Agricultural Science Research Journal 4(1); pp. 21- 29, January 2014
Available online at http://www.resjournals.com/ARJ
ISSN: 2026 – 6332 ©2014 International Research Journals

Full Length Research Paper

Environmental Sustainability of Production Systems with (*Vasconcellea cundinam arcensis*badillo), Wetland Ramsar, Lagoon of Cocha, Nariño, Colombia

***Amanda Silva Parra[1], Carmen Lucia Galvis Chamorro[2], HernandoCriollo Escobar[3], Tulio Cesar Lagos Burbano[4]**

[1]University of Nariño, Colombia, Project of Research assigned to Group of investigation in Production of Fruit Andean.
[2]Institute Educational of Encano, Nariño, Colombia, Project of Research assigned to Group of investigation in Production of Fruit Andean
[3]University of Nariño, Colombia, Project of Research assigned to Group of investigation in Production of Fruit Andean
[4]University of Nariño, Leader Group of investigation in Production of Fruit Andean

*Corresponding Author's Email: amanda.silvaparra@gmail.com

Abstract

The macro invertebrate community was evaluated in four production systems with*V. cundinamarcensis* in the Wetland Ramsar, Lagoon of Cocha, Santa Rosa, Encano, Colombia, by manual separation of soil, was used the methodology of the Tropical Soil Biology and Fertility, and the soil organic matter. Systems of *V. cundinamarcensis*+ pastures and *V. cundinamarcensis* + onions had great abundance with 440and 330individuals/m^{2}and high biomass 158 and 145gweightfresh/m^2. In crops *V. cundinamarcensis* + potato and *V. cundinamarcensis* + onions + potatoes this community was severely affected with a density of 215and 205individuals/m^{2}anda biomass of 70 and 68 g fresh mass/m^2. Finally systems of *V. cundinamarcensis*+ pastures and *V. cundinamarcensis* + onion showed the highest rates of soil organic matter with 23and 21.9%, contrary to *V. cundinamarcensis* + potato and *V. cundinamarcensis* + onion + potato with 17.5 and16.4%. The conservation of much of the wetland soils will be dependent on the implementation of alternative production systems that do not disturb the chemical and biological properties of soils.

Key words: *Vasconcelleacundinamarcensis*, macro fauna, soil, production systems, soil organic matter, sustainability, wetland soils.

INTRODUCTION

Colombia has turned around 70% of the original ecosystems by the activities of forestry and farming. Deterioration of ecosystems caused by human activities such as agriculture makes new ecosystems modified can't provide all the services as those related to the regulation (climate, water, soil conservation), habitat and production, processes which affect the decomposition of organic matter and recycling of nutrients (Lavelle, 2001). Agroecosystems of wetlands in the Andean areas of Colombia are being lost mainly by deforestation of the forest to implement clean crops including potatoes, onions and others crops.

*V.cundinam arcensis*isa promising fruit specie that may be recommended forplantingin associationwithtraditional crops andthus, begin transformingdegraded areas inareasmoreeconomically and environmentallysustainable.The intensity with which soils are cultivated also reduces soil microbial communities as a consequence of the toxic effects of agrochemicals, the physical disruption of their habitats, and the reduction in

litter availability and hence the soil organic matter (SOM) resource base.

Thesoil organic matteris key to optimizingcrop production, minimizing environmental impacts and, thus, improving soil quality and the long-term sustainability of agriculture. SOM benefits crops by providing nutrients, especially N, as it is decomposed by microorganisms, in a natural wetland ecosystem. SOM accumulates with soil development and eventually reaches an equilibrium, which is determined mainly by the environment, natural vegetation and soil organisms;management practices have important consequences on the SOM, density and biomass of soil macrofauna communities (Bonilla et al, 2007).According Lavelle(2001), Wardle (1995), macro fauna responds to management practices as crop sequence soil preparation, incorporation of fresh organic matteras a result of physical disturbancesthat occurs in the manner of distribution waste and plant community present. Authors such as Brown et al., (2001); Feijoo et al., (2001) andAltieri et al., (2005), state that management practices such as tillage, rotation and fertilization of crops andapplication of agrochemicals, are the factors that have the greatest effect on soil macrofauna. Moreover soil organic matter is the most commonly used indicator, to assess soil quality (Burbano, 2003).

