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Article

Analysis of technological packages for corn production in the state of Mexico

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Abstract

Corn is a staple food in the diet of Mexicans and while its consumption is increasing, its domestic production has decreased in the same years largely due to low yields in small-scale production. This paper analyzed two technological packages developed by a public research institute in order to find alternatives to increase agricultural productivity for food security in the state of Mexico; the results were compared with the current form of production and yield, analyzing the impact of the increase in production on the costs and income of small producers. According to the results, by using the medium-impact technological package, the producer obtains a yield of 5 t ha^{-1}, their production cost will increase by $7 739.50 pesos, and their income will be higher than the costs; nevertheless, the expected profit is lower than that obtained with the current form of production. If the high-potential package is applied, with a yield of 6.5 tons per hectare, the cost increases by $13 894.50, and their profit is higher considering a flexibility price of -0.12 and a guaranteed price. With both packages, their returns are positive; therefore, the change from the current form of production to the implementation of any of the technological packages presented is financially feasible; however, only by adopting the high-potential package do they obtain profits higher than those obtained with the current form of production.

Keywords:

agricultural productivity, food security, price flexibility.

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Introduction

The state of Mexico is one of the largest producers of grain corn nationwide; according to data from the Agrifood and Fisheries Information Service-SIAP (for its acronym in Spanish) (2022), more than 1.7 million tons of grain corn were produced in 2022, with an average yield of 3.85 t ha^{-1}. In the preliminary data of the Agricultural Census of the National Institute of Statistics and Geography (INEGI), for its acronym in Spanish, 2023, it is established that 92.9% of the agricultural production units in the state of Mexico are equal to or less than 5 ha, so that grains are mainly produced in areas of small production with limited monetary, technical, and infrastructure resources; their different ways of producing give rise to variable yields and profitability (Erenstein *et al*., 2022), but insufficient to improve their income level significantly and meet market demand.

The development and diffusion of new technologies are considered effective ways to increase agricultural productivity and reduce poverty of small producers (Ruzzante *et al*., 2021); considering that the increase in supply through yield originates only if producers adopt these new technologies and transform their processes (Guerrero *et al*., 2023), science and innovation are key to sustainable production (Gaffney *et al*., 2019) in tune with local conditions (Brown *et al*., 2023).

This document makes a comparative analysis of costs and yields between the current form of production of small farmers and two technological packages developed by the National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), for its acronym in Spanish that would increase yields in production, with the aim of finding alternatives to increase agricultural productivity for food security in the state of Mexico and a higher income for the producer.

Methodology

In order to analyze the economic viability of implementing new technological packages in corn production by small producers in the state of Mexico, the agricultural technical agenda of the state of Mexico developed by INIFAP (2017) was reviewed and additional information was subsequently requested from the same Institute through the National Transparency Platform in order to have details on the technical guidelines and financial indicators.

According to the information provided, there are two proposals for technological packages; the first (Table 1) for corn cultivation of medium potential with a yield of 5 t ha^{-1} and the second (Table 2) for cultivation with high potential with 6.5 t ha^{-1}.

Table 1. Cost of the medium-potential technological package for corn cultivation.

Item	Quantity	Unit of measurement	Unit cost	Total cost	(%)
1. Soil preparation				$2 750.00	11
Plowing	1	(ha)	$1 300.00	$1 300.00	5
Harrowing	1	(ha)	$800.00	$800.00	3
Furrowing	1	(ha)	$650.00	$650.00	3
2. Sowing				$1 800.00	7
Seed	20	(kg)	$60.00	$1 200.00	5
Mechanical sowing	1	(ha)	$600.00	$600.00	2
3. Fertilization (105N-92P-90K)				$17 135.00	66
Urea (46N-00P-00K)	3	Sack (50 kg)	$1 596.00	$4 788.00	18
DAP (18N-46P-00K)	4	Sack (50 kg)	$1 559.00	$6 236.00	24
Potassium chloride (00N-00P-60K)	3	Sack (50 kg)	$1 603.00	$4 809.00	19
Micronutrients (magnesium sulphate)	1	50 kg	$402.00	$402.00	2

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Item	Quantity	Unit of measurement	Unit cost	Total cost	(%)
Labor	3	Daily wage	$300.00	$900.00	3
4. Weed control				$1 072.50	4
Herbicide Primagram	1	(L)	$305.00	$305.00	1
Herbicide Gesaprim	1	(kg)	$316.50	$316.50	1
Herbicide Hierbamina	1	(L)	$151.00	$151.00	1
Labor	1	Daily wage	$300.00	$300.00	1
5. Pest control				$1 059.00	4
Insecticide Foley	1	(L)	$459.00	$459.00	2
Labor	2	Daily wage	$300.00	$600.00	2
6. Harvesting				$2 100.00	8
Manual harvesting	4	Daily wage	$300.00	$1 200.00	5
Seed cleaning	2	Daily wage	$300.00	$600.00	2
Aluminum phosphide	1	Box	$300.00	$300.00	1
Total				$25 916.50	100

Information provided by INIFAP and March 2023 nominal prices.

