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Residues of sweet sorghum promotes suppression of weeds in sugarcane rotation

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Abstract

Sorghum is an important crop to plant in rotation with sugarcane. This is mainly because both are inputs for the ethanol industry. Crop residues of sweet sorghum promote suppression of weed re-infestation, avoiding weed interference to the sugarcane crop due to the strong allelopathic potential of sorghum. In order to determine the suppressive effects of sorghum crop residues on weeds, a field experiment was carried out. Seven vegetation covers were used as options for crop rotation with sugarcane. The treatments were sweet sorghum, velvet bean, sunflower, soybean, sugar cane, fallow, and an area without cover. The experiment was randomized blocks with four replications of 27 m^2 plots. The weed community of each plot was evaluated by phytosociological indexes at 60 and 120 days after the formation of vegetation cover. The composition of soil seed bank was also evaluated. The weeds with the highest indexes of relative importance during the evaluations were *Cyperus rotundus, Raphanus raphanistrum* and *Parthenium hysterophorus*. The diversity of the weed community, estimated by relative importance indexes, was lower in the area with velvet bean as soil cover. Sorghum, velvet bean and sunn hemp covers reduced the soil seed bank compared to the fallow treatment and the treatment without vegetation cover. Crop residues of sweet sorghum and velvet bean provide a decrease in weed infestation in field, and the weed suppression period can last up to 120 days during the dry season.

Keywords: *Sorghum bicolor*, allelopathy, weed community, weed management, ethanol production.

Introduction

Sweet sorghum is known for its strong allelopathic potential (Nimbal, 1996). Its residue (*Sorghum bicolor* (L.) Moench.) is suggested for sugarcane renovation or expansion of areas. It is common to plant sugarcane immediately after a sorghum harvest to meet the industrial demand for ethanol. In this context, the sorghum crop residue is expected to promote a suppression of weed infestation, avoiding weed interference on sugarcane during the whole total period of weed interference, which lasts 127 days after planting according to Kuva et al. (2003).
Weed control by plant cover may occur by both a physical effect, blocking the sun light, and allelopathic effects (Theissen et al., 2000; Fávero et al., 2001). Plant cover significantly reduces the intensity of infestation of weed areas and changes the composition of the weed population (Almeida and Rodrigues, 1985). Cultures used as soil cover generally have the ability to recycle nutrients, promoting soil decomposition, increasing organic matter content, and suppressing weed development (Theisen et al. 2000; Trezzi and Vidal, 2004). Allelopathic effects are promoted by molecules (allelochemicals) belonging to different categories of plant secondary metabolites. Allelochemicals can be found in leaves, stems, roots, fruits, flowers, and seeds. In addition, there is not a standard for the quantity and the distribution of these compounds on the different plant parts (Alves and Arruda, 2002; Weir et al., 2004).
Sorghum straw is widely used as soil cover by North American farmers aiming to suppress weeds (Einhellig and Rasmussen, 1989). Sorghum plants have a high straw production capacity, reaching a dry matter of 39.5 t ha^{-1} (Paziani and Duarte, 2006). Studies on weed suppression by sorghum cover evidence that infestation by annual weeds is often reduced (Einheeler and Ramsmuse, 1989; Weston, 1996). Trezzi and Vidal (2004) reported that sorghum cover linearly reduced weed infestations in field. According to the authors, four t ha^{-1} of sorghum or millet straw was able to reduce 91%, 96% and 59% of *Brachiaria plantaginea, Sida rhombifolia* and *Bidens pilosa* populations, respectively.

Sorghum bicolor (L.) Moench is an excellent alternative for no-tillage systems due to its high capacity of water use and conversion into dry matter (Magalhães et al., 2000). By evaluating different covers for weed suppression in the Brazilian Cerrado, Meschede et al. (2007) demonstrated that forage sorghum presented the highest dry cover weight (11.9 kg ha^{-1}) and a weed suppression capacity similar to millet and sunn hemp. In addition, the cover formed by fallow vegetation had the lowest values of biomass. For weed analyses in an agricultural environment, phytosociological studies have been used to better understand the weed community and its characteristics within an agroecosystem (Braun-Blanquet, 1979). In addition, the dissemination of weed diaspores and weed soil seed bank is very important because it defines the composition of the weed community for the following seasons. However, there is little information on weed community suppression by sweet sorghum residues compared to other rotation or cover crops.

The objective of this work is to study the weed suppression capacity of sweet sorghum residues in the following crops.

