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CHARACTERIZATION OF CORN CULTIVATION IN THE MUNICIPALITY OF FRANCISCO LEÓN, CHIAPAS, MEXICO

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Abstract. Corn (*Zea mays* L.) is the staple food of the inhabitants of Francisco León. The purpose of this research was to determine the technical and socioeconomic factors that limit the advancement of corn cultivation and its growers in the municipality of Francisco León, Chiapas, Mexico. The town has 1109 producers, so the sample size was 33. In 2015, a survey of 116 questions related to the aforementioned factors was conducted. The frequencies of the particular variables were calculated, and several were associated, in pairs and/or triads, using SPSS software (2016). The results identified various factors that limit the development of the crop and its producers. Their ages range from 21 to 85. 39.4% are illiterate and 36.4% have only completed primary school; their main source of income is subsistence corn farming (78.8%), on communal land (57.6%) and communal land (21.2%); 100% plant native corn manually during the rainy season; 48.4% of them plant 40,000 seeds ha^{-1} 87.8% apply herbicides for weeds; 51.5% apply one to eight bags $ha^{-1}$of urea and 45.5% do not apply any; there was damage from corn earworm (72.7%) and corn rootworm (60.6%) with timely control (18.2%) and untimely control (33.3%); no soil analysis is performed (100%) nor is the soil improved even though there was erosion (33.3%); the Plant Health Subdelegation does not function; the crop was profitable (39.4%), without financing (100%); 100% use the grain for self-consumption; support arrived incomplete (33.3%) and untimely (33.3%); 60.6% want new varieties; 15.2% indicated that all tasks benefit production; there was no community impact from support (60.6%); production systems consisted of single-crop maize (18.2%) and maize

associated with beans (81.8%); people do not cooperate in common tasks (48.4%); finally, 77.4% are willing to receive technical assistance for all crop activities, but only 6.1% are willing to pay. Therefore, it is suggested that a comprehensive technical assistance system be developed, which will be applied starting with three main variables: introducing improved varieties, as well as varying planting dates and plant population densities per hectare of corn on farmers' land, in collaboration with the City Council and technicians from different institutions and disciplines.

Keywords: *Zea mays*, factors, productivity, systems, farmers.

INTRODUCTION

Of all existing cereals, corn (*Zea mays* L.) ranks first in the world in terms of production volume, followed in descending order by wheat, rice, barley, and sorghum (SIAP, 2011; Orús, 2022). Among grain producers, Mexico ranked eighth in average production from 2014 to 2023 with 26.741 million tons, which varied from 23.273 to 28.251, behind the United States, China, Brazil, the European Union, Argentina, Ukraine, and India; despite ranking ninth in yield with an average of 3.8 t ha^{-1}.However, it was the second largest importer, with an average of 16 million tons per year, both averages for the same period (SIAP, 2023; FIRA, 2024).

Mexico has two main agricultural techniques: (1) subsistence farming, associated with smallholdings, rooted in the massive use of rural parental labor, whose preference is to supply themselves with corn for consumption during the year and sell the surplus, with the State of Mexico, Guerrero, and Oaxaca standing out with this system; and (2) production for trade, characterized by intensive use of capital and improved seeds, advanced technology, and integration into markets, with the states of Sinaloa, Jalisco, Michoacán, and the State of Mexico standing out (SADER, 2020). A high percentage of the rural population depends on corn production, where the crop is grown from the most backward seasonal production which yields 0.7 t ha^{-1} to irrigation systems, with improved and fertilized seeds that can yield 12 to 14 t ha^{-1} (Vega and Ramírez, 2004).

In 2023, Chiapas produced 1,327,894.58 tons of grain, 69.92% of which was obtained in four economic regions led by the municipalities of Tuxtla Gutiérrez (20.51%), Comitán (17.43%), Villaflores (16.99%), and Palenque (14.99%) (SIAP, 2023). This is attributed to improved seeds and good crop management, given that most of the 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 engage in agricultural, livestock, and forestry activities with very limited land and capital, resulting in smallholdings and extreme poverty (Parra and Díaz, 1997), which intensifies problems of soil fertility and fertilizer use to maintain corn production (Álvarez-Solís and Anzueto-Martínez, 2004), which amounts to 102,737.97 tons (SIAP, 2023). The increase in productivity achieved by introducing industrialized inputs represents high costs and low profitability in areas of dryland farming on slopes. The agricultural harvest in Los Altos de Chiapas faces erosion and declining soil fertility, decreasing yields,

declining labor productivity, and a growing inability to employ relatives and provide the essential ingredients for their maintenance. This is the result of excessive pressure on the land, rugged topography, fragmentation and dispersion of plots, as well as high risk of disaster due to weather conditions and the artisanal nature of production techniques (Pool-Novelo *et al.*, 2000). Adjacent to Los Altos de Chiapas lies the "Mezcalapa Region III," which is also mountainous and comprises nine municipalities with 13,484 corn producers registered in the support programs of the Production for Welfare Program (PpB), Solidarity Corn, Corn and Bean Program (PROMAF), and Corn for Self-Consumption, whose harvested area in 2023 was 19,593.0 ha, with a production of 31,782.33 tons of grain and an average yield of 1.60 t ha^{-1} (SIAP, 2023); However, these programs are not promoted or supervised; in other words, technical assistance is not provided, so it is not known how this support is used or what its impact is on improving the crop and its producers.