For the medium-potential package, local seed varieties or early-cycle yellow-grained varieties, such as V-53, V-54, and V-55, are used (Espinosa *et al*., 2011) and in the case of the high-potential package, H-40, H-42, H-44, H-47, H-48, H-49, H-50, H-51, H-52, H-58, H-64, H-66, H-68, H-70, H-159, H-161, and H-165 are recommended (Espinosa *et al*., 2018; Espinosa *et al*., 2022).

Table 2. Cost of the technological package for high-potential corn cultivation.

Item	Quantity	Unit of measurement	Unit cost	Total cost	(%)
1. Soil preparation				$3 550.00	11
Plowing	1	(ha)	$1 300.00	$1 300.00	5
Harrowing	2	(ha)	$800.00	$1 600.00	3
Furrowing	1	(ha)	$650.00	$650.00	3
2. Sowing				$4 000.00	12
Seed	20	(kg)	$60.00	$1 200.00	4
Supplemental irrigation	2	(ha)	$700.00	$1 400.00	4
Mechanical sowing	1	(ha)	$800.00	$800.00	2
Granular insecticide (Counter 15% ai. terbufos)	1	Sack (7.5 kg)	$600.00	$600.00	2
3. Fertilization (105N-92P-90K)				$20 290.00	63
Urea (46N-00P-00K)	4	Sack (50 kg)	$1 596.00	$6 384.00	20
DAP (18N-46P-00K)	5	Sack (50 kg)	$1 559.00	$7 795.00	24
Potassium chloride (00N-00P-60K)	3	Sack (50 kg)	$1 603.00	$4 809.00	15
Micronutrients (magnesium sulphate)	1	50 kg	$402.00	$402.00	1
Labor	3	Daily wage	$300.00	$900.00	3
4. Weed control				$1 072.50	3
Herbicide Primagram	1	(L)	$305.00	$305.00	1
Herbicide Gesaprim	1	(kg)	$316.50	$316.50	1
Herbicide Hierbamina	1	(L)	$151.00	$151.00	0

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Item	Quantity	Unit of measurement	Unit cost	Total cost	(%)
Labor	1	Daily wage	$300.00	$300.00	1
5. Pest control				$1 059.00	3
Insecticide Foley	1	(L)	$459.00	$459.00	1
Labor	2	Daily wage	$300.00	$600.00	2
6. Harvesting				$2 100.00	8
Manual harvesting	4	Daily wage	$300.00	$1 200.00	5
Seed cleaning	2	Daily wage	$300.00	$600.00	2
Aluminum phosphide	1	Box	$300.00	$300.00	1
Total				$32 071.50	100

Information provided by INIFAP and March 2023 nominal prices.

For the comparative analysis of the current production system and the proposed technological package of small producers, the data of the former were constructed with reference information, such as the Agro-cost System of the Trusts Instituted in Relation to Agriculture (FIRA, 2023) for its acronym in Spanish and the paper entitled Towards the sustainability of corn (*Zea mays* L.) cultivation in Acambay, state of Mexico (Urbano *et al*., 2018) (Table 3):

Table 3. Production costs per ha with the current state of the art.

Item	Quantity	Unit of measurement	Unit cost	Total cost	(%)
1. Soil preparation				$4 700.00	26
Plowing	1	(ha)	$1 700.00	$1 700.00	9
Harrowing	2	(ha)	$1 000.00	$2 000.00	11
Furrowing	1	(ha)	$1 000.00	$1 000.00	6
2. Sowing				$2 740.00	15
Seed	20	(kg)	$77.00	$1 540.00	8
Manual sowing	4	Daily wage	$300.00	$1 200.00	7
3. Fertilization (105N-92P-90K)				$5 688.00	31
Urea (46N-00P-00K)	3	Sack (50 kg)	$1 596.00	$4 788.00	26
Labor	3	Daily wage	$300.00	$900.00	5
4. Pest, weed and disease control				$2 949.00	16
Insecticide	1	(L)	$459.00	$459.00	2
Herbicide	1	(kg)	$390.00	$390.00	2
Weeding (2)	6	Daily wage	$300.00	$1 800.00	2
Labor	1	Daily wage	$300.00	$300.00	10
5. Harvesting				$2 100.00	12
Manual harvesting	4	Daily wage	$300.00	$1 200.00	7
Seed cleaning	3	Daily wage	$300.00	$900.00	5
Total				$18 177.00	100

Documentary review data and March 2023 nominal prices.

Once the costs and yield per hectare that producers currently obtain and those that they could obtain by considering one of the proposed technological packages are known, the new probable income is determined; this change in income is determined with three possible scenarios.

The first uses the guaranteed price established in the operating rules of the program of the same name for 2023. It is worth specifying that the program in question is of national coverage and focused

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on eligible producers and the states where these grains are produced (SADER, 2022); with these clarifications, we start from the assumption that small corn producers in the state of Mexico are eligible population and the government buys their surplus production.

