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CORN CULTIVATION DIAGNOSIS IN THE MUNICIPALITY OF TECPATAN, CHIAPAS

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— Abstract—

The corn grain (*Zea mays L.*) is the basic food of the Mexican people, the objective of this research was to identify the technological and socio-economic factors that impede the development of corn cultivation and its producers in the municipality of Tecpatán, Chiapas. The municipality has a registry of 1,753 corn producers, so the random sample was 59 producers. To meet the objective, in 2015 a questionnaire of 116 questions related to the aforementioned factors was applied to the sample. The individual frequencies of the variables were calculated and some were correlated, by pairs and triads, using the Statistical Package for Social Sciences (SPSS, 2010). The results allowed us to determine the multiple factors that are effectively impeding the development of the corn production chain and its producers in the municipality, therefore, with the information obtained, it is recommended to continue this investigation, which consists of developing a Comprehensive Technical Assistance System for corn producers in the municipality of Tecpatán, Chiapas, which must be applied in an inter-institutional and multidisciplinary manner. The updating of the institutional registers of corn producers is also suggested.

Keywords

Factors, systems, productivity, producers, Zea mays.

Corn (*Zea mays L.*) is the most important cereal in the world and our country, due to the volume of its production. Among the main producing countries of the grain, Mexico has occupied (between 2005 and 2015) the fifth place in annual global production that varied from 17.635 to 24.694 million tons, in a harvested area that ranged between 6.069 and 7.344 million hectares, in both cases after the United States of America (USA), China, Brazil, and Argentina, while in yield it occupied the twelfth place, with an average of 3.18 t ha^{-1}. Despite this, to meet its needs, it was the grain's second-largest importer, in the period from 2006 to 2016, with an average of 8.878 million tons per year, whose average annual value was 2.012 million US dollars (Miramontes, 2012, FIRA, 2016).

In our country there are two production systems: (a) self-consumption agriculture, related to smallholdings, based on the intensive use of rural family labor and whose main priority is to guarantee the supply of corn for self-consumption during the year and whose surpluses are sold. The states where this type of system prevails are Chiapas, Guerrero, Hidalgo, State of Mexico, Morelos, Puebla, Oaxaca, Veracruz, and Yucatan; and (b) market-oriented production, where the main characteristic is the intensive use of capital, advanced technology, market integration and the use of improved seeds. The entities that stand out for this type of system are Sinaloa, Sonora, Jalisco, Tamaulipas, and the Bajío Region (Jillian, 2011).

Vega and Ramírez (2004) indicate that a high percentage of the rural population depends on corn production, where the culture is practiced in the most diverse agroclimatic conditions with technological differences ranging from the most backward rainfed production that obtains yields of 0.7 t ha^{-1}, to irrigation systems, with improved and fertilized seeds that can obtain 12 to 14 t ha^{-1}.

In the state of Chiapas, most of the corn grain production is obtained in three economic regions headed by the municipalities of Villaflores, Ocozocoautla, and Venustiano Carranza (Ministry of Finance, 2012). These results are attributed to the use of improved seeds and good management of the culture, as farmers can carry out the activities of the production chain satisfactorily, given that the largest area is cultivated on flat land where all existing technology can be used.

However, in the mountainous region known as Los Altos de Chiapas, farmers carry out their agricultural, livestock, and forestry activities with very low availability of land and capital, resulting in extreme poverty (Parra and Díaz, 1997), which intensifies soil fertility problems and the use of fertilizers to maintain corn production (Álvarez-Solís and Anzueto-Martínez, 2004). Under these conditions, the increase in productivity, via the introduction of industrialized inputs, faces the problem of the high cost and low profitability of capital investments in hillside agricultural areas

under rainfed conditions. In general, agricultural production in Los Altos de Chiapas presents various problems, including soil erosion and loss of soil fertility, decreased yields, lower labor productivity, and a growing inability to employ family members and basic food supplies. These problems are the result of excessive pressure on the land, rugged topography, the atomization, and dispersion of plots, and the high risk of loss due to weather conditions and the artisanal nature of production techniques (Pool-Novelo *et al*., 2000).