This requires the generation and/or transfer of technologies based on the results of a diagnosis that identifies the edaphic, climatic, biological, socioeconomic, management, or other problems that limit the productivity and production of corn in Region III Mezcalapa, Chiapas, in the particular case of the municipality of Francisco León, and thus be able to develop a Comprehensive Technical Assistance System for corn producers in that municipality, which was chosen because it has 82.84% of the population being indigenous, 98.14% of the population being rural, 32.47% living in extreme poverty, 54.04% living in moderate poverty, and a very high degree of marginalization (GEC, 2013; SB, 2022). Therefore, the objective of this research was to identify the technological and socioeconomic factors that hinder the development of corn cultivation and its producers in the municipality of Francisco León, Chiapas.

MATERIALS AND METHODS

Study site

Francisco León is located in the mountain ranges of northern Chiapas, between parallels 17º 19" North Latitude and meridians 93º 15" West Longitude. It has 7245 inhabitants, a warm, humid climate with rainfall throughout the year, an altitude of 827 m, an average annual temperature of 24 to 26°C, and average annual precipitation of 3000 to 4000 mm (INEGI, 2021).

Information gathering

Information was obtained from institutions in the agricultural sector. The 2012 Producer Registers were provided (during direct visits to offices) by: Agricultural Marketing Support and Services (ASERCA); Ministry of Agriculture and Rural Development (SADER); Ministry of Agriculture (SECAM); and Shared Risk Trust (FIRCO); which joined forces to facilitate the location of producers.

Sample calculation

Considering that the complete study of the Mezcalapa Region, Chiapas, contained nine municipalities with a population of 13,484 corn producers, it was decided to conduct a stratified random sampling ($p \leq 0.05$); with a sample size of 391 producers, distributed proportionally across the

nine municipalities as they contain different numbers of producers (Table 1), calculated using the "stratified random sampling" method, by municipality, which is the most accurate and reliable, using the formula by Scheaffer *et al.* (2004):

In the case of Francisco León, the population studied consisted of 1109 producers, so the random sample size was 33 producers (Table 1); this sample represents the population and was calculated with 95% reliability in the results.

Approximate sample size required to estimate p with a B limit for the estimation error:

$$n = \frac{\sum N_i^2 p_i q_i / w_i}{N^2 D + \sum N_i p_i q_i}, \quad \text{where} \quad D = \frac{B^2}{4}$$

n = Sample size.

N = Population size.

p = Probability of success (0.5).

q = (1 - p) = Probability of failure (1 - 0.5 = 0.5).

B = Limit for estimation error.

w_i = Proportional part, ratio of municipality to population.

N_i = Particular stratum.

Surveys

After preliminary trials, the survey administered to farmers in early 2015 consisted of 116 questions divided into 16 sections: general data, planting systems, cost of cultivation, weed control, pests and diseases, fertilization, harvesting, trade, financing, institutional support, productive, community, ecological, and technical impact, as well as agents associated with impacts and needs for complementary services. Before collecting the data, the project was presented to the authorities and their authorization was requested to visit their territory and carry out the fieldwork . Subsequently, the producers were surveyed at their homes by a team of four thesis surveyors for security reasons. To triangulate the data, interviews were conducted with the leaders of the organizations involved.

Data review

Field data was collected electronically for evaluation and subsequent interpretation. The frequencies of individual variables were calculated, and some were correlated in pairs and/or triads using the Statistical Package for the Social Sciences (SPSS, 2016).

RESULTS AND DISCUSSION

The survey was administered to a random sample of 33 farmers, representing the universe of 1109 corn growers in the municipality of Francisco León. Thus, one farmer equals 3% of the sample, a percentage that in turn represents 33.61 farmers in the universe.

General data

All respondents were located in the ejidos: Francisco León, Río Negro, Azapac Amatal, Viejo Naranjo, Miguel La Sardina, Guadalupe Sardina, San Miguel La Sardina, San José Maspac, and Las Cruces. The area cultivated with corn per producer ranges from 0.5 to 5 ha, with 39.4% having 1 ha;

Municipality	ASERCA 2011 PpB OI[1]	ASERCA 2012 PpB PV[2]	SECAM 2012 Solidarity Corn	FIRCO 2012 PROMAF	SADER 2011 Corn for Self-Consumption	Population	Sample
Chicoasén		250	67		45	362	11
Coapilla		636	282		1114	2032	59
Copainalá	56	641	622	11	1786	3116	90
Francisco León	335	234	81		459	**1109**	33
Mezcalapa	113	377	441		665	1596	46
Ocotepec	106	346			241	693	20
Osumacinta		171	161		98	430	13
San Fernando	140	892	733	53	575	2393	69
Tecpatán	268	613	530	9	333	1753	51
Total	1018	4160	2917	73	5316	**13,484**	**391**
Percentage	7.55	30.85	21.63	0.54	39.42	**99.99**	

[1] AW= Autumn-Winter; [2] SS= Spring-Summer.

Table 1. Population and sample of corn growers in the nine municipalities of Region III Mezcalapa, Chiapas.