Conversion from conventional production systems, characterized by monocultures managed with high inputs to diversified systems of low input is based on two pillars agro ecological: diversification of habitat and soil organic management. The evolution of agroecological transition can be monitored by a set of sustainability indicators to estimates soil quality and crop healthandbiologicalpropertiesof soilsincluding macro fauna (Zebrine et al, 2007).

From the moment in which a natural system of wetland Lagoon of Cocha is modified, to develop agricultural activities, there are important changes in soil properties and affects the abundance and biomass of soil biota. Characteristics of management intensification in systems of wetland are reduction in vegetation diversity, decrease in the quantity of leaf litter (organic matter), decrease in the density of macro fauna, modification of soil microclimate, and greater requirement of pesticides Crop diversification also play an important role in increasing the diversity of food resources and environmental conditions for the soil biota.This project is intended to assess the environmental feasibility of implementing different production models with *Vasconcelleacundinamarcensis*and their effect on thedensity, biomass of macro invertebrate community and soil organic matter, in order to provide guidelines for the implementation of sustainable practices with the use of *V. cundinamarcensis* and maintaining soil and water resources of the wetland.

MATERIALS AND METHODS

This study was conducted in the village of Santa Rosa, Locality Encano in the Lagoon of Cocha, coordinates01 °07'N77 °09'O,the Cocha Lagoon also called GuamuezLake, consists of a large natural reservoir of water of origin glacial, situated in the jurisdiction of the municipality of Pasto, department of Nariño, southwestern Colombia. Is the second largest natural body water of Colombia.This country, in 2000and by decree698 of April 18, registered the Cocha lagoon or Lake Guamués as a wetland of importance international under the Ramsar Convention to be the first with this qualification in the Andean region (Plate 1).

Presents specific weather average temperature of 9°C,high relative humidity and 2750meters above sea level, soils with high organic matter content and high water tables, classificationbyordercorrespondstoaHistosol(IGAC, 1996).

This is an investigation about a macrofauna of soil associated with different land use system with *Vasconcelleacundinamarcensis.*Treatments were four arrangements corresponding to Treatment 1: *V. cundinamarcensis* + pastures. Treatment 2: *V. cundinamarcensis* + potatoes. Treatment 3: *V.cundinamarcensis* + onions and Treatment 4: *V. cundinamarcensis* + potatoes + onions. The pasture in the first systemwas*Pennisetumclandestinum*.These systems were evaluated in four replications for a total of 16 experimental units. We used arandomizedcomplete block design. Five months old*Vasconcellea* trees, were planted during rainy season.

There are basic practices for managing soil and crops in systems of production with *V. cundinamarcensis* (Table 1).

Sampling and the chemical and biological determinations were performed on soil of established production systems and were carried out three samples at 0.20 m depth by each experimental plot, to determine the percentage of soil organic matter (first variable). The soil organic matter was evaluated following the methodology of Walkey-Black by colorimetry according Carreño and Unigarro(2005) and to macrofauna was used the methodology of the Tropical Soil Biology and Fertility (TSBF) (Correia and De Oliveira, 2000) modified in taking only two samples per plot every 5m, along a line whose origin and direction were chosen at random;selected monoliths were taken from the following dimensions0.25mx0.25 mx 0.20m side depth (Plate 3).

Table 1: Agricultural management systems and treatments sampled at the Research Station of Institute Educational of Encano, Cocha Lagoon (2011) (Plate 2).

