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Article

Phytosociological Survey of Sugarcane Crop Weeds in Different Agroecological Areas in Tucumán Province, Argentina

Levantamento Fitossociológico de Plantas Daninhas na Cultura da Cana-de-Açúcar em Diferentes Regiões Agroecológicas na Província de Tucumán, Argentina

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ABSTRACT - Weeds constitute the main constraint on the productivity of sugarcane agroecosystems in Argentina. This work aimed to analyze the floristic and phytosociological composition of sugarcane weed communities in different agroecological areas in Tucumán. Fifteen plots from each area were sampled 60 to 90 days after crop shooting, by throwing a 0.5 m x 0.5 m quadrat metallic frame six times in random directions in each of the plots. Species found within the frame were identified. Later, fresh and dry biomass weight were calculated per quadrat sample and species. Frequency, density, dominance, importance value index, Shannon-Wiener and Simpson species diversity index and Jaccard similarity index were calculated. The unweighted pair group method with arithmetic mean (UPGMA) was used to interpret similarity. Overall, 35 species were identified, 24 of which were dicotyledons and 11 monocotyledons. Eighteen of them were annual species, versus 17 which were perennial. Considering IVI, the most outstanding families were Poaceae, Cyperaceae, Euphorbiaceae, Amaranthaceae and Asteraceae. The results obtained in all the areas revealed the importance of the *species Panicum maximum*, *Sorghum halepense*, *Cyperus rotundus*, *Cynodon dactylon* and *Euphorbia hyssopifolia*. The areas with greater and less diversity were the Depressed Plain–Non-Saline Depressed Plain Subregion and the Subhumid-Humid Chaco-Pampean Plain, respectively. There was a 53% similarity between the Depressed Plain–Saline Depressed Plain and the Depressed Plain–Non-Saline Depressed Plain, and a 47% similarity between the Humid and Perhumid Foothills and the Subhumid-Humid Chaco-Pampean Plain. Hierarchical clustering and Jaccard index led to similar results.

Keywords: *Sacharum officinarum* L., importance value index, diversity, similarity.

RESUMO - As plantas daninhas constituem o principal fator limitante na produção de agroecossistemas de cana-de-açúcar argentinos. O objetivo deste trabalho foi analisar a composição florística e fitossociológica de plantas daninhas na cultura da cana-de-açúcar em diferentes regiões agroecológicas. Entre 60 e 90 dias a partir do surgimento da cultura, para cada região foram amostrados 15 lotes. Em cada um deles foi lançado um quadrado de 0,5 m², seis vezes ao acaso. As espécies encontradas foram identificadas. Posteriormente, o peso da biomassa fresca e seca foi determinado por aro e por espécie. Frequência, densidade, dominância, índice de valor de importância, índice de diversidade das espécies de Shannon-Wiener e Simpson e índice de similaridade de Jaccard foram calculados. Para a interpretação da similaridade, foi utilizado o método de agrupamento da média do grupo (UPGMA). Em geral, 35 espécies foram identificadas, sendo

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24 dicotiledôneas e 11 monocotiledôneas, das quais 18 eram anuais e 17 perenes. De acordo com o índice de importância, as famílias mais importantes foram Poaceae, Cyperaceae, Euphorbiaceae, Amaranthaceae e Asteraceae. Os resultados analisados em cada região coincidem em destacar a importância das espécies ***Panicum maximum***, ***Sorghum halepense***, ***Cyperus rotundus***, ***Cynodon dactylon*** *e* ***Euphorbia hyssopifolia***. *As regiões de maior e menor diversidade foram a planície deprimida sub-região planície deprimida não salina e a planície Chaco-Pampeana subúmida-úmida, respectivamente. A semelhança foi de 53% entre a planície deprimida sub-região planície deprimida salina e a planície deprimida sub-região planície deprimida não salina e de 47% entre Pedemonte úmida e perúmida e a Planície Chaco-pampeana subúmida-úmida. O cluster hierárquico e o índice de Jaccard mostraram resultados semelhantes.*

Palavras-chave: *Sacharum officinarum* L., índice de valor de importância, diversidade, similaridade.