Age (years)	Education					Total
	No education	Incomplete primary education	Primary	Secondary	Does not know	
21-25				1		1
26-30			1			1
31-35						
36-40	2	1	4			7
41-45		2	1			3
46-50			1			1
51-55				1		1
56-60	1		3		1	5
61-65	2	1	1			4
66-70	2					2
71-75	4		1			5
75-80	1					1
81-85	1					1
Don't know					1	1
Total	13	4	12	2	2	33

Table 2. Age and educational level of corn producers in Francisco León, Chiapas.

30.3% having 2 ha; 12.1% having 1.5 ha; 3% having 0.5 ha; 12.1% having 3 to 5 ha; and 3% not responding. The age of all producers ranges from 21 to 85 years, as well as between 10 and 63 years of experience; 39.4% are illiterate; 36.4% completed primary school; 12.1% completed some grade of primary school; 6.1% completed secondary school; and 6.1% did not respond (Table 2). The illiteracy rate described is higher than that of producers in Ocotepec (36%; Grajales, 2015), Mezcalapa (28%; León and León, 2015), Chicoasén (27.3%; León-Velasco, 2016), San Fernando (26.8%; León-Velasco *et al.*, 2018a), Copainalá (21.1%; León-Velasco *et al.*, 2018b), Coapilla (20%; León-Velasco *et al.*, 2021b), Tecpatán (15.3%; León-Velasco *et al.*, 2021a), and Osumacinta (0.0%; León-Velasco, 2016). These complete the nine municipalities in the region studied, whose average illiteracy rate was 23.8%. According to 2010 data for Mexico, Chiapas ranked first in illiteracy among the population aged 15 and over, with an average of 17.8% (INEGI, 2014); t still ranks first in 2020, with an illiteracy rate of 13.7% among the population aged 15 and over and 48.12% who have not completed basic education (SH, 2021).

The main source of livelihood for farmers is agriculture (78.8%), as well as a combination of agriculture and livestock (18.2%), whose main activity is growing subsistence corn. 57.6% have ejido land, 21.2% communal land, 12.1% rented land, and 6.1% private land. One hundred percent grow corn during the rainy season, and 42.4% of them do so using residual moisture. This means that in the municipality of Francisco León, it rains all year round (INEGI, 2021), allowing for two harvests per year.

Planting systems

87.9% of producers plant native corn, 6.1% plant hybrid corn, 3% plant improved corn, and 3% did not respond. In this regard, 60.6% said they obtained the seed from the ejido, their harvest (24.2%), nearby ejidos (12.1%), and 3% did not respond (Table 3). They also commented that they have been growing the same seed for between 10 and 30 years, which shows that they all grow native varieties, and although some varieties retain their original name, according to León-Velasco (2016) they are now native varieties due to their crossbreeding with local corn.

Thus, of the total planted during the rainy season, 66.7% is planted in February, when the rains begin, and 30.3% from May to January. Harvesting takes place from April to November, with 81.8% occurring from July to November. According to these data and the surveys carried out, three types of corn maturity were observed, which are harvested from January to June (15.2%), July (45.4%), and August to November (36.4%), respectively. Similarly, 42.4% plant in residual moisture in August and December, to harvest in January and July, respectively. This explains why they believe that the benefit is insufficient, since they have two crop cycles per year and the aid was earmarked for one per year; a similar opinion is held by 25.4% of producers who plant in residual moisture in Tecpatán, Chiapas (León-Velasco *et al.*, 2021a).

All farmers sow manually using a hoe (78.8%) and a pickaxe (21.2%). The majority (48.4%) plant the seeds 100 cm apart between rows and equally between planted holes (Table 4), with an average of four seeds per hole, planting 40,000 seeds per hectare;

Name	Origin							Total
	Local	Harvest	Chapul Tenango	Madero	Tecpatán	Viejo Naranjo	Doesn't know	
Creole	11	8	1	1				21
Bacalillo	1							1
Quechulteco	1					1		2
White Corn	3							3
Tall Corn	2							2
Hybrid	2							2
Improved					1			1
Don't know							1	1
Total	20	8	1	1	1	1	1	33

Table 3. Origin of corn varieties grown by producers.

Between rows (cm)	**Between holes** (cm)							**Total**
	50	**60**	**80**	**90**	**100**	**130**	**Don't know**	
50	1							1
60		1						1
80			3					3
90				1				1
100		1	1		16	1	5	24
120					1			1
130						1		1
Don't know							1	1
Total	1	2	4	1	17	2	6	33

Table 4. Distance between furrows and between holes where seeds are deposited in the ground.

as in the municipalities of Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), and Tecpatán (León-Velasco *et al.*, 2021a), Chiapas. Commercial and native corn seeds have an 85% germination rate, as guaranteed by seed companies, which means that only 34,000 seeds germinate, not counting those lost due to other factors; Therefore, the density of plants per hectare is low, as are productivity and production, compared to other places where a greater quantity of seed is sown per hectare, similar to what occurs in the municipalities of San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), Coapilla (León-Velasco *et al.*, 2021a), and Tecpatán (León-Velasco *et al.*, 2021a), Chiapas. Additionally, 24.2% of farmers use more than 10,000 holes per hectare, 9.1% use fewer, and 18.2% did not respond (Table 4). On the other hand, 81.8% stated that they sow between 9 and 20 kg ha$^{(-1)}$ of seed and 18.2% did not respond; notably, 9.1%, 45.4%, and 9.1% of them spread an average of 10, 12, and 15 kg ha^{-1},respectively, confirming the low amount of seed sown per hectare; Similar average densities are used in the municipalities of Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), and Tecpatán (León-Velasco *et al.*, 2021a).

