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Article

Weeds in a Sugar Cane Soil Cultivated with Crotalaria juncea

Plantas Daninhas em um Solo Canavieiro Cultivado com ***Crotalaria juncea***

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ABSTRACT - Cover crops play an important role in sustainable agriculture, as they decrease soil erosion, promote the incorporation of nitrogen into the soil and reduce or modify weed communities. Aiming at evaluating the changes related to the cultivation and incorporation of sunn crotalaria (*Crotalaria juncea* L.1753) in a weed community of a soil cultivated with sugarcane, an agro-industrial crop of vital importance to La Chontalpa region, Tabasco, Mexico, an experiment encompassing the cultivation cycle and the incorporation of the dry phytomass of this cover crop was carried out. The treatments included three levels of fertilization and two controls, the plots of the first control were interspersed with those of the treatments, while the second control was placed outside, in order to avoid the shade effect caused by crotalaria. Sampling was carried out monthly, and the data obtained from samplings allowed the calculation of weed diversity and importance value (IVI) indexes, in addition to dry phytomass production values. The results showed that the fertilization did not exert any influence on the composition, diversity or importance of the weeds, factors that were more related to the rainy season, period in which the research on the cultivation, cutting and incorporation of crotalaria into the soil was performed. Although the best represented family was Euphorbiaceae, its species were not among the most important in the community in which *Cyperus rotundus* L. 1753, *Lindernia crustacea* (L.) F. Muell. 1882, *Scleria setuloso-ciliata* Boeckeler 1882, *Ageratum houstonianum* Mill, 1768 and *Acmella repens* (Walter) Rich. 1807 stood out. The dry biomass of the weeds showed statistical differences between the plots with and without crotalaria, considering that lower values were observed in the control groups; however, the total dry phytomass production was extremely higher in the cultivated plots, highlighting the importance of using this species as green manure.

Keywords: sunn crotalaria, *Saccharum*, weed control, cover crop.

*RESUMO - As culturas de cobertura desempenham um papel importante na agricultura sustentável, uma vez que reduzem a erosão do solo, favorecem a incorporação de nitrogênio por este e reduzem ou modificam a comunidade de ervas daninhas. A fim de avaliar as mudanças relacionadas ao cultivo e à incorporação de crotalária (**Crotalaria juncea** L.1753) na comunidade de ervas daninhas presentes no solo comumente cultivado com cana-de-açúcar, cultivo agroindustrial de importância vital na região Chontalpa, Tabasco, foi realizado um experimento que incluiu o ciclo de cultivo e a incorporação de fitomassa seca da referida cobertura. Os tratamentos incluíram três níveis de fertilização e dois controles, as parcelas do primeiro foram intercaladas com as dos tratamentos, enquanto que o segundo foi colocado externamente, com o objetivo de evitar o efeito de sombreamento da crotalária. Foram realizadas amostragens mensais, cujos dados permitiram calcular os índices de diversidade e valor de importância*

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*(IVI) das plantas daninhas, além da produção seca de fitomassa. Os resultados demonstraram que a fertilização não teve influência na composição, diversidade e importância das ervas daninhas, fatores que se relacionaram mais com a estação das chuvas, período em que foi realizada a pesquisa com o cultivo da crotalária, seu corte e incorporação ao solo. Embora a família mais bem representada tenha sido Euphorbiaceae, suas espécies não estiveram entre as mais importantes da comunidade em que se destacaram **Cyperus rotundus** L. 1753, **Lindernia crustacea** (L.) F. Muell. 1882, **Scleria setuloso-ciliata** Boeckeler 1882, **Ageratum houstonianum** Mill, 1768 e **Acmella repens** (Walter) Rich. 1807. A biomassa seca das plantas daninhas apresentou diferenças estatísticas entre as parcelas com e sem crotalária, sendo muito menor nos controles; no entanto, a produção total de fitomassa seca foi extremamente maior nas cultivadas, evidenciando o valor do uso dessa espécie como adubo verde.*

Palavras-chave: sunn crotalaria, *Saccharum*, controle de plantas daninhas, cultivo de cobertura.

