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Weed infestations in soybean grown in succession to cropping systems with sorghum and cover plants

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Abstract – The objective of this work was to evaluate the influence of sorghum and cover plant cropping systems before soybean cultivation on the occurrence of weeds during soybean growing in the Brazilian Cerrado. The experiment was carried out in a randomized complete block design, with four replicates. The treatments comprised six cropping systems before soybean: sorghum (*Sorghum bicolor*), palisade grass (*Urochloa brizantha*), and Congo grass (*Urochloa ruziziensis*) as cover plants, alone or intercropped, in addition to fallowing. Weeds were evaluated as to: density, dry matter mass, diversity, importance value, and similarity. The greatest similarity of weeds ocurred in single crops of sorghum, palisade grass, and Congo grass, in comparison with their intercroppings. Congo grass before soybean promoted a greater reduction in weed diversity overtime, when compared with palisade grass. The absence of cover crops before soybean cultivation increased weed infestation during the soybean cycle. The cropping systems with sorghum intercropped with cover crops before the soybean cultivation affect the diversity and the importance value of weed species.

Index terms: *Sorghum bicolor*, *Urochloa brizantha*, *Urochloa ruziziensis*, importance value index, short-season, similarity.

Ocorrência de plantas daninhas em soja em sucessão a sistemas de cultivo com sorgo e plantas de cobertura

Resumo – O objetivo deste trabalho foi avaliar a influência de sistemas de cultivo de sorgo e plantas de cobertura anteriores ao cultivo da soja, na ocorrência de plantas daninhas durante o cultivo da soja no Cerrado brasileiro. O experimento foi realizado em delineamento de blocos ao acaso, com quatro repetições. Os tratamentos consistiram em seis sistemas de cultivo antes da soja: sorgo (*Sorghum bicolor*), capim-marandu (*Urochloa brizantha*) e capim-ruziziensis (*Urochloa ruziziensis*), isolados ou consorciados, além do pousio. As plantas daninhas foram avaliadas quanto a: densidade, massa de matéria seca, diversidade, valor de importância e similaridade. A maior similaridade de plantas daninhas ocorreu nos cultivos solteiros de sorgo, capim-marandu e capim-ruziziensis do que em seus cultivos consorciados. O capim-ruziziensis antes da soja favoreceu maior redução da diversidade de plantas daninhas no decorrer do tempo, quando comparado ao capim-marandu. A ausência de plantas de cobertura no pousio aumentou a infestação de plantas daninhas durante o ciclo da soja. Os sistemas consorciados de sorgo com plantas de cobertura antes do cultivo da soja influenciam a diversidade e o valor de importância das plantas daninhas.

Termos para indexação: *Sorghum bicolor*, *Urochloa brizantha*, *Urochloa ruziziensis*, valor de importância, safrinha, similaridade.

Introduction

The area explored for crop-pasture systems is increasing in Brazil, in recent years, especially in the Cerrado region. Among many other advantages, crop-pasture systems can reduce weeds in the area, to maintain the soil surface covered all over the year. According to Carvalho et al. (2012), intercropping crops and cover plants is an alternative to face some weed problems, as intercropping integrates combinations that can help to suppress weeds.

The cultivar Marandu of palisade grass [*Urochloa brizantha* (Hochst. ex A. Rich). R.D. Webster] and Congo grass [(*Urochloa ruziziensis* (R. Germ. & Evrard) Crins] are largely recommended for cultivation in the Cerrado because they adapt well to the edaphoclimatic conditions of this region, as well as sorghum [*Sorghum bicolor* (L.) Moench] that is less water demanding than maize. These species can be cultivated before the main crop – soybean, for instance – during the short-season of the Cerrado region. Systems like these may have potential to keep weed population below the economic damage level because of the control during the grasses development, characterizing a strategy of reducing but not eradicating weeds (Noce et al., 2008; Fontes et al., 2019).

Correia et al. (2011) described the effects of soil coverage by palisade grass on weed control, which contributes both to the reduction of chemical application and to the control of herbicide-resistant species, such as *Digitaria* spp. resistant to glyphosate. Congo grass is considered an efficient competitor to weeds (Adegas et al., 2011), which is probably due to its fast growth and dense soil coverage. In this aspect, sorghum can be an interesting option for crop systems to reduce the occurrence of weeds in the cropping area, once it contains allelochemical substances in its tissues that are released to the environment by leaves, stems, and roots (Dayan, 2006).

The seedling emergence of weed species varies throughout the year in the Cerrado region, making it more difficult to propose control techniques (Concenço et al., 2015). The composition and population of a weed community are influenced by the soil management (Sodré Filho et al., 2014). An example of this effect on weed dynamics is the expansion of no-tillage system in Brazil, in recent years, which affected the prevalent species and the weed seed banks in the soil, due to the concentration of seeds on the soil surface (Ikeda et al., 2013). The phytosociological survey is an important tool to recommend rational management techniques, once it provides information on the weed species occurrence and the level of infestation in the area (floristic composition) – either under tillage or pasture systems (Mascarenhas et al., 2009).

