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EVALUATION OF ORGANIC SOLUTIONS IN SUSTAINABLE BANANA (MUSA BALBISIANA COLLA) AGRICULTURE AS AN ALTERNATIVE TO GLYPHOSATE

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Abstract: Plantain (*Musa balbisiana* Colla) is a significant economic resource in the agriculture of Michoacán and Jalisco, and represents an important traditional export product. This study aims to evaluate the biological efficacy of organic products as sustainable alternatives to glyphosate for weed control in plantain (*Musa balbisiana* Colla). The experiment was conducted in a commercial plantain orchard in Coahuayana de Hidalgo, Michoacán, using a randomized complete block design with seven treatments and four replications. The treatments evaluated included mixtures based on carboxylic acid, polyether polymethylsiloxane copolymer and mannitol in different concentrations, Datura stramonium extract, allelopathic extracts of plants of the agavaceae family, glyphosate in different doses, and an absolute control. The results showed that treatment 4 was the most effective in controlling broadleaf and narrowleaf weeds in the plantain crop. In addition, none of the treatments applied postemergence to the weeds caused phytotoxic damage to the crop.
Keywords: alternative, bioherbicide, weed.

INTRODUCTION

Plantain *(Musa balbisiana* Colla) is a crucial economic component of agriculture in Michoacán and Jalisco, and is a significant traditional export product. Its production and marketing generate employment, foreign exchange earnings and, in general, contribute to the socioeconomic well-being of the national economy ("Made in Mexico" plantain production increases seven percent, 2022).

One of the factors that negatively affects the banana crop is the presence of weeds, which compete for essential resources such as water, light and nutrients. The better adaptability of weeds to the environment can cause losses of up to 46% in production (Plaza, 2012).

In 2020, the Official Journal of the Federation (DOF) published a decree that establishes the actions to be followed by the agencies and entities of the Federal Public Administration to gradually replace the use, acquisition, distribution, promotion and importation of glyphosate and agrochemicals containing glyphosate with sustainable and culturally appropriate alternatives. These alternatives must maintain production and be safe for human health, the country's biocultural diversity and the environment.

In Mexico, glyphosate is the main active ingredient used to control weeds. However, this molecule is causing damage to the environment and human health. For this reason, the objective of this study was to evaluate different herbicides to identify alternatives that could replace glyphosate in chemical weed control in banana crops in production areas.

MATERIALS AND METHODS

The work was established in the locality of El Camalote in the municipality of Coahuayana, Michoacán, where a plantain plantation (*Musa balbisiana* Colla) is established. The planting frame of the crop is 3 meters between rows or furrows and 1.5 meters between plants, with a density of 2,200 plants/ha. The weeds present in the experimental site were identified by differentiating between narrow-leaf weeds and broad-leaf weeds and identifying their life cycle. Four treatments (Table I) of organic compounds based on saponins and polymeric nanoparticles were evaluated with different doses of bioherbicide mixture. The mixture doses used were 80, 100, 150 and 115ml/L of the organic compounds; treatment 5 corresponded to the absolute control; treatment 6 to the herbicide with the active ingredient glyphosate 10ml/L and treatment 7 to the organic herbicide based on *Datura stramonium* and allelopathic extracts of different plants 15ml/L.

TREATMENTS	CONTENTS	DOSAGE ml/L
T1	Organic compound 1	80 ml
T2	Organic compound 2	100 ml
T3	Organic compound 3	150 ml
T4	Organic compound 4	115 ml
T5	Absolute witness	0
T6	Glyphosate	10 ml
T7	*Datura estramonium* extract, allelopathic plant extracts	15 ml

Table 1.- Description of treatments of the experiment to evaluate organic compounds for weed control in banana (*Musa Balbisiana* Colla).

A randomized block experimental design with four replications was used. The experimental plots consisted of 3 meter furrows and 1.5 meters between plants. Herbicides were applied on April 6 and May 22, 2022 with a Truper manual sprayer with an adjustable nozzle and a capacity of 2 liters. At the time of application, the weeds had an average height of 15 cm throughout the experiment. A sample of the plants present was previously collected and placed in a wooden press for their conservation and classification according to family and genus (Brenes and Agüero, 2007). The variables evaluated were: narrow-leaf cover (%), broad-leaf cover (%), total cover (%) at 26 DDA. The methodology used was according to (Esqueda and Tosky, 2013). A factorial ANOVA test in completely randomized blocks associated with the Tukey mean comparison test ($p<0.05$) was used to determine the effect of the treatments.

RESULTS AND DISCUSSION

WEED IDENTIFICATION

Twenty-two weed species belonging to 9 families were identified, among which there was a greater abundance of 9 narrow-leaved species (Table 2) with 41% of the area and 13 broad-leaved species with the remaining 59%.

