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Sustainability of cacao farms in the district of Huicungo (San Martín, Perú) with the "rapid agroecological method"

Sustentabilidad de fincas cacaoteras en el distrito de Huicungo (San Martín, Perú) con el "Método Agroecológico Rápido"

Tuesta, O.[1]; Santistevan, M.[1]; Borjas, R.[1]; Castro, V.[2]; Julca, A.[1*]

*Corresponding author: ajo@lamolina.edu.pe

Abstract

This work was carried out with the objective to determine the sustainability of cocoa farms in the district of Huicungo (San Martín, Perú) by using the "Rapid Agroecological Method". The study was conducted in the San Martín region, province of Mariscal Cáceres, district of Huicungo. The zone has an annual precipitation of 1, 200 mm and an annual temperature of 30ºC. For the sustainability analysis, we selected "type farms" from each of the three groups found in the area. In each of these, indicators of soil quality and crop health were evaluated using values ranging from 1 to 10 (1: less sustainable, 10: more sustainable). With the collected data, Duncan Test ($p \leq 0.05$) was performed to determine the statistical differences between the "type farms". Results showed the evaluated cacao farms had values greater than five, therefore, they are sustainable. There were no statistical differences between the three "type farms" studied here.

Keywords: sustainability, farms, soil, health, cultivation**.**

Resumen

Este trabajo se llevó a cabo con el objetivo de determinar la sostenibilidad de las fincas de cacao en el distrito de Huicungo (San Martín, Perú) utilizando el "Método Agroecológico Rápido". El estudio se realizó en la región de San Martín, provincia de Mariscal Cáceres, distrito de Huicungo. La zona tiene una precipitación anual de 1,200 mm y una temperatura anual de 30ºC. Para el análisis de sostenibilidad, seleccionamos "fincas tipo" de cada uno de los tres grupos encontrados en el área. En cada uno de estos, los indicadores de la calidad del suelo y la salud del cultivo se evaluaron utilizando valores que van de 1 a 10 (1: menos sostenible, 10: más sostenible). Con los datos recopilados, se realizó la prueba de Duncan ($p \leq 0.05$) para determinar las diferencias estadísticas entre las "fincas tipo". Los resultados mostraron que las fincas de cacao evaluadas tenían valores superiores a cinco, por lo tanto, son sostenibles. No hubo diferencias estadísticas entre las tres "fincas tipo" estudiadas aquí.

Palabras Claves: sustentabilidad, fincas, calidad, suelo, salud, cultivo**.**

Introduction

The sustainability of agriculture can be defined as the capacity of an agroecosystem to maintain the quality and quantity of natural resources in the medium and long term, reconciling agricultural productivity with the reduction of impacts on the environment and considering social needs of rural communities (Brown, 1987 cited by Zinck et al., 2004). Other authors, cited by Gómez-Limón et al. (2011), define sustainable agriculture as the one that promotes food security, conserves natural resources, protects the environment and is economically viable. To evaluate sustainability, the use of mathematical models, time series, indicators, among others have been suggested (Gómez-Limón et al., 2011). According to De Muner (2011), sustainability evaluation studies of production systems that use indicators turned out to be an effective tool for evaluating the ecological, economic and social sustainability of agricultural production systems, as in the case of the family production system of Arabica coffee in Espírito Santo in Brazil. Meza and Julca (2015) have also used indicators to evaluate cassava cropping systems in Cusco, Perú. Recently, they have also used indicators in Ecuador to evaluate productive units in the Amazon (Bravo-Medina et al., 2017). But there are also authors who indicate that sustainability indicators, in general, cannot be considered universal, and due to the way of inferring the conditions of an agroecosystem, they are not commonly used by farmers (Gómez et al., 1996, Masera, 1999). There are other methodologies that allow the comparison of farms sustainability independently

[1]Departamento de Fitotecnia, Facultad de Agronomía, Universidad Nacional Agraria La Molina, Av. La Molina s/n, Lima 12, Perú.

[2]Facultad de Ciencias, Universidad Nacional Agraria La Molina, Av. La Molina s/n, Lima 12, Perú.

from the existing situations. For example, Altieri and Nicholls (2002), proposed a rapid agroecological method for sustainability evaluation of coffee plantations and has been used by Merma and Julca (2012) to evaluate the sustainability of diverse production systems in Cusco (Perú). However, this method only evaluates the quality of the soil and the health of the crop, and it does not consider the three dimensions of sustainability (Márquez and Julca, 2015). But it is a relatively simple tool, its use can be extended and its practicity widespread between farmers and field technicians, especially for preliminary studies of sustainability of agricultural production systems.

