Article

Competitiveness of sorghum production in northern Tamaulipas, Mexico

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Abstract

This research was carried out in northern Tamaulipas in the autumn-winter 2016-2017 cycle, based on information from 40 grain sorghum producers, where prices of the product, inputs and their technical production coefficients were obtained. With this information, private production costs were calculated. The objective of this work was to determine the competitiveness of the cultivation of sorghum grain by humidity-technology regime and producer size in northern Tamaulipas, by using the methodology of the policy analysis matrix in its private part. The results showed that the three technologies had a positive gain, a private profitability ratio, which was between 20.66% to 26.43% and a private cost ratio that stood between 0.4359 and 0.4642, indicating competitiveness, allowing the payment of internal factors, leaving a positive profit margin, provided that the payment for land rent is not considered. Intermediate consumption was between 62.78% and 71.53% of the value of production, which represents the purchase of inputs and services from other sectors of the economy. The added value varied from 28.47% to 37.22%, representing the minimum contribution in the generation of employment in this crop. In general, the results indicate that on average the three technologies used in production in northern Tamaulipas, without considering the income of the land were profitable and competitive, which allows to expect a future expansion of the production of this grain in the region study.

Keywords: competitiveness indicators, grain sorghum, private profitability, production costs.

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Introduction

In the last two decades of the twentieth century, the countries of Latin America and the Caribbean have implemented a new economic policy, leaving behind a protectionist model to give way to a new economic model based on market liberation, both nationally and internationally (Reinhardt and Peres, 2000). In the agricultural sector, economic reforms covered several areas highlighting the release of basic grains, including sorghum.

This began in 1989, when the government eliminated the previous import permit, but implemented a seasonal *ad valorem* tariff of 15% from May 16 to December 15. In 1994, with the regulatory framework of the North American Free Trade Agreement (NAFTA), the 15% seasonal tariff for sorghum imports from the United States of America was eliminated and it was established that it could increase as long as they did not harm production national (Rebollar *et al*., 2004).

Since 2008, yellow corn does not pay tariffs (Lesley, 2018), as a result of this policy, yellow corn imports increased from 9.5 to 14.6 million tons between 2008 and 2017, therefore, in that same period, imports of sorghum decreased from 1.1 to 0.57 million tons (SIAP-SAGARPA, 2018), which according to the feed industry had to modify its demand for corn and sorghum (CONAFAB, 2018).

In 2017, following the fall of 153 thousand tons in the production of national sorghum (SIACON, 2018) and 89 thousand tons less imported compared to the previous year (SIAP-SAGARPA, 2018), the feed industry replaced the sorghum for imported yellow corn, therefore, the consumption of imported yellow corn for the livestock sector again breaks record with a total of 10.2 million tons (CONAFAB, 2018).

One of the factors for which the feed industry has preferred imported yellow corn over sorghum is the highest international prices of sorghum that have been recorded from 2014 to 2016, even at the same price, the sector tends to prefer corn yellow due to greater convertibility and other factors (USDA, 2018). As mentioned by Rebollar *et al*. (2016), sorghum grain is one of the three basic grains of livestock importance in Mexico, after corn, since it is grown in almost the entire country, except in Tlaxcala and Mexico City.

Nationally, sorghum production data place Tamaulipas as the main producing state of this grain, in 2017 it contributed 45.45% (2 205 thousand tons) of national production (4 853 thousand tons). In the northern region of Tamaulipas are the main grain producing areas (sorghum-corn) with high technification, irrigation infrastructure and areas in temporary conditions. Its socioeconomic importance lies in its contribution of 1 934 thousand tons, equivalent to 87.71% of state production and with an approximate value of $5 544.30 million pesos. This production was obtained in 615 420 ha harvested, distributed in three Rural Development District (DDR): DDR No. 156 Control, DDR No. 155 Diaz Ordaz and DDR No. 157 San Fernando (SIACON, 2018).