There is still a lack of information on the effects of intercropping or crop-pasture systems (Hirata et al., 2018), especially concerning weed dynamics, and weed species resistant to some herbicides have been reported as one of the major problems in no-tillage areas. Poaceae, Asteraceae, and Euphorbiaceae are important weed plant families for Brazilian agriculture, and developed also resistant genotypes to the ALS and EPSPs inhibitor herbicides (Vargas et al., 1999), which are used as pre-emergence, post-emergence, and desiccants herbicides. Therefore, the knowledge on the weed community is essential to propose management techniques, especially for integrating methods, like the combination of chemical control and intercropping, or crop-pasture systems.

The objective of this work was to evaluate the influence of sorghum and cover plants cropping systems, before soybean cultivation, on the occurrence of weeds during soybean cultivation.

Material and Methods

The study was carried out from 2010 to 2011 in an experimental area of Embrapa Cerrados, located in Planaltina (15°35’S, 47°42’W, at 1,008 m of altitude), Distrito Federal, Brazil. The soil was a Latossolo Vermelho, according to the Brazilian Soil Classification (Santos et al., 2013), i.e., a Typical Acrustox. The area remained in fallowing during two years before the experiment. Soil analysis at 0–20-cm soil depth indicated 2.5 g kg^{-1} organic matter; 5.8 pH in water; 6.5 mg dm^{-3} available P and 52.4 mg dm^{-3} available K (both extracted by Mehlich); 0.1, 2.8, and 0.9 $cmol_c$ dm^{-3} of exchangeable Al, Ca, and Mg, respectively (extracted by KCl mol L^{-1}); 8.5 $cmol_c$ dm^{-3} CEC at pH 7.0, and 45% base saturation and 16.13% Al saturation. Meteorological data of rainfall and mean temperature were recorded during the experimental period (Figure 1).

The experiment was carried out in a randomized complete block design, with four replicates. The treatments comprised six cropping systems grown from March to September of both years (2010 and 2011), previously to soybean: sorghum (*Sorghum bicolor*), palisade grass (*Urochloa brizantha* 'Marandu'), Congo grass (*Urochloa ruziziensis*), sorghum intercropped with palisade grass, sorghum intercropped with Congo grass, and fallow. The plot dimensions were 5.0×8.0 m, with a useful area of 28 m^2, totaling 1,120 m^2 of experimental area.

The different cropping systems were sown with a drag seeder, on March 15, 2010 and on March 17, 2011, under no-tillage, at 0.50 m row spacing for *Sorghum bicolor* 'BRS 304', and 0.25 m for palisade grass and for Congo grass. Sorghum was sown at the rate of 18 seed per linear meter of row, in order to achieve a population of 300,000 plants ha^{-1}. Palisade grass and Congo grass were sown at the rate of 14 kg ha^{-1} of pure and viable seed (germination = 81%). The species of cover plants were sown simultaneously, but not at the same rows as sorghum. N-P_2O_5-K_2O (30-10-20) 200 kg ha^{-1} was specially formulated for use in the lines of sowing, and 15 days later, 50 kg ha^{-1} N was applied. Sorghum was manually harvested on June 30, 2010 and on July 13, 2011. Before the beginning of the rainy season (September 23, 2010 and September 15, 2011), natural vegetation and grasses of the experimental area were desiccated with glyphosate (1,800 g ha^{-1} a.e., spray volume of 400 L ha^{-1}).

'BRS Favorita RR' soybean (*Glycine max* L.) was sown on October 13, 2010, and on October 10, 2011, under no-tillage in the row spacing at 0.50 m, with 400 kg ha^{-1} N-P_2O_5-K_2O (00-20-20), to obtain a population of 320,000 plants ha^{-1}. Glyphosate was sprayed (1,800 g ha^{-1} a.e., spray volume of 400 L ha^{-1}) in all plots at 28 days after emergence (DAE) of soybean. Fungicides and insecticide were sprayed in the area to prevent the occurrence of diseases and pests. Soybean was desiccated at 128 DAE, at the stage R8 (beginning of grain drying in the pods, and senescence of the leaves), with paraquat dichloride (400 g ha^{-1} a.i., spray volume of 200 L ha^{-1}).

