

Leguminous species effect in agroforestry systems in the Portuguesa state. Venezuela**Efecto de especies leguminosas en sistemas agroforestales en el Estado Portuguesa. Venezuela**

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Abstract

Six leguminous species Frijol bayo (*Vigna unguiculata*), Frijol white Var. Orituco, Quinchoncho dwarf (*Cajanus cajan* (L.) Millsp., cv. Aroita), Kudzú tropical (*Pueraria phaseoloides*), Crotalaria (*Crotalaria juncea*), Sesbania (*Sesbania grandiflora*) were established in an agroforest systems to assess his effect on the chemical property of a Alfisol soil at municipality Ospino Portuguese state, at the farm La Yaguara planted with *E. urograndis*. In a design in random blocks with 7 processings and 4 repetitions, employing STATIXTIS 9.0 to carry out the ANDEVA and for variables where differences are presented the test was employed of Tukey (5%); obtaining as results that in the soil of the farm The Yaguara alone significant differences were found ($P<0,05$) for the variables relation C/N, CO, Zn, highly significant and differences ($P<0,01$)for N; being the Sesbania and quinchoncho the best treatment in relation C/N; for CO the frijol blanco and the treatment control; for Zn the quinchoncho and treatment control, frijol blanco and kudzú tropical; in the N quinchoncho and Sesbania. To confirm the generated profit to the agroforestry system analysis were completed foliate to the eucalyptus, finding highly significant differences for P with Frijol blanco and Kudzú and significant for Zn where is quinchoncho and treatment control.

Leguminous, Agroforest, Eucalyptus, Green compost

Resumen

Seis especies leguminosas frijol bayo (*Vigna unguiculata*), frijol blanco Var. Orituco, Quinchoncho enano (*Cajanus cajan* (L.) Millsp., cv. Aroita), Kudzú tropical (*Pueraria phaseoloides*), Crotalaria (*Crotalaria juncea*), Sesbania (*Sesbania grandiflora*) fueron establecidas en un sistema agroforestal para evaluar su efecto sobre las propiedades químicas de un suelo alfisol en el municipio Ospino estado Portuguesa, en la Finca La Yaguara plantada con *E. urograndis*. En un diseño en bloques al azar con 7 tratamientos y 4 repeticiones, se utilizó STATIXTIS 9.0 para realizar el ANDEVA y empleó la prueba de Tukey (5%); Los resultados indican que en la finca La Yaguara se encontraron diferencias ($P<0,05$) para las variables relación C/N, CO, Zn, y cambios altamente significativas ($P<0,01$) para N; y al comparar medias la Sesbania y el quinchoncho fueron del mejor grupo en relación C/N; para CO el frijol blanco y el tratamiento testigo; para Zn el quinchoncho, frijol blanco y kudzú tropical; mientras que para el N quinchoncho fue el mejor tratamiento. Para constatar el beneficio generado al sistema agroforestal se realizaron análisis foliares al eucalipto, encontrándose diferencias altamente significativas para P en los tratamientos con Frijol blanco y Kudzú y significativas para Zn en donde se estableció quinchoncho.

Leguminosa, Agroforestal, Eucalyptus, Abono verde

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Introduction

In the search for sustainable production systems, especially for tropical areas where socioeconomic problems added to those of high susceptibility to erosion and low soil fertility produce significant losses in productivity, agroforestry systems appear to be advantageous in the short and long term. , especially for the contribution of organic matter and nutrients through the tree component (Ramírez 2000).

Considering all the advantages and benefits generated by the use of legume species, together with the profitability and sustainability of forest systems; It is interesting to evaluate the effects of the establishment of agroforestry systems with legume species on the chemical properties of an Alfisol soil in the Ospino municipality, Portuguesa state. This allows generating local information that is applicable to soils with similar characteristics, where income can be obtained from the economic point of view in the short, medium and long term, maintaining the ecological balance and the sustainable management of natural resources. In addition, given the sustainable use of soil resources and the management of sustainable commercial plantations, this type of strategies helps to reduce the use of agrochemicals, food production in agroforestry crops , Mulch incorporation among other benefit0073NM .

Methodology

Study area

The test was established in the La Yaguara farm under forest exploitation, the agroecological system that is presented is at an altitude between 170 and 210 meters above sea level; with an almost flat relief and the highest proportion of soils between slopes of 0 to 3%. The La Yaguara farm, planted with *Eucalyptus urograndis*, is owned by the company Forestal SMURFITKAPPA - REFORESTADORA DOS REFORDOS CA, a subsidiary of Cartón de Venezuela located in the Ospino municipality of the Portuguese state.

