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# INDICATORS OF INNOVATION AND PRODUCTIVITY IN FAMILY FARMS: SOUTHERN MEXICO

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## ABSTRACT

Innovation is an opportunity to improve productivity and to achieve the development of marginalized communities. The objective of this study was to analyze the effect of innovation and productivity factors on the development of family farms (FFs) from marginalized localities in southern Mexico, under the systems approach. The study was non-experimental trans-sectional with a mixed approach and random stratified sampling. The indicator that interacted most with others was the farmer's profile, defined by the type of crop in the FF that was independent of the locality, through the Kruskal-Wallis test ($c^2$, 0.05) and Spearman's correlation coefficient. Results show that FFs with greenhouse tomato innovate the most and generate greater economic satisfaction to the human factor, because of the productive system they implement. The interaction of factors implies the inexistence of knowledge that is strictly from the communities, since innovating and improving production requires a combination of influences, a type of crop and its aim, with the active participation of the farmer.

**Keywords:** agriculture, cooperation and learning, rural development, systems approach.

## INTRODUCTION

The Mexican rural sphere has an unbalanced situation, due to the impact exerted by factors such as organization schemes that lack structure, low salaries, low institutional coordination, adoption of technology and scarce innovation, differences in the availability of capital and connectivity to markets, in particular for family agriculture with crops that are mostly for subsistence (Rendón and Aguilar, 2013). In southern Mexico and specifically in the state of Oaxaca, agriculture is the main activity of the economic sector; it is characterized by being totally rainfed, traditional and for subsistence; the population lives in marginalization and poverty (Rendón and Aguilar, 2013), which reflects the low productivity of the sector.

In Mexico, the marginalized rural sphere is characterized by its low population density, deficient agro-ecological attributes, and low connectivity with markets. The National Agriculture and Livestock Survey 2014 (*Encuesta Nacional Agropecuaria*, 2014, ENA), of the National Institute of Statistics and Geography (*Instituto Nacional de Estadística y Geografía*, INEGI, 2014), indicated that 61.8% of the production units in Mexico correspond to subsistence farming with up to 5 ha of rainfed surface, situation that

prevails in the localities of Ejutla de Crespo, Oaxaca. However, to guarantee food security, protect the environment, and reduce poverty it is necessary for the family farms (FFs) to be more productive and sustainable; and for them to innovate in a system that recognizes their diversity and complexity (FAO, 2014).

To reduce poverty in rural zones, increasing the productivity of FFs is required, which in turn depends on access to natural resources, workforce and capital, and degree of connection of the FF to the market (FAO, 2014). Since it is subsistence farming, where the production level is in function of the needs and availability of family workforce (Heynig, 1982), an increase in productivity would be the result of harmony and articulation between technology, human resources, organization and systems directed by people, with the balanced combination of resources, seeking social and economic benefit. This represents innovation, although without risking the environment, analyzed from the human factor and the productive system (Marvel *et al.*, 2011).

The objective was to identify and to analyze the factors of innovation and productivity and their impact on the development of FFs with crops of corn, bean and tomato from localities in conditions of marginalization of the Central Valleys in Oaxaca, Mexico. The hypothesis is that there are factors that prompt FFs to innovate, regarding the type of crop, and this reflects in their productivity.

## THEORETICAL DISCUSSION

A systems approach recognizes the characteristics of family farming in marginalized communities with the participation of FFs in the different strategies to improve productivity through the implementation of innovations (Águila and Padilla, 2010; Garrido *et al*., 2016). The application of new knowledge in productive or organizational processes with the integral participation of internal and external agents is considered to be innovation (Morales *et al*., 2014; Garrido *et al*., 2016), and it happens when there is a social appropriation of knowledge, ideas, practices and technologies, to produce a useful and beneficial change in the productive and organizational work, implementing something that is new for the context and not necessarily for the world (Garrido *et al*., 2016).

In the systemic approach of agricultural innovation, the flows of knowledge happen interactively and holistically between the different stakeholders, in contrast with the traditional linear model where farmers are considered passive receiving beings (Aguilar *et al.*, 2017). According to Morales *et al.* (2014), the systemic approach is found within the view of interactive and evolutionist learning, represented by Nelson, Winter and Dosi. In the rural sphere, for the approach by Röling and Engel, whose theory is sustained in cooperation and learning (FAO, 2012), favorable environments are required to allow the integration of the public sector as a whole that works with the private sector, civil society and farmers and their organizations (FAO, 2014). Morales *et al.* (2014) suggest that the analysis of innovation under this approach considers the integration of internal and external factors that influence the FFs.

In agriculture and rural development, innovation has a place within a socioeconomic context, determined by the level of internal development, institutional and normative frameworks, knowledge and human abilities, demands for innovation imposed by society and the regional environment. It is important for there to be favorable environments (French *et al.*, 2014). Innovation requires something more than the sole participation of farmers; the integration as a whole of the public sector that works with the private sector, civil society and farmers and their organizations (Bisang *et al.*, 2015).

In innovation, it is difficult to establish a generalized implementation process, although factors can be grouped into internal or organizational, and external (organizations and institutions) (Rugeles *et al.*, 2013). The factors that help to understand the interactions in a system are: educational level, farmer's experience, farmer's profile, human resource and training, changes generated or specific innovations, environment for innovation, local or regional links or both, research and development, articulation to the market, participation in social networks, where the main stakeholder is the farmer (FAO, 2012).

The theoretical approach supports the characteristics of family farming in marginalized communities and the way in which these can participate in the different strategies to improve their productive conditions through the implementation of innovations when understanding the factors that have an impact, under a systems approach, with the active participation of FFs (French *et al.*, 2014).

