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Essay

Technology transfer in the PRODETERs of the state of Morelos

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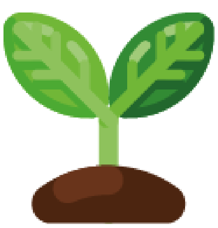
Abstract

The 2019 rural development program aimed to sustainably increase the productivity of family production units in rural areas in order to contribute to improving their income. The units served should be located in rural areas of priority attention and in localities of high and very high marginalization. To achieve the objective, territorial development projects were carried out, which would be aimed at strengthening production units and forming companies integrated into production chains. In this process, they would have technology and technical assistance. In the state of Morelos, eight territorial development projects were formed: agave, minor species, avocado, major species, fruit species, vegetables, corn-sorghum-amaranth, and nopal. The Zacatepec Experimental Field was in charge of technology transfer. In each project, it was carried out in three stages: in the first, a diagnosis of the production units was carried out, from which the problems and the technological model that would solve these problems emerged. Modules were established to transfer the technology, in which demonstrations were carried out, producers and extensionists were trained with courses and workshops, technological exchange trips were carried out and fold-outs and technological chart were printed. To address specific problems, visits to the plots or farms of some producers were scheduled. Although the resources arrived late, the programmed transfer was fulfilled, but it could not be continued because the duration of the program was short, so it could not be evaluated if productivity was improved.

Keywords:

extension work, rural advice, rural development.



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Family production units (FPUs) located in marginalized areas of Mexico are characterized by having an agricultural area of less than 5 ha, are not associated, have low profitability and progressive decapitalization, limited access to formal financial services, face climate risks and have little participation in decisions about their territory. Overall, 97% of FPUs are exclusively engaged in primary production and its value represents only 10% of the final value to the consumer (Ibarra, 2021).

Policies have been designed based on this diagnosis, such as the economic integration policy for the promotion of businesses (Financiera Rural, 2008) and the Rural Development Program of the Secretariat of Agriculture and Rural Development (SADER), for its acronym in Spanish for 2019 (DOF, 2019). The general objective of this program was to sustainably increase the productivity of FPUs in rural areas in order to contribute to improving their income.

The program had four components: 1) strengthening of the FPUs; 2) economic integration of production chains; 3) capacity building, extension work, and rural advice; 4) research and technology transfer. To achieve the objective, territorial development projects (PRODETER), for its acronym in Spanish) were carried out. A PRODETER was the initiative of a group of FPUs grouped formally or informally in a delimited territory to improve primary production and to venture into other links in the production chain.

The FPUs that were served by the program were located in the municipalities of the rural priority attention areas and in localities of high and very high marginalization in other municipalities of the country. The participating producers could be comuneros, ejidatarios, or small landowners. To delimit the territory, the productive potential of crops or livestock or aquaculture species that are priorities for SADER was used as a criterion, as productive potential is understood to be the area with the best agroecological conditions to successfully produce a crop (Medina *et al*., 2009; Vázquez *et al*., 2010).

The demarcation was made with the use of geographic information systems, which overlay maps with the edaphic, climatic, and topographic conditions of the territory and compare them against the biological needs of the crop with which the areas with yield potential are identified. These territories were refined by the agricultural officials of each state by considering their economic, political, and social knowledge of the locality.

This is how the PRODETER avocado or the PRODETER beef cattle emerged. Throughout the country, 413 PRODETERs were formed (SHCP, 2020). Each group of FPU, associated formally or informally, would have advice and technical assistance to design and operate the projects. The program is summarized in the diagram of (Figure 1).

