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Weeds Associated with a *Sisal* Crop (*Agave fourcroydes* Lem.) in the State of Yucatan, Mexico

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Abstract

The objective of this study was to know the weed species associated with a sisal crop (*Agave fourcroydes*) in the State of Yucatán, Mexico. In this sense, best weed control management strategies can be proposed to sisal producers. The weed collection was carried out in a three years old sisal crop. For the taxonomic identification images of the adult plant with flowers, fruits and seeds were taken, supported by a herbarium. The Importance Value Index (IVI) showed 23 predominate species, 78.26% with broad-leaves and 21.74% with narrow-leaves. The most predominant species were: *Melanthera nivea* (Asteraceae), *Dactyloctenium aegyptium* (Poaceae) and *Malvastrum corchorifolium* (Malvaceae) with the higher IVI's, with 61.1%, 46.6% and 37.2% respectively. The presence of weeds represents a significant increase in the production costs of sisal production; so its identification is essential for an effective weed management program.

Subject Areas

Agricultural Engineering

Keywords

Host Weeds, Identification, Weed Taxonomy, Noxious Weeds

1. Introduction

Sisal (*Agave fourcroydes* Lem.) is a crop well adapted to areas with medium and low rainfall and stony soils, such as the north-central region of the state of Yucatán, Mexico. It is considered a low investment crop because producers use very

few agrochemicals. However, before harvesting, maintenance activities are important to keep maximum fiber yields. Control of weeds, especially in the rainy season, can avoid delays in the time of cutting, reduction of the quantity and length of leaves emitted per year, as well as the quantity and length of the fiber.

Without weeds competition, number of leaves increases with a direct influence on fiber yield [1]. Avilés-Baeza and Santamaría-Basulto (1996) [2] suggested that weeds can affect the quality of leaves by reducing rate of emission (48%), length (33.2%), width (45.6%) and Leaf Area (64.2%) during three years.

In this sense, various authors have documented the negative effect of weeds on sisal crop [3] as a result of competition for nutrients, soil, water and light or by harmful substances released to the crop [4] [5] [6] [7] [8].

Weeds have the advantage of being more efficient since they group various species, with different needs and abilities and a non-uniform spatial distribution [9]. They can explore more efficiently the environment in search for the essential factors [10] [11].

According to Oerke, 2006 [12], weeds and crops have similar needs for carbon dioxide and nitrogen from the atmosphere and water and minerals from the soil, but when competition starts, weeds are more efficient and the crop yield is reduced [13].

Producers are very cautious to avoid yield losses [14]. And they use different methods to control weeds such as: mechanical cutting, application of herbicides and burning. Slashing is a conventional practice carried out carefully since in the process the roots or trunks can be damaged favoring the incidence of pathogens [15] [16].

Paraquat is the herbicides commonly used by farmers [17], as well as *glyphosate*, a non-selective, broad-spectrum systemic herbicide widely used to control annual and perennial weeds [18]. Both herbicides are to be used more than one time [19].

Regardless of the method of control it is compulsory to know the bio-ecological characteristics of the species and their interactions with crops. The objective of this study was to determine the dominant weed species and their specific diversity in competition with the *Sisal* crop [13].

2. Materials

2.1. Location

This study was carried out from October to December, 2022 in the facilities of the factory Sisal Tejidos SA of CV in the municipality of Motul, Yucatan, Mexico located at 21˚05'49.51" north latitude and 89˚18'28.48" west longitude at 10 meters above sea level. Soils are classified as *Tzekel lu'um* in the Mayan terminology and *lytic Leptosol* in the World Reference Base (WRB) [20].

2.2. Taxonomic Identification

For the taxonomic identification of weeds, images and live adult plants with

flowers, fruits and seeds were taken and compared with botanical information from different Mexican Institutions such as: The National Commission for the Knowledge and Use of the Land, National Commission for the Knowledge and Use of Biodiversity (CONABIO, http://www.conabio.gob.mx/malezasdemexico/2inicio/paginas/lista-plantas.htm), the Scientific Research Center of Yucatan (CICY, http://www.cicy.mx/sitios/flora%20digital/index.php) and the National Herbarium of Mexico of the National Autonomous University of Mexico (MEXU, http://www.ib.unam.mx/botanica/herbario/).

