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DIAGNOSIS OF CORN CULTIVATION IN THE MUNICIPALITY OF OCOTEPEC, CHIAPAS, MEXICO

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ABSTRACT: Corn (*Zea mays* L.) is the staple food of the people of Ocotepec. The objective of this research was to identify the technical and socioeconomic factors that restrict the development of corn cultivation and its producers in the municipality of Ocotepec, Chiapas. The City Council has a registry of 693 corn producers, so the random sample was 25, to which, in 2015, a survey of 116 questions associated with the aforementioned factors was applied. The absolute frequencies of the individual variables were evaluated, and some were correlated, 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 41 to 85, with between 18 and 70 years of experience. Thirty-six percent are illiterate and 16% have not completed primary school; their main income comes from subsistence corn farming (0.5-2 ha; 92%) on ejido (84%) and communal (8%) land; all of them plant native corn by hand in rainfed fields, 64% of them sowing 50,000 seeds per hectare; 68% control weeds with herbicides and 32% manually; 68% apply one to six bags of urea per hectare (36% two bags); there was damage from Fall Armyworm (56%) and White Grub (48%) (without proper control, 48%); no soil analysis is carried out (100%) nor is the soil improved, even though there was erosion (80%); the Plant Health Sub-delegation does not function (100%); the crop was profitable (40%), without financing (100%); 96% use the grain for self-consumption; support was incomplete (24%) and untimely (48%); 68% want new varieties; all work favors production (52%); there was no community impact from support (80%); corn production systems were: single crop (16%) and associated with beans (84%); people do not cooperate in common tasks (48%) and 20% do; 88% are willing to receive technical assistance, but only 12% want to pay. Finally, it is advisable to design a comprehensive technical advisory system, which will be implemented starting with four main variables: literacy, improved varieties, planting dates, and seed and corn plant population densities on farmers' land, with the collaboration of the City Council and technicians from different institutions and disciplines.

Keywords: *Zea mays*, productivity, systems, producers, technical assistance.

INTRODUCTION

Corn (*Zea mays* L.) is currently a global crop. In fact, it is the world's leading crop: it is grown in 85% of countries and, together with wheat and rice, contributes to providing more than half of the calories consumed by the world's population. In Mexico, corn is considered not only a food, but also a biocultural heritage. Its cultivation and commercialization are therefore fundamental components of the Mexican economy. With an average annual consumption per person of 196.4 kg of corn (white), this crop is the staple food of the Mexican population and accounts for around 85% of the total volume produced in the country. Even so, the corn produced in Mexico is not enough to meet domestic consumption needs. Soil degradation, climate change - and the resulting increase in the incidence of pests and diseases in crops - and unsustainable agricultural practices - such as monoculture or the excessive and inappropriate use of potentially harmful chemicals - are some of the factors that contribute to many Mexican farmers failing to achieve satisfactory production (often struggling to meet their own consumption needs) (CIMMYT, 2020). A high percentage of the rural population depends on corn production, where the crop is grown using everything from the most backward rainfed 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 2024, Chiapas produced 1,389,963.42 tons of grain, 70.97% of which has been obtained in four economic regions led by the municipalities of Tuxtla Gutiérrez (20.41%), Comitán (16.84%), Villaflores (18.74%), and Palenque (14.98%) (SIAP, 2024). These results are attributed to the use of improved seeds and good crop management, as farmers carry out the activities of the production chain satisfactorily, 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 carry out their agricultural, livestock, and forestry activities with very limited land and capital, resulting in smallholdings and extreme poverty (Parra and Díaz, 1997). This intensifies the problems of soil fertility and the use of fertilizers to maintain corn production (Álvarez-Solís and Anzueto-Martínez, 2004), which amounts to 102,484.94 tons (SIAP, 2024). Under these circumstances, increasing productivity through the use of industrialized supplies faces the problem of high costs and insufficient returns on capital investments in dryland hillside agriculture. Overall, agricultural production in Los Altos de Chiapas faces a number of difficulties, including soil erosion and loss of fertility, declining yields, declining labor productivity, and a growing inability to hire family members and provide the essential components of their livelihood. This is the result of excessive pressure on the land, rugged topography, the fragmentation and dispersion of plots, and the 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 study area, recently designated "Region III Mezcalapa", where similar environments predominate, as it is also a mountainous region made up of nine municipalities, four of which were designated as extremely poor by the National Evaluation Council (CONEVAL) of the Social Development Policy, among the 444 municipalities of the National Crusade Against Hunger. This region has 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, with 38.40%, 21.63%, 0.54%, and 39.42%, respectively; whose harvested area in 2024 was 19,588.10 ha, with a production of 32,252.18 tons of grain and an average yield of 1.62 t ha^{-1} (SIAP, 2024). However, there is no appropriate technical advisory program to promote and supervise the use of the programs; in other words, technical assistance has not been instituted, so it is not known how these support measures are used or what their impact is on improving the crop and its producers.