Regarding serials, Rodríguez *et al*. (1999) analyzed the profitability and competitiveness of rice cultivation of the irrigation and temporary production units, financed by the Institutional Relations in relation to Agriculture Trusts (FIRA) of the Bank of Mexico, during the spring-summer cycles

1992-92 and autumn-winter 1992-1993 in the states of Sinaloa, Colima, Michoacán, Morelos and Campeche. The results indicate that only a part of the companies financed by FIRA in the states of Colima, Michoacán and Morelos were profitable.

On the other hand Rodríguez (1994) found that of 118 sorghum producing companies that analyzed in the spring-summer (98 companies) and autumn-winter (A-W) (20 companies) cycles in the 1992-1993 agricultural year in the states of Guanajuato, Jalisco, Michoacán and Tamaulipas, without considering the cost per rental of the land under irrigation by pumping, the profitability was 0.2, 0.14 in gravity and 0.2 in time. Including the cost of renting the land it was 0.05 in pumping irrigation, 0.15 in gravity and 0.12 in temporary. In its published article it indicates that, in an open market scheme, only 11% of farmers could be competitive with respect to sorghum imports from the USA. (Rodríguez *et al*., 1998).

Based on the study on the profitability of sorghum production in Tamaulipas, carried out in the 2005-2006 A-W cycle by the Tamaulipas Matamoros Agency of FIRA (2006) it follows that in fertilized improved gravity irrigation (GMF) technology, the 20 ha companies obtained a profitability of 0.48 and 0.8 including the cost per land rent and without it, in the 60 ha it was 0.13 and 0.74, in the 80 ha of 0.36 and 0.76 and in the 245 ha it was 0.38 and 0.78 respectively; on the other hand, in the technology of temporary, improved without fertilizer (TMS), the companies of 40 ha obtained a profitability of 0.18 and 0.94 and in those of 130 ha it was of 0.23 and 0.91 respectively.

According to the above, the objective of this research was to determine the competitiveness at private prices of the production of sorghum grain in irrigation and temporary by type of technology and size of producer in northern Tamaulipas: fertilized improved gravity irrigation (GMF), temporary improved fertilized (TMF) and temporary improved without fertilizers (TMS), for small, medium and large producers.

Materials and methods

The present investigation was carried out in the north of Tamaulipas, in the most important municipalities in the production of sorghum in irrigation and temporary, taking into account the geographical proximity: Río Bravo, Matamoros, Valle Hermoso and Reynosa. The data of technical coefficients of production of the crop, the prices of the inputs of the production and of the product, with which the production costs, the profit and the profitability for each producer were determined, were obtained from the survey of 40 questionnaires; through randomized direct interviews with producers of the autumn-winter (A-W) cycle 2016-2017, who indicated availability to provide the required information.

For the calculation of profitability, the methodology of the policy analysis matrix (MAP) developed by Monke and Pearson (1989) was used, in its private part corresponding to the private budget, which is calculated by multiplying the matrices of technical coefficients, and of prices of the inputs and of the product previously elaborated, to later determine the levels of income, expenses and profits of the producers. For the above, information on production costs is required, which according to the MAP include: tradable inputs, indirectly tradable inputs, internal factors of production, input and product prices (Monke and Pearson, 1989).

Marketable inputs are those that are acquired in the markets, both nationally and internationally, for example, fertilizers, seeds, agrochemicals and fuels. Indirectly tradable inputs are those that can be marketed and may be composed of tradable and non-tradable parts according to the good, such as tractor parts, thresher and implements. Finally, internal factors are those that do not have an international price such as labor, land, water, credit, insurance, electricity, administration and services; because physically you cannot market between countries, however, you have to assign them a price (Monke and Pearson, 1989).

Profitability and competitiveness indicators

Earnings or profitability at private prices (D)

The private term refers to the observed revenues and costs, which reflect the current market prices that are received and paid by the producer. Profits (D), are the net profits that producers receive as a result of their productive activity and are the difference between their gross income (A) and production costs (B+C), which include tradable inputs and indirectly tradable (B), as well as internal factors (C) estimated at private or market prices. Profits (D) show the competitiveness of the production system, given current technologies, product prices, input costs and transfer policies.

