doi: 10.1590/S0100-83582016340200003

Weed Occurrence in Sugarcane as Function of Variety and Ground Straw Management[1]

Ocorrência de Plantas Daninhas em Cana de Açúcar em Função de Variedade e Manejo do Palhiço

CONCENÇO, G.[2], LEME FILHO, J.R.A.[2], SILVA, C.J.[2], MARQUES, R.F.[3], SILVA, L.B.X.[4], and CORREIA, I.V.T.[3]

ABSTRACT - This study aims to verify the effect of crop varietal architecture and straw removal from planting rows in the occurrence of weeds in sugarcane and infer about the sustainability of the production system with no herbicide application. The experiment was established in 2011 in a randomized block design with split plots and four replications. Main plots were varieties IACSP95 5000 and SP91 1049. In the sub-plots there the straw removal was allocated (evenly scattered in the area, or concentrated in inter-rows). Assessments were conducted in 2012 and 2013 and the absolute levels of infestation, density, frequency and dominance of weed species were obtained. Areas were intra-characterized by the coefficients of Simpson and Shannon-Weiner and sustainability inferred by the SEP coefficient. Areas were grouped by the similarity coefficient of Jaccard. Other factors besides leaf architecture were more significant for level of infestation. Treatments with straw removal from planting rows were more infested than those with evenly scattered straw. In the second year of cultivation, those species most adapted to the system increased their importance value. Wild poinsettia was the dominant weed in all treatments, deserving attention from pre-planting on, to reducing its occurrence in the soil seed bank. Species diversity was higher where straw was evenly scattered due to the occurrence of species other than wild poinsettia. Sustainability was reduced from the first to the second year, indicating that only cultural practices are not enough, even with high shading provided by crop and straw production, demanding herbicides.

Keywords: *Saccharum* spp., phytosociology, sustainability.

RESUMO - Objetivou-se com o presente trabalho verificar o efeito da arquitetura varietal da cultura e da aplicação da prática de desaleiramento na ocorrência de plantas daninhas em áreas de cultivo de cana-de-açúcar, bem como inferir sobre a sustentabilidade do sistema produtivo sem aplicação de herbicidas. O experimento foi implantado em 2011 em delineamento experimental de blocos casualizados com parcelas subdivididas, com quatro repetições. As parcelas foram compostas pelas variedades IACSP95 5000 e SP91 1049. Nas subparcelas, alocou-se o manejo do palhiço (desaleirado ou não desaleirado). As avaliações foram realizadas nos anos de 2012 e 2013, sendo obtidos os níveis absolutos de infestação, a densidade, a frequência e a dominância das espécies de plantas daninhas. As áreas foram intra-caracterizadas pelos coeficientes de Simpson e Shannon-Weiner, e a sustentabilidade, aferida pelo coeficiente SEP. As áreas foram agrupadas por similaridade de Jaccard. Outros fatores, além da arquitetura foliar, foram mais significativos para o nível de infestação; os tratamentos desaleirados foram mais infestados que os não desaleirados; no segundo ano de cultivo as espécies mais adaptadas ao sistema aumentaram seu valor de importância; o leiteiro foi a planta daninha preponderante em todos os tratamentos, merecendo atenção desde a pré-implantação da lavoura, com foco em sua redução no banco de sementes do solo; a diversidade de espécies foi maior em áreas não desaleiradas devido à ocorrência de outras espécies além do leiteiro; e a sustentabilidade foi reduzida do primeiro para o segundo ano, indicando que somente técnicas culturais não são suficientes, mesmo com o elevado sombreamento proporcionado pela cultura e pelo palhiço, demandando herbicidas.

Palavras-chave: *Saccharum* spp., fitossociologia, sustentabilidade.

[1] Recebido para publicação em 5.6.2015 e aprovado em 19.10.2015.
[2] Embrapa Agropecuária Oeste, Dourados, MS, Brasil, <germani.concenco@embrapa.br>; [3] Universidade Federal Grande Dourados, Dourados, MS, Brasil; [4] Universidade Anhanguera, Dourados, MS, Brasil.

INTRODUCTION

During the last decade, the expansion of the sugarcane industry in Brazil has been high, with the area planted with sugarcane increasing 88%, rising from 4.88 to 9.16 million hectares. In the same period, the area planted in the Central-West Region of Brazil increased 219%, from 0.373 to 1.191 million hectares (IBGE, 2012). The Central-West Region of Brazil, by the large availability of land for expansion of the sugarcane and energy industries and climate favorability, tends to be the main area of expansion in the country, where efforts in agricultural research should be directed to.

