

Perception of soil quality in agroecological and conventional horticultural systems of Chaco province (Argentina)

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Abstract: Environmental and socioeconomic crisis facing industrialized agriculture and food production has led to arise of agroecology. Horticultural production systems can be grouped into conventional (CO) or agroecological (AE), based on management and technologies used. It is important to mention that in the present work the use of the term agroecological instead of organic pretends to differentiate diversified systems based on local knowledge of small scale, from certified organic systems that mainly perform input substitution and / or are destined for export. The importance of this characterization lies mainly in the environmental and social consequences of each of these systems that produce food and employ a large amount of labor. Soil management is a key tool to reach sustainability and farmer vision about soil health is a cultural product. The objectives of this study were to describe social profile of AE and CO horticulturists of Chaco (Argentina) and to recognize how such farmers perceive soil quality (SQ) by means of surveys. Family farming was predominant. All farmers responded to a low-income state and study level was diverse. AE farmers were older. CO work for the markets, AE mainly for own consumption. In relation to soil, they did not perceive worms and erosion signs; they recognized the compaction and the presence of crust. Surface coverage was more important for AE farmers. Smell was well-known by all and majority tried to classify texture and detected soil aeration variations. SQ indicators with greater differences perception were surface crust, texture, aeration and soil color.

Keywords: agroecological and conventional horticulturists, perception, soil properties.

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I. INTRODUCTION

The environmental and socioeconomic crisis facing industrialized agriculture has led to the emergence of agroecology as a theoretical and methodological approach, a way to increase agricultural sustainability from the ecological, social and economic perspectives¹. The Agroecology as science and a social and political movement, studies the functioning of agroecosystems, gathers a set of practices that allow cultivating in a more sustainable way without using chemical products and tries to make agriculture more ecologically sustainable and socially fair². The increase in the complexity of agroecosystems and the strengthening of ecological processes (nutrient cycles, natural pest control, and maintenance of biomass and background elements) are necessary to increase the sustainability or generation of environmental services. Ecosystem services as good soil and water quality, biodiversity promotion, energy efficiency increase and the capture of atmospheric carbon generates most resilient systems.

Horticultural production systems oriented to the production of edible vegetables for own consumption or sale, have been characterized according to the land tenure system (tenant or owner), type of production (field or under cover), family labor or transitory, among other classifications³. One way to group these systems is into intensive or conventional systems, based on input technologies, which use chemical synthesis and / or irrigation fertilizers and pesticides, hybrid seeds, greenhouses and strong dependence on fossil energy; or agroecological, ecological or organic systems. The last ones comprehend ecological process technologies, species diversity, biological control of pests and diseases and the use of inputs obtained within the same farm, such as homemade preparations for organic pests, fertilizers and amendments. It is important to mention that in the present work the use of the term agroecological instead of organic pretends to differentiate diversified systems based on local knowledge of small scale, from certified organic systems that mainly perform input substitution and / or

aredestined for export. The importance of this characterization lies mainly in the environmental and social consequences of each of these systems that produce food and employ a large amount of labor.

Soil management is a key tool to reach sustainability and the farmer vision about the health and the state of the soil, is a cultural product. The farmers are indispensable actors to evaluate SQ since they make decisions daily; the decisions they take regarding horticultural systems, directly affect the people who work and the quality of the food. Thus, this study focused on agroecological and conventional horticulturist's perception of SQ in the Province of Chaco.

Agriculture and horticulture are amongst the most dangerous occupations in the world^{4,5,6}. The human health of farmers and farmworkers could be affected due to the exposure to pesticides, or heavy metals in urban and peri-urban horticultural soils^{7,8}. On the other hand, the risk increases when there is direct exposure or ingestion of food grown in contaminated soils, or by the residual of the products used in food⁹ and the impact on the environment¹⁰.

Conventional and organic intensive horticultural systems have previously been compared in order to assess the health self-perception of migrant workers who perform the work⁶ evaluate soil quality parameters¹¹, microbial activity in soils^{12,13}, and the quality of fruits and soil in orchards¹⁴.