Results and Discussion

Phytosociological approaches on the weed community for different plant cover species

The species found during the management of the fallow treatment and number of individuals, accumulated dry matter, relative density, relative dominance, and relative importance are shown in Table 1. The weeds that showed the highest relative importance were *Alternanthera tenella*, *Amaranthus* spp. and *Digitaria insularis*. *A. tenella* and *Amaranthus* spp. had the highest rates of relative dominance of the weed community, while *Digitaria insularis* had the highest relative density index.

At the end of the fallow period, the weed community presented a high index of equitability, and 0.96 of relative importance. Therefore, the different populations of weeds of the community presented a similar participation. There was not a highly dominant species (Table 2). The values for diversity and equitability regarding density and relative dominance were similar, showing that the variables density and dry matter contributed equally to the determination of relative importance. The dry matter of sweet sorghum crop residue was high (12.1 t ha^{-1}), differing from the plant residue produced with soybean and sunn hemp and the fallow treatment (Table 3). The dry matter of the sorghum cover residue was similar to that produced by velvet bean and sugarcane, which was higher than the cover dry matter produced by the soybean crop. Meschede et al. (2007) showed that sweet sorghum presented the highest dry weight (11.9 kg ha^{-1}) among the cover crops evaluated, a value lower than that obtained by Paziani and Duarte (2006) (39.5 t ha^{-1}). In the present experiment, despite harvesting the sugarcane sorghum stem, a large excess of biomass was deposited in the soil. 65 days after obtaining the vegetation cover, the weeds with the highest index of relative importance were *Raphanus raphanistrum*, *Parthenium hysterophorus* and *Cyperus rotundus* (Figure 1). For sorghum, velvet bean, soybean, sugarcane and sunn hemp covers, *C. rotundus* had the highest index of relative importance for each weed community. For the fallow cover and in the area without vegetation cover, *R. raphanistrum* had the highest index of importance. *C. rotundus* is recognized for its tolerance to straws. According to Silva et al. (2003), the dry matter of *C. rotundus* shoots was not affected even when sown under 20 t ha^{-1} of sugarcane straw. Despite the strong presence of *R. raphanistrum* in the area with no cover, Timossi et al. (2006) reported that 14.6 t ha^{-1} of *B. brizantha* straw was not able to suppress the emergence of *R. raphanistrum* seeds. 120 days after cover formation, the weeds with the highest index of relative importance were the same as at 65 days after cover formation (Figure 2). In this second evaluation, *C. rotundus* had a greater relative importance for velvet bean and soybean crop residues. *R. raphanistrum* was the most important weed in fallow and sweet sorghum cover. *P. hysterophorus* presented a higher index under sugarcane cover and in bare soil. The diversity and equitability indexes calculated in reference to relative importance better express the relation of weed populations that composed the weed community as it considers the frequency of occurrence, the number of individuals, and the accumulated dry matter of these populations. The diversity index is maximum when all populations have the same number or expression of biomass. This explains the low value in areas covered by sweet sorghum and velvet bean 65 days after cover formation, where a large amount of straw formed (Figure 3 and Table 1). Regarding this particular result, only a few species showed tolerance to the environments. There was a reduction on the number of individuals and biomass of less adapted plants. Equitability, in relation to the importance among weed populations, was greater than 80% for areas covered with sunn hemp, soybean, sugarcane and fallow and in the uncovered area, evidencing the high similarity among populations (Figure 3). In areas with sweet sorghum and velvet bean as vegetation cover, this index was lower because the populations in the weed community did not show a great similarity. Thus, there was a greater selection of flora imposed by such covers, which produced more mass and probably more allelopathic effects. The weed community was composed predominantly of *C. rotundus* in velvet bean cover and by *C. rotundus* and *R. raphanistrum* in sweet sorghum cover. At 120 days after harvest, the diversity of the weed community, in relative importance, was lower in the area with velvet bean as a cover crop (Figure 4). By this evaluation, the diversity and equitability indexes were similar for the three parameters analyzed (except for the velvet bean cover) (Figure 4). For velvet bean, the diversity and equitability indexes related to relative density were similar to those related to relative importance. Therefore, in this environment, the relative importance was related first to the number of individuals then to the accumulation of dry matter. After 120 days, when the final plant cover was obtained, the equitability among weed populations related to relative importance was greater than 80% for most treatments, evidencing a high similarity among populations (Figure 4). The exception was the velvet bean cover, whose low equitability (50%) evidenced that fewer populations dominated the weed community.