On the other hand, because of the forces of supply and demand in the market, higher production due to the effect of the increase in yields reduces the real price. The effect of this decrease was measured by taking as a reference the average rural price of the immediately preceding year (ARP, 2022) and the flexibility of corn prices. To obtain the flexibility of corn price, previous studies on the subject were used, considering those obtained by Hernández and Martínez (2009), who obtained a price flexibility of -0.12 and -0.38 (Martínez and Hernández, 2012); both data were taken as upper and lower limit ranges in the price decrease.

Results

Considering the 2022 average rural price, the price flexibility, and the operating rules of the Program of Guaranteed Prices for Staple Food Products for fiscal year 2023 (SADER, 2022), as well as the yields already described in the previous section, the comparison of the technical and financial indicators per hectare of the current form of production and the medium-potential technological package is as shown in Table 4.

Table 4. Comparison of technical and financial indicators for MP.

	Current state of the art	Medium-potential technological package		
		Lower limit	Upper limit	Guaranteed price
Modality	Rainfed	Rainfed	Rainfed	Rainfed
Cycle	SS	SS	SS	SS
Production costs	$18 177.00	$25 916.50	$25 916.50	$25 916.50
Yield (t ha^{-1})	3.85	5	5	5
Price	$7 728.82	$7 451.79	$6 851.55	$6 805.00
Production value	$29 755.96	$37 258.95	$34 257.75	$34 025.00
Profits ha^{-1}	$11 578.96	$11 342.45	$8 341.25	$8 108.50

In any of the price levels analyzed, the producer's income is higher than the production costs per hectare; however, it is with the current state of the art that the producer obtains the maximum profit, which is largely explained by the increase in production costs since implementing the medium-potential technological package means increasing the production costs by 42.5%.

In the same way, to implement the high-potential package, the producer would be facing an increase in production costs of 76.4%, but in this case, the maximum profit is obtained by considering the lower limit with a price flexibility of -0.12, which gives a price per ton of $7 090.44 (Table 5).

Table 5. Comparison of technical and financial indicators for HP.

	Current state of the art	High-potential Technological package		
		Lower limit	Upper limit	Guaranteed price
Modality	Rainfed	Rainfed	Rainfed	Rainfed
Cycle	SS	SS	SS	SS
Production costs	$18 177.00	$32 071.50	$32 071.50	$32 071.50
Yield (t ha^{-1})	3.85	6.5	6.5	6.5
Price	$7 728.82	$7 090.44	$5 707.28	$6 805.00
Production value	$29 755.96	$46 087.86	$37 097.32	$44 232.50
Profits ha^{-1}	$11 578.96	$14 016.36	$5 025.82	$12 161.00

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Therefore, if the small producer adopts the high-potential package under the conditions described, their additional profit will be $2 437.40 pesos per hectare considering the lower limit and $582.04 if the guaranteed price is considered.

Applying different technologies in corn production allows us to increase the total production in tons through the yield per hectare (Table 6) shows that, at the state level, production in tons increases by 30% if the medium-potential technological package is implemented and by 70% if the high-potential package is applied. This higher production in tons per hectare also represents a greater availability of a staple food product in the state of Mexico.

Table 6. Increase in state production.

	Sown area (ha)	Yield (t ha^{-1})	Production (t)
Current state	467 285.68	3.85	1 799 049.87
Medium-potential package	467 285.68	5	2 336 428.4
High-potential package	467 285.68	6.5	3 037 356.92

SIAP data on the current state of the art for sown area, production and yield in 2022.

It is worth mentioning that, given that the two proposed packages are likely to be implemented on land with the same characteristics, then we must consider other parameters when deciding on one; for example, the difference in production costs, the variety for sowing, and the availability of water for supplemental irrigation in the case of the high-potential package.

Discussion

In the technological packages proposed by INIFAP and included in this work, it is considered that the potential areas for corn production in the state of Mexico are located between 2 201 and 2 800 masl, without naming specific areas with potential; Sotelo *et al*. (2016) generate a multicriteria analysis methodology for identifying and delimiting areas suitable for corn production by using climate, soil, and physiography information; both studies can be used in a complementary way in order to locate the ideal areas for implementing the medium-potential package and the areas where it is worth applying the high-potential package.

The study by Ramirez and García (2018) estimated the productive potential of corn (*Zea mays* L.) in the state of Mexico; they obtained that the municipalities of Toluca and Texcoco have greater growth capacity with an estimated yield of 4.63 and 4.24 t ha^{-1} and conclude that, if the potential production were reached, food self-sufficiency in white corn would be achieved; both estimated yields are lower than expected if the technological packages proposed by INIFAP were implemented. Orozco *et al*. (2017) analyzed production variables of different products, including corn and warned of scenarios of vulnerability and diminishing yields; they also add that the average rural price and program support are determining factors to maintain its contribution to the value of production.

Conclusions

Implementing a new form of production implies an increase in production costs that will later be reflected in a positive profit; nevertheless, not in all the scenarios analyzed does it represent a higher income for the producer; what is certain is that the corn producer would immediately have to be able to face this additional cost. One way to deal with this increase in production costs will be through the implementation of government actions with the aim of increasing the availability of a staple food product and in cases where it is convenient for the producer, such as in the package with high potential and lower limit of flexibility, price in which their profit increases considerably, access to agricultural credit, an issue that must be thoroughly investigated locally.

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