Adjacent to this region is the study area, recently named "Region III Mezcalapa", where similar conditions prevail since it is also a mountainous region made up of nine municipalities, four of which have been selected as extremely poor, based on the criteria of the National Council for the Evaluation of Social Development Policy, which places them within the 400 municipalities of the National Crusade against Hunger. This region has 13,484 corn producers registered in the PROCAMPO, Maíz Solidario, PROMAF, and Maíz de Autoconsumo corn support programs, with 38.40, 21.63, 0.54, and 39.42%, respectively, however, they do not have a proper technical assistance program to promote and supervise the use of the support, that is, technical assistance is not instituted and therefore it is not known how these supports are used and what their impact is on the improvement of the culture and its producers.

Therefore, it is necessary and urgent to increase the productivity and production of this cereal grain. Thus, is required the generation and/or transfer of technologies, based on the results of a frame of reference or diagnosis, that identifies the edaphic, climatic, biological, socioeconomic, management, or other problems that limit corn culture development in Region III Mezcalapa, Chiapas, in the particular case of the municipality of Tecpatán, to make more accurate approaches through specific research to solve the problems of corn culture, as well as to develop and apply an Integral Technical Assistance System for corn producers in that municipality.

General Objective

To identify the technological and socioeconomic factors that impede the development of corn culture and its producers in the municipality of Tecpatán, Chiapas.

MATERIALS AND METHODS

Study area

Tecpatán is located in the Montañas del Norte, its geographic coordinates are 17° 08" North latitude and 93° 19" West longitude. Its altitude is 320 m. It has 37,543 inhabitants, a warm humid climate with year-round rainfall, an

average annual temperature of 24 to 26° C, and average annual precipitation of 2000 to 3000 mm (INEGI, 2010).

Information collection

The 2012 corn producer lists were provided by four institutions: ASERCA (Apoyos y Servicios a la Comercialización Agropecuaria), SAGARPA (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food), SECAM (Secretaría del Campo), and FIRCO (Fideicomiso de Riesgo Compartido) and were integrated to facilitate their location in the municipality.

In addition, an overview of the regional level was included, which contemplated the agronomic characterization of corn, the geographic location of the producing areas, and the main production and marketing parameters, as well as the phytosanitary regulations, seasonality, industrialization, and production marketing.

Sample calculation

Considering that the complete study of the Mezcalapa Region, Chiapas, contains nine municipalities with 13,484 corn producers, it was decided to do a "stratified random sampling" of them ($p \leq 0.05$), whose stratified sample per municipality is the most accurate and reliable, using the formula of Scheaffer *et al*. (2004). In the case of Tecpatán, the population studied included 1,753 producers, so its sample size was 59 producers. In addition, the producers were informed about the objectives of the survey, to reduce bias in the information obtained.

Surveys

The final questionnaire applied to producers in 2015 consisted of 116 questions divided into 16 sections: general information, cost of cultural work, application of herbicides or cleaning, application of organic or chemical fertilizers, pest and disease control, harvest, marketing, financing, nature of institutional support, productive impact, social impact, environmental impact, technological impact, factors that influenced the impact, needs for complementary services, and observations, to obtain information to recommend improvements to the culture.

Our experience indicates that before starting data collection, it is necessary to visit the community authorities to inform them of the project's objectives and request their authorization and recommendation to travel through their territory. Subsequently, visits were made to the producers, either in their homes or in their work areas. To facilitate the field visits and for security

purposes, a brigade of six surveyors was formed, which also resulted in better interaction with the communities and greater efficiency in the collection of information.

Interviews

To expand and corroborate the data obtained in the field, informal interviews were conducted with managers and staff of the sector's institutions involved in corn production, either for support or in related programs.

Data analysis

The field data were organized in digital form for analysis using the Statistical Package for Social Sciences (SPSS, 2010). The frequencies of all the individual variables were calculated, and some were correlated by pairs and/or triads as deemed appropriate.

RESULTS AND DISCUSSION

The questionnaire applied to the random sample of 59 producers ($p \leq 0.05$) represents the population of 1,753 corn producers in the municipality of Tecpatán, Chiapas. For practical purposes, in some cases, the number of producers is presented, and in others the percentage of them, thus, one producer surveyed is equivalent to 1.7% of the sample, which represents 29.7 producers of the population.