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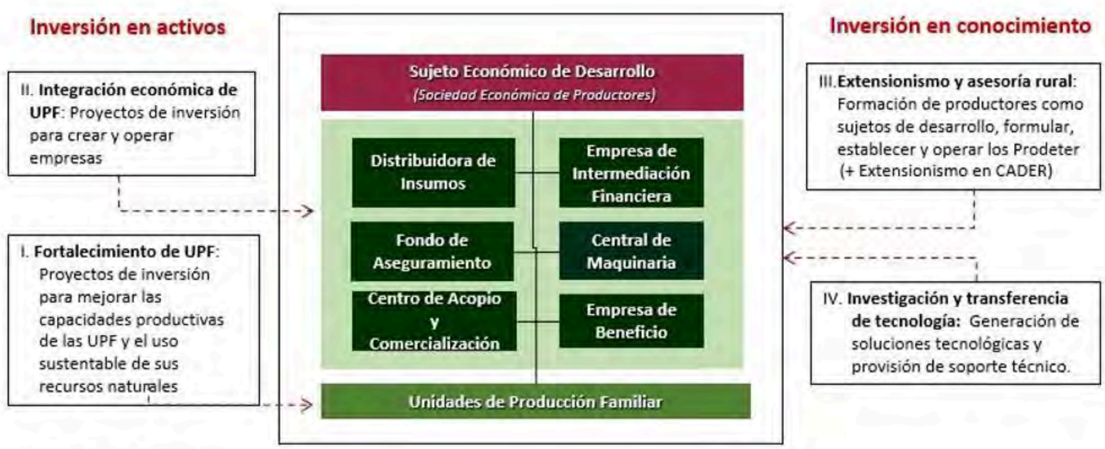
Figure 1. Connection between the four components of the program for the design and establishment of a territorial development project (PRODETER), for its acronym in Spanish.



Fuente: SADER, 2019.

The program began in early May 2019 and officially ended in March 2020. Due to the delay in the delivery of resources and the SarCov-2 pandemic, the completion of the work was extended until August 2020. Monitoring and impact evaluation was not considered. The execution of the program in the state of Morelos began with the determination of the number of projects that were going to be implemented; it was agreed to form eight PRODETERs: agave, minor species, avocado, major species, fruit species, vegetables, corn-sorghum-amaranth, and nopal.

The execution of the Research and Technology Transfer component was in charge of the Zacatepec Experimental Field, under the National Institute of Forestry, Agricultural and Livestock Research (INIFAP), for its acronym in Spanish, which was designated for complying with the requirements established by SADER. The component aimed to articulate research with extension work to promote the application of technological components.

The component was carried out in three stages: technical-productive diagnosis of the FPUs, technology transfer proposal and technical support strategy. To carry out the diagnosis, a survey and meetings with producers and extension agents were carried out. The results were used to characterize the social, economic, and technological conditions of the FPUs; this served to know the context, the productive problems, and the baseline of productive indicators.

The integration and analysis of the information served to propose the appropriate technological model. It indicated what technological components were going to be used, how much the productive indicators would change in the short, medium, and long term, as well as the profile of the extension agent that each PRODETER would need. In the second stage, called technology transfer proposal, the mechanisms for the transmission of knowledge and technical experiences were indicated.

The model used in all PRODETERs was to establish demonstration modules on producers' land where demonstration events were held, courses and workshops were held to teach extension agents and producers the appropriate techniques to solve their problems; trips were organized, inside and outside the state, where leading producers or institutions were visited to exchange experiences and technological knowledge; finally, fold-outs were designed and printed summarizing the technology to improve productivity or solve problems of crops or livestock species of interest.

The third and final stage was called technical support strategy, which consisted of a series of visits to the plots or farms of some producers to provide them with personalized technical assistance, which were programmed according to the phenological stages of the crop, the physiological stages of the

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animals, the recommended technological components, and other particular aspects. The relevant results in each PRODETER of the state of Morelos are described below.

Avocado

The common problems of avocado producers were: a) low yield, 8 t ha^{-1}; b) the producers do not know the phenology and morphology of the tree; c) they do not know how to grow orchards with high population densities; d) they do not know how to manage the plant so that the harvest is obtained in times of better prices; e) they do not know how to produce organically.

Based on the type of FPU, the problems detected, and the goals in the indicators, a technological model was proposed, which consisted of increasing population densities and changing the management of the plant, from formation pruning to fruiting pruning, so that production is obtained in times of better prices. It was also proposed to adapt the nutrition since it must be in accordance with the floral flow. The model included training on how to grow the avocado organic and how to irrigate.

To transfer the technology, two demonstration modules were established, one on high-density orchards and the other with organic management, in which demonstration events were carried out. The exchange trip was to Michoacán, where they visited an orchard with high planting density, a conventional orchard with production for export, a certified plant nursery, and a certified packing house for export.

On that trip, they visited the Uruapan Experimental Field, where they received a course on the prevention and treatment of pests and diseases. In Tetela del Volcán, Morelos, a workshop was held on selection, packaging, and safety processes with the application of good management practices (GMP). A technical sheet for growing avocados in Morelos was published.