3. Methods

Weed Collection

In order to identify and quantify weed population associated to *Sisal*, a plot of 1.0 hectare of a three years old local variety of *Sisal* was selected. A simple sampling model of weeds was implemented, using twelve squares of 1.0 m^2 (1.0 × 1.0 m) randomly located between rows of the crop. Frequency of appearance, abundance and dominance of each species were recorded and the Importance Value Index (IVI) of each weed was calculated adapting the methodology described by Gámez López *et al.* (2011) [21].

The Importance Value Index (IVI) was developed by Curtis & McIntosh (1951) [22]. It is a synthetic structural index, developed mainly to rank the dominance of each species in mixed stands. It was calculated as follows: IVI = Relative dominance (*a*) + Relative density (*b*) + Relative frequency (*c*) [23].

According to Campo and Duval (2014) [24], these three parameters are calculated as follows:

$$(a)\quad \text{Relative dominance} = \frac{\text{Dominance of each species}}{\text{Dominance of all species}} \times 100$$

$$(b)\quad \text{Relative Density} = \frac{\text{Number of individuals of each species}}{\text{Total Number of individuals}} \times 100$$

$$(c)\quad \text{Relative frecuency} = \frac{\text{Frequency of each species}}{\text{Frequency of all species}} \times 100$$

4. Results

Weed Species Found and the Importance Value Index (IVI).

The 23 weed species found on the henequen plot are described in **Table 1** considering: common names according to different countries and regions, scientific names, botanical behaviors (A = Annual; B = Biannual; D = Dicot; M = Monocot; P = Perennial), geographical distribution and impact on agriculture crops.

The Importance Value Index (IVI) of each species are shown in **Figure 1** and the results are showing the presence of twenty-three species of weeds one week before planting Henequen: *Melanthera nivea*, *Dactyloctenium aegyptium*, *Malvastrum corchorifolium*, *Rynchelitrum repens*, *Megathyrsus maximus*, *Bidens pilosa*, *Crotalaria pumila*, *Piscidia piscipula*, *Chamaecrista nictitans*, *Melochia*

Table 1. Characteristics of the predominant weed species associated with *Sisal* (*Agave fourcroydes*).

Family	Scientific name	Common name	*Botanical behavior	Habitat	Impact	Reference
Asteraceae	*Melanthera nivea* (*L.*) *Small*	Pineland squarestem, Snow squarestem (USA), Yerba de cabra, (MEXICO), Botón blanco (GUATEMALA), Dog Bush (TRINIDAD & TOBAGO), Romerillo cimarron (CUBA), Clavel blanco (DOMINICAN REPUBLIC), Cariaquillo blanco, Salaillo, Yerba de cabra (PUERTO RICO) Toplan xiiw, Sak sooj, Sak sajum, Soot'kay, Ts'aan top'an xiiw (MAYAN LANGUAGE-MEXICO).	P D	Medium Subevergreen Forest, Medium Subdeciduous Forest, Low Deciduous Forest, Coastal Dune Shrub.	Attracts butterflies and other insects due to its high-quality nectar. It is a host plant for the lepidopteran *Chlosyne hippodrome*. It can also be used as fodder.	[25] [26] [27] [28] [29] [30] [31]
Poacea	*Dactyloctenium aegyptium*	Pata de pollo, Pata de gallo, Zacate egipcio (MEXICO), Chimes-suuk, k'an Toop su'uk (MAYAN LANGUAGE-MEXICO), Egyptian grass, Crowfoot grass, Beach wiregrass (USA), Katikuti (JAPAN)	A M	Semi-arid, temperate, tropical, sub-tropical and humid regions including Coastal dunes.	It is considered a highly invasive weed, affecting 19 crops in 45 countries.	[32] [33] [34] [35]
Malvaceae	*Malvastrum corchorifolium*	False mallow (USA), Sak xiiw (MAYAN LANGUAGE-MEXICO).	P D	Low and medium deciduous forest.	No reference was found	[36]
Poaceae	*Rynchelitrum repens*	Pasto rosado, Hierba de la lana, Pasto carretero, (MEXICO), Natal grass, Natal redtop (USA)	P M	Low Deciduous Forest, Shrubland and savannas.	No reference was found	[37] [38] [39] [40] [41]
Poacea	*Megathyrsus maximus*	Pasto guineo (MEXICO), Pasto saboya (ECUADOR), Yerba de guinea, Guinea grass (USA)	P M	It is an African native species currently distributed and naturalized in tropical and subtropical regions, adapted to medium and high fertility soils.	It develops successfully in a wide variety of well-drained and humid soils, being tolerant to shading. Due to these characteristics, it is capable of reproducing successfully in competition with various crops. It has been documented as an important weed affecting all crops around the world.	[42]

