

Profitability and comprehensive competitiveness of grain maize in a municipality in economic transition

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ABSTRACT

Objective: to evaluate the private, social and environmental profitability and competitiveness of the production systems of native (Creole) and improved (modified) grain maize in rainfed and irrigated regimes in San José de Gracia, Aguascalientes.

Design/Methodology/Approach: for data collection, participant observation techniques, surveys and official sources from Mexico's National Foreign Trade Information System (SNICE), and the Tax Revenue Administration Service (SAT) were applied. A specific questionnaire was designed for grain maize producers in San José de Gracia to record inputs and production costs. Environmental (reduction of agrochemicals) and private assessments were performed with the Policy Analysis Matrix (MAP) methodology. The social analysis was based on the SAGARPA-FAO methodology for intermediate inputs, considering variables such as tariffs, taxes, inputs, subsidies, insurance-freight costs, transport costs, fuel prices and exchange rate.

Results: a 64.9% of grain maize production was profitable, competitive, and efficient. The presence of agricultural policies and market distortions improved profitability by 37.43% and competitiveness by 12.08% of grain maize production. On the other hand, these indicators were reduced by 20% and 5.3% when implementing environmental strategies.

Findings/Conclusions: at market and economic prices, the improved grain under irrigation presented the highest profitability and the Irrigated Creole system, the greatest competitiveness. In the environmental analysis, the Creole grain maize production system under irrigation showed competitiveness and profitability. However, these indicators were below the values assessed at private costs.

Keywords: sustainability, agricultural policy, private cost, social cost, environmental cost.

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INTRODUCTION

The production of grain maize in Mexican agriculture presents a constant dynamism in the technological, organizational and competitive spheres, moreover after the commercial opening of Mexico in 1994 (De Grammont, 2010; González & Alferes, 2010). This crop has not only been fundamental for food security, but also a central element in the construction of the country's cultural identity. Along these lines, Mexico's Secretariat of Agriculture



and Rural Development (SADER, 2023) emphasized that maize, in addition to being a staple in the national diet and a cultural reference, constitutes a strategic component of the Mexican economy.

However, the use of some production inputs in agriculture, such as commercial agrochemicals, has negative impacts on the environmental system (del Puerto *et al.*, 2014), which compromises the productivity and profitability of the sector in the short, medium and long term.

During the first two decades of the twenty-first century, the state of Aguascalientes experienced economic growth driven by a transition to industrialization, with special dynamism in the automotive sector (López, 2017). This process had a direct impact on agriculture activities, as the population employed in the primary sector decreased from 6% of the state total in 2013 to 3.8% in 2024 according to Mexico's National Institute of Statistics and Geography (INEGI, 2014, 2025). In contrast, employment in the manufacturing sector registered a 2.2% increase in the same period, which reflects a progressive transfer of the rural labor force to this sector. As a result, a growing desertion from agriculture was observed, with negative effects on the profitability of grain maize production in the municipality of San José de Gracia.

Another relevant phenomenon was the economic diversification of some producers towards religious tourism, based on the declaration of San José de Gracia as a Magical Town (Vargas & Rodríguez, 2021). This reorientation reduced attention to agricultural production processes and drove a 62% decrease in the area planted with grain maize. Grain yield decreased from 3594 ha⁻¹ in 2014 to 1366 ha⁻¹ in 2024, according to Mexico's Agrifood and Fisheries Information Service (SIAP, 2025). Such a reduction impacted both the profitability and competitiveness of producers dedicated to this crop.

Currently, agriculture develops within the framework of an international trade network. This requires the implementation of strategic policies that promote sustainable production at the local and national scales. In this context, to provide a comprehensive evaluation of the current situation of grain maize production, providing farmers and agricultural policymakers with well-founded arguments to identify opportunities that improve profitability and competitiveness for this crop, the objective of this research was to evaluate the private, social, and environmental profitability and competitiveness of the production systems of native (Creole) and Improved (modified) grain maize in rainfed and irrigated regimes in San José de Gracia, Aguascalientes.

MATERIALS AND METHODS

The research was conducted in the municipality of San José de Gracia, Aguascalientes, under a semi-humid temperate climate in the western zone and a temperate semi-dry climate in the remaining semi-flat zone, at an average 17 °C annual temperature (INEGI, 2024a).

The sample size was determined by applying the formula developed by Aguilar (2005), which is based on the calculation for finite populations, guaranteeing municipal representativeness.

$$n = \frac{Z^2 N p q}{(N - 1) d^2 + Z^2 p q}$$

where: n =sample size (85); N =maize grain production units (762); Z =confidence level (95%); d =absolute accuracy 0.1; and q =0.5 expected ratio.