INTRODUCTION

Sugarcane is grown in tropical and subtropical regions, and 80% of the world's sugar production is based on this crop (OCDE/FAO, 2015). Argentina produces an average of 2.1 million tons of sugar, with Tucumán province contributing 64.3% to this production and thus leading this economic activity in the country (Anino & Pizzo, 2016).

The main limiting factor affecting the productivity of sugarcane agroecosystems in Argentina is the presence of weeds. Eighty-five percent of the agrochemicals used to control them are herbicides (CASAFE, 2012), and they are applied as long as approximately 28% of the duration of the crop cycle. If during this period weeds continue to invade the crop, they cause significant yield decreases, as they compete with the crop for scarce eco-physiological resources (Arévalo et al., 1977).

In a weed community, weeds cause interference to different degrees, depending on their individual characteristics (Arévalo et al., 1977). The study of the composition of a plant community is known as phytosociology. In the case of weeds, this field analyzes communities from the structural and floristic point of view, by considering quali-quantitative features (Braun-Blanquet, 1979; Concenço et al., 2013). Qualitative descriptions point to the relationships among species present in a certain area, whereas quantitative analyses deal with structure, by considering number of individual weeds and their density (Causton, 1988). In order to find out what species are most prevalent in weed infestations, the importance value index (IVI) is calculated: distribution, number of individual plants and the biomass of weed species present in a given area are estimated (Pitelli, 2000).

Varying soil and climate conditions in the different agroecological regions have an influence on floristic composition and dominance of a weed species over another. In order to program adequate weed management practices, it is essential to find out whether the composition of weed communities and their quali-quantitative characteristics differ from one agroecological region to the other. This type of analysis has never been carried out before in Tucumán province. Thus, this work was undertaken to identify and quantify the floristic and phytosociological composition of weed communities affecting the sugarcane crop in the main agroecological regions of the province.

MATERIALS AND METHODS

The present phytosociological assessment was conducted in the sugarcane area of Tucumán province, Argentina (26º49' S-65º13' O). This area stretches over different agroecological regions, each one with its particular soil and climate conditions (Zuccardi and Fadda, 1985). The regions considered in this study were the following:

Humid and perhumid Foothills

This agroecological region is characterized by its silty loam or sandy loam and well-drained soils, which remain humid all year round. The mean temperature in the hottest month is 25 ºC, with annual precipitation rates higher than 1000 mm.

Subhumid-Humid Chaco-Pampean Plain

This region presents silty loam and silty clay loam soils. The mean temperature in January reaches 24 ^{o}C in the area, and annual rainfall rates amount to 750-1000 mm.

Depressed Plain – Non-Saline Depressed Plain Subregion

Soil types vary from sandy loam to clay loam. The average temperature recorded for January in the area is 26 ^{o}C, and mean annual precipitation rates range from 700 to 1000 mm.

Depressed Plain – Saline Depressed Plain Subregion

The soil in this region is sandy loam, with saline and sodic-saline phases. The mean temperature in January reaches 25 ^{o}C, and average annual precipitation rates decrease from 900 mm in the southwest to 650 mm in the east.

In all the evaluated sugarcane plots, the commercial cultivar was third ratoon LCP 85-384, kept under minimum tillage (a combination of specific mechanical and chemical operations), and without chemical weed control. Samplings were conducted in 2015, during the critical period of weed-crop competition, i.e. between 60 and 90 days after shooting (October-November) (Arévalo et al., 1977). Fifteen commercial plots were sampled per agroecological region, using the quadrat method. In each plot, a 0.5 m square metal frame was thrown six times in random directions, following an oblique line from the actual direction of the planted rows. The species found within the frame were counted, cut flush with the ground and transferred to plastic bags, which were duly labelled. Later in the lab, species were identified and quantified, and fresh biomass was weighed per quadrat sample and species (Braun-Blanquet, 1979; Oliveira and Freitas, 2008). Subsequently, the samples were taken to an oven and heated at 70 ^{o}C for 72 hours, so as to obtain dry biomass. These herbarium specimens were then sent to experts for their identification and classification into families, genera, and species. The phytosociological parameters evaluated in this work were the following: a) frequency (F): species distribution across the plot; b) density (D): number of individual plants per species and unit area; c) dominance (Do): biomass in relation to sampling area. With these parameters, the following calculations were made: d) relative frequency (Fr), e) relative density (Dr) and f) relative dominance (Dor), which offer information about the relationships each species keeps with others found in the area. Using Fr, Dr and Dor values, the importance value index (IVI) was calculated to determine which species were most important in the evaluated area (Mueller-Dumbois and Ellenberg, 1974). Only those species with IVI values higher than 10 were considered relevant..