Weed control undertakes around 8.4% of the production costs for first year sugarcane and 6.1% for ratoon cane (AGRIANUAL, 2012). The presence of ground straw (waste from the mechanized harvesting of sugarcane without burning, consisting of straw, pointers and dead tillers), although it may harm sugarcane regrowth after cutting, can also increase shading level in crop inter-rows (Leme Filho, 2009), which could alter the composition and level of weed infestation. Meirelles et al. (2009) have found that the prevailing weed community of sugarcane areas consisted of *Bidens pilosa* (hairy beggarticks), *Ipomoea grandifolia* (morning glory), *Euphorbia heterophylla* (wild poinsettia) and *Panicum maximum* (guinea grass), while Oliveira & Freitas (2008) highlighted *Brachiaria plantaginea* (plantain signalgrass), *Eleusine indica* (goosegrass), *Bidens pilosa* (hairy beggarticks), *Bidens subalternans* (greater beggarticks) and *Euphorbia heterophylla* (wild poinsettia) as the most important. Martins et al. (1999) reported that hairy beggarticks and wild poinsettia tend to be problems even for straw volumes greater than 10 t ha^{-1}.

After sugarcane is harvested, the ground straw can be kept on soil surface or collected in order to be burned in boilers to produce energy or to serve as raw material for production of cellulosic ethanol, the so called "second generation". Windrowing is defined as the concentration of ground straw collected at every four or five rows for future collection, or it can also be done even when not collecting ground straw, in order to mitigate the negative effects of this one on the crop dividers – in this case, the ground straw is usually concentrated in one at every two or three rows.

Straw removal from planting rows, on the other hand, defines ground straw removal operation from the sugarcane rows, concentrating it on all rows, to stimulate crop regrowth. At straw removal from planting rows, the sugarcane plantation row is unprotected by the absence of ground straw, which is concentrated in inter-rows. Due to the benefits provided by the presence of stubble such as increased soil organic matter, water losses reduction and weed suppression, there is a preference for the straw removal from planting rows operation instead of windrowing (Leme Filho, 2009).

Another major factor in the occurrence of weeds is the crop leaf architecture that could cause different varieties of sugarcane to capture different ratios of the incident solar radiation, with consequent change of infestation in the area, both in quantitative and qualitative aspects (Hale & Orcutt, 1987). Several varietal morphological characteristics, including leaf architecture, growth habit and percentage of lodging, are important for the competitive capacity of different cultivars of sugarcane. Cultivars with high soil shading capacity are generally less affected by weed interference (Martinelli et al., 2011).

The hypothesis is that the differential management of ground straw in sugarcane causes changes in the composition and severity of weeds occurrence and may require a different management of pre-emergence and post-emergence herbicides, as function of the soil coverage. Similarly, most prostrated varieties, which capture a higher ratio of the incident solar radiation, could result in lower incidence of weeds. Therefore, we aimed with this study to evaluate the effect of crop varietal architecture and straw removal from planting rows on the occurrence of weeds in sugarcane growing areas, as well as to infer about the sustainability of weed management system adopted over time.

MATERIAL AND METHODS

The experiment was installed on 06/04/2011 in the experimental area of São

Fernando Usine, located in the Brazilian city of Dourados-MS (22º 13' 48" S, 55º 00' 07" W 430 m asl), in an experimental design of randomized blocks, arranged in split plots with four replications. Sugarcane varieties studied were IACSP95 5000 (in this study called "5000") and SP91 1049 (in this study called "1049"), planted in plots consisting of six rows of sugarcane with 10 m long, spaced in 1.5 m. Sugarcane was mechanically harvested on 07/03/2012, and then plots were split into two subplots of three rows, in which treatments were applied: ground straw removal from planting rows [removed from rows and kept on all inter-rows (S)] and without straw removal from planting rows [in total area (N)]. Straw removal from planting rows was done in the subplots subjected to this treatment on 07/20/2012. The first ratoon cane was harvested on 06/13/2013 and straw removal from planting rows was performed on 07/04/2013. Crop dividers were fertilized on 08/06/2012 with 500 kg ha^{-1} of formula N-P-K 20-00-20 and on 10/31/2013 with 690 kg ha^{-1} of N-P-K 20-04-15. There was no application of herbicides between the implementation of the experiment and the last assessment considered in this work (November 2013).

Phytosociological characterization of weeds emerged from the seed bank was conducted in November 2012 and 2013 in the previously described treatments in a 2 m^2 area (eight 0.25 m^2 samplings) per treatment. In each area, all emerged seedlings and plants were identified, collected and stored by species, being dried in an oven with forced air circulation at 60 °C for subsequent determination of dry mass. Sampling precision based on density and dominance was obtained as follows (Barbour et al., 1998):

$$Pr.De = \frac{1}{s^2(De)} \quad \text{(eq. 1)}$$

$$Pr.Do = \frac{1}{s^2(Do)} \quad \text{(eq. 2)}$$

where s^2 (*De*) = sampling variance based on Density; and s^2 (*Do*) = sampling variance based on Dominance.

The number of plants (no. m^{-2}) and total dry mass (g m^{-2}) of the weed community were presented in histograms in the different treatments with their sampling standard errors. For each species density (number of individuals), frequency (spatial distribution of species) and dominance (ability to accumulate mass) were estimated, which were used to obtain the importance value for each species in each area, according to Pandeya et al. (1968) and Barbour et al. (1998), as follows:

$$rDe = \frac{I}{TI} * 100 \quad \text{(eq. 3)}$$

$$rFr = \frac{Q}{TQ} * 100 \quad \text{(eq. 4)}$$

$$rDo = \frac{DM}{TDM} * 100 \quad \text{(eq. 5)}$$

$$IV = \frac{rDe + rFr + rDo}{3} \quad \text{(eq. 6)}$$

where *rDe* = relative density (%); *rFr* = relative frequency (%); *rDo* = relative dominance (%); *IV* = importance value (%); *I* = number of individuals of species *x* in area *r*; *TI* = total number of individuals in area *r*; *Q* = number of samples evaluated in area *r* where species *x* is present; *TQ* = total number of samples in area *r*; *DM* = dry mass of individuals of species *x* in area *r*; *TDM* = total dry mass of weeds in area *r*.

