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Compatibility of Ancestral and Innovative Agricultural Practices in the Kankuamo People of Colombia

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Abstract: The agricultural practices of the ancestral Latin American peoples hardly lead to optimal productivity integrated with adequate management of resources. This work evaluates the compatibility between the ancestral practices of the Kankuamo community in the vulnerable ecosystem Sierra Nevada de Santa Marta, Colombia, and innovative practices by the [AGROSAVIA] Colombian Agricultural Research Corporation, in biofortified beans of high nutritional value in the face of malnutrition and scarcity of the community's own food. Methodologically, surveys were carried out that identify sustainability tracers and microbiological analysis of soils and the association among the variables evaluated. The results identify the incidence of education, health, self-care, gender and food supply in this vulnerability, verify the exclusion of agrochemicals in production, and show the need for a strategy of technological adoption with a differential approach.

Keywords: Own food, sustainability tracers, ancestral and innovative practices, differential technology transfer.

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Introduction

Microdata from the 2014 National Agricultural Census (DANE, 2017) register 8,805 production units in the Kankuamo indigenous territory from Sierra Nevada in Santa Marta [SNSM] in Colombia, of which 83.93% cultivate associated, permanent, and transitory crops. The permanent crops highlight, coffee, avocado and cocoa, and the transitory crops include yucca, bean, pumpkin, and chili pepper. The population from the reservation rises to 11,855 people of which 29.9% corresponds to those under 14 years of age and 63.7% to ages between 15 and 64 years; likewise, there is an illiteracy index of 7.7% and 90.9% ignore their native tongue (DANE, 2019). Additionally, severe global malnutrition prevails in infants (BUSTOS; ARDILA, 2016), which encourages research centers to make technological linkage with varieties of higher nutritional value (TOFIÑO et al., 2016a).

This exhortation is affected by the problem evidenced not only in this ancestral people, but in other indigenous communities of Colombia and Latin America in general, related with shortage of own foods, a situation that becomes more critical against the outstanding indisposition of the ethnic communities toward innovation and institutional agricultural technological offers. Due to this, few studies tend to promote own crops, with high nutritional levels for which agroecological processes are developed that facilitate the conservation and comprehensive strengthening of ecosystems, which is the purpose of this study.

The Kankuamo people are located in an ecoregion that concentrates high indices of biodiversity and linguistic wealth (ORTIZ, 2015), with registries of environmental deterioration due to anthropic activity (HUERTAS et al., 2017), high susceptibility to climate change and variability (HOYOS et al., 2019), and serious barriers of access to technological innovation available to mitigate the impact of environmental changes on the family productivity (SANABRIA, 2017). Nevertheless, they have processes of indigenous resilience that include self-management, self-organization and innovation strategies prioritized autonomously (PINTON; CONGRETEL, 2016), as the case of the Association of Kankuamo Indigenous Agri-ecological Producers from Sierra Nevada in Santa Marta, SNSM, [ASOPROKAN], registered in the list of coffee operators from the National Control System for ecological production (Ministerio de Agricultura y Desarrollo Rural [MADR], 2007, 2017). This social fabric could be key within the context of food autonomy to articulate new varieties of biofortified beans, highly nutritious own crop, a system of agroecological production that maximizes the edaphic benefits of legume crops (MAKATE et al., 2019). The aforementioned, bearing in mind the vulnerability of the soils from the Colombian dry Caribbean whose desertification and degradation reaches 75% (Ministerio de Ambiente y Desarrollo Sostenible [MADS], Instituto de Hidrología, Meteorología y Etudios Ambientales [IDEAM] and Universidad de Ciencias Aplicadas y Ambientales [UDCA], 2015).

Varieties of biofortified beans with highest concentration of iron, zinc, and tolerance to climate variability (ROZO et al., 2019) are obtained to improve the nutritional conditions of communities whose food availability is associated with rain cycles and

which, hence, endure food insecurity during periods of minimal rainfall (TOFIÑO et al., 2016a). However, agroecological production systems of the biofortified bean crop are yet to be developed in this zone, where soil management is critical due to the soil's tendency to degradation (ROMERO et al., 2011). The previously stated leads toward the characterization of the family agricultural production of the Kankuamo community, from the focus of sustainability indicators, to identify actions that contribute to their ecological production in harmony with their cosmogony.

2. MATERIALS AND METHODS

2.1 Location and general characteristics

The study was conducted principally in the reservation of the Kankuamo indigenous people, also called Kankuaka or Kankuí, located in the township of Atánquez, municipality of Valledupar (department of Cesar), with altitude ranging between 600 and 1,300 masl, with mean precipitation of 1,400 mm annually and geolocation (10°28´00.25" N, 73°15´04.53" W) (ORTIZ et al., 2015). It was also carried out in the township of María Angola, Municipality of Pueblo Bello (department of Cesar) to reference data outside the reservation.