Angosta wood			
Family	**Scientific name**	**Common name**	**Life Cycle**
Poaceae	*Echinocloa colona*	Zacate pinto	Annual
Poaceae	*Rottboellia cochinchinensis*	Caminadora	Perennial
Poaceae	*Eleusine indica*	Pata de galinha	Annual
Poaceae	*Sorghum halepense*	Zacate Johnson	Perennial
Poaceae	*Cynodon dactylon*	Grama	Perennial
Poaceae	*Digitaría velutina*		Perennial
Poaceae	*Panicum maximum*	Zacate guinea	Perennial
Poaceae	*Dactyloctenium aegyptium*	Pata de gallo	Annual

Table 2.- Narrow-leafed weeds identified

Narrow blade

The species identified were: 1) Zacate pinto (*Echinocloa colona*), Annual grass, it grows in humid and flooded places, very tough. Flat leaves, with glabrous sheaths, sometimes purple. It is easily distinguished from other grasses because it has no ligule; 2) Walker (*Rottbolelia cochinchinensis*), is an erect annual grass with vigorous growth, has vigorous adventitious roots, can reach a height of up to 4 m or more. The leaves are linear in shape, with pubescence on both sides, wide and open sheath, bulging lower part of the midrib; 3) Pata de gallo (*Eleusine indica*), annual grass, with canes generally branched from the base, decumbent and radicant at the lower nodes, very compressed, 30 to 50 cm high; 4) Zacate Johnson (*Sorghum halepense*), perennial grass up to 2 m high, with long rhizomes. Pods rounded to flattened. Convolute prefoliation. Blades 50 cm long and with cutting edge. Terminal panicles lax and pyramidal; 5) Grama (*Cynodon dactylon*), Its development is creeping and can reach stem lengths of more than 2 meters. These can also be erect with heights of 30 to 40 cm. It has rhizomes and stolons to colonize soils and reproduce; 6) *Digitaria velutina*, annual grass; decumbent, branched and glabrous stems; papillose sheaths, hairy foliar laminae; panicles with 8 to 30 ramifications; 7) Zacate guinea (*Panicum maxima* perennial rhizomatous, tall, develops mainly in isolated clumps, which can reach up to 3 m in height. The inflorescence is an open spike with lateral branching; 8) Pata de gallo *(Dactyloctenium aegyptium*), has a branched root. The stem with knots of herbaceous consistency. The leaves are linear lanceolate, parallelinervate, with presence of ligule. The inflorescences are arranged in a spike panicle, all spikes emerge from one point. They are hermaphrodite with a succulent ovary; 9) *Urochloca fasciculata*, annual or perennial grasses, cespitose, stoloniferous or rhizomatous; hermaphrodite or polygamous plants. Sheaths rounded; ligule a ciliate membrane; laminae linear to linear-lanceolate. Inflorescences terminal or terminal and axillary (CONABIO, 2022).

Broadleaf

The species identified were (Table 3): 1) Water parrot (*Euploca procumbens*) Water parrot is a nearly cosmopolitan plant genus with about 100 species. Species have leaves with typical C4 Kranz anatomy. 2) Scorpion's tail (*Heliotropium angiospermum*), an annual, hirsute plant that is a common weed in waste places and populated areas. 3) blackberry weed (*Solanum americanum*) annual or perennial plant, with green or purple, erect, branched stem. Leaves alternate, variable in size and shape with entire or wavy margins, with finely winged petioles about 4 cm long, decurrent or not; 4) figwort (Ricinus communis) is a shrub with a large, woody, hollow stem,

