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Adoption of Agricultural Conservation Practices in the Ignacio Agramonte Cooperative of Credits and Services (CCS), Nuevitas, Camaguey

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ABSTRACT

The adoption of sustainable technologies, like Agriculture Conservation Practices in drought-stricken suburban areas is a must for land sustainable management. In order to contribute with the inclusion of this technology at the Ignacio Agramonte CCS, in El Carmen, municipality of Nuevitas, Camaguey, Agricultural Extension tools were used, like systemic diagnostic and participatory orientation. The SWOT matrix was created after three workshops, where agricultural conservation practices were identified for adoption, based on actual conditions at the CCS. As a result, five key problems were identified: lack of water for irrigation, saline waters, saline soils, use of inappropriate management technologies, deforestation and poor training in agriculture. The most critical impact found in the matrix was in Weaknesses - Threats (81.3%). Furthermore, local farmers, inhabitants and public officials agreed on the use of agricultural extension tools to provide positive elements and an effective way to help increase motivation and knowledge about agricultural conservation technology, as an alternative to mitigate the degradation state of lands at the CCS.

Key words/: rural extension, conservation agriculture, adoption of technology, land sustainable management

INTRODUCTION

Many countries, including Cuba, have withstood severe drought events that have caused trouble to social life, and significantly negative impacts on natural and crop ecosystems, with ensuing soil degradation and desertification in fragile areas, with lots of economic losses (Centella *et al.*, 2006). As a result, the impact on natural resources is widespread; large extensions of cropland are considerably reducing yields. Additionally, cattle raising and the environment are undergoing critical changes, losing their appealing landscapes (Begum,

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2010). Therefore, it is important to find alternatives to eliminate or minimize such effects.

Agriculture Conservation (AC) could be one of the measures to implement; it comprises a series of techniques to preserve, improve and make a more efficient use of natural resources, through integrated management of soil, water biological agents and foreign supplies (FAO, 2006). It allows for preservation of the environment, as well as sustainable agricultural production without degrading natural resources, and keeping or increasing today´s production levels.

In Cuba, FAO has encouraged the adoption of the technology. The Guantanamo-Guaso basin is a positive reference of promotion, training and extension of AC technology and its three principles (Hernández *et al.*, 2013). Moreover, each Cuban province has been encouraged to create experimental areas for soil, water and forest preservation, as working platforms intended to implement an integrated technological system of conservation and improvement of the environment on the farms and production units, also becoming scenarios for the application of Sustainable Land Management principles (Vento *et al.*, 2012). However, the application of those principles is different in each region, because it depends on the weather, soil type, water resources, relieve, and anthropization, which are specific for each ecosystem in particular.

Farms at the Ignacio Agramonte CCS do not have appropriate conditions to achieve the desired yields, due to soil erosion by ocean waves, dry wells, and low water availability in areas where the farms are located. Generally, if CCS farmers know about AC technology, or have adopted some of its practices, they only make reference to crop rotation, and many farmers are unaware of their phytosanitary effects; thus, demonstrating ignorance about the technology. Therefore, the goal of this research was to contribute to implementation of new AC practices at the Ignacio Agramonte CCS, in Nuevitas, Camaguey.

MATERIALS AND METHODS

The study was developed between February 2014 to April 2016 at the Ignacio Agramonte CCS, Camalote Agricultural Enterprise, Carmen area, municipality of Nuevitas, in the province of Camaguey. It is located on 210 25l 40" north latitude and the 770 08l 30" west longitude, 0.88 - 0.98 meters above sea level (El Carmen Topographic chart 4680-ll – 1:25 000). The predominant soil is deep, somewhat humid and slightly saline gray-yellow, non-gley dark plastic on transported carbonated or non-carbonated materials. Soil texture was montmorillonitic clay, 1.1- 2% slope, almost flat, according to the genetic classification of Cuban soils (Hernández *et al.*, 1975). Provincial Soil Laboratory (LSP).

A systemic diagnostic was performed, using the procedure suggested by Marzin *et al.* (2014) by a multidisciplinary, participatory team. The perception that farmers have about droughts was taken into account, as well as climatic change, land degradation and AC practices implemented on the farms.

