Acta Agron. (2018) 67 (1) p 9-16 ISSN 0120-2812 | e-ISSN 2323-0118 *https://doi.org/10.15446/acag.v67n1.59316*

An ethnobotanical survey of spice, aromatic and medicinal plants used in La Molana, Atrato-Choco, Colombia: Basis for biodiversity conservation

Estudio etnobotánico de especias, plantas aromáticas y medicinales utilizadas en La Molana, Atrato-Chocó, Colombia: Bases para la conservación de la biodiversidad

Miller Marmolejo-Liloy, Jesús David Ponce-Mendoza*, Leidy Indira Hinestroza-Córdoba and Harold Moreno-Holguín

Universidad Tecnológica del Chocó-UTCH. Quibdó-Chocó, Colombia. Author for correspondence: jedapome@gmail.com

Rec.: 27.07.2016 Accep.: 31.05.2017

Abstract

A characterization and analysis of the production systems of aromatic, medicinal and spice plants (AMSP) was carried out in La Molana, Atrato-Chocó, Colombia throughout the identification of their biophysical, socioeconomic and financial characteristics, in order to propose agroecological alternatives that solve the problems and identified needs in said systems; applying methodologies and evaluation indicators of agricultural systems addressed to sustainable rural development, design, implementation and evaluation of agroforestry arrangements, agroforestry systems accompanied by WOST analysis, and agroforestry planning of productive units (APPU), this information was collected through the application of a focal workshop and semi-structured questionnaires to 40 smallholders. Therefore, eight productive units (UP) with four plots and four rooftop, which was characterized throughout a simple random sampling without replacement. The results indicate that these smallholders destine 15.6 ha to AMSP production, from which 11 ha are crops structured in plots within native forests and 4.6 ha are destined to crops in rooftops around the houses. The units produce on average, 110 units (bunches) per week, which are offered to informal vendors in the market place of Quibdo-Choco, Colombia with prices which ranged from COP $ 1000 to COP $ 3000 according to plant size and species. Likewise, was determined that the economic incomes of the AMSP units depend mainly on the following planted species: Cilantro (*Coriandrum sativum* L.), cimarron (*Eryngium foetidum* L.), Albahaca (*Ocimum basilicum* L.) and Oregano (*Origanum vulgare* L.), which are the most economically important species in the study area.

Keywords: Agroecological alternatives, agroecosystems, agroforestry planning of productive units (APPU), diagnostics and traditional practices, sustainable agriculture, sustainable rural development, traditional knowledge.

Resumen

Se realizó la caracterización y análisis de los sistemas productivos de plantas aromáticas, medicinales y condimentarias (PAMC) de La Molana, Atrato-Chocó, Colombia a través de la identificación de sus características biofisicas, socioeconómicas y financieras, con el fin de proponer alternativas agroecológicas que solucionen los problemas y necesidades identificados en dichos sistemas; aplicando las metodologías e indicadores de evaluación de sistemas agrícolas hacia el desarrollo sostenible, Diseño, implementación y evaluación de arreglos agroforestales, Sistemas Agroforestales acompañado del análisis DOFA, y planificación agroforestal de unidades productivas (PAF), dicha información fue recopilada a través de la aplicación de un taller focal y cuestionarios semiestructurados a 40 productores. Se caracterizaron ocho unidades productivas (UP), cuatro parcelas y cuatro azoteas, a través de un muestreo aleatorio simple sin reposición. Los resultados señalan que estos productores destinan 15.6 ha a la producción de PAMC, de las cuales 11 ha son de cultivos en parcelas dentro de bosques y 4.6 ha son destinadas a cultivos en azoteas alrededor de las viviendas. Las unidades producen en promedio, 110 unidades (manojos) semanales que son ofrecidos a vendedores informales en la plaza de mercado de Quibdó-Chocó, Colombia a precios que van desde COP $1000 hasta COP $3000 de acuerdo al tamaño y la especie. De igual modo se determinó que los ingresos económicos de las UP de PAMC dependen principalmente de las siguientes especies sembradas en las parcelas: Cilantro (*Coriandrum sativum L.*), cimarrón (*Eryngium foetidum* L.), Albahaca (*Ocimum basilicum* L.) y *Orégano* (*Origanum vulgare* L.), las *cuales* son las especies de mayor importancia económica en la zona de estudio.