Species diversity in each region was estimated by calculating Shannon-Wiener's species diversity index (H) (Odum, 1985) and Simpson's index (D) (Simpson, 1949).

In order to assess similarity among weed communities from the different agroecological regions evaluated, a species presence-absence matrix was built up. This matrix was used to create a similarity dendrogram, with the help of R-Project Software (R Core Team, 2016). This also implied considering Jaccard similarity index, where calculated values range from 0 to 100: 100 indicates that all of the species found in an agroecological region are also present in another region, and 0 shows that two regions being compared have no species in common (Mueller-Dombois and Ellenberg, 1974). The unweighted pair group method with arithmetic mean (UPGMA) was used to interpret similarity among regions, so as to group them on the basis of the arithmetic means of the elements. The best fit was the one which showed the highest cophenetic correlation coefficient (Sneath and Sokal, 1973).

Statistic software R (R Core Team, 2016) was run to calculate Shannon-Wiener's diversity and Jaccard similarity indices

The formulas used were the following:

- % Frequency (F) = number of plots with a species / total number of plots studied.
- % Relative frequency (Fr) = frequency of species occurrence * 100 / total occurrence frequency for all the species.

- % Density (D) = total number of individual plants of a species/ total sampled area.
- % Relative density (Dr) = species density * 100 / total species density.
- % Dominance (Do) = accumulated dry biomass of the species / total sampled area.
- % Relative dominance (Dor) = dominance of a species * 100 / dominance of all the species.
- % Importance value index (IVI) = Fr + Dr + Dor.
- % Shannon's index (H) = $-\Sigma pi \ln(pi)$.
- % pi = ni/N; ni = number of individual plants of a species i; N = total number of individual plants.
- % Simpson's index (D) = $1 - \Sigma pi^2$.
- % pi = ni/N; ni = number of individual plants of a species i; N = total number of individual plants.
- % Jaccard similarity index (%) (Sj) = (c/a+b+c)*100.
- % a = number of species found exclusively in area 1; b = number of species found exclusively in area 2; c = number of species common to both areas.

RESULTS AND DISCUSSION

Overall, considering all the sugarcane area and without discriminating agroecological regions, 35 species were identified: 24 dicotyledons and 11 monocotyledons, 18 of which were annual species and 17 perennial ones. Bearing in mind number of species, the most representative families were Poaceae, with 7 species; Asteraceae, with 6, and Euphorbiaceae, with 5. The species grouped into these families represented 51.4% of the species included in Table 1. Taking into account IVI values, the most important families were Poaceae, Cyperaceae, Euphorbiaceae, Amaranthaceae and Asteraceae, as they represented 92.1% of the total IVI. By further analyzing IVI values for each species, it was found that the most important ones were *Cynodon dactylon* (IVI=71.53); *Cyperus rotundus* (IVI=52.09); *Panicum maximum* (IVI=43.89); *Sorghum halepense* (IVI=22.98); *Euphorbia hyssopifolia* (IVI=22.59); and *Digitaria sanguinalis* (IVI=17.53) (Figure 1A). These results agree with previous ones recorded for Argentina and other parts of the world. *C. dactylon* has been reported as a weed present in all the sugarcane areas in the world, together with *C. rotundus*, *P. maximum* and *S. halepense*. As a result, these weeds are held as the most important ones affecting the sugarcane crop. Holm et al. (1977) pointed out that *C. dactylon* and *C. rotundus* are two of the three main sugarcane weeds in Argentina, India, Indonesia and Taiwan, among other countries. On the other hand, *P. maximum* is the main weed affecting sugarcane plantations in Cuba and Hawaii, and the third most important in South Africa, Costa Rica, Mexico and Taiwan, apart from having been reported as affecting 20 other crops. As far as *S. halepense* is concerned, it is known as an important weed affecting sugarcane in Argentina, Australia, Fiji, Pakistan, the United States of America, and Venezuela. Lastly, *D. sanguinalis* is one of the three main weeds found in Brazil and the USA, and the most important one affecting the crop in Australia, Cuba and India. As for *E. hyssopifolia*, there are no reports of its presence in sugarcane plantations in any part of the world. In Tucumán, Argentina, *C. dactylon* and *S. halepense* are considered the most important weeds associated with sugarcane (Chaila and Sobrero, 2009). On the other hand, *P. maximum* is characterized by its highly competitive behavior against LCP 85-384 and LCP 87-3 cultivars, at third, fourth and fifth ratoon crop ages, but it shows little tolerance to hydric and salinity stress conditions (Cabrera, 2016). *C. rotundus* is also characteristically sensitive to salinity, but has an outstanding capacity to adapt to different environmental conditions. Regarding *E. hyssopifolia*, this weed predominantly develops in association with crop mulching. Finally, *D. sanguinalis* is viewed as one of the seven most important sugarcane crop weeds in Argentina, and the first most important annual grass in the country (Chaila and Sobrero, 2009).