The number of production units that constituted the population was taken from data of Mexico's National Institute of Statistics and Geography (INEGI, 2024b).

Surveys were administered through chain sampling. This technique, as it is based on reference networks (Arrogante, 2022), facilitated the participation of rainfed producers, who formed 78% of the sample, compared to 22% of producers with an irrigation regime.

The research was based on the analysis of profitability and competitiveness of four production systems of grain maize: i) Rainfed Native (Creole) grain maize; ii) Irrigated creole grain maize; iii) Rainfed Improved grain maize; and iv) Irrigated improved grain maize. The production systems Irrigated Creole grain maize (ii) and Rainfed improved grain maize (iii) were also evaluated environmentally; this meaning a decrease in the application of commercial agrochemicals in the cultivation activities of both systems in the municipality.

In order to determine the predominant activities and factors in the production of grain maize, information was collected by administering a specific questionnaire to maize producers of San José de Gracia (Aguascalientes, Mexico), and the national accounts for this crop, which provided the technical support for the construction of a matrix for policy analysis (MAP). This was created based on area planted, costs of tradable inputs, costs of factors of production, profits, volume of production, yields, taxes and subsidies.

After the MAP (Monke & Pearson, 1989) was integrated, we performed statistical analysis with SPSS v.27 ($\alpha=0.05$). Economic (Private) profitability was obtained by discounting private costs from private income. Social profitability was obtained by discounting social costs from incomes measured at social prices. Net transfers were obtained from the difference between private and social profitability. Private and social competitiveness were determined by the benefit/cost ratio (Table 1).

In accordance with the methodology proposed by Mexico's Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food, and the United Nations Food and Agriculture Organization (SAGARPA & FAO, 2008), social prices were estimated for the valuation of intermediate inputs. To this end, government sources were used, such as Mexico's National Foreign Trade Information Service (SNICE, 2022) and Mexico's Tax Revenue Administration Service (SAT, 2022), from which information was obtained regarding tariffs, taxes, inputs, subsidies and exchange rates.

The environmental assessment was developed through the MAP, in which the application of agrochemicals such as Sealant and Cypermethrin was reduced, as the use of production factors such as labor increased, by encouraging producers to do so. Therefore, in rainfed conditions, this analysis was called MAP environmental evaluation.

Table 1. Policy Analysis Matrix to evaluate production systems of grain maize in San Jose de Gracia, Aguascalientes, Mexico.

	Income	Costs		Profitability
		Tradable inputs	Factors of production	
Private prices	A	B	C	D
Social prices	E	F	G	H
Divergences	I	J	K	L
Private Profitability	D=A-B-C			
Social Profitability	H=E-F-G			
Transfers through the product	I=A-E			
Transfers through inputs	J=B-F			
Transfers through factors of production	K=C-G			
Net transfers	L=D-H			
	L=I-J-K			

Source: modified from Monke & Pearson (1989).

To assess the status of grain maize production, we used the summary coefficients proposed by Monke and Pearson (1989).

Nominal Protection Coefficients (NPCs) for commercial products and inputs; This indicator reflects the impact of fiscal policies on products and inputs, either through subsidies or taxes. Regarding the NPC for products, the value of $NPC > 1$ indicates that the market price is higher than the social price. On the other hand, a value of $NPC < 1$ for tradable inputs indicates that their market prices are below those that would prevail without the intervention of such policies.

$$NPC \text{ products} = \frac{\text{Income at private prices}}{\text{Income at social prices}}$$

$$NPC \text{ inputs} = \frac{\text{Cost of tradable inputs at market prices}}{\text{Cost of tradable inputs at social prices}}$$

Effective Protection Coefficients (EPCs) which allow for a comprehensive evaluation of the incentives granted to producers. The value of $EPC > 1$ reflects the presence of subsidies to producers, while a $EPC < 1$ value gives evidence regarding the application of taxes to producers.

$$EPC = \frac{\text{Income} - \text{Cost of tradable inputs at market prices}}{\text{Income} - \text{Cost of tradable inputs at social prices}}$$

Coefficient of the Cost of Factors of Production (CFP) that is a measure of efficiency and the presence of comparative advantages in agriculture production. The value of $CFP > 1$ indicates that the value of the factors used in the production process

exceeds the value added, when calculated at social prices. On the other hand, a $CFP < 1$ indicates that the producing area has comparative advantages in the crop analyzed.

$$CFP = \frac{\text{Cost of the workforce} + \text{Cost of capital}}{\text{Income} - \text{Cost of tradable inputs}}$$

RESULTS AND DISCUSSION

Profitability and private competitiveness of grain maize

Private profitability of grain maize expressed the economic situation of agricultural private producers (Table 2). This assessment considered the costs of tradable inputs, factors of production, and government inputs.