In relation to personalized technical assistance, the plot of nine producers was visited, where specific problems were addressed, such as: growth without pruning of the tree, inappropriate fertilization of the trees, empty spaces in the orchard, presence of persea mite (*Oligonychus perseae*), poor management of high-density orchards, and lack of knowledge of ecological disease management.

Major species

The problems encountered in this PRODETER were: a) poor health management, such as scarce use of vaccines and no sanitary baths; cattle management logs are not used either; b) lack of an adequate and enriched diet; c) mating control is not carried out and the methods to stimulate heat are unknown; d) no improvement practices have been carried out on their herd.

Based on the type of FPU and the problems detected, a technological model was proposed, which consisted of managing the health of the herd through the annual application of bacterina, deworming cows after calving and calves after weaning, applying tickicides every month in the dry season and applying vitamins ADE to cows, heifers, and the bull every 120 days. Regarding nutrition, the introduction of other grasses and legumes was recommended, in addition to providing mineral salts.

For reproductive management, embryo transfer was suggested. Finally, it was proposed to initiate a genetic improvement program. The technology transfer actions were: a) two 500 m^2 demonstration modules where the following forage species were sown: Mombasa grass (*Panicum maximum* cv. Mombasa), palisade grass (*Brachiaria brizantha* Stapf), gamba grass (*Andropogon gayanus* Kunth), blue pea (*Clitoria ternatea* L.), and brown hemp (*Crotalaria juncea* L.). Two demonstration modules were also established to show how to implement a health management schedule in cattle, as well as embryo transfer; b) three theoretical and practical courses were held on the health, nutritional and reproductive management of cattle herds in rangelands; c) two exchange trips were made: one within the state and the other to Cocula, Guerrero; d) two fold-outs were printed and distributed.

In the case of personalized technical assistance, two visits were made, one to the community of Quilamula, municipality of Tlaquiltenango, to address problems of nutrition, health, tick incidence,

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poor reproductive management, and low milk production. The other visit was to Zacapalco, municipality of Tepalcingo, where the prevalent problems are poor reproductive management and food shortages.

Fruit species

Based on the survey and interviews with producers, the problems detected were, in citrus: a) the plantations are established in thin, sandy, calcareous soils with little organic matter; b) population density is low; c) some trees with descending death caused by *Lasiodiplodia theobromae* or citricola; d) damage by anthracnose (*Colletotrichum acutatum*); e) presence of leaf miner (*Phyllocnistis citrella*), psyllids (*Diaphorina citri*), and brown aphid (*Toxoptera citricida*); f) they did not prune properly; g) incorrect nutrition.

The problem in figs was: a) presence of a new pest called black fruit fly (*Silba adipata*); b) there is rust and alternaria; c) poor plant nutrition; d) incorrect irrigation management. In dragon fruit, the relevant problems were: the plantations are established on hillside land, with thin soils, poor in organic matter and calcareous, nutritional imbalance in soil and plant, presence of weevil, and damage by anthracnose and Erwinia.

To solve the aforementioned problems, different technological models were proposed. In citrus: apply soil improvers, establish the plantation at the appropriate density and orientation, fertilization doses according to age, carry out training and health pruning, and control pests and diseases. In figs: apply traps to combat *Silba adipata*, use soluble fertilizers and fractionate them during the cycle, efficiently manage irrigation, perform disease prevention and control, perform soil analysis to dose, and manage orchards with high plant density.

In dragon fruit: a) balance the soil with mixed vermicompost and microorganisms; b) organic pest and disease management; c) intensive production. The means to transfer the technology in citrus were: a module to demonstrate how the soil is improved with microorganisms.

In this module, a demonstration was made, two workshops were held on planting, fertilization, pruning and management of citrus pests and diseases; a technological exchange trip was made to the citrus-growing area of Martínez de la Torre, Veracruz, where producers learned how to establish a lemon plantation and how to prune, they exchanged experiences with a producer of the same technological level, they learned how a plant is produced with genetically pure material, they visited a packing house where they learned about the selection and packaging process in an exporting company, and a technological chart on how to grow Persian lime was printed

For fig technology transfer: a) a module was established to show how to combat the black fly, a demonstration was made here; b) two courses were organized: one related to the agrotechnical management of figs and the other on determination of the fertilization dose from a soil analysis; c) a technological exchange trip was made to two fig production units in the state of Morelos, one where they learned about efficient production systems under cover and in the open field and the other with trees of five different varieties; d) a technology chart on how to grow figs was printed.