The cost of capital, defined as the income before tax that the holders of it require to maintain their investments in the system, is within the costs of the internal factors (C), therefore, the profits (D) are profits higher than income if private earnings are negative (D< 0), producers may abandon the activity if there are no adjustments that increase private earnings, at least at a normal level (D= 0). On the contrary, positive private earnings (D> 0) are an indicator of higher income and consequently a future expansion of the activity can be expected (Monke and Pearson, 1989).

Private profitability ratio (RRP)

Another way to measure the competitiveness of an agricultural activity is by using the private profitability ratio (RRP). This is determined by dividing profits (D) by total production costs (B + C). A positive private gain indicates the market competitiveness of a production system, given the prices of inputs and products and government intervention policies (Monke and Pearson, 1989).

Private cost ratio (RCP)

The analysis of private earnings (D) is not enough, these can be residual and could come from production systems that use different levels of inputs to produce goods with greater price differences. This problem can be avoided with the estimation and use of the private cost ratio (RCP), which allows comparison of private efficiency between two different production systems. This is calculated by dividing the private cost of the internal factors (C) by the added value (A-B), which is calculated by subtracting the gross income per hectare and the cost of all tradable and indirectly tradable inputs (B).

This relationship indicates the extent to which the production system, in terms of efficiency, can sustain the payment of internal factors (including a normal return to capital), while remaining competitive, that is, the breakeven point after obtaining normal gains, where (A - B - C)= D= 0. When D> 0, excess earnings are presented, because of the fact that the cost of internal factors is less than the value added at private prices.

If the result of the RCP is less than the unit or greater than zero (0< RCP≤ 1), it implies that producing the crop makes it possible to pay the market value of the internal factors, including a rate of return to capital, this being profitable to the producer based on the prices paid and received, and therefore is competitive. If the RCP= 1, no profits are generated, and the producer only pays the production factors. But when the RCP is greater than the unit or negative (0> RCP> 1), the gain is negative, the activity is neither profitable nor competitive (Morales *et al*., 2011).

Value added at private prices (VAP)

It is the amount expressed in monetary terms that remains in the income received after liquidating the cost of tradable and indirectly tradable inputs (B), without considering the cost of the internal factors of production (C) and is obtained as follows : VAP= A - B (Monke and Pearson, 1989).

Intermediate consumption in total income (PCIP)

It represents the portion of the total income generated by the activity that is destined to the acquisition of the necessary inputs for the production generated by other sectors of the local, regional, national or international economy, that is, the marketable and indirectly marketable inputs: PCIP= B/A (Monke and Pearson, 1989; Franco *et al*., 2018).

Value added in total income (PVAP)

Indicates the portion of the total income generated by the activity that is available after covering the costs of tradable and indirectly tradable inputs to remunerate the internal factors of production, as well as the extraordinary profit of the producer: PVAP = (A - B)/A (Monke and Pearson, 1989; Franco *et al*., 2018).

The calculation of the aforementioned indicators was carried out including and excluding the cost of land rent, since some producers do not resort to it because they are owners, however, since land is a factor of production, a value must be assigned monetary. It was also determined according to existing technologies in the study region: improved fertilized gravity irrigation (GMF), temporary improved fertilized (TMF) and temporary improved fertilizer free (TMS), and production scale classifying producers into small, medium and large.

Results and discussion

Context of northern Tamaulipas

The north of Tamaulipas is made up of 14 municipalities, located above the tropic of cancer, in the plains of Coahuila, Nuevo Leon and the coast of the Gulf of Mexico, covering from San Fernando to Nuevo Laredo between altitudes from east to west of the 0 m at 190 m (Carranco, 2011). It borders to the north with the Rio Bravo, to the west with the Sierra Madre Oriental and to the southeast with the coastal plain of the Gulf of Mexico.

Its richness and biological diversity are due to the fact that it is located between two biogeographic regions, the Antarctic and the Neotropical, receiving drainage from two hydrological regions, the Rio Bravo 24 basin and the San Fernando-Soto La Marina 25. The area's characteristic climate is warm semi-dry with a regular average rainfall of 610 mm distributed in the months of July and October, usually they are scarce throughout the year and extreme average temperatures of 23 °C (Andrade *et al*., 2017).

