaria insularis* (DIGIN), *Eleusine indica* (ELEIN), *Galinsoga parviflora* (GALPA), *Hyptus lophanta* (HYPLO), *Ipomoea triloba* (IPOTR), *Leptochloa panicea* (LEPPA), *Melampodium paniculatum* (MELPA), *Nicandra physaloides* (NICPH), *Panicum maximum* (PANMA), *Pennisetum setosum* (PENSE), *Phylanthus tenellus* (PHYTE), *Rhynchelytrum repens* (RHYRE), *Ricinus communis* (RICCO), *Sida cordifolia* (SIDCO), *Sida rhombifolia* (SIDRH), *Sida santaremnensis* (SIDSA), *Solanum americanum* (SOLAM), *Tridax procumbens* (TRIPR), *Urochloa decumbens* (URODE), *Urochloa plantaginea* (UROPL), *Zea mays* (ZEAMA), and a species non identified (Ni) (Table 1).

The highest values for ALTTE, COMBE and GALPA were observed at 43 and 109 DAA after tembotrione application,

Table 1. Relative importance of weed species evaluated at 43, 109, 178 and 344 DAA of the herbicide tembotrione.

Species	43 DAA – in consortium						109 DAA – harvesting the maize and the forage					
	Doses (g ha^{-1})					Average	Doses (g ha^{-1})					Average
	0	3.78	7.56	15.12	22.68		0	3.78	7.56	15.12	22.68	
AGECO	0	0	0	0	0	0	0	0	2.07	0	0	0.41
ALTTE	28.35	35.53	30.15	2.11	26.7	24.57	27.49	37.22	31.1	34.24	28.12	31.63
AMADE	0	0	0	32.05	1.20	6.65	0	0	0	0	1.25	0.25
BIDPI	0	0	0	0	0	0	0	0	0	1.09	0	0.22
CENEC	0	4.71	0	1.10	1.80	1.52	0	4.57	0	3.47	1.89	1.99
COMBE	25.05	34.93	30.67	3.00	26.6	24.05	24.95	32.61	29.64	29.69	24.68	28.31
DESTO	4.17	0	2.58	31.15	0	7.58	4.19	3.8	2.73	0	0	2.14
DIGHO	0	0	4.86	0	1.56	1.28	0	0	4.43	1.88	1.62	1.59
ELEIN	0	0	0	1.90	1.20	0.62	0	0	0	1.69	1.25	0.59
GALPA	10.38	16.88	10.79	1.70	20.34	12.02	10.36	12.39	11.31	16.77	19.82	14.13
IPOTR	9.48	4.71	1.41	16.96	0	6.51	9.17	5.82	1.4	0	0	3.28
LEPPA	0	1.24	0	0	0	0.25	0	1.24	0	1.39	0	0.53
MELPA	2.07	0	5.09	2.19	0	1.87	2.10	0	5.92	2.07	0	2.02
Ni	2.10	0	1.11	2.11	0	1.06	2.09	0	1.11	0	0	0.64
NICPH	0	0	2.26	0	0	0.45	0	0	1.11	0	0	0.22
PHYTE	1.57	0	0	0	0	0.31	1.59	0	0	0	0	0.32
RICCO	13.67	0	0	0	14.84	5.70	14.95	0	0	5.62	14.98	7.11
SIDCO	3.16	1.99	5.41	5.73	0	3.26	3.10	2.35	4.58	0	2.26	2.46
SIDRH	0	0	0	0	1.80	0.36	0	0	0	0	0	0
SOLAM	0	0	0	0	1.56	0.31	0	0	0	0	1.62	0.32
TRIPR	0	0	2.26	0	2.41	0.93	0	0	2.59	0	2.53	1.02
UROPL	0	0	3.41	0	0	0.68	0	0	4.07	0	0	0.81