Continued

Asteraceae	*Bidens pilosa*	k'an tumbuub (MAYAN LANGUAGE-MEXICO), Romerillo blanco Beggar tick, Black Jack, Spanish needles, Hairy beggarticks (USA), Cadillo rocero (VENEZUELA), Amor seco (PERU), Daun jin zhan yin pan (CHINA), Picão, picão-preto, carrapicho, shilco o Pega pega (BRASIL)	P D	It has a presence in all tropical and subtropical regions of the world.	It is an alternative host to common insect pests during the low crop growing season.	[43] [44] [45] [46] [47] [48]
Fabaceae	*Crotalaria pumila*	Chipilín, Crotalarias, Garbancilla, Tronadora, Hierba del cuervo, Sonadora (MEXICO), Low rattlebox, Small rattle pod (USA)	A D	Deciduous and evergreen tropical forest, but also in pine-oak forest, grasslands, drainage channels and abandoned lots.	It has a mainly edible use cultivated for self-consumption, although can be traded regionally.	[49]
Fabaceae	*Piscidia piscipula*	Jabín (MEXICO) Barbasco, Palo de agua, Chijol, Fish-poison-tree (USA), Fishfuddle, Dogwood (JAMAICA), Guamá (CUBA)	A D	In Mexico it is found in the states of Tamaulipas, Veracruz, Campeche, Yucatán, Quintana Roo, Chiapas, Oaxaca, Guerrero, Michoacán, Colima, Jalisco and Nayarit. It is also found in Florida and in several Caribbean islands.	No reference was found	[50]
Fabaceae	*Chamaecrista nictitans*	Tamarindillo, Tamarindo, Cabal tamarindo, Kabal tamarindo (MEXICO), Xiiw, x'aax (MAYAN LANGUAGE-MEXICO).	A D	Coastal dunes and high forest.	No reference was found	[51]

Continued

Malvaceae	*Melochia pyramidata*	Malva común, Malva cimarrona (CUBA), Bretónica (PUERTO RICO), Coralillo, Escobilla colorada, Escobilla morada (GUATEMALA), Escobilla amarilla, Escobilla guinar, Malva de los cerros, Malvavisco (MEXICO), Chichibé (YUCATAN-MEXICO), Suponite (OAXACA-MEXICO) Chi'chi'bej, chack ch'ooben, sak chi'chi'bej (MAYAN LANGUAGE-MEXICO) Pyramid flower, Angelpod melochia, Broomwood (INDIA)	A D	Medium subevergreen forest, Low deciduous forest, evergreen and deciduous tropical forest.	Reported as host of begomovirus	[52] [53]
Nyctaginaceae	*Boerthavia erecta*	Hierba blanca (MEXICO), Anisillo, escorián, Golondrina (CHIAPAS-MEXICO), Hierba del arlomo, Maravillita, Sanguinaria, Zanca de gallo, Tostón (CUBA), Erect spiderling (USA)	A D	It is originally from the United States, Mexico, Central America and Western South America. It is reported as a cosmopolitan weed in tropical and subtropical regions of the world.	It is reported as a host of whitefly nymphs and viruses.	[54] [55]
Asteraceae	*Cyanthillium cinereum*	Venadillo, Pequeña hierba de hierro, Yerba morada (MEXICO) Little ironweed (USA), Rabo de buey, Yerba socialista (PUERTO RICO)	A D	Tropical areas.	No reference was found	[55]