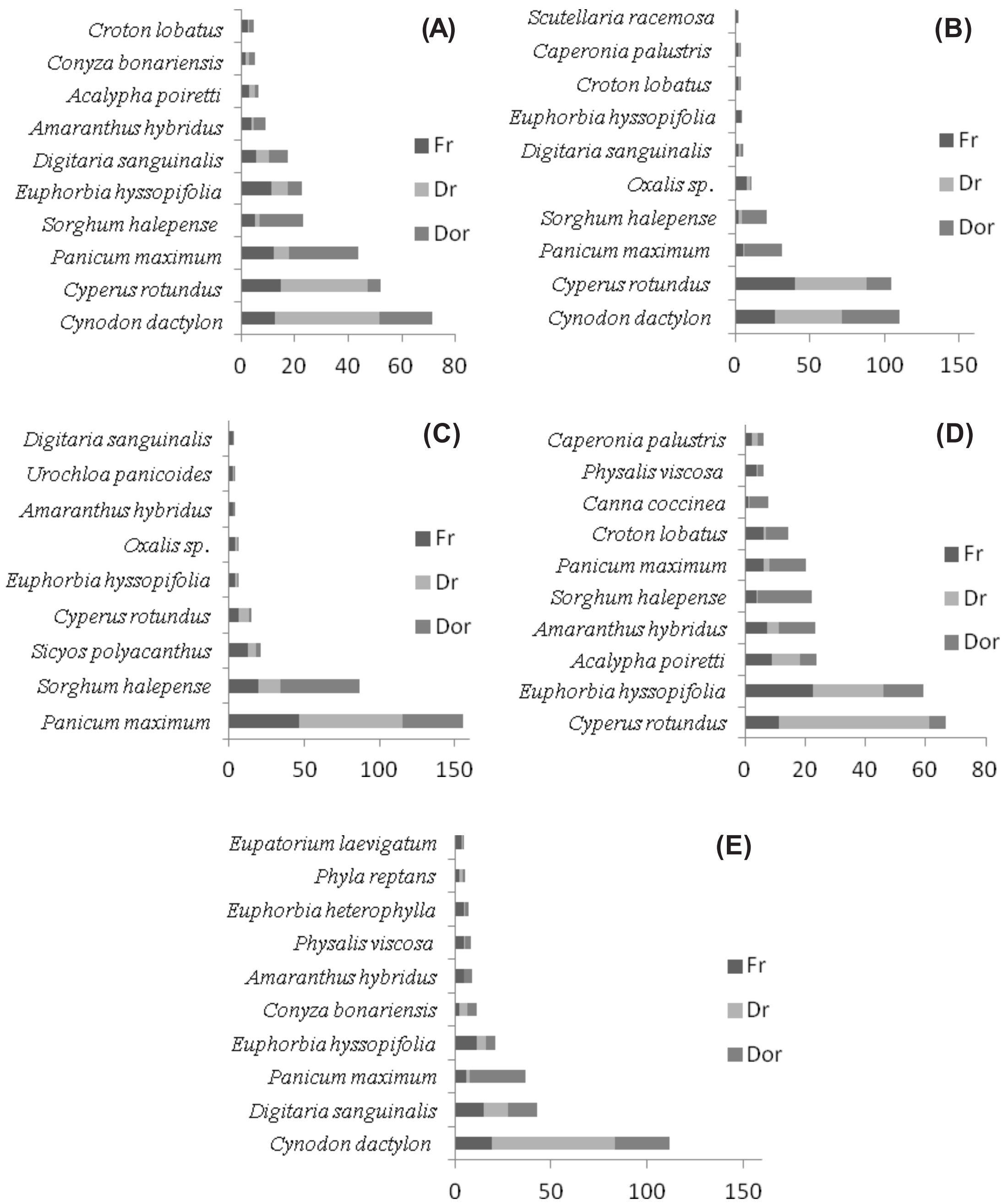
In what follows, the details of the phytosociological analyses carried out as part of the present research work are given for each of the assessed agroecological regions.

