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## Networks of Agricultural Innovation, A Way of Productive and Sustainable Development in Cuba

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### Abstract

**Context:** The networks of agricultural innovation ensure the development of any society. They contribute to food safety and sustainable development of a country's agriculture. However, in Cuba, sociological research is still insufficient in that sense.

**Aim:** To analyze the networks of agricultural innovation among grain farmers in the municipality of Yaguajay, province of Sancti Spiritus.

**Methods:** The analysis of social networks (SNA), based on a methodological convergence of qualitative and quantitative aspects, including observation, interviews, surveys, and the utilization of software UCINET to visualize the relationships. Following directed screening, 28 grain farmer-innovators in the municipality of Yaguajay were selected by triangulation of information collected from several institutions, and criteria for intentionality.

**Results:** Inequalities were observed in the networks of agricultural innovation, since no women or youngsters were part of them. The networks also were discriminatory in terms of age and territoriality.

**Conclusions:** The networks of agricultural innovation in grain production show a low degree of female and youth centrality. The innovation level is scanty due to the weak culture of innovation in institutional and farmer criteria. The networks are barely thick, with few links among farmers, little diffusion of innovation, and lack of effective and extended networks. In that sense, the connectivity of agricultural innovation networks is weak, thus limiting the development and sustainability of agricultural productivity.

**Key words:** networks, innovation, productivity.

### Introduction

Humans have developed under permanent interaction through group, institutions, organizations, or network bonds. Networks are present in personal, working, and neighbor-neighbor relations, etc., which make up society. However, the concept of social networks is associated to the use of some interactive tools found on the Internet, such as Facebook and Twitter, whose usefulness and meaning are limited in the social sciences. From a sociological standpoint, it refers to groups of individuals and social relationships that make up the network, they show their relations and connections among elements.

In Latin America, social networks are often dealt with in areas like migration, family, and working

organizations. Rural-related research is scarce, except *The Methodological Strategy to Build Agricultural Community Networks in favor of Local Development*. Case: banana farmers south of Maracaibo lake, in Venezuela (Delgado, 2003), and analysis of Social Networks, applied to the study of agricultural innovation processes (Monge & Hartwich, 2008), which aim to produce a greater approach among different traditional practices of innovation in agriculture. It includes the effects of farmer links to several relevant actors for decision making on the volume or adoption intensity, placing special attention to farmer interaction with the external agents (input salespeople, product buyers, extensionists, etc.).

Other more recent research refers to a dynamic network analysis, in terms of diffusion of agricultural innovation, management of native goats, development of Analysis of Social Networks (SNA), from a bibliographic angle, in countries like Colombia and Chile, or as a tool for analysis and understanding of innovation processes (Díaz et al., 2013; Flores et al., 2014; Palacio & Vélez, 2014; Aguilar, Olvera, González et al., 2017).

The evolution of research on Analysis of Social Networks (SNA), and agricultural innovation in Latin America and Cuba, show the insufficient number of studies in this area. In face of the new global context, there is a current need to make progress toward productive transformation, by encouraging science, technology, and innovation, as a way to overcome the deep and persistent breaches concerning equity and productivity. In that sense, the study of networks of agricultural innovation is a pending task to Cuban researchers.

The Cuban economic and social policies suggest the application of integrated management oriented to increasing food production and animal health.<sup>1</sup> Nonetheless, the preceding studies related to innovation in rural scenarios, or from a sociological standpoint are few, except the diploma dissertation thesis of Smith (2005), whose abstract relies on the influence of migrating networks on the structure of migrating decisions by young rural inhabitants, and the promotion and management of total immigration flows between Belize and the US. The doctoral dissertation thesis of Tamayo (2012), emphasizes on the consumption of goods and services of plastic arts, based on a structure-action perspective, whose understanding is used in SNA. Rodríguez (2015) studied the exchange and interaction among farmers in the municipality of Camajuani, and the work of the Agroecological Movement known as “Farmer to Farmer”.