Table 1. Density (m^{-2}), dry mass ($g\ m^{-2}$), relative density (RDe), relative dominance (RDo), and relative importance (RIm) of weeds in the fallow treatment before the burndown management.

Specie	Density (m^{-2})	Dry mass ($g\ m^{-2}$)	RDe	RDo	RIm
Alternanthera tenella	10	1,287.06	11.63	33.76	23.46
Digitaria insularis	30	143.08	34.88	3.75	14.55
Cenchrus echinatus	4	772.00	4.65	20.25	9.97
Digitaria nuda	14	140.00	16.28	3.67	9.98
Eleusine indica	8	227.08	9.30	5.96	10.09
Amaranthus spp.	8	800.16	9.30	20.99	16.76
Ipomoea quamoclit	2	264.00	2.33	6.93	4.75
Commelina benghalensis	10	178.52	11.63	4.68	10.44

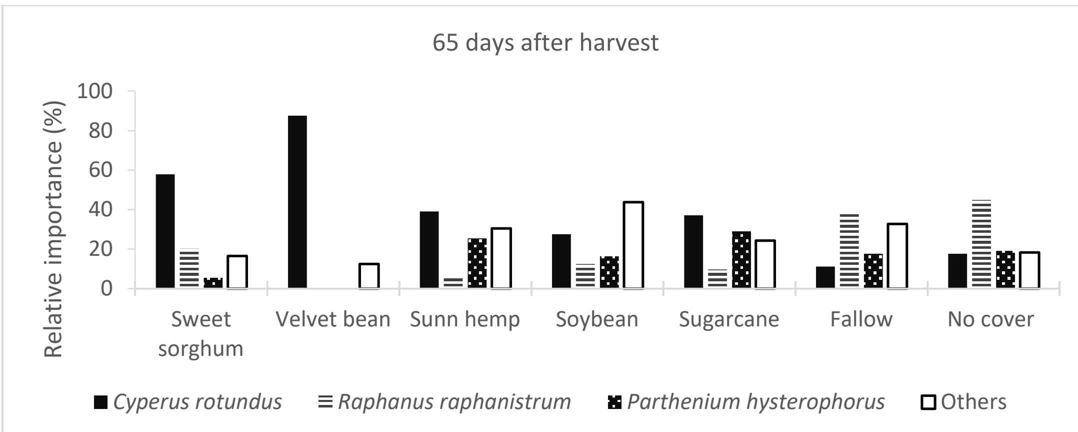

Fig 1. Relative importance of the main populations of weeds in different vegetation covers 65 days after obtaining the cover.

Table 2. Weed diversity (H') and equitability index (E') based on relative density (RDe), dominance (RDo) and importance (RIm) of weeds in the fallow treatment during the harvest period of cover crops.

	RDe	RDo	RIm
H'	1.835	1.759	1.992
E'	0.883	0.846	0.958

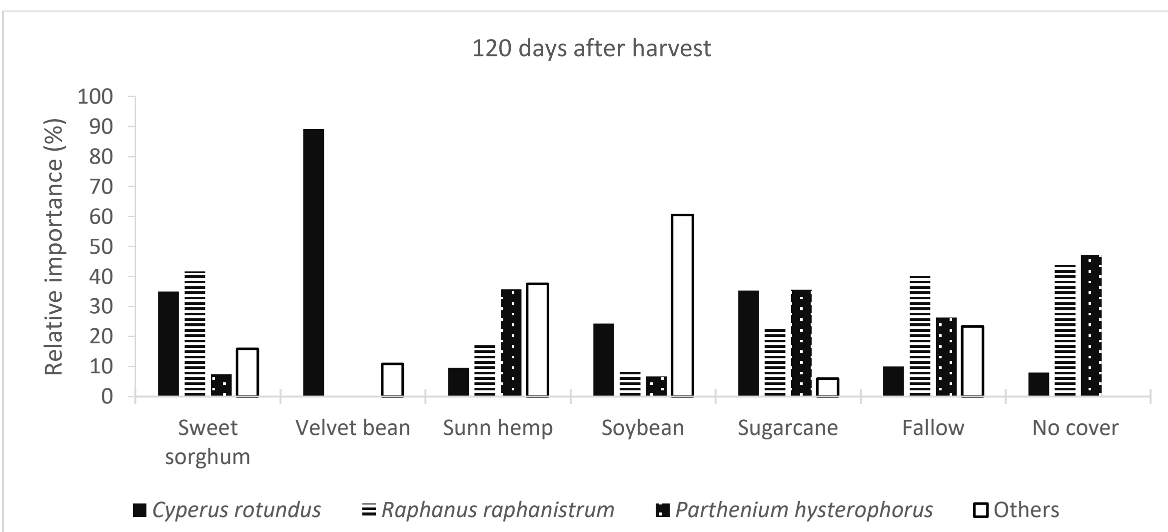

Fig 2. Relative importance of the main populations of weeds in different vegetation covers 120 days after obtaining the cover.

