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Recovery Of Degraded Soils In Former Coca Fields And Its Economic Valuation

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Abstract
The study aimed to evaluate the recovery of degraded soils in former coca plantations and their economic valuation through the cultivation of Inga edulis "huaba" in Ricardo Palma - Tingo María. The study was applied, explanatory in nature, with a non-experimental design. The population under study consisted of degraded soils from former coca plantations in Ricardo Palma Tingo María, covering 4 hectares. A sample of degraded soils from former coca plantations planted with Inga edulis "huaba" aged 2, 4, and 6 years was defined, consisting of 12 plots of 100 m² each. The technique employed was a survey, and the instrument was a questionnaire validated by experts. The results showed that after 4 years of planting Inga edulis in degraded soils, they have recovered to be used in sustainable agricultural activities, and that the economic value at market prices is increasing due to the contribution of macro and micronutrients, which showed significant differences the planting time, which leads to the conclusion that Inga edulis restores degraded soils by providing macro and micronutrients and its economic value is related to the planting time).
***Keywords**: cultivation, planting, economic value, nutrients.*

INTRODUCTION

Deforestation in the Peruvian Amazon is advancing at a rate of 261 thousand hectares per year and that this figure could be higher due to the equipment and machinery that are currently available, which makes it reasonable that the current deforestation rate is higher than 300 thousand hectares per year. More than 9 million hectares have suffered the loss of their original forest cover and, of this figure, 5.5 million are considered degraded or in a state of abandonment (Añasco, 2004). The rest is divided between agricultural activities of low productivity, intensive livestock, coca crops and residual forest extraction. In recent years the degraded and abandoned soils have increased due to the coca eradication process, according to publications of the Peruvian state in Peru more than 120 thousand hectares have been determined with coca cultivation.

This process began in the 1940s, when the State began to promote the occupation of the region in order to secure the Amazon border, take advantage of the Amazon and its enormous resources for the benefit of the national economy and improve communication with the region and the segmented way in which it had been occupied. the construction of the road being the marginal of the jungle that drove this great deterioration (Figueroa, 2002).

Degraded soils are abundant throughout the world and their agricultural use is very difficult, uneconomical or directly impracticable. Nitrogen-fixing trees - legumes and actinorrizae - establish a symbiotic association with soil nitrogen-fixing microorganisms of the genera Rhizobium and Frankia respectively. These trees can also form symbiosis with mycorrhizal fungi. These associations allow the fixation of atmospheric nitrogen and improve water absorption and the assimilation of nutrients from the soil. In many disturbed sites, nitrogen-fixing trees can grow better than non-fixative trees and even better than nitrogen-fixing herbaceous plants (Jager et al., 2001).

The cost of recovering these soils by applying amendments to them is very high that they cannot be assumed by the rural dwellers, causing abandonment and the search for new areas affecting the forest again, the use of legumes to recover degraded soils are being used, but this is little studied, even more so the use of tree legume species to which an economic valuation has not been made in the recovery of degraded soils, and other environmental services provided by them (Martínez et al., 2002).

During the last two decades, there have been multiple efforts to rehabilitate important extensions of degraded forest lands in the Amazon region, through reforestation projects; Land-use alternatives have been proposed with different approaches to soil management and conservation (with emphasis on the application of fertilizers and amendments) and the use of agroforestry, agrosilvopastoral and forestry systems, including the management of "purmas" or secondary forests. These rehabilitation initiatives, however, have been largely not well disseminated, and no efforts have been made to systematize and critically evaluate them to try to extract lessons and recommendations, nor have they been evaluated, many of them with failure due to the lack of acceptance by the population that did not understand their importance (Portilla, 2002).