INTRODUCTION

The sugar cane agro-industry has been an important source of income for Mexico for five centuries, when it was introduced in America by the Spanish; it also represents a significant source of employment, due to the amount of labor required. Although field and factory yields are higher in Mexico than the world average score, the production costs surpass those of other countries (SIAP, 2016); achieving efficiency and maximum productivity with the least investment requires a systematic planning involving the assessment of all aspects related to growing, to avoid excessive use of resources, while reducing their impact on the environment (Subirós-Ruiz, 2000). Several factors may affect field yields, including the selection of cultivars, soil fertility and the use of fertilizers, the plant population density, the presence and control of pests, whether these are animals, diseases or weeds associated with the crop.

Fertilizers, whether organic (animal or vegetable) or synthetic (chemical, inorganic or mineral), provide plants with the essential chemical elements for their development. As in the sugarcane agro-system they represent the most expensive input (50-70%), cover crops have been implemented, as they take advantage of solar energy to produce high-quality phytomass that rapidly incorporates mineralizable organic matter into the soil and positively affects some physical, chemical and biological soil properties, potential future yield growth and the control of weed communities. Several species of Fabaceae are frequently used as cover crops, due to their ability to fix the atmospheric N, enabling them to establish a symbiotic relationship with bacteria of the genus *Rhizobium*. This practice significantly reduces the use of mineral fertilizers, bringing direct benefits to soil fertility, in addition to other economic, social and environmental advantages that pave the way to sustainable agriculture (Gliessman, 2002; Prager et al., 2012).

Among the species used as green manure, one must highlight *Crotalaria juncea* L. (“Madras hemp, sunn crotalaria, Indian hemp”), which increases crop production via intercropping with sugar cane (Vasconcellos-Prellwitz and Cunha-Coelho, 2011) and has proven to be a good alternative source of N (149 kg ha^{-1}) (Muraoka et al., 2002).

Green fertilizers may also perform another function: the control of weeds that compete with crops for space, light, water and nutrients, and whose presence can mean the reduction of yield up to 30% (Berlingeri et al., 2008). However, the implementation of these management practices requires further research aimed at comparing their impact on yield and environment regarding the frequent and inappropriate use of herbicides (Kuva et al., 2003). Moreover, the continuous pre-harvest sugar cane field burning contributes to weed growth, mainly herbaceous weeds, whose competition is usually very aggressive in the early stages of crop development; occasionally, some woody weeds are also observed, and these plants pose serious problems at any stage, as all of them usually have a great ability to spread out (Valdez-Balero et al., 2009).

Severino and Christoffoleti (2004) and Skinner et al. (2012) affirm that sunn crotalaria is one of the most effective Fabaceae to suppress weed emergence, given its rapid growth, large production of phytomass, competitiveness and allelochemical effect. Therefore, the present study aimed at assessing the effect of *Crotalaria juncea* L. on the composition of weed communities and on the production of phytomass in a sugarcane soil under three doses of fertilizer.

MATERIALS AND METHODS

The research was carried out in the Experimental Field of the Colegio de Postgraduados, Campus Tabasco (18°01' N and 93°03' W), km 21 of Cárdenas-Coatzacoalcos Federal Highway 180, located in the state of Tabasco, Mexico. The climate is tropical (warm-humid) with summer rains and annual averages of temperature, precipitation and evaporation of 26.7 °C, 2240 and 1400 mm, respectively.

The soil used in this study, corresponding to a CMeu Eutric Cambisol (Clayey) (Palma-López et al., 2006), was cultivated with sugarcane for 15 years and was flipped up by tilling and rolling, as it had shown significant productivity drop. Sunn crotalaria was broadcast sown into 5 x 5 m plots, on January 9th 2015. The NPK fertilization treatments tested were the following: 00-00-00, 00-60-60 and 120-60-60 with the incorporation of the plant, after harvest. In addition, the study included two control plots where no sunn crotalaria planting occurred neither incorporation, and one of them (*in situ*) was placed next to the fertilized plots, and the other (*ex situ*) in a nearby area, fully clear, in broad daylight, to avoid the shading effect of the Fabaceous plants.