Table 3. Plant cover dry matter (kg ha^{-1}) after harvest (for sweet sorghum, soybean and sugarcane), burndown (for velvet bean and fallow) or cutting (for sunn bean).

Vegetation cover	Dry matter (kg ha^{-1})	
Sweet sorghum	12.072	A[1]
Velvet bean	9.264	AB
Sunn hemp	6.672	BC
Soybean	4.560	C
Sugarcane	10.464	AB
Fallow	7.368	BC
F	2.90**	
VC (%)	24.21	

[1]Means followed by the same letter in the column do not differ by F test (p> 0.05). **Significant values (p<0.01)

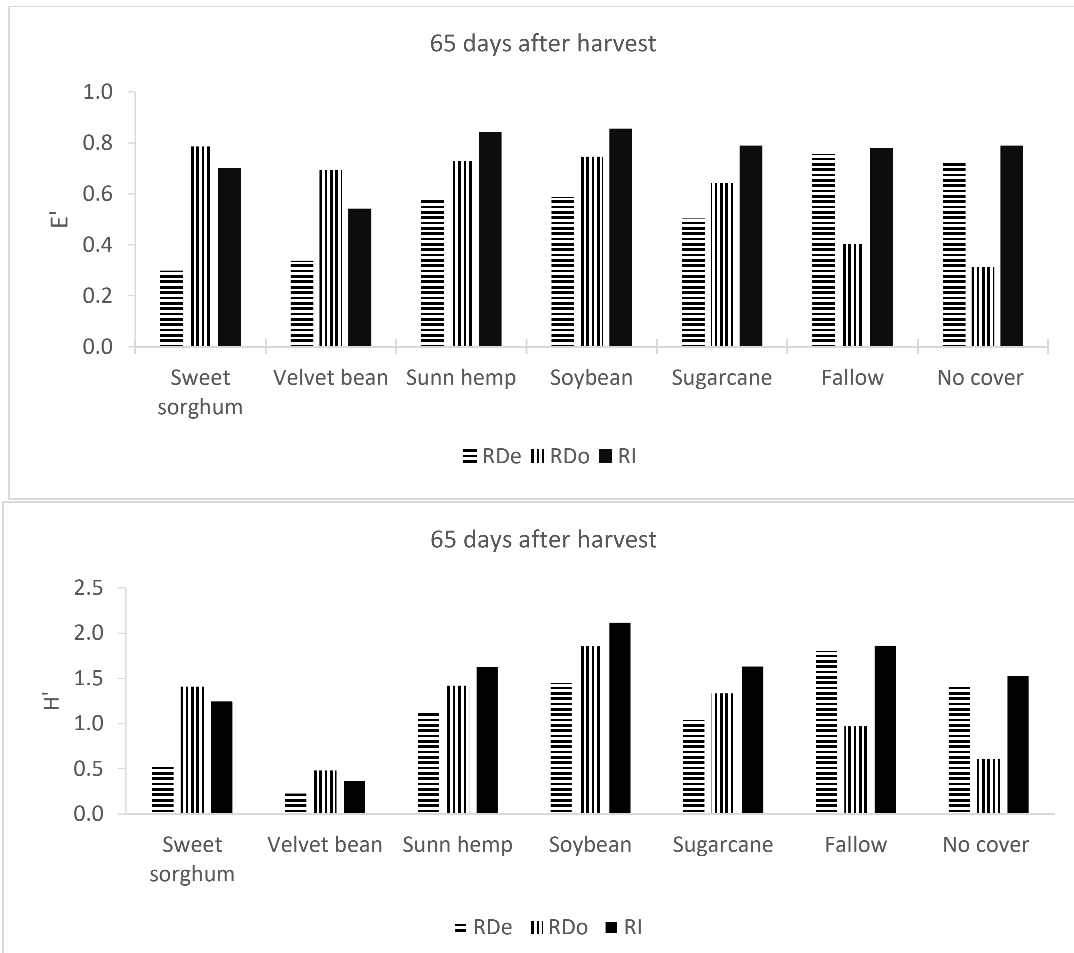

Fig 3. Shannon-Weaver diversity (H') and equitability (E') indexes of weed community components in different plant covers estimated for relative density (De.R.), relative dominance (Do.R.), and relative importance (RI) 65 days after harvest.