Species	178 DAA – 2nd cut of the grass						344 DAA – 3rd cut of the grass					
	Doses (g ha^{-1})					Average	Doses (g ha^{-1})					Average
	0	3.78	7.56	15.12	22.68		0	3.78	7.56	15.12	22.68	
AGECO	15.32	1.55	21.07	10.83	14.9	12.73	0	0	0	0	0	0
ALTTE	48.05	57.47	35.58	40.95	35.62	43.53	46.4	38.4	17.25	19.69	22.55	28.86
BIDPI	2.41	1.15	0	0	0	0.71	0	0	0	0	0	0
CENEC	0	0	1.15	0	1.21	0.47	0	0	0	0	0	0
CHAHI	0	2.14	0	0	0.88	0.60	0	0	0	0	0	0
COMBE	7.66	11.69	19.38	17.18	11.1	13.40	0	0	0	0	0	0
CONBO	3.56	8.21	7.71	9.05	9.74	7.65	11.48	50.55	63.96	54.19	53.75	46.79
DESTO	1.78	0	2.3	1.07	0.90	1.21	0	0	0	0	0	0
DIGHO	4.24	10.36	1.15	2.14	5.80	4.73	0	6.43	10.66	5.38	6.04	5.70
DIGIN	3.92	0	1.15	1.08	0.87	1.40	0	0	0	3.06	0	0.61
ELEIN	0	0	3.93	0	2.96	1.37	0	0	0	7.72	3.64	2.27
GALPA	0	1.47	0	4.16	1.87	1.50	0	0	0	0	0	0
HYPLO	0	0	0	0	0.97	0.19	0	0	0	0	0	0
IPOTR	0	0	0	1.07	2.44	0.70	0	0	0	0	0	0
PANMA	1.78	0	2.08	3.03	1.20	1.61	0	0	0	0	0	0
PENSE	0	2.67	0	0	0	0.53	0	0	0	0	0	0
PHYTE	3.69	2.97	0	2.53	2.84	2.41	0	4.62	0	0	0	0.92
RHYRE	2.20	0	0	1.09	0	0.66	0	0	0	0	0	0
RICCO	2.54	0	0	2.11	4.61	1.85	20.49	0	0	2.33	7.30	6.02
SIDCO	0	0	1.63	0	0	0.33	21.63	0	8.14	7.63	6.72	8.82
SIDSA	0	1.47	0	0	0.87	0.47	0	0	0	0	0	0
TRIPR	0	0	1.71	2.63	0	0.87	0	0	0	0	0	0
URODE	2.84	0	0	1.07	0	0.78	0	0	0	0	0	0
ZEAMA	0	0	0	1.21	0	0.24	0	0	0	0	0	0

totaling 60.64 and 74.07%, respectively, of the RI of the weed community, and no effects of minimal doses of the herbicide were observed in the control of these species (Table 1). The other species had very low mean RI values (< 8%) in the different treatments (Table 1). According to Dan et al. (2012), weed species controlled by tembotrione comprise the grasses *U. decumbens, C. echinatus, D. horizontalis, D. ciliaris* and *U. plantaginea* and dicot species such as *A. tenella, C. benghalensis, Ipomoea nil, I. purpurea, I. acuminata, S. rhombifolia, N. physaloides, Euphorbia heterophylla, Raphanus raphanistrum, B. pilosa, B. subalternans, Richardia brasiliensis* and *Leonurus sibiricus.* However, according to the authors, the control of *A. tenella, B. pilosa* and *A. conyzoides* is generally efficient when using this herbicide combined with atrazine.

At 178 DAA of tembotrione, the weed community in the pasture formed after maize harvest presented a higher richness of species than that found in the evaluations of intercropped maize (Table 1). This behavior may be associated to the cultural control promoted by intercropped crops, reducing the diversity of weed species and also precipitations after harvesting the maize that extended until mid-May (Figure 1), promoting the germination and establishment of several species such as CONBO, DIGIN, HYPLO, PANMA, RHYRE, URODE and ZEAMA (Table 1). After harvesting maize, among the species that stood out in this evaluation and that showed IR values in most treatments were AGECO, CONBO and DIGHO with mean IR of 12.73; 7.65 and 4.73%, respectively. However, higher RI values were still found for ALTTE and COMBE, with RI of 43.53 and 13.40%, respectively (Table 1).

