Private Sector Profitability of Maize Production in the Bajío Region of Guanajuato, Mexico

Rentabilidad Privada de la Producción de Maíz en la Región Bajío de Guanajuato, México

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Abstract. *Agriculture, generally speaking, is the basis of the food system of any country. Mexico's maize crop is particularly important, not only in terms of food security but also as in terms of culture and identity. The fact that, in recent decades, Mexico has positioned itself as the second largest importer of maize is worrying. For the purpose of measuring the private sector profitability of maize production in the Bajío region of Guanajuato, this study analyzed data from 2,996 producers who participate in the "High Yield Maize Assessment Program (PROEMAR)", of the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias- Bajío Experiment Camp (INIFAP-CEBAJ). We used the Policy Analysis Matrix (PAM) developed in 1989 by Monke and Pearson. The results indicate that the benefit-cost ratios of the three technological systems analyzed (considering in their total income, the sale of grain and sub products), were 2.20 for rainfall (T); 1.50 for irrigation with livestock (RCA) and 1.01 for irrigation without livestock (RSA), excluding land costs; including land costs decreased the ratios to 2.13, 1.35 and 0.91. The private cost ratio (RCP), excluding the land, by production system was: T = 0.04, RCA = 0.13 and RSA = 0.85, which implies that the maize producers in the Bajío region of Guanajuato are competitive. When including land rent in the production costs, the rainfall and irrigation with livestock systems remained competitive with a RCP of 0.07 and 0.32, respectively; not so for the production unit with the irrigation system without livestock (2.04). The most significant input was fertilizer costs, which represented 50% of the costs.*

Key words: *Benefit-cost, private cost ratio, competitiveness, net income.*

Resumen. *La agricultura en general es la base del sistema alimentario de cualquier país. En México el cultivo de maíz es de especial importancia, no solo en términos de seguridad alimentaria sino también como parte de su cultura e identidad. El hecho de que durante las últimas décadas México se ha posicionado como el segundo importador de maíz a nivel mundial, resulta preocupante. Con el propósito de medir la rentabilidad privada de la producción de maíz en el Bajío de Guanajuato, se analizaron los datos de 2,996 productores que participan en el "Programa de Evaluación de Maíz de Alto Rendimiento (PROEMAR)", del Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias-Campo Experimental Bajío (INIFAP-CEBAJ). Se usó la Matriz de Análisis de Política (MAP) desarrollada en 1989 por Monke y Pearson. Los resultados indican, que las relaciones beneficio-costo de los tres sistemas tecnológicos analizados (considerando en su ingreso total tanto la venta del grano como de subproductos), fueron de 2,20 en temporal (T); 1,50 en riego con actividad pecuaria (RCA) y 1,01 en riego sin actividad pecuaria (RSA), esto excluyendo la tierra de los costos de producción, mientras que incluyendo la tierra la relación disminuye a 2,13, 1,35 y 0,91. La relación del costo privado (RCP) excluyendo la tierra por tecnología fue: T=0,04, RCA=0,13 y RSA=0,85, lo que implica que el productor de maíz en la región Bajío de Guanajuato es competitivo. Al incluir la renta de la tierra en los costos de producción, los sistemas de temporal y riego con actividad pecuaria siguen siendo competitivos con una RCP de 0,07 y 0,32, respectivamente; no así la unidad de producción bajo el sistema de riego sin actividad pecuaria (2,04). El insumo con mayor importancia en los costos fueron los fertilizantes representando un 50 % de los costos.*

Palabras clave: *Beneficio-costo, relación costo privado, competitividad. Ingreso neto.*

In the agricultural sector in 2010, maize (*Zea mays* L.) was the second most important product produced globally with 840.3 million tons (Mt) after sugarcane (1,711.1 Mt); rice was in third place (696.3 Mt). In terms of value, rice topped the list with 180,479 million dollars (MUSD) followed by products of an animal origin: whole milk (179,820 MUSD), beef (172,301 MUSD), pork meat (167,713 MUSD), chicken meat (122,300 MUSD) and in tenth place was maize with 54,312 MUSD (FAO, 2012).