According to the different approaches to productivity, it is necessary to change the traditional perspective to define it, since they consider the human factor as a resource or input and not as the main stakeholder, responsible for the management of the available resources and generator of change (Marvel *et al.*, 2011).

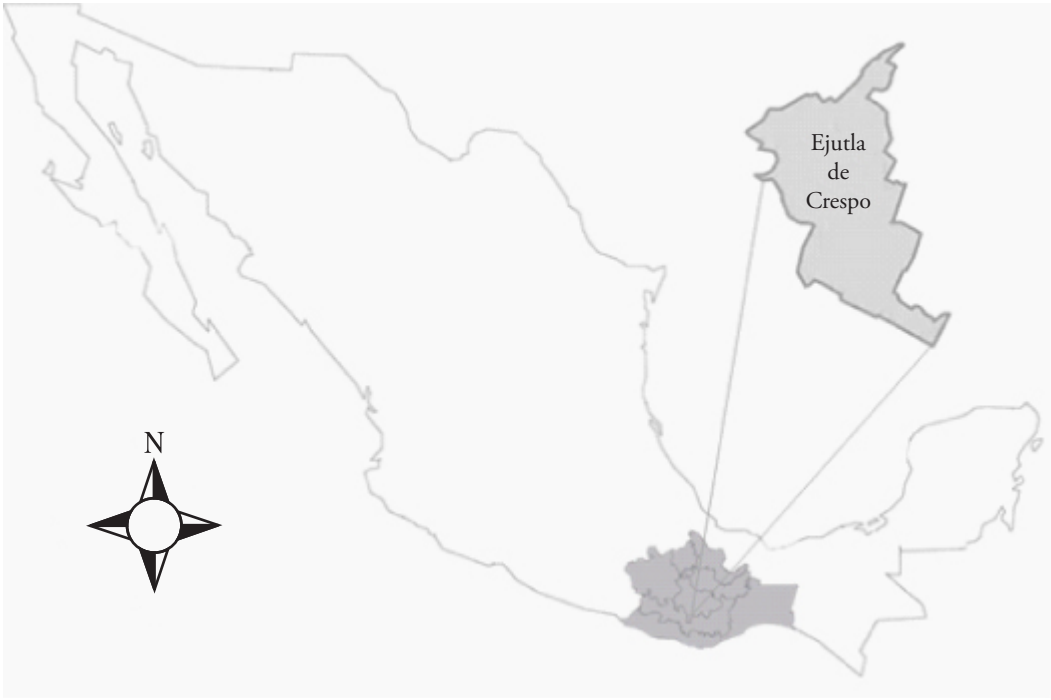
Productivity is analyzed from the human factor, which is the main stakeholder, who manages the resources and reacts to psychological and psychosocial processes when acting in society (Marvel *et al.,* 2011).

To gather this information and to proceed to the analysis from the systemic approach, a study was conducted in 2018 in Monte del Toro, La Noria de Ortiz and Santa Martha Chichihualtepec, which are localities of the municipality of Ejutla de Crespo, Oaxaca, in southern Mexico. The main activity is family farming with crops of corn, bean and greenhouse tomato. These are communities with high marginalization, where there is an unequal distribution of progress, in the productive structure and the exclusion of various social groups from the benefits of development (INEGI, 2014).

## METHODOLOGY

The study was carried out in the localities of Monte del Toro (16°40'39"N, 96°44'19"W), La Noria de Ortiz (16°41'45"N, 96°43'46"W) and Santa Martha Chichihualtepec (16°39'00"N, 96°46'34"W), from the municipality of Ejutla de Crespo, Oaxaca, Mexico (Figure 1).

The methodological process was conducted based on the theoretical model proposed for the variables of agricultural innovation and productivity, which considered 10 indicators




Source: prepared by the authors.
**Figure 1.** Geographic location of the municipality of Ejutla de Crespo, Oaxaca.

in two dimensions for the first (Morales *et al.*, 2014) and nine for the second (Marvel *et al.*, 2011); with a systems approach and human perspective, to improve the productivity of the FFs, and to impact rural development. The starting point of the approach considered is learning and cooperation, as referred by Röling and Engel (FAO, 2012).

The research design was not experimental; a review of the theoretical variables of agricultural innovation and productivity was carried out, as manifested in the rural context, with the support of a sampling (Rojas, 2013) and trans-sectional method. The references were studies conducted in the agriculture and livestock sector by Rugeles *et al.* (2013), who indicated that an interval of time of two to five years is enough to infer without altering the results.

The mixed paradigm aforementioned was supported by the quantitative and qualitative approach, with a greater use of the quantitative, and it considered a defined process since there is a sample size, a questionnaire structured for information collection, a procedure of application and defined statistics, and the second approach complemented with interviews and open field records to qualify the questionnaire.

## Sampling design

The stratified-random sampling for proportions was used, considering the three localities as strata, and the sampling units were the FFs with crops of corn, bean and greenhouse

tomato selected randomly and proportionally to the size of the target population (Díaz *et al.*, 2016).

The FFs are economic production units, subjected to a single management, which have limited access to resources of land and capital, and predominant use of family labor; and the head of the household, in addition to being a manager, participates in the process of agricultural production as any other worker in the family nucleus (Salcedo *et al.*, 2014).