In the evaluation at 344 DAA of tembotrione, a lower number of species was observed in relation to the other evaluated periods, regardless of treatment (Table 1). This indicates that species richness was related to rainfall distribution (Figure 1). Eight species (ALTTE, CONBO, DIGHO, DIGIN, ELEIN, PHYTE, RICCO and SIDCO) were found in this evaluation, being CONBO (46.79%) and ALTTE (28.86%) the ones with higher RI (Table 1). Santos et al. (2013) pointed out that although soil water deficiency affects the germination of CONBO seeds, it does not affect their establishment because this species is tolerant and grows and develops in conditions considered stressful for the establishment of most cultures of economic interest.

In the analysis of the whole weed evaluation period (43, 109, 178 and 344 DAA of the herbicide), an adaptive capacity of ALTTE was observed, considering the minimal doses of the herbicide applied, the intercropped cultures, the formed pasture, and the climatological conditions such as the distribution of rainfall (Figure 1). ALTTE is a weed species of high RI in Brazilian agriculture due to its dissemination and increased density of infestation mainly in pastures and temporary crops (Canossa et al., 2008). Moreover, it is one of the main off-season and no-till farming infectious species, where it is particularly difficult to control (Timossi et al., 2006).

According to Faria (2016), the half-life of tembotrione determined in several Brazilian Latosols was between 32 and over 90 days and its dissipation depends on clay and organic matter content and agricultural practices such as liming that directly influence its adsorption and dissipation. Thus, the maximum dose (22.68 g ha^{-1}) used in this study represented thirty percent of the minimum recommended dose (75.6 g ha^{-1}) for weed control, and therefore, the effects of the doses on the weed community present in the intercropped system (at 43 and 109 DAA), considering the accumulated dry mass, were insignificant (Figure 2B). However, effects on seedling