A survey for the weed population was carried out at 30 DAE of sorghum of all treatments, on April 20 of

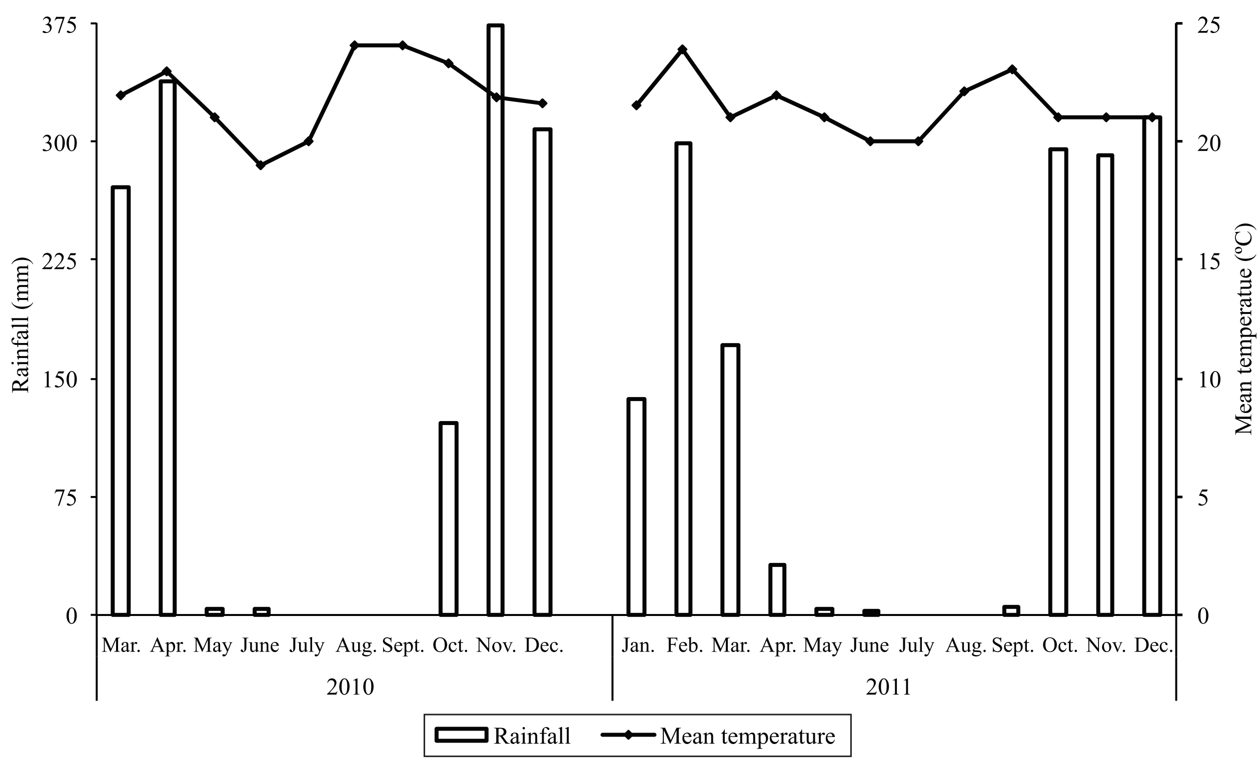

Figure 1. Monthly accumulated rainfall and mean temperature during the experimental period, in the city of Planaltina, in the Distrito Federal, Brazil.

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both 2010 and 2011. During the soybean development – before the recommended chemical control for this crop –, a weed population survey was also undertaken at 19 DAE of soybean cultivation (November 4, 2010, and November 7, 2011) with the random sampling with quadrats. For this purpose, an iron square (0.25 m^{-2}) was randomly thrown four times into each plot, totaling 16 samples for each cropping system. Plants and seedlings of the weed community were collected, identified, counted, and placed in paper bags. Then, they were oven-dried at 60ºC for 72 hours, to obtain the dry matter mass.

The following parameters were evaluated for each weed species: plant density (number of plants per quadrat); frequency (proportion of the quadrats containing at least one individual of a given species); and dominance (dry matter mass accumulation of a given species). Other parameters were also calculated, as follows: relative density (density of a given species × 100 / density of all species); relative frequency (frequency of a given species × 100 / frequency of all species); and relative dominance (dominance of a given species × 100 / dominance of all species). Based on these three parameters, the importance value (IV) of each weed species was calculated using the following equation:

IV (%) = [relative density (%) + relative frequency (%) + relative dominance (%)]/3.

For each period of assessment, the IV was estimated only for the most prevalent weed species in the area. The lowest prevalent weeds were grouped as ‘other species’.

The diversity index of weed species in the cropping systems was estimated by the Simpson’s method (D) and by the modified Shannon-Weiner’s (H’) method, using the equation below:

$D = 1 - \Sigma(p_i)^2$ and $H' = -\Sigma(p_i)(\log_2 p_i)$,

in which: p_i is the proportion of all sampled individuals belonging to the species i. Only the relative abundance (divided by 100) was used for obtaining D and H’. The asymmetric binary coefficient of similarity of Jaccard’s (J) was estimated using the equation:

$J = [c/(a + b - c)] \times 100$,

in which: a is the total number of species in the area A; b is the total number of species in the area B; c is the number of species common to areas A and B. Both diversity indices (D and H’) were compared between cropping systems and within each period of assessment by using the Tukey’s test, at 5% probability. The Sisvar program version 5.6 was used for the statistical analysis (Ferreira, 2011). In order to test the similarity between treatments, the unweighted pair group method (UPGMA) and the Paleontological Statistic (PAST) (Hammer et al., 2001) software were used; clustering was achieved from the arithmetic mean of the elements, and then the similarity matrix was elaborated.