The Kankuamo people call themselves "guardians of the global equilibrium"; they comprise one of the four ancestral ethnicities settled in the SNSM, Colombia, –Kankuamo, Arhuako, Cogui, and Wiwa–, recognized by them as "The Heart of the World". It is a people that guides the passing of their lives by the "Law of Origin" characterized by the continuous search for "good living" through the conservation of their way of life of their pre-Hispanic ancestors, the original people of America.

The agri-food production model of the Kankuamo people is characterized by the development of ancestral production practices whose processes clash with the technological offers from the Colombian Corporation for Agricultural Research – [AGROSAVIA, for the term in Spanish]. Specifically, this confrontation is evidenced in the promotion this institution grants to cultivating biofortified beans, of great nutritional benefits, on the face of malnutrition and shortage of own food endured by the ethnic community settled in a highly vulnerable ecosystem due to its geographic position and climate variability (HUERTAS et al., 2017). It is a degraded and vulnerable ecosystem to which they initially arrived forced by the Spanish invaders and, later, pressured by harassment from settlers. This vulnerability, together with the malnutrition detected and the application of production practices that generate negative environmental impacts, makes it necessary to adopt strategies that promote the conservation of their production resources without altering their recognized autonomy and much less their cosmogony.

2.2 Population and sample

The universe is constituted by all the production units, from which a representative sample was selected, derived from a non-probabilistic sampling by expert selection and referral in which the indigenous technicians from ASOPROKAN indicate the families with typical agricultural production and with lots from 5 - 10 years of production history (OTZEN; MANTEROLA, 2017) as candidates to be consulted. Finally, a sample was obtained of 19 agricultural production units in which the unit of research for the quantitative analysis is the family, the information unit may be the father, the mother or the head of household, whichever is the case, and the socio-spatial unit of analysis is the parcel (PIMIENTA, 2000). Given the need to define the compatibility between the edaphic fertility and the nutritional needs of beans, the study excluded as estimators of the range of fertility present in the SNSM ecoregion, soil analyses from the township of María Angola in the municipality of Pueblo Bello, given that they are outside the reservation.

2.2 Evaluation of sustainability tracers

The work includes three stages: 1) registration and particular definition of the reality to evaluate, 2) definition of the expressions that permit its systematizing and conceptual elaboration of the findings, and 3) analysis of the results and conclusions, presented through statistical analysis, triangulation, and contextualization, in accordance with RODRÍGUEZ et al., (2005). Regarding the sustainability tracers, in accordance with FLORES and SARANDÓN (2009), the repository of the Latin American Scientific Society of Agroecology [SOCLA, for the term in Spanish], the work includes 123 indicators distributed into six components: social, cultural, political, agricultural, livestock, and economic. The proposed purification of the sustainability tracers from the referred survey, applied in this exploratory study, has as base an academic exercise developed by Fabio Luis Jaramillo Vallejo, PhD student in Agroecology at Universidad de Antioquia [UDEA] in Colombia. Soil quality indicators identified by NICHOLLS and ALTIERI (2002) are also considered; these were developed through key questions via semi-structured interviews and Likert scales. To systematize the information, matrices were built per component, analyzed through descriptive statistics, correlations and hierarchical clusters. Amoeba graphs correspond to the sustainability tracers grouped into components, which present the average responses from each group of producers.

2.3 Evaluation of soils

Soil analysis were conducted in 21 lots cultivated with coffee associated with beans to learn the fertility in the SNSM region and its compatibility with the legume's nutritional requirements (19 in Atánquez, 1 in María Angola and 1 in Pueblo Bello). Microbiological analyses were also performed of the principal functional groups in bean rhizosphere from different locations of the dry Caribbean, including Atánquez. The work collected 500 g from five points of random sampling in X form in each lot, with 15-cm depth (microbiological analysis) and 30-cm depth (chemical analysis). Composite samples were standardized, packed in hermetic bags and transported, with refrigeration of 4 °C,

to the analysis laboratory. To measure microbiological variables, the samples were sent to Universidad Popular del Cesar. Mesophilic bacteria, fungi, and actinomycetes were counted in each sample, using the serial dilutions technique and sowing in depth with 20 ml of agar medium in a Petri dish, which are expressed in colony forming units per gram of dry soil (CFU/g of soil). The quantification of fungal genera is performed through macro and microscopic observation, as well as with taxonomic keys according to the protocol by MENA et al., (2018). The chemical analysis of the soils was carried out in the Soils Laboratory at AGROSAVIA in Bogotá (AGROSAVIA, 2017). The indicators determined are: available phosphorus (Bray II); available potassium (Olsen method); pH (1:5 soil-water ratio potentiometer method); organic matter content (Walkley-Black modified), besides Fe, Mn, Cu, and Ca, measured according to the methods described in the Soils Manual from the Agustín Codazzi Geographic Institute [IGAC, for the term in Spanish] (IGAC, 2006).

