Scientific Paper

Biodiversity and management of agricultural waste in a farm of the Perico municipality, Matanzas

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Abstract

Objective: To characterize the biodiversity and management of waste from the agricultural activity in La Palma farm, of the Perico municipality, Matanzas province, Cuba.

Materials and Methods: In order to obtain information, a diagnosis was conducted in a farmer's farm through the combination of several tools, such as exploratory tours and informal interviews, formal surveys and semi-structured dialogs, with observations, measurements or both. The number of individuals of each species, which were characterized according to their purpose in the system, was quantified.

Results: In the farm three subsystems stand out (temporary crops, permanent crops and animals). In the subsystem of permanent crops the natural pastures *Dichanthium caricosum* (L.) A. Camus, *Dichanthium annulatum* (Forssk.) Stapf and *Paspalum notatum* Alain ex Flügé are developed. Meanwhile, among the trees, *Leucaena leucocephala* (Lam.) de Witt stands out with 2 386 individuals. This species can generate 5 t DM/year of non-edible woody biomass and, in turn, an estimate of 1,5 t of biochar.

Conclusions: The functionality of this agroecosystem, represented by diversification and agriculture-animal husbandry integration, was proven. Biochar is a management alternative of waste from the agricultural activity in the farm, which can be enriched with cattle waste.

Keywords: crop residues, excreta, sustainable development

Introduction

In 2015, with the adoption of the Agenda 2030 of Sustainable Development and the Agreement of Paris, for the first time the world agreed to act decisively against two of the most important challenges mankind faces today: achieving sustainable development and approaching the problem of climate change (ONU, 2015).

The risks of climate change for society, especially for developing countries, likewise constitute the main obstacle for reaching sustainable development. It is not possible to overcome successfully one challenge, without approaching the other. Sustainable development reflects the interdependence of the economic, social and environmental dimension, which forces to promote public policies with an integral vision of sustainability (Martín-Murillo *et al*, 2018).

Due to the above-explained facts, to ensure feeding the ever increasing human population, measures must be implemented which mitigate the effects of climate change through the reduction of GHG (greenhouse gases) emissions and the recovery of degraded soils. This would be possible with the sustainable management of productive systems, protection of ecosystems, ecological restoration, environmental education, rescue of traditional knowledge and articulated work among organizations, institutions and communities. All these actions promote the biodiversity conservation and good living of people (Moreira and Castro, 2016).

The adequate dominion of biodiversity is fundamental in the design and management of animal husbandry farms, because it constitutes the basis of life on the planet and of agroecosystem sustainability (Sarandón and Flores, 2014). It is the source of genes, besides providing variety of ecological services, and allowing to reduce the use of external inputs.

According to Vázquez-Moreno (2013), in agricultural systems, biodiversity should perform services that go beyond the production of food, fibers, fuels and incomes. Among these services the control of the local microclimate, regulation of local hydrological processes and of undesirable organisms, detoxification of noxious chemical products and nutrient recycling, can be cited (Altieri and Nicholls, 2007).

One of the alternatives of organic nutrient and carbon recycling, which could contribute to soil fertility, is the use of biochar. This is a material that is obtained from the pyrolysis of woody biomass,

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it is highly porous, with high capacity of nutrient absorption and exchange, as well as of water storage and redox potential (Joseph *et al*, 2015; Husson, 2016). Its cellulosic carbon structure can be impregnated with liquid nutrients (cattle manure, native microorganisms, *Saccharum officinarum* L. bagasse ferment, among others), thus reactivating the biomaterial to enhance the release of organic fertilizer (Pedroso and Pentón, 2019).

The utilization of biochar could be an alternative in the management of agricultural farms, because it increases the functionality of biodiversity in productive systems; in turn, it contributes to organic fertilization, and allows nutrient recycling. Thus, the objective of this work was to characterize the biodiversity and management of waste from the agricultural activity in La Palma farm, of the Perico municipality, Matanzas province, Cuba.