Table 1 - Identified species. 2015

Family	Scientific name	Cycle
Dicotyledons		
Aizoaceae	*Trianthema portulacastrum*	Annual
Amaranthaceae	*Amaranthus hybridus*	Annual
	Amaranthus spinosus	Annual
Araliaceae	*Hydrocotyle bonariensis*	Perennial
Asteraceae	*Ambrosia tenuifolia*	Annual
	Bidens pilosa	Perennial
	Conyza bonariensis	Annual
	Eupatorium laevigatum	Perennial
	Taraxacum officinale	Annual
	Wedelia glauca	Annual
Cannaceae	*Canna coccinea*	Perennial
Commelinaceae	*Commelina erecta*	Perennial
Cucurbitaceae	*Sicyos polyacanthus*	Annual
Cyperaceae	*Cyperus rotundus*	Annual
	Eleocharis crinalis	Perennial
Euphorbiaceae	*Acalypha poiretti*	Perennial
	Caperonia palustris	Annual
	Croton lobatus	Annual
	Euphorbia heterophylla	Perennial
	Euphorbia hyssopifolia	Annual
Lamiaceae	*Scutellaria racemosa*	Perennial
Malvaceae	*Malvastrum coromandelianum*	Perennial
	Sida rhombifolia	Perennial
Oxalidaceae	*Oxalis corniculata*	Perennial
Portulacaceae	*Portulaca oleracea*	Perennial
Solanaceae	*Physalis viscosa*	Annual
Verbenaceae	*Phyla reptans*	Perennial
Monocotyledons		
Poaceae	*Cynodon dactylon*	Perennial
	Digitaria sanguinalis	Annual
	Echinochloa colona	Annual
	Panicum bergii	Perennial
	Panicum maximum	Annual
	Setaria parviflora	Annual
	Sorghum halepense	Perennial

Humid and Perhumid Foothills

In the sugarcane plantations of this region, which is characterized by being free from freeze events and by presenting well-drained soils that remain humid all year long (Zuccardi and Fadda, 1985), 13 species were identified, 7 of them being monocotyledons and 6 dicotyledons. These species could be grouped into 6 families, and there were 6 annual and 7 perennial species among them. Considering IVI values, the most representative families were Poaceae and Cyperaceae. *C. dactylon* and *C. rotundus* species had an IVI of 110.13 and 104.26, respectively. For both, the most significant phytosociological parameters were Dr and Fr. *P. maximum* and *S. halepense* species ranked third and fourth, with IVI values of 31.78 and 21.60, respectively. The most significant phytosociological parameter for both was Dor. Lastly, *Oxalis* sp. showed an



(A) Overall; (B) Humid and Perhumid Foothills; (C) Subhumid-Humid Chaco-Pampean Plain; (D) Depressed Plain – Non-Saline Depressed Plain Subregion; (E) Depressed Plain – Saline Depressed Plain Subregion.

Figure 1 - Importance value index of the main sugarcane crop weeds present in Tucumán.