Under the irrigation regime, the costs averaged at 24 116.83 MXN \$ ha⁻¹; on the other hand, in rainfed regime costs reached an average of 9879.025 MXN \$ ha⁻¹. The cost analysis indicated that the farmers with the highest profitability and competitiveness were those who obtained higher grain maize yields, despite they paid high total costs.

At market prices, 64.9% of the grain maize produced in San José de Gracia was profitable; which was the corresponding to the systems under irrigation. The improved grain with irrigation system presented the highest yield with 7.2 tons (Megagrams) per hectare [Mg ha⁻¹]. Regarding competitiveness, the production system of Creole maize under irrigation reached 83.3%, which represents the greatest private competitiveness with an economic recovery of 78% for each \$ MXN (Mexican peso) invested.

At the opposite extreme of the range, the rainfed systems lacked profitability and competitiveness, registering an average yield of 0.525 Mg ha⁻¹. These systems presented economic losses when investing in agricultural production, estimating that, on average, 0.65 \$ MXN is lost for each Mexican peso invested. This can be attributed to irregular rainfall in the region, and to the lower use of inputs in this small-scale production.

The production system of irrigated Creole maize, evaluated from an environmental perspective, showed profitability and competitiveness, with a cost of compliance with the environmental standard of 2815 \$ MXN per hectare. In contrast, the improved (modified) grain maize in rainfed condition lacked profitability and competitiveness, recording an environmental cost of 3588.75 \$ MXN ha⁻¹. Overall, the environmental assessment showed no evidence of improvement in these indicators; moreover, an average reduction of 20% in profitability and 5.3% in competitiveness was observed, at market prices.

Table 2. Budget for grain maize production systems at private prices, and environmental evaluation in San Jose Gracia, Aguascalientes, Mexico.

Production systems for grain maize						
	i) Rainfed Creole	ii) Irrigated Creole	iii) Rainfed Improved	iv) Irrigated Improved	Irrigated Creole (Environmental)	Rainfed improved (Environmental)
Profitability MXN \$ ha ⁻¹	-7948.0	17 761.0	-4980.05	18 215.33	15 496.60	-5216.25
Competitiveness	0.32	1.78	0.38	1.71	1.70	0.35

Creole: native grain maize; Improved: modified grain maize variety.

In the national private production of grain maize, competitiveness reached 72.3% and profitability 86.9% (González & Alferes, 2010). With these values as reference, the municipal production we evaluated, presented levels of profitability and competitiveness lower than the national averages of Mexican grain maize production. These results suggest the need to improve management practices and strengthen policies and support to bring local indicators (at San Jose de Gracia, Aguascalientes) closer to domestic values (Mexico's national scale).

Social Profitability and Competitiveness of grain maize

Social profitability and social competitiveness of grain maize production were estimated under social efficiency prices, that is, without the influence of market distortions or public policies (Table 3).

This approach made it possible to contrast the results obtained with the actual situation of the producers; as well as, discussing to what extent Mexican Government interventions modified the economic viability of grain maize cultivation.

Compared to the private analysis, profitability and social competitiveness both registered reductions (37.43% and 12.08%). The production system of improved grain with irrigation showed the highest social profitability, followed by the Creole in irrigation system. In contrast, the production systems under rainfed condition did not present competitiveness or profitability. Social costs under rainfed conditions reached an average 10 158.17 MXN \$ ha⁻¹; on the other hand, irrigation costs averaged 26 377.03 MXN \$ ha⁻¹.

Production under irrigation regimes obtained average social benefits of 0.54 MXN ha⁻¹ (*i.e.* 54 cents for each Mexican peso invested per hectare). On the other hand, the systems under rainfed conditions lacked competitiveness, which translated into average economic losses of 70% MXN \$ ha⁻¹ [70 cents for each Mexican peso invested per hectare] (Table 3).

The Irrigated Creole production system, when it was environmentally evaluated at social prices, maintained profitability and competitiveness, even considering the cost of compliance with the standard for sustainability (2818 MXN ha⁻¹). This level of performance reflects greater resilience to environmental demands and a solid productive capacity to adapt. In contrast, the improved maize in rainfed condition presented unfavorable indicators, with a cost for compliance with the environmental standard of 791.65 MXN ha⁻¹. This is evidence of, even though the environmental cost was lower, low productivity prevented achieving conditions of profitability and competitiveness.