Materials and Methods

Locality and geographical location. The study was conducted at La Palma farm, belonging to the Cooperative of Credits and Services Ramón Rodríguez Milián. It is located in the Perico municipality, Matanzas province, at 22º 45’ 45.34’’ North latitude and 81º 03’ 42.63’’ West longitude, at 38 m.a.s.l., according to the geolocation device GPSmap-62SC.

Edaphoclimatic characteristics. The mean annual temperature in 2019 was 25 ºC, with relative humidity of 79 % and rainfall of 1 124 mm (Estación Meteorológica Indio Hatuey, 2019). The farm has 13,42 ha. The soil is compacted ferralitic red (Hernández-Jiménez *et al*. 2015), with flat topography and slope from 0,5 to 1,0 %. The depth to the limestone is 1,50 m. The pH is slightly acid. Table 1 describes the agrochemical characteristics of the soil (Proyecto BASAL, 2015).

The analysis was developed from the Rural Participatory Diagnosis (Schonhuth and Kievelitz, 1994). To obtain the necessary information diverse tools were combined, such as exploratory tours and informal interviews, formal surveys and semi-structured dialogs, with observations, measurements or both (Lores, 2009).

The determination of species diversity in the system was carried out by counting the individuals, per family, purpose or function.

The waste generated from the animal husbandry activity (cattle urine and excreta) and the waste from pruning the legume *Leucaena leucocephala* (Lam.) de Witt were studied, according to Sánchez (2002).

Results and Discussion

The farm has as fundamental activity animal husbandry, and its main source of incomes is milk production, which has been diversified in order to achieve the vision[1] designed by the family in 2014, when it started its work in the Local Agricultural Innovation Program (PIAL, for its initials in Spanish), after constructing the farm plan, according to the methodology proposed by CATIE[2] (Palma and Cruz, 2010).

The reported diversity stands out from the multiple functionality of the farm. Fundamentally, five uses were observed (figure 1). The highest percentage corresponded to the area of natural pastures (39 %), and it was followed by silvopastoral systems (32 %). In

Table 1. Soil chemical properties of La Palma farm.

Horizons	Depth, cm	pH		C mol						Saturation, %	OM, %
		H_2O	KCL	Ca	Mg	K	Na	BEC	CEC		
Ap	0-13	6,59	5,59	8,19	2,21	0,59	0,02	11,01	16,00	68,81	2,58
B1	13-36	6,59	5,59	7,32	2,24	0,27	0,02	9,85	15,00	65,67	1,23
B21	36-126	6,69	5,69	6,44	2,29	0,02	0,02	8,77	11,00	79,73	
B22	126-176	6,80	6,00	6,03	2,34	0,02	0,02	8,41	10,60	79,34	

[1]Farmer’s vision: There is an integral and diversified farm, with paddocks and electricity. There is also irrigation system to produce feed and food, from the use of agroecological practices that allow productive increases.

[2]CATIE (Tropical Agricultural Research and Higher Education Center) is a regional center, dedicated to research and postgraduate teaching in agriculture, management, conservation and sustainable use of natural resources. Its members are the Inter-American Institute of Cooperation for Agriculture (IICA), Belize, Bolivia, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Dominican Republic, Venezuela and Spain.

Figure 1. Soil distribution, according to its use.

turn, the farm has three subsystem, which correspond to temporary crops (vegetables), permanent crops (fruit trees, feed for cattle) and animals.

The silvopastoral system (SPS) occupies 4,3 ha. Two of them are dedicated to calf feeding, in which *Cenchrus purpureus* (Schumach.) Morrone variety OM 22 and as tree legume *L. leucocephala*, predominate. The remainder of the silvopastoral area is aimed at feeding the cows, where *Megathyrsus maximus* (Jacqs.) B.K. Simon & S.W.L. Jacobs prevails as basis pasture.

The categories milking cows and calf demand higher nutritional requirements, related to milk production and growth, respectively. This determines that priority is given to a feed offer of better quality, nutritional value and digestibility.