During 2000-2009, global maize production averaged over 700 Mt. The United States was the largest producer of maize with 279.8 Mt on average, followed by China and Brazil with 136.1 Mt and 43.9 Mt. In fourth place was Mexico (20.9 Mt). For global maize trade in 2010: a) the United States led world grain exports (but 5.7% lower than in 2008) at 50.9 Mt and 10,110 MUSD in value, representing 47% of the total amount of maize exported globally, followed by

Argentina and Brazil with 16.2 and 10%; Mexico was in sixteenth place with 558,617 t (111.3 MUSD), b) in terms of imports, Japan ranked first in maize import volume with 16.2 Mt, representing 15% of total world grain, followed by South Korea (8.5 Mt, 7.9%), Mexico (7.8 Mt, 7.3%), China and Egypt (6.2 Mt, 5.8% each one) and Iran (5.8 Mt, 5.4%) (FAO, 2012).

In Mexico, during 2011, 7.8 million hectares of maize were planted and the states that allocated more hectares for maize included: Sinaloa (10.8%), Chiapas (9.18%), Jalisco (7.8%), Oaxaca (7.76%) and Puebla (7.6%). For production during 2010-2011, Sinaloa produced 19.9% (8.2 Mt) of the total maize production, followed by Jalisco with 14.4% (5.9 Mt), Chiapas (7.2%, 2.95 Mt), Michoacan (7.1%, 7.91 Mt) and Guerrero (6.7%, 2.7 Mt) (SAGARPA-SIAP, 2011).

For yield in 2011, it is important to differentiate by hydric condition: a) in Chihuahua, irrigation recorded 8.6 tons per hectare (t ha^{-1}) followed by Guanajuato with 7.8 t ha^{-1}, Aguascalientes and Nayarit with 7.7 t ha^{-1}, and in fifth place was Sinaloa with 7.5 t ha^{-1}, b) under rainfall conditions, Jalisco, Nayarit, Colima and Morelos recorded 4.7, 3.9, 3.7 and 3.1 t ha^{-1}, while Guanajuato ranked 13 with 1.57 t ha^{-1} (SAGARPA-SIAP, 2011).

Statewide, according to statistics from the State Information Office for Sustainable Rural Development (OEIDRUS), maize remains one of the most representative crops in Guanajuato. Between 2000 and 2009, cultivation averaged 407,222 ha, while the harvested area averaged 315,364 ha and production has averaged around one million tons under irrigation and rainfall conditions. The maize production in Guanajuato by irrigation districts (DDR) in 2009 behaved as follows: Cortazar DDR contributed 59%, followed by 23.14% from the Leon DDR, while the northern area of the state was represented by the San Luis de la Paz DDR which contributed 2.2%. For yield, the Cortazar DDR averaged 5.7 t ha^{-1}, while the state average reached 3.8 t ha^{-1}; in terms of production value, this district contributed almost 50% with 1.3 million mexican pesos (MXN) (OEIDRUS-GTO, 2011).

Within the production of basic grains, some of the main economic sectors of greatest impact on production costs are the factors that limit the growth of crops and the use and management of water and chemical fertilizers (Fixen, 2010). The lack of suitable methods of production has affected the ability of the soil to produce. Paradoxically, the use of maize

varieties with higher yield potentials and intensive production systems requires the use of greater amounts of fertilizer. This results in a high production cost and the oil crisis and increased natural gas have caused a disproportionate increase in the price of fertilizers, which significantly affects the economy of the producers (Castellanos, 2005). This results in low yields, undermining the interest of producers to continue production in corn or other crops to the extent of selling their land or renting them out. Added to this, the adoption of alternatives that would reduce costs and improve soil conditions, such as conservation tillage[1], has been slow due to entrenched habits and the stalks from the burning of stubble and excessive soil movement to prepare the ground for planting (Govaerts, 2010).

To contribute to the characterization of this problem and the generation of solutions, this paper analyzed the private sector profitability of corn production systems in the Bajío region of Guanajuato with three different water-technology environments. The research hypothesis was that the entry of fertilization represents more than 50% of total production costs.