Palabras clave: Agricultura sostenible, agroecosistemas, alternativas agroecológicas, conocimiento tradicional, desarrollo rural sostenible, diagnósticos y prácticas tradicionales, planificación agroforestal de unidades productivas (PAF).

Introduction

The use of AMSP is considered as part of history, customs and traditions in many parts of the world, in Colombia there are 156 identified species of aromatic, medicinal and spice plants reported by the naturist laboratories, from which 40.4% (63 species), are registered in the Instituto Nacional de Vigilancia de Medicamentos y Alimentos (INVIMA) Colombia, as natural products with medicinal or pharmacological properties (MADR, 2014).

The special characteristics of the PAMC had achieved a considerable and significant increasing in the national and international demand, medicinal plants contains an active principles that exert a beneficial or harmful pharmacological action on the alive organism, the aromatic plants are those whose active principles are constituted totally or partially by essences and the spices or condiments, are used in food preparation to accentuate or improve their taste, smell and color. Bearing this in mind, a specific market is given for AMSP, especially in the pharmaceutical, food and cosmetic industries. Therefore, due to their importance, we must pay attention to the productive dynamics, which are produced in Colombia in terms of AMSP, since they have great potential in the local, regional, national and international markets, especially in North America and The European Union, from the consumer cultures of products of this nature (Castro, Díaz, Serna, Martínez, Urrea, Muñoz & Osorio, 2013; Caballero-Gallardo, Pino-Benitez, Pajaro-Castro, Stashenko & Olivero-Verbel, 2014).

It is important to note that is prudent to warn in the rural community of La Molana, as in other rural communities in the Choco department of Colombia, there is an employment deficit; whereby many families belonging to these rural communities have supported the AMSP cultivation in a craft and traditional form as an income alternative; which have allowed them to have a vision about AMSP cultivation is not only for their families sustainment, but also helps to preserve the agrobiodiversity. In fact, has granted them a certain degree of importance in the region, due to their invaluable cultural, culinary and medicinal contribution. However, currently there is a little available information of their functional and cultural characteristics of these productive systems.

In this sense, is necessary to wonder: What is the real state of the PU for AMSP in La Molana-Atrato-Chocó, Colombia and how to improve their agroecological conditions?. Given these concerns, the aim of this research was to characterize and analyze the AMSP production systems from La Molana-Atrato, Choco, Colombia based on their biophysical, socio-economic and financial characteristics.

Materials and methods

Study area

La Molana, is located to the west of the municipality of the Atrato- Choco over the left margin of the Atrato River. Its geographical position is 05º 36’ north latitude and 76º 40’ west longitude, has an area of 28.4 km^2, with approximately 367 inhabitants and is 13 Km from Yuto municipality. The plant cover which predominates in La Molana is very humid tropical forests (Bmh-T), which is located in the greatest part of the territory that bathes the Atrato River. La Molana has clay loam soils, an average annual rainfall of 8000 mm and a medium temperature of 28ºC, with relative humidity higher than 85% (EOT, 2015).

PU identification and selection

For PU identification was applied the methodologies and indicators for agricultural systems evaluation which are addressed to sustainable development (Bolivar, 2011), performing a focal workshop where participated 40 smallholders, primary information was compiled from interviews and semi-structured questionnaires, identifying general characteristics such as type or form of the crop, species variety, cultural work, size of the units, crop age, inputs, tools, education and technological level. According to the above criteria, eight PU were selected (4 plots and 4 rooftops), characterized through a simple random sampling without replacement.