Cost of cultural activities

According to 100% of farmers, in 2014, the cost of production for tilling the plantation ranged from 1000 to 4500 MXN ha^{-1} , the value of the harvest from 500 to 15000 MXN ha^{-1} and a ton of grain sold for MXN 5000. The correlation between the first two variables showed contrasting differences; for example, the 15.2% who invested MXN 3000 ha^{-1} had a harvest worth between MXN 2500 and MXN 7500 ha^{-1} , with an average of MXN 4200; Similarly, when 24.2% of farmers invested between 1600 and 4500 MXN ha^{-1} with an average of 3179 MXN, they achieved an income of 5000 MXN ha^{-1} ;all of which indicates a profitable grain harvest for all of them; profitability also manifested by 17, 25.2, 25.5, 26.7, and 34% of producers in the municipalities of Tecpatán, San Fernando, Coapinalá, Coapilla, and Mezcalapa, Chiapas, respectively (León-Velasco, 2016). Some farmers did not make a profit, as the harvest barely covered their investment; thus, the 18.2% who invested between 2000 and 4000 MXN ha^{-1} and an average of 3033 MXN, achieved a harvest valued at 2500 MXN ha^{-1} .Others suffered losses due to weather conditions, lack of fertilizers, or other causes; nevertheless, they continue to plant corn as it is their main food source.

Weed control

Weeds are a factor that reduces corn yields in the state. Climate and soil conditions favor their growth and allow them to compete with an advantage to the detriment of crops. Weed control refers to all practices, measures, tools, and products that limit weed infestation to such an extent that it does not affect or interfere economically with crop production (Cadena *et al.*, 2009). To control weeds, producers generally use chemicals. The main weeds mentioned by respondents were: *Cenchrus echinatus* L. (27.3%), *Leptochloa filiformis* and *Echinochloa crusgalli* (18.2%), *Leptochloa filiformis* (9.1%), *Ipomea tilleaceae* (9.1%), General (6.1%), Mata Monte (3%), and 27.3% did not know; those that were controlled

with Paraquat (45.4%) and Glyphosate (9.1%), among others (33.3%), 6.1% do manual weeding, and 6.1% did not answer (Table 5). Thirty-three percent apply pre-emergent herbicides and 69.7% did not respond; 63.6% apply postemergent herbicides and 36.4% did not respond. In addition, they explained that few know the formulas of the chemicals they use and are unaware of the names of weeds. The same was explained by producers in Ocotepec (Grajales, 2015), Mezcalapa (León y León, 2015), San Fernando (León-Velasco *et al.,* 2018a), Copainalá (León-Velasco *et al.*, 2018b), and Tecpatán (León-Velasco *et al.*, 2021a), Chiapas.

Fertilization

Regarding fertilizer application per hectare, 51.5% of farmers use between one and eight 50-kg bags of urea (46-00-00 N); 21.2%, 9.1%, and 6.1% apply two, three, and four bags, respectively; 3% used two bags of 17-17-17, and 3% applied 5 L ha-^{1} of Bayfolan Forte; while 15.2% do not apply fertilizers due to lack of resources, and 27.3% did not respond, mentioning that they do not have resources for fertilizers (Table 6). In general, 30.3% make the first application of urea 30 days after sowing; 3% at 15 days; 12.1% at 40 to 50 days; and 54.5% did not respond. Three percent apply urea for the second time 45 days after planting; 3% do so 60 days after planting; 3% do so at the stage known as "parando punta" or (appearance of the visible flag leaf); 3% do so at the flowering stage 17-17-17; and 87.9% did not respond. Urea is recommended to accelerate crop growth. In this sense, the first application between 40 and 50 days, as well as the second at 60 days and flowering, is a mistake, since in these last two stages the plants have already reached their height limit. Clearly, farmers need recommendations on fertilizers, as well as the correct amounts and stages of application. INIFAP has published a technology package with a fertilization dose of 120 kg of nitrogen and 70 kg of phosphorus per hectare for the central region of Chiapas (Cadena *et al.*, 2009).

Pest and disease control

Separately, respondents reported damage from fall armyworm (*Spodoptera frugiperda*) (72.7%), cutworm (*Phyllophaga* spp.) (60.6%), armyworm (*Spodoptera exigua*) (6%), (*Trichoplusia ni* Hübner) (3%), and Pinta fly (*Euxesta stigmatias)* (3%) (Table 7). For fall armyworm, Arrivo Cypermethrin (36.4%), Foley Parathion Methyl (30.3%), and Karate Lamda Cyhalothrin (3%) were applied, with only 36.4% using the correct dosage. For Gallina Ciega, Arrivo Cypermethrin (21.2%), Foley Methyl Parathion (30.3%), Foley Arrivo Methyl Parathion + Cypermethrin (3%) and Faena Glyphosate (3%) were applied, but only 33.3% used the correct doses, although Faena Glyphosate is not appropriate as it is a herbicide. For the armyworm, Arrivo Cypermethrin (3%) and Foley Methyl Parathion (3%) were applied; and in the case of the leafroller, Foley Methyl Parathion (3%) and the spotted wing drosophila, Foley Arrivo Methyl Parathion + Cypermethrin (3%) were applied. This information was obtained from triads of variables; similarly, farmers reported the presence of diseases (Table 8) identified as asphalt spot (9.1%) and smut (3%) (both are the same disease, caused by the synergy of three fungi: *Phyllachora maydis* Maubl., *Monographella* maydis Muller and Samuels, and *Coniothyrium phyllachorae* Maubl.; Merino