2.4 Analysis of association

This was performed from the 123 variables included in the instrument of sustainability tracers for each of the 19 Kankuamo agricultural production units. The Spearman (Rho) association method was applied, recommended for ordinal or nominal variables, free distribution (not necessarily normal) and small samples (<30), it was also applied to the different indicators included in the soil fertility analysis. Bearing in mind that the correlation between two variables refers to the degree of joint variation existing between them, it is considered strong when it is significant at 0.01 and moderate at 0.05.

3. RESULTS

3.1 Evaluation of sustainability tracers

Most of the family agricultural production units (63%) have income fluctuating between one and three annual legal minimum wages, LMW, (without estimating self-consumption), 21% have lower income, and only 16% receive higher income. Work in the parcel is an activity complemented with other wage-earning activities, both in the same agricultural sector as in construction, commerce, and education sectors, or in independent sectors, like handicrafts, to support the household. With respect to studies completed, the results show that, effectively, the community has access to basic education and that it even achieves higher education, given that 58% of the households has at least one person who completed a career. Regarding soil management, the ecological practices reported in the surveys evidence crop rotations, polyculture, dead or living barriers, minimum tillage and crop distribution, and no land burning, agrochemicals, disposal of organic waste, and maintenance of the natural vegetation; however, the frequency of applying these practices is variable in reference to the level of schooling. In general, for the farm's production, the lunar cycles are usually consulted to schedule tasks.

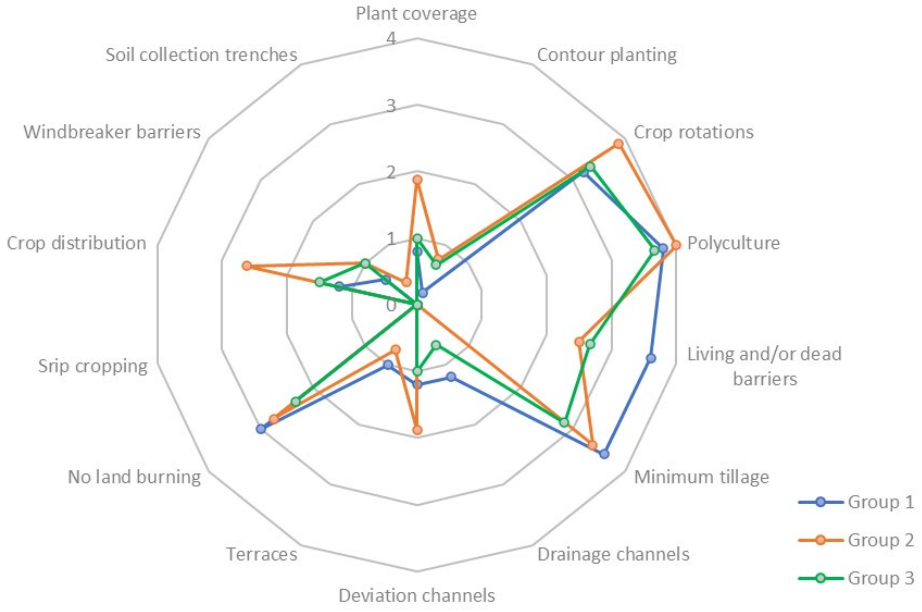
The peasant economy prevails in the households evaluated, where the participation

of women in supporting the household stands out, given that in 58% of the households, women share responsibilities with the father, and in 10% they are directly responsible for the home. In 21% of the cases, the father maintains the home and is responsible for the activities in the parcel; often with the family's labor. In the farm, women are frequently consulted to make decisions and tasks often involve the family members.

The cluster analysis generated three typologies in the agricultural family units from the results with sustainability tracers: Group 1 includes 26.3% of the households not reporting animal production because its interest focuses on the agricultural component to generate income; however, its indicators in the economic variables are low; Group 2 gathers 42.1% of the sample with the highest social and cultural variables of value with respect to the other two; finally, Group 3 includes 31.6% with the lowest indicators in the global level. A more-detailed revision of the behavior of the conservationist ecological practices –soil, hydric resource, sanitary management, and parcel administration– evidences that in Group 2, with the highest level of schooling, these are carried out with greater frequency and prolificacy (Figures 1 and 2).