Results and Discussion

Sorghum intercropped with Congo grass was the most efficient system to reduce weed population over the evaluation period (Figure 2), as a result of the soil coverage by sorghum and Congo grass, which prevented most of weed establishing and further development. Otherwise, the fallow treatment showed the highest weed plant density over time. The maintenance of spontaneous vegetation during the fall/winter seasons (short-season in Cerrado) is probably responsible for increasing the seed bank in the soil because of the constant renewal of seed in the area (Correia et al., 2006).

Twenty-two weed species, distributed in nine botanical families, occurred in the experimental area. The number of species per family were: 8, Asteraceae; 6, Poaceae; 2, Euphorbiaceae; and 1 species each for the families Amaranthaceae, Commelinaceae, Convolvulaceae, and Rubiaceae (Table 1). The variability of weed species and families is common in crop integrated systems, although some botanical families are most prevalent in the Brazilian Cerrado region. The most important weed families in cropping-pasture systems in this region are Poaceae, Malvaceae, Asteraceae, and Rubiaceae (Mascarenhas et al., 2009); and the families Poaceae and Asteraceae show the largest number of species in the Brazilian Cerrado region, according to Concenço et al. (2011) and Ikeda et al. (2013).

From April 2010 to November 2011, all cropping systems attained a decreased weed dry mass in the area (Figure 2), probably due to the presence of mulch,

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the competition of crops, and the efficiency of the chemical control. These results confirm the importance of mulching produced by some crop systems to reduce the weed dry mass.