Product	Weed							Total
	General	Broadleaf	Bush	Weed	Grass	Grass Bush	Does not know	
Esterón	1							1
Faena				1		1		2
Gramoxil					1			1
Gramoxone		3		4	1	4	3	15
Paraquat				1	1			2
Sanfosate	1			1		1		3
Tordón			1	1				2
Foley							2	2
Not applicable							2	2
Don't know				1			2	3
Total	2	3	1	9	3	6	9	33

Table 5. Weed control carried out by producers in corn cultivation.

Product	Bags ha^{-1}								L ha^{-1}		Total
	1	1.5	2	3	4	5	6	8	5	Don't know	
Urea	1	1	7	3	2	1	1	1			17
Bayfolan									1		1
Not applicable										5	5
Don't know										10	10
Total	1	1	7	3	2	2	1	1		15	33

Table 6. Fertilizer products and doses applied to corn crops.

Product	Pest				
	Corn earworm	Stalk borer	Cutworm	Measurer	Spotted Wing Drosophila
Arrivo	7	12	1		
Foley	10	9	1	1	
Foley Arrival	1				1
Karate		1			
Methyl		1			
Work	1				
Not applicable	1	1			
Subtotal	20	24	2	1	1
No response	13	9	31	32	32
Total	33	33	33	33	33

Table 7. Pest control carried out by producers in corn cultivation.

Product	Disease					Total
	Asphalt spot	Scorch	Leaf spots	Unknown	No response	
Foley			1	1		2
Not applicable	2					2
Don't know	1	1			27	29
Total	3	1	1	1	27	33

Table 8. Disease control measures implemented by producers in corn cultivation.

et al., 2008), Leaf Spot Brown Spot *Physoderma maydis* (3%), and Unknown Disease (3%). The first two were not controlled, and for the latter two, Foley Methyl Parathion was applied inappropriately, as the diseases are controlled with fungicides. It is observed that in this territory, corn diseases are not serious, or perhaps the farmers are unaware of them.

Harvest

All producers harvest the corn cobs manually. 15.2% pack the stubble; 39.4% graze livestock and 45.4% burn the stubble. Grain yield fluctuated between 0.10 and 3 t ha-^{1} with 54.5% harvesting only between 0.50 and 1.0 t ha^{-1}(Table 9). This low yield is similar to that of the other eight municipalities in the region studied, whose municipal average yield according to SIAP (2015) was 1.23 t ha^{-1}.It is confirmed that a high percentage of the rural population depends on corn cultivation, where the latest seasonal production is grown, obtaining yields of 0.7 t ha-^{1}(Vega and Ramírez, 2004). On the other hand, some reported damage to the grain by weevil (*Sitophilus zeamais* Motschulski) (12.1%), weevil (*Sitophilus zeamais* Motschulski) and moth (*Sitotroga cerealella* Oliver) (6%), weevil (*Sitophilus zeamais* Motschulski) and common rat (*Rattus norvegicus* Berkenhout) (3%), as well as fungi (*Aspergillus* spp.) (3%). For this reason, they store grain for food and seeds for planting in the next cycle in granaries, hard plastic containers, ixtle sacks, whole or defoliated corn cobs on the floor of their storage rooms, or tied by the joloche to the beams of their houses.

Trade

81.8% of respondents use the grain for self-consumption, while 18.2% did not respond (Table 9). 69.7% do not sell the fodder and 30.3% did not respond. When producers obtain surpluses, there is an unforeseen variation in the prices of products without a guaranteed price (Volke, 1986). In this regard, 51.5% said that the buyer was satisfied with the grain, 27.3% said no, and 21.2% did not respond. In addition, 100% are not aware of a corporation that favors the negotiation of production, and have not received the benefit labeled for official grain sales.

Financing

100% of producers did not receive credit for their crops in 2014 and earlier, nor did they sell their harvest in advance, as reported by 100% of corn producers in the municipalities of Ocotepec (Grajales, 2015), Mezcalapa (León and León, 2015), Osumacinta (León-Velasco, 2016), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), Coapilla (León-Velasco *et al.*, 2021b), and Tecpatán (León-Velasco *et al.*, 2021a), Chiapas. In subsistence agriculture, it is common for farmers to work with their own money and without agricultural insurance (Volke, l986). In addition to official support (Table 1), 33.3% did not receive support from SADER, SECAM, or the Municipal Presidency, and 66.7% did not respond; however, 15.3% of Tecpatán did receive support from SADER and the Municipal Presidency (León-Velasco *et al.*, 2021a). Some producers said that only ejido members are entitled to institutional benefits, as dictated by the assembly; the same was said by producers in the municipalities of Ocotepec (Grajales,

2015), Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.*, 2021a), Copainalá (León-Velasco *et al.*, 2021b), Tecpatán (León-Velasco *et al.*, 2021a), and Coapilla (León-Velasco *et al.*, 2021b), Chiapas. Therefore, it is advisable to make proposals that also benefit these neighboring producers.