Currently, the region under study is characterized as an agricultural area, mainly sorghum cultivation. In the agricultural year 2017, its planting represented the largest area with 620 thousand hectares, of which 146 thousand hectares are irrigated and the rest is temporary, with an average yield of 3.14 t ha^{-1}, obtaining 39.86% (1 934 thousand tons) of production nationwide (SIACON, 2018).

Private production costs per hectare

In percentage terms, the costs of producing sorghum grain in fertilized improved gravity irrigation (GMF) in northern Tamaulipas, were formed primarily by internal factors (37.16%), followed by tradable inputs (34.75%), of indirectly tradable inputs (25.06%) and finally (3.04%) in administration and services. On the other hand, in temporary improved fertilized (TMF) total production costs were higher due to tradable inputs (40.67%), followed by internal factors (28.52%), non-tradable inputs (27.05%) and in the end administration and services (3.77%).

In temporary technology, but without fertilizer use (TMS), the costs were structured in the order of non-tradable inputs (34.78%), internal factors (31.22%), marketable inputs (29.96%) and administration and services (4.04 %). The results indicate that under temporary conditions more is incurred either in marketable inputs or in non-tradable inputs, due to the simple fact that no water quota is paid and the value of the land is lower than in irrigation, therefore, Irrigation producers invest more in internal factors, followed by tradable inputs (Table 1).

The main component of tradable inputs was diesel, which in GMF producers accounted for 15.30%, followed by TMF producers with 16.44%, finally, TMS producers with 20.21%. The other component was fertilizers, in GMF and TMF they constitute 12.87% and 15.24%. Among the internal factors, land is the largest component, for producers using GMF technology accounted for 22.52% and in TMF and TMS temporary technologies, 18.74% and 21.96%, respectively.

While, within the indirectly tradable inputs, the concept of tractor and implements was the most important component, highlighted in the producers that use the TMS technology with 26.65%, followed by the TMF and GMF technologies with 18.17% and 15.88%, respectively. In summary, these results represent as a whole for GMF producers, 66.58%, for those of TMF and TMS, 68.58% and 68.82% respectively (Table 1).

Table 1. Percentage disaggregated structure of production costs per hectare of grain sorghum by technology in northern Tamaulipas, Mexico, A-W cycle 2016-2017.

Concept	GMF (%)	TMF (%)	TMS (%)
Marketable supplies	34.75	40.67	29.96
Fertilizers	12.87	15.24	0
Herbicides and insecticides	1.69	2.04	1.56
Seed	4.86	6.89	8.02
Diesel	15.3	16.44	20.21
Biological control and contracted services	0.02	0.06	0.17
Internal factors	37.16	28.52	31.22
Manual labor	2.67	0.72	0.77
Manual labor	1.49	1.5	2.33
Avio Credit	4.92	5.13	3.78
Agricultural insurance	1.67	2.44	2.37
Water quota	3.88	0	0
Land	22.52	18.74	21.96
Indirectly tradable inputs	25.06	27.05	34.78
Tractor and implements	15.88	18.17	26.65
Threshing and freight	9.18	8.88	8.13
Administration and services	3.04	3.77	4.04
Cost per hectare	100	100	100

Elaboration based on field information. GMF= enhanced gravity fertilized; TMF= improved temporary fertilized; TMS= temporary improved without fertilizers.

GMF technology coincides with those of FIRA (2006), with the same production system in northern Tamaulipas, reported fertilizer costs of 10.31%, diesel 16.25%, land rent 23.86% and costs for machinery and 15.55% team. The total of these costs is 65.97%. On the other hand, for TMS technology it reported a total cost of 69.93%, distributed in fuels, maintenance of machinery and equipment and the rent of the land in 14.28%, 19.32% and 36.33%, respectively.

