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Research Paper

Weed Suppression with Cover Legumes in Orange Plantations Cv. Valencia

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ABSTRACT: *Weed control is crucial for enhancing orchard productivity, as weeds compete with crops for water and nutrients available in the soil. To manage this, manual, mechanical, and chemical control methods are employed, with the latter being the most common. However, improper application of chemical methods can cause serious environmental and human health problems. Therefore, it is essential to seek eco-friendly alternatives, such as using cover crops with legumes due to the benefits they provide to the soil. The objective of this study was to determine the weed suppression capacity of various cover legumes established between September and December 2021 in a Valencia orange orchard. The study was conducted in the municipality of Martínez de la Torre, Veracruz, using a randomized block design with four replications. Seven species of cover legumes were evaluated, with assessments carried out from January to August 2022. The variables measured included plant height, ground cover, and dry matter (DM) production. The results indicated significant differences (p<0.05) between treatments for ground cover. Perennial legumes such as Pueraria phaseoloides, Neonotonia wightii, Centrosema pubescens, and Arachis pintoi showed soil coverage ranging from 84% to 100% one year after establishment. In contrast, annual legumes like Mucuna pruriens and Lablab purpureus provided soil cover of 1% and 41%, respectively. Significant differences (p<0.05) were also observed in legume biomass production, with Pueraria phaseoloides (kudzú), Centrosema pubescens (centrosema), and Neonotonia wightii (soya perenne), whether grown individually or as a mix (cocktail), outperforming the other treatments with a dry matter production of 1,290 kg/ha. For comparison, dry matter production using mechanical tillage, glyphosate herbicide, and weedy control ranged from 1,020 to 1,580 kg/ha. In conclusion, during the first year of evaluation, kudzú, centrosema, and soya perenne either individually or in association produced the best results, reflected in efficient weed suppression.*

KEYWORDS: Dry Matter, Citrus, *Pueraria phaseoloides, Centrosema pubescens, Neonotonia wightii*

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I. INTRODUCTION

Mexico is the fourth-largest citrus producer in the world, contributing 5.4% (8,826,144 tons) of global production [4]. It is also the fourth-largest orange producer globally, after China, Brazil, and India, with over 349,339 hectares cultivated across more than 15 Mexican states, yielding approximately 4.8 million tons annually. The state of Veracruz is the leading national producer of this citrus, accounting for 2.5 million tons, which represents over 50% of the country's total production. The value of orange production in 2022 was 7,089 million pesos. The cultivated area has remained stable, with a slight increase of 0.3% from 2021 to 2022 [16].

In citrus-growing regions, over 95% of producers use the non-selective herbicide glyphosate for weed control. Glyphosate is highly effective against annual and perennial weeds compared to herbicides like paraquat and glufosinate, which only target annual weeds. Paraquat is generally cheaper or similarly priced to glyphosate, while glufosinate costs about twice as much. Glyphosate is applied three to four times a year [9] at doses ranging from 3 to 6 liters of commercial product per hectare. However, repeated applications of glyphosate over the years have led to the emergence of herbicide-resistant weed biotypes [1,8] and increased environmental contamination risks [13].

Given these challenges, it is necessary to develop practices that optimize soil use and conservation while protecting the environment in both young and mature plantations. Cover crops with legumes offer a viable alternative, as they prevent soil fertility depletion and reduce weed incidence. A cover crop is defined as "a living vegetative cover that temporarily or permanently covers the soil, grown in association with other plants, intercropped, relay-cropped, or rotated." Cover crops are valued for their broad, multipurpose functions, which include weed suppression, soil and water conservation, pest and disease control, and providing food for humans and animals [11].

Cover plants can belong to any taxonomic family, though legumes are generally preferred for their benefits to certain tree crops, such as citrus. Citrus orchards have an herbaceous stratum between the trees that must be managed through agricultural practices such as manual or mechanical mowing or chemical applications [12]. The benefits of cover crops include contributing organic matter, fixing nitrogen in the soil, preventing erosion, providing animal feed, producing seeds, reducing orange fruit damage from mites, and mitigating the negative environmental impacts of herbicide use [12,15].

The goal of legume cover crops is to combine as many beneficial attributes as possible within a given species. In this case, the objective is rapid soil coverage to replace existing weeds with plants that help reduce agrochemical use. However, the ability to achieve this in a specific crop depends on various factors, such as crop species, age, growth habit, management practices, climate, soil, and other relevant conditions. Therefore, it is essential to identify suitable legume species with high establishment rates and shade tolerance [10,3,2].