Each treatment had four repetitions, and each plot covered a sampling of weeds, using a 50 x 50 cm metal box, according to the method of quadrants (Mostacedo and Fredericksen, 2000), in four different periods: 1) during the crotalaria sowing operation (45 days after flipping up the soil); 2) 40 and 3) 60 days after the emergence of crotalaria plants, on October 20th 2015 and on November 9th 2015; and 4) 40 days after its incorporation into the soil, on December 19th 2015. For each of the species present, name (common and/or scientific), number of individuals and percentage of coverage were recorded. All the plants included in the tables were collected, taken to the CSAT Herbarium for subsequent identification of their taxonomic identity by consulting specialized bibliography (Castillo-Campos, 1978-2015), Flora del Bajío y de Regiones Adyacentes (“Flora of Bajío and Adjacent Regions”) (Rzedowski y Rzedowski, 1991-2015), Flora del valle de México (“Flora of the Valley of Mexico”); Malezas de México (“Mexico Weeds”) (Vibrans, 2012); the samples were dried in a forced circulation oven at 60°C and weighed (Sadzawka et al., 2007). The data recorded were systematized and analyzed using Microsoft® Office Excel 2007 software, and were applied to calculate the diversity indices: S, H’ and E (Magurran, 1988), the following components of the importance value index (IVI) of weeds: Density (De), Frequency (Fr), Dominance (Do) and their relative values (rDe, rFr y rDo) (Gámez-López et al., 2011; Concenço et al., 2016) were also determined by using the formulae:

S= Number of species

$$H' = -\sum[pi * \ln(pi)]$$

$$E = \frac{H'}{\ln S}$$

De = Number of plants per species/unit area (m^2).

Fr = Number of samples in which the species is observed x 100/Total number of samples.

Do = Number of individuals of a species x 100/Total number of individuals of all species.

rDe = De/Det*

rFr = Fr/Frt*

rDo = Do/Dot*

IVI = rDe + rFr+ rDo

t* = total

The dry weight of all weeds was analyzed according to a randomized complete block design, with five treatments and four repetitions each. The analysis of the variance was performed using the Statistica 2003 software and a Tukey’s multiple comparison test was applied.

RESULTS AND DISCUSSION

In the four samplings, a total of 51 species belonging to 22 botanical families were identified (Table 1), 80% are dicotyledonous and the rest all are monocotyledonous, a proportion similar to that reported by García-Jiménez (2015) and Pérez et al. (2014) for sugar cane, and by Sánchez-Blanco and Guevara-Fefer (2013) for maize. The families with the greatest number of species were Euphorbiaceae (7), Poaceae (5), Asteraceae (5), Scrophulariaceae (5), Convolvulaceae, Fabaceae and Cyperaceae (4), and Lamiaceae and Onagraceae (2) (Figure 1); the nine families totaled 80%; the remaining 13 families were represented by a single species.

Table 1 - Floristic list of the species found in the weed samplings in a sugar cane soil cultivated with *Crotalaria juncea*