Soil is a dynamic natural system of great complexity in terms of physical, chemical and biological processes. These processes maintain the life of other ecosystems, nutrient cycles and water cycles and, therefore, favor human survival. Currently, there are many degraded areas in the Peruvian Amazon (Martínez, 2004). The deforested area amounts to more than 10 million hectares and the traditional practices of slashing, slashing and burning cause the loss of biodiversity, including vegetation, with a projected loss of 150 000 ha on average per year. Farms located on slopes have higher levels of degradation. The production of illegal crops with inadequate agricultural practices can also generate erosive processes, due to burning practices on sloping properties, many of which are currently abandoned due to the eradication of these crops (Reyes, 2001).

FAO (2011) estimates indicate that a quarter of the planet's land has a high tendency to degradation or is heavily degraded land. According to Rodríguez (1995), more than half of the 576 million hectares of arable land in Latin America, particularly 74% in Mesoamerica and 45% in South America, are affected by degradation processes due to changes in land use, overexploitation, climate change and social inequality. This shows the climatic vulnerability that exists in the region and that is generally more critical for small producers (Rojas et al, 2002).

In the last thirty years, the National Agrarian University La Molina has researched various technological options that allow farmers to create more stable and continuous systems in degraded areas. The agricultural recovery and extension programs seek to stop the expansion of the agricultural frontier towards virgin forests, which are being seriously affected, in the case of Peru, amounting to a total of 60 million hectares. Rather, it is expected that the frontier will be extended to soils that have already been degraded prior to a recovery process and through a more sustainable and environmentally friendly agriculture (Inter-American Institute for Cooperation on Agriculture –IICA- 2016: 12).

The purpose of the research was to evaluate the recovery of degraded ex-coca soils by planting Inga edulis with different planting ages. The importance of the work lies in demonstrating the recovery of the soils degraded ex coca by the cultivation of Inga edulis "huaba" to be incorporated into agricultural projects in which the cost of applying amendments to improve these soils will be reduced. There were no limitations.

MATERIALS AND METHODS

This research work was carried out in plots of agroforestry crops in the Ricardo Palma town center, Padre Felipe Luyando district, Leoncio Prado province, Huánuco department. The study was quantitative (Hernández & Mendoza, 2018) and applied (Arias, 2012; Sánchez & Reyes, 2017). It was developed at the explanatory level (Ñaupas, et al., 2018), with an experimental design (Hernández et al, 2006; Robledo, 2018).

The population under study was made up of degraded soils of former coca plantations of Ricardo Palma Tingo María, 4 hectares. A sample of degraded ex-coca soils with Inga edulis "huaba" planting of 2, 4, 6 years of sowing time was defined, 12 plots of 100 m^2.

As for the technique, the survey was used (Gil, 2003) and the questionnaire was validated by experts (Pérez, 2008).

To take soil samples from the different plots, we proceeded according to the established protocol, the physical-chemical analyses were carried out in the soil analysis laboratory of the National Agrarian University of the Jungle.
Farms were located with degraded soil ex coca crops, with cultivation of Inga edulis "huaba" of 2.4, and 6 years of planting. Once located, the plots with an area of 10 X 30, with 3 subplots of 10 X10, were delimited with raffia, the same that were geo-referenced with GPS.
With a soil sampler tube, samples were taken at a depth of 20 cm with an approximate weight of one kilogram, which were deposited in polyethylene or paper bags that are clean, previously labeled with the plot and sub-plot code, then they were taken to the laboratory for the corresponding analysis.
Soil samples were prepared, dried, crushed and analyzed. The analyses were carried out in the soil laboratory of the National Agrarian University of the Jungle, Tingo María.
For the interpretation of the recovery of degraded ex-coca soils, it was carried out through analysis and interpretation considering the change in pH, texture, increase in macronutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur), as well as micronutrients (Boron, Copper, Zinc, Iron, Molybdenum, etc.), cation exchange capacity, changeable bases, changeable % of acids, concentration of aluminum, among others.
The calculations to determine the amount in kg/ha of N.P.K. in the soil were carried out as follows:

For Nitrogen

% N X soil weight X degree of exploitation X mineralization coefficient = kg of N/ha.
Soil weight = 28,000
Degree of Utilization = 0.4
Mineralization coefficient = 0.03

For the match

Phosphorus in ppm X weight of one ha X transformation coefficient X degree of utilization = kg of P2O5/ha.
Weight of one ha = 2.8
Transformation coefficient = 2.3
Degree of utilization = 0.2

For potassium

Available potassium X weight of one ha X transformation coefficient X degree of utilization = kg of K2O/ha.
Calculations of the amount in kg/ha of N.P.K. equivalent in commercial products and economic value in soles. The calculations were made as follows:

For Nitrogen

kg N/ha X 100/% nitrogen in urea = kg urea equivalent
kg of urea equivalent X commercial price = economic value in soles

For Phosphorus

kg P2O5/ha X 100/% phosphorus in triple super calcium phosphate = kg triple calcium super phosphate equivalent.
kg of super phosphate triple calcium equivalent X commercial price = economic value in soles.

For potassium

kg K2O/ha X % potassium in potassium chloride = kg potassium chloride equivalent.
kg of potassium chloride equivalent X commercial price = economic value in soles.
Calculation of the economic value based on the presence of NPK macronutrients.
It was done by summing for the different treatments.
Economic value of nitrogen + economic value of phosphorus + economic value of potassium = economic value NPK.

RESULTS

After the analysis of the physical and chemical results in the laboratory, for treatment I, plots with degraded ex-coca soils without sowing of Inga edulis "huaba" the pH varies between 4.15 and 4.59, that is, strongly acidic soils, not very productive soils, because, in these lots, all the macronutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulfur), as well as micronutrients (Boron, Copper, Zinc, Iron, Molybdenum, etc.) are poorly available or assimilated by plants.

These soils have between 41.85 and 55.13 % of changeable bases, and between 44.87 to 58.15 % of changeable acidity with aluminum saturation between 43.08 and 55.51 %, which means that there is a high concentration of available aluminum, with the presence of iron phosphates, aluminum and manganese phosphates, which are little available or are poorly assimilated by plants. so it needs to make amendments with whitewash material such as dolomite or magnocal, to raise the pH and generate phosphates, monophosphates and diphosphates which are available.

When performing the analysis for treatment II, according to the results, the degraded ex-cocal soils with planting of Inga edulis "huaba" of 2 years of age, improvements begin to be seen, in which it is appreciated that the three soil samples continue to be strongly acidic with pH between 4.51 and 4.91, that is, poorly productive soils. because in these batches all the macronutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulfur), as well as the micronutrients (Boron, Copper, Zinc, Iron, Molybdenum, etc.) are little available or assimilated.

These soils have between 53.27 to 59.30 % of changeable bases, and between 40.70 to 46.73 % of changeable acidity with aluminum saturation between 37.63 and 43.78 %, which means that there is a high concentration of available aluminum, with the presence of iron phosphates, aluminum and manganese phosphates, which are not assimilable, so it is necessary to make amendments with whitewash material such as dolomite or magnocal, so that when the pH rises, phosphates, monophosphates and diphosphates are generated, which are available or assimilable, these improvements in the soil are still not enough for them to be used in agricultural activities.

For treatment III, and according to laboratory results, for plots with degraded ex-cocal soils with 4-year-old planting of Inga edulis "huaba" are also acidic soils but in this case the pH fluctuates between 5.08 to 5.20, that is, soils that are little to moderately productive, because in these lots all the macronutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur), as well as micronutrients (Boron, Copper, Zinc, Iron, Molybdenum, etc.) are little to moderately available or assimilable to carry out agricultural activities in the crop.

These soils have between 74.14 and 83.39 % of changeable bases, and between 16.61 to 25.86 % of changeable acidity with aluminum saturation between 14.95 to 25.20 %, which means that there is a moderate to high concentration of available aluminum, with the presence of iron phosphates, aluminum and manganese phosphates, which are poorly assimilated by plants. so it also needs to make amendments with liming material such as dolomite or magnocal, at intermediate doses so that when the pH rises and more phosphates, monophosphates and diphosphates are generated which are available to the plants.