Continued

Acanthaceae	*Elytraria imbricata*	Purple scalystem (USA); Cola de alacrán, Cordoncillo, Pata de pollo, Pie de gallo, Riendilla (MEXICO; Mabal-xan (MAYAN LANGUAGE-MEXICO).	A P	It is found mainly in arid areas, low deciduous and high evergreen forest, sometimes reaching the pine-oak of temperate zones.	In Michoacán, Nayarit and Yucatán in Mexico, this species is commonly used to cure diarrhea; More information can be found in the page of the Digital Library of Traditional Mexican Medicine of UNAM. As for Mexico, it has been listed several uses such as medicine or fresh water in Sonora. In Culiacán for livestock fodder. Tea in Baja California to treat fever and urinary problems.	[56] [57]
Commelinaceae	*Commelina erecta*	Espuelitas, Hierba del pollo, Mataliste, hierba de Santa Lucía (ARGENTINA); Pah-tsá, X-habul-ha y yáax-ha-xiu, paj ts'a (MAYAN LANGUAGE-MEXICO); Erect dayflower, Whitemouth dayflower, Widow's tears (USA); Flor de la virgen, Hierba de lluvia (MEXICO); Nuub en nuub ojo, corrimiento xiiw (MAYAN LANGUAGE-MEXICO).	P M	No reference was found.	It is reported as a weed in rice, coffee, sugar cane, citrus, ornamental plants and banana (Villaseñor and Espinosa, 1998). It is not normally a worrying weed, but since it is not very susceptible to glyphosate, can become a problem in conservation tillage agriculture.	[58] [59] [60] [61]
Poaceae	*Cynodon dactilon*	Bermuda grass, devilgrass (USA); Bramilla, grama, gramilla, zacate agrarista, zacate Bermuda, zacate pata de gallo, Bermuda de la costa, Grama de la costa, Zacate borrego, Gallitos, Grama de bermuda, Pata de perdiz (MEXICO); Zacate conejo (CHIHUAHUA-MEXICO); acacahuiztli (NAHUATL-LANGUAGE-MEXICO), kan-suuk (MAYAN LANGUAGE-MEXICO); guixi-biguiñi, guixi-guitoo, guixi-piguiñe (ZAPOTECO-LANGUAGE-MEXICO)	P M	No reference was found.	It is the host of the nematode *Meloidogyne incognita.*	[62]

Continued

Convolvulaceae	*Ipomoea nil*	Campanilla, Enredadera, Bejuco, Porotillo (MEXICO); Whiteedge morningglory, Japanese morningglory, Blue morningglory (USA); Bejuco (ARGENTINA); Corriola, Corda-de-viola (BRASIL); Ke'elil, Tso'otsk'abil (MAYAN LANGUAGE-MEXICO).	A D	No reference was found	It is a vine growing along roads and highways, covering the host trees. It is a weed in fruit trees, corn, cactus and sorghum. In Argentina it is an important weed in cotton, soybeans, corn and other grains.	[63] [64] [65] [66]
Euphorbiaceae	*Tragia yucatanensis*	P'oop'ox (MAYAN LANGUAGE-MEXICO).	P D	Medium subdeciduous Forest and Low deciduous Forest.	It causes painful irritations in the skin.	[67] [68]
Euphorbiaceae	*Euphorbia cyathophora*	Jobon xiiw, jobon k'aak (MAYAN LANGUAGE-MEXICO). Dwarf poinsettia (USA)	A D	Low deciduous forest and costal dunes.	No reference was found	[69]
Gynandropsis	*Gynandropsis gynandra*	Hierba del zorrillo (MEXICO); barbana xiiw, tu' xiiw (MAYAN LANGUAGE-MEXICO); Maman (MALAYSIA).	A	Scattered in tropical and sub-tropical regions of the world.	It is considered as a medicinal plant, growing in many tropical countries and cultivated as a native leafy vegetable. It is widely used in several countries of asia, Africa, North and Central America. As a remedy against headache, neuralgia, cough, wounds and irritations. The medicinal or healing properties are due to bioactive components, such as phenolic and flavonoids compounds.	[70] [71]
Malvaceae	*Sida acuta*	Ironweed (India); Vavalisin de Filipinas (PHILIPPINES); malva del Brasil (BRASIL); Malva de caballo (CUBA); Ancoacha del Perú, pickna del Perú (PERU); Broom grass, Broom weed, Common wireweed (USA).	A y P D	It is commonly found in improved grasslands and disturbed places.	It is reported as a natural reservoir of geminivirus.	[72] [73] [74]