MATERIALS AND METHODS

Information was collected on: amounts of tradable inputs, internal factors of production, products and sub-products, in addition to input prices, products and sub-products; differentiated for three technologies (rainfall (T), irrigation with livestock (RCA) and irrigation without livestock (RSA)) via a survey form that integrated crop management information, soil and maize production costs of the spring-summer 2010 production period for 2,996 farmers participating within the framework of the "High Yield Maize Assessment Program (PROEMAR)", which represented 93% of the region total (T = 34%, RCA RSA = 38% and = 28%); the program is managed and coordinated by the Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias-Bajío Experiment Camp (INIFAP-CEBAJ). The municipalities of Guanajuato that participated

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[1] Also known as zero tillage: A soil preparation technique consisting of the use and management of previous crop residues to continue and maintain a nutritional balance mineral cycle. Its fundamental principle is to increase the organic matter content without "flipping" the ground so that it forms a structure with sufficient aggregates and biological life, obtaining a decisive effect and preventing erosion, reducing the presence of weeds and restoring soil fertility (Navarro, 2011).

in the study were: Abasolo, Acambaro, Apaseo el Grande, Celaya, Cortázar, Huanimaro, Irapuato, Jaral del Progreso, Jerecuaro, León, Penjamo, Purísima del Rincón, Romita, Salamanca, Salvatierra and Valle de Santiago.

The Policy Analysis Matrix (PAM) developed by Monke and Pearson (1989) was used to concentrate and process the information, building double-entry matrix columns counted in the categories of incomes, costs and profits and, in the rows of private prices, the economic prices and the effects of policy. For the development of the matrix, it was essential to build technical coefficient matrices, prices and private budgets, to determine levels of income, expenses and profits of the production units (Table 1).

Table 1. Structure of the Policy Analysis Matrix used to evaluate maize production in Bajío of Guanajuato, Mexico.

Concept	Total Income	Production costs		Profits
		Tradable inputs	Internal factors	
Private prices	A	B	C	D
Economic prices	E	F	G	H
Policy effects	I	J	K	L

Where: Cost of production to private prices: CP=B+C; Production costs to economic prices: CE=F+G; Profit to private price: D=A-B-C; Profit to economic prices: H=E-F-G; Transfer by product price: I=A-E; Transfer by input prices: J=B-F; Transfer by internal factors prices: K=C-G Total transfer or total effect of policies: L=I-J-K or L=D-H.
Source: Monke and Pearson, 1989.

The PAM was determined by two accounting identities: the first measured the profit as the difference between the incomes and production costs and the second set the policy effects, determined by the differences between private and economic evaluations of incomes, costs and profits; in this study, the analysis was performed only in the first row, which corresponded to the array information private budget. The empirical evidence indicates that this tool has been widely used in Mexico; for example, Arreola (1997) conducted an economic analysis of production technologies of basic grains in Michoacan; Lara *et al.* (2003) measured the competitiveness and comparative advantages of milk production systems in Jalisco; Hernández *et al.* (2004) determined the competitiveness and profitability of the production of tomato (*Lycopersicon esculentum* L.) in Sinaloa; Guzman *et al.* (2004) analyzed the private sector profitability of red raspberry (*Rubus idaeus* L.) produced in Valle de Bravo, Mexico; Hernández *et al.* (2008) analyzed the private sector profitability of pig farms in southern Mexican states; González and Alferes (2010) determined the competitiveness and comparative advantage of maize production nationwide; Rebollar *et al.* (2011a) determined the competitiveness and profitability of cattle production in feedlots in southern Mexican states; Rebollar *et al.* (2011b) measured the profitability of potato (*Solanum tuberosum* L.) crops in the southwest of Mexico and Rodriguez *et al.* (2013) analyzed the competitiveness of Rural Production Units in Santo Domingo and San Jacinto Teojomulco Tlacotepec in the Sierra Sur of Oaxaca. Jiménez and Quirós (1999) applied the methodology of policy analysis matrix (PAM) in potato cultivation in Costa Rica; Esmaeili (2008) measured the competitiveness of shrimp farming in Southern Iran and Reig *et al.* (2008) used a policy analysis matrix with profit-efficient data for evaluating profitability in rice cultivation.