Considering the population of 1,753 producers registered in the institutional registers, it was observed that the number indicated did not coincide with the number engaged in the exploitation of the culture. The main causes of these differences were: six people are in the register and did not plant corn in 2014, five of them answered the questionnaire, however, one assured that he has a degree and did not receive support from Procampo, and another who received support, no longer receives it because he stopped cultivating it, the person who did not answer, only said that he appears in the register, but does not receive support and no longer cultivates corn. Therefore, we suggest updating (biannually) the official lists of corn producers, since there are also people who produce corn and should be included in the list.

General information

The representative ejidos of the municipality of Tecpatán, where the 59 corn producers that were surveyed live, stand out, in this way, 88.1% were located in descending order in the ejidos Francisco I. Madero, El Porvenir,

Emiliano Zapata, and the remaining (11.9%) in Miguel Hidalgo y Costilla, Juan Sabines and Nuevo Vicente Guerrero. In addition, it was observed that the area planted ranged between 0.25 and 5 ha, with 42.4% planting 1 ha, 25.4% 2 ha, 10.2% 1.5 ha, and 10.2% cultivating between 2.5 and 5 ha.

The majority (79.7%) of the farmers are between 41 and 70 years old, 15.3% are between 71 and 90 years old, and 5.1% are between 31 and 40 years old. All of them have been growing corn for between 5 and 70 years, while 66.1% of the total have been growing corn for between 30 and 50 years. Likewise, schooling ranged from illiterate to bachelor's degree, where 54.2% finished primary school, 16.9% between 1st and 3rd grade, 15.3% are illiterate, 10.2% graduated high school, and 1.7% have a degree. The illiteracy described is lower than in the Chiapas municipalities of Coapilla (20.0%, Pérez & Hernández, 2016), Copainalá (21.1%, Posada & Domínguez, 2014), San Fernando (26.8%, Sánchez & Sánchez, 2013), Chicoasén (27. 3%, León-Velasco, 2016), Mezcalapa (28%, León & León, 2015), Ocotepec (36%, Grajales, 2015), and Francisco León (39%, Sánchez & López, 2016), which coincides with the 2010 information regarding that in our country, Chiapas ranks first in illiteracy in the population aged 15 years and older, with an average of 17.8% (INEGI, 2011).

Marginalization index indicators concerning education show that, at the national level, 8.3% of the population over 15 years of age is illiterate. In all marginalized and indigenous territories, the proportion of illiteracy for these ages doubles or triples. On the other hand, some factors prevent people from finishing elementary school, for example, the high opportunity cost that education represents for poor families, who see children as an additional workforce, or simply the lack of an adequate and complete educational offer. This has generated a higher dropout rate at the elementary level in municipalities and marginalized and indigenous localities. In this sense, in the national aggregate, 23.0% of people over 15 years of age who did not finish elementary school were recorded, in very high and high marginalization municipalities the proportions were 57.0 and 43.9%, respectively, while in very high and high marginalization localities the percentages are close to the average, and in indigenous municipalities, on the contrary, their proportion increases to 34.8% (SEDESOL, 2012).

The main source of income of those surveyed was agriculture (54.2%), those who practice it in subsistence whose main activity is the culture of corn, similarly 40.7% obtain their income from agriculture and livestock, while for 3.4% it was livestock.

Regarding land tenure, the majority (93.2%) own ejido land, 5.1% private land, and 1.7% rented land. On the other hand, 96.6% of producers in the seven ejidos plant corn under rainfed conditions, which are governed by climatic factors; however, 25.4% of them, distributed in six ejidos, also

plant corn under residual humidity, due to excess rainfall on their land, which means that they obtain two harvests per year. This means that in the municipality of Tecpatán there is a rainy season that begins in May and ends in February, with greater intensity and duration from May to August. In addition, from September to February there is a season known by the producers as "nortes" or "chipi chipi" during which the rains continue, although of less intensity and duration, however, this humidity allows them to establish a second culture season and obtain a second harvest. Excessive burning and deforestation have caused changes in rainfall patterns, resulting in prolonged periods of drought or severe flooding, causing crop losses, making rainfed farming the riskiest in production units.

76.3% of producers stated that they plant criollo corn, and 22.0% mentioned other names of hybrid corn and improved varieties, however, when asked where they obtained the seed, 35.6% indicated that they obtained it from the same ejido, the same harvest or that they bought it ten or more years ago, and 6.78% that they bought it from seed distributors, or people from other municipalities, but the highest frequency (57.6%) did not respond. This shows that all of them sow criollo seeds and although some corn still has their original names, they are now criollos because of the crossbreeding they have had with local maize and because the producers have selected from their harvest for the next sowing.