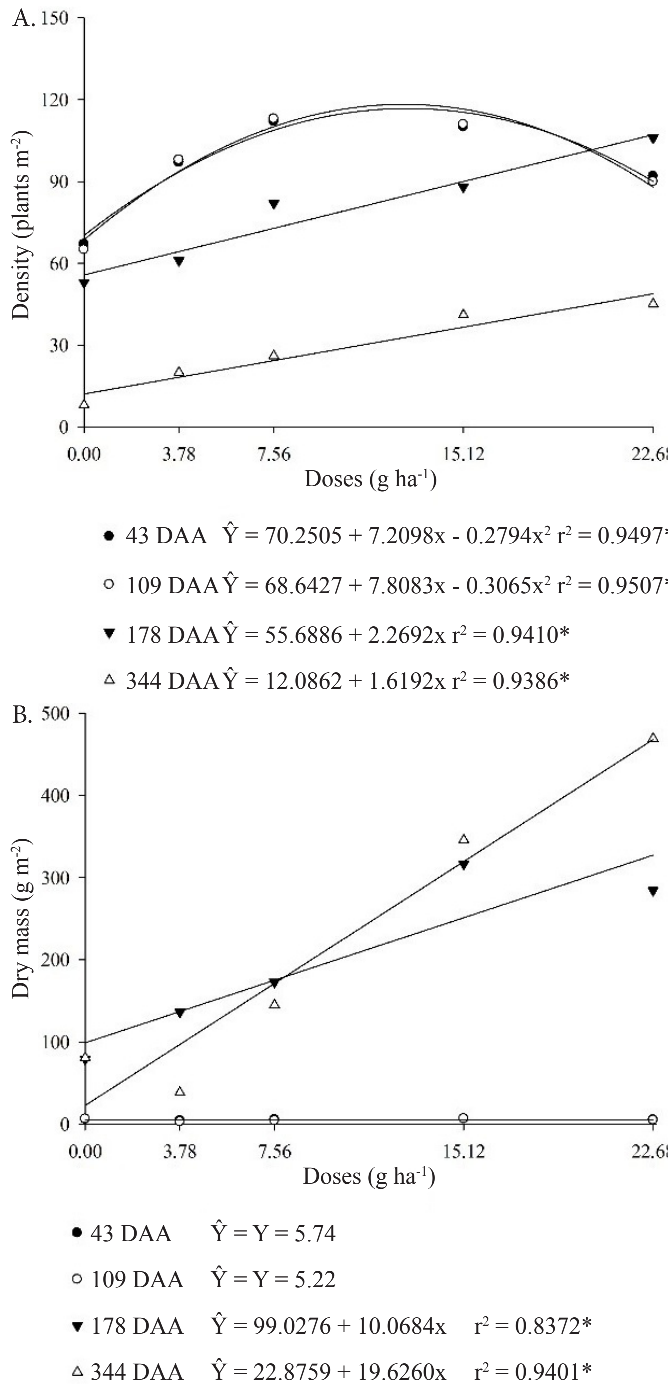

Figure 2. Density (a) and dry mass (b) of weeds evaluated at 43, 109, 178 and 344 DAA of the herbicide tembotrione.

density, explained by the quadratic models for both seasons, may be associated with heterogeneity of the soil weed seed bank (Figure 2A). According to Pereira et al. (2010), the divergences found in plant germination in areas that adopt the same management system can be explained in terms of spatial variations, both horizontally and vertically, that is, the variations between sites within the same area and changes in soil depth.

According to Dan et al. (2011), what further aggravates the problem is that the doses that are used for the forage to be suppressed in relation to the grain crops are lower than those recommended for the weed control. They are therefore minimal doses that facilitate the weed species to escape that control, especially grasses. However, it is worth mentioning the importance of a balanced dose of the herbicide in the intercrop, because the simple fact of suppressing the weeds may help in the cultural management performed by the forage, as observed by Ceccon et al. (2010). This assertion corroborates the results found for both the density of individuals (Figure 2A) and the cumulative dry mass (Figure 2B) of the weed community in the evaluations performed 178 and 344 DAA of tembotrione, demonstrating that the linear ascending effects explained by the models reflect the participation of the forage grass in the cultural control over the weed community.

The application of minimal doses of tembotrione, the weed community, and the coexistence with the forage grass *U. brizantha* did not affect the variables measured in the maize crop (Table 2). According to Ikeda et al. (2013), intercropping does not reduce weed density, but may reduce weed dry matter mass when intercropped with *U. brizantha* Cv 'Marandu' and 'Piatã'. The same authors commented that maize intercropped with cultivars of *Urochloa* spp. did not influence yield components or the biometrics of maize plants. On the other hand, Dan et al. (2010) observed the importance of forage management in maize productivity and that competition among intercropped species should be suppressed.

The presence of *U. brizantha* growing freely with the maize crop promoted significant reductions on the variables height of insertion of the first spike, plant height and grain yield of maize when compared to maize monoculture. Similar reductions occurring due to the interspecific competition involving the intercropped species were also reported by Gimenes (2011).

Regarding the variables evaluated in the forage, we observed in the evaluations carried out at 109 DAA of tembotrione herbicide (maize harvest and first cut of the grass) and 178 DAA (second cut of the grass) in the established pasture that there were statistical differences in plant height (PH) and forage yield (FY) of *U. brizantha* intercropped and in single crop (Table 3). Highest PH and FY were obtained in the monoculture of the grass, indicating that the maize exerted a competitive effect when associated with the forage grass and that this reflected on the subsequent harvesting of the crop for both variables (Table 3).

Considering only the minimal doses of tembotrione used to manage the coexistence between forage grass and maize, the PH of the grass intercropped and shaded by maize was not significantly affected (Table 3). However, after removal of maize from the pasture grown, significant differences were observed in PH between the single and intercropped established forage, both at 178 and 344 DAA of the herbicide. In intercropping, the effects in this variable decreased according to the applied minimal doses (Table 3). However, the phytotoxic effect of the herbicide on the forage was manifested in terms of FY, with a sharp drop of 20.93 kg ha^{-1} for each increase in the dose of the herbicide, persisting until the 178 DAA of the herbicide, reflecting over the FY and the percentage of soil cover (PSC) with a reduction of 68.89 kg ha^{-1} and 2.32%, respectively, for each increase in the dose of the herbicide (Table 3).