The objective of this study was to evaluate the effect of ground cover and biomass production of cover legumes on weed control in Valencia orange plantations, as an alternative to reduce herbicide use in citrus orchards.

II. MATERIALS AND METHODS

Experiment Location

In September 2021, an experiment with Valencia orange was established at Rancho Lomas de Arena, located in the municipality of Martínez de la Torre, Veracruz, Mexico (20°10'01" N, 97°06'20" W) at an altitude of 103 m. According to García [5], the region has a warm-humid climate with an average temperature of 24°C, annual rainfall of 1,980 mm, and no defined dry season. The experiment was conducted in a 32-year-old Valencia orange plantation with tree spacing of 4 m within rows and 8 m between rows, and tree heights ranging from 8 to 10 m.

Physicochemical Characteristics of the Experimental Site's Soil

The crop was established on a loam soil with a pH of 5.84 (moderately acidic) and free of salinity and total carbonates. Organic matter and phosphorus contents were moderately low at 1.71% and 18.8 ppm, respectively, while potassium levels were low at 117 ppm.

Treatments

Cover legumes were established in the spaces or alleys between two rows of trees. Fourteen treatments were evaluated (Table 1), including seven legume species planted individually and four combinations of legumes. Additionally, treatments included mechanical tillage, a glyphosate application, and a weedy control.

Table 1. Treatments Evaluated in a Valencia Orange Plantation in Martínez de la Torre, Veracruz.

Treatment	Legume Cultivar or Mixture
1	*Arachis pintoi* + *Clitoria ternatea*
2	*Centrosema pubescens* (Centrosema)
3	*Arachis pintoi* (Cacahuatillo)
4	*Clitoria ternatea* (Clitoria o tehuana)
5	*Lablab purpureus* (Dolichos)

6	*Mucuna pruriens* (Mucuna o pica-pica mansa)
7	Rastreo
8	*Pueraria phaseoloides* (Kudzú)
9	Dolichos + Mucuna
10	*Neonotonia wightii* (Soya perenne)
11	Kudzú + Centrosema + Soya perenne
12	Coctel (Todas las leguminosas)
13	Glifosato 2.5 L/ha de producto comercial
14	Testigo absoluto

In this research, the evaluation corresponded to the development of the cover crops one year after planting in September 2021, and the results of establishment and a biomass production cut were recorded by Matilde et al. [7]. From January to May, the cover legumes remained in the field undisturbed until early May, when they received a mowing or uniformity cut considered as maintenance. Therefore, the reported results correspond to the behavior of the legumes after a cut made in August, one year after planting. For this, the variables of plant height and ground cover were measured, and the biomass produced was harvested through cuts in 1 m² samples, with four replications per treatment. The results were analyzed using a randomized block design with four replications, PROC GLM of SAS, and mean comparisons with Tukey's test ($p \leq 0.05$).

III. RESULTS AND DISCUSSION

Plant Height

The maximum height reached (Table 2) was for the species Dolichos at 53 cm, while the lowest height was for Cacahuatillo at 20 cm. The weeds were taller, ranging from 24 to 73 cm, with no significant differences ($p<0.05$) between treatments. These values were recorded in the treatments with Clitoria and Cacahuatillo, respectively.

Legume and Weed Cover

Soil cover was different ($p<0.05$) between treatments, with seven treatments involving legumes achieving coverages from 70% to 100%, and only four of them, Dolichos, Mucuna, Clitoria, and the Dolichos-Mucuna combination, having coverages below 52%. In fact, Mucuna alone had only 1% coverage. Shade also affected weed cover in all treatments, as the values were low; the control, mechanical tillage, and glyphosate treatments had higher coverages. However, the low coverage of Mucuna allowed the highest weed infestation, with 96% cover (Table 2). Perennial legumes like Kudzú, Soya perenne, Centrosema, and Cacahuatillo had high coverage values (Table 2), providing good weed control by preventing its presence in the plots. Additionally, being perennial species, they showed greater persistence on the land.

Table 2. Height and Cover of Weeds and Cover Legumes in a Valencia Orange Plantation in Martínez de la Torre, Veracruz, One Year After Establishment.