The surveys were applied according to questionnaires made by Rodríguez *et al.* (2005), to 14 farm administrators (22 total farms), 13 key informers and 28 inhabitants. The perception and knowledge they have on drought effects and the consequences of climatic change to land degradation, the alternatives used and recommended, the AC practices, and skill acquisition aspects, were analyzed. Each group contributed with different approaches that ensured information triangulation to guarantee a balance of sources from the farmer´s perspective, knowledge, experiences and leadership.

A semi-structured interview based on recommendations by Zhu *et al.* (2012), cited by Hernández (2015), was designed, and applied to the 14 administrators. It cosidered four aspects: integrated nutrient management (INM), integrated management of sols (MIS), integrated water management (IWM), and integrated pest management (IPM). It made possible to identify the present state of AC technology on the CCS farms. The agroecosystem included the following AC practices (Table 1).

Table 1 AC practices on the farms

Agroecosystem management	**AC practices**
Integrated nutrient management (INM)	Residue management
	Fertilizer type
	Manure use
Integrated soil management (ISM)	Farm technical level
	Crop rotation
	Soil tilling
	Soil preservation
	Erosion control
Integrated water management (IWM)	Barren soil
	Windbreak
	Shelterbelt
	Stalks layer
Integrated pest and disease	Chemical

management (IPDM)	Integrated management
	Agroecological

Collectively, the most suitable AC practices for implementation were identified, according to the CCS real conditions. Three participatory workshops were made, using the methodology of people´s education (Jara, 2004). Farmers, decision makers, soil specialists, phytosanitary specialists, officials from the Provincial Delegation of the Ministry of Agriculture, ACTAF, university students and teachers (all members of the national project Innovation and Agricultural Management in Prevention and Protection of Suburban Arid Agroecosystems), attended the workshops for approximately 2-3 hours. Fruitful exchanges took place between farmers and specialists.

The SWOT matrix was designed during the workshops, as a tool to identify or determine the main factors that influence AC implementation at the CCS. It was created with data and information collected with the application of the diagnostic tools.

A database was compiled with information processed by Excel 2007, for Windows. SPSS, version 15.0 (2006) was used for statistical analysis of the study indicators.

RESULTS AND DISCUSSION

The area is slightly flat-waved, commonly observed in the province, located in a humid subtropical region, and influenced by climate change effects.

The results of the diagnostic showed (Table 2) that the CCS now is located on 791.78 ha (295. 24 ha owned by farmers, and 496.54 ha granted by decree No. 259). The cooperative is made of 22 farms (6 for various crops and 16 for various crops and livestock combined). Today, the number of members is 82 (14 women and 68 men).

Table 2 General characteristics of the CCS

Social objective	Various crops and livestock	
Total area (Ha)	791.78 ha	295.24 ha. Land owners
		496.54 ha. Owners by decree No. 259
Number of farmers	82	14 women
		68 men
Number of farms	22	6 for various

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		crops
		16 for various crops and livestock combined
Active founders	18	
Main productions	Onion, garlic, maize, papaya, cassava, plantain, beans, tomatoes, and milk	
Average of inhabitants per home.	5 people, including 2 children	
Predominant education	Junior high school	
Average age of heads of families	60	
Average age of farmers	60	

Average age of farmers is 45, and average age of head of family is 60. That age may be suitable for AC adoption, considering the experience acquired by the farmers and their willingness to adopt measures that change the existing reality. They have sought for new alternatives to manage the edafoclimatic conditions (a new maize variety was created that could adapt to the ecosystem: David Carralero (DCI)). It coincides with FAO (2010), in that farmer experience is a pivotal factor to incorporate AC.

All the persons surveyed keep their lands cultivated along the year, particularly maize, beans, water melon, tomatoes, papaya, onions, garlic, cassava and plantain. According to farmers, those crops undergo droughts, climatic change conditions, and land degradation. The production means are insufficient and most are private; however, they can be used by the majority.

The farms have conditions for AC implementation and development, considering that 98% of the families live on the fields where they work. The surveys concluded that 57% of the population agreed that the drought conditions are very severe (Table 3), 36% used the term severe, and 7% called it moderate (Table 3).

Table 3 Farmer drought assessment

Drought	%
Severe	57
Very severe	36

moderate	7

When the drought effects are most severe at the CCS, farmers said that the greatest damages are observed in the lack of water for irrigation and human consumption, followed by the occurrence of livestock deaths, dried wells and ground saline water.