Thus, of the total number of producers who plant in rainfed crops, 78.0% do so in May and 20.3% in June, which is when the rainy season begins, and harvest variably from August to December, predominantly in September, October, and November. According to these data and the authors' field visits, it was observed that there are early, intermediate, and late corn, which are harvested in September (27.1%), October (23.7%), and November (32.2%), respectively. On the other hand, 25.4% of producers who make a second corn culture under residual moisture conditions did not indicate the respective planting and harvesting dates. This explains why this 25.4% of producers believe that the subsidies are not enough, since they have two crop cycles per year and the subsidies were labeled for one cycle per year.

100% of growers plant manually with a tiller or barreta. 91.5% sow at 100 cm between rows and also between sowing points, which results in 10,000 points per hectare. As they throw an average of four seeds per point, then there is a density of 40,000 seeds sown in a hectare. Assuming that both the commercial corn seed and the criollo seed sown by the producers have 85% germination, as guaranteed by the seed companies, this means that only 34,000 seedlings germinate from the amount of seed indicated, without counting those that are lost due to the action of other factors, therefore, the density of plants per hectare is low and consequently the productivity and production is also lower, compared to the places where a greater amount of

seeds are sown per hectare. Seed planting density ranged between 8 and 15 kg ha^{-1}, with 22.0% and 45.8% of producers planting an average of 10 and 15 kg ha^{-1}, respectively.

The total cost of cultural work

According to the opinion of the total producers, in 2014 the cost of culture labor varied widely between 1000 and 7920 pesos ha^{-1}, and the value of production between 2500 and 20,000 pesos ha^{-1}, as well as the value per ton of grain, was 5000 pesos. A cross-analysis of the first two variables showed that most of the producers obtained different profits. For example, 10.2% invested 5000 pesos ha^{-1} and obtained a grain production whose value was between 2500 and 20,000 pesos ha^{-1} and an average of 7833 pesos, as well as when 6.8% of producers invested between 4600 and 6500 pesos ha^{-1}, with an average of 5525 pesos, they obtained a production with a value of 7500 pesos ha^{-1}, which means that corn grain production was profitable for these producers. Undoubtedly, some producers did not obtain profits and with the value of the production the profit is lower concerning the investment, in this way, 27.1% who invested between 1000 and 7920 pesos ha^{-1} with an average of 4368 pesos, achieved a harvest with a value of 5000 pesos ha^{-1}. Others commented that they had losses in the harvest, either due to the damage of some climatic factors or the lack of fertilizers or some other cause that they do not know, however, they stated that they have to continue planting corn because the grain is of vital importance for their family's meals.

Weed control

To control weed problems, producers generally resort to chemical products, which can be applied at different stages of the culture, either pre-emergent or post-emergent (Ruiz *et al*., 2001). Note that the weeds mentioned by the growers were Zacate (35.6%), Monte Común (28.8%), as well as Monte y Zacate (10.2%), mainly, and 25.4% did not respond, which were controlled by different herbicides such as Gramoxone (45.8%), Faena (10.2%), and Esterón (8.5%), among others, with 6.8% not applying herbicides and 3.4% doing the cleaning manually with a machete. Of the total number of farmers, 39.0% said that they apply herbicides pre-emergent, and 44.1% separately, also post-emergent. In addition, they explained that few of them know or read the instructions of the agrochemicals they apply and do not know the names of the weeds, so they only said Monte, Monte Común, and Zacate.

Chemical and organic fertilizers

Regarding the application of fertilizers on a hectare of culture, 47.5% of producers use urea with quantities that varied from 15 kg to four bags of 50 kg each, highlighting 22.0% of them that apply two bags, and 13.6% that only apply one bag. On the other hand, 1.7% applied humus and another 1.7% applied humaíz, at a rate of 1 and 3 L ha^{-1}, respectively, however, 35.6% did not apply fertilizers, commenting that they did not have the economic resources for this product, and 8.5% did not respond.