Other precedents of this research are the study of Martínez & Pérez (2016) on agricultural innovation, the thesis of Velázquez (2017), which analyzes the techno-economic networks of Cooperatives of Credits and Services (CCS) in Camajuani, for the tourist sector, the thesis of Zorio (2018), which analyzes the networks of agricultural innovation among grain producers in the municipality of Yaguajay, the thesis of Pérez (2018), analyzing networks of agricultural innovation among various crops farmers in Cabaiguan, and the doctorate thesis of Martínez (2018), which determines the potential and limitations of networks for diffusion of agricultural innovation in CCSs, in the municipality of Camajuani.

<sup>1</sup> Guidelines of the Social and Economic Policies of the Party and the Revolution, in the Fourth Congress of the Communist Party of Cuba, 2011. Decree No. 323 “The entities of science, technology, and innovation” in the Official Gazette of the Republic of Cuba, August 29, 2014

The province of Sancti Spíritus has played an outstanding role in terms of agricultural yields nationally, the municipality of Yaguajay alone contributes with more than 34% of total bean production in the province, with yields of 1.2 tons of grains per ha (t/ha) in a total cropland of 7838,4 ha (ONEI, 2016). Besides, the municipality has been benefitted by the implementation of research projects that favor producers with training, inputs, and equipment, which contribute to improved grain production in the territory.

The study of agricultural innovation from a reticle approach is a novel research line of agrarian sociology. Following the logic of agriculture, innovation can be included to fulfill productivity and quality when implementing new technologies, and networks can be used to analyze connectivity among producers, and between producers and other key actors of innovation. Besides, the work of three cooperatives of credits and services in the municipality of Yaguajay is analyzed, considering the principles of the International Cooperative Alliance (ACI), particularly the principle of cooperation among cooperatives. In that sense, the diffusion of innovation can be strengthened locally, and productivity and food safety can be enhanced nationally. It also allows institutions to better organize and design their actions in the areas of science, technology and innovation. Hence, not only agrarian and economic development is ensured, but also rural, local, and territorial.

Therefore, this research suggests the analysis of networks of agricultural innovation among grain farmers in the municipality of Yaguajay, province of Sancti Spíritus. In that sense, the density and closeness of network connections, the relations of power based on connectivity, network centrality, the way farmers establish their relations, the information they spread, the degree of betweenness, the inequalities of gender and age, and so on, are considered.

## Materials and Methods

This study was done in the municipality of Yaguajay, province of Sancti Spíritus. It was selected due to the high yields in grain production, and because of the benefits received by projects like Agrocadenas<sup>2</sup>, Palma<sup>3</sup>, and other initiatives directed by the municipal government that contribute to agricultural innovation development. The main cooperatives of grain production are CCS Juan Darias, CCS Gelacio Did, and CCS Felino Rodríguez.

### Population and sample

<sup>2</sup>Support program of strengthening local agrofood chains. It is the association of local farmers to stimulate seed production in the municipality, which contributes with technology and training.

<sup>3</sup>Support program for local upgrading of agriculture in Cuba. This project has brought benefits to grain producers in terms of input, technology, and training, to achieve local food safety and sovereignty.

The population included in the study totaled 44 farmer-innovators, of which 28 (63.64 %) make up the sample of farmer-innovators. Then, sampling was established according to criteria for intentionality.<sup>4</sup>

### Farmer identification

To identify the farmer-innovators of the municipality, the criteria of municipal institutions in Yaguajay were triangulated<sup>5</sup>, namely the National Association of Small Farmers (ANAP), the Ministry of Science, Technology, and the Environment (CITMA), Obdulio Morales agro-company, Valle Caonao Agroindustrial Grain Company, the Center for Reproduction of Entomophagous and Entomopathogen (CREE); Simon Bolivar Municipal University Facility (CUM); and the Ministry of Agriculture in the municipality<sup>6</sup>.

Structured observation was performed in order to observe the types of agricultural innovation, material resources, and associations, based on the diffusion of agricultural innovation among producers of several social spaces, such as farms, CCS meetings, and training workshops.

### Identification of effective and extended networks

The survey was applied to 28 farmers to identify the effective and extended networks, the connectivity with egos in the municipality, and the general data of producers. The survey contains 13 questions, including the types of agricultural innovation disseminated, adopted, and created by farmers, and their results. Besides, it facilitates graph making and analysis.