Institutional aid

18.2% of respondents received assistance from the PpB during the spring-summer agricultural cycle, 51.5% did not, and 30.3% did not respond; while 15.2% admitted to receiving benefits during the fall-winter cycle, 48.5% did not, and 36.4% did not respond. On the other hand, 21.2% of the total said they had the same support in 2014 and before, 39.4% did not, and 39.4% did not respond. The negative opinion about the spring-summer PpB is questionable, as their names are on the producer registers. In separate proportions, respondents said that these resources were used for plowing (9.1%), harrowing (9.1%), seeds (15.2%), planting (27.3%), herbicides (18.2%), fertilizers (21.2%), pest control (18.2%) and disease control (15.2%), harvesting (27.3%), sacks (6.1%), and grain transport (12.1%). The trend in this information is consistent with that obtained in Ocotepec (Grajales, 2015), Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), Coapilla (León-Velasco *et al.*, 2021b), and Tecpatán (León-Velasco *et al.*, 2021a), except that in San Fernando, 59.1% of respondents perform harrowing because they have more flat land that allows for the use of agricultural machinery. On the other hand, they were given incomplete (33.3%), untimely (33.3%), unbiased (48.5%), and unconditional (48.5%) support; although the minority responded that it was complete (27.3%), timely (24.2%), with favoritism (12.1%) and conditional (12.1%); in each pair of opposing variables, 39.4%, 42.4%, 39.4% and 39.4%, respectively, did not respond (Table 10). Evidently, there was no supervision of the donation and use of supplies, nor of land ownership and crop planting, for the supported farmers.

Productive impact

60.6% of farmers are interested in new corn varieties; 33.3% said no, because they do not want to discard the ones they have been growing, indicating that they plant the ones best suited to their locality, and 6.1% did not respond. Separately, they favored corn from the transnational companies Asgrow (12.1%), Pioneer (30.3%), Dekalb (21.2%), and Cargill (12.1%), as well as the national companies Proase (6.1%) and Tacsa (12.1%); Others mentioned Criollo (3%), Tuxpeño (3%), and adapted varieties (3%). The characteristics preferred by the majority are: corn for grain (45.4%), with plants of average appearance (33.3%), producing two or more ears (42.4%), with good coverage (57.6%) and white grain (54.5%) (Table 11). This preference indicates that farmers have experience with traits related to yield and damage prevention from wind, fungi, and insects, as well as a preference for the taste of white grain corn. On the other hand, 15.2% of producers believed that "all tasks" benefit production; 21.2% pointed to other practices, notably "fertilization"; 27.3% said none; and 36.4% did not respond (Table 12). This 15.2% is lower than that obtained in Ocotepec, Mezcalapa, San Fernando, Copainalá, Coapilla, and Tecpatán, Chiapas, where an average of 57.4% of

Yield ($t\ ha^{-1}$)	Use of grain		Total
	Self-consumption	No response	
0.10	1		1
0.25		1	1
0.50	6		6
0.70	2	1	3
0.90	1		1
1.0	6	2	8
1.2	1		1
1.5	4		4
1.8	1		1
2.0	2		2
2.5	1		1
3.0	2	1	3
No response		1	1
Total	27	6	33

Table 9. Yield and usefulness of corn harvested in Francisco León, Chiapas.

Response	Complete (%)	Timely (%)	With favoritism (%)	Conditional (%)
Yes	27.3	24.2	12.1	12.1
No	33.3	33.3	48.5	48.5
Don't know	39.4	42.4	39.4	39.4
Total	100	100	100	100

Table 10. Institutional support received by producers.

Characteristic		Producers (%)	
Type of corn	Grain	45.5	
	Grain and fodder	12.1	
	No response	42.4	
		100	Total
Plant transport	Intermediate	33.3	
	Tall	15.2	
	Low	3.0	
	No response	48.5	
		100	Total
Corn tip	Cover	57.6	
	No response	42.4	
		100	Total
Number of ears	Two or more	42.4	
	Two	12.1	
	No response	45.5	
		100	Total
Grain color	White	54.5	
	Yellow	3.0	
	No response	42.4	
		100	Total

Table 11. Agronomic characteristics of corn varieties preferred by producers.

Practice	Frequency	Percentage
None	9	27.3
All	5	15.2
Cleaning or good practices	2	6.1
Cleaning and fertilization	1	3.0
Fertilization	3	9.1
Herbicide application	1	3.0
No response	12	36.4
Total	33	100

Table 12. Which cultivation task benefits production the most.

respondents indicated that "all tasks" benefit production (León-Velasco, 2016). even though everyone was previously described the influence that each cultivation task has, which confirms that they have not obtained technical advice related to crop management. According to Lardizábal (2012), what allows for greater productivity is the scheduling and execution of necessary tasks at the ideal time for the crop.