The importance value (IV) locates each weed species within the community, depending on its ability to cause damage (severity of occurrence), based on the three parameters previously mentioned. Areas were also intra-analyzed for species diversity by Simpson's (D) and Shannon-Weiner's (H') indices (Barbour et al., 1998), and the SEP (Shannon-Weiner Evenness Proportion) sustainability coefficient was determined according to McManus & Pauly (1990), being:

$$D = 1 - \frac{\sum ni * (ni - 1)}{N * (N - 1)} \quad \text{(eq. 7)}$$

$$H' = \sum (pi * ln(pi)) \quad \text{(eq. 8)}$$

$$SEP = \frac{Hd'}{H'} \quad \text{(eq. 9)}$$

where D = Simpson's diversity index; H' = Shannon-Weiner's diversity index (based on density); ni = number of individuals of species "*i*"; N = total number of individuals in the sample; pi = proportion of individuals in the sample belonging to species "*i*"; SEP = Shannon-Weiner Evenness Proportion; and Hd' = Shannon-Weiner's diversity index (based on dominance).

Subsequently, areas were compared by the binary asymmetric similarity coefficient of Jaccard. Based on Jaccard's coefficients, the similarity matrix was prepared, and from this one the dissimilarity matrix was obtained (1-similarity), as follows:

$$J = \frac{c}{a+b-c} \quad \text{(eq. 10)}$$

$$Di = 1 - J \quad \text{(eq. 11)}$$

where J = Jaccard's similarity coefficient; a = number of species in area "a"; b = number of species in area "b"; c = number of species common to areas "a" and "b"; and Di = dissimilarity.

Multivariate analysis of hierarchical clustering was performed from the dissimilarity matrix, by the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) hierarchical clustering method (Sneath & Sokal, 1973). The critical level for separation of groups in the cluster analysis was based on the arithmetic mean of similarities in the original matrix of similarity (Barbour et al., 1998), disregarding crossing points between the same areas in the matrix. Group validation was accomplished by the cophenetic correlation coefficient (Sokal & Rohlf, 1962), obtained by Pearson's linear correlation between the original matrix of dissimilarity and its respective cophenetic matrix. Diversity and similarity coefficients and cluster analysis were obtained in the R statistical environment (R Development, 2011).

All formulas and procedures, both of areas sampling as of description of communities and species clustering, followed recommendations by Barbour et al. (1998) for synecological analyses.

RESULTS AND DISCUSSION

Sampling precision proved that all areas were reliably sampled (Table 1), according to the described by Bordeau (1953) and Goldsmith & Harrison (1976), who established that the variance of sample means increases in the reverse order to the number of sites sampled per area. Barbour et al. (1998) have consolidated sampling precision in defining that the inverse of the variance (eq. 1) should be used as precision indicator. In this study, data was standardized previously to this analysis according to Concenço (2015), and "1" was considered as the minimum precision value for a reliable sampling.

In 2012, both the number of weeds emerged and dry mass (Figure 1) were higher in variety 5000 (IACSP95 5000), and in this variety the general infestation was 175% higher than that observed for 1049 (SP91 1049). Similarly, weed dry mass was 113% higher in the same situation. Both differences between varieties were significant at 5% using the t test. In comparison, 5000 is more upright than 1049, also with a lower percentage of lodging, which may have contributed for the inter-rows area to remain less covered, allowing greater establishment

Table 1 - Sampling precision based on the density and dominance of weed species due to the agricultural season, sugarcane variety and application or not of the straw removal from planting rows practice. Embrapa Western Agriculture, Dourados MS, 2014

Treatment	November 2012		November 2013	
	P. De.*	P. Do.*	P. De.*	P. Do.*
IACSP95-5000-N	709	93	8	151229
IACSP95-5000-S	17	3	287	12
SP91-1049-N	2	228	262	5417
SP91-1049-S	315	248	59	23937

* Pr. De. = sampling precision based on weed density; Pr. Do. = sampling precision based on the weeds dry matter. N = without straw removal from planting rows; S = with straw removal from planting rows.