Therefore, there is a need to generate and/or transfer technologies based on the recommendations of a diagnosis that identifies the environmental, socioeconomic, management, and other issues that limit corn yield and production in Region III Mezcalapa, Chiapas, in the case of this particular study of the municipality of Ocotepec, in order to develop more accurate proposals, through specific research, that resolve the complications of corn planting, as well as to design and implement a Comprehensive Technical Advisory System for corn producers in that municipality, which was chosen because it has 97.33% of the population being indigenous, 59.61% of the population being rural, 46.7% in extreme poverty, 45.2% in moderate poverty, and a very high degree of marginalization (GEC, 2013; SB, 2022). Therefore, the objective of this research was to identify the technical and socioeconomic factors that restrict the development of corn cultivation and its producers in the municipality of Ocotepec, Chiapas.

MATERIALS AND METHODS

Study area

Ocotepec is located in the northwest of the state in the northern mountains. Its geographical position is 17º 13' north latitude and 93º 09' west longitude. It has 14,088 inhabitants, and its altitude ranges from 400 to 2100 meters. The climate is hot and humid with rainfall throughout the year (67.78%) and semi-hot and humid with rainfall throughout the year (32.22%); average temperature of 18 to 26º C and annual precipitation of 2000 to 4000 mm (INAFED, 2009; 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 the Countryside (SECAM); and Shared Risk Trust (FIRCO); which were concentrated to simplify 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 ≤ 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 Sheaffer *et al.* (2004):

In the case of Ocotepec, the population studied consisted of 693 producers, so that the random sample size was 20 producers (Table 1), plus five to increase accuracy; 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:

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

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.

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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 cultural practices, weed control, pests and diseases, fertilization, harvesting, trade, financing, institutional support, productive, community, ecological, and technical impact, as well as factors associated with the 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 students acting as interviewers, for security reasons. To triangulate the data, interviews were conducted with the leaders of the organizations involved.

Analysis of the information

The field data was organized into digital files for subsequent analysis and interpretation using the Statistical Package for the Social Sciences (SPSS, 2016). Next, the absolute frequencies of all variables were evaluated individually, and some were also correlated in pairs and/or triads.

RESULTS AND DISCUSSION

The survey administered to the sample of 25 people ($p \leq 0.05$) represents the total of 693 corn farmers in the municipality of Ocotepec, Chiapas. Thus, one respondent corresponds to 4% of the sample, which in turn represents 27.72% of the farming population.

General data

The municipal capital was representative of the municipality of Ocotepec, where the 25 farmers surveyed live, equivalent to 100% of the population. It was observed that the area cultivated with corn per farmer ranges from 0.5 to 4 ha, with 40% having 2 ha, 28% having 1 ha, followed by two cases of 12% with 0.5 and 1.5 ha each, and two cases of 4% with 3 and 4 ha each.

All producers are between 41 and 85 years old; most (84%) are betwe ; 12% are between 76 and 85; and 4% are between 41 and 45 (Table 2); where 100% have been growing corn for between 18 and 70 years; and 92% of them for between 20 and 60 years; highlighting the 12, 16, 12, and 12% who have 20, 30, 45, and 60 years of experience, respectively. Likewise, 36% are illiterate; another 36% completed primary school; 16% completed 1st and 2nd grade; 8% completed high school; and 4% completed teacher training college (Table 2). The illiteracy rate described is lower than that of producers in Francisco León (39.4%; León-Velasco *et al.*, 2025) , and higher than that of 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); a position it still holds 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).

Municipality	ASERCA 2011 Procampo Fall-Winter	ASERCA 2012 Procampo Spring-Summer	SECAM 2012 Solidarity Corn	FIRCO 2012 PROMAF	SADER 2011 Corn for Personal 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	32
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**	

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

Age (years)	Education					Total
	No schooling	Elementary (1st - 2nd)	Elementary	High school	Higher education	
41-45				1		1
46-50	1	2	2			5
51-55	1	1	1	1		4
56-60		1	1		1	3
61-65	3					3
65-70	2					2
71-75	1		3			4
76-80			1			1
81-85	1		1			2
Total	**9**	4	**9**	2	1	25

Table 2. Ages and levels of education of corn producers in Ocotepec, Chiapas.

The interviewees' main source of income was agriculture (100%), which they practice for subsistence, their main task being to grow corn. Most (84%) own ejido lands; 8% own communal lands; 4% own private lands; and 4% rent lands. On the other hand, all of them plant corn in dry seasons, which are determined by environmental factors; however, 4% of them also plant in residual moisture, due to the excess rainfall in their land, meaning that they grow two crops per year. This means that in the municipality of Ocotepec, it rains all year round (INEGI, 2021), with a rainy season that begins in March and ends in February, with greater intensity and duration from March to August. In addition, from September to February there is a season known by producers as "nortes" or "chipi chipi," during which the rains continue, although with less intensity and duration; however, this humidity allows for a second crop cycle to be established and a second harvest to be obtained.