PU characterization in the selected units

The characterization of the productive systems (PU) was developed from the use of the designed methodologies, the implementation and evaluation of agroforestry arrangements (Possu, Jurado & Navia 2009), agrobiodiversity (Valois-Cuesta, Córdoba-Arias, Rentería-Arriaga, 2016) and agroforestry systems (Reed, Van Vianen, Foli, Clendenning, Yang, MacDonald, Petrokofsky, Padoch & Sunderland, 2017), making routes in the selected PU, evaluating the agroecological practices implemented by smallholders and at the same time, were measured and recorded data from the biophysical, socio-economic and financial variables, using semi-structured formulary and working tools such as GPS, tape measure, shovel, machete, scissors trimmers, materials for collection and camera. Taking into account the above mentioned, we assessed the following components:

a) Biophysical diagnosis. The characteristics and general conditions of the PU were identified throughout location and farms georreferencing with coordinates and delimitations with GPS, similarly, was carried out the verification of soil use and importance for the producer through a detailed description by smallholders and spatial distribution as well as importance of their crops, contemplating the location, occupied area per each plot and rooftop, planting distance, planting density, topography, climate, soil, among others.

b) Socioeconomic diagnosis. The socioeconomic diagnosis have allowed to know the hierarchical crop composition, throughout application of a form that includes the background and land tenure, the members information in the PU, education level, and vision of the future, type of empowerment and mode of payment.

c) Financial diagnosis. Profitability is determined by the information gathering related with the production destiny, prices, wage value, economic importance of the crops, finance, labor required, income and PU inputs.

Data analysis for the formulation of agroecological alternatives

At this stage, the analysis of the current situation of the units was carried out, determining their components from collected information in the field (Phase II), supported by agroforestry planning of productive units (APPU) (Somarriba, 2009; Duque, Saldarriaga, Meyer & Saatchi, 2017), therefore, priority factors were determined as follows: problems, needs, limiting factors and agroecological alternatives to improve the productive efficiency, economic and sustainable systems, among others. Subsequently, an adaptability analysis was performed for the proposed alternatives, where the recommendations were enunciated taking into account attributes like: superiority over other alternatives, economic feasibility and observability of results, ease to be implemented and compatibility with the farm climatic conditions.

Results

Bearing this in mind, the present work is intended to present a PU identification and selection in the Molana-Atrato, Choco, Colombia. Table 1, shows the average area of all PU plots, which was 458.3 m^2, and the rooftops area, which was of 63.8 m^2, demonstrating that the producer handles on average between 6 plots and 18 Rooftops, which confirmed its status of small smallholders, since they have smallholdings and micro holdings lower than 0.5 ha.

Conversely, PU characterization selected in the biophysical diagnosis, for instance, was found that the units are located in the alluvial plains of the middle part of the Atrato river and are moderately favorable in terms of the environmental conditions for agricultural work. Despite having clay loam soils with moderately acid reaction (pH = 5.9), flat terrain with little pronounced slopes 1-7%; soils originated from alluvial sediments; are moderately deep and its natural drainage is imperfect, are soils that are potentially used to produce specialty crops and ornamental plants.

Table 1. List of selected PU in La Molana, Atrato-Choco, Colombia.

Smallholders	Production type		Number of Units		Average dimension	Average area
	Plot	rooftop	Plot	rooftop		
1	X		5		25m x 15m	375m^2
2	X		4		22m x 12m	264m ^{2}
3	X		8		30m x 23m	690m^2
4	X		6		28m x 18m	504m^2
5		X		14	3.6mx 0.18m	64.8m^2
6		X		16	3.8m x 0.16m	68.4m^2
7		X		22	4.3m x 0.15m	64.5m^2
8		X		18	4.4m x 0.13m	57.2m^2

On the other hand, in Table 2, can observe 40 smallholders that have 15.6 ha for AMSP production in the study area (11 hectares of crops in fields submerged in the native forest and 4.6 hectares in rooftops around the houses), where crops like cilantro (*Coriandrum sativum* L.), cimarron (*Eryngium foetidum* L.), basil (*Ocimun basilicum* L.) and oregano (*Origanum vulgare* L.) are the most important, these species have the largest number of planted hectares, a 70% of the area used and have the highest production bunches weekly.