T1=*V. cundinmarcensis* + pastures permanent crop covers of pastures of *P. clandestinum* no tillage practices mulching on the soil surface no apply insecticides, employ management practices that prevent the insects fertilizationwithorganic matter andlime oftree*ofV.cundinamarcensis*	**T2= V. cundinamarcensis + onion** conventional tillage liming on soil preparation sequential cropping continuous onion with *V. cundinamarcensis* apply insecticides, fungicides apply fertilizers organics control of weeds using shovel fertilizationwithorganic matter andlime oftree*ofV.cundinamarcensis*
T3=*V. cundinamarcensis* + potatoes conventional tillage, degrading organic matter liming on soil preparation sequential cropping continuous potatoes with *V. cundinamarcensis* soil arrume in potatoes with shovel apply insecticides, fungicides apply fertilizers synthetics control of weedusingshovel fertilizationwithorganic matter andlime of treeofV.cundinamarcensis	**T4=*V. cundinamarcensis* + potatoes + onion** sequential cropping continuous potatoes/onion double crop with V. cundinamarcensis liming on soil preparation conventional tillage and more soil disturbance soil arrume in potatoes with shovel application ofpesticidesin largeproportions apply fertilizers organic and synthetic control of weed using shovel fertilizationwithorganic matter andlime of treeofV.cundinamarcensis

Samples were takenevery two weeksduring thelifetime oftraditional cropsand invertebrates collected were preserved in 4% formaldehyde. Organisms obtained were recorded on earthworms and other species of macrofauna different annelids and data were expressed in number (individuals/m^2)or density (second variable);these individuals were weighted on a precision balance and biomass was calculated using fresh mass/m^2 (third variable).

The variables were analyzed using analysis of variance and in the case of statistically significant differences between treatments were applied the Tukey test. We used for data analysis Univariate statistical programSAS, version 8.2 (SAS, 1999).

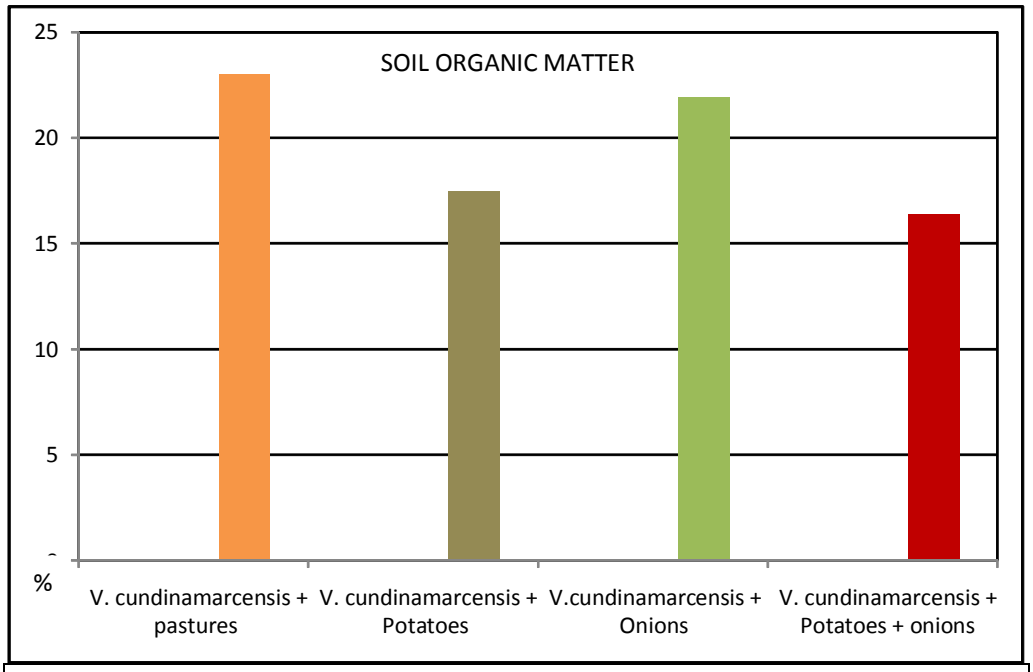
RESULTS AND DISCUSSION

Soil organic matter(%). There were highly significant differences between treatments ($p < 0.01$), and the Tukey test showed that when *V. cundinamarcensis*was associated with potatoes and onions,the percentage values of soil organic matter was decrease, similar to*V.cundinamarcensis* with potatoes, differing statistically from *V. cundinamarcensis* with onions and *V. cundinamarcensis* + pastures, the latter being the model that presented the highest organic matter percentages (Figure 1).