Farmers only recommended general measures to mitigate drought problems; such as irrigation systems, deeper old wells and digging new ones, enlarging the Monte Grande dam, and cultivating the land in advance. These results show the poor knowledge about other possible measuresto be applied, or good AC practices, which may ease the negative effects on agriculture. Farmers also said that specialists of the Ministry of Agriculture and ANAP have alerted on droughts, but they have been unable to mitigate the effects. Farmers have heard about climate change and global warming, but they have failed to explain their meaning and consequences. They claimed that the media are the television, the radio, the periodicals, and to a lesser extent, local decision makers. Farmers stated there has been lack of communication, and ignorance by most farmers. Benítez (2013) claimed that proper communication within a production unit, among all actors, is important for adequate disemination and adoption of AC technology.

The results of the diagnostic proved that farmers acknowledge land degradation, manifested as an increase in soil salinity caused by the elimination of coastal vegetation and fertility losses. They also said that not only crops and animals were affected by poor water availability. They added that there are no alternatives to face this situation on the location. Accordingly, López (2015) noted that these changes are also caused by natural sources, like the hurricanes that have struck the location. These results coincided with Ramírez (2013), when he stated that soil fertility was low before AC application. He added that to set up the technology, some requisites must be met, depending on the production system used, also started with plot diagnostic. It set the course for soil conditioning prior to the application practices, like soil analysis, subsoiling labor, leveling, contour coultivation or slope cultivation (depending on the case), previous practices to improve soil fertility and pH (application of lime or gypsum), among others.

According to Hernández *et al.* (2013), agriculture conservation relies on a fundamental concept of integrated nutrient, water, soil and biological agent management.

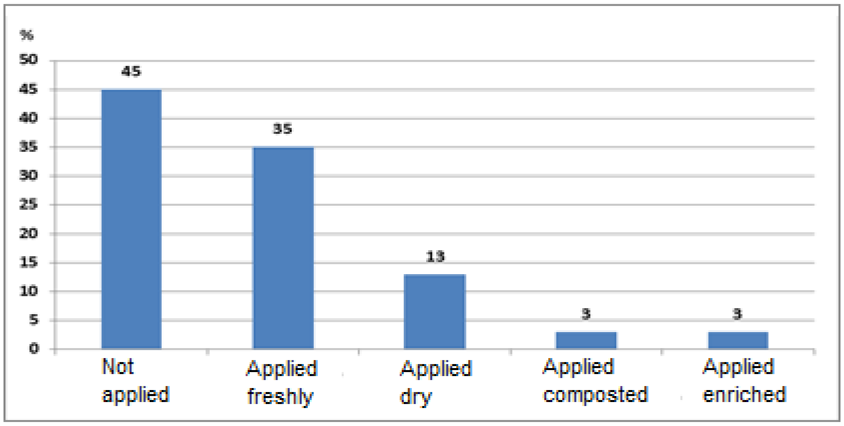

Figure 1. Manure use

The previous figure shows the use of manure made at the CCS farms. Forty-five percent of farmers do not use it as an AC practice, at all. Thirty-five percent of farmers apply it fresh, and thirteen percent does it in dry form. Only three percent applies it as compost, another three percent does it with supplements. The use of manure as an organic fertilizer is one of the most commonly known measures to preserve soil. In any form, it increases organic matter contents in it (Vento *et al.*, 2012).

Although the CCS farmers have natural resources that can be used for organic fertilization, they make excessive use of chemical fertilizers, as shown in figure 2.