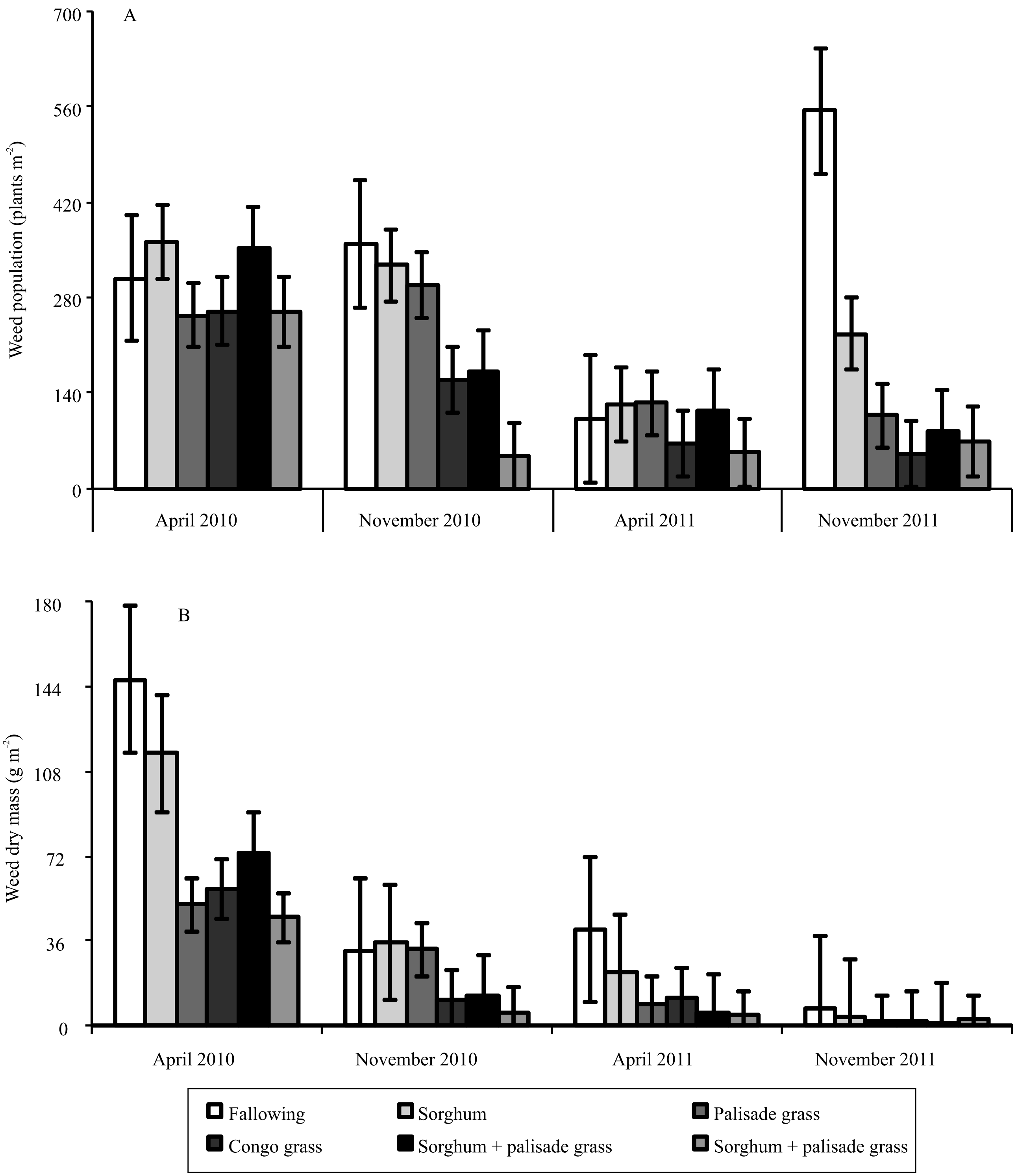

Figure 2. Weed population (A) and weed dry mass (B) in different crop systems in April 2010, November 2010, April 2011 and November 2011. Error bars are presented above each column.

Table 1. Phytosociological analysis of weed composition in different cropping systems including fallowing, sorghum and forage grasses (April) followed by soybean (November), in 2010 and 2011, at the Brazilian Cerrado region.

Crop systems	Weed species	April 2010				November 2010				April 2011				November 2011			
		DEr[(1)]	FRr	DOr	IV	DEr	FRr	DOr	IV	DEr	FRr	DOr	IV	DEr	FRr	DOr	IV
		(%)															
Fallowing/ soybean	*Ageratum conyzoides*	14.95	8.00	17.68	13.54	1.74	3.70	4.99	3.48	6.98	12.50	6.52	8.67	18.03	17.65	15.41	17.03
	Bidens pilosa	1.87	4.00	4.42	3.43	53.49	14.81	38.28	35.53	6.98	12.50	6.52	8.67	36.89	23.53	23.64	28.02
	Chamaesyce hirta	30.84	16.00	18.23	21.69	11.05	14.81	7.91	11.26	13.95	18.75	8.70	13.80	0.82	5.88	2.10	2.93
	Digitaria insularis	8.41	16.00	4.97	9.79	61.04	15.79	53.71	43.51	18.92	17.65	14.97	17.18	19.36	15.38	17.91	17.55
	Eleusine indica	-	-	-	-	-	-	-	-	25.58	18.75	15.94	20.09	-	-	-	-
	Emilia fosbergii	-	-	-	-	-	-	-	-	-	-	-	-	5.74	11.76	7.36	8.29
	Richardia brasiliensis	19.63	12.00	15.47	15.70	5.81	7.41	8.32	7.18	16.28	18.75	10.14	15.06	29.51	11.76	37.83	26.37
	Others	24.30	44.00	39.23	35.84	25.58	44.44	38.84	36.29	44.19	43.75	65.22	51.05	9.02	29.41	13.66	17.36
Sorghum/ soybean	*Ageratum conyzoides*	9.09	15.00	7.84	10.64	0.64	5.00	2.15	2.60	14.89	10.53	18.58	14.67	25.61	18.18	16.98	20.26
	Bidens pilosa	9.09	10.00	11.76	10.29	74.52	20.00	62.90	52.48	4.26	5.26	10.62	6.71	24.39	13.64	21.56	19.86
	Chamaesyce hirta	20.45	15.00	17.65	17.70	7.01	20.00	5.91	10.97	17.02	15.79	14.16	15.66	13.41	13.64	11.86	12.97
	Digitaria insularis	26.14	15.00	22.55	21.23	-	-	-	-	-	-	-	-	-	-	-	-
	Eleusine indica	-	-	-	-	-	-	-	-	31.91	15.79	26.55	24.75	-	-	-	-
	Emilia fosbergii	-	-	-	-	5.73	15.00	6.45	9.06	-	-	-	-	9.76	9.09	12.94	10.60
	Richardia brasiliensis	23.86	15.00	20.59	19.82	2.55	10.00	4.30	5.62	23.40	15.79	19.47	19.55	7.32	9.09	9.70	8.70
	Others	11.36	30.00	19.61	20.32	9.55	30.00	18.28	19.28	27.66	52.63	39.82	40.04	19.51	36.36	26.95	27.61
Palisade grass/ soybean	*Ageratum conyzoides*	5.06	13.04	5.44	7.85	-	-	-	-	1.85	6.25	5.61	4.57	17.14	14.29	21.69	17.70
	Bidens pilosa	1.27	4.35	4.08	3.23	62.24	23.08	59.14	48.15	7.41	12.50	11.22	10.37	11.43	21.43	9.64	14.17
	Chamaesyce hirta	27.85	17.39	22.45	22.56	23.78	30.77	16.94	23.83	31.48	25.00	23.83	26.77	34.29	21.43	28.92	28.21
	Eleusine indica	-	-	-	-	-	-	-	-	12.96	18.75	13.08	14.93	-	-	-	-
	Emilia fosbergii	-	-	-	-	0.70	7.69	1.99	3.46	-	-	-	-	8.57	14.29	10.84	11.23
	Richardia brasiliensis	30.38	17.39	24.49	24.09	11.19	15.38	15.95	14.17	42.59	25.00	32.24	33.28	-	-	-	-
	Others	24.05	34.78	31.29	30.04	2.10	23.08	5.98	10.38	12.96	31.25	30.84	25.02	28.57	28.57	28.92	28.69
Congo grass/ soybean	*Ageratum conyzoides*	1.69	4.17	5.37	3.74	-	-	-	-	7.69	7.14	13.19	9.34	-	-	-	-
	Bidens pilosa	22.03	12.50	23.27	19.27	71.05	40.00	52.94	54.66	15.38	21.43	8.79	15.20	50.00	28.57	42.10	40.23
	Chamaesyce hirta	17.80	16.67	14.09	16.19	19.74	30.00	19.61	23.11	15.38	14.29	13.19	14.29	6.25	14.29	10.53	10.35
	Eleusine indica	-	-	-	-	-	-	-	-	11.54	14.29	9.89	11.90	-	-	-	-
	Emilia fosbergii	-	-	-	-	1.32	10.00	3.92	5.08	-	-	-	-	31.25	28.57	26.31	28.71
	Richardia brasiliensis	33.05	16.67	26.17	25.30	5.26	10.00	15.69	10.32	42.31	21.43	24.18	29.30	-	-	-	-
	Tridax procumbens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Others	20.34	41.67	23.04	28.35	2.63	10.00	7.84	6.82	30.77	50.00	52.75	44.51	12.50	28.57	21.05	20.71