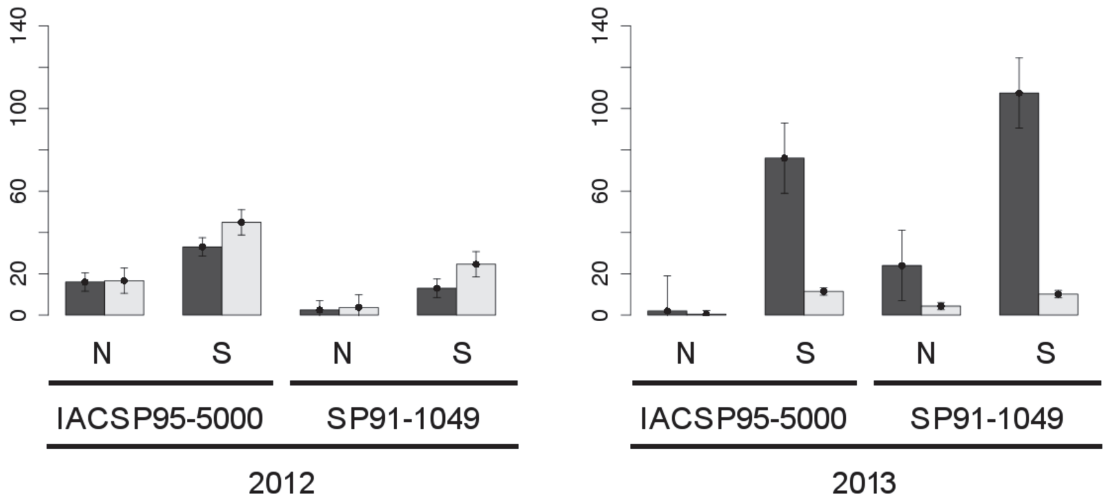


Figure 1 - Samplings density (■ no. m^{-2}) and dry matter (□ g m^{-2}) of weeds due to the agricultural season, sugarcane variety and application (S) or not (N) of the straw removal from planting rows practice. Embrapa Western Agriculture, Dourados MS, 2014.

of weeds. While the first variety is described by the owner as usually "very upright," the second one is referred to as "semi-erect," which distinguishes them in relation to the competition with weeds infesting the area.

In the second year of cycle, in 2013, the occurrence of weeds tended to increase when compared to the first year of cultivation (Figure 1). In the first year, variety 5000 showed an average of 55 weeds m^2, while in the second year 48 plants m^2 were noted (nonsignificant difference by the t test at 5%). For variety 1049, however, 20 plants m^2 were observed in the first year, while 64 plants m^2 were recorded in the second year (Figure 1), with significant differences at 5% by the t test. For weed dry mass, variety 5000 was 36% less infested in 2013 compared to 2012, and the difference was nonsignificant for 1049.

The application of the straw removal from planting rows also had great impact on the occurrence of weeds (Figure 1). While straw removal from planting rows can improve regrowth of varieties that are more sensitive to shading (Caldeira, 2002), weeds benefit from stubble removal to start the germination and emergence processes in the presence of light (Silva et al., 2007). In 2012, straw removal from planting rows increased infestation from 18 to 38 plants m^{-2} of weeds for variety 5000, and from 6 to 14 plants m^{-2} for 1049 (Figure 1). The increase observed for weed dry mass was proportional to plant density.

In 2013 the effect of the straw removal from planting rows was even higher, showing that weed management practices adopted in the first year of the experiment were not effective in preventing weeds seed production. The straw removal from planting rows increased infestation from 4 to 68 plants m^{-2} of weeds for variety 5000, and from 27 to 112 plants m^{-2} for 1049 (Figure 1). In fact, there was no application of herbicides between the implementation of the experiment and the last evaluation, in November 2013. Therefore, differences in the occurrence of weeds described in this work are due exclusively to the competitive potential of varieties.

Stalk yield of varieties 5000 and 1049 in this experiment is shown in Figure 2. There was no effect of the year on the productivity of varieties; 1049 accumulated higher fresh mass of stalks per hectare in the first year of cycle. It is highlighted that the ground straw dry mass left on soil after mechanized harvesting of raw sugarcane is equivalent to approximately 14% of the fresh mass of stalks produced (Mariani Filho, 2006). Leme Filho (2009) reported that variety 1049 deposited in the crop 14.7% of its fresh volume of stalks. Thus, as there is no difference in productivity in different years or between cultivars in the second year (Figure 2), probably the volume of residual straw deposited is not responsible for the differential infestation levels between varieties – particularly not in the second year – or by differences in the composition of the weed species in the treatments. The straw volume helped, of course, in the suppression of certain species in the area, affecting more the community composition (Tables 2 and 3) than the level of infestation (Figure 1).

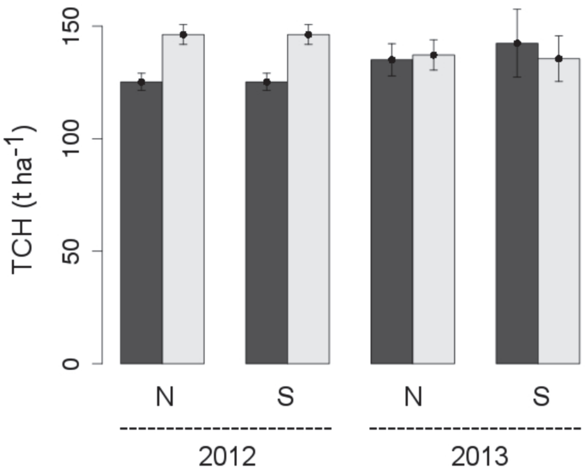


Figure 2 - Stalks yield (t ha^{-1}) of varieties IACSP95 5000 (■) and SP91 1049 (□) due to the agricultural season and the application (S) or not (N) of the straw removal from planting rows practice.