IVI of 10.26, with a significant Fr (Figure 1B). In this region, neither *E. hyssopifolia* nor *D. sanguinalis* exhibited IVI values higher than 10.

Subhumid-Humid Chaco-Pampean Plain

This region shows a yield decrease towards the east, coincidentally with diminishing precipitation rates and the occurrence of more intense freezes (Zuccardi and Fadda, 1985). Nine species were identified and these belonged to 6 different families. The species found in the region were fewer than the ones identified in the Humid and Perhumid Foothills, with monocotyledons (5) being also slightly more numerous than dicotyledons (4). In contrast to the species from the Humid and Perhumid Foothills, annual weeds (5) were slightly superior in number than perennial ones (4). The highest IVI values were recorded for species belonging to the Poaceae, Cucurbitaceae and Cyperaceae families. The most important species were: *P. maximum* (IVI=155.62), thanks to equally good values for the 3 parameters considered; *S. halepense* (IVI=86.64), with Dor being the most important parameter; *Sicyos polyacanthus* (IVI=20.93), with a Fr value of 12.76; and finally, *C. rotundus* (IVI=14.50), with Fr y Dr as the most important parameters (Figure 1C). In Tucumán province, *S. polyacanthus* is held as the main broad-leaved weed invading sugarcane plantations (Chaila and Sobrero, 2009). In this study, this species had high IVI values only in this region.

Depressed Plain – Non-Saline Depressed Plain Subregion

Zuccardi and Fadda (1985) observed that sugarcane plants reached maturation later, produce had a lower quality, and that summer-autumn harvest, tillage, and autumn-winter planting all became more difficult in this region. These authors also observed a major invasion of sugarcane plantations by weeds. Twenty-two species were identified here: 8 monocotyledons and 14 dicotyledons. These species, out of which 13 were annual and 9 perennial plants, could be grouped into 12 different families. The most representative were the Euphorbiaceae, Cyperaceae and Poaceae families. *C. rotundus* showed an IVI of 66.75, with Dr as its most significant phytosociological parameter. *E. hyssopifolia* came next, with an IVI of 59.14. *Acalypha poiretti* ranked third with an IVI value of 23.84. For the last two species, Fr and Dr were equally decisive; *Amaranthus hybridus* reached an IVI of 23.29, with Dor being the most important parameter. Finally, *S. halepense* and *P. maximum* exhibited IVI values of 20.27 and 14.49, respectively, the same as in the Humid and Perhumid Foothills, again with Dor being the most significant parameter for both (Figure 1D). In this specific agroecological region, in contrast to the ones previously described, the Euphorbiaceae family was among the most representative ones. Moreover, for species *E. hyssopifolia*, *A. poiretti*, and *A. hybridus* (which belongs to the Amaranthaceae family), IVI values higher than 10 were recorded (Figure 1D).

Depressed Plain – Saline Depressed Plain Subregion

As in the case of the regions described above, sugarcane is the most important crop in the area. One of its main problems, however, is its actually and potentially saline and alkaline soils. Under dry farming management, there are constraints on production due to hydric deficits recorded during winter and spring. The probability of freezes occurring and their intensity are also higher than in the regions previously dealt with (Zuccardi and Fadda, 1985). In the present survey, 27 weed species were identified, 10 being monocotyledons and 17 dicotyledons. These weeds, which comprised 15 annual species and 12 perennial ones, could be assigned to 11 different families. The most relevant among them were the following, on the basis of IVI calculations: Poaceae, Euphorbiaceae and Asteraceae. The species with the highest IVI (111.96) was *C. dactylon*, and its most significant phytosociological parameter was Dr. *D. sanguinalis* came next, with an IVI value of 42.47, to which the three phytosociological parameters evaluated contributed to a similar degree. Ranking third, *P. maximum* had an IVI value of 36.75, with a major contribution made by Dor. Fourthly, *E. hyssopifolia* reached an IVI value of 21.23, with Fr being the most significant phytosociological parameter. *Conyza bonariensis* came last, with an IVI of 11.69, and a similar contribution to this value by Dr, Fr and Dor (Figure 1E). In this region, as in the Depressed Plain – Non-Saline Depressed Plain Subregion, Euphorbiaceae was one of the most relevant families. By contrast, the Asteraceae family was only representative of the Depressed Plain –Saline Depressed Plain Subregion.