Planting systems

Ninety-two percent of producers said they plant native corn, while 8% plant hybrid corn. However, when asked where they obtained the seed, 76% said they obtained it from the same ejido, 16% from their own harvest, and only 8% did not respond (Table 3). They also commented that they have been growing the same seed for 20 to 30 years. Evidently, all of them plant native corn, and although some varieties retain their original names, they are now native due to crossbreeding with local native corn, according to León-Velasco (2016).

Origin	Variety		
	Creole	Hybrid	Total
The community	19		19
Same harvest	2	2	4
Did not respond	2		2
Total	23	2	25

Table 3. Origin of corn grown by producers.

Thus, of the total number of farmers who plant rainfed crops, 68% do so in the months of March (24%) and April (44%), which is when the rainy season begins, and harvest in varying proportions from August to November, mainly from August to October. According to these data and field observations, there are early, intermediate, and late corn varieties, which are harvested in August (16%), September (36%), and October (12%), respectively. On the other hand, 4% of farmers who grow a second crop of corn in residual moisture did not indicate the respective planting and harvesting dates. This explains why 4% of producers believe that the support is insufficient, as they have two crops per year and the support was earmarked for one, as also stated by 25.4% of producers who plant in residual moisture in Tecpatán (León-Velasco *et al.*, 2021a) and 42.4% in Francisco León (León-Velasco *et al.*, 2025), Chiapas.

All farmers plant manually using a hoe or crowbar. Most (64%) plant at 100 cm between rows and also between planting holes, resulting in 10,000 holes per hectare (Table 4); as in the municipalities of Mezcalapa, Francisco León, San Fernando, Copainalá, Tecpatán, and Coapilla, Chiapas (León-Velasco, 2016). In Ocotepec, an average of five seeds are deposited per hole, resulting in a planting density of 50,000 seeds per hectare. Considering that the commercial and native corn seeds grown by farmers have an

85% germination rate, which is the percentage guaranteed by private seed companies, this means that of the aforementioned seed quantity, only 42,500 seeds have the potential to germinate, not counting those lost for other reasons. Therefore, the concentration of plants per hectare is insufficient and, as a result, productivity and production are also lower compared to other locations where the plant density per hectare is higher. Of course, the remaining 36% of producers sow fewer seeds per hectare (Table 4). Seed planting density ranged from 5 to 18 kg ha^{-1}, with 36% and 40% of producers planting an average of 12 and 15 kg ha^{-1}, respectively, confirming the low amount of seed planted per hectare; similar to the average densities used in the municipalities of Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.* 2018a), Copainalá (León-Velasco *et al.* 2018b), Tecpatán (León-Velasco *et al.*, 2021a), and Francisco León (León-Velasco *et al.*, 2025), Chiapas.

Between rows (cm)	Between holes (cm)				
	100	120	150	200	Total
100	16	2			18
120		1			1
150	1		4		5
200				1	1
Total	17	3	4	1	25

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

Cost of cultural activities

According to all farmers, in 2014, investment in cultivation fluctuated considerably between MXN 1200 and MXN 4270 ha^{-1}; the price of harvested grain ranged between MXN 500 and MXN 9000 ha^{-1}; and the price per ton of grain was MXN 5000. When correlating the two variables, it was observed that 100% of farmers obtained different incomes from production. For example, 20% invested MXN 2000 ha^{-1} and obtained grain production worth between MXN 2000 and MXN 9000 ha^{-1} and an average of MXN 4400; similarly, 20% of producers invested between MXN 1350 and MXN 3000 ha^{-1}, with an average of 2270 MXN, achieved a production value of 4000 MXN ha^{-1} (Table 5); which means that in both cases, corn grain production was profitable for those producers; profitability also mentioned by 17, 26.7, 34, and 39.4, % of farmers in the municipalities of Tecpatán, Coapilla, Mezcalapa, and Francisco León, Chiapas (León-Velasco *et al.*, 2021a; León-Velasco *et al.*, 2021b; León and León, 2015; León-Velasco *et al.*, 2025), respectively. Undoubtedly, there are producers who did not make a profit and, with the value of their production, barely recovered their investment or lost part of it; thus, the 20% who invested between MXN 1200 and MXN 3000 ha^{-1} with an average of MXN 2110, achieved a harvest with a value of MXN 1500 ha^{-1} (Table 5). Others suffered losses in their production due to damage from certain environmental agents, a lack of fertilizers, or other causes; however, they have to continue planting corn because the grain is their family's food source.