No.	Family	No.	Species	Samplings			
				Sept.9th/15	Oct 20th/15	Nov 9th/15	Dec 19th/15
Dicotyledonous							
1	Acanthaceae	1	*Ruellia nudiflora* Urb.				X
2	Asteraceae	2	*Acmella repens* (Walter) Rich.		X	X	X
		3	*Ageratum houstonianum* Mill.		X	X	X
		4	*Conyza bonariensis* (L.) Cronq.				X
		5	*Melanthera nivea* (L.) Small		X	X	
		6	*Tridax procumbens* L.			X	
3	Boraginaceae	7	*Heliotropium filiforme* Lehm.		X		X
4	Convolvulaceae	8	*Ipomoea trifida* (L.) Lam.	X	X	X	
		9	*Ipomoea triloba* L.		X		
		10	*Jacquemontia thamnifolia* (L.) Griseb.		X		
		11	*Merremia umbellata* (L.) H. Hallier		X	X	X
5	Euphorbiaceae	12	*Acalypha arvensis* Poepp. & Endl.	X	X	X	X
		13	*Acalypha indica* L.	X		X	
		14	*Caperonia palustris* (L.) A. St.-Hill	X		X	
		15	*Croton lobatus* L.	X			
		16	*Euphorbia hirta* L.			X	
		17	*Phyllanthus niruri* L.	X	X	X	X
		18	*Phyllanthus urinaria* L.		X		
6	Fabaceae	19	*Clitoria ternatea* L.		X	X	X
		20	*Crotalaria juncea* L.				X
		21	*Desmodium incanum* DC.	X			X
		22	*Mimosa pudica* L.		X	X	X
7	Lamiaceae	23	*Hyptis brevipes* Poit.		X	X	X
		24	*Hyptis mutabilis* (L. Rich.) Briq.			X	
8	Loganiaceae	25	*Spigelia anthelmia* L.		X	X	X
9	Lythraceae	26	*Cuphea carthagenensis* J.F. Mac			X	
10	Malpighiaceae	27	*Stigmaphyllon humboldtianum* (D.C.) Juss.	X	X		
11	Malvaceae	28	*Sida rhombifolia* L.	X			
12	Molluginaceae	29	*Mollugo verticillata* L.		X	X	X
13	Onagraceae	30	*Ludwigia erecta* (L.) H. Hara	X	X		
		31	*Ludwigia octovalvis* (Jacq.) Raven	X	X	X	X
14	Rubiaceae	32	*Borreria latifolia* L.		X		X
15	Scrophulariaceae	33	*Bacopa procumbens* (Mill.) Greenm.		X	X	X
		34	*Lindernia crustacea* (L.) F.Muell.		X	X	X
		35	*Lindernia dubia* (L.) Pennell		X	X	X
		36	*Mimulus glabratus* Kunth			X	
		37	*Scoparia dulcis* L.			X	
16	Sterculiaceae	38	*Melochia pyramidata* L.		X	X	X
17	Tiliaceae	39	*Corchorus orinocensis* Kunth	X	X		
18	Violaceae	40	*Hybanthus attenuatus* (H. & B. ex Wiild.) Schulze-Menz	X			
19	Vitaceae	41	*Cissus verticillata* (L.) Nicholson & Jarvis			X	X
Monocotiledóneas							
20	Cannaceae	42	*Canna indica* L.	X	X	X	
21	Cyperaceae	43	*Cyperus rotundus* L.	X	X	X	X
		44	*Fimbrystilis miliacea* (L.) Vahl		X		X
		45	*Rhynchospora contracta* (Nees) J. Raynal				X
		46	*Scleria setuloso-ciliata* Boeckeler	X	X	X	X
22	Poaceae	47	*Acroceras zizanioides* (Kunth.) Dandy				X
		48	*Echinochloa colona* (L.) Link			X	
		49	*Paspalum conjugatum* P.J. Bergius	X			
		50	*Saccharum* sp.				X
		51	*Urochloa fusca* (Sw.) Wunderlin & Hansen		X		

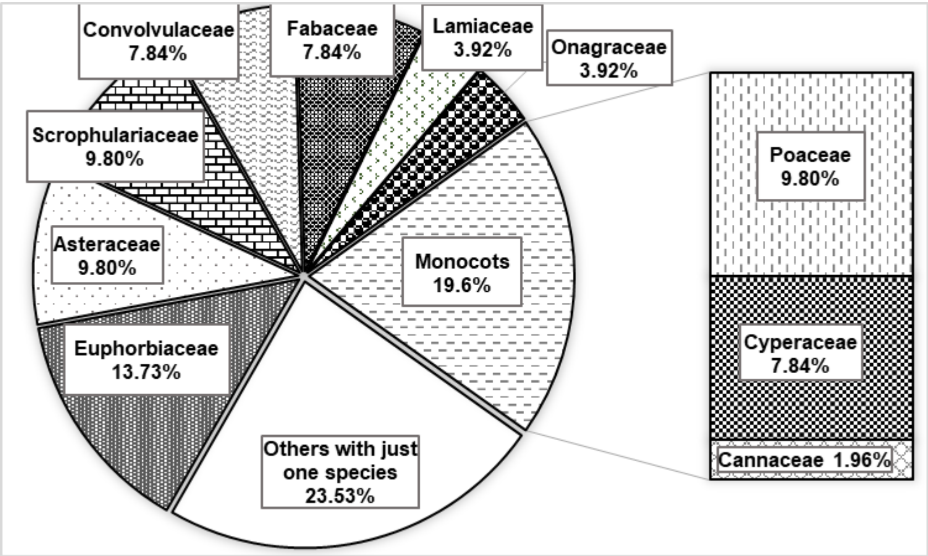

Figure 1 - Plant families identified in weed samples, in a sugar cane soil cultivated with *Crotalaria juncea*.