Table 2. Soil use and crop importance for the producer

Unit	Species	Scientific name	Land Surface (ha)	Plants (ha)	Production (M/S)	Importance
Plot	Basil	*Ocimum basilicum* L.	7	47.620	1300	1
	Cimarron	*Eryngium foetidum* L.	4	50.000	800	2
	Cilantro	*Coriandrum sativum* L.				
Rooftop	Oregano	*Origanum vulgare* L.			400	3
	Pennyroyal	*Mentha pulegium* L.			280	4
	Purple Basil	*Ocimum campechianum* Mill.			230	5
	Mint	*Mentha rotundifolia* (L.) Huds.			220	6
	Peppermint	*Mentha spicata* L.			180	7
	Melissa	*Melissa officinalis* L.			160	8
	Linden	*Justicia pectoralis Jacq.*	4.6		140	9
	Descancel	*Alternanthera pubiflora (Benth.) Kuntze*			140	10
	Wormseed	*Chenopodium ambrosioides* L.			140	11
	Celandine	*Peperomia pellucida* L.			140	12
	Plantain	*Plantago major* L.			140	13
	Amaranth	*Nerium oleander* L.			130	14
Total			**15.6**		4.400	

Table 3, exhibits the labor composition in PU. It was observed that most of the required labor on the PU is supported by breadwinner mothers, carrying out work every day of the week, sometimes they receive support from their husbands and children in some specific activities, where each member plays a key role and spends time established to the necessary work in the system management and utilization.

Table 3. Labor composition in the PU-productive units

Members	Age range	Relationship	Rol/ labor	Education level	Days/ hours
Women	35 – 50	Mother	Planting and crop protection, harvest and postharvest	Elementary	7/6
Men	45 – 65	Father	Heavy work and soil tillage and land adequacy	Neither	3/8
Children	12 – 16	Son-daughter	Support to crop production and postharvest	High school	2/6

Table 4, exposes the relation of activities carried out in PU systems. It is evident that PU requires 264 wages per year, from which 73% are represented in harvesting, post-harvest and weed control. As a result, it has long been thought that the labor required in the activities is usually developed for the same family, and are only hired others in special cases, such as, the land adequacy.

Table 5, shows the economic income of the PU where it was found that cilantro (*Coriandrum sativum* L.), cimarron (*Eryngium foetidum* L.), basil (*Ocimun basilicum* L.) and oregano (*Origanum vulgare* L.), are the species of major economic importance in the area, with an annual production of 9360k, 5760k and 2880 k, respectively, which is equivalent to COP $132’.480.000.

Table 4. Use of labor

Activity	Wages per month	Wages per year
Land adequacy	1	12
Planting and replanting	2	24
Weed control	4	48
Rooftops maintenance	1	12
Pests and diseases control	2	24
Harvest	8	96
Postharvest	4	48
Total	22	264

Table 5. PU inputs

Unit/species	Production year (kg)	Price (kg)	Cost.year^{-1}
Plots			
Ocimun basilicum L.	9.360	8.000	74’880.000
Eryngium foetidum L.	5.760	4.000	23’040.000
Roofstops			
Origanum vulgare L.	2.880	12.000	34’560.000
Mentha pulegium L.	1.656	12.000	19’872.000
Ocimum campechianum L.	1.584	12.000	19’008.000
Mentha rotundifolia L.	1.296	12.000	15’552.000
Mentha spicata L.	1.152	12.000	13’824.000
Melissa officinalis L.	1.008	8.000	8’064.000
Justicia pectoralis Jacq.	1.008	4.000	4’032.000
Alternanthera pubiflora (Benth.) Kuntze	1.008	12.000	12’096.000
Chenopodium ambrosioides L.	1.008	8.000	8’064.000
Peperomia pellucida L.	1.008	4.000	4’032.000
Plantago major L.	1.008	8.000	8’064.000
Nerium oleander L.	936	8.000	7’488.000
TOTAL	30.672		252’576.000

Alternatively, Figure 1, shows the income generation in terms of the farmer participation (%). In fact, the species with major economic participation are cilantro (*Coriandrum sativum* L.), cimarron (*Eryngium foetidum* L.), basil (*Ocimun basilicum* L.) and oregano (*Origanum vulgare* L.), which represents the 52.45 % of the annuals income of the PU estimated in COP $ 252’.576.000.