In general, 54.2% of growers said that they apply fertilizer for the first time between 7 and 60 days after seedling emergence, with 50.8% of them applying it between 15 and 45 days after emergence, indicating that growers have different criteria for defining the time to apply fertilizer. Similarly, of those who make a second application, 5.1% said that they apply it when the culture is in the stage they call "parando punta", and 16.9% erroneously apply it during flowering.

Nitrogen fertilizers are recommended during corn culture growth; therefore, it was considered erroneous to apply them during the flowering stage, since at that stage the plants have already reached their maximum growth. Therefore, it is evident that producers require technical assistance, which considers both the amounts and types of fertilizers recommended, as well as the stages of the culture in which their application is more correct.

Pest and disease control

Like weeds, pests and diseases reduce crop production. Respondents stated that their culture was attacked by codling moths (84.7%), blind hen (55.9%), false cutworm (22.0%), bollworm (6.8%), armyworm (5.1%), and aphid (1.7%). In the case of the Cogollero, only 55.9% applied some products such as Foley (30.5%), Arrivo (22.2%), Gallito (1.7%), and Monitor (1.7%), where only 20.3% mentioned that they used the recommended doses. Now, for the Blind Hen, only 33.9% of producers applied Foley (16.9%), Arrivo (10.2%), both (3.4%), and Gallito (3.4%), but only 13.6% said they applied the recommended doses, although these products are not appropriate because they are contact products and the blind hen lives below the soil surface. In the case of the False Mealworm, 13.6% applied Arrivo (5.1%) Foley (5.1%) and both products (3.4%), however, only 3.4% of them indicated the recommended doses. For armyworm, Arrivo (1.7%) and Gallito (1.7%) were used, in armyworm Foley (1.7%) and aphid was not controlled. The data presented resulted from the cross-analysis of three variables (product × pest × dose ha^{-1}), as well as where there was a Pinta fly attack (16.9%) and other pests of lesser presence (6.8%). For the Pinta fly, Arrivo (3.4%)

and Foley (1.7%) were applied, where only 1.7% said they used the recommended dose. On the other hand, 3.4% controlled Ants with Foley without indicating the doses. In addition, the presence of three diseases identified by the producers as Ear Rot (1.7%), Fusarium (1.7%), and Asphalt Spot (1.7%) was observed, which were not controlled, except for Asphalt Spot in which the producer erroneously applied Arrivo, since it is an insecticide and the diseases are controlled with fungicides. In any case, in this municipality, corn crop diseases are not economically important, or possibly the producers are not aware of them.

Harvest

94.9% of farmers indicated that they harvest the ears by hand, stating that this way they make better use of the grain, i.e. it is not wasted because all the ears are lifted, even if the plants are lying down. On the other hand, 91.5% do not bale the stubble, 3.4% do, and 5.1% did not respond. However, 23.7% stated that they put cattle in after harvest, the remaining 71.2% leave the residues on the field to reincorporate them or burn them, and 5.1% did not respond.

Grain productivity fluctuated between 0.5 and 4 t ha^{-1}, where the majority (44.1%) obtained between 1 and 2 t ha^{-1}, 39.0% between 0.5 and 0.9 t ha^{-1}, as well as 5.1% between 2.5 and 4 t ha^{-1}, with 27.1% of the total who only harvested 1 t ha^{-1}. According to 94.9% of producers, the price per ton of grain in 2014 was 5,000 pesos.

After harvesting, the risk to the grain continues, as there are always insects or fungi that feed on its contents. Thus, producers commented that the grain was damaged by weevils (50.8%) and house rats (5.1%). Therefore, they use various ways to store the grain for their own food, as well as the seed for planting the following year, among which they mentioned the troja, the plastic drum, the ixtle sacks, the cobs with or without *totomoxtle* in a room, the cobs tied by the *totomoxtle* to the beams of the houses, among others.

Commercialization

83.1% of producers said that they use the corn grain harvest to feed their families, 1.7% do the same and also sell it to private individuals, while 6.8% only use it to sell to private individuals. Evidently, in Tecpatán, Chiapas, subsistence agriculture is practiced, since the majority (78.0%) cultivate between 1 and 2 ha of corn, and also the majority (84.7%) use the grain to feed their families.