The area under horticulture in Argentina annually is about 700,000 ha of which 90% goes to the domestic market and employs about 10 million salary a year. Horticulture is an activity of great social value, being Chaco one of the provinces that stand out for the area devoted to horticultural production¹⁵. The management of these agroecosystems has a direct and indirect impact on a large number of people. There are several guides for agroecological horticulture aimed primarily at small-scale family and school gardens^{16,17}. Commercial or larger-scale horticulture uses the intensive approach with a highest chemical input load, regulated by the Best Management Practices, term installed by the agriculture public policy area.

The production of food in small-scale horticultural systems, self-consumption orchards, school, with the sale of surplus is carried out on soils altered by intensive use or urbanization. In Chaco, studies are available about the quality of agricultural, livestock and forest soils, but there are not family farming soils studies and no technological tools have been developed for horticulturists to recognize and evaluate the quality of their soils in situ.

The perception of different soil properties by farmers has traditionally been linked to aspects that have to do with the management and productivity of agricultural soils: poor or rich, sandy or light, clayey or heavy. Most farmers know the difference between a productive and a non-productive land, however this knowledge has not been valued.

Adeyolanu et al, 2018 evaluated soil quality issues for crop production function based on farmer's perception¹⁸. To reach a successful management of soil for sustainable production, there is need to identify issues affecting it. These are problems facing the capacity of soil to perform its functions and thus reducing its productivity. In addition, the similarities and differences between farmer's perception of SQ and that of soil scientist are very pertinent. This study, which was carried out at Itapaji watershed in Ikole local government area of Ekiti state, aims to identify SQ issues using participatory approach and a conventional method. A diagnostic survey was used for a participatory approach that involves farmer's judgment using questionnaires. The results were analyzed to identify the main issues from farmer's perspectives. For the conventional method, major soil types were identified and SQ issues were recognized using soil management assessment framework. The relationship between the soil issues from farmers' interview and soil analysis were established by correlation analysis at $\alpha = 0.05$.

Regional studies in Chaco (Argentina), with an approach based on evaluating the impact of agroecological and conventional practices are almost non-existent, and there are no studies in Chaco about soil destined for food production with emphasis on farmer's perception.

Purpose and objective of the study:

The objectives of the present study were:

- i. Describe social profile of a group of agroecological and conventional horticulturists of the Province of Chaco.
- ii. Study how such farmers perceive soil quality with the main objective of developing SQ evaluation systems based on the characteristics in which farmers observe variations better.

II. MATERIALS AND METHODS

Two groups of orchards, agroecological (AE) and conventional (CO) were selected of Comandante Fernández, Sargento Cabral and General Güemes (Chaco) departments, in urban and peri-urban soils.

AE orchards only apply homemade fertilizer and natural pest control preparations, use seeds from previous crops or delivered by the state and perform manual or mechanical weed management.

CO orchards use commercial seeds, mechanical or chemical control of pests and mineral fertilizers.

The species cultivated in the orchards were: chard (*Beta vulgaris subsp.bulgaris*), lettuce (*Lactuca sativa*), arugula (*Eruca vesicaria*), parsley (*Petroselinum crispum*), scallion (*Allium fistulosum*), carrot (*Daucus carota*), squash (*Cucurbita sp.*), bean (*Phaseolus vulgaris*), strawberry (*Fragaria sp.*), corn (*Zea mays*), beet (*Beta vulgaris*), pepper (*Capsicum annuum*), cabbage (*Brassica oleracea var. capitata*), oregano (*Origanum vulgare*), chicory (*Cichorium intybus*) and cassava (*Manihot esculenta*).

The profile of the producers was built upon surveys: the questions were asked to the respondents about aspects as age, purpose of the vegetable production, type of studies, experience in orchards, family composition, complementary work, family member in charge of the orchard and if it serves as a family support. These data were useful to characterize the social dimension of agroecological (AE) and the conventional (CO) orchards.

Soil survey: it was based on the one developed by Romig et al. (1995)¹⁹. Productive actors were interviewed, the unit of analysis was the perception of the horticulturists and the sampling was of casual or incidental type. The group of surveyed horticulturists involved people of different ages, studies and knowledge. Each survey consisted of a series of 17 indicators divided into 3 levels or categories that represented the indicator state (better or worse). The indicators were presence of worms, erosion signs, tillage facility, structure, wet color, compaction, infiltration, drainage, water retention, soil fertility, decomposition of organic debris, touch feeling, surface crust, surface coverage, hardness, smell, soil texture and aeration. The categories presented an attached score according to the chosen option. The ranges varied from 0 to 4, where zero is the lowest quality of soil perceived, 2 the intermediate situation and 4 the highest.