Community impact

Regarding the activities carried out on the plantation, 63.6% of respondents employed family labor, 15.2% employed family and hired labor, 15.2% employed hired labor, and 6.1% did not respond . The owners indicated that their families improved their standard of living (36.4%), maintenance (63.6%), and clothing (15.2%); however, in the case of hired workers, the same landowners believed that the families of these workers improved their standard of living (18.2%), maintenance (33.3%), and clothing (9.1%). In each of these six cases, the remaining percentage that completes 100% denied these improvements. Given the differences between the pairs of percentages for landowners *vs.* hired workers, it can be deduced that the hiring landowners are more favored, since they are the landowners surveyed; the same occurred in the municipalities of Ocotepec (Grajales, 2015), Mezcalapa (León y León, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), and Tecpatán (León-Velasco *et al.*, 2021a), Chiapas. Separately, respondents stated that other individuals in the locality have not imitated the recent efforts (78.8%), have not improved the organization of the congregation (69.7%), have not detected any usefulness in the subsidies (63.6%), which have not caused inequalities (72.7%), nor has their use been supervised (81.8%), do not participate in a farmers' association (81.8%), or in a savings group (75.8%). Therefore, it is suggested that farmers' associations be established to manage support and technical advice in order to achieve a more profitable and commercial territory.

Environmental impact

Some producers carry out conservation work on their land, for example, leaving stubble (9.1%), not burning (9.1%), reincorporating stubble (9.1%) and not grazing livestock (3%); while 69.7% do not improve**.** Seventy-five point eight percent of respondents have not increased the area they cultivate, 6.1% have, and 18.2% did not respond. Thirty-three point three percent said their soil has eroded, fifty-one point five percent said it has not, and fifteen point two percent did not respond. In addition, eighty-one point eight percent do not analyze their soil because they are unaware of its usefulness, and eighteen point two percent did not respond (Table 13). The same trend in opinions was expressed by producers in the municipalities of Ocotepec (Grajales, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), and Tecpatán (León-Velasco *et al.*, 2021a). Technical assistance is essential; however, 78.8% stated that the Plant Health Subprogram does not work and 21.2% did not respond. As a result, 69.7% do not follow the recommendations for applying chemicals; 9.1% do; and 21.2% did not respond. On the other hand, 81.8% do not know if, due to low prices, anyone stopped growing corn in 2015 or earlier, and 18.2% did not respond (Table 13). As for corn cob

residues, 9.1% use them as firewood, 24.2% burn them, 9.1% throw them away, 21.2% do not use them, and 36.4% did not respond; however, farmers can obtain other income from corn husks and corn cobs that they have not considered.

Agricultural systems are characterized as groups of individual farms with broadly similar basic resources, business practices, family livelihoods, and constraints (FAO, 2021). Thus, 27.3% of producers grow corn as a monoculture and 72.7% grow it in association with beans, obtaining additional income (Table 14). These proportions are similar to those presented in the corn cultivation assessments in Ocotepec (Grajales, 2015), Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), Coapilla (León-Velasco *et al.*, 2021b), and Tecpatán (León-Velasco *et al.*, 2021a), confirming that the predominant production system in the nine municipalities of the Mezcalapa Region, Chiapas, is corn associated with beans (León-Velasco, 2016).

Technical impact

According to farmers, yields from modernized seeds were good (9.1%) and acceptable (27.3%), while 63.6% did not respond; there was untimely (33.3%) and timely (18.2%) control of pests and diseases, and 48.5% did not respond; the crop is no better than before (36.4%), 12.1% said yes, and 51.5% did not respond; subsidies did not allow for the renewal of farming methods (45.5%), 6.1% said yes, and 48.5% did not respond; the plantations are not more even than before (39.4%), 12.1% said yes, and 48.5% did not respond; the quality of the harvested corn did not increase (39.4%), 12.1% said yes and 48.5% did not respond; neither did the buildings (48.5%) and 48.5% did not respond; nor the equipment (51.5%) and 45.5% did not respond. To increase productivity, producers must become more involved in field work, which does not necessarily require a larger budget than they normally use during cultivation (Lardizábal, 2012). 18.2% of producers require backpack pumps and basic tools, which they will not purchase (6.1%), or will purchase when they have money (6.1%), or when the government provides support (6.1%).

Agents associated with impacts

Regarding the factors that affected the impacts, producers mentioned that they did not collaborate in community work (48.5%) and 12.1% did; they were not prepared to receive support (57.6%) and 3% were; there was no training before or after delivery (60.6%); suppliers did not comply with requests (57.6%) and 3% did; there was no advice on the management and care of support (60.6%); in each of these five cases, the remaining 39.4% did not respond (Table 15). It is noteworthy that 12.1% collaborate in common tasks in the locality, which should be taken advantage of to form an association that consolidates the progress of corn cultivation. In addition, 24.2% of respondents reported damage (25-75%) from strong winds, 6.1% (40-50%) from heavy rains, and 3% (50%) from drought, while 18.2% had no losses and 48.5% did not respond. Obviously, environmental factors cannot be controlled, but they can be prevented with better crop management, for example, by varying planting dates, cultivating early, intermediate, or late varieties, as appropriate, with different plant hei-

Variable	Frequency	Percentage
Increases crop area		
Yes	2	6.1
No	25	75.8
Did not respond	6	18.2
Their soil has been eroded		
Yes	11	33.3
No	17	51.5
Did not respond	5	15.2
Performs soil analysis		
No	27	81.8
Did not respond	6	18.2
Plant Health Sub-delegation supervises cultivation		
No	26	78.8
Did not respond	7	21.2
Works Subdelegation of Plant Health		
No	25	75.8
Did not respond	8	24.2
Follows chemical product recommendations		
Yes	3	9.1
No	23	69.7
Did not respond	7	21.2
Knows a producer who switched crops due to low corn prices		
No	27	81.8
Did not respond	6	18.2

Table 13. Environmental impact of support for corn producers.