Semi-structured interview was performed to key institutional reporters, totaling 13 questions. Generally, to acknowledge the farmer-innovators and the state of innovations in the municipality during the last four years, and to characterize the sample according to the levels reached in the process of innovation, agricultural productivity, and extent of networks of agricultural innovation in Yaguajay.

Snow ball technique: the main goal was to query on the particularities of links among egos and the effective network based on agricultural innovation.

### Software used

Net-Draw was used with UCINET 6. 85, to graph and calculate the innovation network analysis measurements in grain production, and to interpret

<sup>4</sup> These criteria were, participation in Science and Technology Forums; the presentation of at least one innovating practice in production; farmer accessibility; and stability of outstanding productive grain yields.

<sup>5</sup>The general criteria used to identify agricultural farmer-innovators are, participation in innovation projects, the Science and Technology Forum, to be highly productive, and be recipient of inputs and technology from projects Agrocadenas and Palma.

<sup>6</sup>These institutions were selected for their social role, and their experience, linked to a social and scientific character in agricultural innovation, and because they are associated to the farming sector with a research, training, and advisory perspective.

and analyze the relations among the actors within the innovation networks in terms of grain production, in Yaguajay.

## Results and discussion

The analysis of social networks has a broad spectrum of study from biological, educational, and economic perspectives. It is also applicable in agriculture, especially in science, innovation, and technology.

Innovation is present in any sector, it is a huge transversal process, including economic, social, cultural, educational, and technological processes, along with the production of goods and services, and it is a challenge to creativity and change, and it can also be inserted in agriculture. Knowing the novelty degree allows researchers to identify the developers of innovation and the ones who adopt it, examine diffusion patterns, and identify leaders and followers. Innovation is fundamental for growth of both production and productivity. Therefore, the study of this phenomenon is closely linked to agricultural development and sustainability. However, studies in this area are insufficient, which has been caused by little research that can put the concepts of network and innovation in agriculture together.

### Characterization in Yaguajay

This municipality was founded in January 1879. It is situated in the province of Sancti Spiritus, with a total extension of 1 055.57 km<sup>2</sup>, and a population of 55 509 distributed in 14 people's councils in rural and urban locations (ONEI, 2016). It has borders with province Ciego de Avila to the south east, province Villa Clara to the south west, the Atlantic Ocean to the north, and municipalities Cabaiguan and Taguasco (Sancti Spiritus province) to the south.

Yaguajay has 40 base organizations, of which 30 are CCS and 10 are Cooperatives of Agricultural Production (CPA). The social scope of the municipality is various crops, particularly grains (green and dry corn, beans, and chickpeas). Additionally, it shows satisfactory results in milk and beef production.

The main varieties of grains planted in the cooperatives are transgenic maize and black beans: BAT 304, CC 25-9 N, Liliana, Tomeguín 93, Cul-156, Milagro villareño, CUEFIG-48, Red: Delicias 364, Buenaventura, CC 25-9 R and CUEFIG-110, and White: Quivicán, CUEFIG-145, and Aluvias españolas.

The greatest grain producer in the municipality is in the southern territory, approximately 42 km from the municipal capital city, with a total extension of 1 042 km<sup>2</sup>. Other facilities in the area are the Base Crop Collecting Unit (UEB), the Drying, Cleaning, and Packing Plant, the only one in the nation, and three CCSs with higher grain yields: CCS Juan Darias

García, CCS Felino Rodríguez Delgado, and CCS Gelacio Cid López

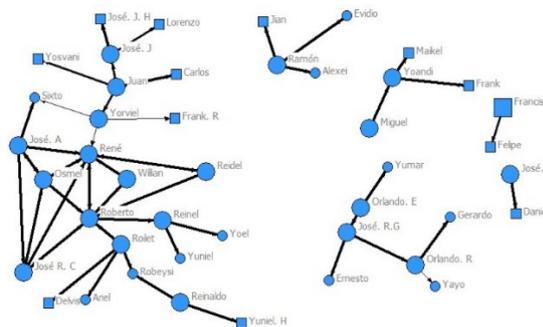
The concentration of productivity, the resources, and innovations are part of the grain producing pole in Yaguajay: San José, Jarahueca, Rancho Chico, Iguará, Itabo, and La Lolita, which do not go beyond their boundaries, into other locations, which shows a lack of proportion in local innovations.