Specifically, in calves, the adequate feed offer is very important in order to raise satisfactorily the animals that will serve as replacement (Soca, 2016). In this sense, the combination of the tree and herbaceous stratum, dry matter availability, nutritional quality of the diet and comfort conditions determine a better productive performance and the appreciable decrease of diseases.

Regarding milk production, in SPS it tends to be higher; although it varies depending on the availability, quality of the basis diet and dairy potential of the animals. In general, the research works developed in SPS in different tropical regions show increases in milk production, between 10 and 30 % (Aguilar-Pérez, 2019).

According to Montagnini (2015), SPS can also contribute to the mitigation of climate change, due to the carbon sequestration, over and below the soil, with the additional advantage of increasing short- and long-term productivity, favoring biodiversity and providing the farmer with social and economic benefits. They are an example of resistance for the adaptation to climate variability with the diversification that is characteristic of them, which decreases risks and offers flexibility for the change towards species or varieties that adapt to the new conditions (Jiménez-Ruiz, 2019).

In the area of natural pastures of the farm *Dichanthium caricosum* (L.) A. Camus, *Dichanthium annulatum* (Forssk.) Stapf and *Paspalum notatum* Alain ex Flügé stand out, besides other weed species that are grouped within the families *Amarantaceae, Asteraceae, Boraginaceae, Esterculiaceae, Euphorbiaceae, Fabaceae, Malvaceae, Papaveraceae, Poaceae, Verbenaceae.*

This floristic composition (figure 2) of the silvopastoral area is a limitation of the entity, if it is considered that natural pastures show low levels of forage biomass production. In addition, they generally have low nutritional quality and low carrying capacity, which results in the decrease of animal productivity (Pezo, 2018).

In the grazing areas it is necessary to increase the sowing of cultivated pastures and trees, because they improve feed quality, availability and production (Milera *et al*., 2014). In addition, they propitiate different habitats for the insect species, by creating a microclimate that favors their development. They also allow the establishment of complex interactions, which imply higher balance between phytophagous organisms and bioregulators.

In the subsystem of permanent crops there are various trees with different purposes, fruits, timber, forage, among others, which help to preserve soils and biodiversity. Table 2 shows the diversity and quantity of trees present in the farm, per species, family and purpose.

Leucaena is the most outstanding genus, with 2 386 individuals. As it has been referred, this species,

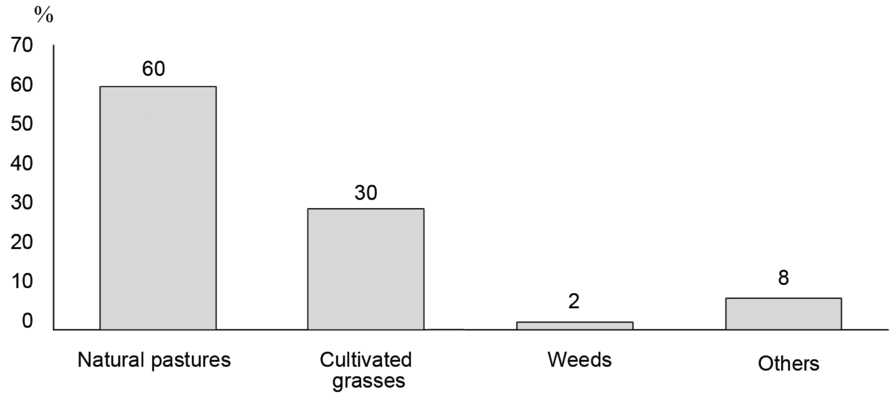

Figure 2. Floristic composition in the grazing areas.

Table 2. Most representative trees in the farm.