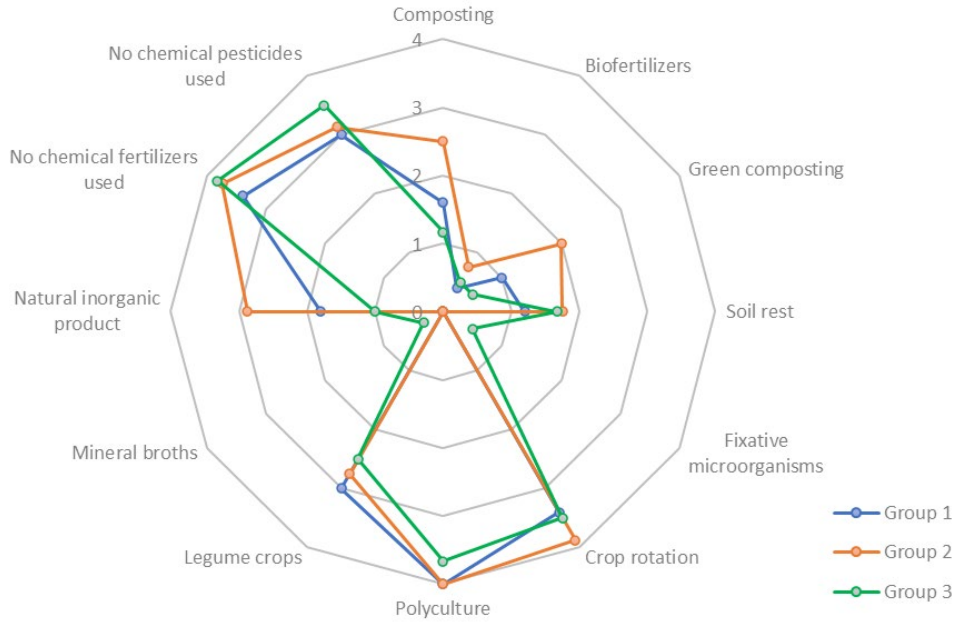
With respect to the management of the hydric resource, three ecological advantages are highlighted: no pesticides or chemical fertilizers are used and water waste is avoided, but they do not frequently carry out other practices, such as protection of water and the harvest, management of sewage or its treatment. Also, it is uncommon to see composting of manure for use as organic compost and rarely do the soils rest or are stone barriers built in sloping areas. This is evidenced in the results from managing the soil resource in which, of 14 practices consulted, only four are stated as quite frequent: crop rotation, polyculture, minimum tillage, and use of dead or living barriers.

Figure 1. Soil management by the Kankuamo community (Strip cropping)



Source: elaborated by the authors.

Figure 2. Crop fertilizer management in the Kankuamo community



Source: elaborated by the authors.

3.2 Evaluation of soils

Deterioration of the edaphic chemical fertility in farms with coffee in polyculture, which includes beans, is evidenced in the results from the soil analyses that show how the parcels included in the study have limitations in the nutritional balance for both crops. These results warn of the need to redesign the structure and function of the Kankuamo traditional agroecosystem, which permits maintaining biodiversity above and below the soil, which implies a high content of organic matter and maximizing the microorganism-mediated biological cycles; likewise, it implies optimized recycling of nutrients, biological activation of the soil, and water conservation (NICHOLLS et al., 2017).

The soils evaluated are characterized for having acid pH, high iron content, moderate organic matter (N of 0.23 g/100 g), and low content of phosphorus, magnesium, zinc and boron (Table 1). Given that the moderate level of organic matter limits the dynamics of edaphic microorganisms and maximization of the biogeochemical cycles, fundamental factor of ecological agriculture, it is suggested to promote practices that increase their content and the subsequent edaphic carbon storage, in accordance with recommendations by experts (ALTIERI; NICHOLLS, 2017).

Table 1. Physicochemical analysis of soils in two locations of Sierra Nevada de Santa Marta, department of Cesar

