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Characterization of weed flora in a cassava crop in Tabasco

García-López, Eustolia[1]; Magaña-Valenzuela, Wanderley[1]; Obrador-Olán, José J.[1*]; Castelán-Estrada, Mepivoseth[1]; Carrillo-Ávila, Eugenio[2]; Valdez-Balero, Apolonio[1]; Juárez-López, José F.[1]

[1] Colegio de Postgraduados, Campus Tabasco. Periférico Carlos A. Molina km 3.5, H. Cárdenas, Tabasco, México. CP. 86500.

[2] Colegio de Postgraduados, Campus Campeche, Carretera Federal Haltunchén-Edzná km 17.5, Sihochac, Champotón, Campeche, Mexico. CP. 24450.

* Correspondence: obradoro@colpos.mx

ABSTRACT

Objective: To evaluate the effect of the incorporation of *Crotalaria juncea* L. as green manure on the weed community in a cassava crop in Tabasco.

Design/methodology/approach: The study was carried out in the Experimental Field of Colegio de Postgraduados, Campus Tabasco (18° 01' N and 93° 03' W). The samplings were made on four dates: 1) at the planting of crotalaria (12/03/2018); 2) at flowering (31/01/2019); 3) 20 days after incorporation (22/02/2019); 4) at cassava harvest (25/04/2019), using metal squares 50×50 cm. Two planting densities, 50 and 80 cm (16,600 and 10,375 plants ha^{-1}), two doses of NPK fertilization (160-40-80 and 00-40-80+GM), and a control were tested. The name of the species, number of individuals and coverage (percentage) were recorded to calculate the richness (S), Shannon diversity (H') and uniformity (E) indices, and the importance value index (IVI).

Results: The weed community consisted of 32 species, 28 genera and 16 families, of which the best represented are: Convolvulaceae, Asteraceae, Cyperaceae and Poaceae. The most frequently recorded species are *Lindernia crustacea*, *Ludwigia octovalvis*, and *Ageratum houstonianum*. The diversity indices reflected a poor community, especially with GM treatments; diversity ranged from low to medium and uniformity from medium to high. The importance of the families was more related to the environmental conditions than to the treatments; Cyperaceae were more important in the rainy season and Asteraceae in the dry season. *L. crustacea* appeared throughout the cycle.

Limitations/implications: It is advisable to extend the investigation period.

Findings/conclusions: The weed flora consisted of 32 species; the Convolvulaceae family was the most diverse and *L. crustacea* was the most recorded species during the cycle. The diversity indices reflected a poor community. The importance of the families was related to environmental conditions, where Cyperaceae stood out in the rainy season and Asteraceae in the dry season.

Keywords: *Crotalaria juncea*, fertilization, green manure.

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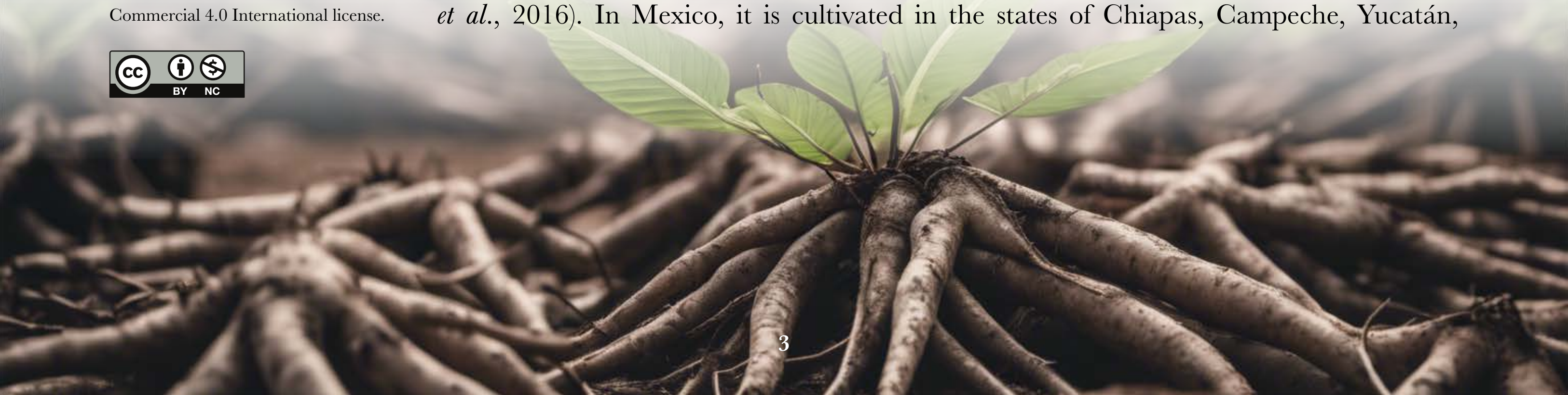
INTRODUCTION