**Characterization of networks of agricultural innovation in Yaguajay**

Within the essential elements of innovation are the necessary inputs to produce, adopt, and disseminate knowledge, and the outcome of production. It is not enough to produce and implement a given innovation, it is also important to share it so productivity is offered to other areas. Here is when the networks make a useful and decisive contribution. An innovation network is a tool of social change whose ultimate goal is to promote technological development, through the creation, generation, and dissemination of knowledge (Polo, 2013). This research allows for the articulation of fundamental concepts of SNA, to analyze the connectivity of agricultural innovation networks among grain farmers in the municipality of Yaguajay.

**Density**

Density is basically a measurement of the number of links found in the network, as a proportion in the number of possible links (Aguilar, Martínez & Aguilar, 2017). The production of grains in Yaguajay is 13%, which is low compared to the number of possible links. Connectivity is characterized by poor extended networks, the ego producers relate to two or more producers (Fig. 1), except Francisco, José M., and Miguel, who only relate to one producer. The capacity of producers to create links with other producers is limited.

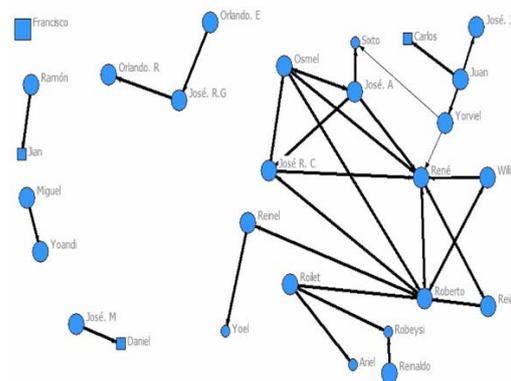


**Fig. 1.** Graph of agricultural innovation networks among grain farmers in the municipality of Yaguajay.

Source: Self-creation based on the research data.

**Note:** Blue is male. The large figure is ego and the small one is effective network. The geometric figure represents age: circle=older than 35, square=younger than or equal to 35. The width of ties or arrows equals the frequency of the link: narrow arrow=little frequency, fairly narrow arrow=frequently, broader darker arrow=very frequently.

There is little reciprocity, and the relations among actors of innovation who limit agricultural productivity, are weak. However, there are exchanges among the egos, and they are linked to one another. In some cases, reciprocity is achieved between the egos and effective network; for instance, between Roberto and René, Reidel and René, and Osmel and José A, which favors communication within the innovation networks (Fig. 2).



**Fig. 2.** Graph of agricultural innovation networks of the sample in the study, in the municipality of Yaguajay.

Source: Self-creation based on the research data.

**Note:** Blue is male. The large figure is ego and the small one is effective network. The geometric figure represents age: circle=older than 35, square=younger than or equal to 35. The width of ties or arrows equals the frequency of the link: narrow arrow=little frequency, fairly narrow arrow=frequently, broader darker arrow=very frequently.

Producers often exchange inputs and empirical knowledge; in a lesser degree, they also exchange practical demonstrations and written information. Innovation is conceived as invention, a novelty, advancement, discovery, and creation, which ratifies the poor information and little knowledge about it. Innovation is not only invention, it is the result of an intensive process of generation of ideas that will lead to new and better solutions, as stated by Ramírez, Ruilova & Garzón (2015), that the presence of innovation is a positive component to foster productivity, based on including and sustainable development.

**Connectivity**

The criteria used by academic and business institutions to acknowledge farmer-innovators or elite producers, are associated to productivity. The ones the produce most, who meet production plans, or have excess production or those who attend municipal or provincial forums, are the recipients of by projects. Therefore, the levels of institutional innovation are very empirical, they lack theoretical grounds in terms of innovation. The institutions that legitimate innovation fail to expand their results throughout the territory. Moreover, they generate inequalities, and tend to benefit producers with satisfactory results. That way, connectivity is limited through the networks of agricultural innovation.

Connectivity shows low accessibility conditioned by territoriality, coinciding with the networks of agricultural innovation dissemination in Camajuani and Cabaiguan (Martínez, 2018, and Pérez, 2018). Connections are mainly directed to friends and partners of the same cooperatives, which show their limitations toward the neighborhood, the family, partners of other cooperatives, etc. In face of that scenario, there is a need to project the work of cooperatives, and the work of producers from a reticle perspective, in order to enhance and increase the impact of innovations on other territories.

