AGRO PRODUCTIVIDAD

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Dynamics of agricultural practices in corn (*Zea mays* L.) cultivation in the municipality of Jilotepec, Estado de Mexico

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ABSTRACT

Objective: Determine which agricultural practices are currently used by corn (*Zea mays* L.) growers in the municipality of Jilotepec, Estado de México.

Design/methodology/approach: An individual survey composed of both open and close-ended questions was applied to 93 corn producers from the municipality of Jilotepec, Estado de México, in order to obtain information about the planting practices they carry out. From there, 10 producers were selected for on-site monitoring their plots.

Results: Maize growers in Jilotepec, Estado de México, are conscious of the genetic and cultural richness of native maize. However, the agricultural practices they use for their production are centered on the conventional agricultural model using chemical compounds obtained by chemical synthesis and a part is focused on monoculture production.

Study limitations/implications: The applied survey consisted of 13 questions, and the main limitation was the fact that it was not an extensive questionnaire because it is hard for people to devote a lot of time to this kind of polls; it is known that few questions generate more accurate information, while detailed polls have high levels of inaccuracy.

Findings/Conclusions: The results of this study showed that most of the producers are dedicated to growing native corn with a single crop per year and do not use any agroecological practices for their production or only very limited ones; they are also convinced that it is important to preserve native corn as it is a wealth for the Mexican people.

Keywords: Corn, native, culture, practices

Image by Whisker Flowers at Pixabay

INTRODUCTION

The corn (*Zea mays*) was cultivated by Mexican ancestors between 7,000 and 10,000 years ago, originated in the Tehuacán valley of Puebla (México) and in caves near the Balsas River (Zizumbo-Villareal & Colunga-García, 2010; Ramos-Madrigal *et al.*, 2016). Its ancestor is the teosintle or teosinte (Stitzer & Ross-Ibarra, 2018). The ancient settlers of Mexico through observation and expertise managed to generate several breeds with different qualities, adapted to produce in different geographic regions of the country in a diversity of climates and different altitudes above sea level (Araus *et al.*, 2012).

Nowadays there are 64 breeds in Mexico, 59 are exclusive of this country and five have been found also in other regions of the world, these breeds constitute a genetic and cultural richness (Bellon *et al.*, 2018; CONABIO, 2020). Each one of these breeds has different characteristics that make them appropriate for the elaboration of a great variety of dishes, some breeds are better for tamales elaboration such as toluqueño and the chalqueño breeds, others are better for totopos elaboration such as the bolita, the Nal-Tel and the zapalote chico breeds, others are ideal for the atoles elaboration such as the conical breed and some others are appreciated for elaboration of more sophisticated foods such as the pozole which uses cacahuacintle breed (Turrent *et al.*, 2012). The above are examples of the versatility that this crop offers in the elaboration of flours in Mexico. In addition, as result of crosses between existing breeds, several varieties or hybrid corn have been generated and are now cultivated in other regions of the world (Turrent *et al.*, 2012). For this reason, native corn has an immense and an invaluable potential for the varieties that in the future can be obtained from crosses of currently existing breed (CONABIO, 2020).

On the other hand, they not only provide a food source for humans, but also for animals, which in addition of eating their grains, also feed on the stubbles in such a way that the plant can be better used to produce forage, a source of animal feed (Boschini & Amador, 2000).

Maize has been such an important food source for the Mexican people, during the domestication of this plant as well as other crops such as beans, chili, squash, purslane, tomatoes and many others, the first Mesoamerican populations began to become sedentary and settled in specific places where they could control the growing of various crops that would allow them to subsist and so on (Zizumbo-Villareal & Colunga-García, 2010; Aguilar *et al.*, 2019). Therefore, agricultural systems began to be developed where corn was the main crop for its production, however, along this cereal, other species were cultivated, so that polyculture was established since ancient times, so the "milpa" was a system that has been managed over time, however this type of agricultural system has experienced several changes through time (Aguilar *et al.*, 2019).

When the green revolution arrived, which aimed at producing more food, caused a drastic change in the way cultivation was traditionally practiced in our country in terms of the strategies employed to keep the plants healthy and disease-free (Aguilar *et al.*, 2019). These strategies mainly promoted the use of vast tracts of land for the cultivation of a single type of plant (monoculture), and in order to increase production, it is common to use chemical fertilizers and insecticides (Martínez, 2009).