Cassava is one of the most important tropical crops in the world, and it serves as basic food and fodder for animals, in addition to having multiple uses in industry (Pinto-Zevallos *et al.*, 2016). In Mexico, it is cultivated in the states of Chiapas, Campeche, Yucatán,



Oaxaca, Michoacán, Jalisco and Tabasco; the largest surface is reported in the latter, of 1,764 ha (SIAP, 2018). For their part, Rivera-Hernández *et al.* (2012) report that Tabasco has 476,617 hectares with high edaphoclimatic potential for cassava production, whose yield could reach 42.3 t ha^{-1} of fresh roots, which exceeds the averages: state (12.44), national (13.52) and global (10.50). The low yields are attributed mainly to the low fertility of the soil where it is cultivated and the excessive use of chemical products such as fertilizers, pesticides and herbicides (López-López *et al.*, 2018).

On the other hand, competition with weeds decreases the yield of crops, generally in 10%; however, if no control is exerted, it could decrease so much that it could cause the total loss due to competition over light, water and nutrients. In cassava, weed infestation since 15 days after the budbreak of cuttings causes an important decrease in the yield, so it is advisable to control weeds until the plantation has dense foliage, which can take about four months. For weed control, there are different options: cultural, mechanic, chemical or a combination of these. Chemical control is based on the use of herbicides, but its excessive use causes economic losses, environmental damage, and harm to health (Rubiano Rodríguez and Cordero-Cordero, 2019).

This makes sustainable alternatives for the management of this crop necessary, where technologies such as the use of green fertilizers (GF), among others, could allow maintaining or improving their yield and controlling weeds, thus preventing or minimizing the use of agrichemicals (Prager *et al.*, 2012). Legumes used as GF have the ability to improve soil fertility and to fix atmospheric nitrogen. In this context, *Crotalaria juncea* L. germinates and develops quickly, it has a dense growth habit so there can be an impact on weed control, and it reduces the population of nematodes in the soil; in addition, the species fixes atmospheric nitrogen and produces abundant organic matter which contributes N to the system (Skinner *et al.*, 2012). The objective of this study was to evaluate the effect of the cultivation and incorporation of *Crotalaria juncea* L. as green fertilizer, on the weed community in a cassava crop.

MATERIALS AND METHODS

The research was carried out in the Experimental Field of Colegio de Postgraduados, Campus Tabasco, located on Km 21 of the Federal Highway 180 Cárdenas-Coatzacoalcos, in Tabasco, Mexico (18° 01' N - 93° 03' W) from September 2018 to April 2019. The climate is tropical warm-humid with abundant summer rains (Am(g)w") with annual precipitation of 2,342 mm; the mean annual temperature is 26 °C and the soil is a clayey eutric Cambisol (CMeu) (Palma-López *et al.*, 2007).

The weed samples were made using metal squares of 50×50 cm (Mostacedo and Fredericksen, 2000) in four stages: 1) at the time of sowing *Crotalaria juncea* L. (03/12/2018); 2) at flowering (31/01/2019), 3) 20 days after incorporating the GF (22/02/2019); and 4) at the time of harvesting cassava (25/04/2019). Two sowing densities were studied, two fertilization treatments plus a control: 1) C: Control; 2) GF-50: with GF+PK (00-40-80) and 50 cm distance between plants (16,600 plants ha^{-1}); 3) GF-80: with GF+PK (00-40-80) and distance of 80 cm (10,375 plants ha^{-1}); 4) D-50: with doses of NPK fertilizer (160-40-80) and distance of 50; 5) D-80: with NPK fertilizer (160-40-80) and distance of 80 cm.