In dragon fruit, the means of transferring technology were: a demonstration module in a plantation with thin soil, poor in organic and calcareous matter. Here a demonstration was carried out on how to improve the soil with beneficial microorganisms, a workshop was organized to teach how to prepare organic inputs to nourish and manage pests and diseases, a technological exchange trip was made to the dragon fruit-producing area in Molcaxac, Puebla, where they visited intensive production orchards and support system with live plants and a technological chart was printed. In relation to personalized technical assistance, four plots of citrus producers, four of figs and four of dragon fruit were served.

Vegetables

Based on the survey and interviews with producers, the problems detected were in green beans: a) poor soils with less than 1% organic matter; b) slightly alkaline (pH 7.2) and high electrical

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conductivity (2.8 milliSiemens), presence of *Fusarium oxysporum* Schltdl, *Rhizoctonia solani* Kuhn, and *Pythium ultimum*; c) very high populations of whitefly (*Bemisia tabaci* Gennadius); d) inadequate nutrient management.

In cucumber: a) hard soil with 1% organic matter; b) presence of *Fusarium oxysporum*, *Rhizoctonia solani* and *Pythium ultimum*, sporadic presence of root-knot nematodes (*Meloidogyne incognita*); c) very high populations of whitefly (*Bemisia tabaci* Gennadius), red spider mites (*Tetranychus urticae* C.L. Kock), thrips (*Frankliniella occidentalis* Pergande), and aphids (*Myzus persicae* Sulzer); d) inadequate nutrient management.

In tomatoes: a) soil with 0.5% organic matter and slightly high electrical conductivity (1.7 milliSiemens); b) presence of *Fusarium oxysporum*, *Rhizoctonia solani*, *Pythium ultimum*, and *Clavibacter michiganensis* subsp. *Michiganensis*, sporadically appearance of late blight (*Phytophthora infestans* (Mont) de Bary) powdery mildew (*Leveillula taurica*) and leaf mold (*Cladosporium fulvum*); c) presence of whitefly (*Bemisia tabaci*), tomato russet mite (*Aculops lycopersici* Tryon) and thrips (*Frankliniella occidentalis*); d) inadequate nutrient management.

To solve the problems, the following technological models were proposed for green beans, cucumbers and tomatoes, the components that were applied were: a) carry out soil and water analyses to determine nutritional management; b) apply macro and micronutrients of organic origin, as well as resistance inducers; c) manage pests and diseases with microorganisms and plant extracts.

The means to transfer the technology were three modules; those for green beans were located in Marcelino Rodríguez, Axochiapan and those for cucumber and tomatoes in Huitchila, Tepalcingo. In each of them, it was taught how to make a rapid diagnosis of the soil to know its physical, chemical, and biological conditions, so that, based on this data, choose the measures that will improve soil conditions, nutrition, and disease prevention. In each module, oxygenators, nitrogen fixers, solubilizers, minerals, activators and controllers of pests and diseases were applied; three workshops were also held, one on the safety of water in tomato crops, the second on the dosage of fertilization based on soil analysis, and the third on preparation of ecological inputs.

Applicable to the three crops, a technological exchange trip was made to a farm located in Chinameca, municipality of Ayala, which produces tomatoes, husk tomatoes, jalapeño peppers, cucumbers, and green beans with organic management. There, the producer explained to them what is needed to be able to market organic vegetables, inside and outside the country; he also explained the requirements for a demanding certifier to grant the certificate of organic production.

He emphasized the inputs that must be used in production, which must be authorized by SENASICA and must have the Organic Materials Review Institute (OMRI) registration. A tour of the production area of organic tomato and husk tomato seedlings was also carried out. To disseminate the technology, three technological charts were printed, which teach how to grow green beans, cucumbers, and tomatoes. In relation to personalized technical assistance, four plots of green bean producers, four of cucumbers, and four of tomatoes were visited.

Corn, sorghum, and amaranth

Based on the survey and interviews with producers, the problems detected for both corn and sorghum were: a) restricted use of certified improved high-yielding seed; b) presence of fall armyworm [*Spodoptera frugiperda* (J. E. Smith)] and spider mite (*Tetranychus urticae*); c) high cost of improved seed and inputs; d) deficiencies in fertilizer doses and management; e) poor weed control; f) poor use of conventional tillage.