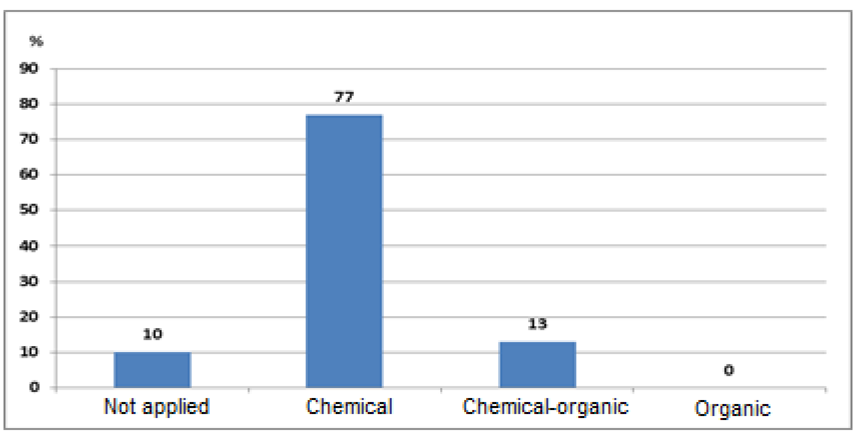

Figure 2. Application of organic fertilizers

The interviews revealed that 77% of farmers used chemical fertilizers on their farms, 13% combined it with organic fertilizers, and 10% did not apply it either. Apparently, farmers have no culture of organic fertilization and the benefits it can bring. They noted that as long as chemical products are available and affordable, it is better to use them to increase productions. Kassam *et al.* (2009)

and Hernández *et al.* (2013) stated that to avoid soil losses, it is important to apply techniques like the rational use of chemical fertilizers, and the inclusion of stalks as natural protection and fertilization means for soils. They were able to increase the levels of organic matter, improving their composition, which led to similar crop productivity.

Residue management on the CCS farms (Fig.3) is done by removing them from the soil, not incorporating them. Only 16% of farmers leave some residues and placed back in the soil. No farmer leaves all residues on the field, though it is one of the most widely used agricultural practices of conservation used by farmers who have adopted AC globally.

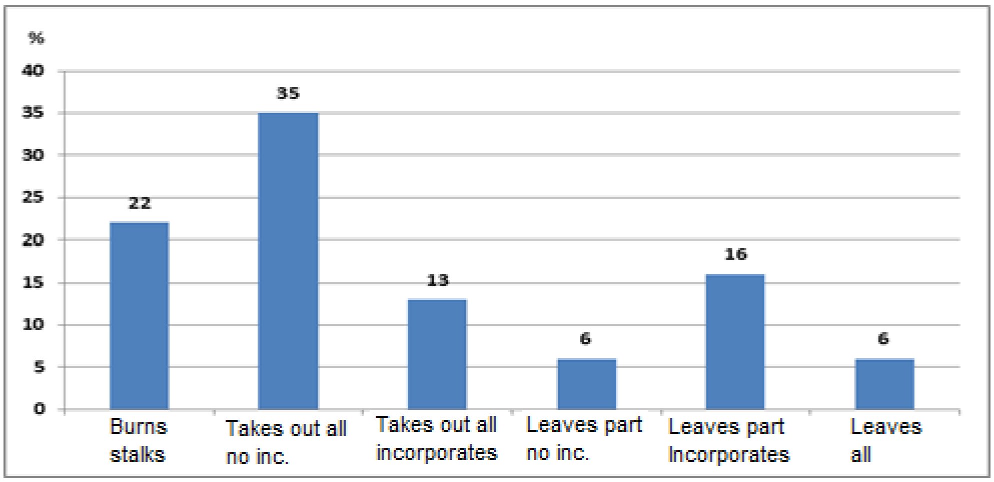

Figure 3. Residue management

Stalks act as a protective layer that cushions the pressure from tractors and other heavy harvest equipment on the soil, thus preventing compressing.

The use of organic fertilizers on the CCS farms is an easy AC practice to implement, because the natural resources, the worm culturing potential, and composting, are available. However, farmers claimed they were reluctant to use these practices because they do not have the skills or knowledge; others said that those were unreliable practices.

Another AC principle is no tilling (when the technology has been adopted). Figure 4 shows the results of the diagnostic. Though oxen and manual tools were used, machinery use was predominant (48%). Farmers said that the number of tractors was insufficient, but they preferred to use the machinery, and managed to have it operational.