In Peru, cacao (*Theobroma cacao*) is a crop of great importance and there are several regions that have edapho-climatic conditions that favor the development of this crop, as is the case of San Martín (Arévalo et al., 2004). The crop is grown under shade in agroforestry systems, associated almost exclusively with small producers and has always been used in alternative development programs in coca-growing areas. This work was carried out with the objective of knowing the sustainability of cacao farms in the district of Huicungo (San Martín, Peru) with the "rapid agro-ecological method".

Materials and Methods

This study was carried out in the middle part of the sub-basin of the Huayabamba River, located in the San Martín region, province of Mariscal Cáceres, Huicungo district. The area is a tropical humid forest (bh-t), with an average annual rainfall of 1,200 mm, an average annual temperature of 30°C, a maximum annual average of 35°C, and the minimum annual average is 23.2°C. For the sustainability analysis, we selected three "type farms" from each of the three groups that exist in the area. Group I (68% of the farms), is characterized by developing other activities parallel to the cultivation of cacao, has a conventional production system, with polyclonal plantations and a yield of 963 kg/ha. Group II (13% of farms) basically has organic production farms, where hybrid plantations associated with CCN51 predominate, with a yield of 623 kg/ha. In group III (19% of the farms), monoclonal plantations exist using only CCN-51, with a yield of 933 kg/ha (Tuesta et al., 2014). Studies using "type farms" have been carried out by Salazar (2012), Collantes (2016) and Santistevan et al. (2017). Indicators of soil quality and health of the cacao crop were evaluated in each of the "type farms". Each indicator can have values ranging from 1 to 10, with 1 being the least sustainable value and 10 the most sustainable value. The valuation given to each indicator was validated with producers and professionals with experience with this crop. The indicators used in the present study were obtained from the proposal of Altieri and Nicholls (2002) and Araujo et al. (2008). Details are shown in Table 1. With the collected data, a Duncan Test ($p \leq 0.05$) was performed to determine the statistical differences between the "type farms". Subsequently, amoeba graphics were made for soil quality and crop health.

Results and Discussion

***Soil quality*—**In general terms, a different behavior of soil quality was found in each "type farm"; but type II, had higher values for half of the indicators evaluated as CS3 (color, smell and organic matter), which logically is related to CS4 (moisture retention), CS6 (lower risk of erosion), CS7 (structure) and CS10 (microbial activity). This is important, because the physical properties of the soil and the organic matter content of the soils are the variables with the greatest contribution to the integral fertility, suggesting an adequate physical and biological condition, which helps the penetration and development of roots. Hence, they favor the use of nutrients and water in the soil (Power, 2010, Viana et al., 2014, Bravo et al., 2015, cited by Bravo-Medina et al., 2017). The structure and moisture retention are favored by the presence of organic matter (Julca et al., 2006). Soil quality had average values greater than five, although practically similar to each other (6.99, 7.04 and 6.97, for "type farms" I, II and III, respectively), so there were no statistical differences between them, as shown in table 2 and illustrated in figure 1. These results are explained as a response to the fact that cacao cultivation is mainly developed under an agroforestry system, being the one that most resembles a natural forest (Müller, 2006). Somarriba (2006), points out that agroforestry systems promote the conservation and fertility of soils, besides being the best form of land use in tropical climates (Lobão et al., 2004) and recommended for organic production. Other authors state that organic production has a positive impact on soil quality, on the amount of microorganisms (Hole et al., 2005) and can reduce soil erosion (Arnhold et al., 2014). Larrea (2007) and Araujo et al. (2008), report a partial sustainability in agroforestry systems with cocoa using indicators for the soil.

***Crop health*—**It was different in each "type farm". Farm type I, had higher values for most of the indicators studied, with the exception of SC3 (damage incidence) and SC7 (management system), which was better for type III and II, respectively. The average values were greater than five, although the "farm types" I (6.56) and III (6.28) were statistically superior to type II (5.76). But, there are still some aspects that can be improved by performing some cultural activities that could improve the performance of the crop in general, as shown in Figure 1. For example, Pria and Camargo (1997), point out that pruning is one of the ways to control many diseases in the cultivation of cacao. In other crops of the tropics, such as coffee, its effect has also been demonstrated to reduce the incidence levels of rust (Rafael-Rutte et al., 2014). The development of suitable technological practices and their application by the grower helps to improve yield and quality of cacao (PROAMAZONÍA, 2003). The potential of cacao will be exhibited by using profitable and sustainable technologies to guarantee the livelihood of the grower now and in the future (IICA, 2006).