Table 4. Weed populations found in the experimental area.

Family	Scientific name
Amaranthaceae	*Alternanthera tenella* Colla
	Amaranthus spp.
Asteraceae	*Xanthium strumarium* L.
	Acanthospermum hispidum D.C.
	Conyza bonariensis (L.) Cronquist
	Gnaphalium spicatum Lam.
	Parthenium hysterophorus L.
Brassicaceae	*Raphanus raphanistrum* L.
Commelinaceae	*Commelina benghalensis* L.
Convolvulaceae	*Ipomoea hederifolia* L.
	Ipomoea nil (L.) Roth
	Ipomoea purpurea (L.) Roth
	Ipomoea quamoclit L.
	Ipomoea grandifolia (Dammer) O'Donell
Cyperaceae	*Cyperus rotundus* L.
Euphorbiaceae	*Euphorbia heterophylla* L.
Fabaceae	*Indigofera hirsuta* L.
	Senna obtusifolia (L.) H.S.Irwin & Barneby
Phyllanthaceae	*Phyllanthus tenellus* Roxb.
Poaceae	*Digitaria insularis* (L.) Fedde
	Digitaria nuda (Schumach.)
	Eleusine indica (L.) Gaertn.
Portulacaceae	*Portulaca oleracea* L.
Rubiaceae	*Richardia brasiliensis* Gomes

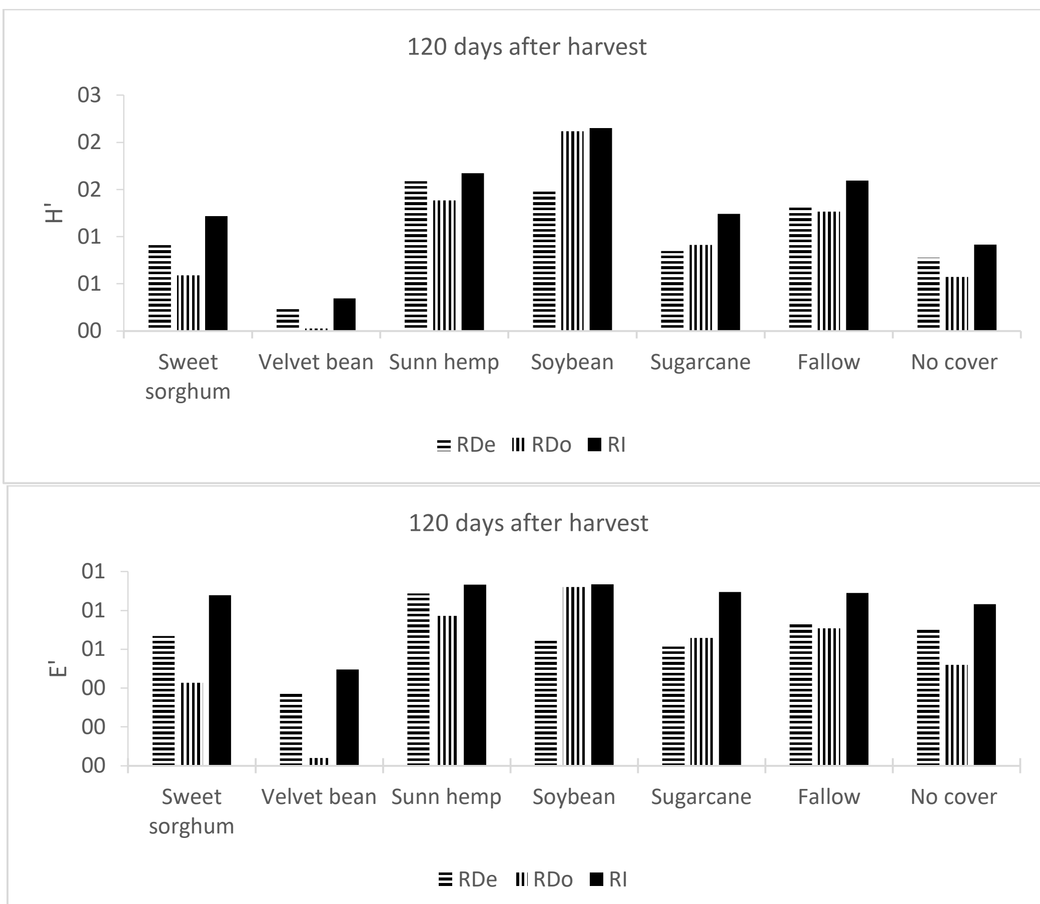

Fig 4. Shannon-Weaver diversity (H') and equitability (E') indexes of weed community components in different plant covers estimated for relative density (De.R.), relative dominance (Do.R.), and relative importance (RI) 120 days after harvest.