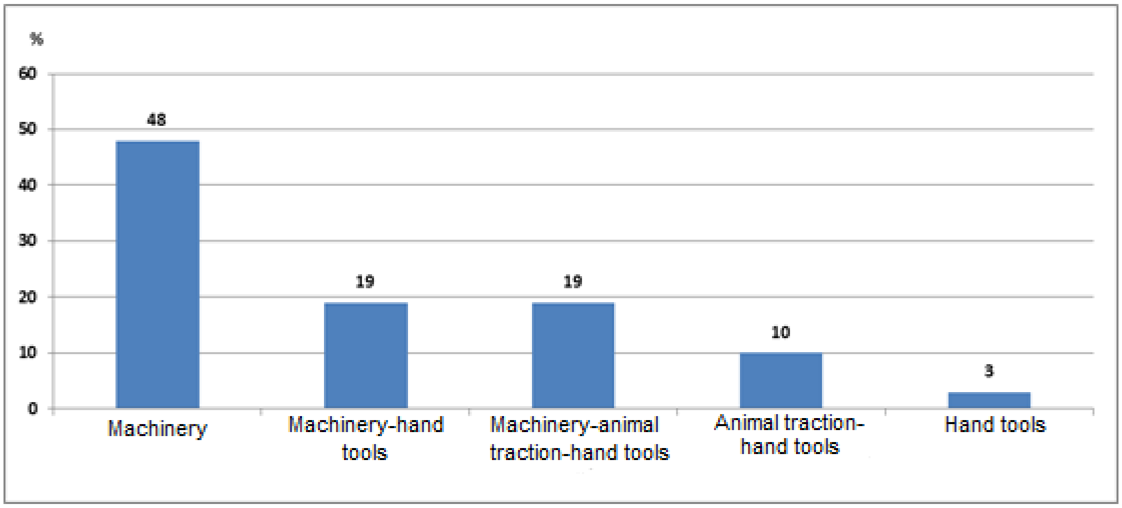

Figure 4. Mechanization

Several studies make reference to the benefits of minimal tilling. Vento *et al.* (2012), in Cuba, said that by introducing minimal land tilling as part of AC, led to a reduction of tilling actions and oil consumption in Camaguey. Ordóñez *et al.* (2008) in comparison trials made on the Tomejil farm, in Carmona, (Sevilla, Spain), after 19 years of direct seeding (compared to conventional practices), demonstrated that 18 t/ha of carbon have been fixed to a 52 cm soil profile, increasing about 40% of organic matter content. FAO (2010) claimed that no tilled fields act as CO_2 drains, and farmers who implement AC practices could eventually achieve carbon credits.

Rotation as part of farm diversification (Fig 5) showed that 47% of farmers do not rotate crops, but those who do are ignorant of the phytosanitary benefits achieved. Only 14% stated that legumes provided nitrogen to the soil so they included them in the rotation.

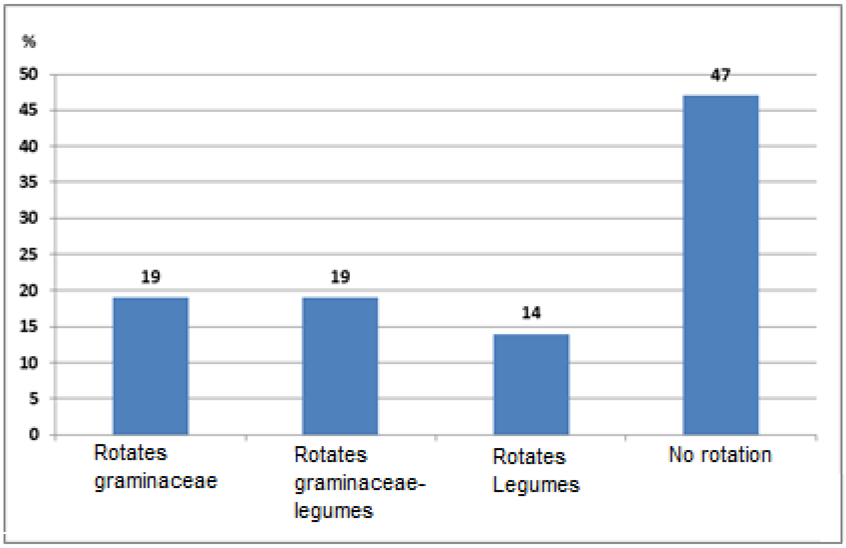

Figure 5. Crop rotation

Hernández *et al.* (2013) claimed that before starting AC, one of the most important aspects is to plan proper crop rotation. Those authors assured that the ideal crop rotation for AC is when grains and pasture /graminaceae) are diversified with criciferous, malvaceae and other species. This type of rotation blocks pests and diseases; production of various amounts and types of residues; residue management; and it improves nutrient cycles, and helps change sowing times.