Not only the infestation was affected by straw removal from planting rows and the year of cultivation (Figure 1), but also the composition of weed species in the weed community (Tables 2 and 3). In the first year (Table 2), 54% of the infestation in variety 5000 was attributed to wild poinsettia, which also accounted for 85% of the area dominance. Straw removal from planting rows not only increased the importance of this species as infesting the area (from 54 to 72%), but also its dominance (from 85 to 94%).

Straw removal from planting rows for the stubble of variety 5000 caused the disappearance of southern sandspur, arrowleaf sida and sowthistle, weeds of marginal

Table 2 - Density, frequency, dominance and importance value of weed species in the first year (2012) due to the sugarcane variety and application or not of the straw removal from planting rows practice. Embrapa Western Agriculture, Dourados MS, 2014

Species	IACSP95-5000 N				Species	IACSP95-5000 S			
	DE	FR	DO	IV		DE	FR	DO	IV
Cenchrus echinatus	3.12	8.33	4.72	5.39	*Cenchrus echinatus*	0	0	0	0
Digitaria horizontalis	6.25	16.67	0.78	7.9	*Digitaria horizontalis*	1.52	10	0.18	3.9
Leonotis nepetifolia	28.12	16.67	8.38	17.72	*Leonotis nepetifolia*	6.06	10	1.46	5.84
Sida rhombifolia	3.12	8.33	0.6	4.02	*Sida rhombifolia*	0	0	0	0
Euphorbia heterophylla	43.75	33.33	84.8	53.96	*Euphorbia heterophylla*	83.33	40	93.94	72.42
Richardia brasiliensis	0	0	0	0	*Richardia brasiliensis*	1.52	10	0.89	4.14
Sonchus oleraceus	3.12	8.33	0.03	3.83	*Sonchus oleraceus*	0	0	0	0
Commelina benghalensis	12.5	8.33	0.69	7.17	*Commelina benghalensis*	7.58	30	3.53	13.7
	SP91-1049 N					SP91-1049 S			
Cenchrus echinatus	0	0	0	0	*Cenchrus echinatus*	0	0	0	0
Digitaria horizontalis	0	0	0	0	*Digitaria horizontalis*	0	0	0	0
Leonotis nepetifolia	0	0	0	0	*Leonotis nepetifolia*	11.54	28.57	0.51	13.54
Sida rhombifolia	0	0	0	0	*Sida rhombifolia*	7.7	28.58	1.59	12.62
Euphorbia heterophylla	100	100	100	100	*Euphorbia heterophylla*	80.77	42.86	97.91	73.85
Richardia brasiliensis	0	0	0	0	*Richardia brasiliensis*	0	0	0	0
Sonchus oleraceus	0	0	0	0	*Sonchus oleraceus*	0	0	0	0
Commelina benghalensis	0	0	0	0	*Commelina benghalensis*	0	0	0	0

Table 3 - Density, frequency, dominance and importance value of weed species in the second year (2013) due to the sugarcane variety and application or not of the straw removal from planting rows practice. Embrapa Western Agriculture, Dourados, MS, 2014

Species	IACPS95-5000 N				Species	IACPS95-5000 S			
	DE	FR	DO	IV		DE	FR	DO	IV
Brachiaria decumbens	0	0	0	0	*Brachiaria decumbens*	1.32	3.45	20.45	8.41
Conyza sp.	0	0	0	0	*Conyza* sp.	0.66	3.45	1.26	1.79
Digitaria insularis	0	0	0	0	*Digitaria insularis*	0.66	3.45	15.57	6.56
Digitaria horizontalis	0	0	0	0	*Digitaria horizontalis*	3.29	3.45	5.32	4.02
Brachiaria plantaginea	0	0	0	0	*Brachiaria plantaginea*	6.58	10.34	5.02	7.31
Ipomoea hederifolia	0	0	0	0	*Ipomoea hederifolia*	0.66	3.45	1.7	1.94
Leonotis nepetifolia	0	0	0	0	*Leonotis nepetifolia*	1.97	10.34	0.52	4.28
Euphorbia heterophylla	100	100	100	100	*Euphorbia heterophylla*	75.66	37.93	46.53	53.37
Gnaphalium coarctatum	0	0	0	0	*Gnaphalium coarctatum*	1.97	6.9	2.57	3.81
Commelina benghalensis	0	0	0	0	*Commelina benghalensis*	7.24	17.24	1.05	8.51
	SP91-1049 N					SP91-1049 S			
Brachiaria decumbens	0	0	0	0	*Brachiaria decumbens*	0	0	0	0
Conyza sp.	2.08	8.33	55.47	21.96	*Conyza* sp.	0	0	0	0
Digitaria insularis	0	0	0	0	*Digitaria insularis*	0.47	5	2.22	2.56
Digitaria horizontalis	0	0	0	0	*Digitaria horizontalis*	0	0	0	0
Brachiaria plantaginea	0	0	0	0	*Brachiaria plantaginea*	0.47	5	0.15	1.87
Ipomoea hederifolia	0	0	0	0	*Ipomoea hederifolia*	0	0	0	0
Leonotis nepetifolia	45.83	8.33	1.15	18.44	*Leonotis nepetifolia*	0	0	0	0
Euphorbia heterophylla	47.92	66.67	25.66	46.75	*Euphorbia heterophylla*	93.49	60	92.71	82.07
Gnaphalium coarctatum	4.17	16.67	17.72	12.85	*Gnaphalium coarctatum*	0	0	0	0
Commelina benghalensis	0	0	0	0	*Commelina benghalensis*	5.58	30	4.93	13.5