In amaranth: a) there is a lack of plant varieties of intermediate height and with inflorescences with parity of female and male flowers; b) no mechanization of sowing and harvesting; c) deficient dosages of fertilizers; d) application of residual herbicide, harmful to amaranth.

To solve the aforementioned problems, the following technologies were proposed both for corn and sorghum: a) conservation agriculture (CA) production system; b) sowing of genotypes with high

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yield potential and industrial quality; c) agroecological management of fall armyworm; d) correct management of fertilization; e) integrated weed management. For amaranth, the following was proposed: a) use of machinery for furrowing, sowing, fertilizing; b) nutrition with the correct fertilizers and fractionally.

The means to transfer technology for corn and sorghum: a) a module and demonstration of sustainable production of corn and sorghum under the conservation agriculture system at the facilities of INIFAP-Zacatepec Experimental Field, Morelos; b) two courses, one on soil sampling, fertility and fertilization programs for corn and sorghum, and another to teach agroecological pest management and weed control in corn and sorghum; c) a technology exchange trip to the conservation agriculture research platform (INIFAP-CIMMYT-MasAgro), established at INIFAP-Zacatepec Experimental Field, Morelos; d) two technology charts were printed, one with the corn technological package and the other for sorghum.

In amaranth, the transfer of technology was through: a) a module in Tlacotepec, municipality of Temoac. In this, two demonstrations were carried out, the first to show the preparation of the soil, sowing, and cultivation. In the second demonstration, it was taught how to carry out semi-mechanized harvesting of amaranth; b) three courses were held, the first was on nutritional and economic importance, genetic diversity, environmental requirements for the crop and the phenological stages of the plant. In the second course, it was taught how to manage the crop, from the preparation of the land to the harvest. In the third, the operation of the thresher, harvesting and postharvest management were taught; c) a technological chart with the amaranth technological package was printed. In relation to personalized technical assistance, the plots of seven corn and sorghum producers were visited. In amaranth, only one producer was advised, but from the beginning to the end of the crop, interested producers and extension agents were invited on each visit, so that knowledge was extended.

Nopal

With the data from the survey and interviews with the producers, the following problems were determined: a) presence of the cactus weevil (*Metamasius spinolae* (Gyllenhal)); b) presence of wild cochineal (*Dactylopius opuntiae* (Cockerell)); c) lack of knowledge on the dosage and timing of fertilization; d) lack of knowledge on the dosage and frequency of application of insecticides; e) lack of a production scheme and logs are not used; f) indiscriminate use of insecticides and residual analysis is not performed on their product; g) high costs of the certification process; h) little added value to the nopal.

Based on the type of FPU and the problems detected, the following technological model was proposed: a) application of compost; b) integrated management of pests and diseases with plant extracts; c) chemical fertilization of the soil and foliar fertilization based on soil analysis; d) analysis of residuality and pre- and postharvest biological contamination of nopal; e) crop management focused on safe production.

The technology transfer actions that were carried out were: a) two demonstration modules in Tlalnepantla, where it was taught how to calculate the amount of compost per hectare and how to apply it. A module was also established in Tlayacapan, where a demonstration was carried out, in which the basic concepts of organic agriculture were explained and then it continued with the preparation of an organic insecticide for cochineal; b) three workshops for producers: one on the identification and biological cycle of *Dactylopius opuntiae*, another on soil fertilization with compost and the third on the preparation of insecticides for the control of cochineal; c) the printing of a technological chart for the safe production of the vegetable cactus in the state of Morelos.

In the case of personalized technical assistance, 20 plots were visited. In each visit, the researcher and at least one extension agent were present. Advice was mainly given on nutritional management and control of cochineal. To understand the scope of the results of technology transfer in PRODETERs, it is first necessary to examine the program as a whole. The diagnosis of the rural

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development program is solid and the general objective that was proposed was consistent with the problem, but the procedure that was proposed to reach the objective was not adequate.

A development model with a territorial approach must consider the area and time necessary for integration and interaction to take place as a functional unit of human beings (social), natural resources (environmental), the economy (production and consumption of goods and services) and policies; in addition, it must have a prospective and long-term vision.

The rural development program did not comply with the aforementioned requirements since it only considered, for the territorial delimitation, the areas suitable for the development of a crop, but not the area required for the entire economic process of adding value and marketing to be carried out. It is in exchange that wealth is generated, not in production. Nor did it have enough time for the maturation of the projects since it was only in force for one year.