This leads to soil degradation and erosion, the loss of forests and jungles, pest resistance, and so on, which fails at protecting the environment and biodiversity (Martínez, 2009). In contrast, in Mexico exist several ways to produce food in an eco-friendly way, these practices are called agroecological, however, this type of practices are not all new (Sans, 2007). Traditionally, besides corn, other plants such as beans, squash, chili, as well as medical plants and flowers, were grown at the same time. In this system, organic fertilizers and composts are used *in situ*, and for pest control, plants or products with insecticidal or repellent properties are also used (Aguilar *et al.*, 2019).

These practices are environmentally sustainable, in other words, they contribute to the preservation of the environment and biodiversity because they are not aggressive which is not the case of insecticides or chemical fertilizers used in the cultivation of crops. Due to the increasing demand to produce more food and globalization, several practices from the conventional agricultural model have penetrated the traditional way of production in Mexico, giving way to a more sustainable form of agriculture that has significant environmental impacts (Nichols *et al.*, 2015; Sans, 2007; Martínez, 2009).

MATERIALS AND METHODS

Sample size: This study was carried out in the municipality of Jilotepec, a name derived from the náhuatl, xilotl (jilote, meaning tender cob) and tepetl meaning hill, which can be translated as "on the hill of the xilotes" or the hill of the tender ears of corn. This municipality is known for being a large corn production area in the Estado de México. The municipality has an area of 586.53 km^2 and the population consisted of 87,671 habitants in 2020, according to INEGI 2020 data.

A personal survey was applied to 93 producers in this municipality in order to obtain information about the habits and customs of corn cultivation in this part of Estado de México. After the information obtained was analyzed, 10 growers were selected to follow up *in situ* on the type of agricultural practices they carry out during production in order to photographically record the development of their fields.

Application: In order to determine the type of agricultural practices employed by corn growers in Jilotepec, a survey was conducted to find out if they are using conventional farming practices, meaning that they prefer single-crop production and use synthetic fertilizers to prevent insect pests, or whether they use agro-ecological practices that include organic composts and fertilizers which are environmentally friendlier, as well as the types of seeds they grow, whether native or hybrid. The survey consisted of thirteen questions about the crops production, whether it was for self-consumption, third-party sales or mixed production. Also, the exact location where the plot or cropland was established, in order to set up a database. As well as the number of sowings per year and the expected planting dates if they were devoted to sowing in rainy season or if they had an artificial irrigation system that could help them in case there was a delay in the rainfall system.

RESULTS AND DISCUSSION

This study was carried out in order to obtain information about different aspects related to corn cultivation in the municipality of Jilotepec de Molina Enríquez in the Estado de México (Figure 1A).

For the purpose of knowing the current situation about the type of practices used for corn production, the present study was performed between april-august 2022, initially a survey was applied to 93 producers consisting of closed and open-ended questions to have the possibility of collecting additional information that the producers might share and to allow the management of additional data. Afterwards, from the results obtained, 10 plots were selected to be followed up directly in the field until the biological material (cobs) were obtained.

After analyzing the results, most of the farmers (96.7%) obtained one harvest per year, while only 3.3% obtained two harvests per year (Figure 1B). These results suggest that most of the farmers obtain the harvest taking advantage of the rainy season because of the greater water availability and it does not generate additional costs derived from the use of systems for extraction and distribution. These activities help to keep low costs during production; farmers prefer to use these resources as supplies that are considered important to ensure their production, which are further discussed in the next section.

Another interesting feature is the way of designing the milpa, most of the farmers imitate the traditional agricultural system, which is based only on planting corn, so the monoculture is the strategy used by 60.2% of the producers, Figure 1C. The rest of the farmers (39.8%) are dedicated to multi-crop production, in addition to corn, they grow squash, chili, beans, sunflower, oats, wheat, barley and grass, in an interspersed arrangement in the plots and rotating the areas in use.