Continued

Malvaceae	*Corchorus siliquosus*	Chichibe, chichivo, chi' chi' begmalva con vaina (CAMPECHE-MEXICO); Malvilla, Malvilla de platanillo, alahuao-xipahuas (PUEBLA-MEXICO); Chichibe (QUINTANA ROO-MEXICO); Malva, Malvavisco blanco (TABASCO-MEXICO); Escobilla blanca, Malva de castilla, Malva de platanillo, malva de puerco (VERACRUZ-MEXICO); Chichibe, Putschichibe (MAYAN LANGUAGE-MEXICO); malva té, té de la tierra (CUBA); Escobillo (GUATEMALA); Té de perla, Té de monte (EL SALVADOR); Escobilla, Té (PANAMA); Escoba blanca, Malva té (PUERTO RICO); Brusca dulce, Escoba, Malva té, Balai glisse, Balai lalo, Guimauve à petites fleurs, lalo, Petit lalo, Tilalo (DOMINICAN REPUBLIC AND HAITI).	A D	Scattered throughout the tropical and subtropical regions of the world.	It is a natural reservoir of geminivirus.	[75]
Convolvulaceae	*Distimake aegyptius*	campanilla trompillo (MEXICO); tso' ots' aak', tsots-ak' (MAYAN LANGUAGE-MEXICO).	A	pantropic	No reference was found	[76]
Boraginaceae	*Heliotropium curassavicum*	Alacrancillo de playa (YUCATAN-MEXICO); Cola de alacrán, Cola de mico, Hediondilla, Heliotropo cimarrón, Rabo de mico (MEXICO); tso' ots' aak' (MAYAN LANGUAGE-MEXICO) Wild heliotrope, Chinese pusley, seaside heliotrope, white-weed, devil-weed, alkali heliotrope (USA); Cresta de gallo (BRASIL); Jaboncillo, cola de alacrán (CHILE); Doble gama, Cola de gama (ARGENTINA).	A Y P D	No reference was found	Highly toxic plant.	[77] [78]

*A = annual; D = dicot; M = monocot; P = perennial.

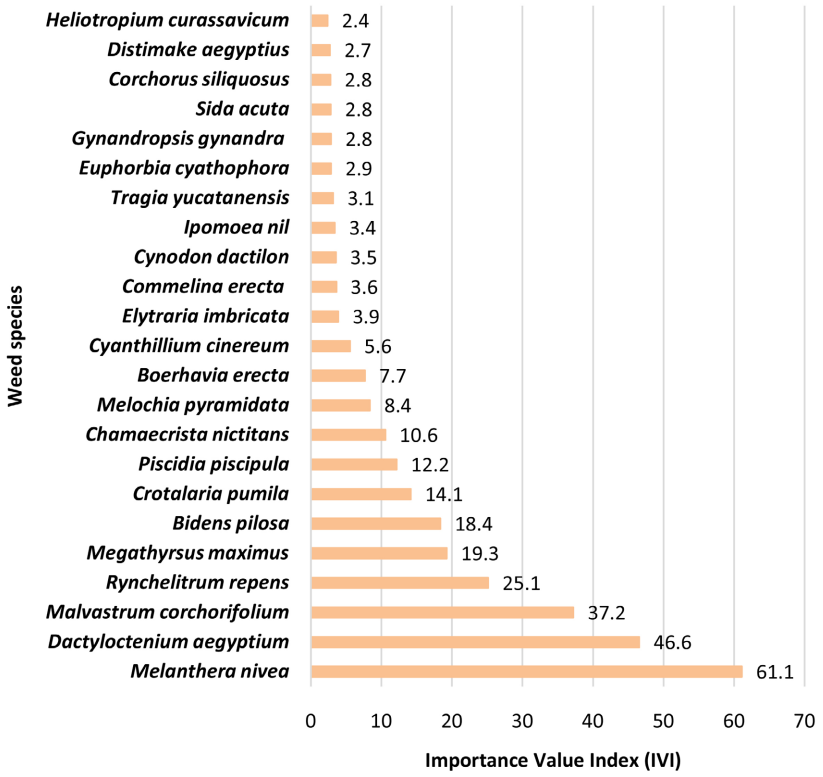

Figure 1. Importance Value Index (IVI) of weeds associated to *Sisal* crop.