Weed control

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). The main weeds mentioned by respondents were: *Leptochloa filiformis* grass (44%),

Investment (MXN ha^{-1})	Sale of grain production (MXN ha^{-1})													
	500	1250	1500	2000	2500	3000	3500	4000	4500	4750	5000	7500	9000	Total
1200			1											1
1350			1					1						2
1610						1								1
2000		1	1	1	1			1	1				1	7
2500								2						2
2580							1							1
3000			2	1		1		1						5
3290												1		1
4000	1				1					1		1		4
4270											1			1
Total	1	1	**5**	2	2	2	1	**5**	1	1	1	2	1	25

Table 5. Cost of growing and selling corn grain production in the municipality of Ocotepec, Chiapas.

Echinochloa crusgalli grass (16%), *Ipomea tilleaceae* broadleaf (8%), as well as all types (4%), and 28% did not respond; which were controlled by various poisons such as Paraquat (64%) and Glyphosate (4%); 28% did not apply herbicides and 4% cleaned manually with a machete (Table 6). Sixty-eight percent of all farmers apply herbicides before the emergence of crops and weeds; separately, 16% of the total apply them post-emergence. In addition, they explained that few know the formulas of the poisons they apply and are unaware of the names of the weeds; the same was explained by producers in Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), Tecpatán (León-Velasco *et al.*, 2021a), and Francisco León (León-Velasco *et al.*, 2025), Chiapas.

Fertilization

With regard to fertilizer application on one hectare of crops, 68% of farmers reported using urea (46-00-00 N) in quantities ranging from one to six 50-kg bags, with 36% applying two bags, 20% one bag, 8% three bags, and 4% six bags. while 32% do not apply fertilizers because they cannot afford them (Table 7).

In general, 56% of farmers apply urea for the first time between 20 and 45 days after seedling emergence, with 32% of them doing so between 20 and 30 days; in this regard, farmers have several methods for determining when to apply fertilizers. Similarly, of those who make a second application, 12% do so when the crop is 60 days old or in the flowering stage.

Nitrogen fertilizers are prescribed during foliage growth, so it is a mistake to apply urea for the first time 31 to 45 days after emergence, as 24% of farmers do, or

Product	Weed					
	Grass	Bush	Broadleaf	All types	Did not respond	Total
Glyphosate	1					1
Paraquat	10	3	2	1		16
Machete blow		1				1
Not applicable					7	7
Total	11	4	2	1	7	25

Table 6. Weed control carried out by producers in corn cultivation.

Product	Bags per hectare					
	0	1	2	3	6	Total
Urea		5	9	2	1	17
Not applicable	8					8
Total	8	5	9	2	1	25

Table 7. Fertilizer products and doses applied to corn crops.

to apply it for the second time during the flowering stage or after 60 days, especially in these last two stages when the crop has already reached its maximum growth. 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 control and disease

Similar to weeds, pests and diseases reduce crop yields. Separately, respondents reported that their crops had been attacked by Fall Armyworm (*Spodoptera frugiperda*) (56%), White Grub (*Phyllophaga* spp.) (48%), and corn borer (*Diatraea saccharalis*) (8%); as well as smut disease (*Sporisorium reilianum* f. sp. zeae) (4%) (Table 8). For Fall Armyworm, only 40% applied products such as Foley Rey Chlorpyrifos Ethyl and Permethrin (36%), as well as Arrivo Cypermethrin (4%), with only 20% using the prescribed doses of Foley. Now, for White Grub, only 32% of farmers applied Foley Rey Chlorpyrifos Ethyl and Permethrin, but only 24% applied the prescribed doses. The data presented resulted from the cross-association of three variables (product × pest × dose per hectare). In the case of the corn borer (4%), no poison was applied, nor was any applied for smut (4%). The low incidence of corn crop diseases in this municipality indicates that they are not of economic importance, or perhaps farmers are unaware of them, as is the case in the municipality of Francisco León, Chiapas (León-Velasco *et al.*, 2025).

Harvest

All farmers harvest the ears of corn manually, arguing that this makes better use of the grain, i.e., nothing is wasted because all the ears are collected, even if the stalks

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Product	Pest			Disease
	White Grub	Fall Armyworm	Stem borer	Smut
Arrivo		1		
Foley	8	9		
Not applicable	3	1	1	1
Did not respond	1	3	1	
Subtotal	12	14	2	1
Did not respond	13	11	23	24
Total	25	25	25	25

Table 8. Pest control carried out by producers in corn cultivation.

are lying on the ground. On the other hand, 96% do not pack the stubble and 4% did not respond. However, 4% graze livestock after harvesting, and the remaining 96% leave the stubble on the ground to be reincorporated or burned.