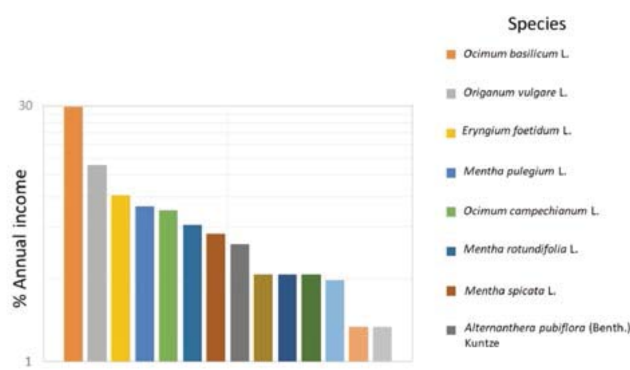

Figure 1. Participation of aromatic, medicinal and spice plants in PU income

Similarly, Table 6 exhibits the major part of the production expenses, which is represented in the harvest, postharvest and weed control, such exes are equivalents to COP $5’.600.000 (192 wages), which represents more than 70% of incomes.

Table 6. PU incomes

Activity	wage, unit of inputs/ year	Wage cost/unit of inputs($)	Total year($)
Land adequacy	12	25000	300.000
Planting	24	25000	600.000
Weed control	48	25000	1’200.000
Pest and disease control	24	25000	600.000
Rooftop maintenance	12	25000	300.000
Harvest	96	25000	2’400.000
Postharvest	48	25000	1’200.000
TOTAL	**264**	------	**6’600.000**

Table 7, exhibits the WOST analysis of PU. weaknesses such as lack of planning and poor crop protection, threats such as loss of soil fertility due to lack of crop rotation and renewal are observed, however, they have sufficient available area for expansion and implementation of crops, which becomes a great opportunity to firm up the clean production agreement and free of chemical inputs.

Table 7. WOST matrix of PU for AMSP system

Weaknesses	Opportunities
Lack of planning and crop protection. Lack of drainage systems well defined. Lack of standardization in weight and quantity of sold products. Lack of crop protection and delimitation. Unskilled labor.	Available area for crop expansion and establishment. Free planting materials. AMSP products have a great potential for cosmetic, pharmaceutical and culinary industry. An increasing market growth for organic products.
Threats	**Strengths**
Loss of soil fertility due to lack of crop rotation and renewal. Massive attacks of pests and diseases due to a poor crop protection Unexpected floods by the crop location on the bank river. Thefts of products and/or plot inputs.	Optimal geographical location for crop production Clean production, free of chemical fertilizers and inputs. Desired products on the market, for their organic characteristics. Crops do not require a lot of labor. Low production cost and proximity to the market.

Table 8, argues different weaknesses, opportunities, threats, strengths, basic needs, priorities and limiting factors of PU, some agroecological alternatives that would improve the productive, economic and sustainable crop efficiency and profitability.

Table 8. Matrix of analyses in the alternatives production

Alternative	Productivity	Economic feasibility	Sustainability	Adaptability
1. Rows with medicinal and legume plants.	An increasing biomass production; diversification of forage production; an increasing production from the first trimester.	Low cost of establishment and management; harvest protection; investment and net profit is higher due to a decreasing fertilizers use.	Soil erosion control throughout riverbed effect; crop protection from strong winds and animals; an increasing durability compared with artificial cultivation.	Easy handling due they are native species; availability of seeds and/or cuttings; formal boundaries establishing and land tenure.
2. Cultivation under the influence of medicinal plants, cover crops and legumes.	Optimized solar radiation on crops AMSP; crop diversification and an increasing production; sustainable production, provides a partial crop shading.	Net profit is higher due to a crop diversity in production; low costs of establishment and management.	An increasing soil organic matter; water regulation; stimulates the mitigation effect of runoff and decrease the raindrop impact in the lower species and soil.	It is attractive due to product diversification; it is adoptable because the production is the medium term; it is adoptable because farmer knows the use and management of the species to be used.
3. Medicinal plants and legumes dispersed in crops.	Diversifying production in the medium term; biomass production in the short term due to pruning; holds production as provides partial crop shading.	More empowerment is needed for crops; an increasing productivity of the system; a decreasing fertilizer costs policy.	Regulates the microclimate; mitigates the raindrop impact; controls the weed proliferation.	The species used are native from region and are also present in the area; the farmer may not be willing to plant oregano on the soil; an increasing likelihood of adoptable because the farmer owns the farm.