Element	pH	MO	Calcium (Ca)	Magnesium (Mg)	Potassium (K)	Phosphorus (P)	Iron (Fe)	Sulphur (S)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)	Boron (B)
Unit	p H	g /100 g	cmol (+) / kg			mg/kg						
Kankuamo reservation. Township of Atánquez, municipality of Valledupar (Department of Cesar)	6.0	1.8	6.41	1.47	0.15	95.28	36.11	4.05	< 1.00	< 1.00	1.38	0.33
	5.0	4.3	2.18	0.57	0.42	7.40	83.97	6.94	11.91	< 1.00	2.96	0.15
	5.7	4.6	2.99	0.69	0.28	12.49	57.30	3.71	2.89	< 1.00	1.01	0.15
	5.1	6.8	3.96	0.68	0.24	6.24	383.61	4.19	9.08	1.46	1.89	0.18
	5.5	5.7	6.09	0.48	0.28	8.61	49.63	7.90	9.40	< 1.00	< 1.00	0.40
	6.5	5.8	11.48	1.69	0.50	19.76	42.59	3.71	7.33	< 1.00	< 1.00	0.35
	5.2	3.3	1.39	0.59	0.30	4.59	62.55	5.00	51.43	< 1.00	< 1.00	0.25
	5.8	3.1	7.51	1.88	0.65	6.01	56.28	6.45	7.18	< 1.00	< 1.00	0.35
	5.3	5.7	1.44	0.85	0.36	5.39	252.86	6.13	8.11	< 1.00	1.69	0.30
	5.3	4.0	4.57	0.84	0.35	7.24	53.26	8.06	19.13	< 1.00	< 1.00	0.20
	5.0	7.0	9.80	1.77	0.30	14.20	237.05	9.19	96.67	3.83	< 1.00	0.38
	5.2	6.4	4.80	1.72	0.48	10.42	234.15	5.97	10.04	3.16	2.04	0.38
	5.9	7.2	10.54	1.61	1.08	8.99	58.01	5.48	2.43	< 1.00	< 1.00	0.42
	4.6	5.1	2.57	0.84	0.28	12.94	225.10	10.32	51.38	1.80	1.78	0.33
	5.8	3.3	5.82	1.05	0.45	8.20	70.86	5.00	2.80	< 1.00	< 1.00	0.23
	5.5	2.7	7.59	2.38	0.43	6.26	50.93	5.97	23.21	< 1.00	< 1.00	0.25
	5.3	4.1	9.07	1.37	0.14	8.13	140.73	7.10	27.60	< 1.00	< 1.00	0.40
	6.1	6.5	15.61	2.24	0.43	7.10	54.32	7.58	28.13	< 1.00	< 1.00	0.40
	5.4	4.7	2.19	0.63	0.51	6.15	73.94	7.58	19.48	2.46	< 1.00	0.35
Township of María Angola Municipality of Pueblo Bello (Department of Cesar)	**4.7**	2.3	0.79	0.24	0.14	3.6	497	3.5	11	5	3.6	0.24
	6.0	2.8	6.6	1.67	0.33	48.6	31.3	2.09	6.0	1.2	3.0	0.37

Middle range. organic matter = 2-4%; Sulphur= 20 - 80 mg/kg; Phosphorus= 13 - 30 mg/kg; iron = 56 - 112 mg/kg; manganese = 28 - 112 mg/kg; copper = 1.7 - 3.4 mg/kg; zinc = 1.7 - 3.4 mg/kg; boron = 0.5 – 8.0 (micronutrients obtained with DTPA) (TOLEDO, 2016). Source: elaborated by the authors

Of the two locations evaluated in the SNSM, the Kankuamo reservation in the

township of Atánquez in Valledupar and township of María Angola, settlement of El Descanso in the municipality of Pueblo Bello, it is the settlement of El Descanso, located beyond the reservation limits, which shows the best fertility indicators (Table 1).

The fact that elements, like phosphorus, have average values of 9.01 mg/kg, below the recommended 15 mg/kg, evidences the need to add mineral or organic sources, given that biofortified beans are more demanding (TOFIÑO et al., 2016a); due to this, managing the soil's pH is essential for the plants achieving better efficiency by using this nutrient (TOLEDO, 2016). However, in addition to the amendments, the nutritional deficiencies identified can be supplied from the combination of mineral broths, green manures and compost, which increase the total organic matter content and neutralize acidity (NICHOLLS et al., 2017). Mineral broths, like "Visosa", also have fungistatic, bacteriostatic, and acaricidal effects, which improve soil fertility and the agroecosystem sanitation (FÉLIX et al., 2008). These management practices in the long term enhance the soil's chemical quality, specially of zero tillage and application of compost and manure, although the magnitude of the effect depends on climate conditions, soil texture, and duration of the practice (PECIO; JAROSZ, 2016).

In addition, the count analysis of the main functional groups of bean rhizosphere microorganisms suggests that, in general terms, the hillside soils evaluated, including in the Kankuamo reservation, have low population levels of bacteria, fungi, and actin, which are at the lower limit with respect to arid soils in other regions (Table 2). These low microbial levels and the diversity of fungi, as indicators of soil health, suggest depressed microbial activity that can affect not only nutrition, but also the crop's response to the biotic and abiotic constraints influenced by the plant-microorganism interaction (ACHARI; RAMEISH, 2018).