Treatment Legume Cultivar or Mixture	Height of Legumes (cm)	Height of Weeds (cm)	Cover of Legumes (%)	Cover of Weeds (%)
Cacahuatillo + Clitoria	42 ab	53 a	70 a	14 cd
Centrosema (*C. pubescens*)	32 ab	68 a	84 a	15 cd
Cacahuatillo (*A. pintoi*)	20 bc	24 a	99 a	1 d
Clitoria (*C. ternatea*)	46 ab	73 a	41 ab	20 cd

Dolichos (*L. purpureus*)	46 ab	62 a	41 ab	37 bcd
Mucuna (*M. pruriens*)	27 abc	68 a	1 b	96 a
Rastreo	0 c	67 a	0 b	92 a
Kudzú (*P. phaseoloides*)	41 ab	35 a	100 a	0 c
Dolichos + Mucuna	53 a	37 a	52 ab	25 cd
Soya perenne (*N. wightii*)	28 ab	31 a	97 a	0 d
Kudzú + Centrosema + Soya perenne	36 ab	39 a	98 a	2 d
Coctel (Todas las leguminosas)	33 ab	31 a	88 a	4 d
Glifosato	0 c	26 a	0 b	78 ab
Testigo absoluto	0 c	21 a	0 b	48 bc

Different letters between columns indicate differences between treatments (Tukey's test, $p<0.05$).

Dry Matter Production

Kudzú produced the highest amount of dry biomass, with 2,856 kg/ha, which was statistically similar ($p>0.05$) to Soya perenne and the combinations of Soya perenne, Kudzú, and Centrosema, as well as the combination of all legumes (Table 3). Due to its ability to tolerate high levels of shade, rapid ground coverage, and high biomass production, Kudzú has been used for many years as an important cover crop in rubber, African palm, and other tree crop plantations [14,6].

Biomass from grass weeds was only recorded in treatments where no legumes were planted: control, glyphosate, and mechanical tillage, with values ranging between 1,020 and 1,583 kg/ha of dry matter. On the other hand, the dry matter of weeds was high in the Dolichos and Mucuna treatments, with 4,437 and 2,860 kg/ha of broadleaf weeds, respectively, due to the annual life cycle of these two species. The rest of the treatments exhibited maximum values of 1,067 and minimum values of 103 kg/ha of dry matter, with no significant differences between treatments.

It is important to note that the behavior of the annual legumes Dolichos and Mucuna, as well as their combination in this cycle, showed very poor contributions to soil cover and legume biomass production. During the establishment phase in the first year, they were the best due to their speed of coverage and biomass production, as noted by Matilde et al. [7]. Perennial legumes had slower establishment compared to annual legumes, but over time, they have shown excellent soil coverage capacity, and consequently, better weed suppression or displacement, as well as greater biomass production.

Table 3. Dry Matter Production of Legumes and Weeds in a Valencia Orange Plantation in Martínez de la Torre, Veracruz, One Year After Establishment.

Treatment Legume Cultivar or Mixture	Dry Matter (kg/ha)		
	Legume	Grass	Weed
Cacahuatillo + Clitoria	2,263 ab	0 b	593 a
Centro (*C. pubescens*)	2,210 ab	0 b	1,067 a
Cacahuatillo (*A. pintoi*)	1,943 ab	0 b	517 a
Clitoria (*C. ternatea*)	1,967 ab	0 b	1,040 a
Dolichos (*L. purpureus*)	766 ab	0 b	4,437 a

Mucuna (*M. pruriens*)	143 b	0 b	2,860 a
Rastreo	0 b	1,580 a	493 a
Kudzú (*P. phaseoloides*)	2,856 a	0 b	177 a
Dolichos + Mucuna	1,550 ab	0 b	883 a
Soya perenne (*N. wightii*)	2,593 a	0 b	247 a
Kudzú + Centrosema + Soya perenne	2,850 a	0 b	283 a
Coctel (Todas las leguminosas)	2,603 a	0 b	240 a
Glifosato	0 b	1,343 a	103 a
Testigo absoluto	0 b	1,020 a	197 a

Different letters between columns indicate differences between treatments (Tukey's test, $p<0.05$).

IV. CONCLUSION

Perennial cover legumes P. phaseoloides, C. pubescens, and N. wightii, either individually or in combination, exhibited the highest coverage, biomass production, and persistence, efficiently suppressing weed presence.

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