According to Rodrigues & Almeida (2011), tembotrione is recommended for maize crops at the dose of 75.6 g ha^{-1}, because this value is efficient to control species of the genus *Urochloa*. However, at minimal doses, the herbicide promotes delay in forage establishment. Rezende et al. (2014) studied the effect of herbicides applied in maize intercropped with *U. brizantha* Cv Marandu and found that tembotrione at the dose of 42 g ha^{-1} did not reduce FY and when it was applied associated with atrazine and bentazon, FY was reduced, mainly that of leaves and stems.

Table 2. Plant height (PH), height of spikes (HS), stem diameter (SD), spike length (SL), spike diameter (SD), number of rows per spike (NRS), number of grains per row (NGR), 100-grain mass (100GM) and grain yield (GY) of maize intercropped with *Urochloa brizantha* Cv MG-5 Vitória as a function of the application of tembotrione doses.

Variables	Doses (g ha^{-1})					Regression	MM	$F_{5\%}$	CV%
	0	3.78	7.56	15.12	22.68				
PH (m)	1.97	1.95	2.02	2.01	1.98	$\hat{Y} = \bar{Y} = 1.987$	2.05	2.359^{ns}	2.43
HS (m)	1.09	1.08	1.07	1.10	1.06	$\hat{Y} = \bar{Y} = 1.08$	1.09	0.057^{ns}	3.69
SD (mm)	18.48	19.67	19.60	19.09	19.40	$\hat{Y} = \bar{Y} = 19.37$	19.35	0.823^{ns}	5.56
SL (cm)	15.93	16.53	17.20	16.98	16.48	$\hat{Y} = \bar{Y} = 16.62$	17.30	2.255^{ns}	4.15
SD (mm)	52.06	51.75	50.87	52.50	52.18	$\hat{Y} = \bar{Y} = 51.87$	51.84	0.377^{ns}	3.48
NRS	17.90	17.90	18.55	18.70	17.85	$\hat{Y} = \bar{Y} = 18.18$	18.25	0.766^{ns}	4.62
NGR	31.89	33.88	33.35	33.80	33.55	$\hat{Y} = \bar{Y} = 33.29$	33.78	1.059^{ns}	4.39
100GM (g)	30.57	31.32	29.97	34.67	27.35	$\hat{Y} = \bar{Y} = 30.78$	32.83	0.922^{ns}	16.77
GY (kg ha^{-1})	6,083.75	6,296.75	5,939.05	8,629.38	7,552.04	$\hat{Y} = \bar{Y} = 6,900.19$	8,812.54	2.188^{ns}	19.90

MM - maize monoculture. ns not significant.

Table 3. Plant height (PH), forage yield (FY) and percentage of soil cover (PSC) of the forage grass *Urochloa brizantha* Cv MG-5 Vitória as a function of the treatments evaluated at 109, 178 and 344 DAA of the herbicide tembotrione.