Common name	Scientific name	Family	Purpose	Quantity
Mango	*Mangifera indica L*	*Anacardiaceae*	Fruit	25
Avocado	*Persea americana* Mill	*Lauraceae*	Fruit	70
Guava	*Psidium guajava* L.	*Myrtaceae*	Fruit	15
Orange	*Citrus cinensis* L.	*Rutaceae*	Fruit	3
Lemon	*Citrus x limon* (L.) Burm f.	*Rutaceae*	Fruit	2
Mamey sapote	*Pouteria sapota* Jacq.	*Guttiferae*	Fruit	2
June plum	*Spondias dulcis* Parkirson.	*Rosaceae*	Fruit	4
Coconut	*Cocos nucifera* L.	*Arecaceae*	Fruit	1
Soursop	*Annona muricata* L.	*Annonaceae*	Fruit	19
Sherry	*Prunus cerasus* L.	*Rosaceae*	Fruit	3
Coffee	*Coffea canephora* Pierre ex A. Froehner	*Rubiaceas*	Fruit	38
Carob	*Ceratonia siliqua*	*Fabaceae*	Timber	1
Quickstick	*Gliricidia sepium* Jacq.	*Fabaceae*	Timber	15
Copperwood	*Bursera simaruba*	*Burseraceae*	Timber	5
Royal palm	*Roystonea regia* Kunth	*Arecaceae*	Timber	1
White leadtree	*Leucaena leucocephala* (Lam.) de Wit	*Fabaceae*	Animal feeding	2 386

besides serving in cattle feeding, has other uses, like firewood production. It is stated that, due to pruning, a silvopastoral system with more than three years of establishment generates 2,0 kg DM/plant of woody material (Sánchez, 2002). Thus, as the farm has 4,3 ha dedicated to SPS, with density of 555 plants/ha (3 x 6 m), it produces 5 t DM per year, which could become 1,5 t of biochar, if it is considered that it represents 30 % of the generated DM (Pentón *et al*., 2018).

Biochar can be a fertilization alternative (Trazzi *et al,* 2018) to be used in soil amelioration, especially in the 2,34 ha dedicated to temporary crops, because they represent an income source to support the family.

Among the most economically important species for the farm, harvested in this subsystem are: squash (*Cucurbita moschata* (*Duchesne* ex Lam.) *Duschesne* ex Poir.), chili (*Capsicum annuum* L), papaya (*Carica papaya* L), lettuce (*Lactuca sativa* L), Swiss chard (*Brassica rapa* subsp. chinensis), beet (*Beta vulgaris* subsp.vulgaris), parsley (*Petroselinum sativum* P), leek (*Allium ampeloprasum* var porrum) and string beans (*Vigna unguiculata* subesp. sesquipedalis).

In turn, biochar could be enriched with organic waste from cattle manure composting. According to Milera *et al.* (2014), a cow can produce between 6 and 7 % of the live weight as fresh feces, for which, in the case of this farm, which has 59 cows, it can produce in the year 10 676,25 kg of feces. If the grazing animal is only there for 16 h, one third of the time it is generating 3,6 t/cow/year, which represents 212,4 t/year for the farm. The urine (4 927,5 kg of urine/animal/year) could be also used from the construction of collecting channels.

According to Schmidt *et al.* (2017), there are high concentrations of organic nitrogen, potassium and other compounds present in the semiliquid manure and in the cattle manure, composted and mixed with biochar. In this regard, Chidumayo (1994) proved that biochar is better in its function of nutrient for the plants, when used as substrate component. This can be given by the capacity of biochar to absorb and hold water and solutes present in the semiliquid manure, if it is compared with other nutritional solutions or lactoferments (Brunet *et al*., 2019).

Schmidt *et al*. (2017), when studying the possibility of enriching biochar with semiliquid cattle or sheep-goat manure, showed that such combination can be more effective than the mineral fertilizer NPK, because 1 m^3 can contain 10 kg of nitrogen and 10 kg of potassium. One cow can guarantee the enrichment of 5 m^3 per year of biochar and such quantity of organic fertilizer is equivalent to 120 kg of each one of these elements.