The sample size was determined with the stratified sampling formula (Scheaffer *et al.*, 2007) for a questionnaire with too many questions (Rojas, 2013).

$$n = \frac{\sum_{i=1}^{L} \frac{\left(N_i^2 p_i q_i\right)}{w_i}}{N^2 D + \sum_{i=1}^{L} N_i p_i q_i}$$

where $n$: sample size (86); $N$: study object population (717); $Z$: 95% level of confidence; $D$: accuracy of sampling 0.10; $p$=0.80 and $q$=0.20 proportion that they are and are not FFs, respectively (variability of the population). $N_i$: target population of each stratum, Santa Martha Chichihualtepec $N_1$: 436 FFs; Monte del Toro $N_2$: 178 FFs; and La Noria de Ortiz $N_3$: 103 FFs, $w_i$: proportional value according to the number of FFs in each stratum.

The sampling error (SE) is considered to be within what is allowed for studies in the social area, since variations higher than 10% with regards to their mean reduce the validity of the information. The sample (n) used generated a minimum SE of 2.3%, which was calculated based on the proportion of FFs that produce crops that are the object of this study; the value of the stratified mean was $\overline{y}_{ST}$ = 49.42, the variance of the stratified mean Var($\overline{y}_{ST}$)=1.148, the confidence interval CI (95%)$(t_{\alpha/2})^2$=49.42 ± 2.14 (Scheaffer *et al.*, 2007; Kulshreshtha, 2013).

**Instrument used: questionnaire and interview**

In the elaboration of the questionnaire, the operationalization of the two theoretical variables was necessary: innovation and productivity. Thus, the innovation variable covered two dimensions (internal and external factors), each with five indicators; while the productivity variable contemplated two dimensions: the human factor and the productive system, with their respective indicators. The process of operationalization consisted in going from the abstract (theoretical variable) to the concrete (measurable variables), that is, to define the indicators that helped with the interpretation of the theoretical variables in specific areas.

The indicators were integrated in two dimensions for each variable and measured through items or questions that were included in the questionnaire. The interpretation was

supported by the qualitative analysis of the interviews, to strengthen the discussion and the conclusions.

The variable innovation considered ten indicators and they were: in the dimension of internal factors, the farmer's educational level, age and experience, the farmer's profile, human resource and training, and changes generated or specific innovations; in the dimension of external factors, the innovation environment, local or regional links, research and development, articulation to the market, and participation in territorial networks. For the variable productivity, the dimension of the human factor considered five indicators: work satisfaction, motivation, identification, commitment and cohesion; and the dimension of the productive system: human capital, technological capital, public capital, work and inputs.

The method used for the quantitative analysis was probabilistic sampling of the population, the technique of structured survey, and the instrument of questionnaire (Rojas, 2013), which included 156 questions in three sections. The first section of general information, the second of information of the innovation variable which was divided into two parts: the first corresponded to the dimension of internal factors and the second to the dimension of external factors; the third section approached indicators of the productivity variable. The questions were Likert type with five alternatives of response (Rojas, 2013).

The definitive in-person questionnaire was preceded by a pilot test to confirm the reliability and validity of the instrument. This test was carried out randomly with 20 farmers.

### Information processing and analysis

For the test it was necessary to generate an Excel® database and to filter questions, especially the "non-response" found in the questionnaire. This instrument was codified to make its capture easier and to facilitate its analysis through the statistical package Statistical Analysis System® (SAS) (SAS Institute, 2015).

The Kruskal-Wallis test ($c^2$, 0.05) was carried out to compare more than two independent groups and to determine if the differences are not due to chance (Levin and Rubin, 2010), and the significant variables (indicators) of agricultural innovation and productivity of FFs with corn, bean and tomato were detected. Spearman's correlation coefficient test ($r_s$, 0.05) supported the search for relation between indicators of each theoretical variable and between indicators of the two variables. The interviews supported the discussion and the conclusions.

## RESULTS

### Internal and external factors of innovation related to the family farm (FF)

The innovation variable, in the indicators of the two dimensions, did not show significant differences ($p>0.05$) when compared between localities; however, the analysis between FFs shows differences ($p<0.01$) between the types of crops that were grown as main crop. It is seen that the internal factor, farmer's experience, influences ($\chi^2$=19.21, $p<0.01$) for the farm to innovate (Table 1).

**Table 1.** Dependency of internal and external innovation factors with relation to the type of family farm (FF).

| Type of FF | | | |
|---|---|---|---|
| Internal factors | $\chi^{2*}$ | External factors | $\chi^{2*}$ |
| Experience of the farmer: | | Innovation environment: | |
| Time of being a farmer and income obtained | 19.21 | Development of significantly new activities are with ideas from the producer and government institutions | 50.22 |
| Changes to the production process | 14.24 | | |
| Profile of the farmer: | | Local and regional link or both: | |
| Is part of a RPS | 33.30 | Relation with farmers | 28.56 |
| Operates as a FF | 18.97 | Relation with suppliers | 54.02 |
| Human resource and training: | | Relation with institutions | 38.58 |
| Non-family workers | 25.12 | Research and development: | |
| Expertise of the farmer is enough | 45.03 | With resources of third parties (INIFAP, Fundación Produce) | 19.40 |
| Training for production | 50.96 | Articulation with the market: | |
| Specific innovations of process: | | The sale is carried out in the locality | 33.53 |
| Use of different varieties | 56.13 | The total of the sale is done outside the locality | 65.89 |
| Management of the crop | 42.65 | Participation in territorial networks: | |
| Product: | | | |
| Different variety and classification of the product | 58.99 | For enterprises in the FF with other producers | 49.39 |
| Organization: | | Creating productive organizations | 46.81 |
| Personal tasks are defined | 58.08 | | |
| Training in tasks | 55.51 | | |
| Relation with institutions | 44.30 | | |
| Market: | | | |
| Participates all year | 60.57 | | |

Kruskal-Wallis ($\chi^2$, $\alpha$=0.05) range test. * Values with high significance (p≤0.01). RPS: Rural Production Society.
Source: prepared by the authors.