Continuation...

Table 1. Continuation...

Crop systems	Weed species	April 2010				November 2010				April 2011				November 2011			
		DEr[1]	FRr	DOr	IV	DEr	FRr	DOr	IV	DEr	FRr	DOr	IV	DEr	FRr	DOr	IV
		(%)															
Sorghum with palisade grass/ soybean	*Ageratum conyzoides*	13.92	10.00	17.84	13.92	2.60	10.53	3.43	5.52	27.03	17.65	21.39	22.02	16.13	15.38	14.93	15.48
	Bidens pilosa	7.59	10.00	9.73	9.11	61.04	15.79	53.71	43.51	18.92	17.65	14.97	17.18	19.36	15.38	17.91	17.55
	Chamaesyce hirta	34.18	20.00	21.89	25.36	12.99	21.05	8.57	14.20	18.92	23.53	11.23	17.89	29.03	30.77	13.43	24.41
	Digitaria insularis	2.53	5.00	6.49	4.67	-	-	-	-	-	-	-	-	-	-	-	-
	Eleusine indica	-	-	-	-	-	-	-	-	13.51	17.65	10.70	13.95	-	-	-	-
	Emilia fosbergii	-	-	-	-	-	-	-	-	-	-	-	-	3.23	7.69	5.97	5.63
	Richardia brasiliensis	18.99	20.00	12.16	17.05	1.30	5.26	3.43	3.33	29.73	17.65	23.53	23.64	12.90	15.38	11.94	13.41
	Tridax procumbens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Others	22.78	35.00	31.89	29.89	16.88	36.84	17.14	23.62	37.84	41.18	54.55	44.52	19.36	15.38	35.82	23.52
Sorghum with Congo grass/ soybean	*Ageratum conyzoides*	6.52	13.33	5.52	8.46	-	-	-	-	22.22	30.00	13.12	21.78	7.69	7.14	10.17	8.33
	Bidens pilosa	6.52	6.67	11.04	8.08	50.00	33.33	26.83	36.72	-	-	-	-	19.23	21.43	8.47	16.38
	Chamaesyce hirta	28.26	20.00	15.95	21.40	9.09	22.22	7.32	12.88	11.11	20.00	9.84	13.65	7.69	14.29	5.08	9.02
	Digitaria insularis	6.52	6.67	11.04	8.08	-	-	-	-	-	-	-	-	-	-	-	-
	Eleusine indica	-	-	-	-	-	-	-	-	16.67	20.00	14.75	17.14	-	-	-	-
	Emilia fosbergii	-	-	-	-	-	-	-	-	-	-	-	-	7.69	7.14	10.17	8.33
	Richardia brasiliensis	15.22	20.00	8.59	14.60	13.64	11.11	21.95	15.57	44.44	30.00	26.23	33.56	3.85	7.14	5.08	5.36
	Others	36.96	33.33	47.85	39.38	27.27	33.33	43.90	34.84	27.78	30.00	49.18	35.65	53.85	42.86	61.02	52.57

[1]DEr, relative density; FRr, relative frequency; DOr, relative dominance; IV, importance value.

The species with higher importance value (IV) were similar between all agricultural systems in April 2010 (Table 1). Since the experimental area was maintained in fallow during two years before the experiment, the effect of the crop systems was not evident after 30 days of the installation of the experiment. In the sorghum with Congo grass, the IV of *Chamaesyce hirta* was 21.40% in April 2010, which was relatively high, indicating a large number of plants of this species in the field. But the IV of *C. hirta* decreased over time in this crop system to an index of 9.02%, in November 2011.