In general, families with more species coincide with those reported in the studies mentioned in the above paragraph. It is striking that Euphorbiacea showed the greatest number of species in this research, superseding Asteraceae and Poaceae which, besides being among the most diverse, include several pioneer species – found in disturbed environments – that have the ability to settle in hostile environmental conditions, such as areas that have been modified for agricultural activity (Aleman-Zeledón*,* 2004).

Another finding that did not go unnoticed is the scarce presence of Fabaceae, only three of the 12 registered by García-Jiménez (2015) for sugar cane cultivation were observed; and this may be related to the fact that *C. juncea* has been reported as one of the most effective in suppressing the emergence of weeds, due to its rapid growth, competitiveness and allelochemical effect (Skinner et al., 2012), an aspect that is also reflected in the difference found in the species richness when comparing the plots with and without sunn crotalaria.

The lowest diversity indices corresponded to the first sampling (Table 2); species richness (S) and diversity (H') increased as the crotalaria cultivation cycle progressed, hence the highest number of species (30) was registered in October and November, 17 in September and 28 in December. In general, the highest S and H' values were observed in the control groups (*ex situ* and *in situ*); however, no clear differences were found between the fertilizer treatments.

The highest H' observed in November and October in the low-fertilization plot (0-60-60) implies a poor crotalaria growth; in the control plots, this value remained high throughout all months, indicating the normal behavior of a natural herbaceous community in the absence of cultivation, considering that S and H' values increase as those of E decrease (Perdomo et al., 2004). This finding reveals that the weed species composition was influenced by seasonality, the presence of sunn crotalaria and agricultural practices (cutting), since S and H' values increased until the third month in the control groups and decreased in the last month for all treatments. The low values of

Table 2 - Species richness (S), diversity (H') and uniformity (E) of the weed community in a sugar cane soil cultivated with sunn crotalaria at different doses of fertilizers

Treatment	S	H'	E
September			
Initial	4.67	1.08	0.71
October			
0-60-60	7.75	2.81	1.37
120-60-60	7.25	2.41	1.22
In situ	9.50	2.70	1.20
Ex situ	9.75	2.67	1.17
November			
00-00-00	4.25	1.67	1.16
0-60-60	7.50	3.28	1.64
120-60-60	5.50	2.38	1.38
In situ	9.75	2.68	1.20
Ex situ	11.0	3.22	1.34
December			
00-00-00	4.00	1.75	1.24
0-60-60	2.50	0.97	0.76
120-60-60	4.75	1.91	1.24
In situ	7.50	2.48	1.24
Ex situ	8.25	2.66	1.28

the cultivated plots support Queiroz et al. (2010) and Mosjidis and Wehtje (2011) assertion that this fabaceous affects the reduction of weeds, according to the area.

Although the best represented family was Euphorbiaceae, its species were not the most important in the evaluated sugar cane agrosystem, where *C. rotundus, L. crustacea, S. setuloso-ciliata, A. houstonianum* and *A. repens* displayed the highest IVI rates. Table 3 shows the five

Table 3 - Relative density (rDe), frequency (rFr) and dominance (rDo) and Importance Value Index (IVI) of the relevant species found in a sugar cane soil cultivated with sunn crotalaria at different doses of fertilizers