Tabla 1. Indicators for the rapid evaluation of cacao farms in Huicungo (San Martín, Perú)* considering soil quality and crop health

Indicator	Established value	Characteristics
Soil quality (SQ)		
SQ1. Compaction	1	Compacted soil
	5	Thin compacted layer
	10	No compaction
SQ2. Soil depth	1	Exposed subsoil
	5	Thin superficial soil
	10	Superficial soil >1m
SQ3. Organic matter color	1	Pale, no presence of humus
	5	Light brown, some presence of humus
	10	Dark brown, abundant humus
SQ4. Moisture retention	1	Dry soil, does not hold water
	5	Limited moisture level available or short time
	10	Reasonable moisture level for a reasonable period of time
SQ5. Soil cover	1	No cover, 100% exposed
	5	Less than 50% soil covered by residues
	10	More than 50% soil covered by residues
SQ6. Erosion	1	Severe erosion
	5	Low erosion signs
	10	No visible signs of erosion
SQ7. Structure	1	Loose, powdery soil without visible aggregates
	5	Few aggregates that break with little pressure
	10	Well-formed aggregates – difficult to break
SQ8. Status of residues	1	Slowly decomposing organic residues
	5	Presence of last year's decomposing residues
	10	Most residues well-decomposed
SQ9. Presence of invertebrates	1	No signs of invertebrate presence or activity
	5	A few earthworms and arthropods present
	10	Abundant presence of invertebrate organisms
SQ10. Microbiologic activity	1	Very little effervescence after application of water peroxide
	5	Light to medium effervescence
	10	Abundant effervescence
Crop health (CH)		
CH1. Appearance of the crop	1	Chlorotic, discolored foliage with deficiency signs
	5	Light green foliage with some discoloring
	10	Dark green foliage, no signs of deficiency
CH2. Crop growth	1	Uneven stand; short and thin branches; limited new growth
	5	Denser. but not uniform stand; thicker branches; some new growth
	10	Abundant branches and foliage; vigorous growth
CH3. Damage incidence	1	Susceptible, more than 50% of plants with damaged leaves and/or fruits
	5	Between 20-45% plants with damage
	10	Resistant, with less than 20% of plants with light damage
CH4. Insect pest incidence	1	More than 15 leafhopper nymphs per leaf, or more than 85% damaged leaves
	5	Between 5–14 leafhopper nymphs per leaf, or 30–40% damaged leaves
	10	Less than 5 leafhopper nymphs per leaf, and less than 30% damaged leave
CH5. Actual or potential yield	1	Low in relation to local average
	5	Medium, acceptable
	10	High, above average
CH6. Vegetational diversity	1	Monoculture
	5	2-3 clones with low number of tree species
	10	More than 5 clones and more than 10 tree species

Continuation table 1

CH7. Management system	1	Conventional
	5	In transition to organic with IPM or input substitution
	10	Organic, diversified with low external biological inputs
CH8. Harvest residue	1	Not using them, put them where harvest ocurred
	5	Residues are collected, but not use them
	10	Uses all residues, humus is produced

*Adapted from de Araujo et al., (2008), and Altieri and Nicholls (2002)

Table 2. Soil quality of "type farms" with cacao in Huicungo (San Martín)

Indicators	Type farms I	Type farms II	Type farms III
Compaction	7.80	7.40	7.20
Soil depth	6.40	6.20	6.60
Color, odor, ad organic matter	5.50	6.20	5.80
Moisture retention	8.60	9.10	8.80
Soil cover	7.20	6.50	7.10
Erosion	5.20	6.20	5.80
Structure	6.50	7.40	7.00
Status of residues	7.40	6.10	7.20
Presence of invertebrates	7.80	7.10	7.20
Microbiological activity	7.50	8.20	7.00
Average soil quality	6.99 a	7.04 a	6.97 a

Same letter indicate significative difference, according to Duncan test ($p \leq 0.05$)

Table 3. Crop health of "type farms" with cacao in Huicungo (San Martín)

Indicators	Type farms I	Type farms II	Type farms III
Appearance	6.2	6	6
Crop growth	7.8	7.1	7.8
Disease incidence	8.5	7.5	8.9
Insect pest incidence	7.4	5.2	7
Actual or potential yield	9.2	6	9
Vegetational diversity	5.4	4	3.5
Management system	3	6.7	3
Harvest residues	5	3.6	5
Average crop health	6.56 a	5.76 b	6.28 a

Same letter indicate significative difference, according to Duncan test ($p \leq 0.05$)

If we do the exercise of obtaining the average for each farm [(CS + SC) / 2], we obtain values of 6.8, 6.4 and 6.6 for farms type I, II and III, respectively. The three groups exceed the value of five, considered as the "threshold of sustainability" (Altieri and Nicholls, 2002), meaning that all cacao farms evaluated with the "rapid agro-ecological method" can be considered sustainable. This can be explained due to the work conducted for years in the San Martin region with the cultivation of cacao since the development of sustainable production systems implies a continuous adaptation to local or regional socioeconomic and ecological circumstances (Nieto and Caicedo, 2012).