The farmer's profile was defined according to the type of crop in the FF; that is, the farmers who get organized and are part of a production society tend to innovate and this is in function of the crop considered the main one in the FF, in this case tomato. These are farmers who operate as FF, although they belong to a production organization, as recognized by Espejel *et al.* (2017), since it improves the relationship between stakeholders. And innovation under the systems approach is promoted, with the interaction of different stakeholders, considering participative planning that includes the farmers to generate significant and acceptable changes (Arcos *et al.*, 2015; Verduzco *et al.*, 2016). The human resource and their training show a direct relation with the type of crop, and this relation is how training is required, of family or non-family workers and of technical assistance (Table 1), a need that is higher in FFs with tomato whose production is destined to the market.

The indicators of the dimension of external factors of the innovation variable showed significant differences (p<0.01) between the FFs; it was seen that the development of new

activities comes from the environment that is generated with government institutions, that is, they come from the outside; and in order to strengthen specific innovations, there are relationships with suppliers and institutions to receive technical assistance and training. In research and development, the relationship that happens with FFs depends on the type of crop, and it is through the State and with suppliers; of these, with the validation of agricultural products and equipment (Table 1), it was seen that farmers assume changes as something natural and necessary depending on the crop, which agrees with what was expressed by Garrido *et al*. (2016) who recognize change as an intrinsic part of work, valuing knowledge as a fundamental part, with the participation of the environment as a result of the farmer's interest. This was described by Verduzco *et al*. (2016) when speaking of changes in the poor rural sphere in Mexico through the intervention of the State with the PESA program (Strategic Project of Food Security, *Proyecto Estratégico de Seguridad Alimentaria*), as a strategy for poverty reduction.

**Dimension of the human factor and productive system of the productivity variable with relation to the family farm (FF)**

Through the Kruskal-Wallis range test ($\chi^2$, $\alpha$=0.05), the indicators of the human factor and the productive system show highly significant differences ($p \leq 0.01$) in terms of the type of crop of the FF. Work satisfaction happens when the FF has the equipment and materials necessary and there is support between producers, situation that is more consolidated in an FF where the main crop is greenhouse tomato and the benefits obtained from the crop bring economic and educational improvement in the family, which motivates farmers to improve their processes, determined by the type of FF; that is, by the crop and its aim, aspect that generates a differentiation in the human factor of identification and commitment, which the farm acquires with its environment by sharing improvements. As Garrido *et al*. (2016) describe, the innovations should generate benefits and be a functional strategy for the quandary of the rural sector and consequently improve their standards of living.

There are highly significant differences ($p \leq 0.01$) in the degree of cohesion that happens inside the FFs and between them, and the causes that mark the difference between FFs of corn, bean and greenhouse tomato are the degree of organization, coordination with institutions and acquisition of inputs and materials, where the services of training and advice provided by the State are determinant. This is described by Aguilar *et al.* (2017) as the access to knowledge and information to improve productivity and to reduce poverty through agricultural extension programs. Therefore, the identification and commitment at first is with family, since they consider that the benefits are the family's sustenance, and tomato farmers are the ones who show this trend and from this the differences from other FFs, although the farmers manifest they are not abandoning corn and bean production, under a subsistence scheme, since they are part of their diet as pointed out by Turrent *et al.* (2017), and their systems should be strengthened with the conservation of their landrace cultivars and cultural aspects.

The factors of the productive system, through the Kruskal-Wallis test ($\chi^2$, $\alpha$=0.05), express highly significant differences (p≤0.01), with relation to the type of crop considered as the main one in the FF; it is in the greenhouse tomato farms where education and training of the human capital requires attention, to adequately participate in the processes that technological capital considers, such as the use of new technologies for the improvement of the productive system. In this dimension of productive system, highly significant differences (p≤0.01) are observed between the different FFs compared to the public capital available, the use and availability of labor, and the use of inputs, with the greenhouse tomato farms being the ones that demand more family and non-family workforce and where there is a greater use of inputs.

## Correlation between innovation factors and specific innovations in family farms (FFs)

Regarding the farmer's profile in terms of the training of the human resource in the FF, there is a significant positive relation between them ($r_s$=0.65; p<0.01), and it was found that the farmers who are part of an organization receive more training in processes of production, organization and commercialization, and more than one person in the FF received training.

The opposite situation is observed if the farmer manifests performing activities in the FF individually, since there are fewer opportunities for training and technical assistance ($r_s$=-0.66; p<0.01), as described by Rugeles *et al.* (2013); the farmer's profile is related to education, although in this case, schooling was similar between farmers from the three localities and between FFs (average education of 5.1 years), which is why an important relationship is observed with the training that they receive through different training processes. Thus, the profile of the farmer who works in association, through an organizational scheme, tends to innovate in different processes and the extension service provided by the State plays an important role (Aguilar *et al.*, 2017), which is confirmed by the farmers in their responses.