III. RESULTS

Social profile of the producers

All the orchards were in production in the moment of the surveys. Tables 1 and 2 show the socioeconomic profiles of the producers.

Table n° 1: Socioeconomic profile of agroecological (AE) and conventional (CO) horticulturists.

	Level of study	Previous experience in orchards	Family composition	Other job	Person more dedicated to the orchard
Agroecological	Student of Language and Literature (tertiary)	Has experience, was raised in the field	A woman and two teenager daughters	Takes care of an old man, cooks and sells bread with her daughters.	Woman
	Police officer	Grew up in the countryside	Older couple	Retired police, teenage son, also has a farm where he raises farm animals.	Man
	Primary School	80 years school. Its director has been in contact with INTA since the middle of-90s.	87 students and school staff	Elementary School	Teachers and students
	Complete primary school	10 years old marriage	Married couple	The woman works taking care of an elderly man	Man
	Complete primary school	Farmer during his entire life	Retired elderly couple	They also have a 2-hectares farm with farm animals and 6 hives.	Woman
	Incomplete primary school (1st grade)	3 years	Marriage with three children of different ages	Farm of 2 hectares, with few animals	Both man and woman for equal

Conventional	Incomplete primary school	Grew up in the countryside	Couple with several children. The smallest one lives with her.	Occasionally sells baked goods, door to door. In addition to the orchard that is in the town, she occupies a farm in succession, lived for a long time in Buenos Aires. and returned few years ago. Takes care of an old woman.	Woman
	Primary school	13 years	Elderly people marriage	Small scale producer	Man
	Incomplete secondary	Learning by his family	Marriage with children of school age	Small scale producer, day laborer	Man
	Primary complete	Yes	Older marriage	Small scale producer, farm animals	Man
	Secondary	15 years	Young marriage with several children	Small scale producer, farm animals, entrepreneur, commercializes in different fairs and greengrocer's, make group with neighbors and cooperate in production.	Woman
	Complete primary	15 years	Older marriage	Small scale producer	Man
	Incomplete secondary	Yes	Marriage with small school-age children	Small scale producer, markets their products	Man

Table 2: Socioeconomic characteristics of agroecological (AE) and conventional (CO) horticulturists.

	Agroecological farmers	Conventional farmers
Predominant age	Older adults	Young adults
Purpose	Self-consumption, what is left over is commercialized	First objective: marketing
Technology	Manure technology, homemade preparations, tools, half shade, and irrigation.	Fertilizers, mechanical seeder, phytosanitary products, machines and tools of own production, irrigation, half shade, harrows, cultivators
Studies	Primary	Primary
Orchard experience	Yes	Yes
Family composition	Senior marriage	Marriage with school-age children
Complementary Work	Day laborers, care for the elderly	Other tasks developed by small farmers
In charge of orchard	Women	Men
Family support	Yes, but most do activities outside the orchard	Yes, main income

Soil perception obtained by surveys

Figure 1 presents the results of the soil survey by indicator and groups.