Grain yield fluctuated between 0.10 and 1.80 t ha^{-1}, with an average of 0.75 t ha^{-1}, where the majority (68%) obtained between 0.30 and 0.80 t ha^{-1}; 8% between 0.10 and 0.25 t ha^{-1}, and 24% between 0.90 and 1.80 t ha^{-1}; notably, 20% of the total harvested only 0.30 t ha^{-1}, while another 20% obtained 0.80 t ha^{-1} (Table 9). This low yield is similar to that of the nine municipalities in the region studied, whose municipal average yield according to SIAP (2015) was 1.22 t ha^{-1}. It is confirmed that a high percentage of the rural population depends on corn cultivation, where the most backward seasonal production is cultivated, obtaining yields of 0.7 t ha^{-1} (Vega and Ramírez, 2004).

After harvesting, the grain remains at risk, as insects, fungi, and rodents appear and consume its contents. Respondents reported that the grain was damaged by the corn weevil (*Sitophilus zeamais* Motschulski) (12%) and the brown rat (*Rattus norvegicus* Berkenhout) (4%) (Table 10). Therefore, they use various methods to store their grain for food, as well as their seeds for the next planting cycle, in barns, plastic barrels, ixtle sacks, whole or defoliated corn cobs on the floor of a room, or tied with their joloche to the crossbeams of their rooms, among others.

Trade

100% of producers stated that they use their corn harvest to feed their families (Table 9). It is clear that subsistence farming is practiced in Ocotepec, Chiapas, as the majority (92%) cultivate between 0.5 and 2 ha of corn, and all farmers use their grain harvest for self-consumption (Table 9). When producers obtain surpluses in their grain production, another problem arises, which is the lack of a market or good prices for agricultural products, as is often the case (Volke, 1986). On the other hand, 40% said that the merchants were satisfied with the type of grain they sold them; 56% said no, and 4% did not respond. In addition, 96% do not belong to an organization that helps market the harvest, nor did they receive institutional support for trading grain, as was the case in the municipality of Francisco León, Chiapas (León-Velasco *et al.*, 2025).

Yield (t ha^{-1})	Use of grain		
	Self-consumption	No response	Total
0.1	1		1
0.25	1		1
0.3	5		5
0.4	2		2
0.5	1	1	2
0.6	2		2
0.7	1		1
0.8	5		5
0.9	1		1
0.95	1		1
1.0	1		1
1.5	2		2
1.8	1		1
Total	24	1	25

Table 9. Yield and profitability of corn harvested in Ocotepec, Chiapas.

Pest	Frequency	Percentage
Grain weevil	3	12
Rodents	1	4
None	8	32
Does not store	2	8
Did not respond	11	44
Total	25	100

Table 10. Pests that damage stored grain.

Financing

100% of producers did not receive bank loans to sustain their crops and/or use them for their own purposes, both in 2014 and before; nor did they receive loans from individuals or sell their harvest in advance; this was also confirmed by 100% of corn producers in the municipalities of Mezcalapa, Francisco León, Osumacinta, Chicoasén, San Fernando, Copainalá, Coapilla, and Tecpatán, Chiapas, which complete the nine municipalities studied in the general project (León-Velasco, 2016). In subsistence agriculture, it is common to work with one's own money and without agricultural insurance (Volke, 1986).

In addition to the official support received by producers in Ocotepec (Table 1), they did not receive support from other institutions; however, 15.3% of Tecpatán did receive support from SADER and the Municipal Presidency (León-Velasco *et al.*, 2021a). In addition, some farmers stated that only registered ejido members are beneficiaries of institutional aid, as determined by the general assembly of ejido members. The same has been ruled by the ejido members of the municipalities of Mezcalapa, Francisco León, San Fernando, Copainalá, Tecpatán, and Coapilla (León-Velasco, 2016). Consequently, it is appropriate to request support that also benefits these local producers.

Institutional aid

Sixty-four percent of corn farmers received aid from the Spring-Summer Production for Welfare Program (PpB), formerly PROCAMPO; on the other hand, 24% received support from the Fall-Winter PpB. Likewise, 72% of the total mentioned that they had received the same aid in 2014 and previous years, 12% had not, and 16% did not respond. The negative opinion of the spring-summer PpB is questionable, as their names are on the producer registers.

In split shares, farmers commented that this aid has been used for plowing (4%), seeds (8%), sowing (60%), herbicides (60%), fertilizers (36%), pest control (12%), harvesting (32%), sack rental (4%), grain transport (8%), and field expenses (4%). The trend in this information coincides with that obtained in the municipalities of Mezcalapa (León and León, 2015), Chicoasén and Osumacinta (León-Velasco, 2016), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), Coapilla (León-Velasco *et al.*, 2021b), Tecpatán (León-Velasco *et al.*, 2021a), and Francisco León (León-Velasco *et al.*, 2025), Chiapas; except that in San Fernando, the majority (59.1%) use a harrow, because it has more flat land, which allows agricultural machinery to pass (León-Velasco *et al.*, 2018a).