As Rugeles *et al.* (2013) mention, in order to innovate in the agriculture and livestock sector, a factor is the organization that the farmer is willing to establish, and therefore, in this study the farmer's profile has a close relation with the different types of innovation that take place in the FFs, such as: introduction of varieties and use of different infrastructure for the production process, acquisition of inputs and equipment through their organization schemes, through agreements with suppliers ($r_s$=0.85; p<0.01), in addition to farmers who receive training being the ones that carry out most innovations ($r_s$=76; p<0.01) (Table 2). If the farmer works in isolation, the changes or innovations in the process are minor ($r_s$=-0.63; p<0.01), and a similar situation is seen for product innovations where a $r_s$=-0.66; p<0.01 is observed for organizational innovations of the FFs; the correlation is $r_s$=-0.63; p < 0.01, showing a similar trend in the market innovations $r_s$=-0.76; p<0.01 (Table 2). In general, as Garrido *et al.* (2016) describe, innovations tend to be related with the farmer's profile and to generate innovation in the rural sphere, the interaction between different

**Table 2.** Relation between the farmer's profile and specific innovations.

| Farmer's profile – Process innovations | | | | | |
|---|---|---|---|---|---|
| Specific innovations: | IP29 | IP33 | IP34 | IP35 | IP38 |
| In the production system | 0.73 | | 0.72 | 0.86 | 0.80 |
| New varieties | | | | | 0.85 |
| Crop management | | | | | 0.77 |
| Use of agrichemicals | 0.78 | | 0.72 | 0.78 | |
| Farmer's profile – Product innovations | | | | | |
| Product from different varieties | | | | 0.67 | 0.84 |
| Product classification | | -0.66 | | 0.68 | 0.74 |
| Farmer's profile – Organizational innovations | | | | | |
| Hiring of staff based on knowledge | | -0.60 | | | |
| Training in tasks | 0.66 | -0.63 | | | |
| Farmer's profile – Market innovations | | | | | |
| Commercialization in: | | | | | |
| Regional market | 0.68 | | 0.60 | | |
| State market | 0.72 | -0.69 | 0.70 | 0.78 | 0.79 |
| Wholesale | 0.70 | -0.76 | 0.66 | 0.71 | 0.65 |
| Yearlong production | 0.67 | -0.66 | | 0.69 | 0.84 |

Spearman's correlation test ($r_s$, $\alpha$=0.05). All the values showed high significance ($p<0.01$). IP items of the farmer's profile, 29: is part of a rural production society, 33: individualized form of organization, 34: acquisition of inputs and materials through an organization, 35: individual verbal or written contract with suppliers, and 38: conducts agreements with suppliers and clients.
Source: prepared by the authors.

stakeholders is necessary; this happens when operating under the systems principle, in this case due to the profile that the farmer acquires (association) due to type of crop and its aim. The farmer's organization, both inside the FF and with other farmers, is related to a change in the type of market and the type of sale (wholesale) of the product, it shows a correlation value of $r_s$=0.79 ($p<0.01$), and it establishes agreements with suppliers and clients to guarantee production and sale throughout the year ($r_s$=0.84; $p<0.01$) (Table 2). As mentioned by Jarquín *et al.* (2017), currently, peasants, in their pluriactivity and farming, need to diversify their agricultural production to cover their needs and to be increasingly better organized.

## Relation between the farmer's profile, external innovation factors and productivity factors

Through Spearman's correlation test ($r_s$, $\alpha$=0.05), the internal innovation factor and farmer's profile showed highly significant values compared to the external innovation factors of innovation environment, local links, research and development, articulation to the market, and territorial networks that are generated around the FFs, where the crop is what determines the high correlation observed between the internal innovation factor of the farmer and the external factors.

The farmer's profile is one of the most decisive internal factors, and it is related to all the factors considered, both of innovation and of productivity; this profile defines a model of organization of the different FFs according to the crop and the innovation environment is generated based on this model, which happens when there is collective participation through a productive organization ($r_s$=0.64; p<0.01), agreements are made with suppliers and there is participation of government institutions of different levels ($r_s$=0.83; p<0.01); this agrees with what was presented by Cadena *et al.* (2018) who mention that participative schemes are necessary in the most vulnerable producers who require the extension service as a bridge between FFs and the environment, including them in their needs.

In this case, if the innovation environment is generated with only the farmer's ideas, the organization model shown by the farmer's profile tends to be individualist, it does not belong to any organized manner for different activities in the FFs ($r_s$=-0.45; p<0.01), and the relationship with institutions tends to be lower ($r_s$=-0.62; p<0.01).

The links established by FFs and their relationship with the farmer's profile are defined by the relationship with institutions, suppliers and between producers, to obtain materials and inputs and to receive training or technical assistance from the family farm's production process; that is, the organizational model is related to the type of FF, so if the farmer's profile tends to be collective, the relationship with institutions is higher ($r_s$=0.89; p<0.01). This situation agrees with Cadena *et al.* (2018) when they describe their training and organization model to improve the productivity with the farmer's participation. The authors mention that when peasants from the marginalized rural sphere organize and coordinate actions with external agents, there is a technological, economic and social impact and it is in function of the integration of the system formed by diverse agents.

The market, the research and the incipient networks have a similar relationship to the factors already described, but there is a positive relation with the farmer's profile when he becomes organized with other producers and if the profile has the tendency to work in isolation, the relationship is negative, which happens with institutions for enterprises by the FF and to receive technical assistance or training in some productive process.

The farmer's profile shows a positive relationship with three indicators of the human factor dimension, and this relation is seen when the farmer is part of a production society or organization related positively with equipment and materials available for the FFs, and the supports given between producers mainly in different production and commercialization processes (rs=0.64; p<0.01) (Table 3).