For each weed species sampled, the name (common and/or scientific) was recorded, the number of individuals, and the percentage of coverage. All the plants that were inside the squares were collected, to be taken to the CSAT Herbarium, where their taxonomic identity was verified through the use of specialized bibliography, a stereoscopic microscope, and verification of botanized specimens. The data were systematized and analyzed in Excel 2007 to calculate the following indices: richness (S), Shannon diversity (H'), uniformity (E) (Magurran, 1988); and the importance value index (IVI), including the absolute and relative values of its components: Density (De, rDe), Frequency (Fr, rFr) and Dominance (Do, rDo) (Concenço *et al.*, 2016).

RESULTS AND DISCUSSION

The floristic list of weeds in the cassava crop included 32 species that were placed in 28 genera and 16 botanical families (Table 1); 26 species are dicotyledonous (81.2%) and similar values were reported by García-Jiménez (2015), Naranjo-Landero (2020) and Obrador-Olán *et al.* (2019) in sugarcane in the same region. The best represented families were: Convolvulaceae with 5 species, and Asteraceae, Cyperaceae and Poaceae with 3 each. It is evident that no previous study had reported Convolvulaceae as the most diverse family in the region; the species sampled in the area have crawling or climbing habit, or both, which eases their development and distribution (Carranza, 2008a, 2008b). Among the species that are most frequently recorded in the cassava crop, there are: *L. crustacea*, which was present in all the samples and treatments, except in C in January and GF-50 in April; it is a typical plant of flooded sites present with the northern winds season (Trópicos, 2019); these conditions also eased the presence of clavillo (*L. octovalvis*), which was practically not found in the sample from the driest month, pincel (*A. houstonianum*) and navajuela (*S. setuloso-ciliata*).

The behavior of richness (S), diversity (H') and uniformity (E) of the weed community in the cassava crop is presented in Figure 1. The number of species (S) presented the lowest values in the first sample, with it being generally higher where complete fertilization was applied, and lower in C; in the last sample all the values decreased, except in C. The diversity (H') varied from low (<1.5) to medium (1.5-3.5), except in C, where it was low during the entire cycle; the highest values were observed where the distance of planting was greater; due to the availability of more surface and light, the weeds developed more vegetative growth (Blanco-Valdez, 2016). In the four treatments, H' decreased at harvesting of the cassava because of a greater development of the crop and the consequent increase of shade, which eventually affected weed growth negatively (Aristizábal *et al.*, 2007).

For its part, the Uniformity (E) tended to increase its value from medium to high in the four treatments, decreasing in the last sample, which highlights its inverse relationship with species richness (Perdomo *et al.*, 2004); in general, the lowest values were seen in C.

Table 2 shows the values of the IVI from the three main weeds by sample and treatment. The species that stood out in the first sample, when the crotalaria was planted, was navajuela, which had the highest IVI in C, where it far exceeded the other species, and in D-50, where it was surpassed in density by *F. dichotoma* which occupied the first

Table 1. Floristic listing of weed species present in a cassava crop, under two densities of plantation and two doses of fertilization, in Tabasco, Mexico.