The results obtained for each of the evaluated agroecological regions point to a greater weed species diversity in the Depressed Plain, both in the Non-Saline and in the Saline Depressed Plain Subregions, with the predominance of dicotyledons and annual species.

In all the regions, *P. maximum*, *S. halepense*, *C. rotundus* and *C. dactylon* were recorded as relevant weed species. All these species are actually characterized by having a cosmopolitan distribution (Holm et al., 1977). As three of them belong to the Poaceae family, it can be suggested that this family constitutes an important weed group affecting the sugarcane crop. In the case of *E. hyssopifolia*, a high IVI was recorded in two agroecological regions. This weed has been reported as affecting sugarcane plantations in Tucumán (Argentina), but not in other regions in the world. As regards the number of species identified per region, the values coincide with the ones reported for other sugarcane areas in the world. In Brazil, in ratoon sugarcane plantations, the average number of species found reached 11,33 (Oliveira and Freitas, 2008), as compared with the number of species reported in this study, which ranges from 9 to 27 species.

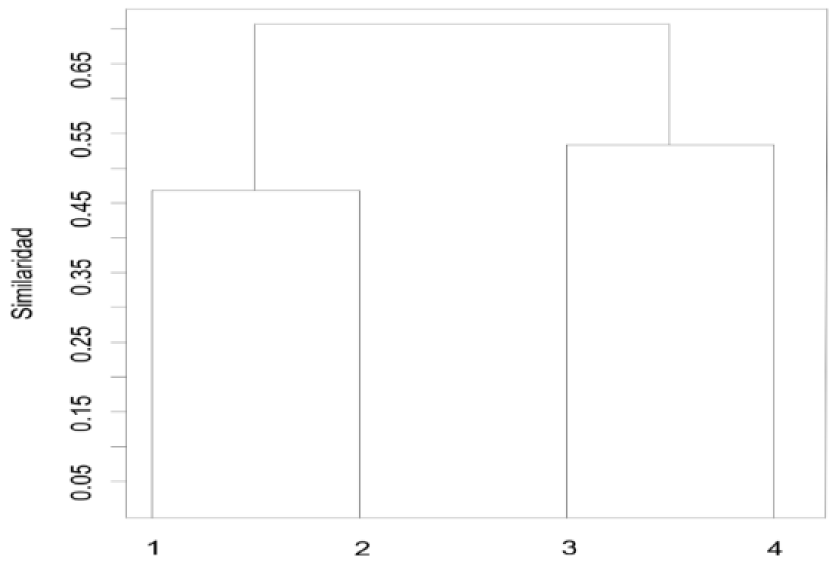
Another finding was that, on the basis of the calculated indices in this study, the competitive capacity of the species and weed communities found in each region was different. Hence, *C. rotundus* presented a high IVI value in all the regions, except in the Depressed Plain – Saline Depressed Plain Subregion, whereas *S. polyachanthus* only exhibited a high IVI in the Subhumid-Humid Chaco-Pampean Plain. As for *C. dactylon*, a high IVI value was recorded for the Humid and Perhumid Foothills, the same as with *Oxalis* sp., but in the Depressed Plain – Saline Depressed Plain Subregion, it was the former that presented a high IVI, and not the latter, with *E. hyssopifolia* and *C. bonariensis* also showing superior IVI values. These differences were appreciated by calculating Shannon-Wiener's (H), Simpson's (D), and Jaccard similarity indices, and by building up a hierarchical cluster by means of the UPGMA method. Shannon-Wiener's (H) and Simpson's (D) indices made it possible to determine the degrees of diversity and similarity among the different agroecological regions evaluated. Shannon-Wiener's index is more sensitive to not very frequent species, whereas Simpson's index covers numerous species better. With values of 1.67 and 3.17 according to Shannon-Wiener's and Simpson's indices, respectively, the region with most diversity was the Depressed Plain – Non-Saline Depressed Plain Subregion. Considering Simpson's index, the areas with less diversity were the Subhumid-Humid Chaco-Pampean Plain and the Depressed Plain – Saline Depressed Plain Subregion, with values of 2.00 and 2.34, respectively. According to Shannon-Wiener's index, the regions with less diversity were the Humid and Perhumid Foothills, together with the Subhumid-Humid Chaco-Pampean Plain again, with values of 1.06 and 1.09, respectively (Table 2).