Experimental design

A randomized block design was established with 7 treatments and 4 repetitions, where the treatments were made up of the different legume species established in the street of two threads of the forest species by repetition and each one constituted by 6 forest plants per thread; with an area of 54 m² per repetition, for a total test area of 1512 m²; where:

T0 = Control (Forest species without legumes on the street)

T1 = Bayo Bean T2 = White Bean T3 = Dwarf Quinchoncho

T4 = Tropical Kudzú T5 = *Crotalaria* T6 = *Sesbania*

Chemical determination of the soil

4 composite samples were taken at different depths 0-20 cm; 20-40 cm and 40-60 cm; before establishing the forest plantation and then 15 days after the establishment of the forest plantation and associated legumes. The samples were analyzed by EDAFOFINCA where analysis methods are used for fertilization purposes: Texture: distribution and particle size (Bouyoucos) * pH (Soil-water ratio: 1: 2.5) *; Phosphorus (Olsen, 1954) *; Potassium (Olsen,) *; Calcium (Morgan) *; organic matter (OM; Moisture combustion, modified Walkey and Black) *; Exchangeable aluminum, (extracted with 0.5 M BaCl₂ ratio 1: 10) * and EC (mS / cm 25 °C conductimeter). A database was created with the information provided by the analyzes and statistical analysis was used as a tool to determine possible differences in the system.

Quantification of the nutritional quality of the forest species during the association

The elements determined in the foliar analysis were: N, P, K, Ca, Mg, Fe, Cu, Zn and Mn. The nutritional content of the foliar samples allowed for statistical analysis and comparisons that allowed identifying the legume that provides substantial improvements to the system or determining whether there are changes.

Statistic analysis

In the statistical analysis, a database was elaborated and it was analyzed with STATISTIS 9.0 to perform the analysis of variance (ANDEVA) and for the comparison of means between the variables where differences are present, the Tukey test at 5% was used.

Results

Table 1 shows initial characteristics of the soil of the La Yaguara farm (lot 16) planted with *Eucalyptus urograndis*, where pH between 5.5 - 6.5, normal or non-saline EC, medium to low CO% stands out. , N at low levels, C / N ratio, P, K, Fe and Cu at medium levels and very high values for the elements Ca, Mg, Zn and Mn.

PTO	1	2	3	4
PH	6,05	5,88	6,11	5,4
ECmS/cm	0,06	0,1	0,04	0,07
CO%	1,93	1,37	0,92	1,84
N%	0,157	0,114	0,081	0,125
Relationship C/N	12,3	12	11,4	14,7
P**	17	14	11	7
K**	115	150	95	70
Ca*	14,85	11,35	10,25	12
Mg*	3,21	3,44	4,85	2,88
Fe*	33	66	93	53
Cu*	1	2	2,8	2,2
Zn*	11,5	5,2	4,6	5,5
Mn*	155	97	165	94

Table 1 Initial soil characteristics of the La Yaguara farm (lot 16) planted with *Eucalyptus urograndis*

Source: EDAFOFINCA Analysis - Own Data

* = $cmol (+) Kg^{-1}$

**= mg/lt

The initial values of elements determined in foliar samples of the established forest species are shown, which when compared with the values and deficient for *Eucalyptus* species at the foliar level presented by Ortiz C. and Salamanca V. (2018) based on Aparicio (2001), the macronutrient values (N (2.77%), P (0.2), K (1.2), Ca (1.15), Mg (0.24) and S (0.2) present values very low, close to or below the deficiency limits; while for microelements such as Fe (310 mg / l), Cu (12), Zn (36) and Mn (114), the values are within the ranges adequate or above these. Which indicates that there is an obvious lack of nutrients in the soil, so contributions must be made via chemical fertilization.

Trial established at the La Yaguara farm

Table 2 shows the analysis of variance (ANDEVA), F values and their degree of significance, showing significant differences ($P < 0.05\%$) for the variables carbon-nitrogen ratio (C / N), phosphorus (P), Organic Carbon (CO) and Zinc (Zn), with a coefficient of variation (CV) of 5.15; 12.29; 5.5; and 12.87% respectively; which indicates that the design used was adequate.