Motivation happens as a result of the benefits obtained from the FF and the incomes from the farming activity, which affords the family better educational opportunities; and it is related positively with the farmer's profile, and the cohesion between producer increases when they are grouped to acquire inputs and materials, trade their products, and coordinate with government institutions ($r_s$=0.73; p<0.01). This cohesion shows a negative relationship if the producer works in isolation $r_s$=0.50; p<0.01 (Table 3). Results show that there is motivation in the three types of FFs, and what differentiates this motivation is the satisfaction of the product as stated by Chayanov in the paper by Heynig (1982); which,

**Table 3.** Relationship between the farmer's profile and productivity factors.

| | IP29 | IP33 | IP34 | IP35 | IP38 |
|---|---|---|---|---|---|
| Farmer's profile – Labor satisfaction | | | | | |
| Has equipment and materials for production | | | | | 0.62 |
| Due to changes in processes, he is an example in the community | | | | | 0.64 |
| Farmer's profile– Motivation | | | | | |
| The incomes cover their needs | 0.51 | -0.60 | 0.59 | 0.73 | 0.77 |
| This activity improves the family welfare | | | | | 0.59 |
| Farmer's profile – Cohesion | | | | | |
| Performs activities collectively | 0.54 | -0.47 | 0.51 | 0.55 | 0.63 |
| Is part of an organization | 0.64 | -0.50 | 0.52 | 0.59 | 0.77 |
| Farmer's profile – Human capital | | | | | |
| Trains to improve processes | 0.58 | -0.51 | | 0.56 | 0.74 |
| Invests or manages resources in training | 0.53 | -0.68 | 0.57 | 0.59 | 0.67 |
| Technical assistance is paid in group | 0.53 | -0.63 | 0.58 | 0.68 | 0.75 |
| Farmer's profile – Technological capital | | | | | |
| Uses new technology to improve | 0.67 | -0.64 | 0.56 | 0.71 | 0.81 |
| Coordinates with research institutions | | -0.56 | | 0.51 | 0.69 |
| Has sufficient equipment and inputs | 0.70 | -0.63 | 0.62 | 0.68 | 0.71 |
| Farmer's profile – Public capital | | | | | |
| Sufficient agricultural infrastructure | | -0.54 | | 0.59 | 0.74 |
| Has electric energy | 0.53 | -0.55 | 0.54 | 0.65 | 0.71 |
| Farmer's profile – Work | | | | | |
| Can pay for labor | | -0.43 | 0.54 | 0.58 | 0.64 |
| Technical assistance by the state | 0.53 | -0.50 | 0.57 | 0.58 | 0.71 |

Spearman's correlation test ($r_s$, $\alpha$=0.05). All the values showed high significance p<0.01; IP 29: is part of a rural production society, IP33: is part of an individualized organization, IP34: acquisition of inputs and materials through an organization, IP 35: individual verbal or written contract with suppliers, and IP 38=conducts agreements with suppliers and clients. FF=family farm.
Source: prepared by the authors.

while some have a use value (corn and bean), others have an exchange value (tomato) and this is what motivates the producer to continue cultivating. Therefore, there must be a differentiation in the public policies that considers the different FFs for their motivation and to obtain differentiated results according to the type of farm (Jarquín *et al*., 2017). However, in contrast with what was reported by Zarazúa *et al*. (2011), where the results are cease to produce unprofitable crops or change their traditional system, in this case the farmers continue with the cultivation of corn and bean with subsistence aims, since they are part of their diet, as they manifested.

From the indicators of the productive system, the farmer's profile has a positive relationship: if the FFs are part of an organization and carry out formal or informal agreements with third parties, then the human capital receives greater training, whether individually or collectively ($r_s$=0.62; p<0.01), resources for training are managed collectively, and the farmers need the presence of a technical professional. The more organized the FFs are,

there is a positive relationship with regards to the payment that can be made collectively of the technical assistance service ($r_s$=0.76; p<0.01) (Table 3). In this regard, Jarquín *et al.* (2017), in a study of pluriactivity and family farming, consider that the adoption of new production systems or introduction of innovations, affects not only the way of practicing agriculture, but rather the way of seeing and living through it with which peasant work is modified; this is confirmed in this study's results with the introduction of a crop with market aims, such as tomato.

Within technological capital, the use of new technology or different from that of common application, holds a positive relation with the farmer's profile when he tends to be organized ($r_s$=0.81; p<0.01), and this affects the needs for labor that is required to a greater extent in FFs that have an organizational model with collective work, through a form of organization ($r_s$=0.71; p<0.01); in this situation, the farmers manifest that the workforce needed can be paid with the income obtained (Table 3).

## Relationship between the organizational model of the FFs and the benefits obtained

Within the factors of innovation, the farmer's profile was always significant and determinant in the processes of specific types of innovation and with all the indicators considered. From this profile, the organizational model followed by farmers is defined, and it is related to the crop that the FF considers, which has a positive relationship with the benefits or incomes obtained. Garrido *et al.* (2016) mention that in small-scale agriculture, the type of crop and its aim determines the actors and the links between them, with an effect on the development of the farms. Therefore, the farmer's profile tends to be more organized and to perform activities in coordination with other producers and increasing their incomes ($r_s$=0.64; p<0.01); however, their costs also increase, although the first is higher and this happens when the aim of the production is a market. When they are part of an organizational model where various activities are shared among FFs, their incomes and costs will hardly remain the same (Table 4). These producers innovate more quickly, which agrees with what was reported by Cano *et al.* (2015) in organized producers of the state of Veracruz.