Ghezzehei *et al*. (2014) proved that biochar, when imbibed during 24 h in liquid manure, can absorb 20-43 % of the ammonium, and 19-65 % of the phosphate. Only in the state of California (USA), from cattle waste, each year from 11 440 to 57 200 t of ammonium and 920-4 600 t of phosphate, can be sequestered. At the same time, up to 8-40 million tons of excess biomass can be eliminated.

All this recycling decreases the system outputs, which is in agreement with the report by Bover *et al.* (2018), who state that, in integrated or mixed systems, the outputs of an agricultural activity can be used as inputs for another. This contributes to reducing the adverse effects for the environment, and to decrease the dependence on external inputs through recycling. Thus, the pruning waste from trees would be used in the elaboration of biochar, which allows to increase the integration and functionality of the system (figure 2). In turn, this waste recycling alternative would contribute to the integration of subsystems in the farm object of study.

Conclusions

The functionality of this agroecosystem, represented by diversification and agriculture-animal husbandry integration, was proven.

Biochar is a management alternative of waste from the agricultural activity in the farm, which can be enriched with cattle waste.

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Authors' contribution

- Katerine Oropesa-Casanova. Conception, data acquisition, analysis and interpretation, manuscript writing and revision
- Gertrudis Pentón-Fernández. Research conception and design, manuscript writing and revision.
- Juan Carlos Lezcano-Fleires. Research conception and design, manuscript writing and revision.
- Julio Brunet-Zulueta. Research conception and data acquisition.
- Taymer Miranda-Tortoló. Research conception and design, manuscript writing and revision.
- Néstor Francisco Núñez-García. Research conception and design, manuscript writing and revision.

Conflict of interests

The authors declare that there are no conflicts of interests among them.

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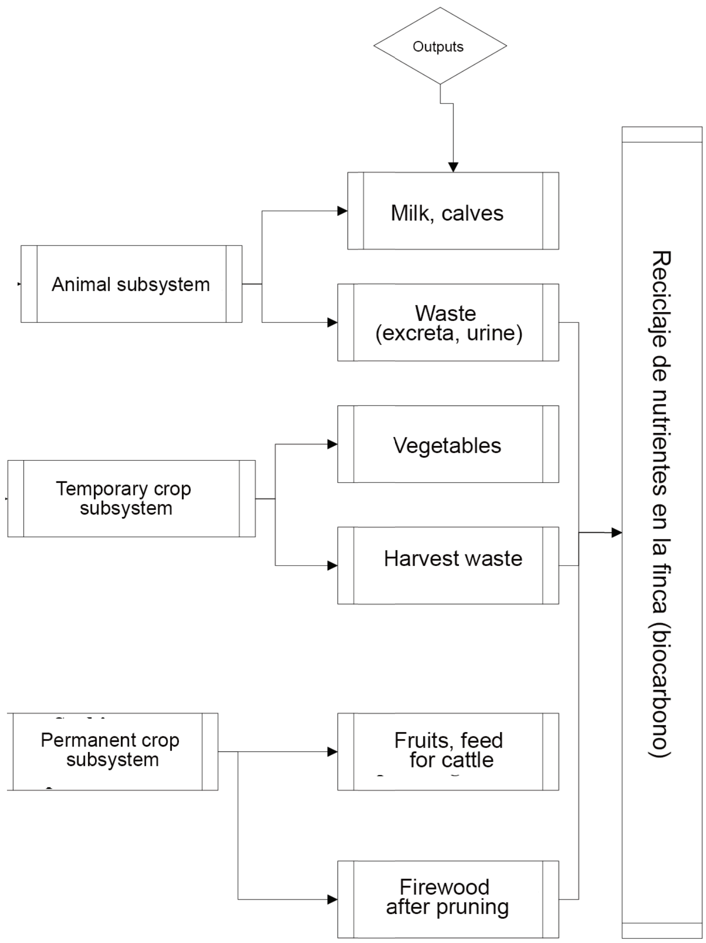

Figure 3. Waste recycling alternative in the farm.
Source: Elaborated by the author

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