The method used in the present study is relatively simple and can be used by farmers and field technicians, especially for preliminary sustainability studies of agricultural production systems. Because sustainability studies should have a broader criterion always considering the three dimensions of sustainability (Márquez and Julca, 2015).

Conclusions

Using the "rapid agro-ecological method", the cacao farms of Huicungo (San Martín) are sustainable. The method is relatively simple and can be used especially for preliminary sustainability studies of agricultural production systems.

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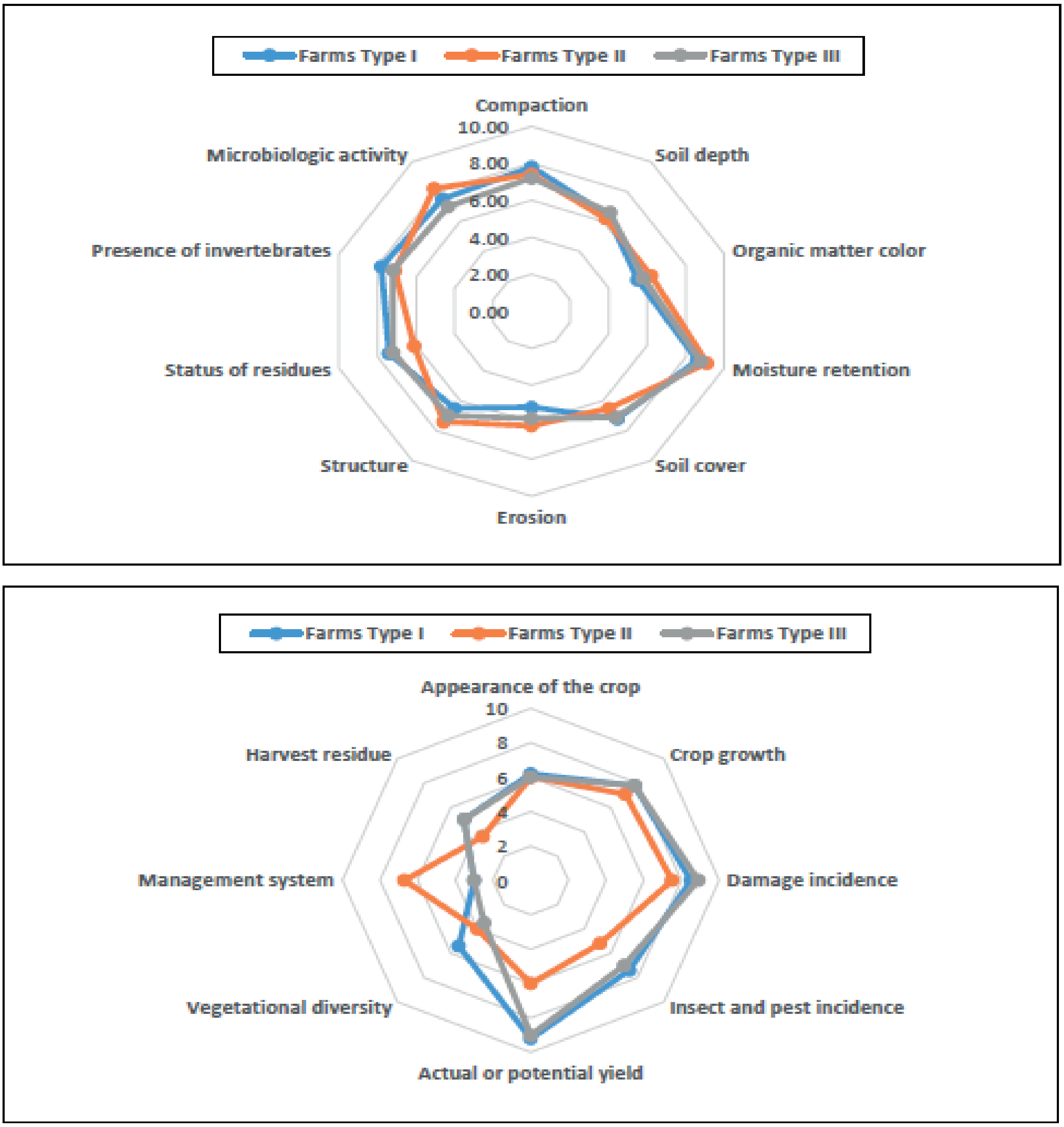

Figure 1. Soil quality (top) and crop health (bottom) of cacao farms in Huicungo (San Martín)