Although less than half of the growers are inclined to cultivate in the polyculture mode, a good part of them imitates the traditional way of cultivating, incorporating other vegetables

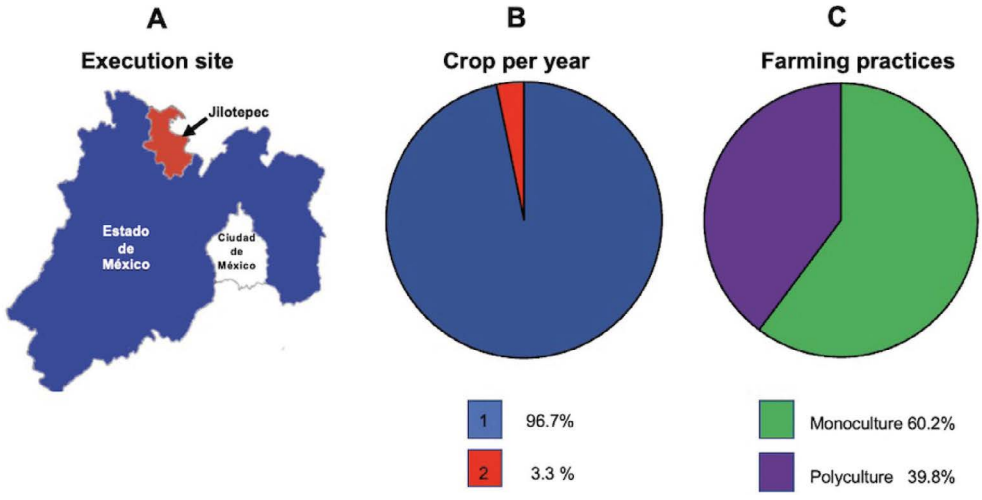

Figure 1. Study site of this work and types od agricultural practices. (A) Location of the municipality of Jilotepec in the State of Mexico. (B) Number of plantings per year carried out by producers in Jilotepec, 1 indicated in blue and 2 indicated in red. Type of planting carried put by producers, monoculture (green) and polyculture in purple.

for production. These results suggests that this type of practice, which has ancestral origins, is not entirely lost. Therefore, it is relevant that polyculture continues to be a conserved method. Because, in the same way as corn, it can preserve other plant species, besides the fact that it is produced in a more ecological way, without depleting the soil and favoring diversity.

In order to find out if farmers grow corn for self-consumption or for sale to third parties, they were asked about the area of land dedicated to this activity. The results obtained strongly suggest that the farmers interviewed are in the range of small to medium producers because the extensions of land dedicated to corn production oscillate between 0.5-5 hectares (Figure 2) and only a few of them have more land dedicated to this activity with over 10 hectares while only 1 producer reported having more than 40 hectares dedicated to corn cultivation.

Additionally, it was documented that the municipality of Jilotepec grows different corn seeds; native and hybrid varieties, both have a significant impact on the producers' preferences.

Half of the growers raise exclusively native corn (Figure 3), even though hybrid varieties tend to give higher yields per hectare, growers are aware that native corn has qualities that make it unique for production, even though in some cases the yield is lower than improved varieties. A quarter of the farmers plant only hybrid varieties and the remaining 24.7% plant native corn in combination with hybrid varieties.

Moreover, 48.4% of the producers in Jilotepec plant native corn breeds, as can be observed in Figure 3A, this percentage was readjusted as 100% to obtain a relative value regarding native breeds planted in this municipality. The results obtained show that the most sown race is the chalqueño (53.3%), followed by the cacahuacintle (23.4%), while the yellow mountain is sown by 10% of the producers, the coscomatepec race is sown by 6.5% of the producers and the negrito is the race that is sown the least, with 3.4% (Figure 3B). In the same proportion, it was found that there are producers who plant native breeds, but they could not clearly state which breeds they are. The five breeds that are planted in the municipality of Jilotepec represent 8.4% of the 59 native breeds that are registered in our