The above results show that those models that soil is more removed as in the case of *V. cundinamarcensis* + potatoes and in the case of *V.cundinamarcensis* + onion + potato soil organic matter is more exposed to the environment producing a rapid oxidation naturalcausing losses and lower values with respect to the other two models, while in systems where there is less removal as in the case of *V.cundinamarcensis* + onion and *V. cundinamarcensis*+ pastures the soil organic matter percentages were higher, possibly due to less alteration in these wetland soils that have high water tables and a higher accumulation of soil organic matter. In conventional agro-ecosystems of potatoes and onion associated with *V. cundinamarcensis*, the crop residues of natural vegetation are removedduring tillage.

The wetland soils can become suitable for agriculture by draining; this allows increased the aeration of soils and improves mineralization. It is recommended in future researches evaluate other soil properties, such as correlations between mineralization of N and P with yield; in this research, the models of *V.cundinamarcensis* + potato and *V.cundinamarcensis* + onion gave better yields of fruity compared with *V.cundinamarcensis*+ pastures; these outcomes maybe due to the increased mineralization of organic matter, which helps the plants to be more efficient to obtain available nutrients, such as P and N, and water, elements vital to plant survival, where as in wetland soils with little disturbance, there is high accumulation of soil organic matter and low mineralization (Burbano, 2003).

Density and biomass of organisms: The treatment*V.cundinamarcensis* + pastures produced a greater number of earthworms (annelids), and differed