Family		**Species/sampling * Treatments**		**03/Dec/2018**					**31/Jan/2019**					**22/Feb/2019**					**25/Apr/2019**				
				1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Dicotyledons																							
1	Asteraceae	1	*Acmella repens* (Walter) Rich.						x					x			x	x	x	x	x	x	x
		2	*Ageratum houstonianum* P. Mill.		x	x	x	x	x	x	x	x	x		x	x	x	x					
		3	*Melanthera nivea* (L.) Small					x										x					
2	Capparaceae	4	*Cleome viscosa* L.	x		x		x							x								
3	Convolvulaceae	5	*Ipomoea purpurea* (L.) Roth		x	x	x												x	x	x		x
		6	*Ipomoea trífida* (L.) Lam												x								
		7	*Ipomoea triloba* L.													x		x		x		x	
		8	*Jacquemontia thamnifolia* (L.) Griseb									x			x	x							
		9	*Camonea umbellata* (L.) Simões & Staples								x		x				x	x					
4	Euphorbiaceae	10	*Caperonia palustris* (L.) A. St.-Hill																		x	x	
		11	*Euphorbia hirta* L.			x																	
5	Fabaceae	12	*Crotalaria juncea* L.		x	x				x													
		13	*Mimosa pudica* L.					x				x			x		x		x	x	x	x	x
6	Lamiaceae	14	*Hyptis brevipes* Poit															x					
7	Linderniaceae	15	*Lindernia crustacea* (L.) F.Muell.	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x
		16	*Lindernia dubia* (L.) Pennel.								x		x				x	x					x
8	Loganiaceae	17	*Spigelia anthelmia* L.					x															
9	Lythraceae	18	*Ammannia coccinea* Rottb.,											x					x				
		19	*Cuphea carthagenensis* J.F.Macbr.						x					x	x	x							x
10	Malvaceae	20	*Corchorus orinocensis* Kunth										x										
		21	*Melochia pyramidata* L.				x									x							
11	Molluginaceae	22	*Mollugo verticillata* L.								x	x	x		x	x	x	x					
12	Onagraceae	23	*Ludwigia octovalvis* (Jacq.) P.H. Raven		x	x	x	x		x	x	x	x		x	x	x	x			x		
13	Phyllanthaceae	24	*Phyllanthus niruri* L.			x	x			x	x	x	x					x				x	
		25	*Phyllanthus urinaria* L.			x						x			x	x	x			x	x	x	
14	Scophulariaceae	26	*Bacopa procumbens* (Mill.) Greenm.															x					
Monocotyledons																							
15	Cyperaceae	27	*Cyperus rotundus* L.	x	x	x	x	x									x		x				x
		28	*Fimbristylis dichotoma* (L.) Vahl	x		x	x	x					x										
		29	*Scleria setuloso-ciliata* Boeckeler	x	x	x	x	x	x	x	x		x		x								
16	Poaceae	30	*Echinochloa colona* (L.) Link													x	x	x				x	
		31	*Paspalum fasciculatum* Willd. ex Flüggé										x										
		32	*Paspalum notatum* Flüggé						x	x		x	x										

* Treatments: 1) Control; 2) DB-NPK; 3) DB-PK-AV; 4) DA-NPK; 5) DA-PK-AV.