Evaluation of water management on the farms showed that 77% of the soil is barren during productions, only 13% uses windbreak, 6% uses shelterbelts, and 3% uses stalks (Fig. 6), as measures to preserve the soil and improve water management.

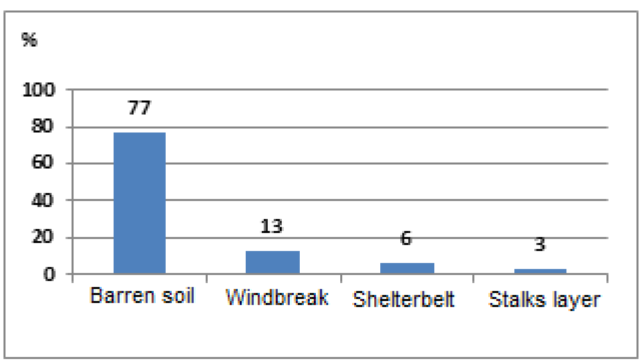

Figure 6. Water management

Permanent coverage (by stalks or live coverage), not only protects the soil, it also contributes to integrated water management on the farms. Hernández *et al.* (2013) and Friedrich (2015) claimed that it keeps and improves the physical, chemical and biological features of the soil, protecting it from the impact of dropping water, excessive insolation and the action of winds.

Likewise, integrated pest and disease management is an important practice for farmers. Figure 7 shows that 74% of farmers used chemicals on their farms, and only 19% performed integrated management of pests, and 7% implemented agroecological practices.

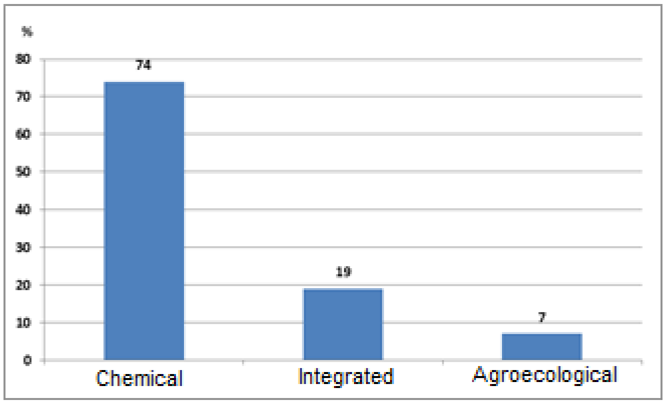

Figure 7. Pest management

Farmers said that chemicals had a better effect on pathogens, not biologicals. They argued they are aware of few agroecological alternatives, but it would not solve water and soil issues on their farms. These results coincided with Lozano (2004), who said that farmers cannot successfully adopt a new technology, unless they know it, or are able to incorporate it to the crop systems. Hence, it proves the need to consider the participation and integration of all the actors involved in the process, the real conditions of their areas, and the purpose in the use of technology.

Figures 10a, 10b, 10c, and 10d show instances of the workshops where agriculture extension tools were used to increase motivation and knowledge of AC technology.

Fig.10b. Participatory techniques (cross threading)

Figure 10c. Group work (board)

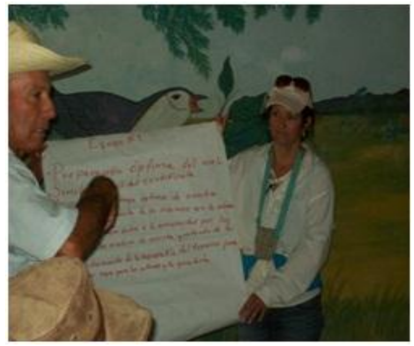

Figure 10d. Farmer Actions

The result of the first workshop was the hierarchical organization of the main issues found in the diagnostic (Table 4).

Table 4. Problems detected and hierarchical order.

No	Problem	Priority level	Type of solution
1	Water shortage, saline well water, most areas are not irrigated	1	Mid and long term
2	Saline soils and use of inappropriate management technologies.	1	Mid and long term
3	Preference of chemicals to biologicals.	2	Short term
4	Area deforestation	1	Mid and long term
5	Poor farmer training	1	Short term

Throughout the workshop, the farmers´ interest and motivation were evident. They looked inhibited at the beginning, but as they gained confidence and expressed their important views, new elements were brought up. The results of the workshop coincided with López, T (2015) in that farmer participation during the technology adoption process is a key element that guarantees concrete results.