When producers obtain surpluses in their grain production, another problem arises, which is the lack of market or good prices for agricultural

products, as is often the case. In this sense, 39.0% said that buyers were satisfied with the quality of the grain they purchased, 57.6% said the opposite and 3.4% did not answer. On the other hand, 96.6% said that they do not belong to an organization that helps to market the harvest and that they did not receive the institutional support that exists for marketing the grain.

Financing

96.6% of producers did not receive bank credits to sustain their culture and/or use them at their service, both in 2014 and in previous years, neither did they receive credits from individuals nor did they sell the harvest in advance, as also stated by 100% of maize producers in the municipalities of San Fernando, Copainalá, Ocotepec and Coapilla, Chiapas (Sánchez & Sánchez, 2013, Posada & Domínguez, 2014, Grajales, 2015, Pérez & Hernández, 2016, respectively).

In addition to the official support that producers have, they received herbicides (3.4%) from SAGARPA, as well as fertilizers (10.2%) and spray pumps (1.7%) from the municipal Presidency. According to these results, it is convenient to manage credit and/or support programs that allow working the culture with greater scale and technology, in addition, some producers indicated that only *ejidatarios* benefit from institutional support because that is what the assembly decides.

Nature of institutional support

86.4% of corn producers said that they received support from Procampo spring-summer, 37.3% received support from Procampo fall-winter, and 1.7% received support from the state government's Maiz Solidario program. Likewise, 89.8% of the total commented that they have received the same support during 2012, 2013, and 2014, 6.8% said no, and 3.4% did not respond.

In general, in separate percentages, producers thought that such support has been used by them in expenses for various activities in their culture such as seed purchase (13.6%), sowing (88.1%), herbicides and application (62.7%), fertilizers, and application (47.5%), pest (39.0%) and disease control (11.9%), harvest (78.0%), and grain hauling (18.6%). The trend of this information coincides with that obtained in the municipalities of San Fernando (Sánchez & Sánchez, 2013) and Copainalá (Posada & Domínguez, 2014), except that in San Fernando the majority (59.1%) carry out tracking because it has more flat land, which allows the passage of agricultural machinery.

In addition, the majority of producers stated that the support arrived on time (61.0%), complete (83.1%), without favoritism (94.9%) and without conditions (94.9%), while a minority responded that it was untimely (32.2%),

incomplete (10.0%), with favoritism (8.9%) and conditional (1.1%). This shows that there is no official supervision in the delivery and support management, nor in the land tenure and exploitation of the corn culture by registered producers.

Productive impact

84.7% of the farmers are interested in growing other corn varieties and 11.9% said no, perhaps because they do not want to discard the varieties they have been planting, which indicates that these farmers plant the varieties that have worked well for them or those that are best adapted to the climate of their municipality. Thus, those interested lean their preference for Asgrow (3.4%), Pioneer (52.5%), Cargill (5.1%), Tacsa (5.1%), and Criollo (6.8%) corn, in addition, others said Chaparra (1.7%), Tuxpeño (1.7%), yellow corn (1.7%) and the best variety (30.5%),

Similarly, the corn characteristics that farmers would prefer to grow are corn for grain (67.8%), with plants of intermediate size (64.4%), producing two (37.3%) and two or more ears (44.1%), with covered tops (84.7%), and white grain (83.1%). This preference shows that producers have some experience in the characteristics related to better productivity and production, prevention of damage caused by wind, insects, and fungi that attack the grain, as well as the taste for the flavor of the white grain, since this cereal is for self-consumption.

When asked "which crop management practice is most beneficial to production", 62.7% of producers said that "all tillage" benefits the crop, with 5.1% of them saying "all on time", and the rest said other practices, with "cleaning" (10.2%) and "fertilization" (8.5%) standing out, even though the importance of each practice during the crop season was previously explained to all respondents, showing that they have not received technical assistance related to the management of the crop.

These results coincide with those obtained by Domínguez *et al*. (2001) in Villacorzo, Chiapas where 60% of corn and sorghum producers stated that "all activities performed on time" improve production, likewise, 46.2 and 65.6% of respondents in San Fernando (Sánchez & Sánchez, 2013) and Copainalá (Posada & Domínguez, 2014), respectively, stated that "all labors" benefit corn crop production.