Table 3. Budget for production systems of grain maize at social prices, and environmental evaluation in San Jose Gracia, Aguascalientes, Mexico.

Production systems of grain maize						
	i) Rainfed Creole	ii) Irrigated Creole	iii) Rainfed improved	iv) Irrigated improved	Irrigated creole (environmental)	Rainfed improved (environmental)
Profitability MXN \$ ha ⁻¹	-9095.14	14 003.87	-5391.20	14 902.08	11 130.37	-6236.15
Competitiveness	0.23	1.54	0.36	1.55	1.43	0.31

Creole: native grain maize; Improved: modified grain maize variety.

This difference underscored the structural vulnerability of rainfed production systems and highlights the importance of strengthening technological water management in these schemes to prevent sustainability requirements from becoming an additional barrier to their economic viability.

Net Transfers: Grain Maize

The benefits transferred to grain maize production systems by Mexican Government market policies were assessed at private prices (Table 4). Creole grain under irrigation showed the highest transfer, with a benefit of 21.15%, followed by the improved grain in irrigation system (18.18%); then the rainfed Creole (14.43%), and the rainfed improved grain (8.25%). All of this shows the significant differences of the influence of government policies and the market on each production system.

Efficiency of grain maize production systems

Local grain maize producers obtained private support through the prices of the products. In contrast, the rainfed production system of improved grain maize did not show such economic aids, since its nominal protection coefficient for the commercial product was equal to 1 (Table 5).

The level of input prices for the irrigation and rainfed regimes were below the prices obtained in the absence of market distortions and Government policies. This indicated the presence of subsidies, reflected in the nominal protection coefficients for products and tradable inputs whose values were less than 1. Overall, the nominal protection coefficients for products and inputs showed that the production systems of grain maize, irrigated creole, rainfed improved, and irrigated improved, received economic supports, while the creole grain maize production system in rainfed condition presented levies.

Table 4. Net transfers for grain maize cultivation in San Jose de Gracia, Aguascalientes, Mexico.

	Rainfed Creole	Irrigated Creole	Rainfed improved grain	Irrigated improved grain
Private Profitability MXN \$ ha ⁻¹	-7948	17761	-4980.05	18215.33
Social Profitability MXN \$ ha ⁻¹	-9095.13	14003.86	-5391.20	14902.08
Divergences MXN \$ ha ⁻¹	1147.13	3757.13	411.15	3313.25

Table 5. Summary coefficients for the production systems of grain maize in San Jose de Gracia, Aguascalientes, Mexico.

Production system	Nominal Protection Coefficient		Effective Protection Coefficient	Costs of factors of production
	Product	Input		
Rainfed Creole maize	1.36	0.96	0.23	-5.00
Irrigated Creole maize	1.01	0.81	1.17	0.38
Rainfed Improved maize	1.00	0.81	1.51	7.52
Irrigated Improved maize	1.05	0.92	1.13	0.42

The combined effects of the policies on tradable goods markets indicated that only the rainfed creole maize producers faced levies, since the value of their EPCs turned out to be less than 1. The value of $EPC < 1$ can be attributed to the fact that the budget of the net supports was insufficient. This can be explained by the absence, or inadequacy of direct subsidies, as well as by market distortions or low-cost imports.

The grain maize production systems under the irrigation regime showed comparative advantages because they yielded coefficients of cost of the factors of production less than 1, around the levels reached at the national scale, 43.2% (González and Alferes, 2010). However, these indicators (profitability, competitiveness, and efficiency) are insufficient compared to other competing sectors of the labor market, such as the automotive industry or the local religious tourism, which are respectively 166% and 320% more profitable. In regard to the wages per agricultural worker, they obtained average benefits of 36.16 monthly minimum wages, while the automotive industry and religious tourism pay respectively, amounts of 47.68 and 77.13 minimum wages. According to Mexico's National Commission on Minimum Wages (CONASAMI, 2023), the minimum wage in 2024 was \$ 248.93 MXN, which indicates greater benefits and economic opportunities for workers in the manufacturing and tourism production chains (SALARYEPLORER, 2024).

CONCLUSIONS

At market and private prices, the irrigated improved grain production system presented the highest profitability, whereas the irrigated creole grain production system was superior for greater competitiveness. In the environmental analyses, both systems under irrigation regime maintained conditions of competitiveness and profitability. However, these indicators were lower compared to those obtained in the evaluation at private prices.

As a recommendation, it is suggested to implement policies and support that allow producers to internalize environmental costs without compromising profitability and competitiveness. This can strengthen the economic and environmental sustainability of grain maize production, as well as improve the resilience of irrigation systems while facing productive and climatic challenges.

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