The second participatory workshop ended up with assessment of the results and the impacts of the SWOT matrix (Table 5). The matrix was a powerful tool to determine that the strongest item at the Ignacio Agramonte CCS was the availability of natural resources required for the adoption of AC. The weakest item was the lack of skilled personnel to provide technical advice to the CCS. The greatest threat was the non-existence of infrastructure for water supply to people and for irrigation. The best opportunity was the existence of a program for improvement and preservation of the soil.

Table 5. Evaluation of matrix impact.

	Opportunities	Threats
Strengths	SO (61.1 %)	ST (73.3 %)
Weaknesses	WO (64.4 %)	WT (81.3 %)

Evaluation of the matrix impact showed that the highest impact, according to the incidence levels, was produced with 81.3%, in Weaknesses and Threats. It means that the Ignacio Agramonte CCS is within a survival position, with more weaknesses and threats. It indicated the need to perform improving actions to address the issues identified, considering ensuing strategic goals from variable hierarchical organization offered by the methods used. These results coincided with Vidal (2000) who stated that the matrix provided information to set up strategies.

In the third participative workshop, AC practices for adoption were identified by the farmers (based on the main issues identified, from the SWOT matrix, and the real CCS conditions). Fifty-eight farmers attended the workshop (70% participation).

Table 5 AC practices identified

Problem	AC practice selected
1	Integrated water management (IWM). Incorporation of good practices (reforestation). Incorporation of species that withstand droughts and high salinity. • Create windbreak • Create shelterbelts • Create stalks layers • Use of high yielding quality seeds resistant to biotic and abiotic stress
2	Adopt AC technology and its three principles • No soil tilling • Permanent coverage • Crop rotation First stage • Evaluation of species resistant to droughts and salinity. • Correct acidity and fertility deficiencies • Elimination of soil compression • Proper soil leveling • Minimal soil tilling • Integrated management of soil, water, nutrients, pests and

	diseases • Only use of selective low-risk pesticides when necessary • Weed management • Crop rotation • Use of biofertilizers • Worm casting production • Compost production • Use of rice peels • Application of biogas residues as organic fertilizer • Produce organic amenders with animal and crop residues • Manure use • Leaving all stalks on the soil Second stage: when soils are improved • No soil tilling • Permanent coverage • Crop rotation • Start with crop stalks • Use proper equipment and machinery
3	• Ecological management • Use of biopesticides • Preservation of biorregulators • Agroecological management
4	Create windbreaks and hryoregulating shelterbelts • Reforestation • Create shelterbelts • Crop mixing
5	Designing a farmer training program that includes decision makers and technicians, based on, • Seminars • Farmer discussions • Field days • Video and slide shows • Workshops • Talks • Brochures • Testing areas • Topics related to MST and AC.

As farmers embraced AC practices in the workshops, they commented on training needs, and their accomplishment. This behavior coincided with Freyre (2003) in that honest discussions will lead to practice.

Main achievements of the three workshops.

1- Farmer acknowledgement of AC technology adoption for farm sustainability.

2- Change of mind toward the need to rationalize and preserve the use of available resources.

3- A testing area was defined, and agreement was reached on participatory work in farmer networks.

The workshops concluded with a calculation of the farmers willing to adopt the technology and its three principles. After acquiring the recommended practices, 17 farmers (27%) signed an adoption agreement to implement the AC technology and its three principles, accounting for 21% of all farmers. The ones who refused to embrace the technology demanded higher confidence in that AC could solve the issues posed by droughts in the area. These results coincided with Hernández *et al.* (2013) in that farmers must be knowledgeable, and willing to change perspectives before implementing AC. Its adoption is a gradual process that requires extension specialists and pioneer farmers, to a large extent. They must assume a facilitating role that will stimulate beginner´s confidence that the technology is working.

CONCLUSIONS

• The application of agricultural extension tools at the Ignacio Agramonte CCS contributed with positive elements and an effective way to increase motivation and knowledge of AC technology, as an alternative to mitigate land degradation at the CCS. One out of two farmers decided to adopt AC technology on their farms.

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