importance which together accounted for 13% of the amount of infestation, favoring wild poinsettia, tropical Mexican clover and Benghal dayflower (Table 2).

Variety 1049 with no straw removal was infested only by wild poinsettia, which has already been reported as infesting sugarcane crops even under 10 tons of ground straw (Martins et al., 1999). When straw was removed from crop rows, the resulting space was occupied by klip dagga and arrowleaf sida, besides wild poinsettia (Table 2), which accounted for 74% of the infestation in this treatment.

Regardless of the sugarcane harvesting system, less than 15 t ha[1] of straw on the soil surface did not affect emergence of seedlings of *E. heterophylla* (Correia & Durigan, 2004), proving that this species is adapted to cropping systems with high stubble volumes. The difficulty in managing this species lies in the ineffectiveness in inhibiting new emergence flows, even at greater soil depths (Yamauti, 2011).

Tropical Mexican clover (*Richardia brasiliensis*) and *Commelina benghalensis* (Benghal dayflower) are species relatively tolerant to the herbicide glyphosate (Galon et al., 2014). Since in the Brazilian state of Mato Grosso do Sul sugarcane ends up occupying areas where longtime previous crop was soybeans, the occurrence of these species is expected in most sugarcane plantations, and their progressive elimination is to be done during the sugarcane cultivation. *Commelina benghalensis*, besides being tolerant to glyphosate, is a problem because of the different means of reproduction (shoots and underground seeds, as well as vegetative reproduction) (Kissmann & Groth, 1999).

The second year of cultivation (Table 3) was characterized not only by greater infestation – mainly in straw removal from planting rows treatments (Figure 1) – but also by a larger number of weed species compared to 2012. In the first cycle (Table 2), eight weed species were observed, while ten species occurred during the second year (Table 3).

For variety 5000 without straw removal from planting rows, the second crop was marked by the occurrence of only wild poinsettia, a weed species widely recognized as problematic in sugarcane plantations (Martins et al., 1999; Meirelles et al., 2009; Oliveira & Freitas, 2008). Variety 1049 without straw removal from planting rows was infested with four weed species, especially wild poinsettia and horseweed, the latter constituting a cosmopolitan species resistant to herbicide glyphosate, widely distributed throughout the Central-West Region of Brazil, difficult to control, drought-tolerant and with a large production of seeds (Kissmann & Groth, 1999; Wu & Walker, 2006; Moreira et al., 2010).

These two species differ, however, in the mechanism by which they succeed in infestation: while horseweed was highly dominant, being responsible for half of the dry mass measured in this treatment (50% of dominance), wild poinsettia was very frequent. Horseweed, in turn, was less frequent. This is of concern because horseweed showed to be able to dominate the environment where it is located, removing other weed species, even at low levels of occurrence. As its seeds are carried by the wind, it is probably a matter of time for this weed to turn from highly dominant and infrequent to highly dominant and also frequent. This dynamic would make horseweed important not only in sugarcane areas, but also the sugarcane plantation would be considered a source of propagules of this species to neighboring crops.

Straw removal from planting rows in 2013 (Table 3) resulted in infestation levels above those seen in removal applied in the first year (Table 2), with a slightly different composition from the major species. In general terms, wild poinsettia remained the main weed species, accounting for 53% and 82% of the amount of infestation in treatments with straw removal planted with varieties 5000 and 1049, respectively (Table 3). Variety 5000 with straw removal, although at a lower level of absolute infestation than 1049 (Figure 1), was the only one to present in the same treatment all weed species identified in the experiment (Table 3). As a result, in this treatment all weeds, except wild poinsettia, showed marginal significance in infestation.

Diversity is a concept that considers the balance of plant communities in a given agricultural area as a result of good management (Pandeya et al., 1968). Simpson's diversity index (D) quantifies, in simple terms, the probability of two individuals randomly collected in the same area to belong to the same species. The Shannon-Weiner diversity index (H'), on the other hand, is derived from the Information Theory (Shannon, 1948) and confuses diversity with species richness (Barbour et al., 1998).

The diversity of species in 2012 (Table 4) by both coefficients indicated a greater balance of occurrence in variety 5000 with no straw removal where all species observed in the experiment that year (except tropical Mexican clover) were present. The main reason for the imbalance in diversity in the other treatments was wild poinsettia, which demonstrated the importance of infestation between 72% and 100%, while for 5000 with no straw removal it was 54% (Table 2). In 2013, the greatest diversity was found for variety 1049 without straw removal from planting rows as well as for 5000 with straw removal from planting rows (Table 4). This demonstrates that both the ground straw cover as the architecture of the variety can be directly affecting diversity, and probably different species are selected by each of these factors. Lower diversity in 2013, similarly to 2012, was also associated to higher occurrence of wild poinsettia (Table 4).