Variables	Doses (g ha^{-1}) 0	3.78	7.56	15.12	22.68	Regression	FM	$F_{5\%}$	CV%
				109 DAA – harvesting the maize and the forage					
PH (cm)	74.16	65.52	58.34	61.00	63.40	$\hat{Y} = \bar{Y} = 64.48$	117.16	12.75*	14.67
FY (kg ha^{-1})	1,232.00	956.00	1,059.00	816.00	703.00	$\hat{Y} = 1.158.91 - 20.9313x$ $r^2 = 0.8525$*	2,527.00	5.10*	42.18
				178 DAA – 2nd cut of the grass					
PH (cm)	57.40	58.15	50.60	46.00	42.65	$\hat{Y} = 58.046 - 0.7210x$ $r^2 = 0.9217$*	87.55	48.53*	8.12
PSC (%)	69.16	57.08	38.75	28.33	15.00	$\hat{Y} = 64.49 - 2.323x$ $r^2 = 0.946$*	87.08	21.11*	23.76
FY (kg ha^{-1})	2,040.02	1,355.16	1,163.15	671.27	349.47	$\hat{Y} = 1.792.96 - 68.89x$ $r^2 = 0.9264$*	3,894.17	44.62*	24.18
				344 DAA – 3rd cut of the grass					
PH (cm)	56.95	51.00	48.60	45.95	47.15	$\hat{Y} = 56.43 - 1.3699x$ $r^2 = 0.9832$*	54.95	11.06*	5.21
PSC (%)	78.33	75.00	71.67	62.50	50.83	$\hat{Y} = 79.582 - 1.2125x$ $r^2 = 0.9873$*	79.582	12.06*	9.14
FY (kg ha^{-1})	2,913.96	2,885.53	2,635.58	1,979.89	1,837.39	$\hat{Y} = \bar{Y} = 2.450.47$	2,802.15	2.32^{ns}	24.96

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

The lower yield of the grass in relation to the monoculture control can be explained by the shading caused by maize plants on the forage, because, in this condition, C4 species, including those of the genus *Urochloa*, generally present lower dry matter mass production (Portes et al., 2000). The growth of forage plants is defined by their net daily accumulated photosynthetic activity under the available resources, and when exposed to shading, the daily growth rate is rapidly restricted due to the limited energy necessary for photosynthetic processes (Varella, 2008). Shade-tolerant plants have restricted photosynthetic capacity and when shading modifies the carbon supply, the plants reduce the

Table 4. Mineral matter (MM), ethereal extract (EE), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (LI) and dry matter (DM) of *Urochloa brizantha* Cv MG-5 Vitória according to the treatments evaluated at 109, 178 and 344 DAA of the herbicide.

Variables	Doses (g ha^{-1}) 0	3.78	7.56	15.12	22.68	Regression	FM	$F_{5\%}$	CV%
				109 DAA – harvesting the maize and the forage					
MM (%)	11.63	12.48	11.76	13.23	13.54	$\hat{Y} = \bar{Y} = 12.53$	8.62	2.26^{ns}	19.82
EE (%)	6.63	6.51	7.30	6.80	8.26	$\hat{Y} = \bar{Y} = 7.10$	6.93	0.58^{ns}	23.71
CP (%)	12.59	11.70	12.99	13.62	13.39	$\hat{Y} = \bar{Y} = 12.86$	10.89	1.12^{ns}	15.74
NDF (%)	60.92	61.16	63.21	67.30	62.51	$\hat{Y} = \bar{Y} = 63.02$	72.11	1.40^{ns}	11.41
ADF (%)	36.53	33.84	38.42	38.42	33.02	$\hat{Y} = \bar{Y} = 36.04$	37.94	1.36^{ns}	11.27
LI (%)	11.36	8.93	12.65	11.30	12.73	$\hat{Y} = \bar{Y} = 11.39$	13.76	0.86^{ns}	30.67
DM (%)	22.87	22.76	23.01	22.80	22.26	$\hat{Y} = \bar{Y} = 22.74$	22.75	0.37^{ns}	3.63
				178 DAA – 2nd cut of the grass					
MM (%)	9.05	10.72	11.25	8.96	11.13	$\hat{Y} = \bar{Y} = 10.22$	9.35	1.60^{ns}	16.77
EE (%)	8.20	7.05	8.87	7.65	11.28	$\hat{Y} = \bar{Y} = 8.61$	6.85	5.98*	16.02
CP (%)	13.52	14.78	16.25	14.12	16.02	$\hat{Y} = \bar{Y} = 14.94$	13.45	1.59^{ns}	13.18
NDF (%)	71.46	67.93	69.68	70.62	71.25	$\hat{Y} = \bar{Y} = 70.18$	72.84	1.47^{ns}	3.93
ADF (%)	40.22	35.53	40.14	34.37	39.21	$\hat{Y} = \bar{Y} = 37.90$	37.75	0.59^{ns}	16.77
LI (%)	8.73	7.24	6.79	8.01	8.77	$\hat{Y} = \bar{Y} = 7.91$	7.67	0.91^{ns}	21.20
DM (%)	21.90	21.90	21.19	23.15	21.76	$\hat{Y} = \bar{Y} = 0.81$	0.70	0.90^{ns}	28.00
				344 DAA – 3rd cut of the grass					
MM (%)	7.96	7.37	8.26	7.48	7.29	$\hat{Y} = \bar{Y} = 7.67$	7.29	1.035^{ns}	10.54
EE (%)	9.89	8.89	8.01	9.30	10.50	$\hat{Y} = \bar{Y} = 9.316$	9.69	1.461^{ns}	15.21
CP (%)	10.11	10.21	12.73	13.65	13.87	$\hat{Y} = 10.33 + 0.182x$ $r^2 = 0.8193$*	9.99	4.970*	14.13
NDF (%)	69.33	70.25	76.26	67.67	68.72	$\hat{Y} = \bar{Y} = 70.44$	70.07	1.068^{ns}	8.33
ADF (%)	32.42	32.27	34.34	31.36	31.27	$\hat{Y} = \bar{Y} = 32.33$	32.69	0.980^{ns}	6.94
LI (%)	15.29	11.42	10.96	10.17	12.17	$\hat{Y} = \bar{Y} = 12.00$	11.04	0.425^{ns}	46.91
DM (%)	31.28	29.66	26.98	28.49	28.00	$\hat{Y} = \bar{Y} = 28.88$	30.71	1.785^{ns}	8.49