Table 5. Weed density and dry matter found in different cover areas 65 days after cover formation.

Vegetation cover	Density m^{-2}		Dry matter g m^{-2}	
Sweet sorghum	7.94	CD	2.38	DE
Velvet bean	4.25	D	0.30	E
Sunn hemp	9.13	C	17.05	BC
Soybean	14.39	B	22.30	B
Sugarcane	7.25	CD	9.92	CD
Fallow	34.00	A	32.38	A
No cover	15.83	B	14.37	BC
CV (%)	14.15		24.50	
F	113.83**		41.96**	

[1]Means followed by the same letter in the column do not differ by F test (p> 0.05). **Significant values (p<0.01)

Table 6. Weed density and dry matter in different cover areas 120 days after cover formation.

Vegetation cover	Density m^{-2}		Dry matter g m^{-2}	
Sweet sorghum	2.04	C	6.83	B
Velvet bean	2.06	C	0.40	B
Sunn hemp	8.86	BC	37.94	AB
Soybean	9.94	B	61.84	A
Sugarcane	2.88	BC	35.51	AB
Fallow	26.17	A	73.75	A
No cover	6.67	BC	65.57	A
CV (%)	39.84		47.44	
F	25.90**		9.09**	

[1]Means followed by the same letter in the column do not differ by F test (p> 0.05). **Significant values (p<0.01)

Table 7. Number of weed seeds per sample of 100 g of soil 120 days after cover formation.

Vegetation cover	Weed									
	RAPRA		PTNHY		RCHBR		ALRTE		DIGIN	
Sweet sorghum	1.25	A[1]	0.75	C	0.00	B	0.00	B	1.75	A
Velvet bean	0.25	A	1.75	BC	0.25	B	0.50	B	0.50	A
Sunn hemp	2.25	A	5.75	ABC	1.50	AB	0.50	B	3.25	A
Soybean	23.25	A	12.50	A	0.00	B	2.75	AB	1.00	A
Sugarcane	2.50	A	16.75	A	0.00	B	0.50	B	2.50	A
Fallow	29.50	A	11.25	AB	0.00	B	10.00	A	0.50	A
No cover	15.33	A	13.00	A	20.33	A	0.00	B	0.33	A
F	3.82^{NS}		7.66**		4.21**		4.89*		0.35^{NS}	
CV (%)	57.52		28.33		78.3		51.32		64.58	
	CCHEC		ACNHI		DIGNU		ELEIN		AMASS	
Sweet sorghum	0.25	A	0.00	A	0.00	A	0.00	A	0.00	A
Velvet bean	0.00	A	0.25	A	0.75	A	0.50	A	1.00	A
Sunn hemp	0.25	A	0.00	A	0.25	A	0.25	A	0.25	A
Soybean	0.00	A	0.00	A	1.00	A	0.00	A	0.00	A
Sugarcane	4.25	A	4.25	A	0.00	A	0.50	A	0.00	A
Fallow	2.00	A	0.00	A	0.75	A	1.75	A	0.00	A
No cover	0.67	A	0.67	A	0.67	A	0.00	A	0.00	A
F	0.64^{NS}		0.96^{NS}		0.76^{NS}		2.44^{NS}		1.82^{NS}	
CV (%)	72.74		66.84		46.26		39.15		33.97	
	XANST		COMBE		CHRPO		SIDRH		Total	
Sweet sorghum	0.00	A	0.00	A	0.00	A	0.00	A	4.00	D
Velvet bean	0.00	A	0.00	A	0.00	A	0.00	A	5.75	CD
Sunn hemp	0.00	A	0.00	A	0.25	A	0.25	A	14.75	BCD
Soybean	0.00	A	0.25	A	0.00	A	0.00	A	40.75	AB
Sugarcane	0.00	A	0.00	A	0.00	A	0.00	A	31.25	ABC
Fallow	0.75	A	0.25	A	0.00	A	0.00	A	56.75	A
No cover	0.00	A	0.00	A	0.00	A	0.00	A	51.00	AB
F	1.00^{NS}		1.00^{NS}		2.66^{NS}		1.00^{NS}		8.58**	
CV (%)[2]	30.83		22.77		18.25		18.25		26.19	

[1] Means followed by the same letter in the column do not differ by F test (p> 0.05); * and **: Significant values (p <0.05 and p <0.01, respectively); [2]CV for the data transformed into $\sqrt{x}$+1.