The SEP (Shannon-Weiner Evenness Proportion) coefficient (Table 4) is able to infer about sustainability of managements applied

Table 4 - Diversity of weed species due to the agricultural season, sugarcane variety and application or not of the straw removal from planting rows practice. Embrapa Western Agriculture, Dourados MS, 2014

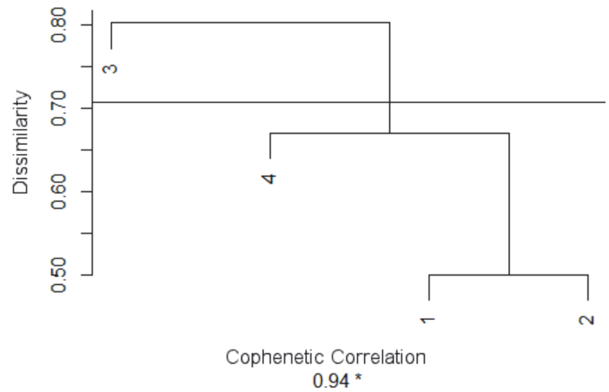
Treatment	2012			2013		
	D*	H'*	SEP*	D*	H'*	SEP*
IACSP95-5000-N	0.71	1.48	0.4	0	0	–
IACSP95-5000-S	0.3	0.64	0.45	0.42	1	1.56
SP91-1049-N	0	0	–	0.56	0.92	1.12
SP91-1049-S	0.33	0.67	0.18	0.12	0.27	1.14

* D = Simpson's diversity index; H' = Shannon-Weiner diversity index; SEP = Shannon-Weiner Evenness Proportion.

to production systems from static data (McManus & Pauly, 1990), and values near zero indicate longevity of the management practice applied and consequently of the production system. Of course, only one area or only two years are not sufficient for measurements on sustainability, but comparison of 2012 with 2013 indicates that weed infestation in the areas tended to worsen, because in 2012 SEP was between 0.18 and 0.45, while in 2013 the values were between 1.12 and 1.56 (Table 4).

The similarity of weeds composition between treatments within each year was evaluated by the inverse of Jaccard coefficient with the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) hierarchical clustering method (Figure 3). In 2012, only 1049 without straw removal from planting rows differed from the other treatments by the exclusive occurrence of wild poinsettia as a weed. The similarity between treatments with straw removal from planting rows (T2) and without straw removal from planting rows (T1) in the first year was of 50%, which is considered high by the Jaccard coefficient (Mueller Dombois & Ellenberg, 1974), with 33% of similarity between this cluster (T1 + T2) and 1049 under straw removal from planting rows (T4) (Figure 3), which is also considered similar by the same coefficient. In 2013, the clustering reliability was not enough to allow inferences (cophenetic correlation below 0.85), being thus not considered.

In the conditions under which the experiment was conducted, the difference in infestation between varieties was small, showing that factors other than leaf architecture are more significant to the level of infestation. Treatments with straw removal from planting rows (with removal of stubble from rows to inter-rows) were more infested than without straw removal. In the second year of cultivation, the species most adapted to the system increased their importance value. Wild poinsettia was the dominant weed in all treatments, deserving attention since the pre-planting of the crop, focusing on its reduction in the soil seed bank. Species diversity was higher in areas without straw removal from planting rows due to the occurrence of species other than wild poinsettia. And sustainability of the production system worsened from the first to the second year, indicating that only cultivation techniques for weed suppression are not enough in sugarcane crops, even with high shading provided by the culture and ground straw, requiring the application of herbicides.



(1) = IACSP95 5000 N; (2) = IACSP95 5000 S; (3) = SP91 1049 N; (4) = SP91 1049 S. Embrapa Western Agriculture (Embrapa Western Region Agriculture), Dourados MS, 2014.

Distances were obtained by inverting the Jaccard similarity coefficient and the cluster was performed by the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) hierarchical clustering method.

Figure 3 **-** Cluster analysis by dissimilarity of treatments in 2012 due to the sugarcane variety and application or not of the straw removal from planting rows practice.

LITERATURE CITED

AGRIANUAL 2012: **Anuário da agricultura brasileira**. São Paulo: FNP, 2012.

BARBOUR, M. G. et al. **Terrestrial plant ecology**. Menlo Park: Benjamin/Cummings, 1998. 688 p.

BORDEAU, P. F. A. Test of random versus systematic ecological sampling. **Ecology**, v. 34, n. 3, p. 499-512, 1953.

CALDEIRA, D. S. A. **Palhada residual de cana de açúcar (*Saccharum* spp.) colhida mecanicamente (sem queima prévia): manejo, fertilização, influência no perfilhamento e produtividade da cultura**. 2002. 101 f. Tese (Doutorado em Agronomia) – Universidade Estadual de São Paulo, Botucatu, 2002.