On the other hand, the support arrived complete (76%), timely (52%), without favoritism (64%), and without conditions (68%); while the minority responded that it was incomplete, they did not know (24%), untimely (32%), with favoritism (12%), and conditional (8%); in each pair of opposing variables, 0, 16, 24, and 24%, respectively, did not respond. Clearly, there is no official inspection of the donation and management of aid, nor of land ownership and crop use by the supported farmers.

Productive impact

Sixty-eight percent of farmers are interested in new corn varieties, and 32% are not, probably because they refuse to discard the native varieties they have grown, which indicates that they grow the varieties that have produced well or those that are best suited to the local environment. Thus, in separate proportions, those interested lean toward corn from Pioneer (32%), Dekalb (28%), Proase (4%), Tacsa (4%), and chaparro corn (4%).

Similarly, the characteristics most preferred are: corn for grain (56 %), with medium-sized plants (40%) and small plants (16%), producing two ears (52%) or more (16%), with covered tips (68%) and white grain (60%) (Table 11). This preference shows that farmers have experience with traits related to production and the prediction of damage from wind, insects, and fungi, as well as a preference for white grain, since it is consumed by their families.

Characteristic		Producers (%)		
Type of corn	Grain	56		
	Grain and fodder	12		
	Don't know	32		
			100	Total
Plant height	Tall	8		
	Tall and short	4		
	Intermediate	40		
	Low	16		
	Don't know	32		
			100	Total
Type of cob	Covered tip	68		
	Don't know	32		
			100	Total
Number of ears	Two or more	16		
	Two	52		
	Don't know	32		
			100	Total
Grain color	White	60		
	White and yellow	4		
	Yellow	4		
	Don't know	32		
			100	Total

Table 11. Agronomic characteristics of corn preferred by producers.

With regard to "which farming practice is most beneficial to production," 52% of farmers said that "all tasks" benefit crops, with 4% of them also saying "all on time"; the rest mentioned other practices, notably "cleaning" (16%), "cleaning and fertilizing" (8%), "burning" (8%), "fertilizing" (4%), and 12% did not respond (Table 12). This 52% was lower than that obtained in Coapilla (58.4%), Mezcalapa (60%), Tecpatán (62.7%), and Copainalá (65.6%), but higher than that of San Fernando (46.2%) and Francisco León (15.2%), where an average of 51.35% of respondents indicated that "all tasks" benefit production (León-Velasco, 2016); although the influence of each cultivation task was explained to all respondents beforehand, this shows that they have not received 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.

Practice	Frequency	Percentage
All on time	1	4
All	12	48
The Cleaner	4	16
Cleaning and fertilizer	2	8
Fertilization	1	4
Burning	2	8
Did not respond	3	12
Total	25	100

Table 12. Cultivation practice that most benefits production.

Community impact

With regard to farming tasks, 72% of producers employed family labor and 28% hired labor. Respondents mentioned that their families improved their standard of living (36%), food (52%), and clothing (20%); however, for the families of hired workers, the same respondents said that they also improved their standard of living (20%), food (24%), and clothing (4%). In these six cases, the percentage of respondents needed to complete 100% of each question denied improvements or did not respond. Given the differences between the pairs of proportions for the same improvement "producers *vs*. hired workers," it can be inferred that the contractors benefit more, since they are the owners surveyed; the same trend occurred in the municipalities of Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al*., 2018a), Copainalá (León-Velasco *et al*., 2018b), Tecpatán (León-Velasco *et al*., 2021a), and Francisco León (León-Velasco *et al*., 2025), Chiapas.

In separate proportions, farmers said that other people in the community have not imitated the new farming practices (92%); they have not improved the organization of the community (88%); have not noticed any benefits from the support (80%); the support has not made any difference between them (96%); its use has not been supervised (88%); they do not belong to a farmers' association (96%); or to a savings fund group (100%) (Table 13). In this regard, it is suggested that producer associations be established to manage support and technical advice in order to achieve a more productive and commercial agricultural sector.

Ecological impact

Producers practice conservation tillage on their land, for example, they leav , or incorporate stubble (8%) and do not burn (12%). However, 4% do not know how to do this and 76% did not respond, considering that it does not improve the soil in which they plant their crops.