Private sector profitability. The information that was incorporated into the first row of the table of the PAM provides an estimate of private returns, which was derived from private budgets. The private term refers to incomes and observed costs that reflect current market prices that are received or paid by the producer. In Table 1, the private sector profits (D) are the difference between incomes (A) and costs (B + C), where all the entries in the top row estimated private prices.

The private sector profitability calculations show the competitiveness of the production system, given current technologies, product values and costs of inputs and transfer policies. The cost of capital is defined as income before tax to capital holders required to remain invested in the system, is included within the cost of internal factors (C), the profits (D) are higher than normal income of producers within the system. The

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competitiveness of agricultural activity is calculated by the private profit ratio (RRP), a division of the profit (G) between the total cost of production (B + C), which include investment in tradable inputs and internal factors; this is commonly known as benefit-cost ratio (Monke and Pearson, 1989).

Private cost ratio. To compare identical product systems that generate private sector profits (D: A-B-C), the competitiveness under existing policies was shown. The analysis of private sector earnings is not enough; the performance results are residual and systems may come from different levels of inputs used to produce goods that may also have substantial differences in prices.

The private cost ratio (RCP) allows for private efficiency comparisons between two different production systems, it is a ratio of internal factor costs (C) and value added (A-B) at private prices. RCP indicates how a production system, in terms of efficiency, can sustain the payment of internal factors (including normal capital remuneration) while still remaining competitive; this is the equilibrium point after normal profit, where

(A-B-C) = D = 0. When D>0 excess earnings as a result of the internal factor cost are less than the value added to private prices (Monke and Pearson, 1989).

RESULTS

The MAP allowed for the analysis of the results under two scenarios: excluding and including the land in the producer's costs for private or market prices for the technologies evaluated.

Cost structure. For the maize production excluding land in the study region, the entry with the greatest impact on costs was tradable inputs (which are inputs or parts thereof, which are available in the markets, both domestic and international) with values of 91% for rainfall and 83.4% for irrigation, with and without livestock. Within these, fertilizer was where the producer payment was higher, with 71.1 and 58.8%, with the same technical order, followed by seed with 17.7% under the irrigation system without livestock, with 5.6% for rainfall; the difference from the other systems should be due (in part) to lower seeding, as some producers use local seeds (Table 2).

Table 2. Bajío of Guanajuato: Cost structure for maize production, Spring-Summer 2010 Period.

Concepts		Excluding land			Including land		
	Region	1	1	1	1	1	1
	Technology	T[1]	RCA[2]	RSA[3]	T	RCA	RSA
	Area	11456	2738	2738	11456	2738	2738
Tradable inputs		**91.0%**	**83.3%**	**83.3%**	**88.3%**	**75.4%**	**75.4%**
Fertilizers		71.1%	58.8%	58.8%	69.0%	53.1%	53.1%
Herbicides		6.0%	1.9%	1.9%	5.4%	1.8%	1.8%
Insecticides		4.5%	1.7%	1.7%	4.6%	1.6%	1.6%
Seed or plant		5.4%	17.7%	17.7%	5.5%	16.0%	16.0%
Diesel		4.0%	3.2%	3.2%	3.8%	2.9%	2.9%
Internal factors		**5.3%**	**7.8%**	**7.8%**	**8.1%**	**16.8%**	**16.8%**
Work manuals		0.0%	5.2%	5.2%	0.0%	4.7%	4.7%
Work mechanized		5.3%	2.4%	2.4%	5.1%	2.2%	2.2%
Water use		0.0%	0.2%	0.2%	0.0%	0.2%	0.2%
Land		0.0%	0.0%	0.0%	3.0%	9.7%	9.7%
Indirectly tradable inputs		**3.7%**	**8.9%**	**8.9%**	**3.6%**	**7.8%**	**7.8%**
Tractor and equipment		3.7%	2.4%	2.4%	3.6%	2.1%	2.1%
Thresher or equivalent		0.0%	6.5%	6.5%	0.0%	5.7%	5.7%
Total cost		**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

[1] Rain fed; [2] Irrigation with livestock; [3] Irrigation without livestock.
Source: Based on information from the PAM.