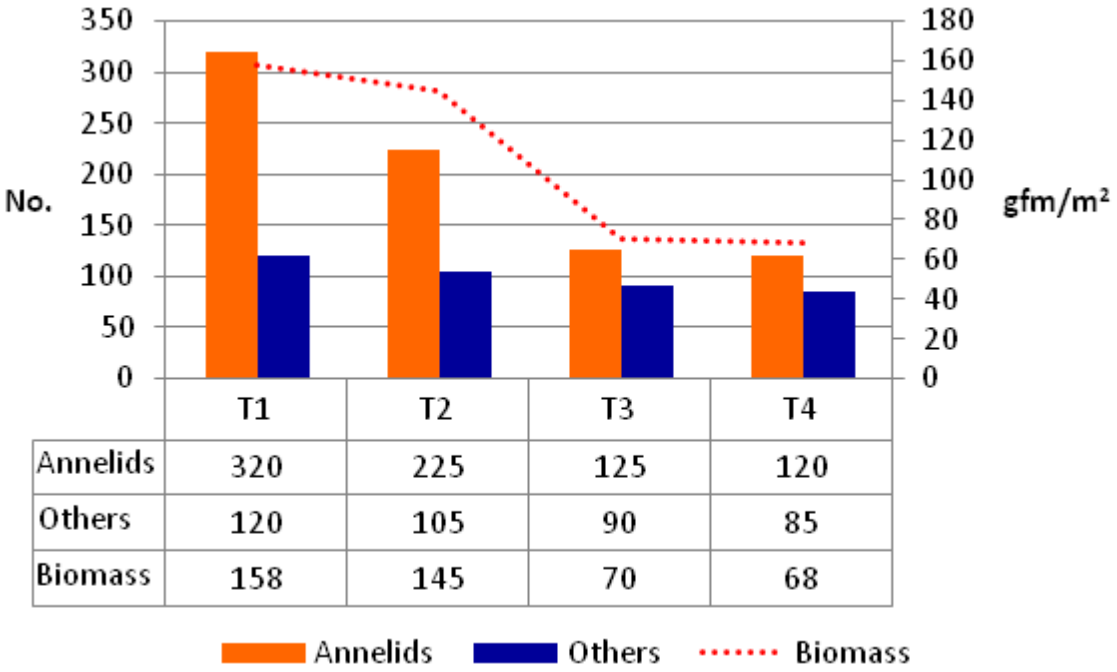


Treatments	Averages SOM (%)	Groups
V. cundinamarcensis+ pastures	23,0	a
V. cundinamarcensis+ potatoes	17,5	b
V.cundinamarcensis+ onions	21,9	a
V. cundinamarcensis + potatoes + onions	16,4	b

Different letters indicate significant differences (p <= 0.01)

Figure 1: Organic matter content in different production systems with *V.cundinamarcensis*, Santa Rosa, El Encano, 2011 (Tukey test).

significantly with *V. cundinamarcensis* + onion,*V. cundinamarcensis* + potato and *V. cundinamarcensis* + potatoes + onionssystems, which had a similar number to annelids, with the lowest values;the numbers of annelidswere the lowest reported in Colombia.in systems with high agricultural inputs, Delgado et al., (2010)observed a dramatic decrease in density and total biomass soil macrofauna, which is attributed to the use of agrochemicals, reduction in roots production and modification in the micro climate of the soil, after the disappearance of natural vegetation.In *V. cundinamarcensis* + potatoes and *V. cundinmarcensis* + potatoes + onion systems, the loss of SOM has a negative effect on soil macroinvertebrates, whose abundance decreases as a consequence of the reduced amount of food available. In addition, conventional systems are characterized by repetitive tillage, which physically disturbs the soil and reduces greatly the abundance of soil macro fauna.Soil tillage modifies soil structure, mechanical implements destroy the soil structure by reducing the aggregate size, and conventional tillage methods are a major cause of disappearance of soil macrofauna. Earthworms and litter communities soon disappear and are not replaced.
Othermacrofauna groups such as termites tend to be more persistent (Decaëns et al., 2001) (Figure 2).
Regarding other different annelids, *V. cundinamarcensis*+ pastures differed significantly from the other three models, which were significantly similar; so in this case the annelids are major contributors of soil macro fauna. Integrated systems of Vasconcellea trees with pastures of *P. clandestinum*are an option to maintain macro invertebrate populations as well as bringing other benefits for soil physical and chemical parameters. The worms



Treatment 1: *V. cundinamarcensis* + pastures. Treatment 2: *V. cundinamarcensis* + potatoes. Treatment 3: *V. cundinamarcensis* + onions and Treatment 4: *V. cundinamarcensis* + potatoes + onions.

Figure 2. Densityand biomass of soil macrofauna (numbers individuals/m^2) and (g fresh mass/m^2) in different production systems with *V.cundinamarcensis*, (Santa Rosa, 2011) (Turkey test).

are more organisms for which we have evaluated the effect of practices in annual crops; these practices intervening in the production systems and alter the density or activity of specific groups of organisms (Pardo et al, 2006).In most disturbedsystems as*V.cundinamarcensis*+potatoes and*V.cundinamarcensis*+onion+potatoes, the contribution of annelidsis lowercompared with systems less disturbed, this may indicate greater resistanceofothermacroinvertebratesto changesin theirhabitat and increased susceptibilityofannelids.FAO (2002) indicates that these aspects are biological indicators of the sustainability of agricultural systems; if we take into account other technical indicators in this work, as financial aspects, we can conclude that with the implementation of traditional crop with *V. cundinamarcensis* + onion, onions growers have a very good alternative as production model in these ecosystem. Also, some agricultural management practices have positive impacts on soils, increasing SOM levels and improving soil functioning, such as, the organic manuring helps to enrich or favour the multiplication of soilmacrofauna and microorganisms.