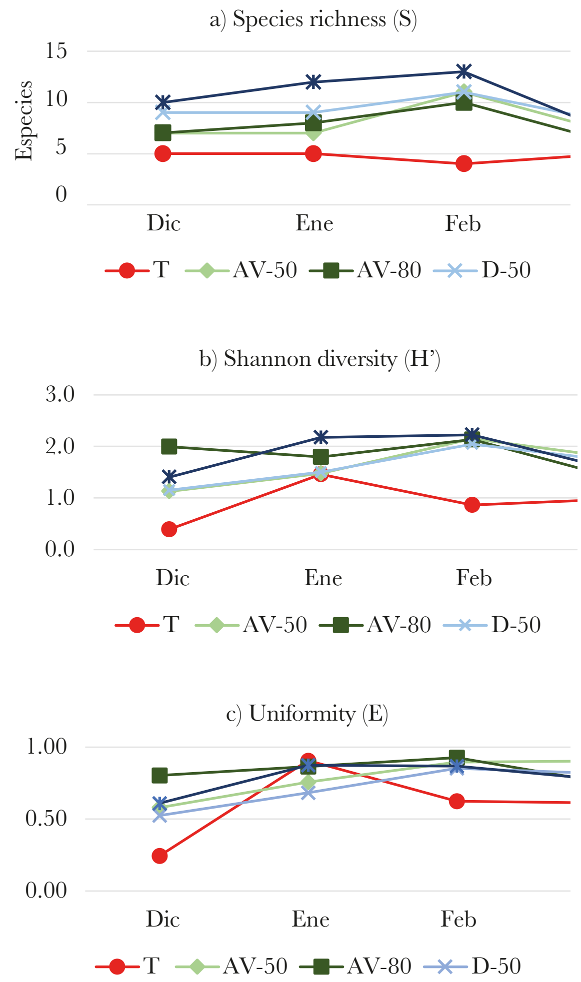


Figure 1. Behavior of: a) richness (S), b) diversity (H') and c) uniformity (E) of weeds in the cassava crop with two fertilization treatments and two planting distances: control (C), GF and 50 cm (GF-50), GF and 80 cm (GF-80), fertilization NPK and 50 cm (D-50), and fertilization NPK and 80 cm (AV-80).

place in GF -80; these and coquillo (*C. rotundus*), which stood out in C, GF-50 and D-80, belong to the Cyperaceae family. The species *L. crustacea* was the main one in GF-50 and D-80. Coquillo is an introduced perennial plant, considered as the most important weed in the tropics, since it has been found in more countries, regions and localities of the world (Torres and Ortiz, 2022). All the plants mentioned before tending to develop well in flooded, swamped soils, stream banks, small lagoons, canals, and fields flooded during the rainy season in the study area (Vibrans, 2009; Rzedowski and Rzedowski, 2008). Campanita (*I. purpurea*), which occupied the second place in GF-80 and third in D-50, has been recorded as weed in at least 25 crops where dense populations that climb over the crops can form, making their harvest difficult (Villaseñor and Espinosa, 1998). Finally, *C. viscosa*, which is characterized by a sticky pubescence and unpleasant smell, was in the second position in C, is native to Asia, although it currently presents a pantropical distribution (Guzmán-Vázquez and Quintanar-Castillo, 2017).

Table 2. Importance value index (IVI) and its components: Relative Density (DeR), Relative Frequency (FR) and Relative Dominance (DoR) of the three main weeds in a cassava crop under two planting densities and two fertilization doses in Tabasco.