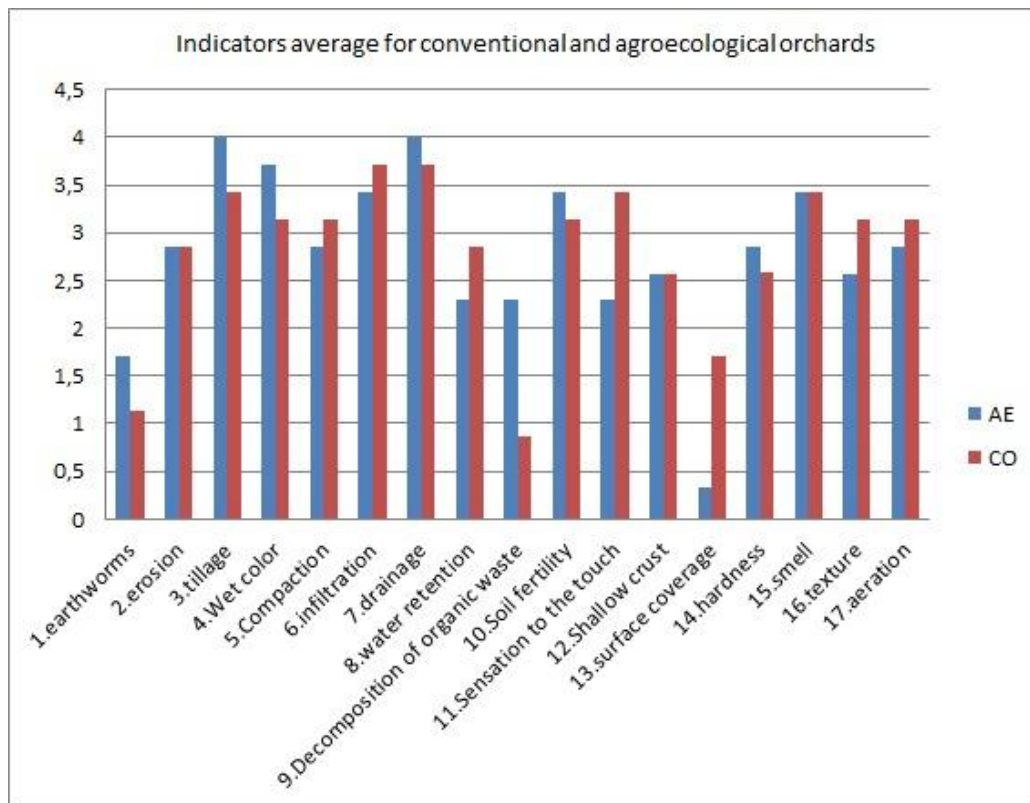


Figure 1: Soil quality indicators scores average, by agroecological(AE) and conventional(CO) horticultors. The ranges varied from 0 to 4, where zero is the lowest quality of soil perceived, 2 the intermediate situation and 4the highest.

Producers rated each indicator mentioned in the survey as follows:

Earthworms:most of the interviewees, both in AE and CO, said they had not seen worms, and did not associate this indicator with soil quality. Less than 28% of respondents gave the highest score to the presence of worms, even when worms were found in some orchards.

Erosion: the result was similar in AE and CO. More than 80% of respondents said they did not perceive signs of erosion.

Tillage:in this item, all AE producers expressed that the soil of their orchards is friable, tillage is not difficult; in CO only one farmer observed difficulties.

Wet color: AE producers said the soil is dark, except one of the respondents who said the soil is reddish brown; 70% of the CO also observed a dark soil, 15% a reddish soil, and the remaining 15% a light gray soil.

Compaction:71% of AE producers perceived a loose soil and the remaining compacted; in CO, 71% spoke of a loose soil, but 14.5% observed a soil with as thin and fragilecompacted layer, and the rest as compacted soil.

Infiltration:for this attribute, the majority valued it as optimal. A 71% of AE spoke of a spongy soil, where water penetrates quickly; the rest indicated that water penetrates slowly. 86% of CO expressed that water infiltrates quickly, and only 14% said it infiltrates but that the passage is slow.

Drainage: they did not mention problems for this property. Almost the total of those interviewed gave the highest score; however, one of the CO producers, which gave it an intermediate score.

Water retention:CO producers were more satisfied with water retention than AE. 57% of AE said the soil retains moisture well, but the rest said the soil dries too quickly. In contrast, in CO producers, 71% said the soil retains moisture well, and 29% said dries too quickly.

Decomposition of organic waste: in many cases the producers acknowledged not making contributions of organic waste in their orchards. Only five of the 14 respondents assumed to use organic waste, 3 of them gave to this indicator the highest score.

Soil fertility: 65% of respondents said that fertility is balanced; the rest said there is no need to add amendments or fertilizers. 71% of AE perceive that in their soil fertility is balanced, in CO 57% spoke of a balanced fertility, and the rest said they needed amendments or fertilizers in their orchard.

Touch sensitivity: 57% of the producers referred to a loose, fluffy or spongy soil, 28% to a soft or granular soil, but which is compressed when imprisoned, and the rest referred to a sticky or adhesive floor. Positive responses on good soil quality were superior in CO producers.