When including the land situation, the cost structure was maintained; the entry of tradable inputs remained the highest for rainfall (88.3%) and irrigation (75.3%), with and without livestock. Fertilizer represented 69 and 53.1%, followed by seed with 5.4 and 16%, in the same technology order. On the other hand, internal factors changed significantly with a value of 8.1% of the costs over time and increases to 16.8% in irrigation without livestock; land represented 3 and 9.7% for rainfall and irrigation, respectively. Mechanized and manual labor occupied 5.1 and 6.9% of total expenditure in the order of water regime.

Income structure. While production costs are lower under rainfall as compared to irrigation because the farmer spends less, the income highlights the difference. From

the income structure excluding land, the value added accounted for 56.9, 38.5 and 9% and the rest was made up of intermediate consumption in the three production systems analyzed: rainfall, irrigation with livestock and without livestock. In value added, the capital remuneration was the most important with 95.8% for rainfall, 86.5% for irrigation with livestock and 14.7% for irrigation without livestock, followed by the labor category with 4.2%, 13.1% and 82.9%, in the same cited technological order (Table 3). In the case of irrigation technology with livestock, the income was added based on the sale of the sub-product of maize grain (fodder) and the use of this in the secondary livestock based on its opportunity cost. With the inclusion of land, the participation of value added in the income structure remained 56.9, 38.5 and 9% for rainfall, irrigation with livestock and

Table 3. Bajío of Guanajuato, Mexico: Income structure for maize production, Spring-Summer 2010 Period.

Concepts	Region	Excluding land			Including land		
		1	1	1	1	1	1
	Technology	T[1]	RCA[2]	RSA[3]	T	RCA	RSA
	Area	11456	2738	2738	11456	2738	2738
Total Income		100%	100%	100%	100%	100%	100%
Intermediate consumption		43.1%	61.5%	91.0%	43.1%	61.5%	91.0%
Value added		56.9%	38.5%	9.0%	56.9%	38.5%	9.0%
Intermediate consumption		100%	100%	100%	100%	100%	100%
Tradable inputs		96.1%	90.4%	90.4%	96.1%	90.4%	90.4%
Indirectly tradable inputs		3.9%	9.6%	9.6%	3.9%	9.6%	9.6%
Net value added		100%	100%	100%	100%	100%	100%
Labor remuneration		4.2%	13.1%	82.9%	4.2%	13.1%	82.9%
Water remuneration		0.0%	0.4%	2.4%	2.5%	19.1%	120.7%
Capital remuneration		95.8%	86.5%	14.7%	93.3%	67.8%	-103.6%

[1] Rain fed; [2] Irrigation with livestock; [3] Irrigation without livestock.
Source: Based on information from the PAM.

irrigation without livestock; in this account, capital remuneration was the most representative with 93.3 and 67.8% for rainfall and -103.6% for irrigation without livestock, meaning that if the income of the production unit only depended on grain sales, the activity was unprofitable. If crop sub-products were used in animal feeding, whose sales and profit were counted as part of the income of the unit, the profitability situation changed significantly. The water remuneration reached 2.5, 19.1 and 120.7% in the same technological order; the latter excess

compensated for the capital remuneration for the irrigation system without livestock.

Indicators. In absolute terms, the total cost per hectare (ha) amounted to MXN$16,063 for rainfall and MXN$46,379 for irrigation, with and without livestock, excluding land and MXN$16,563 and MXN$51,379 including land. In both scenarios, the concept of tradable inputs was highest with MXN$14,618 ha^{-1} for rainfall, MXN$38.672 ha^{-1} for irrigation with and without livestock. Excluding land, indirectly tradable

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inputs were second with amounts of MXN$600 and MXN$4,100 ha^{-1} in the same order technological and, including land, it was followed in importance by the internal factors with MXN$1,345 ha^{-1} for rainfall and MXN$8,607 ha^{-1} for irrigation, with and without livestock (Table 4).