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

tillering rate as a result of competition between leaves and axillary buds (Soares et al., 2009). However, *U. brizantha* and *U. decumbens* are considered to have a certain level of tolerance to shade, presenting morphological changes as adaptations to low light, with less dry matter mass in the roots and more in the leaves in relation to plants grown in the presence of light (Souto et al., 2009).

In the third cut (344 DAA), there was no further fall in FY, demonstrating the ability of the species to recover from the effects caused by the herbicide. This ability derives from several factors, including the spacing between rows, the type of sowing, the leaf architecture of maize, and the edaphoclimatic conditions of the region (Jakelaitis et al., 2010). PH and PSC of the grass were affected by minimal doses of the herbicide even in the evaluations at 344 DAA (Table 3).

Bromatological variables related to MM, EE, CP, NDF, ADF, LIG and DM were not influenced by the intercropping or by minimal doses of tembotrione in the evaluation performed at 109 DAA of the herbicide when compared to the monoculture control treatment (Table 4). However, in the second cut, at 178 DAA, there was a significant difference between treatments for EE and, in the third cut, at 344 DAA, increases in CP levels due to the increase in minimal doses of tembotrione. No bibliographic references were found on the effects of these variables on forages treated with this herbicide in intercropped systems.

Conclusions

Minimal doses of tembotrione intercropped and in monoculture as well as the distribution of rainfall throughout the evaluated period affected the density of individuals and dry mass accumulation of the infesting community.

A. tenella, C. benghalensis and *G. parviflora* were not affected by minimal doses of tembotrione and were the most important species present in the intercrop between maize and *U. brizantha*. After harvesting maize, still in the rainy season, at 178 DAA of the tembotrione, the most important species were *A. tenella, C. benghalensis* and *A. conyzoides*, and in the period after the rains, at 344 DAA, *C. bonariensis* and *A. tenella.*

The intercropped forage grass does not affect maize production capacity, but maize reduces *U. brizantha* production during and after intercropping in the pasture.

Minimal doses of tembotrione affect forage yield, grass height and percentage of soil cover after maize harvest.

The bromatological variables ethereal extract and crude protein are affected by the treatments in the pasture formed after harvesting maize.

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