Shallow crust: 57% of AE respondents responded that the soil surface was porous, without crust, 29% spoke of a thick crust and 14% noticed a thin crust. In CO, 57% also assigned the highest score (without crust), 29% recognized a thin crust, and 14% a thick crust.

Surface coverage: the majority of respondents perceive that the soil has no coverage; only 14% of AE farmers indicated that the surface has little residue and the remaining 86% indicated that the surface of the soil was bare. As for CO producers, 29% said that the surface is covered, another 29% indicated that there was little residue on the surface, and the rest said that the surface was bare.

Hardness: 50% of the total considered that the soil was soft and easily flaked, 36% replied that the soil was firm and broke between the fingers under moderate pressure, and the rest said that the soil was dense and broke between the fingers. The responses were similar between both groups.

Smell: more than 70% of the respondents gave this item the highest score, saying that the soil has a smell of soft and fresh earth, the remaining 30% assumed no smell. The responses were similar between both groups of AE and CO.

Texture: almost 65% of respondents responded that the soil was of loam texture, 14% said that the soil was clayey and 21% that it was sandy. 57% of AE perceived a loam, 14% a clay soil, and the remaining 29% a sandy soil. As for those of CO, 71% perceived a loam, 14% a clay soil, and the remaining 15% noticed a sandy soil.

Aeration: of the total AE, 57% noticed a porous soil, 28% a dense soil with few pores, and 15% a soil without pores. Of the CO producers, 57% expressed that the soil is porous and breathes, 14% spoke of a dense soil, almost without pores, and 29% of a soil almost without pores.

IV. DISCUSSION

In relation to the socioeconomic profile and as is presented in Table 1, the horticulture producers under study belong to a low-income stratus. For the type of study achieved, the situation is quite different, with producers with incomplete primary education, even a tertiary level student, and a retired police officer. In all cases, those who work the land are the same owners; born and raised in rural area, so they have experience in rural topic. Family composition shows variability, but marriages with or without children predominates. Horticulture in none of the cases was enough to meet family economic needs; they usually have to work apart to get some extra income: prepared dishes to sell in local markets or other activities as small farmers, take care of old people or in other cases are retired earning a retirement income. In relation to gender, work is divided equally between men and women.

Predominant age

Age ranges vary between AE and CO producers. In the AE group, the producers surveyed were mostly older adults, some retirees, who carry out the work of the garden; in the CO group, farmers are young head of families and the work is carried out in conjunction with family members, in contrast to what Ferrazino et al. (2012) found²⁰.

Purpose of vegetable production

The main objective of the production of CO horticulturists was the market. On the other hand, the AE ones produce mostly for their own consumption, and sell the surplus at local fairs. The fairs are located in small and intermediate cities on public spaces ceded by the state to guarantee the proximity of the producers and their commercial operations some days of the week. Bromatological and hygiene conditions are guaranteed from local areas. The main strategy of the traders is to achieve consumer loyalty, based on a committed work so that the product is differentiated, basically for food quality and the absence of toxic substances applied. The possibility of selling directly, from the producer to the consumer, acquires counter-hegemonic characteristics in which not only the possibility of improving the price for the producer prevails but also improving the product quality for the consumer²¹.

Technology

There is a contrast in the technology used in the different groups. AE producers are limited to the use of homemade preparations, to increase the diversity of species, mechanical management practices, irrigation, sunblock shade cloth, as mentioned by Paleologos and Flores (2014)²². In contrast, CO horticulturists also made use of synthetic fertilizers, commercial seeds, seeders and agrochemicals.

Family composition

CO farmers were younger, so the family groups that predominated were young marriages with school-age children; unlike AE farmers, where mostly of older marriages were predominant. This difference could have several causes but it would be interesting to profound if is related to the work time needed in each system.

Complementary work

Most of the AE producers surveyed, responded that in addition to their work in the orchard, they perform other jobs, not formal but those that arise in the day to day.

In both cases, the work of the orchards becomes important, but it is not enough to survive. As seen in Table 1, agroecological producers turned to work outside the farm, marketing handicraft products, with some trade, or in care work.