Treatment	Species	rDe	rFr	rDo	IVI
	September				
Initial	*Cyperus rotundus*	84.91	56.45	78.02	219.38
	Scleria setuloso-ciliata	6.25	3.70	4.21	14.16
	Stigmaphyllon humboldtianum	2.68	7.89	3.26	13.83
	Ipomoea trifida	0.88	8.49	4.11	13.48
	Phyllanthus niruri	1.94	8.17	3.02	13.12
	October				
0-60-60	*Lindernia crustacea*	68.47	28.81	37.63	134.91
	Scleria setuloso-ciliata	8.97	14.52	18.85	42.35
	Acmella repens	2.77	9.17	5.36	17.29
	Acalypha arvensis	3.37	6.67	6.64	16.68
	Phyllanthus niruri	2.55	6.79	4.24	13.57
	Cyperus rotundus	1.56	1.79	2.57	5.92
120-60-60	*Lindernia crustacea*	68.11	36.44	43.70	148.24
	Scleria setuloso-ciliata	9.51	17.87	22.09	49.47
	Mollugo verticillata	1.78	9.38	3.54	14.69
	Acmella repens	3.96	4.33	5.50	13.80
	Ageratum houstonianum	2.37	4.51	5.00	11.89
	Heliotropium filiforme	3.95	4.33	2.05	10.33
	Phyllanthus niruri	2.66	2.94	3.45	9.05
	Phyllanthus urinaria	1.84	4.33	2.61	8.77
	Acalypha arvensis	2.37	2.86	3.30	8.52
	Stigmaphyllon humboldtianum	0.71	3.13	4.17	8.01
In situ	*Lindernia crustacea*	70.08	20.97	41.82	132.87
	Scleria setuloso-ciliata	13.73	18.59	19.58	51.90
	Mollugo verticillata	4.16	12.57	5.74	22.47
	Ageratum houstonianum	2.08	7.52	8.08	17.67
	Bacopa procumbens	1.67	9.35	4.32	15.34
	Acmella repens	2.63	5.55	4.54	12.73
	Cyperus rotundus	1.94	3.26	2.38	7.59
Ex situ	*Lindernia crustacea*	72.09	17.28	45.63	134.99
	Scleria setuloso-ciliata	11.08	10.48	12.87	34.43
	Mollugo verticillata	4.91	15.96	10.18	31.06
	Bacopa procumbens	2.72	9.41	4.88	17.00
	Cyperus rotundus	2.38	9.00	4.29	15.66
	Ageratum houstonianum	1.08	6.91	5.90	13.89
	Acmella repens	1.66	5.96	5.15	12.78
	November				
0-0-0	*Acmella repens*	26.39	22.86	20.52	69.77
	Scleria setuloso	23.61	11.90	15.14	50.65
	Lindernia crustacea	17.36	16.79	14.96	49.11
	Stigmaphyllon humboldtianum	12.50	17.50	18.57	48.57
	Clitoria ternatea	6.25	8.33	15.00	29.58
	Cyperus rotundus	0.69	1.79	2.25	4.73
0-60-60	*Scleria setuloso-ciliata*	20.18	15.71	25.70	61.59
	Acmella repens	15.14	17.38	17.99	50.50
	Lindernia crustacea	20.83	12.79	13.01	46.63
	Phyllanthus niruri	7.96	10.55	6.97	25.48
	Lindernia dubia	7.56	7.09	8.38	23.02
	Ageratum houstonianum	5.98	5.26	7.70	18.94
	Cyperus rotundus	1.17	2.98	0.88	5.03

To be continued ...

Table 3, cont.