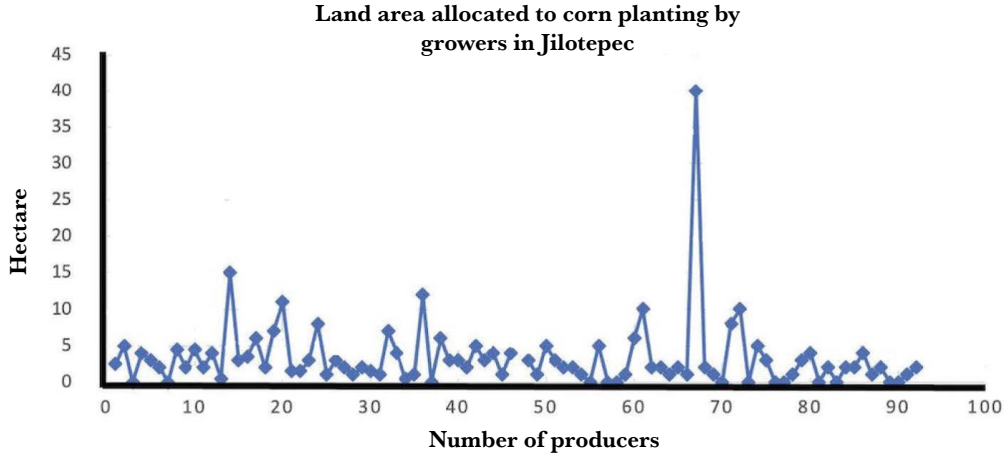

Figure 2. Number of growers and corn planting area in Jilotepec. The majority produce on 5 hectares or less.

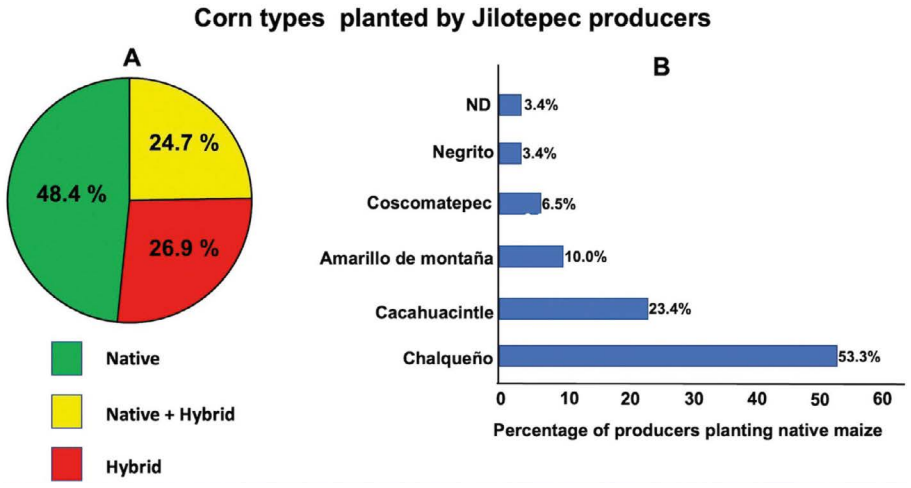

Figure 3. Types of corn seeds planted by growers in Jilotepec. (A) green=native, red=hybrid and yellow=native and hybrid. Figure B is the percentage of producers who planted only native corn as a subgroup of 48.4%. These data was readjusted to be the 100%.

country, so this part of the Estado de México is contributing to these breeds preservation. The harvest of the different breeds continues because small producers, which allows this genetic heritage to remain present for the benefit of future generations, all over Mexico and the rest of the world.

The results suggest that, despite the producers of Jilotepec prefer native seeds for production, it is also a matter of fact that hybrid varieties have become more popular, and it is noteworthy that hybrid varieties may soon displace native maize, which would be a significant loss due to the biological and cultural bastion it represents for both the country and the whole world. Such a change in the type of corn that is planted is possibly caused by experienced producers who refuse to opt for a different type of seed and usually choose the ones they have been collecting for a long time, possibly preserved, and provided by their parents and grandparents. Alternatively, companies dedicated to the production and sale of hybrid maize may provide technical support and demonstrations to growers, so that the higher yield per hectare may be a motivating factor that allows some of them to make changes towards this type of seed they must purchase, leaving aside the native seeds and adopting those generated by traditional breeding. Among the modified seeds used in the municipality of Jilotepec, it is observed an ample range of brands (Table 1), such as Asgrow, Ceres, Hartz Seeds, Bayer-Monsanto, Corteva-Agriscience.