Concerning the similarity among regions, Mueller-Dombois and Ellenberg (1974) consider that two regions are 'similar' when Jaccard index is equal to or higher than 25%. For all the areas under study values higher than 25% were recorded, with the exception of the Subhumid-Humid Chaco-Pampean Plain and the Depressed Plain – Saline Depressed Plain Subregion, which presented a 20% index value. It was observed that there was a high similarity degree between the Depressed Plain – Saline Depressed Plain Subregion, and the Depressed Plain – Non-Saline Depressed Plain Subregion, with a 53% value. Next to this value was the one recorded for similarity between the Humid and Perhumid Foothills and the Subhumid-Humid Chaco-Pampean Plain, i.e. 47% (Table 2).

Hierarchical clustering following UPGMA chaining criteria led to a grouping of the regions with most similarities. Thus, the Depressed Plain – Non-Saline Depressed Plain Subregion and the Depressed Plain – Saline Depressed Plain Subregion were grouped together, whereas the Subhumid-Humid Chaco-Pampean Plain and the Humid and Perhumid Foothills formed a different cluster (Figure 2). The results obtained with Jaccard similarity index and UPGMA hierarchical

Table 2 - Diversity and similarity indices recorded for agroecological regions in Tucumán, Argentina. (Shannon-Wiener's diversity index (H), Simpson's index (D), Jaccard similarity index (Sj)). 2015

Agroecological regions	Diversity		Similarity (Sj) %		
	H	D	Humid and Perhumid Foothills	Subhumid-Humid Chaco-Pampean Plain	Depressed Plain – Non-Saline Depressed Plain Subregion
Humid and Perhumid Foothills	1.06	2.34	-	-	-
Subhumid-Humid Chaco-Pampean Plain	1.09	2.00	47	-	-
Depressed Plain – Non-Saline Depressed Plain Subregion	1.67	3.17	35	29	-
Depressed Plain – Saline Depressed Plain Subregion	1.46	2.30	33	20	53



1. Humid and Perhumid Foothills; 2. Subhumid-Humid Chaco-Pampean Plain; 3. Depressed Plain – Non-Saline Depressed Plain Subregion; 4. Depressed Plain –Saline Depressed Plain Subregion. Cophenetic coefficient: 0.90. 2015.

Figure 2 - Similarity cluster for floristic composition of weeds present in the sugarcane agroecosystem, for the different agroecological regions sampled.

clustering were similar. These outcomes also coincide with Zuccardi and Fadda's observations (1985) that the Depressed Plain – Saline Depressed Plain Subregion and the Depressed Plain – Non-Saline Depressed Plain Subregion were areas with suboptimal conditions for sugarcane plantations, as compared with the Humid and Perhumid Foothills and the Subhumid-Humid Chaco-Pampean Plain, which presented optimum conditions for growing sugarcane crops.

By means of a phytosociological analysis, conducted both generally and per region, this study has shown that *C. dactylon*, *C. rotundus*, *P. maximum*, *S. halepense* and *E. hyssopifolia* are important weed species. Among these, the ones belonging to the *Poaceae* and *Cyperaceae* families -and not *E. hyssopifolia*- can be commonly found in any sugarcane growing area in the world. The indices measured in this study, except for Simpson's index, have also revealed that there is a higher similarity level between the phytosociological systems found in the Depressed Plain – Non-Saline Depressed Plain Subregion and those found in the Depressed Plain – Saline Depressed Plain Subregion, on the one hand, and between those in the Subhumid-Humid Chaco-Pampean Plain and those in the Humid and Perhumid Foothills, on the other hand. These results show that there exist different weed community structures that need to be considered whenever an integrated weed management program is designed for protecting sugarcane crops.

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