CONCENÇO, G. **Análises fitossociológicas de plantas daninhas – método aplicado ao ambiente "R".** Dourados: Embrapa Western Agriculture, 2015. 33 p. (Documentos, 129) Disponível em: <http://ainfo.cnptia.embrapa.br/digital/bitstream/item/131016/1/DOC-129-2015-completo-anexos.pdf>

CORREIA, N. M.; DURIGAN, J. C. Emergência de plantas daninhas em solo coberto com palha de cana-de-açúcar. **Planta Daninha**, v. 22, n. 1, p. 11-17, 2004.

GALON, L. et al. Tolerância de plantas daninhas a herbicidas. In: AGOSTINETTO, D.; VARGAS, L. (Org.). **Resistência de plantas daninhas a herbicidas no Brasil**. 2.ed. Pelotas: UFPel, 2014. v. 1. p. 33-43.

GOLDSMITH, F. B.; HARRISON, C. M. Description and analysis of vegetation. In: CHAPMAN, S. B. (Ed.) **Methods in plant ecology**. New York: John Wiley & Sons, 1976. p. 85-155.

HALE, M. G.; ORCUTT, D. M. **The physiology of plants under stress**. New York: John Wiley & Sons, 1987. 206 p.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. **Base de dados *SIDRA***. Disponível em: <http://www.ibge.gov.br>.

KISSMANN, K. G.; GROTH, D. **Plantas infestantes e nocivas**. 2.ed. São Paulo: BASF, 1999. 978 p.

LEME FILHO, J. R. A. **Desenvolvimento da cana-de-açúcar (*Saccharum* spp.) sob diferentes formas de colheita e de manejo do palhiço**. 2009. 111 f. Tese (Doutorado em Fitotecnia) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, 2009.

MARIANI FILHO, L. **Utilização da palha de cana-de-açúcar para aumento da capacidade energética de plantas de utilidades**. 2006. 58 f. (Trabalho de Conclusão de Curso em Engenharia Mecânica) – Escola Politécnica, Universidade de São Paulo, São Paulo, 2006.

MARTINELLI, C. A. et al. Interferência de plantas daninhas na cultura da cana de açúcar e algumas práticas de controle. **R. Ci. Elet. Agron.**, v. 10, n. 20, p. 1 6, 2011.

MARTINS, D. et al. Emergência em campo de dicotiledôneas infestantes em solo coberto com palha de cana de açúcar. **Planta Daninha**, v. 17, n. 1, p. 151-161, 1999.

McMANUS, J. W.; PAULY, D. Measuring ecological stress: variations on a theme by R. M. Warwick. **Marine Biol.**, v. 106, n. 2, p. 305-309, 1990.

MEIRELLES, G. L. S.; ALVES, P. L. C. A.; NEPOMUCENO, M. P. Determinação dos períodos de convivência da cana soca com plantas daninhas. **Planta Daninha**, v. 27, n. 1, p. 67-73, 2009.

MOREIRA, M. S. et al. Crescimento diferencial de biótipos de *Conyza* spp. resistente e suscetível ao herbicida glyphosate. **Bragantia**, v. 69, n. 3, p. 591-598, 2010.

MUELLER-DOMBOIS, D.; ELLENBERG, H. **Aims and methods of vegetation ecology**. New York: Wiley, 1974. 547 p.

OLIVEIRA, A. R.; FREITAS, S. P. Levantamento fitossociológico de plantas daninhas em áreas de produção de cana de açúcar. **Planta Daninha**, v. 26, n. 1, p. 33-46, 2008.

PANDEYA, S. C.; PURI, G. S.; SINGH, J. S. **Research methods in plant ecology**. New York: Asia Publishing House, 1968. 272 p.

R DEVELOPMENT CORE TEAM. **R: A language and environment for statistical computing**. Vienna: R Foundation for Statistical Computing, 2011. Disponível em: <http://www.R-project.org/>. Acesso em: 22 mar. 2012

SHANNON, C. E. A mathematical theory of communication. **Bell System Technol. J.**, v. 27, n. 7, p. 379-423, 1948.

SILVA, A. A. et al. Biologia de plantas daninhas. In: SILVA, A. A.; SILVA, J. F., (Ed.). **Tópicos em manejo de plantas daninhas**. Viçosa, MG: Universidade Federal de Viçosa, 2007. p. 17-61.

SNEATH, P. H.; SOKAL, R. R. **Numerical taxonomy:** the principles and practice of numerical classification. San Francisco: W. H. Freeman, 1973. 573 p.

SOKAL, R. R.; ROHLF, F. J. The comparison of dendrograms by objective methods. **Taxon**, v. 11, n. 1, p. 33-40, 1962.

WU, H.; WALKER, S. **Fleabane:** fleabane biology and control. 2004. Online. Disponível em: <www.weeds.crc.org.au/documents/fleabane_ proceedings%20_mar_04.pdf>.

YAMAUTI, M. S. et al. Emergência de plantas daninhas em função da posição da semente e quantidade de palha de cana-de-açúcar. **Sci. Agr.**, v. 12, n. 2, p. 75-80, 2011.