The total income per hectare for the three technologies totaled MXN$35,300 in rainfall and MXN$69,500 for irrigation with the two modalities. The income gap between rainfall and irrigation income is due in

part to the higher yield obtained under the second system, which generally doubles due to higher rates of fertilization and water supply to the plant. Excluding the land, in the category of irrigation there is a significant contrast in terms of the profitability recorded by producers with livestock and those devoted exclusively to agriculture, with amounts of MXN$19,238 and MXN$23,121 ha^{-1} and, under the system of rainfall, it was MXN$621 ha^{-1}. When considering land rent, the profits dropped to MXN$18,738 for rainfall and MXN$18,121 ha^{-1} for

Table 4. Bajío of Guanajuato, Mexico: Summary of private budget indicators for the production of maize, Spring-Summer 2010 Period.

Indicators	Region	1	1	1
	Technology	T[1]	RCA[2]	RSA[3]
	Area	11456	2738	2738
1. Total cost MXN$ (excluding land)		16,063	46,379	46,379
Tradable inputs		14,618	38,672	38,672
Internal factors		845	3,607	3,607
Indirectly tradable inputs		600	4,100	4,100
2. Total cost MXN$ (including land)		16,563	51,379	51,379
Tradable inputs		14,618	38,672	38,672
Internal factors		1,345	8,607	8,607
Indirectly tradable inputs		600	4,100	4,100
3. Total income MXN$		35,300	69,500	69,500
4. Net profit MXN$ (excluding land)		19,238	23,121	621
5. Net profit MXN$ (including land)		18,738	18,121	-4,379
6. Intermediate consumption MXN$		15,218	42,772	42,772
7. Intermediate consumption / total income (%)		43	62	91
8. Value added MXN$		20,083	26,728	4,228
9. Value added / total income (%)		57	38	9
10. Labor remuneration MXN$		845	3,505	3,505
11. Absolute capital remuneration producer MXN$ (excluding land)		19,238	23,121	621
12. Absolute capital remuneration producer MXN$ (including land)		18,738	18,121	-4,379
13. Relative capital remuneration producer (%) (excluding land)		120	50	1
14. Relative capital remuneration producer (%) (including land)		113	35	-9

[1] Rain fed; [2] Irrigation with livestock; [3] Irrigation without livestock.
Source: Based on information from the PAM.

irrigation with livestock; irrigation without livestock presented a loss of MXN$4,379 ha^{-1}.

The labor remuneration was MXN$845 ha^{-1} for rainfall, given that most of the agronomic practices are performed by the family, while irrigation with and without livestock was MXN$3,505 ha^{-1}. The producer capital remuneration, excluding land, was MXN$19,238, MXN$23,121 and MXN$621 ha^{-1} for the technologies evaluated. When including land remuneration, it was MXN$18,738 and MXN$18,121 ha^{-1} for rainfall and irrigation with livestock and a loss equivalent to MXN$4,379 ha^{-1} in the irrigation system without livestock (Table 4).

DISCUSSION

From a system approach, agriculture and animal husbandry are related and dependent on each other; stubble is a sub-product of the maize crop and it is used as a feed source for at least one cow within the production unit, which provides milk or meat during the no-grain-sale periods. A custom observed by seasonal producers is that the farmer sells maize at retail prices within the community, providing income during the grain shortage season.

By integrating the sub-products derived from the maize production, such as stubble (in two modes: sales bales and livestock feed) as well as meat and milk, incomes rose significantly in the analyzed systems: rainfall MXN$35,300 ha^{-1}, irrigation with livestock MXN$69,500 ha^{-1} and irrigation without livestock MXN$47,000 ha^{-1}, which outweighed the production costs, excluding land, in the three systems. However, including land production costs, only irrigation without livestock exceeded costs.