Similarly, for treatment IV, plots with degraded ex-coca soils with 6-year-old Inga edulis "huaba" planting have a pH between 5.63 and 6.11, that is, slightly acidic where the soils are productive, because in these lots all the macronutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulfur), as well as the micronutrients (Boron, Copper, Zinc, Iron, Molybdenum, etc.) they are available or assimilable by plants, especially in production; because these soils have 100% changeable bases, and 00% changeable acidity, which means that there is the presence of phosphates, monophosphates and diphosphates which are available or easily assimilated by plants in the performance of agricultural activities.

Table 1 shows the analysis of variance and indicates that there are statistically significant differences between the 4 treatments applied for OM and P for a level of 1%.

Table 1. Analysis of variance

		Sum of squares	Gl	Quadratic mean	F	Gis.
MO	Between groups	14,228	3	4,743	10,478	0,004
	Within groups	3,621	8	0,453		
	Total	17,849	11			
N	Between groups	7,909	3	2,636	0,896	0,484
	Within groups	23,531	8	2,941		
	Total	31,440	11			
P	Between groups	24,293	3	8,098	18,307	0,001
	Within groups	3,539	8	,442		
	Total	27,832	11			
K	Between groups	8023,171	3	2674,390	5,007	0,030
	Within groups	4273,004	8	534,125		

	Total	12296,175	11			

Duncan's test corroborates what was reported in the analysis of variance where organic matter presents significant differences, where it also indicates that treatments II, III, and IV, that is, degraded ex-coca soils with planting of Inga edulis "huaba" of 2, 4 and 6 years show higher averages, but these treatments do not show differences in their averages, being superior to treatment I, degraded ex-cocal soils without sowing of Inga edulis "huaba", which presented the lowest average and showed different behavior from the other treatments.

Duncan's test corroborates what was reported in the analysis of variance where phosphorus shows significant differences, where treatment IV presented a higher average very different from the treatments of II and III years, that is, the degraded ex-cocal soils with Inga edulis sowing "huaba of 6 years of sowing is the one that presented the highest average, very different from the treatment with degraded ex-cocal soils with sowing of Inga edulis "huaba" of 2 and 4 years of planting, these last two treatments do not show differences in their averages. Treatment I, degraded ex-cocal soils, presented the lowest average and very different behavior from all the treatments evaluated.

Duncan's test corroborates those reported in the analysis of variance where potassium showed statistical differences at a level of 5%. Where treatment IV, degraded ex-coca soils with planting of Inga edulis "huaba" presented a higher average very different from all treatments. Treatments I, II, and III, degraded ex-coca soils without planting of Inga edulis "huaba" and with planting of "huaba" of 2 and 4 years, showed the same behavior.

Duncan's test corroborates what was reported in the analysis of variance where nitrogen did not show statistically significant differences between the treatments evaluated, presenting the same behavior between them; these results are corroborated with Duncan's test. However, numerically treatment I, degraded ex-coca soils without planting of Inga edulis "huaba" presented a higher average compared to the other treatments.

When making the contract and according to the result, it can be determined that there are significant effects on the economic valuation in the recovery of degraded ex-coca soils, so the general hypothesis is accepted.

Meza et al. (2006) regarding soil indicate that high levels of aluminum (toxic element in the nutrition of the vast majority of plant species) and low levels of nutrients (nitrogen, phosphorus and exchangeable bases) are important indicators of degradation. Other relevant indicators are the deterioration of the soil structure, expressed as the low capacity for moisture infiltration, aeration and high resistance of the soil to penetration; the low levels of organic matter and the composition of the macrofauna, in the present work we agree with what has been stated where the analysis of the soils of the ex-coca plots shows the low levels of macronutrients, the high content of aluminum and the structure of the soil and how the planting of Inga edulis "Huaba" increases macronutrients, decreases aluminum levels and changes the soil structures that make these degraded ex-coca soils recover over time and can be used in agricultural activities.