Sampling 1 (03-12-2018)					**Sampling 2 (31-01-2019)**				
Name	**DeR**	**FR**	**DoR**	**IVI**	**Name**	**DeR**	**FR**	**DoR**	**IVI**
Control					**Control**				
S. setuloso-ciliata	91.7	44.4	85.8	221.9	*A. repens*	38.6	22.2	23.5	84.3
C. viscosa	3.6	22.2	7.5	33.3	*A. houstonianum*	22.8	22.2	34.1	79.1
C. rotundus	2.4	11.1	4.0	17.5	*S. setuloso-ciliata*	21.1	22.2	15.3	58.6
Green manure-50 cm					**Green manure-50 cm**				
L. crustacea	54.9	37.5	27.9	120.3	*L. crustacea*	48.0	27.9	29.3	105.2
S. setuloso-ciliata	30.9	25.0	43.9	99.7	*C. juncea*	25.2	24.8	23.0	73.0
C. rotundus	3.1	12.5	8.6	24.2	*A. houstonianum*	8.0	13.9	13.2	35.2
Green manure-80 cm					**Green manure-80 cm**				
F. dichotoma	37.5	25.8	37.1	100.4	*L. crustacea*	40.9	20.2	26.5	87.5
I. purpurea	8.1	7.1	28.8	44.1	*L. octavalvis*	13.2	13.0	19.7	45.9
L. crustacea	18.9	14.3	6.4	39.6	*L. dubia*	10.5	16.0	13.9	40.3
Dose-50 cm					**Dose-50 cm**				
S. setuloso-ciliata	25.1	24.2	24.4	73.7	*L. crustacea*	46.6	30.0	26.1	102.7
F. dichotoma	33.1	16.5	20.8	70.4	*A. houstonianum*	20.8	15.8	26.4	63.1
I. purpurea	10.1	20.4	33.1	63.6	*L. octavalvis*	17.8	25.8	18.3	61.9
Dose-80 cm					**Dose-80 cm**				
L. crustacea	50.1	25.0	29.8	104.9	*A. houstonianum*	16.6	17.7	23.0	57.3
C. rotundus	21.8	21.9	25.0	68.7	*C. umbellata*	9.2	15.3	17.1	41.6
S. setuloso-ciliata	10.5	15.6	21.9	48.1	*L. octavalvis*	11.3	17.7	10.8	39.8
Sampling 3 (22-02-2019)					**Sampling 4 (02-04-2019)**				
Control					**Control**				
A. repens	54.7	33.3	57.6	145.6	*A. repens*	67.8	37.5	48.5	153.8
A. coccinea	40.7	33.3	35.9	110.0	*L. crustacea*	10.3	25.0	24.5	59.9
L. crustacea	3.5	22.2	4.0	29.7	*I. purpurea*	16.1	12.5	20.2	48.8
Green manure-50 cm					**Green manure-50 cm**				
A. houstonianum	16.4	10.3	22.7	49.4	*M. pudica*	13.3	13.8	32.2	59.3
I. trifida	13.0	15.5	17.7	46.2	*L. crustacea*	23.9	15.4	18.5	57.8
L. crustacea	19.7	15.3	9.5	44.5	*I. purpurea*	14.3	21.5	16.8	52.6
Green manure-80 cm					**Green manure-80 cm**				
P. urinaria	14.3	18.2	20.2	52.6	*M. pudica*	27.8	28.6	36.1	92.4
A. houstonianum	20.8	13.6	14.5	49.0	*A. repens*	33.9	20.0	31.1	85.0
J. thamnifolia	11.4	18.2	16.2	45.7	*C. palustris*	23.1	24.3	17.9	65.3
Dose-50 cm					**Dose-50 cm**				
C. umbellata	12.2	15.9	21.2	49.3	*A. repens*	38.0	27.4	36.8	102.2
A. repens	22.2	4.2	20.3	46.7	*M. pudica*	28.0	31.0	30.8	89.8
L. dubia	19.8	11.8	13.6	45.2	*I. triloba*	10.0	10.7	14.2	34.9
Dose-80 cm					**Dose-80 cm**				
A. houstonianum	19.1	14.6	45.6	79.3	*A. repens*	34.1	22.2	40.3	96.6
A. repens	15.9	12.5	8.3	36.7	*M. pudica*	34.6	12.5	29.5	76.6
M. verticillata	12.7	14.6	7.3	34.6	*I. purpurea*	11.3	27.8	16.9	56.0

In the sample from January, flowering from the GF, *L. crustacea* was the most important species in the treatments GF-50, GF-80 and D-50. Pincel, an Asteraceae that had the highest IVI in D-80, the second in C and D-50, and the third in GF-50, has a fleeting annual habit that is associated with its great plasticity in the growth form, development speed, great seed production, and efficient use of carbon (Singh *et al.*, 2011). The presence of clavillo (*L. octovalvis*), in the second place in GF-80 and third in D-50 and D-80, tends to be associated to conditions of high moisture in the soil (Vibrans, 2009). Botón de oro (*A. repens*), the one with highest IVI in C, is also an Asteraceae, family of invaders because they are very efficient in the use of resources and due to their plasticity in terms of development and seed production (García-López, 1990). Bejuco (*C. umbellata*), which occupied the second place in D-80, is a Convulvulaceae that due to its climbing habit tends to cause problems in the harvest of several tropical crops; crotalaria occupied the second place in GF-50, while navajuela and *L. dubia*, species that is quite close to *L. crustacea*, had the third place in C and GF-80, respectively.