which may have a dark purple color in some varieties, as well as petioles, nerves and even the leaves themselves. These parts are usually covered with a white, wax-like powder. The leaves are very large, with palm-shaped veins and divided into 5 to 9 lobes, with irregularly toothed margins; 5) Chelite (*Amaranthus spp*) Erect, dioecious herbs. Cycle: Annual. Stems: Green to reddish striated stems, lignified at the base in larger specimens. 6) Golondrina (*Euphorbia hirta*) Annual herbaceous plant, erect or decumbent, or else, creeping and spreading radially, densely hairy, the hairs often multicellular and yellow. The stem is dichotomously branched. Leaves are opposite, stipules small, aristate; 7) Swallowvine (*Euphorbia hypericifolia*) annual herbs, erect or ascending; stems glabrous, red or green. Leaves oblong, apex rounded or obtuse, base oblique, obtuse to cordate, margins serrate, glabrous; stipules united, slender, entire or divided; 8) Conchita (*Blechum pyramidatum*) erect to inclined herbs; younger stems quadrangular. Leaves ovate to ovate lanceolate, apex acute, base cuneate to obtuse, margins crenulate to entire, sparsely hairy to glabrous, inflorescences are terminal; 9) Milkweed *(Euphorbia heterophylla*) An abundant species, stem simple, with milky juice; leaves heterophyllous; flowers yellowish, small, bract-like. The leaves at the upper end of the stem, near the sciate, have a striking scarlet red color. The leaves are lobed. The stem exudes a toxic milky white sap. The cyathia, or false flowers, are found in clusters at the head of the stem and are greenish-yellow. They have no petals, the red color they are part of the young leaves by coloration. The fruits are small, segmented into capsules; 10) Cow's Gut (*Cissus verticillata*): It rises to a height of 6 to 10 m, with tendrils; stems very flexible, jointed branches; leaves, up to 15 cm long by 12.5 cm wide, simple, oblong to obovate or heart-shaped, setose toothed margin, inflorescences opposite the leaves, branched, rounded outline, umbelliform compound top; 11) Bejuco (*Ipomoea spp*): They are perennial herbs, rarely annual, sometimes found lignified at the base. They can be rhizomatous or tuberous, pubescent or glabrous. The stems are voluble, rarely decumbent, polygonal or circular in section, with hyaline latex, rarely white The leaves are entire or lobed, sometimes very variable on the same stem, petiolate. Inflorescences are dicasial and axillary cymes, rarely with solitary flowers; peduncles of variable length; 12) Turkish carpet (*Phyla nodiflora*) The genus Phyla is distinguished by being herbaceous (Lippia in the narrower sense encompasses only woody species), simple leaves, a dry fruit that separates into 2 partial fruits at maturity (not 4) and having the inflorescence in elongated head. The flowers have 4 lobes. The habit is decumbent and the plants root at the nodes (CONABIO, 2022).

Narrowleaf weeds			
Family	**Scientific name**	**Common name**	**Life Cycle**
Poaceae	*Echinocloa colona*	Zacate pinto	Annual
Poaceae	*Rottboellia cochinchinensis*	Caminadora	Perennial
Poaceae	*Eleusine indica*	Pata de galinha	Annual
Poaceae	*Sorghum halepense*	Zacate Johnson	Perennial

Table 3.- Identified broadleaf weeds

EFFECT OF HERBICIDE ON WEED COVER 26 DAYS AFTER APPLICATION

According to the results of the initial sampling (Table 2), weed density did not show significant differences between treatments, so it is considered that the weed species showed similar distributions. The variable herbicide effect on weed cover 26 days after application showed a positive effect and significant statistical differences among the evaluated treatments, with the best weed control and no toxicity effects in treatment 4.

Origem	DF	Sum of squares	Mean square	Value of F	Pr > F
Model	8	19358.57	2419.82	1693875	<.0001
Erro	12	0.017	0.00143		
Total corrected	20	19358.59			

Table 4.- Anova for the variable effect of herbicide on weed cover 26 dda.

Source: SAS Studio

In this variable, the ANOVA (Table 4) showed significant differences between the treatments evaluated in the different treatments compared to the control. The effect of herbicides on weed communities is influenced by several variables, including environmental conditions, such as soil water content, air temperature and even the type of adjuvants (e.g. sufactants) used (Dicksen et al., 1990).

The Tukey procedure (Table 5) for the variable weed control after 26 days of application divided the treatments into 6 groups: in group A, treatment 4; in group B, treatment 6; in group C, treatment 7; in group D, treatment 2; in group E, treatment 3; in group F, treatment 3; in group G, treatment 5 and the absolute control; the best treatment was T4 with 95% coverage.

Treatments	Estimate	Grouping
T4(Organic compound 4)	95.65	A
T6 (Glyphosate)	92.65	B
T7 (*Datura estramonium* extract, allelopathic plant extracts)	83.00	C
T2 (Organic compound 2)	81.80	D
T3 (Organic compound 3)	80.00	E
T1 (Organic compound 1)	73.80	F
T5 (Absolute witness)	0.00	G

Table 5.- Tukey test for the variable herbicide effect on weed cover 26 dda.

Source: SAS Studio

The use of natural substances for weed control has been in increasing demand because they are considered safer and less polluting than conventional herbicides. This is one of the reasons for examining, investigating and then using these products in conventional and organic agriculture (Dayan, 2014). When observing the results obtained in the variable to be evaluated, we can see that there are significant differences between the treatments evaluated, with treatment 4 showing the best performance in relation to the percentage of control compared to the other treatments.

CONCLUSIONS

In the present study, it was observed that treatment 4 offered the best results in weed control in the plantain crop, achieving an effectiveness of 95% in both narrow-leaf and broad-leaf weeds throughout the different dates evaluated. The effects of the herbicides established and evaluated in the field were compared with glyphosate, which was used as a regional reference control. As a preliminary result, some herbicides with a good effect on weed control were identified.

There were no phytotoxicity effects on the first two evaluation dates, being rated as 1 (no effect on the crop) according to the EWRS scale.

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