In April 2011 and in November 2011, new species emerged only in the fallow, like *Eleusine indica* (20.09%) and *Emilia fosbergii* (8.29%) (Table 1). In the systems with grasses, the IV of some weed species varied from 2010 to 2011, showing an alternation of importance during both short-season assessments, in April of both years.

The IV index of *Digitaria insularis* reduced in the system with sorghum intercropped with palisade grass (by 4.67%) and with Congo grass (by 8.08%) (Table 1). According to Noce et al. (2008), sorghum can reduce the infesting flora by up to 74%, which was also observed in the sorghum straw effect on the emergence reduction of weed seedlings (Correia et al., 2006). The results of the present study show that intercropping systems including sorghum and cover plants are more efficient in the control of weeds than sorghum alone.

When palisade grass was cultivated alone, from April 2010 to November 2010, a reduction of the weed diversity was observed, according to the indices of Simpson and Shannon-Weiner (Table 2). Our results corroborate those obtained by Correia et al. (2011), who concluded that grass straw can reduce the establishment of some weed species in the area.

Sorghum intercropped with Congo grass resulted in the lowest diversity coefficients of the weed species (Table 2). This cropping system also resulted in the lowest density of weeds, which may be related to competitive aspects and the sorghum ability to produce alellochemicals (Dayan, 2006). According to Adegas et al. (2011), the intercropping of sorghum with Congo grass may help to control weeds due to the competitive features of both species. Single Congo grass showed the lowest index of diversity between all crop systems tested. In the fallow, no difference was observed for the diversity of weed species in the same year, that is, between the first phytosociological survey, in April 2010, and the second one, in November 2010.

According to the Simpson index, the most important plant species are the most abundant ones within each agricultural system. Both Simpson's and Shannon-Weiner's diversity coefficients showed similar pattern of differences between crop systems and times of the year. Agricultural systems apparently affected the botanical composition of the prevalent weed species in the area. The Shannon-Weiner's index is more

Table 2. Diversity coefficients of Simpson (D) and modified Shannon-Weiner (H') for weed occurrence in different cropping systems including fallowing, sorghum and forage grasses (April) followed by soybean (November).

Crop systems[1]	April 2010	November 2010	April 2011	November 2011
	Simpson coefficient (D)			
Fallowing/soybean	0.78bA	0.63bD	0.68bC	0.73cB
Sorghum/soybean	0.80aA	0.43fC	0.71aB	0.80aA
Palisade grass/soybean	0.76dA	0.54dD	0.68bC	0.75bB
Congo grass/soybean	0.77cA	0.45eD	0.66cB	0.63eC
Sorghum with palisade grass/soybean	0.77cB	0.58cD	0.61eC	0.80aA
Sorghum with Congo grass/soybean	0.75dA	0.65aB	0.64dC	0.65dB
	Modified Shannon-Weiner coefficient (H')			
Fallowing/soybean	2.30bB	1.80aD	2.38dA	2.10cC
Sorghum/soybean	2.45aB	1.33eC	2.57bA	2.45aB
Palisade grass/soybean	2.18fB	1.44dD	2.20fA	2.14bC
Congo grass/soybean	2.24dB	1.26fD	2.52cA	1.65eC
Sorghum with palisade grass/soybean	2.28cC	1.61cD	2.86aA	2.45aB
Sorghum with Congo grass/soybean	2.23eB	1.72bD	2.30eA	1.97dC

[1]Means followed by equal letter, lowercase in the columns and capital letters in the lines, do not differ by Tukey's test at 5% of probability.

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sensitive to infrequent species, whereas the Simpson's index accounts for numerous species more efficiently (Cabrera et al., 2019).

The similarity index between crop systems was high in April 2010, with values higher than 0.66, regardless whether they were intercropped or single crops (Figure 3). At this point, there was still not enough time for the agricultural systems to affect weed dynamics in the area. Values above 25% (0.25) by the Jaccard index indicate similarity between the compared factors (Oliveira & Freitas, 2008).

In November 2010, the similarity values were different between systems, suggesting that there was effect of the treatments on the weed floristic composition and on the population dynamics (Figure 3). The cultivation including sorghum showed similarity of 0.68 in comparison with the fallow and, when