Table 2 shows the total production costs per hectare, including land rent (IT) shows the highest costs that vary by producer size between $17 080.00 and $18 133.00 in producers using GMF technology, followed by the temporary TMF of between $10 028.00 and $11 113.00 and a lower cost in producers using TMS technology, which varied between $8 695.00 and $9 534.00. By excluding the cost of land rent (ET), the costs Weighted totals for GMF, TMF, and TMS are lower than the previous ones, due to the cost of land rent that fluctuated from $4 000.00 ha^{-1} and $2 000.00 ha^{-1} in irrigation and temporary, respectively.

Income and net profit

The producers using GMF technology are those who presented a higher income per hectare ($16 342.00 to $18 047.00), followed by the producers of TMF ($10 293.00 to $11 151.00) and those of TMS ($7 970.00 to $9 497.00), (Table 2). The price paid to grain sorghum producers in the 2016-2017 autumn-winter cycle was the corresponding target price of $2 970.00 t^{-1} (DOF, 2016), plus a complementary incentive granted by the government of $135.80 t^{-1} in average (ASERCA, 2017). An additional income was also considered for the incentive to the Proagro Productive component taking the general average of $180.00 ha^{-1} with a limit of 80 hectares (SAGARPA, 2017). Another benefit for farmers in the region is contract farming that allows them to ensure the sale of their future crop by protecting them against adverse market movements (Carranco, 2011).

Table 2. Total costs, income and profits of producers of sorghum grain per hectare in irrigation (GMF), temporary (TMF and TMS) in northern Tamaulipas, Mexico, A-W cycle 2016-2017.

Producer size	Area (ha)	Yield (t ha^{-1})	Production (t)	Income ($ ha^{-1})	Cost ($ ha^{-1})		Gain ($ ha^{-1})	
					IT[1]	ET[2]	IT [1]	ET[2]
GMF	144.8	5.7	825.5	17 409	17 769	13 769	-360	3 640
Small	12.2	5.4	66.1	16 342	17 080	13 080	-738	3 262
Medium	61.2	5.7	348.8	17 562	18 133	14 133	-571	3 429
Big	317.3	6	1903.6	18 047	17 940	13 940	106	4 106
TMF	76.9	3.5	269.1	10 485	10 690	8 690	-205	1 795
Small	12.5	3.3	41.3	10 296	10 704	8 704	-408	1 592
Medium	47.3	3.6	170.4	10 293	11 113	9 113	-820	1 180
Big	250	3.6	900	11 151	10 028	8 028	1 123	3 123
TMS	72.5	2.8	202.9	8 723	9 126	7 126	-403	1 597
Small	10.6	2.6	27.6	7 970	8 695	6 695	-724	1 276
Medium	37	3	111	9 094	9 534	7 534	-440	1 560
Big	400.0	3	1200	9 497	8 789	6 789	708	2 708

Elaboration based on field information. [1]Including land; [2]Excluding land. GMF= enhanced gravity fertilized; TMF= improved temporary fertilized; TMS= temporary improved without fertilizers.

Regarding the gain or private profitability in the three production technologies, when considering the income of the land, the results indicate that this was negative and by excluding such cost, the three technologies allow to obtain a positive net profit. The results indicate that the producers of TMF and TMS obtained the lowest gain, which stood at $1 795.00 ha^{-1} and $1 597.00 ha^{-1}, respectively. Those of irrigation by GMF perceived a gain of $3 640.00 ha^{-1}.

When considering the area harvested by each producer in irrigation in the technology (GMF), in temporary (TMF) and (TMS) it is had that these obtained a total profit of $527 072.00, $138 036.00 and $115 783.00 respectively, which originates during a year one income per day of $1 444.00, 378.00 and 317.00 pesos, which is higher than the current rural minimum wage. By size of producer, the most affected are small producers with an income per day of $107.00, 52.00 and 35.00 pesos.

Private profitability ratio

Given that this ratio measures the level of private earnings (D) as a proportion of total costs (B + C), by excluding land rent in the three types of technologies, it was observed that for each peso invested the producer obtained an additional income that was between 20.66% and 26.43%. By strata in each technology, the large producers obtained a higher profitability than the small and medium producers (Table 3).