Effectiveness of cover crops to weed management

Weed density and biomass varied according to vegetation cover (Tables 5 and 6). In the fallow cover, the weed community density and the dry matter at 65 days after cover formation were higher than the other treatments: 34 plants m^{-2} and 32 g m^{-2}, respectively. On the other hand, sweet sorghum, velvet bean and sugarcane straw decreased weed density (7.9, 4.2 and 7.2 plants m^{-2}, respectively). Weed dry matter was also lower due to the presence of sweet sorghum and velvet bean covers (2.38 and 0.40 g m^{-2}, respectively), followed by sugarcane and sunn hemp. Soybean cover and no cover did not show a high density and dry matter of weeds, unless it was compared to the treatment with fallow cover.

Weed density generally decreased after 120 days of cover formation compared to the first evaluation (at 65 days after formation). This can be explained by the death of seedlings due to the drought during this period, typical in the winter of northern São Paulo state, Brazil. The dry matter of the weed community in general increased (Tables 5 and 6).

120 days after cover formation, the weed density and dry matter decreased mainly by the straw cover of sweet sorghum (2.04 plants m^{-2} and 6.83 g^{-2}) and velvet bean (2.06 plants m^{-2} and 0.40 g m^{-2}) (Table 6). These treatments did not differ from the sunn hemp and sugarcane covers and the absence of cover as for weed density, and for sunn hemp and sugarcane covers as for dry weed matter.

The cover formed by spontaneous vegetation had the highest number of weeds per area (26.17 plants m^{-2}) at 120 days after cover formation ("burndown"), differing from the other treatments by Tukey test (Table 6). Regarding dry matter accumulation, this fallow cover and the absence of cover had the highest values (73.75 and 65.57 g m^{-2}, respectively), differing from the treatments with sweet sorghum and velvet bean.

More than 14 weed species were found in soil seed bank analyses. The total number of weed seeds per sample varied according to the vegetation cover (Table 7). The weed seed bank found in the treatment with sweet sorghum, velvet bean and sunn hemp was lower, differing from the fallow cover and the treatment without vegetation cover. The high number of seeds in the seed bank of fallow cover is possibly due to the production of seeds during the cover production period when different weed species with different reproductive characteristics reached biological maturity. The common characteristics of weeds, such as fast germination, short development cycle, fast diaspore production, and high resource partitioning in breeding structures reinforce the statement above (Grime, 1989).

A. tenella seeds was mostly found in the soil with fallow cover. This is probably due to the number of new seeds deposited by this plant, which previously have grown spontaneously (Table 1 and 7). For *P. hysterophorus*, one of the weeds with the highest relative importance index during weed re-infestation (Figures 1 and 2), there was a lower number of seeds in soils treated with sweet sorghum and velvet bean compared to other weeds.

The results found for the treatment with fallow cover corroborate the affirmation of Borges et al. (2014), according to which areas should not remain in fallow and crop rotation management and cover plants are necessary. An increase in the weed seed bank may occur without cover, which potentiates weed interference on crops.

Materials and Methods

Rotation crop settlement, experimental design, and soil preparation

A field experiment was carried out with seven treatments that consisted of plant covers commonly used as a rotation crop with sugarcane: T1 - sweet sorghum (*Sorghum bicolor* (L.) Moench, hybrid CVSW 81198), T2 - velvet bean (*Mucuna pruriens* (L.) DC), T3 - sunn hemp (*Crotalaria juncea*), T4 - soybean (*Glycine max* L.), T5 - sugarcane (*Saccharum officinarum* L.), T6 – fallow, and T7 - area without vegetation cover. Each plot had a size of 6 x 4.5 m. The treatments were arranged in randomized blocks, with four replications. In order to obtain the covers, sweet sorghum, velvet bean, sunn hemp and soybean were sown in the experimental area. For sugarcane, there was no sowing. Later, however, the straw of a five-year-old sugarcane crop was collected at the same day of harvest, and then transferred to the plots. The soil was collected in the area for chemical analysis, whose results were used for soil fertilization following the IAC (1997) recommendation for each crop. The density of sweet sorghum, velvet bean, sunn hemp, and soybean plants were 162,000 plants ha^{-1} (12 plants m^{-1} and 0.8 m between rows), 80,000 plants ha^{-1} (4 plants m^{-1} and 0.5 m between rows), 666,000 plants ha^{-1} (20 plants m^{-1} and 0.3 m between rows), 389,000 plants ha^{-1} (13 plants m^{-1} and 0.45 m between rows), respectively.