Table 2. Microbiological indicators of soils in different locations of the Colombian dry Caribbean

Location	% MO	pH	Bacteria CFU/g*	Fungi CFU/g*	Actin CFU/g*	Genera
Codazzi	2.27	6.07	1.6×10^7	1.8×10^4	3.0×10^5	4
Valledupar (Atánquez)	1.8	6.43	4.4×10^7	1.4×10^5	2.7×10^5	4
Manaure	3.64	6.08	3.5×10^5	1.3×10^4	1.5×10^4	6
Pueblo Bello	2.3	5.30	1.1×10^6	1.5×10^4	2.5×10^5	4
Tamalameque	1.07	5.58	1.1×10^6	1.3×10^4	2.2×10^4	3
La Jagua	0.81	5.45	1.9×10^6	1.1×10^4	1.7×10^4	2

Values for tropical soils: Bacteria 106-8 CFU/g; Actin 104-6 CFU/g Fungi 102-4 CFU/g (OGATA; ZUÑIGA, 2005). Source: elaborated by the authors

3.3 Analysis of association

The results analyzed permit stating that adequate soil management becomes a fundamental element to preserve the rural economy of the Kankuamo people and that a higher level of schooling of its inhabitants improves the management of the agricultural unit. Development of desirable practices, from the sustainability point of view, encourages using economic and financial calculations and permits greater understanding of ancestral knowledge for their application and reproduction by the institutional players.

According with the aforementioned, from Pearson's coefficient, the variables with significant correlation were identified for the level of schooling presenting as result a strong positive correlation for the variables for adapted and/or resistant species and determination of cash flow (Table 3). This allows affirming that households that improve their level of schooling increase their skills in administrative tools and pay more attention to selecting species with better yields in their crops.

Table 3. Correlational analysis of the variables of studies completed and annual income

Correlation between studies completed and their responses to the variables		
Rho	**Significance**	**Variable**
0.609**	0.006	Var 13. Management of animal manure
0.477*	0.039	Var 19. Contour planting
0.519*	0.023	Var 29. Crop distribution
0.465*	0.045	Var 30. Windbreak barriers
0.475*	0.040	Var 33. Biofertilizers
0.698**	0.001	Var 34. Green manures
0.751**	0.000	**Var 44. Adapted and/or resistant species**
0.560*	0.013	Var 45. Fertilization natural
0.494*	0.032	Var 51. Tool disinfection
0.664**	0.002	Var 66. Plant species adapted and/or resistant
0.606**	0.006	Var 93. Ancestral techniques and knowledge on conservation
0.456*	0.050	Var 94. Exchange of ancestral techniques and knowledge
0.704**	0.001	Var 102. Determination of production costs
0.765**	0.000	**Var 103. Determination of cash flow**
0.606**	0.006	Var 105. Work planning
0.692**	0.001	Var 106. Determination of productivity
Correlation between annual income of the production unit and responses to variables		
Rho	**Significance**	**Variable**

0.638**	0.003	Var 27. No land burning used
-0.482*	0.037	**Var 29. Crop distribution**
0.511*	0.025	Var 32. Composting
0.465*	0.045	Var 62. Management of organic wastes
0.505*	0.028	Var 97. Participation in social, community, or political groups
0.465*	0.045	Var 102. Determination of production costs
0.457*	0.049	Var 103. Determination of cash flow
0.679**	0.001	Var 104. Management of registries
0.499*	0.029	Var 106. Determination of productivity
0.532*	0.019	Var 108. The farm generates income

** The correlation is significant at 0.01 (bilateral).

* The correlation is significant at 0.05 (bilateral).

Source: elaborated by the authors.

Under the same line of thought, abandoning land burning as agricultural practice and managing registries are the variables that correlate most (moderately) with the farm's annual income. Generally, it should be expected that the economic, administrative, and financial variables are identified as important in the income, as well as participation in groups and associations, and basic management with use of agricultural wastes. In contrast, a weak negative correlation was found between income and crop distribution, given that, apparently, producers who do not delimit the areas for each of their crops on their farms receive a higher income (Table 3).

4. DISCUSSION

4.1 Evaluation of sustainability tracers

The socioeconomic characterization of the Kankuamo agricultural production units reflects novel elements with respect to prior studies, like high diversification of the family income in activities different from agricultural production and the increasingly leading role gained by women in supporting the family and participating in family decisions, aspects that coincide with that reported by ARIAS (2011) and MONTERO (2016). The previous panorama suggests that the premises of the new rurality permeate the reservation's way of life upon diversifying the economic activities of the production units toward non-agricultural sectors, as resistance strategy against the precariousness of the agricultural sector experienced not only in Colombia, but throughout Latin America, according with that reported by PITA et al., (2014).