Argentina presents a strong depopulation phenomenon in rural areas, 90% of the population lives in urban areas. Although the distribution of men and women in rural areas is quite homogeneous, there is a small prevalence of men in more dispersed areas. Rural women are more in grouped rural areas, a situation frequently associated with having young children and with the search for better educational, work, health, care, connectivity and quality of life offers. Women in the countryside have an intense workload: they are responsible for domestic and care tasks, productive tasks within family units (mainly for self-consumption and the sale of surpluses), in addition to participation in community spaces. The lack of care services and the blurred frontier between the productive and reproductive make invisible all the effort that rural women make to reconcile these worlds²³. In recent decades, the work of women in agriculture has become more visible, and also with increasing frequency is falling on their shoulders the responsibility for family support. This trend has been called "feminization of agriculture". Women take over important part of agricultural tasks previously done only by men, such as site preparation, and are devoting a lot more work to cash crops²⁴.

The role of family farming

According to FAO (2014)²⁵ family farming is the predominant form of agriculture in developed and developing countries. There are more than 500 million family farms in the world. Family farmers range from small to medium-scale farmers, and include farmers, indigenous peoples, traditional communities, anglers, farmers in mountainous areas, pastoralists and many others that represent all regions and biomes of the world. They manage diversified agricultural systems and preserve traditional food products, which contributes to obtaining balanced diets and safeguarding global agrobiodiversity. Family farmers are integrated into territorial networks and local cultures, spending their income mainly in local and regional markets and thereby generating numerous agricultural and non-agricultural jobs. This is why family farmers have extraordinary potential to move towards more productive and sustainable food systems if they have the support of regulatory environments. Today, it is necessary to promote sustainable agriculture in order to meet the triple challenge of produce more food, create more jobs and conserve the natural resource base: small family farmers are a fundamental part of the solution.

Soil perception in agroecological and conventional farms

The perception of AE and CO farmers about soil quality in orchards was good and they showed to be aware about some differences and the need of a better soil condition in several cases. The majority valued infiltration and drainage as optimal and gave positive responses to soil fertility and touch sensation.

CO producers were more satisfied than AE with water retention. Most producers observed the soil as dark coloured, being the color one of the properties about which they observed more differences. The farmers did not perceive worms and erosion signs but generally were sensitive to compaction and recognized the presence of crust in their soils.

Surface coverage was more important for AE producers and the hardness was not a problem for them. The smell was a well-known property for all, with similar values given for AE and CO. The majority tried to classify soil texture considering it as an important property, also expressed interest and could detect variations in soil pores related to soil aeration. SQ indicators for which farmers detected greater differences were surface crust, texture, aeration and soil color.

These results coincide only for the issue of soil compaction identify by farmers in Nigeria, but differs in soil erosion, drainage and fertility, being the last one the highest positive relationship soil issue between farmer's perception and the conventional method¹⁸. After future laboratory analysis, it could be useful to relate fertility values to soil color and texture with the objective of give a most complete tool for soil quality evaluation to familiar farmers.

V. CONCLUSIONS

In this study, all surveyed horticultural farmers of Chaco responded to a low-income state and the type of study scholar level performed was diverse. Respect to the age range, AE horticulturists were older, and CO younger, it would be interesting to profound if this age difference is related to the work time needed in each system. The CO farmers worked for the markets, the AE for their own consumption and the surplus for the local fairs, highlighting a good contrast in used technology in each case. Family farming was predominant in both horticulture systems. Women had an intensive work in the feeding of the family, the control of the orchards, and also sometimes having complementary jobs.

The perception about soil quality in orchards was good and they seemed to be aware of the need of a better soil condition. Generally, the surveyed, did not perceive worms and erosion signs but perceived compaction and recognized the presence of crust. Surface coverage was more important for AE. The smell of soil was a well-known property for all. The majority tried to classify soil texture considering it as an important property, also expressed interest and could detect variations in soil pores related to soil aeration. Soil properties for which farmers detected more differences were surface crust, texture, aeration and soil color.

This study results suggests that many tools developed for SQ evaluation should have in account the farmer perception to be more useful as a simple technology. It could be useful to relate fertility values to soil color and texture with the objective of give a most complete tool. Given the low level of income and study of farmers in family food production systems in the orchards of Chaco, the availability of simple technical tools to assess SQ, easy to adopt and based on their perception, can accompany them in achieving better soil management.

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