Treatment	Species	rDe	rFr	rDo	IVI
November					
120-60-60	*Scleria setuloso-ciliata*	20.80	17.71	19.55	58.06
	Acmella repens	21.35	16.67	19.23	57.25
	Lindernia crustacea	18.92	19.44	15.38	53.74
	Phyllanthus niruri	16.87	19.44	13.24	49.55
	Stigmaphyllon humboldtianum	6.82	8.33	16.83	31.98
	Ageratum houstonianum	7.36	6.94	5.96	20.26
In situ	*Lindernia crustacea*	65.01	19.79	35.54	120.34
	Scleria setuloso-ciliata	14.38	11.67	18.00	44.05
	Mollugo verticillata	7.43	11.74	8.06	27.23
	Ageratum houstonianum	3.42	10.82	6.98	21.22
	Ipomoea trifida	1.33	9.97	6.56	17.86
	Acmella repens	0.40	3.56	2.16	6.12
	Cyperus rotundus	0.23	1.85	0.39	2.47
Ex situ	*Lindernia crustacea*	66.51	19.34	39.58	125.42
	Scleria setuloso-ciliata	7.58	10.20	14.05	31.82
	Cissus verticillata	3.21	14.08	5.78	23.07
	Mollugo verticillata	5.07	9.51	7.39	21.98
	Lindernia dubia	5.29	7.83	4.07	17.19
	Ageratum houstonianum	3.01	8.30	4.97	16.29
	Cyperus rotundus	0.46	2.79	0.39	3.63
	Acmella repens	0.28	1.00	0.48	1.75
December					
0-0-0	*Ageratum houstonianum*	41.25	36.76	54.17	132.18
	Merremia umbellata	24.69	19.20	22.73	66.61
	Phyllanthus niruri	15.31	19.20	11.90	46.41
	Scleria setuloso-ciliata	7.19	6.70	2.96	16.84
	Lindernia crustacea	5.00	8.33	3.13	16.46
0-60-60	*Ageratum houstonianum*	24.79	20.37	26.83	71.99
	Cyperus rotundus	23.93	24.07	21.14	69.14
	Lindernia crustacea	24.36	24.07	14.56	62.99
	Phyllanthus niruri	16.67	16.67	21.21	54.55
	Ruellia nudiflora	5.13	7.41	11.38	23.92
	Acmella repens	2.56	3.70	2.85	9.11
120-60-60	*Lindernia crustacea*	35.27	28.75	32.01	96.03
	Ageratum houstonianum	33.66	25.83	30.46	89.95
	Bacopa procumbens	11.90	11.88	10.58	34.36
	Scleria setuloso-ciliata	4.86	6.25	6.01	17.12
	Cissus verticillata	4.46	7.50	5.11	17.08
In situ	*Lindernia crustacea*	71.09	27.38	37.02	135.50
	Ageratum houstonianum	7.49	16.69	22.66	46.84
	Bacopa procumbens	2.67	8.91	7.52	19.10
	Scleria setuloso-ciliata	6.36	5.51	6.18	18.05
	Desmodium incanum	1.69	5.00	5.96	12.65
Ex situ	*Lindernia crustacea*	63.66	23.34	35.68	122.68
	Scleria setuloso-ciliata	13.76	14.90	25.28	53.95
	Ageratum houstonianum	6.06	13.88	11.77	31.71
	Merremia umbellata	4.85	14.39	6.29	25.52
	Lindernia dubia	3.92	9.29	3.99	17.20

most important species of each treatment and the values of the aforementioned species per month, when they were not among the first-ranked.

C. rotundus displayed high values in the first and last month of the cycle, when competition with other weeds was lower. Doll (1996) affirms that this species is well endowed to compete in early stages of development for nutrients, water and light, since it sprouts and grows more rapidly than most of the cultivable plants. Although its seed has a low germination percentage, it has a wide capacity to propagate vegetatively through rhizomes and tubers, besides, the latter cause allelopathy, and that is the reason why it has been considered the world's worst weed, becoming important for intensive and open-air crops (Vibrans, 2012). A ten-day delay between sowing and first weeding in corn decreased the yield by 19% in Colombia (Cruz and Cárdenas, 1974).

L. crustacea was the species with the highest IVI rate from October, when it showed the highest value in all treatments (from 132.87 to 148.24), to the end of the cycle; it is rarely mentioned as a weed in agricultural production systems and it has only been reported for rice and malanga, since it is adapted to flooded conditions (Kostermans et al., 1987; CABI, 2016), an aspect that favored its presence in all plots studied. In Bangladesh, India, Indonesia, Vietnam and the Philippines it is considered a major problem in rice fields, alongside the roads and in dam croplands (Moody, 1989). In Venezuela, its presence in family orchards has been related to its asexual propagation, which is favored by soil preparation and crop cultivation practices (Gámez-López et al., 2014).

S. setuloso-ciliata also showed a high IVI throughout the cultivation cycle, the greatest value was observed in November in the fertilized plots (58.06 and 61.59). It is reported that this species has a broad distribution in open, humid and marshy areas (Adams et al., 1994), and that it is difficult to control in rice cultivation (Esqueda, 1999), because its leaves have rough, sharp margins, which can be knifelike (Vibrans, 2012); it is appreciated in some traditional systems because it contributes to biomass and improves the soil (Rojas-Chávez, 2012b).