The farmer's profile has a high correlation with the type of crop that the FF considers ($r_s$=0.81, p<0.01), which has an impact on the innovations implemented, result that agrees with what was reported by Damián *et al.* (2014), who mention that the corn crop has few changes or innovations if it is for subsistence aims and the farmer works alone. With regards to the incomes and costs, they have a positive relationship with the type of crop that the FF considers ($r_s$=0.84; p<0.01); that is, if the costs and incomes increase, there is a change in the crop with market aim and if this happens the cultivated surface is reduced (Table 4).

## CONCLUSIONS

In family farms (FFs), there are internal and external factors that have an influence for them to innovate. The degree of interaction between them is in function of the type of crop that is considered as the main crop. Therefore, the indicator 'farmer's profile' of

**Table 4.** Relationship between the farmer's profile and benefits obtained by the type of FF (FF=family farm).

| Farmer's profile – Benefits obtained in the production and commercialization process | | | | | |
|---|---|---|---|---|---|
| | IP29 | IP33 | IP34 | IP35 | IP38 |
| In the last 5 years the FF has increased its incomes | 0.64 | -0.67 | 0.64 | 0.77 | 0.81 |
| Its costs have increased but their incomes even more | 0.63 | -0.75 | 0.62 | 0.78 | 0.79 |
| Incomes and costs remain the same | -0.53 | 0.75 | -0.55 | -0.67 | -0.70 |
| | Farmer's profile – Type of FF | | | | |
| Main activity (corn, bean or tomato) | 0.69 | -0.70 | 0.69 | 0.81 | 0.96 |
| | Type of FF – Benefits obtained | | | | |
| | FN116 | FN117 | FN118 | | |
| IGP Main crop | 0.84 | 0.82 | -0.85 | | |

Spearman's correlation test ($r_s$, $\alpha$=0.05). All the values had high significance p<0.01; IP29: is part of a rural production society, IP33: form of individual organization, IP34: acquisition of inputs and materials through an organization, IP35: individual verbal or written contract with suppliers, and IP38: conducts agreements with suppliers and clients. FN116: increase of FF incomes, FN117: increase in costs, although their incomes in higher proportion, and FN118: incomes and costs remain the same, and IGP item of the FF type according to the crop of corn, bean or greenhouse tomato.
Source: prepared by the authors.

the innovation variable determines the level of interaction between factors. The three types of production units need to improve the links with research and higher education institutions; however, there is greater interaction when the main crop is tomato.

The behavior of the indicators of the two variables has to do with the crop, although it does not happen this way between localities. In this case, the farms with greenhouse tomato crop, whose aim is the market, presented more innovations and economic benefits by being more productive. However, in family farming of these communities, bean and corn are not less important since they are part of their diet and farmers will continue to cultivate these crops; their aim is not for the market, which is the case of family farming.

In the farms of marginalized communities, the factors of innovation and productivity and their degree of interaction are in function of the crop and its aims, which means that if the crop is for self-consumption, the innovation factor is practically static and the productive levels are determined by family consumption; or if the product is for a market, the innovation factor is dynamic.

It is necessary to perform an analysis under a theoretical approach that contemplates new dimensions of peasant family farming, which could analyze the phenomenon from different theoretical perspectives, since in the agriculture practiced in the region considered by the study, there are farms found within a model that obeys to indicators of the Neoclassical current, although there are crops such as corn and bean which acquire importance for family subsistence and whose main aim is not the market; in this case, the approach

of extension work required to make the innovations in family farming in marginalized communities more dynamic, is important.

## REFERENCES

Águila AR, Padilla A. 2010. Factores determinantes de la innovación en empresas de economía social. La importancia de la formación y de la actitud estratégica. Revista de Economía Pública, Social y Cooperativa. (67). 129-155.

Aguilar N, Olvera JA, Martínez EG, Aguilar J, Muñoz M, Santoyo H. 2017. La intervención en red para catalizar la innovación agrícola. Revista Hispana de Análisis y Redes Sociales. 28(1). 9-31. https.//doi.org/10.5565/rev/redes.653.

Arcos C, Suárez M, Zambrano SM. 2015. Procesos de innovación social (IS) como fuente de transformación social de comunidades rurales. Academia y Virtual. 2(8). 85-99. https.//doi.org/10.18359/ravi.1425

Bisang R, Anlló G, Campi M. 2015. Políticas tecnológicas para la innovación. la producción agrícola Argentina, 1ª ed.; CIEPLAN. Santiago, Chile, 2015. https.//scioteca.caf.com/handle/123456789/773. pp. 16-18.

Cadena P, Rodríguez RF, Camas R, Cadena J, Fernández I, Martínez J, Espinosa N. 2018. El extensionismo a partir de la gestión de la innovación en áreas de alta marginación de México. Revista Conexao UEPG. 14(3). 315-32. https.//doi.org/10.5212/Rev.Conexao.v.14.i3.0001.

Cano O, Villanueva JA, Reta JL, Huerta A, Zarazúa JA. 2015. Investigación participativa y redes de innovación en agroecosistemas con papayo en Cotaxtla, Veracruz, México. Agricultura Sociedad y Desarrollo. 12(2). 219-237.

Damián MA, Romero O, Ramírez B, López L, Parraguirre C, Cruz A. 2014. Agricultura familiar y seguridad alimentaria entre productores de maíz de temporal en México. Agroecología. 9(1-2). 89-99.

Díaz JF, Ojeda MM, Valderrábano DE. 2016. Metodología de muestreo de poblaciones finitas para aplicaciones en encuestas, 1ª ed.; Imaginarial Editores. Xalapa, México, 2016; pp. 98-119.

Espejel A, Barrera A, Cuevas V, Ybarra MC, Venegas JA. 2017. Sistemas de innovación y patrones de interacción local en el sector rural en México. Nova Scientia. 9(19). 595-614. https.//doi.org/10.21640/ns.v9i19.827.