The International Cooperative Alliance (ACI) suggests some principles to achieve success in the work and organization of cooperatives (Piñeiro, 2011). One of the principles is related to cooperation among cooperatives. It has to do with establishing relations among cooperatives to increase the productive capacity and technical counseling. It is a tool for stronger cooperatives to assist other not so strong cooperatives. The cooperatives included in this study can train other cooperative partners, and ensure that the networks of agricultural innovation can reach other locations in the territory.

The eigenvector measures popularity or centrality of known forms; it has to do with the degree a node is connected to other well-connected nodes; it does not measure the number of contacts, but whether these contacts are good (Aguilar, Martínez & Aguilar, 2017). In that sense, Table 1 shows that René has the highest eigenvector, he is a partner in the cooperative with the best yields (grain CCS Juan Darias), and is the second person with the highest degree of betweenness (Table 2).

**Table 1. Centrality degree of eigenvector of networks of agricultural innovation**

Producer	Eigenvect	nEigenvec	Producer	Eigenvect	nEigenvec
José. M	0.000	0.000	Reidel	0.287	40.651
Reinaldo	0.007	0.994	Willian	0.220	31.161
Roilet	0.122	17.246	René	0.480	67.888
Francisco	0.000	0.000	José. A	0.308	43.501
Orlando. R	0.000	0.000	Osmel	0.381	53.900
José. RG	0.000	0.000	José R. C	0.381	53.900
Juan	0.007	1.060	Reinel	0.115	16.195
José. J	0.001	0.165	Daniel	0.000	0.000
Yorviel	0.044	6.276	Robeysi	0.030	4.258
Orlando. E	0.000	0.000	Ariel	0.028	4.026
Miguel	0.000	0.000	Carlos	0.002	0.248
Yoandi	0.000	0.000	Sixto	0.075	10.644
Ramón	0.000	0.000	Jian	0.000	0.000
Roberto	0.464	65.588	Yoel	0.027	3.781

Source: Self-creation

The networks ensure the establishment of association and cooperation relationships among producers. Hence, it would be useful to replicate the experiences of this producer in other producers like him, so that a greater productive development is reached in the municipality.

**Closeness and betweenness**

The degrees of closeness and betweenness are SNA measurements, which facilitate access to the rest of nodes in the network, and influence on the other producers. The betweenness degree indicates the frequency a node appears in the shortest leg connecting other two nodes. In other words, it shows when a person mediates between other two in the same group, but who have not met before (Aguilar, Martínez & Aguilar, 2017).

The actors with a high betweenness capacity (bridging actors) tend to hold positions of power as they control information and communication flows. However, the innovation networks studied showed that only 8 producers acted as intermediaries, making them bridging actors. The other producers (20) have no control of information and communication within the network. Table 2 shows that Roberto, who has an betweenness degree equal to 50.500, and Rene, with 23.333, are the strongest nodes to act as intermediaries during communication, and the relation with the other nodes. These are key producers in the diffusion of innovation, since they act as intermediaries in the flow of information, and can influence on the other producers they connect to.

**Table 2. Betweenness degree of networks of agricultural innovation**

Producer	Betweenness	nBetweenness	Producer	Betweenness	nBetweenness
Roberto	50.500	7.194	Reidel	0.000	0.000
Rene	23.333	3.324	Willian	0.000	0.000
José R. C	20.333	2.896	Roilet	0.000	0.000
Osmel	15.333	2.184	Francisco	0.000	0.000
Yorviel	10.000	1.425	Orlando. R	0.000	0.000
Reinel	10.000	1.425	Ramón	0.000	0.000
José. A	7.500	1.068	Juan	0.000	0.000
José. R.G	1.000	0.142	Daniel	0.000	0.000
Reinaldo	0.000	0.000	Robeysi	0.000	0.000
José. M	0.000	0.000	Ariel	0.000	0.000
José. J	0.000	0.000	Carlos	0.000	0.000
Yoandi	0.000	0.000	Sixto	0.000	0.000
Orlando. E	0.000	0.000	Jian	0.000	0.000
Miguel	0.000	0.000	Yoel	0.000	0.000

Source: Self-creation

**Social inequalities**

Furthermore, the productive work is done by men only, and the role of women is reserved for office work. Although the projects include the participation of women in productive work, there are no positive results in this sense in all the CCSs studied. Hence, the incorporation of women to productive work like drying the covering, in the drying area, and others, is a pending task.