Most of the growers recognize which hybrid they are handling from these brands. However, others do not recognize them at all and just identify the seeds according to the brand name. It is relevant to point out that they are also using seeds developed by the public sector. One of the hybrids used is HIT-7, which was developed by the Instituto de Investigación y Capacitación Agropecuaria, Acuícola y Forestal (ICAMEX) for high valleys and whose grains are white crystalline. A further hybrid used is H52, developed by the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP),

Table 1. Hybrid corn seed used.

Hybrid	Business/Institution
Albatros	Asgrow
Cenzontle	Asgrow
Cherokee	Asgrow
Cimarrón	Asgrow
Faizan	Asgrow
Niebla	Ceres
Z-25	Hartz Seeds
Z-60	Hartz Seeds
Hit-7	ICAMEX
H-52	INIFAP
unrecognized	Asgrow
unrecognized	Bayer-Monsanto
unrecognized	Corteva Agriscience

Brands and hybrids varieties used by Jilotepec's producers.

adapted for the central highlands of Mexico, a material that has been widely tested and registered in the Catalog of Feasible Varieties since 2006.

To determine whether additional supplies are used in corn production to achieve optimal yields, we asked which compounds, such as fertilizers, herbicides and pesticides, were used to increase yields. The results clearly suggest that producers, despite planting very small-scale plots (of about ¼ hectare), are using various chemical compounds. Slightly more than half of the farmers use urea and diammonium phosphate, 51.6%.

In addition to fertilizers, 16.1% of the producers use both herbicides and insecticides to avoid the risk of weeds, and to minimize and eliminate pests that could hinder the

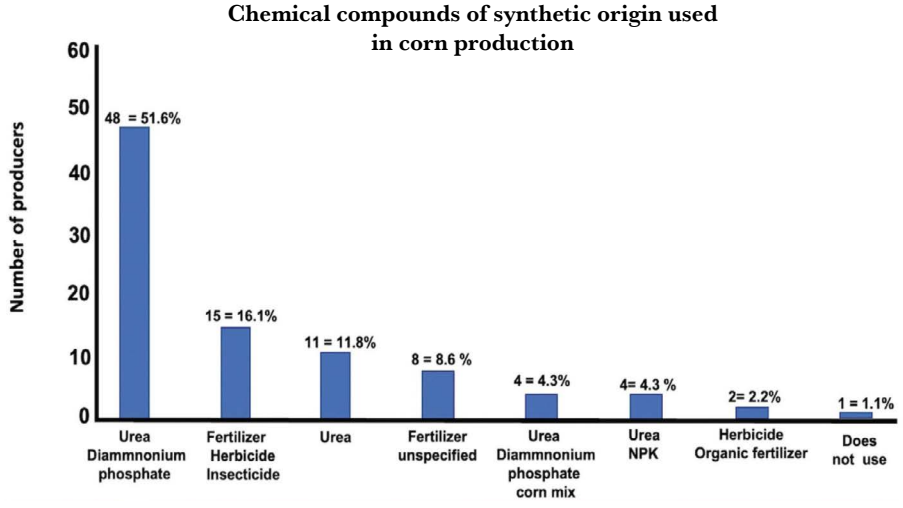

Figure 4. Commercial compounds obtained by chemical synthesis that are used in the municipality of Jilotepec for the development and growth of corn plants. They were applied alone or in combination, as indicated for slash.

normal development of the crop by severely affecting yields per hectare. On the other hand, 8.7% of the producers mentioned using chemical fertilizers to obtain favorable harvests, however, they could not specify what type of fertilizers they use in the handling of their crops. A smaller percentage of producers (4.3%) use a combination of different formulations to improve yields, *i.e.*, some use urea, diammonium phosphate and corn blend fertilizer (composed of total nitrogen, urea, nitrogen, total sulfur, boron, silicon and zinc). Another group of producers also uses urea and nitrogen,phosphorus and potassium (NPK).