Eighty-four percent of farmers have not increased the area planted with corn, while 16% have. Similarly, 64% said their soil has eroded, and 36% said it has not; in addition, 100% have not conducted soil analysis, possibly because they do not know the usefulness of such a study (Table 14); similar trends in opinion were reported by producers in the municipalities of San Fernando (León-Velasco *et al*., 2018a), Copainalá (León-Velasco *et al*., 2018b), Tecpatán (León-Velasco *et al*., 2021a), and Francisco León (León-Velasco *et al*., 2025), Chiapas. Technical assistance is basic; however, all farmers mentioned that the Plant Health Sub-delegation does not provide advice for their crops, which is why 88% confirmed that it does not work. As a result, 100% do not follow the recommendations for applying chemical products. On the other hand, 100% do not know if, due to low prices, any producers stopped planting corn in 2014 or earlier or changed activities.

Regarding corn cob waste, 32% of farmers do not use it; 24% burn it; 12% throw it away; and 32% did not respond. However, the potential benefits of joloche and olote generate another benefit that producers have not taken into account.

Agricultural systems are characterized as groups of individual farms with similar basic resources, business practices, family livelihoods, and constraints in general (FAO,

Variable	Frequency	Percentage
Community personnel copy new practices		
Yes	1	4
No	23	92
Did not respond	1	4
Improved community organization		
Yes	3	12
No	22	88
Note: profits with subsidies		
Yes	5	20
No	20	80
Aid causes differences between them		
Yes	1	4
No	24	96
Use of aids is monitored		
Yes	3	12
No	22	88
Belongs to a farmers' organization		
Yes	1	4
No	24	96
You benefit from them		
Yes	1	4
No	19	76
Did not respond	5	20
Participates in savings fund		
No	25	100

Table 13. Social impact of support on corn producers.

Variable	Frequency	Percentage
The area under cultivation has increased		
Yes	4	16
No	21	84
Its soil has been eroded		
Yes	16	64
No	9	36
Has performed soil analysis		
No	25	100
The Plant Health Sub-delegation supervises its cultivation		
No	25	100
The Plant Health Sub-delegation is operational		
Yes	2	8
No	22	88
Did not respond	1	4
Follows recipes for applying chemicals		
No	25	100
Knows someone who has switched crops due to the low price of corn		
No	25	100

Table 14. Environmental impact of support for corn producers.

2021). Thus, 16% of producers plant corn as a single crop, while 84% grow it in association with beans (Table 15), thereby obtaining additional income from grain production. The trend in these proportions is similar to that presented in the diagnosis of corn cultivation in the municipalities of Mezcalapa (León and León, 2015), San Fernando (León-Velasco *et al.*, 2018a), Copainalá (León-Velasco *et al.*, 2018b), Coapilla (León-Velasco *et al.*, 2021b), Tecpatán (León-Velasco *et al.*, 2021a), and Francisco León (León-Velasco *et al.*, 2025); confirming that the predominant production system in the nine municipalities of the Mezcalapa Region, Chiapas, is corn associated with beans (León-Velasco, 2016).

Single crop	Associated with beans		
	Yes	Did not respond	Total
Yes		4	4
No	8		8
Did not respond	13		13
Total	21	4	25

Table 15. Corn production systems practiced in Ocotepec, Chiapas.

Technical impact

According to the interviewees, the performance of modern seeds was good (4%), fair (16%), and did not respond (80%). Timely pest and disease control was not carried out (48%), 24% said yes and 28% did not respond; crops are not more uniform (52%), 20% said yes and 28% did not respond; support did not allow for changes in cultivation techniques (68%), 4% said yes and 28% did not respond; crops are not more uniform (60%), 12% said yes and 28% did not respond; nor did the quality of the corn produced improve (64%), 8% said yes and 28% did not respond; nor have the facilities (72%), with 28% not responding; nor has the equipment (72%), with 28% not responding (Table 16). 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).

In general, farmers have not renewed their crops due to a lack of guidance and commercial interest in their production. Only 32% of those interviewed purchased backpack sprayers and machetes. Fifty-two percent need tools, particularly backpack sprayers, fertilizers, and herbicides, as well as picks and hoes, which they plan to purchase when they have the budget (8%) or when the government provides assistance (40%), while 4% do not know how or when to purchase them.

Factors associated with impacts

With regard to the factors that influenced the results, farmers commented that: people do not collaborate in community work (48%) and 20% do; they were not prepared to obtain support (60%) and 8% were; there was no training before or after the support was provided (60%) and 8% did; when the support arrived, the expert did not show up to train them (64%) and 4% did; and suppliers did not respect the products requested (60%) and 8% did. In all cases, the remaining 32% of producers did not respond (Table 17). It is noteworthy that 20% of farmers collaborate in community work; however, they do not do the same for other tasks related to their crops. Such cooperation could also be used to form an association to manage the development of corn cultivation, as is the case with 12.1% of farmers in the municipality of Francisco León, Chiapas (León-Velasco *et al.*, 2025).