Action Network on Alternatives to the Use of Agrochemicals – RAAA (1999), indicates that soil degradation is the loss of its capacity to fulfill its functions as a means for plant growth, as a regulator of the water regime and as an environmental filter. Unfavourable changes in the physical, chemical and biological properties of the soil have negative effects on crop productivity and environmental quality. Likewise, chemical degradation includes the modification of the mineral balance, reduction of the cation exchange capacity, salinization and alkalinization, soil acidity, aluminum and manganese toxicity, nutrient deficiency and accumulation of toxic compounds. For the present work, we coincide with what has been stated where when doing the respective analysis of the soil samples of the ex-coca plots, it is possible to appreciate the deterioration of their properties and how they change in the recovery process thanks to the planting of Inga edulis "huaba"

Meza et al. (2006) indicate that the technologies to recover degraded areas mainly for the lowland forest have been mainly reforestation and agroforestry systems with a series of variants in terms of species and spatial arrangements. Where a mixture of tree species have been used and some legumes are reported, including the "tornillo", "ishpingo", "pashacos" among others, identifying species with aptitudes for degraded areas; the design of appropriate agroforestry systems to generate income and protect the environment in degraded areas. For the present work, it is agreed that the planting of legumes, especially

the tree legume species, allows us to recover degraded soils, as is the case of the planting of Inga edulis "huaba", where the results of the analyses show the recovery of degraded ex-coca soils.
Meza et al. (2006) made a list of the most commonly used tree species to recover degraded areas in the Peruvian Amazon, where they report Inga edulis "huaba", Inga feuillei "pacae" and among other tree legumes, as soil improvers, their usefulness as shade, and living barriers, agreeing with what can be seen in the present work where the recovery of degraded soils of former coca crops with the planting of Inga edulis "huaba" in different years of planting and how the entire soil structure and the presence of macronutrients gradually change, which makes them can be used again in agricultural activities.
Reynel (2003) states that Inga edulis C. Martius "huaba" has a high potential for the recovery of degraded soils; its growth is very fast and provides a large amount of leaf litter and organic matter. It is excellent for revegetating areas where the vegetation cover has been roughened, as it facilitates the subsequent establishment of trees that are more demanding in soil quality. The rate of biomass generation in this species is high, and averages of 25 t/ha/year are recorded, coinciding with this research, since the recovery of degraded ex-coca soils can be seen with the planting of Inga edulis "huaba" and the contribution of organic matter to these soils.
Rangel et al. (2013) state that scientific research has gained great strength in the relationship between the economy and the environment, especially the quantification of the value of the latter's components (Gómez, 2002). Although some natural resources have a market price, this price does not contemplate in most cases, the wide variety of environmental functions that add a greater economic value, the latter generally underestimated when making decisions related to their management. Coinciding with what has been stated since for the present research the economic value of the influence of Inga edulis is reported "huaba in the recovery of degraded soils, often dismissed since more importance is given to products valued in the markets and that are disregarded when making decisions.
Castiblanco (2003) indicates that the economic valuation, proposed by environmental economics, consists of assigning monetary values to the goods, services or attributes provided by natural and environmental resources, regardless of whether or not they have a market, for the present work it coincides with what has been stated where there is an economic valuation in the process of recovery of degraded ex-coca soils through the planting of Inga edulis "huaba" in the incorporation of NPK macronutrients and that when making the calculations and assigning market values the economic valuation of Inga edulis "huaba" is obtained, it should be noted that this economic valuation is partial, since for the work other values are not considered, such as the value of direct uses for the value of the firewood and the fruits that are commercialized, and the economic value for environmental services is not considered either, which are many

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