For the nitrogen variable (N), a highly significant behavior ($P < 0.01$) was found among the treatments with a variation coefficient of 7.12%, which indicates that the experimental design and the statistical analysis used are the most appropriate. This coincides with what was obtained by UNAL (2005), Arteaga *et al.*, (2016), Luciana (2016), where significant changes were observed in the elements specifically analyzed in relation to C / N, CO and nitrogen when studying the effect of different legumes.

Variation Source	Treatment	CV (%)	Significance
C/N	2,83	5,15	*
EC (mS/cm)	2,32	21,66	n.s
CO (%)	2,89	5,5	*
Cu (mg/l)	0,90	12,99	n.s
Fe (mg/l)	1,59	13,44	n.s
K (mg/l)	1,13	11,93	n.s
Mn (mg/l)	0,82	20,9	n.s
N (%)	5,07	7,12	**
P (mg/l)	1,66	12,29	n.s
Zn (mg/l)	2,92	12,87	*

Table 2 ANDEVA (Value of F and degree of significance) for the variables analyzed in the Finca La Yaguara, Ospino municipality of the Portuguese State

Degree of significance: * significant differences ($P < 0.05$), ** highly significant differences ($P < 0.01$), n.s. There are no significant differences

Source: own calculations

The previous table shows the comparison of means analyzed, where it is observed that in the variable Carbon / Nitrogen (C / N) ratio, two homogeneous groups were formed, where the best group (a) is constituted by treatment 6 with 18, 20 for the *Sesbania* species, and a second group formed by treatment 3 (group b) that corresponds to the association with quinchoncho with 15.75, which coincides with the results obtained by UNAL (2005) whose initial values of the C relation / N was similar for all species and fluctuated between 9.4 and 13.

Regarding the percentage of CO, two homogeneous groups were formed consisting of treatment 2 (group a) corresponding to white beans with 2.15% and group b formed by the control treatment (T0) without legume species with 2.10%. In a similar way, but with other legume species Rivero (1997) in a study carried out under greenhouse conditions, the result was significant differences with an increase in CO in all treatments, where the treatment responsible for the highest CO values was crotalaria, even when not statistically differentiated from the mix. Paolini (2017) mentions the importance of organic agriculture, presenting the highest total organic carbon values, mentioning that organic production is a sustainable management system.

The cation exchange capacity increases as a function of the increase in organic matter and thus the bioavailability of other important elements such as phosphorus may improve and the toxicity of other elements may be inhibited by the formation of chelates or other bonds, for example, aluminum and organic matter. Similarly, for the element nitrogen (N), 2 homogeneous groups were formed, where the best group (a) consisted of treatment 3 (quinchoncho) with 0.1325% and a group C formed by treatment 6 with the species *Sesbania* with 0.1048%, while the rest of the treatments formed heterogeneous groups with intermediate values between group a and c.

Even though the best species in our case did not turn out to be crotalaria, within the trial carried out by Ojeda (2019) with the aim of selecting effective species of arbuscular mycorrhizal fungi in the *Crotalaria juncea* species, used as green manure, it presented a fundamental aspect in the decomposition of green manures in the soil is its carbon / nitrogen ratio, which indicates the feasibility of using this legume as green manure to improve the soil in areas destined for production.

In Table 3 of comparison of means for the nitrogen variable in the Yaguara farm, the best group was made up of the treatment with quinchoncho associated with *Eucalyptus* (treatment 3), this coincides with Torres *et al.*, (2018) mention that agroecological techniques are a viable alternative to improve soil fertilization, generating suppression for weeds, conservation of soil nutrients N, P, K, thus increasing ecological and economic benefits.

Treatment	C/N	CO	N	Zn
0	16,82 ab	2,10 b	0,1170 abc	2,85 b
1	16,72 ab	2,00 ab	0,1283 ab	3,50 ab
2	16,95 ab	2,15 a	0,1218 abc	2,85 b
3	15,75 b	2,08 ab	0,1325 a	5,05 a
4	16,92 ab	1,89 ab	0,1122 bc	2,80 b
5	16,75 ab	1,92 ab	0,1150 abc	3,10 ab
6	18,20 a	1,91 ab	0,1048 c	3,30 ab

Table 3 Comparison of means for the variables analyzed at Finca La Yaguara, Ospino municipality of the Portuguese State

a, b, c: significantly different homogeneous groups

Source: own calculations

Analyzing the results obtained in the C / N, CO and N relationship, Rivero and Paolini (1995) mention that the effect achieved has been pointed out by many researchers such as: Wade and Sánchez (1983), Heng and Goh (1984), Clay and Clapp (1990), Costa *et al.*, (1990), Duxbury *et al.*, (1991); Prasad *et al.*, (1991) and is due, in the case of nitrogen, to the content of this element in incorporated tissues and its subsequent mineralization. Regarding the C / N relationship, due to the values presented by the legumes under study, the quinchoncho, the white beans and the bay beans are presented as a good option to improve soils in the short term.