Discussion

Undoubtedly, the number of plants per hectare was not possible to calculate in rooftops due to the complexity and variety of species established in the same unit of land with planting distances highly irregular (Duque, Saldarriaga, Meyer & Saatchi, 2017).

With regard to socioeconomic diagnosis, La Molana has been recognized for its production of ornamental plants, which processed minimally and are marketed in their natural state in the marketplace of Quibdo-Choco, Colombia. It should be noted that the surpluses are subsistence consumption. In fact, most AMSP crops are led by small families, especially adult women who are called breadwinner mothers by themselves with ages ranging from 35-60 years, cohabiting, have their own house, electric energy, and are supplied with rainwater and streams. Their PU are clearly organic based on two types of production: Plots and rooftops, which are obtained on average 110 bunches per week per family. In both systems, is applied a traditional management to crops, which is to clean and adjust the planting area, pulling weeds and crop checks. However, these PU do not have technified crops and an adequate space distribution, lack of drainages well defined, a poor phytosanitary crop control, poor crop protection and do not keep planting and performance records.

Nevertheless, to facilitate a more precise assessment in the land tenure and land value, was recorded that La Molana is denominated under collective title, where most of the PU had achieved land tenure by inheritance, with the exception of some areas that were granted by the Community Council. The value of the PU was impossible to determine because the smallholders expressed ignorance and lack of interest in this regard. Conversely, with the vision to future, the smallholders expect an increasing production of their crops improving their technological and productive process through the potentiation and innovation of clean practices of production in order to supply the local and regional market of AMSP under the terms of organic products and fair trade.

This study evaluated the effects of the economic importance of crops, this provides more accurate and reliable estimates of financial diagnosis, the products obtained from the plots and rooftops are offered on the fresh leaves and on average 96% are transferred to the Quibdó marketplace, while only 4% is for home consumption. It is important to highlight the smallholders themselves consume the products obtained from the rooftops in greater proportion.

In Bogotá, Barrientos, Reina & Chacón (2012), reports that AMSP are collected from the field in small quantities for sale without value added (fresh leaves) in the local market places; besides the AMSP not cultivated have a production technology and market underdeveloped.

It was possible to determine that in La Molana are handled two types of production: plots and rooftops, where it is evidenced that the PU the handling of the economy is agrarian characterized by be focused on smallholdings and micro holding lower than 0.5 ha, destined to small crops combined with other products or collection of wild product. These units do not have irrigation equipment, nor do they have technical management of cultivation and are linked mainly to the domestic market, with direct destination to the market place of Quibdó-Chocó, Colombia.

A possible explanation for this can be addressed to the sector of AMSP both La Molana as in Bogotá, despite having great social, cultural, culinary and medicinal interest is not generating added value, being that their crops are rustic and low scale, these have retained on small plots and their products are not subject to processes of good agricultural practices and large scale industrial processing, is the case of Mexico and other countries.

Juárez, Aguilar, Bugarín, Juárez & Cruz (2013), reports that the collection and production of aromatic and medicinal herbs is a profitable activity for collectors, smallholders and processors to be considered as an alternative to a growing market and high added value. Is believed to be an outcome of a direct cause of the emerging technological development for the sector of the AMSP and related fields in Colombia, with a new productive line, which has not been given the necessary importance to potentiate it.

This information is useful in the determination of the relation between inputs (252.'576.000) vs outputs (6.'600.000), which is believed to be an outcome of the PU, this type of relationship results profitable and presents a financial profit of COP$245.'976.000 and on the basis of the 40 smallholders, was considered that each unit generates nearly $ 6'.149.400 annual profits with a benefit/cost of COP$38, which can be translated into a COP conversion, that is to say for every Colombian peso invested in the AMSP system, this generates COP $38.

These results are comparable in variability to the report by MADR (2014), which defines the types of AMSP smallholders in Colombia. In this sense, in La Molana the AMSP have allowed a contribution of 110 bunches per family weekly, equivalents to 22 kg per week and in the region of Sumapaz (Cundinamarca), Cardona & Barrientos

(2011) found out that aromatic plants have an offer around 10 kg per week. In Valle del Cauca (Saldarriaga, Sánchez, Bonilla, Sánchez & Torres, 2010), such information support that currently very few lands are being allocated for cultivation of AMSP in Colombia, where it may conclude that low volumes of market demand are due to the lack of products diversification as of the generation of added value.