FAO (Organización de las Naciones Unidas para la Agricultura y la Alimentación). 2012. Estudios sobre innovación en la agricultura familiar. Experiencias y enfoques de procesos participativos de innovación en agricultura. http.//www.fao.org/docrep/017/i3136s/i3136s.pdf.

FAO (Organización de las Naciones Unidas para la Agricultura y la Alimentación). 2014. The state of food and agriculture. Innovation in family farming. https.//www.fao.org/3/i4040e/i4040e.pdf.

French J, Montiel K, Palmeri V. 2014. La innovación en la agricultura. un proceso clave para el desarrollo sostenible, IICA, https.//repositorio.iica.int/handle/11324/2607.

Garrido MF, Martínez JC, Rendón R, Granados RE. 2016. Los sistemas de innovación y su impacto en el desarrollo territorial. Revista Mexicana de Ciencias Agrícolas. 7(Pub. Esp. 15). 3143-3152.

Heynig K. 1982. Principales enfoques sobre la economía campesina. Revista de la CEPAL (Comisión Económica para América Latina y el Caribe). (16). 115-142. https.//doi.org/10.18356/b5448774-es.

INEGI (Instituto Nacional de Estadística y Geografía). 2014. Encuesta nacional agropecuaria 2014. ENA. https.//www.inegi.org.mx/app/biblioteca/ficha.html?upc=702825073923.

Jarquín NH, Castellanos JA, Sangerman DM. 2017. Pluriactividad y agricultura familiar. retos del desarrollo rural en México. Revista Mexicana de Ciencias Agrícolas. 8(4). 949-963. https.//doi.org/10.29312/remexca.v8i4.19.

Kulshreshtha AD. 2013. Basic concepts of sampling. Brief review. sampling design. Second RAP regional workshop on building training resources for improving agricultural & rural statistics sampling methods for agricultural statistics-review of current practices SCI. U.N. Statistical Institute for Asia and Pacific, Tehran, Islamic Republic of Iran, 10-17 September 2013, pp. 52-56.

Levin RI, Rubin DS. 2010. Estadística para administración y economía, 7ª ed.; Pearson educación. México, 2010; pp. 630-639.

Marvel M, Rodríguez C, Núñez MA. 2011. La productividad desde una perspectiva humana. dimensiones y factores. Intangible Capital. 7(2). 549-584. http.//dx.doi.org/10.3926/ic.2011.v7n2.p549.584.

Morales ME, Ortiz C, Arias MA. 2014. Factores determinantes de los procesos de innovación. Una mirada a la situación en Latinoamérica. Revista Escuela de Administración de Negocios. 72. 148-163. https.//doi.

org/10.21158/01208160.n72.2012.573.

Rendón R, Aguilar J. 2013. Gestión de redes de innovación en zonas Rurales Marginadas, 1ª ed.; MAPorrúa. México, 2013. https.//ciestaam.edu.mx/libro/gestion-redes-innovacion-en-zonas-rurales-marginadas/. pp. 141-163.

Rojas R. 2013. Guía para realizar investigaciones sociales, 38ª ed. Plaza y Valdés Editores. México, 2013. https.//raulrojassoriano.com/cuallitlanezi/wp-content/themes/raulrojassoriano/assets/libros/guia-realizar-investigaciones-sociales-rojas-soriano.pdf. pp. 169-292.

Rugeles L, Guaitero B, Saavedra D, Ariza C, Noreña HE, Betancur I, Castillo O, Humanez NM, Arosa C, Barrera LM, Vargas M. 2013. Medición de la innovación Agropecuaria en Colombia, 1ª ed.; Universidad de Medellín. Colombia, 2013. http.//avalon.utadeo.edu.co/servicios/ebooks/innovacion_agropecuaria/#4/z. pp. 47,54,120,154.

Salcedo S, De la O AP, Guzmán L. 2014. El concepto de agricultura familiar en América Latina y el Caribe. *In.* Agricultura familiar en América Latina y el Caribe. recomendaciones de política. Salcedo S., Guzmán L., Eds.; FAO. Santiago, Chile. https.//www.fao.org/3/i3788s/i3788s.pdf. pp.17-32.

Scheaffer RL, Mendenhall W, Ott RL. 2007. Elementos de muestreo, 6ª ed.; Thomson editores. Madrid, España, 2007; pp. 98-99.

SAS Institute. 2015. Programming with Base SAS® 9.4, 2nd ed.; SAS Institute Inc. NC, USA, 2015.https.//documentation.sas.com/api/docsets/basess/9.4/content/basess.pdf. 900 p.

Turrent A, Cortés JI, Espinosa A, Hernández E, Camas R, Torres JP, Zambada A. 2017. MasAgro o MIAF ¿Cuál es la opción para modernizar sustentablemente la agricultura tradicional de México? Revista Mexicana de Ciencias Agrícolas. 8(5). 1169-1185. https.//doi.org/10.29312/remexca.v8i5.116.

Verduzco C, Martínez EG, Muñoz M, Santoyo VH, Aguilar J. 2016. Estrategia de gestión de la innovación para la avicultura de traspatio en zonas rurales marginadas de Oaxaca, México. Transitare. 2(2). 165-182.

Zarazúa JA, Almaguer G, Ocampo JG. 2011. El programa de apoyos directos al campo (PROCAMPO) y su impacto sobre la gestión del conocimiento productivo y comercial de la agricultura del estado de México. Agricultura, Sociedad y Desarrollo. 8(1). 89-105.