Additionally, studying the indigenous agricultural systems provides important data for alternative production systems and their socioeconomic organization. According to ALTIERI (2018), stability is the constancy of production in a given set of environmental,

economic and management conditions, and the challenge is to evaluate the health of agroecosystems to guarantee balanced monitoring of productivity and ecological integrity. The ecological agricultural practices– derived from processes of innovation and technology transfer under the principles of the ecology– become alternatives that contribute to the sustainability of agroecosystems and management of natural resources. These consider the complexities of the local agriculture, in contrast to conventional extension mechanisms, which are driven by public policies associated with the Green Revolution (ACUÑA; MARCHANT, 2016).

Now, the Kankuamo production, in general, is quite affected, besides the bank loans, by fumigations of illicit crops with glyphosate, which affects negatively the food staple crops, medicinal plants, pigeon pea (bean) and coca, which is not used for illicit purposes, but in small domestic crops for traditional spiritual practices (ARIAS, 2011; MONTERO, 2016). Within this context, the results identify the spiritual authorities as the primary basis for consultation regarding cultivation decisions. According to the Kankuamo model, the entire agricultural cycle is part of the relation with mother Earth, the vegetable orchards in the houses, the land clearing that the family carries out and the other activities are a fundamental part of the construction of the social fabric and their very existence (MONTERO, 2016). For the crops to remain healthy for a long time and prevent plagues and diseases, it is not enough to follow technical protocols as thought in western culture, but it is also important to cure each activity with the due confession of the parcel, and to cultivate (normally their own seeds) due permission must be obtained from the spiritual fathers, dictated by their own cosmogony.

The Kankuamo Reservation also highlights the importance of training and raising awareness in the community on the management and treatment of wastes and protection of biodiversity with farms of native animals and endemic species to contribute to sustainable development (MONTERO, 2016).

Moreover, socioeconomic and heterogenous technical-productive bases were identified in the family agricultural units evaluated, configuring different typologies. Analysis of "producer typology" supports identifying the best technological linkage strategies and, at decision-maker level, planning of the investment and of inclusive public policies (SANGERMÁN et al., 2014). In this sense, the notion of producer typology constitutes an effective tool for decision making with respect to the possible strategies available to achieve organic horticulture, with soil management being one of the aspects with greatest dependence, especially for the conditions in the Colombian dry Caribbean (ORTIZ, 2018; Resolution 0187 of 2006; ROZO et al., 2019). Thus, it must be manifested that the Kankuamo community not only accepts the biofortified bean varieties, but also disseminates the seed to new beneficiaries in consideration that these constitute own food, according to their culture (ROZO et al., 2019), although legumes are also associated with the recovery of degraded or contaminated soils (MUJICA et al., 2006).

In the Caribbean coast in general, as in the Kankuamo reservation, the ancestral local production technology has some warning elements, like burning of the land that affect the soil quality, given that they impact the biodiversity of microorganisms and

organic matter content and generate erosion and deterioration of the edaphic fertility, in spite of their apparent stimulating effect of productivity in the short term (TOFIÑO et al., 2016b). In addition to the poor practices identified, the soils from SNSM are constitutively vulnerable not only because of their slope, but also because of their chemical nature and due to the aridity of the area of their geographic location, given that they are exposed to high temperatures that mineralize rapidly the organic matter and to the high speed of the trade winds from the northeast that intensify erosion processes (ORTIZ, 2018).

4.2 Evaluation of soils

Land burning, as agricultural practice, is conserved among indigenous groups in Colombia, in spite of identifying within the communities the notion of ecological affectation (HUERTAS et al., 2017). Also, studies in the low tropics indicate that land burning affects the dynamics of the microbiome at structural and functional levels, increases vulnerability to physical degradation and leaching of nutrients (COMBES et al., 2017). Although the results of the biomass of the principal microbial groups in soil from the Kankuamo reservation are within the averages reported in other studies from arid zones, the diversity of fungal genera is low (OGATA; ZÚÑIGA, 2005). This indicator of quality loss suggests the need to implement bio-stimulation practices of biological control agents, fungi and plant-growth promoting bacteria. These practices improve the availability of nutrients and water, control pathogens directly and indirectly, and stimulate the response of plants against infection upon activating their mechanisms of acquired systemic resistance (BARRERA et al., 2018).