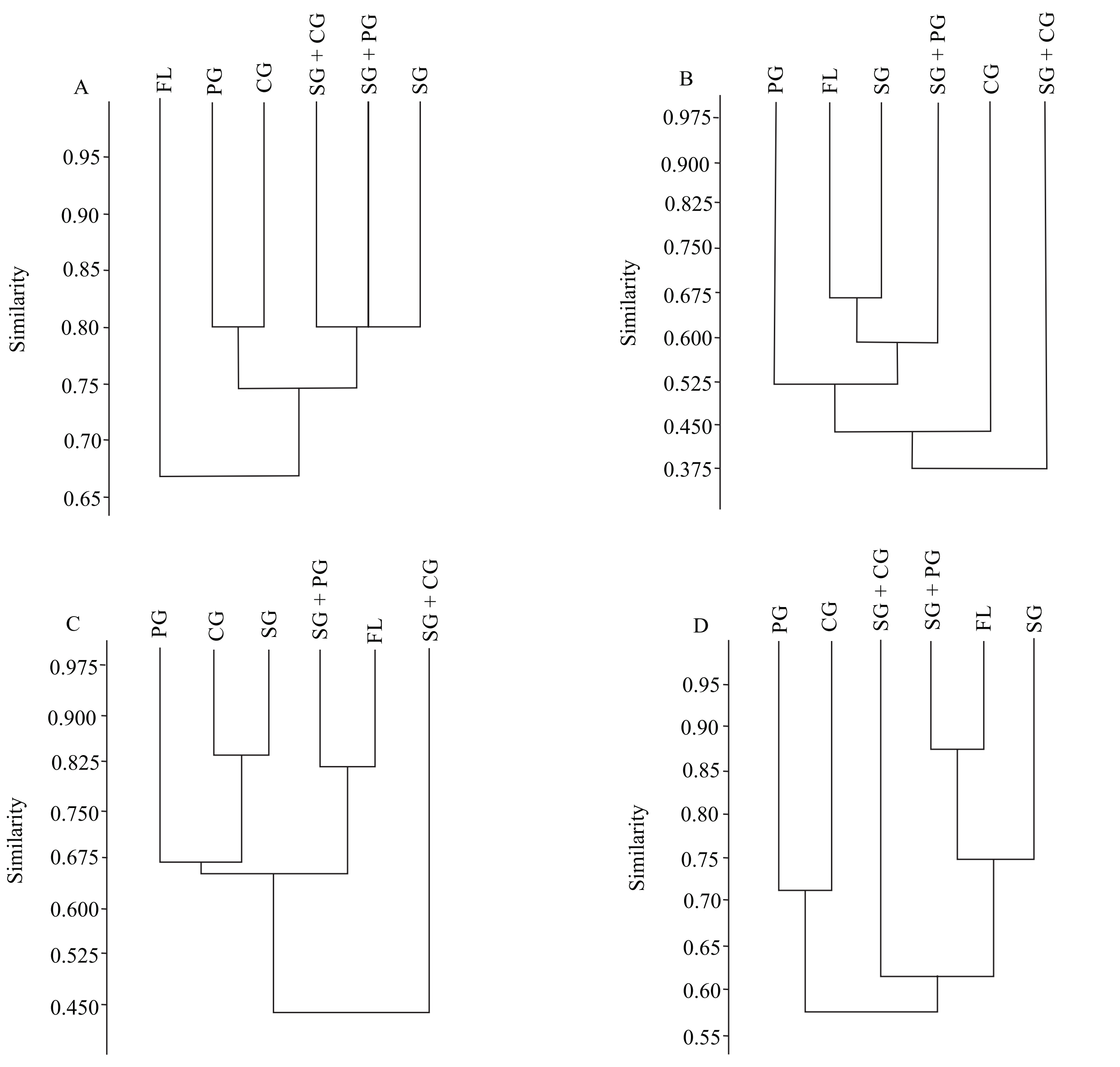

Figure 3. Dendogram of similarity (Jaccard) of weed population between agricultural systems in April 2010 (A), April 2011 (B), November 2010 (C) and November 2011 (D). Paired groups were established based on the UPGMA method. Where FL: fallowing/soybean; SG: sorghum/soybean; PG: palisade grass/soybean; CG: Congo grass/soybean; SG + PG: sorghum with palisade grass/soybean; SG + CG: sorghum with Congo grass/soybean.

this species was intercropped with palisade grass, a similarity of 0.60 with the fallow was observed.

The similarity between systems did not increased from the first to the second year (Figure 3). In April 2011, the single cultivation of sorghum, palisade grass, and Congo grass were similar to each other, with values of similarity above 0.67. However, when there was an intercropping, like sorghum with Congo grass, a low similarity of 0.45 with all other systems occurred, probably due to the increasing in the amount of straw in the soil surface. According to Fontes et al. (2019), the number of germinated seeds on the soil surface reduces as the amount of straw increases.

The use of crop systems during the short-season, before the soybean cultivation, allied to the no-tillage practice reduces weed infestation throughout the years, in comparison with fallow. Intercropping systems including sorghum and Congo or palisade grasses are more effective to control weeds than these crops cultivated alone.

Conclusions

1. The crop systems with sorghum intercropped with cover crops before soybean cultivation affect the diversity and the importance value of weed species.
2. Single sorghum and single cover plant species show higher similarity of weed species than intercropping systems.
3. Congo grass before soybean promotes a greater reduction in weed diversity overtime.
4. The absence of crops during the short-season increases the weed infestation during the soybean cycle.

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