Social impact

Referring to the work carried out in the culture, 44.1% of producers mentioned that they used family labor, 35.6% family and hired labor, and the remaining 16.9% only hired labor. In the case of the producers' family

members, they stated that their family improved their way of life (78.0%), their food (86.4%), and their clothing (67.8%), while for the families of the hired people, the same respondents indicated that they also improved their way of life (42.4%), their food (45.8%) and their clothing (32.2%). In these six cases, the proportion of respondents missing to complete 100% of each variable denied that they had had improvements or did not respond. From the differences observed between the pairs of improvement proportions of producers vs. hired personnel, it is inferred that producers are more benefited than hired workers.

On the other hand, the producers said that other people in the community have not copied the new culture practices (81.4%), the organization of the community has improved (72.9%), they have noticed benefits with the support (59.3%), the support has not caused differences among them (86.4%), nor has the use of the support been supervised (83.1%), they do not belong to a producers' organization (94.9%), nor do they participate in a group that has a savings fund (94.9%). In this regard, it is necessary to motivate and promote the formation of corn producers' organizations, whose objectives are to manage support for their culture and also to be in a position to receive professional technical assistance, to achieve a field with greater productivity, and commercial efficiency.

Environmental impact

Producers carry out work to conserve their land, for example, by leaving or incorporating stubble (30.5%), as well as preventing erosion and planting trees (5.1%). However, 18.6% do not know how to do it, and 47.7% did not answer, so it is considered that they are not interested in conserving or improving the soil where they grow corn.

88.1% of farmers mentioned that the area under corn cultivation has not increased, and 6.8% said that it has. Likewise, 57.6% said that their soil has eroded, and 39.0% said that it has not, and 96.6% said that they have not performed soil analysis, possibly because they do not know how useful this study is. Technical assistance is essential to improve the work and consequently the productivity and production of the culture, however, 94.9% stated that the plant health board does not supervise their culture, so 86.4% consider that this institution does not work. Therefore, 79.7% indicated that they do not follow the recommendations for the application of chemical products, 15.3% that they do, and 5.1% do not apply or did not answer. On the other hand, 84.7% do not know if due to the low price of corn grain any producer no longer planted it, in 2013, or has changed the culture, only 10.2% answered yes between 2000 and 2012, because they did not have institutional support.

Regarding corn cob residues, 20.3% of producers use them as livestock feed, 8.5% leave them on the plot to fertilize the soil, 5.1% use them for tamales or as fuel, 32.2% burn or discard them, 20.3% do not use them, and 13.6% did not respond. In all forms, except burning and discarding, the use that producers give to *totomoxtle* and *olote*, generates other direct or indirect income that has not been considered within the profits of the culture.

The production systems are defined as the various ways in which the land is exploited, so 66.1% of farmers grow corn associated with beans, so they also obtain an additional income to grain production, while 30.5% only grow corn as a single crop. In this case, the proportions observed are similar to those presented by the diagnosis of corn culture in the municipality of San Fernando (Sánchez & Sánchez, 2013) and Copainalá (Posada & Domínguez, 2014), reaffirming that the predominant production system in the Mezcalapa region, Chiapas, corresponds to corn associated with beans (León-Velasco, 2016).

Respondents carried out work in 2014 to improve corn productivity and production, including cornfield improvement (23.7%), land preparation (25.4%), the reincorporation of crop residues (20.3%), planting of live barriers (8.5%), the use of contour lines on the land (5.1%), and irrigation of cattle or poultry manure to improve the soil (3.4%); in contrast, no terraces are laid out on the land (93.2%), nor are surface water detour canals built (94.9%). It was observed that few people carry out some practices to conserve their land for culture in the municipality of Tecpatán, Chiapas, which could be improved through organization, training, and technical assistance.

Technological impact

According to the opinion of the respondents, the results of the improved seed were good (35.6%), regular (32.2%), and bad (10.2%). There was no timely pest control (72.9%), the crops are not in better condition (88.1%), the support did not allow changing cultivation techniques (79.7%), the crops are not more uniform (83.1%), and the quality of the corn produced (84.7%), the facilities (91.5%), and the equipment (94.9%) did not improve. In general, it can be seen that producers have not improved their culture because they have no guidance or training, as well as no commercial interest in their crop. Only 18.6% of those surveyed acquired some tools to use in their work, such as backpack pumps and machetes. The 42.4% said that they need to acquire a series of tools, especially backpack pumps, machetes, hoes, and wheelbarrows, which they plan to acquire when they have money (18.6%), or there is some government support (15.3%), and 8.5% do not know how or when to acquire them.