While *Sesbania* due to its high C / N ratio would be very useful if you want to maintain the nitrogen supply in the soil more slowly and for a longer duration. For the variable Zinc (Zn), since there were significant differences in the previous table of comparison of means, it is observed that two homogeneous groups were formed, consisting of treatment 3 (group a) with quinchoncho, mean of 5.05 mg / l and the group b with treatments 0.2 and 4 (control, white beans and tropical kudzu) with a mean of 2.85; 2.85 and 2.80 mg / l respectively.

Castro (2017) mentions that the annual legume species of rapid establishment, high biomass production and tolerance to drought are an alternative to be used as green manures. Higuera *et al.*, (2001), where they determined the effect of cutting height and age on the mineral content of the elements P, K, Ca, Na, Mg, Zn and Mn, in leaves and stems of quinchoncho *Cajanus cajan* (L.) Millsp; found significant differences (P <0.01) between varieties for the elements P, K, Mg, Zn and Mn. Where there was also a differential response in cutting heights for all elements (P <0.01), except for Na.

All the elements varied in concentration during the cutting ages except for phosphorus, which tended to remain constant. The high Zn content in the quinchoncho could be the source to increase the existing values in the soil and given the C / N ratio of the quinchoncho, it can be easily decomposed and provide all the elements available in the plant in leaves, roots and stems. In this particular Ratto and Miguez (S.f.), indicate that nitrogen fertilization or the incorporation of organic matter in the soil, promotes the absorption of Zn by the plant, although the most common is to find Zn deficiencies due to excesses of P.

Quantification of the nutritional quality of the forest species during the association. farm la yaguara

To determine the nutritional quality of the forest species, the analysis of variance (ANDEVA), F values and their degree of significance for the variables analyzed 10 months after establishing the trial with legume species are shown. There were highly significant differences (P <0.01) for the element phosphorus (P) with a coefficient of variation of 13.61% and significant differences (P <0.05) for the element Zn with a coefficient of variation of 17, 10%, which indicates that the experimental design and the analysis carried out are adequate for the variables measured in the trial.

Table 4 shows the comparison of means for the variables analyzed in the foliar samples of Eucalyptus urograndis, it is observed that for the element phosphorus (P) two homogeneous groups were formed where group a was constituted by treatment 1 corresponding to bay beans with 0.1725 mg / l.

Treatment	P(%)	Zn(mg/l)
0	0,1225 b	11,75 b
1	0,1725 a	18,00 a
2	0,1475 ab	3,25 ab
3	0,1500 ab	18,00 a
4	0,1275 b	13,50 ab
5	0,1200 b	14,25 ab
6	0,1200 b	14,70 ab

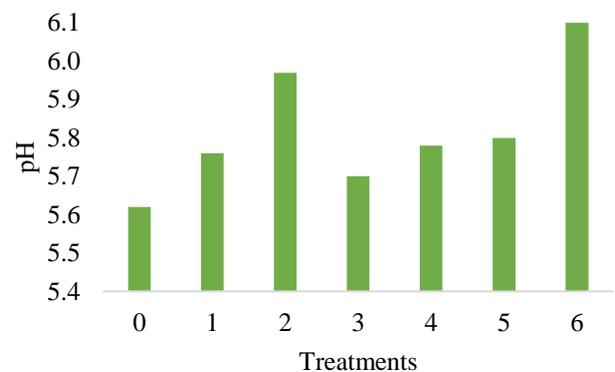
Table 4 Comparison of means for the variables P and Zn in the samples of Foliares in the Finca La Yaguara, Ospino municipality of the Portuguese state
a, b, c: significantly different homogeneous groups
Source: own calculations

For the variable zinc (Zn), two homogeneous groups were formed where the best group (a) is made up of treatments 3 and 1 of the legumes quinchoncho and beans bayo respectively with 18 mg / l of Zn on average.