Rotation crops management and plant cover deposition

It was performed all the crop protections necessary for growing the crops, such as insecticide and fungicide application for each crop.

For the fallow treatment, the plots were kept without weed control for the formation of a fallow cover. Weeds were weeded every 14 days in order to simulate a commercial area containing five-year-old sugarcane, i.e., prior reformation, where a straw of a freshly harvested five-year-old sugarcane was deposited.

The harvest of soybean, sweet sorghum, velvet bean and fallow ("burndown"), sunn hemp cutting, and sugarcane straw deposition occurred on the same day. Soybean was harvested manually, and the cultural residues were dispersed throughout the plots, simulating a mechanized harvest. Sorghum stalks were also harvested manually, and the leaves and the grain head were dispersed throughout the plot to simulate a mechanized commercial harvest. Velvet bean and fallow areas were "burned down" with glyphosate at 720 g a.i. ha^{-1} using a pressurized backpack spray operating at a constant pressure of 3.5 kgf cm^{-2}. It contained XR 8003 nozzles and 250 L ha^{-1} of syrup.

The covers were sampled on the day of management (harvest, "burndown," or cut) using a 0.25 m^2 square iron frame flung four times randomly in the plot. The samples were submitted to drying in a forced air circulation oven at 65 ± 2ºC until reaching a constant mass, when the dry matter was determined.

Phytosociological analyses of the weed community

The weed community was analyzed in the fallow treatment on the day of the burndown management. In addition, phytosociological analyses were performed 65 and 120 days after velvet bean and fallow burndown, and deposition of sweet sorghum, soybean and sugarcane plant remains. The infesting community was sampled using an iron square of 0.25 m^2 placed randomly four times in each plot to determine the plant density and the dry matter of each weed population. The weeds were collected, separated by species, and submitted to forced air circulation drying at approximately 65ºC until constant weight. Then, the dry matter was determined. The relative constancy, relative density, and relative dominance were used to determine the relative importance index as proposed by Müeller-Dombois and Ellenberg (1974). In addition, weed diversity in the communities was measured by the diversity and equitability index proposed by Shannon-Wiener and mentioned by Carvalho et al. (2008).

Weed seed bank analyses

During the analyses of the re-infestation of weed communities at 120 days after harvest, the soil was collected for weed seed bank studies according to a method used by Isaac and Guimarães (2008). For soil sampling, 12 sub-samples were collected per plot at the 0-5 cm depth, comprising a full sample of 1.5 kg of soil. The samples were collected, packed in plastic bags, labeled, and identified. Then, the soil samples were sieved and homogenized.

100 g were extracted from each sample, and then washed with water using a 0.3 mm stainless steel mesh (ABNT 50) in order to remove small soil fractions. The resulting fraction, consisting of coarser soil particles (sand), weed seeds, straws and vegetable remains, was dried in an oven at 80ºC for 40 minutes. The seeds were then separated by flotation in a saturated $CaCl_2.2H_2O$ solution with a density of 1.40-1.42 g cm^{-3} controlled by a hydrometer. The seed solution was stirred in a beaker for 5 min, and left for decantation for about 2 h. The supernatant was then poured onto the sieve, obtaining weed seeds and plant residues. This material was washed, oven-dried at 80°C, and then packed in a labeled paper bag. The seeds were manually separated from the vegetal remains, identified based on Lorenzi (2006) and Kissman and Groth (1997, 1999, 2000), and finally counted using a stereoscopic microscope. The seed viability was measured by touching using tweezers. The hard seeds were considered viable. In addition, broken seeds were considered non-viable.

Statistical analysis

The data were submitted to analysis of variance, and the means were compared by Tukey test at a 5% probability. Data from soil bank seeds were transformed into $\sqrt{x}$+1 before analysis (Steel and Torrie, 1989).

Conclusion

The results support the hypothesis according to which the cultural residues of sweet sorghum, as well as velvet bean, decrease in field weed infestation. Under the conditions of this experiment, the weed suppression period may last 120 days. This makes sweet sorghum a rotational crop with multiple benefits to sugarcane crops.

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