A. houstonianum, a species native to Mexico, Central America and the Caribbean, began to emerge in October and its importance in the sugar cane soil evaluated has increased; it showed the highest values in December. It abounds in fields cultivated with coffee and sugar cane and grows well in humid, sunny or shady places, in pathways and gardens; but this weed is very difficult to eradicate due to its abundance, high resistance and easy dissemination (Villaseñor-Ríos and Espinosa-García, 1998; Ordóñez-Barahona, 2000).

A. repens was found in the sugar cane soil from October to December, its highest values were observed in November; it is considered an occasional weed in irrigation crops and humid places; it is commonly found on the edges of the margins and plots; it blooms throughout the year, but it is more abundant during the rainy season (Rojas-Chávez, 2012a).

The species that showed the highest IVI values in the study corresponded to weeds that grow in humid tropical habitats, similar to those assessed here, whose presence was favored by the period of the year in which the study was carried out, when an appropriate level of moisture saturation predominated in the soil.

Finally, the results of the analysis of the dry weight of the weeds showed statistical differences between the plots with and without crops, highlighting a much lower value in the cultivated areas (Figure 2); nevertheless, the total production, including that of sunn crotalaria, was also significantly higher in the cultivated crops (Figure 3), emphasizing the importance of this species as green manure and weed suppressor (Mansoer et al., 1997; Mosjidis and Wehtje, 2011).

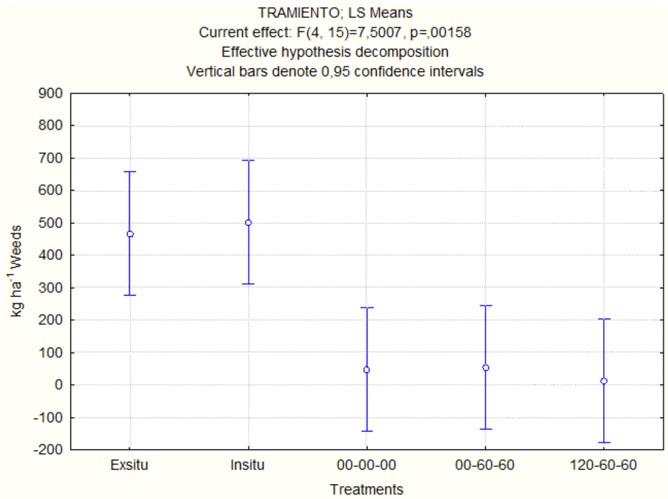

Figure 2 - Behavior of the phytomass of the aerial portion of weeds, in a sugar cane soil cultivated with sunn crotalaria at different doses of fertilizers.

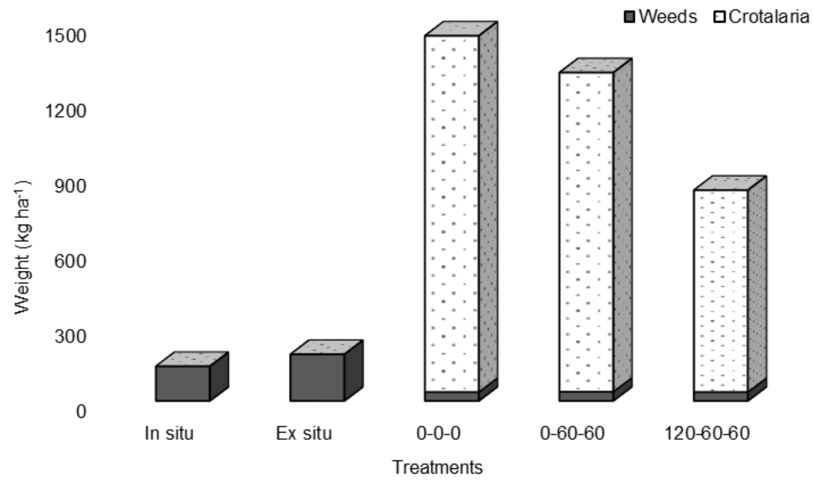

Figure 3 - Phytomass of weeds and sunn crotalaria in in a sugar cane soil treated with different doses of fertilizers.

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