A strategy to improve the physical, chemical, and biological characteristics of the soils from Sierra Nevada and contribute to mitigating the environmental impact from the local palm industry is the use of Biochar enriched with plant-growth promoters (JONES et al., 2010). Recent studies in the Colombian dry Caribbean suggest the relevance of using residues from the oil palm agribusiness, considered potentially contaminant, for the recovery of degraded soils, especially those affected by mining. These studies manage to increase the soil pH and diminish its toxicity through salts against the grass seed germination (DIAZ et al., 2017). Adding Biochar also increases cationic exchange capacity (CEC), pH, and availability of nutrients, like P, Ca, and K (GUNDALE; DELUCA, 2006; LIANG et al., 2006). Specifically, when inoculated with rhizobia and arbuscular mycorrhizae, it increases its recovery capacity for degraded soils in arid areas. (LEHMANN et al., 2011).

Another approach, beyond the technological aspects of crop management for the Kankuamo people, confessions and payments continue being an important part of a healthy crop, especially for the elders, who also recommend practices to manage plagues and diseases, among them: maintain natural vegetation, perform planting density calculations, and constantly monitor the crops for manual removal if necessary. Within this context, poor waste disposal, low contention of contamination sources, and deficient management of soils and sanitation of the agroecosystem require an improvement plan for ASOPROKAN to renew their certification as ecological operator, according with the

Colombian norm (Resolution 187, 2006; Resolution 199, 2016).

This environmental limitation may end up affecting commercial options in specialized markets for this indigenous community. In this sense, comprehensively, all the ancestral traditions reported in this document are linked with "good living", a term that indicates that in this territory all its models are aimed at the permanent search for a harmonious relationship with each other, with the community, living or dead nature, with the cosmos, the universe, and their spiritual beings (HUANACUNI, 2005; 2010; Medina, 2008).

4.3 Conclusions: analysis of association

- According to the contribution of the 123 sustainability indicators, included in the survey, for the variables of schooling and the farm's annual income, it is inferred that the production challenge in the dry Caribbean lies in the development of systems for ecological production. These must be, according to the particular characteristics of their vulnerable soils, in the scenario of an agro-chain with low articulation derived in good measure from depressed sociocultural conditions, also identified in the studies by COTLER et al., (2007).

- A general look at the management of the production system of the Kankuamo community permits concluding that soil conservation is compromised given that while they use slopes > 40%, no batch breaks are applied, and no compost, biofertilizers, green manures, natural inorganic products, or mineral broths are used.

- With respect to sanitary management, lack of biological controls and not using the eco-systemic potential of biodiversity, like allelopathic principles, repellents, use of entomopathogens, antagonistic microorganisms, parasitoids, natural predators, traps, and plant extracts identify irregular sanitary management in this community. The aforementioned agrees with the low index of innovation registered in the department of Cesar, where, according to ZAMBRANO et al., (2015), the agricultural sector does not have a regional production of bio-supplies.

- Technological linkage and sectoral policy activities in Colombia must be anchored in territorial baselines in which the types of producers are discriminated, according with their capacity to receive and apply the innovation and technological transfer available. This, because technological progress is directly associated with the industrial and economic development of each territory. Due to this, the regions with greatest economic development attract and congregate a higher percentage of the scientific and technological inputs, while regions whose economic activity is predominately traditional agriculture have limitations to generate, access and incorporate technological progress productively. Consequently, the Caribbean region in which the agricultural sector contributes significantly to the gross domestic product (GDP), requires with greater urgency the application of differentiated actions to maximize the efficiency of technological linkage resources, given the risk of perpetuating a divergent dynamic of technological progress among regions in the long term.

- Use of innovation is necessary to generate alternative production systems, which include biotechnological and information technologies—, according with the resources available in each production unit, to achieve a coherent relation among technology, market, and environment. The foregoing becomes more relevant in the scenario of climate variability endured by the Colombian dry Caribbean in which bean exploitation is highly vulnerable under the conventional production scheme and offers greater resilience under the premodern production scheme (PÉREZ et al., 2019). However, the standards of organic horticulture and compliance with the norms of its certification system requires the producer's empowerment on using the technique and knowledge to minimize the environmental impact of the production. Given that innovation begins and ends with understanding the producer's rationality, in this case, it is innovation that does not clash with the cosmogony of the Kankuamo people.

Conflict of interests

The authors declare having no conflict of interest.

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SciELO

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Diego Armando Ospina Cortés
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Artigo Original

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Palavras-chave: Comida própria; rastreadores de sustentabilidade; práticas ancestrais e inovadoras; transferência de tecnologia diferencial

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***Palabras-clave*:** Alimento propio; trazadores de sostenibilidad; prácticas ancestrales e inovadoras; transferencia tecnológica diferencial.

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