Similarly, MADR (2014), holds that the cultural activities generate more than 1080 wages per ha.year^{-1}, which is equivalent to 4 direct jobs. ha.year^{-1}. Therefore, in La Molana more direct jobs and less wage per ha.year^{-1} are generated, as is estimated that 1 ha generates around 677 daily wages per ha.year^{-1} and 5 direct jobs in the PU of AMSP system. This difference is because in La Molana, unlike other regions in the country, production systems plots are immersed in the native forest, therefore have no handling or constant visits to crops (96 times year).

In this sense, could be developed further research seeking to improve and increase the performance of each of the components of the systems here described, especially those related to performance in production, organizing the plot and rooftop techniques by separated, the required parameters in families that require counseling as planting distance, need of light and shade, species to be used, among other things. All this in order to favor an increasing productivity and generate higher returns for PU system due to each unit currently generates an average of COP$ 512.450 per month, which is not enough to sustain a family of at least four members.

The total annual production per hectare for the 14 identified species in the production systems of aromatic, medicinal and spices plants in La Molana is almost 2 tons, much lower than the annual production of basil reported by Tahami, Jahan, Khalilzadeh & Mehdizadeh (2017) and Singh, Soni, Patel & Kalra (2013), whose evaluations in basil equates to more than 10 times this amount.

Conclusion

This methodology can be further improved by including the PU system characterization, which can lead to stage conclusion that all the alternatives mentioned in Table 8 are adoptable for the smallholders, since with them the PU does not suffer many changes in its composition. In addition, to implementing these alternatives are thought to contribute with a decreasing in management costs and relatively low inputs, which had achieved a more attractive attention to smallholders when making decisions.

Given these concerns, could be developed further research seeking to improve and increasing the performance of each system component here described. Finally, our findings support the use of plot and rooftop techniques addressed to improve crop production, the required parameters in families that require counseling as planting distance, need of light and shade, species to be used, among others.

References

Barrientos, J. Reina, M. & Chacón, M. (2012). Potencial económico de cuatro especies aromáticas promisorias para producir aceites esenciales en Colombia. *Rev Colomb Cienc Hortic,* 6(2), 225-237. *https://doi.org/10.17584/rcch.2012v6i2.1979*

Bolivar, H. (2011). Metodologías e indicadores de evaluación de sistemas agrícolas hacia el desarrollo sostenible. *CICAG*, 8(1), 1-18. *http://publicaciones.urbe.edu/index.php/cicag/article/view/726/2343.*

Caballero-Gallardo, k., Pino-Benitez, N., Pajaro-Castro, N., Stashenko, E., Olivero-Verbel, J. (2014). Plants cultivated in Choco, Colombia, as source of repellents against *Tribolium castaneum* (Herbst). *J Asia-Pacific Entomol*, 17(4), 753-759. *https://doi.org/10.1016/j.aspen.2014.06.011*

Cardona, J. & Barrientos, J. (2011). Producción, uso y comercialización de especies aromáticas en la región Sumapaz, Cundinamarca. *Rev Colomb Cienc Hortic,* 5(1), 114-129. *https://doi.org/10.17584/rcch.2011v5i1.1258*

Castro, D., Díaz, J., Serna, R., Martínez, M., Urrea, P., Muñoz, K., & Osorio, E. (2013). Cultivo y producción de plantas aromáticas y medicinales. 2da Edición. Universidad Católica de Oriente- UCO Eds. 98p. *http://www.uco.edu.co/investigacion/fondoeditorial/libros/Documents/Libro%20Plantas%20Aromaticas%202013.pdf.*

Duque, A., Saldarriaga, J. Meyer, V., Saatchi, S. (2017). Structure and allometry in tropical forests of Choco, Colombia. *Forest Ecol Manag*, 405, 309-318. *https://doi.org/10.1016/j.foreco.2017.09.048*