For totalmacro faunabiomass, the system *V. cundinamarcensis* + pastures showed a total biomass of 158 g fresh mass/m^2, differing statistically ($p < 0.01$) with the system *V. cundinamarcensis* + onion, with values of 145 g fresh mass/m^2; the systems of *V. cundinamarcensis* + potato and *V. cundinamarcensis* + onion + potatoes caused the lower values (70 and 68 g fresh mass/m^2), beingstatisticallysimilarbetween them.The major contributions of this biomass were obtained mainly by numbers of annelids/m^2, up to 50% of the overall macro fauna numbers in *V. cundinamarcensis* + pastures and *V. cundinamarcensis* +onion. Generallymacro fauna populations are more abundant and have higher biomass in direct sowing crops and pastures in continuous cropping (Rodríguez, 2005; Gamboa and Castillo, 2009; Edwards et al., 1995; Elliott, 1997; Yeates et al. 1998), This is a common feature of many tropical pastures where earthworm biomass often ranges from 30.2 to 153.0 g fresh mass/m^{2}with extreme

values up to 400 g fresh/m^2 (Fragoso et al., 1999), these contributions are consistent with the results obtained in this research, where it is considered that the system *V. cundinamarcensis* + pastures withouttraditional crop and where the soil was not disturbed, is the model indicated as the more environmentally acceptable, according biological and chemical indicators.

CONCLUSIONS

1.-The results obtained in these studies suggest some options for conserving and stimulating the activities of soil macro fauna in the systems of the wetland. Alternatives as *V. cundinamarcensis* + pastures and *V. cundinamarcensis* + onion causing higher values in the percentages of soil organic matter, density and biomass of macro fauna.

2.-Cropping potatoes and onion associated with *V. cundinamarcensis*results in a dramatic decrease in soil organic matter, density and biomass of macro fauna. The negative effects of semiannual crops associated with *V. cundinamarcensis* of could be reduced by decreasing the intensity of perturbations such as tillage, the use of pesticides and weeded andremoving hedges.

3.-Environmentally wetland soils could adapt to growing association of *V. cundinamarcensis* + pastures and *V. cundinamarcesis* + onion without causing further unrest in some chemical and biological indicators of soil. Integrated systems of crops than increasing the quantity and quality of the energy resources used by the macroinvertebratesasorganic fertilization as for exampleinthesystem *V. cundinamarcensis* + onion is also an option for maintaining macroinvertebrate populations in order to developsustainablesystems without affectsoiland water resourcesof the wetland.

ACKNOWLEDGEMENT

The authors gratefully acknowledges the generous support of the Vicerrectoría of Research and International Postgraduate the University of Nariño, Colombia, for his financing and cooperation and express their deep sense of gratitude to Institution Educational Municipal of Encano for their support during the course of this research.

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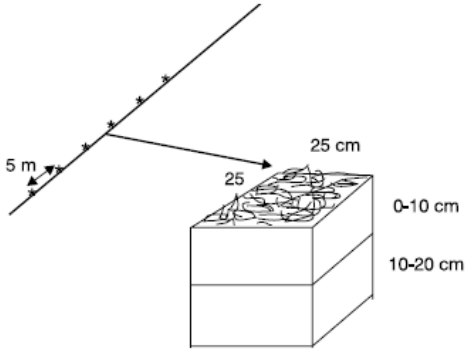
Plate 1: Wetland Ramsar Lagoon of Cocha (Encano, Nariño, Colombia)

Plate 2: Differentmodels of productionsystemwith*Vasconcelleacundinamarcensis*.1) Preparationofsoilforplantingtraditionalcrops, disappearanceofnatural vegetation cover2)*Vasconcellea*trees +pasture, doesnotincludetraditionalcrops, 3)Integrationof*V. Cundinamarcensis*+onion



Manual sampling density biomass

Plate 3: Sampling methodology by the Tropical Soil Biology and Fertility (TSBF, IUBS/UNESCO) Programmed