Surprisingly, a remarkably low percentage reported the use of organic fertilizers, such as composts based on plant residues and animal excrements, though not exclusively because chemical compounds are also used. Only one producer mentioned not using any type of chemical compound to favor the yield of his plot. As can be seen, the use of chemical compounds is widespread among producers in Jilotepec, Estado de México, possibly because these compounds can be used to manage weeds and pests more efficiently, because the use of fertilizers results in more vigorous plants, which are able to assimilate more energy due to a healthy foliage development that results in higher yields. This can be observed at a glance since the visited plots contained healthy plants, which not only was noticed after germination since a photographic record of the selected plots was made, figure 5A-F, are examples of how these plots devoted to corn production look like, and when monitoring them, healthy maize was seen to have reached successful growth, this can be seen in figure 5A-C, with are plots under monoculture. In figure 5D-F while something similar occurs in the plots under polyculture production.

However, this kind of farming practices are not environmentally friendly, even if the compound applications are not spread over very large areas, we must not lose sight of the effect they have on these fields.

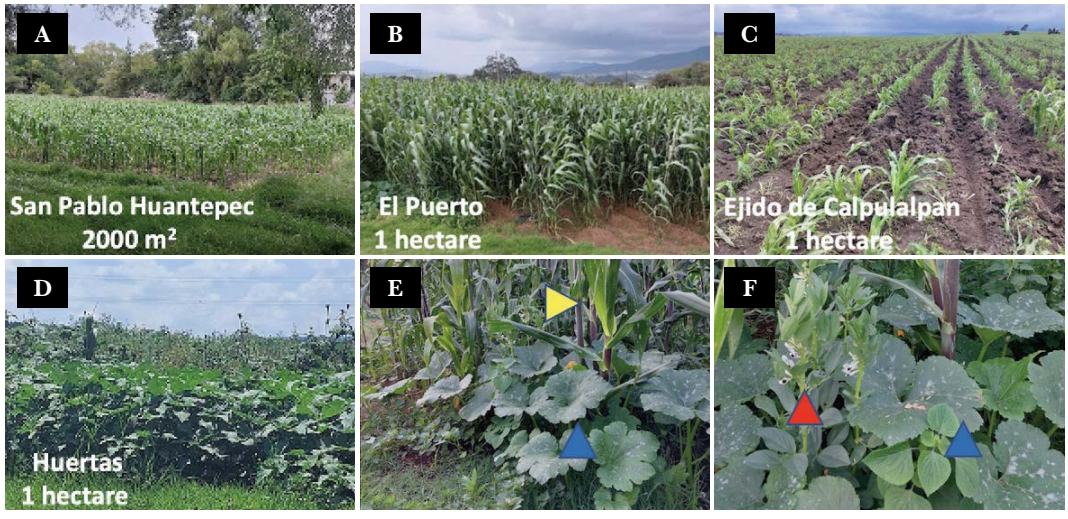

Figure 5. Plot types found in Jilotepec. A, B and C, are plots with different extension used only for maize monoculture. Plot dedicated to polyculture (D). In addition to maize (yellow triangle) could be associated with pumpkins, blue triangle (E) and broad bean, red triangle (F). E and F are close up of D.

CONCLUSIONS

The obtained results in this paper suggest that although there are several companies dedicated to certified corn seed selling that offer higher yields per hectare than native seeds, most corn producers in Jilotepec prefer native seeds, which contributes to maintain the heritage of the diverse corn breeds that are adapted to the high valleys of Mexico.

Even though the milpa was originated in pre-Hispanic Mexico, it has suffered changes in the way it is planted. One of the biggest differences is that polyculture is disappearing among Jilotepec's producers, since less than half prefer this mode of production, and the most widely used monoculture as a conventional agricultural model. In addition, the organic fertilizers to promote growth and plant development, such as the use of organic plant compounds to prevent insect pests, have been replaced by synthetic compounds, which means that traditional agricultural practices that are environmentally friendly are also gradually disappearing among the small producers in the municipality of Jilotepec, which basically use harvested crops for their own consumption and rarely for sale to third parties.

Finally, although the Jilotepec producers are not strongly implementing agroecological methods in corn cultivation, it can be mentioned that these methods are partially present in the productive activity as they favor the native corn cultivation, lean towards polyculture and do not use artificial irrigation systems, unfortunately, the use of chemical compounds is still prevalent in the plots' management.

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