Variable	Frequency	Percentage
Improved seed performance		
Good	1	4
Regular	4	16
Did not respond	20	80
Timely control of pests and diseases		
Yes	6	24
No	12	48
Did not respond	7	28
Crops are better than before		
Yes	5	20
No	13	52
Did not respond	7	28
Support favored cultivation technique		
Yes	1	4
No	17	68
Did not respond	7	28
Crops are more uniform		
Yes	3	12
No	15	60
Did not respond	7	28
Improved quality of corn produced		
Yes	2	8
No	16	64
Did not respond	7	28
Improved facilities		
No	18	72
Did not respond	7	28
Improved equipment		
No	18	72
Did not respond	7	28

Table 16. Practices for improving corn cultivation.

Variable	Frequency	Percentage
People cooperate in common tasks		
Yes	5	20
No	12	48
Did not respond	8	32
People eligible for assistance		
Yes	2	8
No	15	60
Did not respond	8	32
Advice was provided prior to accessing aid		
Yes	2	8
No	15	60
Did not respond	8	32
Training was appropriate		
Yes	2	8

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No	15	60
Did not respond	8	32
Upon arrival, frequent technical support trains		
Yes	1	4
No	16	64
Did not respond	8	32
Supplier delivers requested material		
Yes	2	8
No	15	60
Did not respond	8	32
Support management counseling		
Yes	2	8
No	15	60
Did not respond	8	32

Table 17. Behavior of corn farmers in the communities.

Now, 28% of respondents reported losses (of 25%, 30%, and 50%) due to strong winds; 20% (50%) due to heavy rain and wind; 8% (25% and 30%) due to heavy rain; and 4% (90%) due to drought; however, 12% had no losses and 28% did not respond. Obviously, the effect of environmental factors cannot be controlled, but it can be prevented with better crop management, for example, by varying planting dates, planting early, intermediate, or late varieties, as appropriate, with different plant heights, respectively, among other measures (León-Velasco, 2016).

Complementary service needs

Once the objectives of this research had been set, the need arose to include technical assistance as another working tool in production systems. Thus, an average of 88% of respondents are willing to receive it for all their cultivation activities, but only 12% of that number are willing to pay for it (Table 18), out of an interest in learning more and improving production; as also stated by producers in Mezcalapa (22%; León and León, 2015), San Fernando (25.4%; León-Velasco *et al.*, 2018a), Copainalá (14.4%; León-Velasco *et al.*, 2018b), Coapilla (10%; León-Velasco *et al.*, 2021b), Tecpatán (33.9%; León-Velasco *et al.*, 2021a), and Francisco León (6.1%; León-Velasco *et al.* 2025). Of the 84% of farmers who are unwilling to pay, 68% cite limited resources, 4% are not interested, and 12% say the government should give it away. Finally, 4% did not respond, simply saying that they know everything.

CONCLUSIONS

Corn production in the municipality of Ocotepec, Chiapas, is limited by smallholdings (0.5-2 ha), subsistence corn farming (92%), as well as ejido (84%) and communal (8%) lands; the rain-fed corn planting system (100%), manual planting of native seeds (100%), seed selection and soil preparation methods, planting season and density, cultivation tasks and phenology, the use of fertilizers [68% apply one to six bags of urea per hectare (36% two bags)], 24% mistakenly make the first application between 31 and 45 days and the second

Service	Yes (%)	No (%)	Don't know (%)	Total (%)
Land improvement	88	8	4	100
Seed selection	88	8	4	100
Sowing method	88	8	4	100
Equipment management	88	8	4	100
Use of supplies	88	8	4	100
Weed control	88	8	4	100
Pest control	88	8	4	100
Disease control	88	8	4	100
Financing	88	8	4	100
Marketing	88	8	4	100
Organization	88	8	4	100
Is willing to pay for these services	12	84	4	100

Table 18. Training required by corn farmers in the municipality of Ocotepec, Chiapas.

during flowering (12%); inappropriate control of weeds (68%) and pests (48%); the Plant Health Sub-delegation not functioning (100%); as well as non-use of stubble, conservation tillage, and corn cob residues (100%).

The development of producers is affected by age (41-85 years) and experience (18-70 years); education (36% illiterate, 16% without completing primary school, and 36% with completed primary school); lack of training (100%); desire for new varieties (68%), covered corn cobs (68%), and white corn (60%); use of labor (family 72% and hired 28%), lack of financing (100%), no organization (96%) or participation in common tasks (48%); low production for self-consumption (100%); need for technical assistance services (88%), but only 12% are willing to pay for it and the rest want government support for everything.

It is suggested that a comprehensive technical advisory system be designed and implemented, starting with four main variables: literacy, improved varieties, planting dates, and seed and corn plant population densities on the plots of interested farmers, with the collaboration of the City Council and technicians from various institutions and disciplines.

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