Private sector profitability. The Private Profitability (RRP) or benefit-cost ratio (considering the sale of grain and sub-products as part of total income in the production unit), excluding land costs, indicates that production units of rainfall and irrigation with livestock with private sector prices are profitable, but not those of irrigation without livestock technology, with values of 2.2, 1.5 and 1.01. This means that for every peso invested, more than 1.2 pesos is recovered if production is rainfall and 0.5 in irrigation with livestock, but, under irrigation without livestock, only the investment is recovered. When including land in production costs, the RRP was reduced to 2.13, 1.35 and 0.91 in the same technological order. These results are consistent with those reported by González and Alferes (2010), who found that, during 2007, 86.9% of the maize produced in Mexico was profitable at private sector prices; with Sinaloa, Jalisco, and Guanajuato being the states that recorded the higher private se tor profits. Arreola (1997) analyzed 17 maize production technologies (seven proposals by INIFAP and ten implemented by producers) for the regions of the Meseta Purepecha (rainfall and residual moisture), Bajío (rainfall and irrigation by gravity and pumping) and East (rainfall, surface irrigation and irrigation pumping) of Michoacan during the periods: spring-summer 1995 and autumn-winter 1995-96, finding that six production systems had costs per ton above the price of the grain, with a range of MXN$1,241 to MXN$1,706 and three had negative returns -12%, -9% and -2% for rainfall and residual moisture systems on the Plateau and rainfall in Bajío of Michoacan, respectively.

Table 5. Bajío of Guanajuato, Mexico: Private cost ratio for maize production, Spring-Summer 2010 Period.

Concept	Excluding land			Including land		
	Rain fed	Irrigation with livestock	Irrigation without livestock	Rain fed	Irrigation with livestock	Irrigation without livestock
Internal factors (MXN$ ha^{-1})	845	3,607	3,607	1,345	8,607	8,607
Total Income (MXN$ ha^{-1})	35,300	69,500	47,000	35,300	69,500	47,000
Cost of inputs (MXN$ ha^{-1})	15,218	42,772	42,772	15,218	42,772	42,772
Value added (MXN$ ha^{-1})	20,083	26,728	4,228	20,083	26,728	4,228
RCP	**0.04**	**0.13**	**0.85**	**0.07**	**0.32**	**2.04**

Source: Based on information from the PAM.

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Private cost ratio. The private cost ratio (RCP) allowed for comparison of private efficiency excluding land with values of 0.04, 0.13 and 0.85 between the three systems (rainfall and irrigation with and without livestock). Given that RCP is less than unity, the maize producer is competitive and gains windfalls, since, after remuneration of production factors, both internal (land, seed) and contract (wages, machinery), there is a residue in the added value in the return of the work, given the current subsidy policy (Table 5). Maize producers who have their own lots are competitive when complementing the agricultural system with livestock and obviously not including the land rent in income expenses; when including land, the rainfall and irrigation with livestock systems are still considered profitable: RCP 0.07 and 0.32. The RCP of irrigation without livestock system was 2.04, indicating that the production units under this scheme are not competitive.

Comparatively, Rodríguez *et al.* (2013) reported in 2010 competitiveness for Rural Production Units (UPR's) of Santo Domingo and San Jacinto Teojomulco Tlacotepec, Sierra Sur, Oaxaca, which had 2.51 ha of cultivable surfaces producing maize and irrigation vegetables such as tomato (*Lycopersicum sculentum*) and chili (*Capsicum annuum*)] and 21 head of cattle (including cows, pigs and goats), and using labor for almost four months with a RCP of 0.55, but not for the rest of the UPRs tested, with different characteristics from the above; on the other hand, González and Alferes (2010) found for 2007 RCP levels from 0.08 to 0.62 for 87% of the national maize production, while, for 1990, González (1991) reported that only 60% of corn production had private sector price competitiveness, this confirms that the scientific and technological progress of a society is the most important factor for dynamic development processes and the competitiveness of a nation's comparative advantages (González and Alferes, 2010).

CONCLUSIONS

The tradable input with greatest impact on total production costs, excluding and including land, was fertilizers with more than 50%, so the hypothesis was not rejected. The income of the production unit concept grain maize without livestock is not enough to cover the production costs; under these terms, the maize crop in the Bajío of Guanajuato is not considered profitable, so the hypothesis was accepted.

Nevertheless, in terms of RCP, when excluding land, the maize producers in the Bajío region of Guanajuato are competitive with all three analyzed technologies (T = 0.04, RCA = RSA = 0.13 and 0.85), thus the hypothesis was rejected. By including land rent in production costs, T systems (0.07) and RCA (0.32) remained competitive but not the production unit under the irrigation without livestock system (RSA = 2.04).

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