In the sample from February 22, a month after the incorporation of the GF, a better development of pincel was noted; it had the highest IVI in GF-50 and D-80, and the second in GF-80; and botón de oro, which appeared again with the highest IVI in C and second place in D-50 and D-80, although in D-50 it exceeded bejuco in density. The species of *Lindernia* appeared in third place: *L. crustacea* in C and GF-50, which in the latter had the highest value in density, while in D-50, *L. dubia* exceeded botón de oro in frequency. *P. urinaria* was the most important in GF-80, it is originally from Asia, and high contents of N have been found in it, particularly in buds of plants under shade conditions, with a positive correlation observed with soils with good content of that element (Dogra *et al.*, 1978). In the second site in the control plot, *A. coccinea* was found, which has been reported as a very aggressive weed in rice crops in many countries and apparently is dispersed by mixing with the crop's seed (Graham, 1991). *I. trífida* occupied the second place in GF-50, although it surpassed pincel in frequency, which was also surpassed in frequency and dominance by *J. tamnifolia* in GF-80, where it occupied the third place; the advantage of the two Convulvulaceae is that they have crawling and voluble growth habit, which gives them the capacity of climbing over other plants and extending over the ground, so that one or a few individuals can cover important surfaces (Carranza, 2008a, 2008b). Finally, although *M. verticillata* had third place in D-80 and exceeded botón de oro in frequency, it is a species of undefined origin, although with a wide distribution area and has been reported as weed in corn, sugarcane, rice, bean and tomato (Ocampo-Acosta, 2002; Villaseñor and Espinosa, 1998).

For the month of April, just before the cassava harvest, botón de oro was the most important species in C, D-50 and D-80, and the second one in GF-80. By this date, the presence of dormilona (*M. pudica*) also stood out, which presented the highest IVI in the two plots with GF, and occupied the second position in the two fertilized; it is a dangerous weed because its stems are protected by spines of up to 7 mm and a wide base, which tends to form dense populations reducing the impact of light on the ground level, so many plants do not manage to persist and form monospecific shrubs (Witt *et al.*, 2020). *L. crustacea* was found in the second place in the C and GF-50 plots, campanita was found occupying the third place in the same ones and in D-80, *I. triloba* in D-50, and *C. palustris* in GF-80, which is reported as annual and perennial. Koger *et al.* (2004) point out that a plant produces ±900 seeds with 90% viability; the seeds germinate at between 30 and 40 °C but not under flooding, although the seedlings can survive to it for several weeks.

In general, the presence or importance of the species with the highest IVI do not seem to be related to the type of fertilization or the density of cassava plants, but rather with the environmental conditions associated to the region's climate. In this sense, Cyperaceae stood out in the first sampling: navajuela, coquillo and *F. dichotoma*, when the soil remained mostly flooded. Of the Asteraceae, pincel was very important in the January and February samples, and although it appears in January, botón de oro stood out in February and April, as the soil was becoming drier; the fleeting annual habit of this group is associated with its huge plasticity when it comes to its growth form, flowering speed, and high seed production, which is related to the efficient use of carbon and the development of competitive strategies such as the increase in biomass and relative growth rate (García-López, 1990). Dormilona was notable in February and April, its presence also coinciding with the decrease in soil moisture. Instead, the importance of clavillo was concentrated in the month of January, and *L. crustacea* stood out during the entire cycle.

CONCLUSIONS

The community of weeds in this study consisted of 32 species, 28 genera and 16 families, and the most represented were Convolvulaceae, Asteraceae, Cyperaceae and Poaceae. The most frequent species in the samples were *Lindernia crustacea*, *Ludwigia octovalvis* (clavillo) and *Ageratum houstonianum* (pincel). The diversity indices reflect a poor community. The lowest richness was found in the Control during the entire cycle, increasing in the treatments with lower cassava density and incorporation of Green Fertilizer. The treatments with Green Fertilizer were poorer in weeds than the treatments with fertilizers. The diversity varied from low to medium, being highest in the treatments with lowest density of plantation; in the Control it was low during the entire cultivation cycle. The uniformity varied from medium to high. The abundance of weeds was more related with environmental conditions than with the density of cultivation and fertilization. The Cyperaceae were more important in the first two samples, which coincide with the rainy season, while the Asteraceae and *Mimosa púdica* (dormilona) stood out from January to April, when the soil was drier. *Lindernia crustacea* was present during the entire cultivation cycle.

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