Trends of the variables pH, electrical conductivity and nitrogen in the soil of the farms under study

– pH

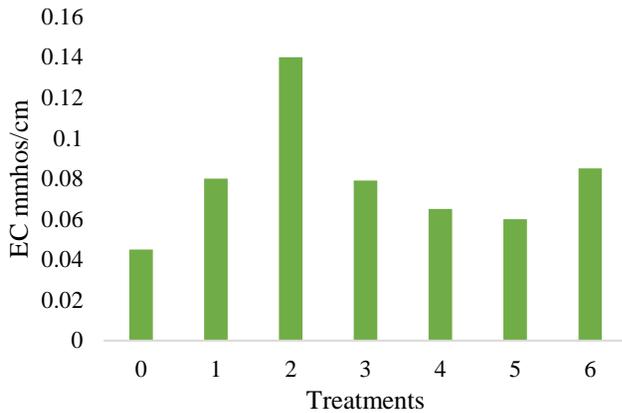
Graphic 1 shows how in the La Yaguara farm, only treatment 2 and 6 increased the pH by ± 0.3 units, while the rest of the treatments decreased it between 0.05 and 0.2 units; being treatments 4 and 5 they lowered them less units (<0.05) of pH. This information allows defining the legume species to be established according to the needs of the forest species to be established. At an operational level, the ideal is to use species that help maintain the pH in the case of the soils of the Yaguara that are between 5.6 and 6.



Graphic 1 pH of the soil at the beginning and end of the treatment trial at La Yaguara farm
Source: own calculations

– Electrical Conductivity (EC)

In the La Yaguara farm (Graphic 2) it is observed how treatment 2 kept the EC stable, when the rest of the treatments decreased it between 0.1 and 0.04 mS/cm.

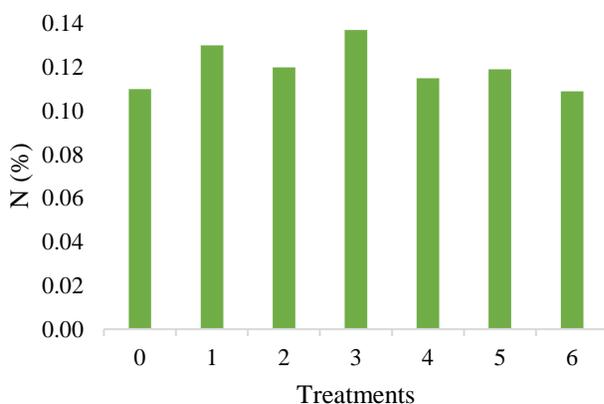


Graphic 2 Electrical conductivity (EC) of the soil at the beginning and end of the treatment trial at La Yaguara farm

Source: own calculations

– Nitrogen

Graphic 3 shows the changes generated in the test established in the La Yaguara farm, due to the association with leguminous species of the forest species, where treatment 1 (bay beans) and 3 (Quinchoncho) increased the nitrogen content. and treatment 2 (white beans) maintained it. Castro *et al.*, (2018) mention that the species *Vigna unguiculata* has been evaluated as green manure in an agricultural system which has allowed to obtain an average of 60 to 300 kg of N / ha. However, treatments 4, 5, 6 and the control, decreased N by 0.02%, which allows defining legume species of interest and chemical fertilization plans necessary according to the legume species that is established.



Graphic 3 Percentage of total soil nitrogen at the beginning and end of the trial by treatment at La Yaguara farm

Source: own calculations

Conclusions and recommendations

The establishment of legume species in agroforestry systems generates significant changes in the chemical properties of an Alfisol soil in the Ospino municipality in the Portuguese state. In the soil of the Yaguara farm, the variables in which the greatest chemical changes occurred in the soil were in the levels of the C / N, CO, N and Zn ratio.

During the association, nutritional changes were presented in Eucalyptus at the level of important macroelements such as P and microelements such as Zn. The legume species that provide the best benefits to the soil and to forest plantations are the Quinchoncho, the white bean and the bayo bean in the short term; and in the long term Sesbania.

The pH condition of the soils of the La Yaguara farm favored the expression of the changes produced during the association. Although in most of the variables measured in the trial there were no statistical differences between the treatments, visually and numerically improvements were observed in the chemical properties of the soil and the forest species. It is recommended to establish legume species for two consecutive cycles to obtain greater changes in the levels of nitrogen, phosphorus, potassium and zinc.

For future trials, it is recommended to determine the nutritional content of the legume species to be associated, to quantify the contributions to the soil and to the forest species.

Considering that the growth rate of forest species is lower than that of legumes, it is desirable to increase the sowing distance between the forest species and legumes to avoid competition.

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