Durán, G. L.A., Castro, V.D.F., Sánchez, O.M.S. & Bonilla, C.C.R. (2016). Calidad fisiológica de semillas de variedades de Ocimum producidas bajo condiciones del Valle del Cauca, Colombia. *Acta Agron*, 65(1), 38-43. *https://doi.org/10.15446/acag.v65n1.45377*

EOT- Esquema de Ordenamiento Territorial. (2015). Esquema de Ordenamiento Territorial Municipio de Atrato-Chocó. Documento de diagnóstico "Una propuesta social donde cabemos todos". Alcaldía Municipal del Atrato. Instituto de Investigaciones Ambientales del Pacífico. Convenio BID-Plan Pacífico- MAVDT-Gob.Chocó-U.T.CH-IIAP. (Eds.). 201 p. *http://www.elatrato-choco.gov.co/Nuestros_planes.shtml?apc=gbxx-1-&x=1819183*

Juárez-Rosete, C. Aguilar-Castillo, J. Bugarín-Montoya, R. Juárez-López, M. & Cruz-Crespo, E. (2013). Hierbas aromáticas y medicinales en México: Tradición e innovación. *Revista Bio Ciencias,* 2(3), 119-129. *https://doi.org/10.15741/rev%20bio%20ciencias.v2i3.42*

MADR-Ministerio de Agricultura y Desarrollo Rural. (2014). Cadena plantas aromáticas, medicinales y condimentarias y afines. Las PAMCyA en Colombia. *https://sioc.minagricultura.gov.co/PlantasAromaticas/Documentos/004%20-%20Documentos%20Competitividad%20Cadena/D.C.%20%E2%80%93%202014%20Septiembre%20-%20Pasto.pdf.*

Possu, W. B., Jurado, H. R. O. & Navia, J. F. (2009). Diseño, implementación y evaluación de arreglos agroforestales para la costa pacifico de Nariño. *Revista de Ciencias Agrícolas*, 26(1), 154-170. *http://revistas.udenar.edu.co/index.php/rfacia/article/view/60/64.*

Reed, J., Van Vianen, J., Foli, S., Clendenning, J., Yang, K., MacDonald, M., Petrokofsky, G., Padoch, C., Sunderland, T. (2017). Trees for life: The ecosystem service contribution of trees to food production and livelihoods in the tropics. *Forest Policy Econ*, 84, 62-71. *https://doi.org/10.1016/j.forpol.2017.01.012*

Saldarriaga, C.L.F., Sánchez, M.G.M., Bonilla, C.C.R., Sánchez, O. M.S., Torres, C.H.G. (2010). Evaluación agroindustrial de los aceites esenciales de *Artemisia dracunculos* L., *Franseria artemisioides* Willd., *Salvia officinalis* L., *Lippia dulcis* Frev., y *Occimun americanum* L. en condiciones del Valle del Cauca. *Acta Agron*, 59(3), 293-302. *https://revistas.unal.edu.co/index.php/acta_agronomica/article/view/17658/18516.*

Singh, R., Soni, S.K., Patel, R.P. & Kalra, A. (2013). Technology for improving essential oil yield of *Ocimum basilicum* L. (sweet basil) by application of bioinoculant colonized seeds under organic field conditions. *Ind Crop Prod,* 45, 335-342. *https://doi.org/10.1016/j.indcrop.2013.01.003*

Somarriba, E. (2009). Planificación agroforestal de fincas. CATIE- Centro Agronómico Tropical de Investigación y Enseñanza (Eds.). 102 p. *http://www.sidalc.net/repdoc/A4945E/A4945E.PDF.*

Tahami, M.K., Jahan, M., Khalilzadeh, H., Mehdizadeh, M. (2017). Plant growth promoting rhizobacteria in an ecological cropping system: A study on basil (*Ocimum basilicum* L.) essential oil production. *Ind Crop Prod,* 107, 97-104. *https://doi.org/10.1016/j.indcrop.2017.05.020*

Valois-Cuesta, H., Córdoba-Arias, J.A., Rentería-Arriaga, E. (2016). Patrones de diversidad de plantas en un gradiente de baja elevación en el Chocó, Colombia, usando especies indicadoras (Rubiaceae). *Rev Mex Biodiv*, 87(4), 1275-1282. *https://doi.org/10.1016/j.rmb.2016.10.001*