The program had a long-term vision, but there was not enough time to meet the medium-term goals. Another shortcoming of the program was the delay in the delivery of resources for the execution of all components, particularly for the purchase of assets. Most of the PRODETERs received their assets until June 2020 when it should have been between August 15 and November 15, 2019.

This caused chain delays to such an extent that the time was only enough for the delivery of works, machinery, and equipment, but not for their operation. It should be noted that the SarCov2 pandemic may have affected some actions, but they were minimal because it worsened after March, when the program had legally ended. In the case of annual crops, the resources arrived when the rainy season had already ended, so it was not possible to establish demonstration modules of corn and sorghum. The amaranth is rainfed, but the module could be established because it had irrigation.

From this situation, it can be deduced that this program should have started before the crops were sown because then modules can no longer be established. The timely start of operations is an important factor for the performance of an extension program (Ramírez *et al*., 2022). In the case of perennial crops and livestock species, it was possible to install modules where some technological components were applied, but in some cases, demonstrations could not be made because the program concluded early (March 2020).

In relation to the evaluation of the technology transfer component, the first thing to highlight is that technology was very important to improve the productivity of the FPUs. This technology is generated by research centers, but for them to have an impact, there has to be transfer. This is a process in which an element or idea created in one place is transferred to another to obtain benefits (Cadena *et al*., 2009).

In the case of the PRODETERs of the state of Morelos, the technology was transferred faithfully and timely because the generating and extension institution was the same. In most agricultural development programs implemented in Mexico, one institution generates the technology and another transfers it, but the results have not been optimal (Amaro-Rosales, 2016). To transfer the technology, it had been planned to apply one of the 14 transfer models used by INIFAP, of which seven are participatory (the most appropriate for sustainable territorial projects) (Cadena *et al*., 2009).

Nonetheless, the delay of the supports forced the use of a unidirectional model, which was the installation of demonstration modules, in which a demonstration of one or two components was carried out. This model has the disadvantage that the recommendation is not interactive and is so general that some do not apply it because each producer has particular agroecological and economic conditions (Tapia, 2009).

The inconvenience of the demonstration events was corrected with personalized visits, but due to lack of time, only very few producers could be visited. Regarding the training of producers and technicians, there were no complications because courses and workshops were designed aimed at specifically solving the problems encountered in each PRODETER. These events were usually attended by many technicians and producers (sometimes even their wives and children), but never by the entire target population. The events were taught by INIFAP specialists or by external parties.

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So that the researchers' technical recommendations would not be forgotten, fold-outs and technology charts were printed, which were well received because the recommendations were graphic and because their explanation was concise. The exchange trips were the most appreciated because the producers got to know FPUs from innovative colleagues and advanced production areas that served as an example and motivation.

Unfortunately, very few producers benefited from this activity since the quota was limited. For technology transfer to reach all producers and have an impact, the participation of sufficient extension agents is necessary to satisfactorily serve the entire target population and at least for a complete production cycle. In the case of the PRODETERs, an extensionist was hired to serve 30 producers for six months.

The number of extension agents was sufficient, but the time was short and extemporaneous since the hiring was from October 2019 to March 2020, when the rainy season had already passed. In order for the extension agents to contribute their part to achieve the objective, it is necessary that they receive permanent employment from the government, with benefits, office, equipment and training (Vázquez *et al*., 2015).

Conclusions

The 2019 Rural Development Program was a territorial development program, but its delimitation did not meet the requirement of covering the area required to carry out the entire process of adding value and marketing. Nor did it have enough time for the maturation of the projects since it was only in force for one year. The research and technology transfer component was carried out faithfully and in a timely manner because the generating and extension institution was the same.

The technology that was proposed was appropriate because it was based on a diagnosis and consultation with the target population. To transfer the technology, modules were established in which demonstrations were carried out; producers and extension agents were trained through courses and workshops; technology exchange trips were carried out and fold-outs and technology charts were printed. To address specific problems, visits to the plots or farms of some producers were scheduled.

The resources for the transfer arrived late, which caused, apart from affecting the start of the projects, that interactive transfer models were not applied. This was partially remedied with personalized visits to family production units. Because the program was only in force for one year, it was not possible to evaluate whether the objective of improving the productivity of family production units was met.

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