It is necessary to work with mass organizations in the territory, toward the inclusion of women in the productive process, in the Board of Directors of cooperatives, and to foster production. Also important it is to stimulate granting usufruct land to them, empowering women in the productive process,

and labor, so women have greater protagonism in decision-making, by placing more women in the Board of Directors of cooperatives.

The young is also another vulnerable group in terms of innovation and agricultural productions. Most farmer-innovators are over 35, only one ego and three producers in the effective network are 35 or less (Fig. 2), which represents unequal distribution of innovation to the young members of the cooperatives. The main difficulties or risks are within an aged population, and badly-paid jobs, since the municipality is located in one of the most important tourist area in the country, stimulating migration to that sector, especially the young.

Innovation networks are only made of four young people, of which one is a land owner (Jian), two of them work on usufruct land (Daniel and Carlos), and the other (Francisco) is both owner and holds usufruct land. Nonetheless, they do not hold an influencing position in the network. The low centrality of the young population in the networks of innovation, the centrality degree of the eigenvector, and the Bonacich power, reveal the disadvantages, and the access to resources with respect to the network leaders (Tables 1 and 3). Therefore, quality of productivity and motility of young people in the networks act differently.

**Table 3. The power of Bonacich in the networks of agricultural innovation**

Producer	Eigenvec	nEigenvec	Producer	Eigenvec	nEigenvec
José. M	0.000	0.000	Reidel	0.287	40.651
Remaldo	0.007	0.994	William	0.220	31.161
Rodol	0.122	17.246	Rene	0.480	67.888
Francisco	0.000	0.000	José. A	0.308	43.501
Orlando. R	0.000	0.000	Osmel	0.381	53.900
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Yeriel	0.044	6.276	Robeysi	0.030	4.258
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Ramón	0.000	0.000	Jian	0.000	0.000
Roberto	0.464	65.588	Yoel	0.027	3.781

The study of agricultural innovation networks in Yaguajay revealed breaches in innovation diffusion. Based on gender inequalities, and differences in age and location, an apparent sexist, patriarchal, territorial culture is limiting agricultural productivity. However, the production of grains in the municipality is high, which owes in a great deal to the cooperation among producers, and exchange of knowledge, experiences, and goods. In that sense, the networks of agricultural innovation are an effective way to reach food safety and enhanced productive development in agriculture. It offers the location and the nation an opportunity to develop in economic, social, and human terms.

Hence, a social interaction is guaranteed as to the form producers exchange to one another, and the satisfaction of the growing demands of food for the

population, with a higher variety and quality. Progress will be achieved only if innovation is kept as an interactive and permanent process. Hence, it is necessary to promote local and national innovation, based on exchanges of knowhow and training, in order to accomplish higher impact on the dissemination of agricultural innovation in grain and food production, and to make possible intergenerational and gender approaches, through which women and young people are truly represented in productive labors.

## Conclusions

The networks of agricultural innovation in grain production show a low degree of female and youth centrality. The innovation level is scanty due to the weak culture of innovation in institutional and farmer criteria. The networks are barely thick, with few links among farmers, little diffusion of innovation, and lack of effective and extended networks. In that sense, the connectivity of agricultural innovation networks is weak, thus limiting the development and sustainability of agricultural productivity.

Therefore, it is recommended to strengthen research on networks of agricultural innovation, conduct studies that contribute to systematization of experiences in agricultural innovation based on a reticle approach, with the participation of institutions and farmers, perform comparative studies of innovation networks of other productions, and other territories.

## Author contribution

Eliany de la C. Zorio González: Conceptualization, critical review, interpretation and analysis of articles, redaction, and final review of the manuscript.

Annia Martínez Massip: Analysis of results, final review.

## Conflicts of interest

The authors declare no conflicts of interest.

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