Single crop	Associated with beans			Total
	Yes	No	No responded	
Yes	**3**	2	4	9
No	5			5
Did not respond	17		2	19
Total	25	2	6	33

Table 14. Corn production systems practiced in Francisco León, Chiapas

Variable	Frequency	Percentage
Producers cooperate in common tasks		
Yes	4	12.1
No	16	48.5
Did not respond	13	39.4
Producers were prepared to receive support		
Yes	1	3.0
No	19	57.6
Did not respond	13	39.4
Training was provided prior to the arrival of support		
No	20	60.6
Did not respond	13	39.4
Since he arrived, the coach has trained them		
No	20	60.6
Did not respond	13	39.4
Suppliers comply with requested material		
Yes	1	3.0
No	19	57.6
Did not respond	13	39.4
Advice was provided on the management and care of aids		
No	20	60.6
Did not respond	13	39.4

Table 15. Behavior of corn producers in communities.

Service	**Yes** (%)	**No** (%)	**Don't know** (%)	**Total** (%)
Soil improvement	75.8	15.2	9.1	100
Seed classification	78.8	9.1	12.1	100
Planting method	75.8	12.1	12.1	100
Equipment management	75.8	12.1	12.1	100
Use of supplies	75.8	12.1	12.1	100
Weed control	75.8	12.1	12.1	100
Pest assessment	78.8	9.1	12.1	100
Disease assessment	78.8	9.1	12.1	100
Financing	78.8	9.1	12.1	100
Marketing	78.8	9.1	12.1	100
Organization	78.8	9.1	12.1	100
Average	77.44	10.74	11.83	
Willing to pay for these services	6.1	81.8	12.1	10

Table 16. Training required by corn growers in Francisco León, Chiapas.

ghts, among other measures (León-Velasco, 2016).

Complementary service needs

Once the objectives of this research had been set, it became necessary to include technical assistance as another working tool in corn production systems. Thus, 77.4% of respondents are interested in receiving it for all aspects of cultivation, but only 6.**1%** of them are willing to pay for it (Table 16) to improve grain yield and production. This was also expressed by producers in Ocotepec (12%; Grajales, 2015), Mezcalapa (22%; León and León, 2015), and San Fernando (25.4%; León-Velasco *et al.*, 2018a), Copainalá (14.4%; León-Velasco *et al.*, 2018b), Coapilla (10%; León-Velasco *et al.*, 2021b), and Tecpatán (33.9%; León-Velasco *et al.*, 2021a). Sixty-six point seven percent do not have money; six percent do not feel like it due to their age; six percent do not want to; and 12.1 percent did not respond.

Of the 81.8% of farmers who are not willing to pay for technical assistance services, or who did not respond (12.1%), the majority (66.7%) said they have limited resources, 6.1% consider themselves too old, and 6.1% simply do not want to.

CONCLUSIONS

Corn production in the municipality of Francisco León is limited by smallholdings (1-2 ha; 81.8%), subsistence corn farming (78.8%) on communal land (57.6%) and communal land (21.2%); the seasonal corn planting system (100%), manual planting of native seeds (100%), seed selection (from their harvest) and land preparation (herbicides 87.8% and manual), planting season and density (10, 12, and 15 kg ha-^{1}, as well as cultivation tasks and phenology. 51.5% apply one to eight bags ha-^{1}of urea (21.2% two bags) and 45.5% do not apply any; erroneously, 12.1% make the first application between 40 and 50 days and the second during flowering (6.1%). Weed control (87.8%); corn earworm attack (72.7%) and corn rootworm (60.6%), controlled (18.2%) and without timely control (33.3%); the Plant Health Subdelegation does not function (100%); 30.3% practice conservation tillage and do not use stubble (69.7%) or corn cob residues (100%).

The development of producers is affected by age (between 21 and 85 years old) and experience (between 10 and 63 years); education (39.4% illiterate and 36.4% completed basic education); lack of training (100%); desire for new varieties (60.6%), preferably with covered cobs (57.6%) and white kernels (54.5%); use of labor (family 63.6%, as well as family and hired 30.4%); lack of financing and organization (100%); does not participate in common tasks (48.4%); has low production for self-consumption (100%) and needs technical assistance services (77.4%), but only 6.1% are willing to pay for it and the rest want government support for everything.

It is recommended that a comprehensive technical assistance system be developed and implemented, starting with three main variables: introducing improved varieties, varying planting dates, and varying plant densities per hectare of corn on the plots of interested farmers, with the collaboration of the City Council and technicians from different institutions and disciplines.

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