pyramidata, *Boerhavia erecta*, *Cyanthillium cinereum*, *Elytraria imbricata*, *Commelina erecta*, *Cynodon dactilon*, *Ipomoea nil*, *Tragia yucatanensis*, *Euphorbia cyathophora*, *Gynandropsis gynandra*, *Sida acuta*, *Corchorus siliquosus*, *Distimake aegyptius*, *Heliotropium curassavicum.*

Of the total species, 78.26% were broad-leaved and 21.74% narrow-leaved. The species *Melanthera nivea* (Asteraceae), *Dactyloctenium aegyptium* (Poaceae) and *Malvastrum corchorifolium* (Malvaceae) were the most predominant ones with the highest IVI's with 61.1%, 46.6%, and 37.2% respectively.

5. Discussion

According to Poggio (2012) [14], the specific impacts of agricultural practices, as well as the crop dominance during its growth period, influence the presence of weeds through changes in flowing materials, energy and information. These changes modify both the diversity and species composition of weed communities and their abundance (biomass and density of individuals).

As was observed in this research, broad-leaved species predominated over narrow-leaved species. This could be related to the type of soils on which the *Sisal* crop is established, in the state of Yucatán, and the months of lower temperaturas and rainfall (October to December).

This crop adapts well to stony soils of the north-central region of the state where agricultural machinery is omitted and in consequence weed seed dispersal is limited. In contrast, the weed species found such as: *Cyperus ligularis* (Cype-

raceae), and *Megathyrsus maximus* (Poacea) [79], were not so abundant in the South of the state where agricultural machinery is highly used.

The weed species most associated to *Sisal* was *Melanthera nivea* (Asteraceae). However, it is a protecting plant for beneficial insects [80] such as butterflies and other insects attracted by its nectar for honey production [25]-[31]. Therefore, for future research or decision-making, it would be important to consider the advantage or disadvantage that this plant may have in agricultural production systems.

The three botanical families identified, (*Asteracea*, *Poaceae* and *Malvaceae*) are among the most important botanical families of weeds in Mexico, according to the Catalog of Weeds of Mexico [60].

6. Conclusions

Weeds are considered a problem when they affect a crop, due to their invasive action and high level of competition for resources. They can behave as hosts for pests and diseases. Identification of weeds can contribute to better control management in a more sustainable way. In fact, knowledge of weed communities associated with a specific crop, as well as the importance value index (IVI) of each one, allows a more precise selection of an effective control measures, especially when chemical control is used. In this study of weed species associated with a sisal crop, the following is concluded:

1) Twenty-three species of weeds were found associated to Sisal crop: *Melanthera nivea*, *Dactyloctenium aegyptium*, *Malvastrum corchorifolium*, *Rynchelitrum repens*, *Megathyrsus maximus*, *Bidens pilosa*, *Crotalaria pumila*, *Piscidia piscipula*, *Chamaecrista nictitans*, *Melochia pyramidata*, *Boerhavia erecta*, *Cyanthillium cinereum*, *Elytraria imbricata*, *Commelina erecta*, *Cynodon dactilon*, *Ipomoea nil*, *Tragia yucatanensis*, *Euphorbia cyathophora*, *Gynandropsis gynandra*, *Sida acuta*, *Corchorus siliquosus*, *Distimake aegyptius*, *Heliotropium curassavicum.*

2) From the total amount of species found, 78.26% were classified as broad-leaved and 21.74% as narrow-leaved.

3) *Melanthera nivea* (Asteraceae), *Dactyloctenium aegyptium* (Poaceae) and *Malvastrum corchorifolium* (Malvaceae) were the most important species, according to their highest IVI values: 61.1%, 46.6% and 37.2%, respectively.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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