Factors that influenced the impact

Concerning the variables that influenced the technological impact, the respondents indicated that they cooperate in common tasks (76.3%) and were not prepared to receive the support (55.9%), there was no training before the delivery of the support since the support arrived the technician does not show up to train them (86.4%), the suppliers have not complied with the requested material (81.4%), and there was no advice in the care of the support (91.5%). The 76.3% of producers who cooperate in the common tasks of the population stand out, however, they do not do it for other tasks related to their culture, and such community cooperation could also be used to initiate the organization that allows the better development of their main source of income.

Now, the highest frequency (45.8%) of respondents indicated having had losses in their culture, between 20 and 100% due to strong winds, likewise, 15.3% between 30 and 75% due to strong rains and winds, 13.6% between 50 and 100% due to drought and heat, although 30.5% denied having had losses. The effect of environmental factors cannot be controlled, but they can be prevented with better management of the cultures, for example, varying planting dates, planting early, intermediate or late varieties, depending on the case, with different plant heights, respectively, among others (León-Velasco, 2016).

Complementary service needs

Once the objectives of this research have been raised to the respondents, it has awakened in them the need to include the use of technical assistance as one more working tool in the production systems, in this way, there was an average of 85.2% who are willing to receive technical assistance for the activities carried out in their culture, but only 33.9% of that amount are willing to pay for it, as long as there is a guarantee of higher production, as also expressed by the Chiapas producers of Villacorzo 68% (Domínguez *et al*., 2001), Tapachula 71.8% (Ruiz *et al*., 2001), San Fernando 25.4% (Sánchez & Sánchez, 2013), Copainalá 14.4% (Posada & Domínguez, 2014), Ocotepec 12%, (Grajales, 2015), Mezcalapa 22%, (León & León, 2015), Coapilla 11.9%, (Pérez & Hernández, 2016) and Francisco León 6.1%, (Sánchez & López, 2016).

Of the 61.0% of Tecpatán producers who are not willing to pay for these services, some said that: the service is expensive, it does not work, they do not have enough money to pay, they are of low resources, and finally others because they consider that the government should provide them for free.

CONCLUSIONS

In the municipality of Tecpatán, Chiapas, 79.7% of the farmers are between 41 and 70 years old. 54.2% finished elementary school, 16.9% between 1st and 3rd grade, 10.2% finished middle school, 1.7% finished high school, 1.7% have a degree, and 15.3% are illiterate. 42.4% farm 1 ha, 10.2% 1.5 ha, 25.4% 2 ha and 10.2% between 2.5 and 5 ha. The source of income is agriculture (54.2%), and 40.7% is obtained from agriculture and livestock. 93.2% own *ejido* land, 5.1% private land, and 1.7% rented land. 100% of them manually plant *criollo* corn in rainfed conditions, and 25% of them also plant in residual humidity. 91.5% sow at 100 cm between furrows and between points, with four seeds per point. 39% controlled pre-emergent weeds, 44% controlled post-emergent weeds separately, and 10% did it manually. There was an attack of codling moth (85%) and, separately, blind chicken worm (56%). 48% of producers apply between 15 and 200 kg ha^{-1} of urea.

36% of growers indicated that the culture is profitable. 85% use the grain for self-consumption. 58% have eroded soil and do not analyze it (97%) nor improve it (68%), and 31% leave the stubble. The production systems in the municipality are: monoculture corn (31%) and associated with beans (66%). Respondents cooperate in common tasks (76.3%) and were not prepared to receive support (55.9%), there was no training before the delivery of support (79.7%) since the support arrived the technician does not show up to train them (86.4%) and suppliers do not comply with the requested material (81.4%).

Finally, 85% of producers are interested in receiving technical assistance for all the activities of the culture, but only 34% of them are willing to pay for these services.

RECOMMENDATIONS

With the information presented, it is recommended to continue this research, which consists of elaborating an Integral Technical Assistance System for corn producers in the municipality of Tecpatán, Chiapas. It is necessary to apply this Integral Technical Assistance System in an interinstitutional and multidisciplinary way. It is suggested to update (at least biannually) the institutional lists of corn producers in the municipality of Tecpatán, Chiapas.

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