Table 3. Profitability, intermediate consumption and added value of grain sorghum producers per hectare in irrigation (GMF) and temporary (TMF and TMS) in northern Tamaulipas, Mexico, A-W cycle 2016-2017.

Producer size	Profitability (%)		‡RCP		†PCIP		§PVAP	
	IT[1]	ET[2]	IT[1]	ET[2]	($)	(%)	($)	(%)
GMF	-2.03	26.43	1.0554	0.4642	10 929.00	62.78	6 480.00	37.22
Small	-4.32	24.93	1.1149	0.4928	10 205.00	62.45	6 137.00	37.55
Medium	-3.15	24.26	1.0852	0.4883	11 194.00	63.74	6 368.00	36.26
Big	0.59	29.46	0.985	0.4216	11 215.00	62.14	6 832.00	37.86
TMF	-1.92	20.66	1.104	0.462	7 500.00	71.53	2 985.00	28.47
Small	-3.81	18.29	1.1464	0.4285	7 700.00	74.78	2 596.00	25.22
Medium	-7.38	12.95	1.2788	0.5986	7 669.00	74.51	2 624.00	25.49
Big	11.2	38.9	0.7569	0.324	6 847.00	61.41	4 304.00	38.59
TMS	-4.42	22.41	1.1775	0.4359	6 126.00	70.22	2 598.00	29.78
Small	-8.33	19.05	1.3289	0.4208	5 902.00	74.05	2 068.00	25.95
Medium	-4.62	20.7	1.1504	0.467	6 424.00	70.64	2 670.00	29.36
Big	8.06	39.89	0.8318	0.3567	5 604.00	59	3 894.00	41

Elaboration based on field information. [1]= including land; [2]= excluding land; GMF= enhanced gravity fertilized; TMF= improved temporary fertilized; TMS= temporary improved without fertilizers; ‡= private cost ratio; †= intermediate consumption in total income; §= added value in total income.

Competitiveness relationship

The competitiveness of sorghum producers is better determined by the private cost ratio (RCP) than by the analysis of the profit and the profitability ratio. The average RCP excluding land rent for producers using GMF technology was 0.4642, which means that the cost of internal factors represents 46.42% and earnings 53.58%, compared to value added, then there are those of temporary with the use of fertilizers, TMF technology (0.462) and without the use of fertilizers, TMS technology (0.4359), in which the profits represent 53.8% and 56.41%, respectively with respect to the added value; this is due to the fact that these technologies dedicate a low proportion of the added value to the payment of their internal factors such as land, labor and rainwater, which for them has a zero cost of use, and since there is no marked difference in product prices for the type of technologies in this area, which largely compensates for the average yields they obtain, which are lower compared to those obtained with GMF technology.

The results indicate that, for the three technologies by excluding land rent, production was profitable and competitive. On the contrary, when considering this cost, for GMF producers it was 1.0554, those of TMF 1.104 and those of TMS 1.1775. This indicates that for the three technologies production is not profitable or competitive, depending on the prices received and paid by the producer (Table 3).

Contribution to the sector and regional economy

The remainder in total income after having covered the cost of tradable and non-tradable inputs for the sale of grain produced in one hectare, corresponds to the value added at private prices. That is, for GMF technology producers, after paying the cost of inputs, there was a differential in the income received from the sale of the product of one hectare of $6 480.00, necessary for the payment of labor and producer profit, greater amount compared to the producers that produce in TMF and TMS ($2 985.00 ha^{-1} and $2 598.00 ha^{-1}) (Table 3).

The effects in the study region on grain sorghum production are observed by disaggregating the value of production. Part of this value represents the intermediate consumption (PCIP) and the other corresponds to the added value (PVAP). The PCIP was between 62.78% and 71.53%, which indicates that most of the value of the production of this crop corresponds to the payment to other sectors of the economy for concepts of acquisition and payment of tradable inputs (fertilizers, agrochemicals, seeds, fuels, etc.), agricultural insurance, electricity and indirectly tradable inputs (tractor and implements, threshing and freight, etc.).

The PVAP varied between 28.47% and 37.22% with respect to total income, these values mean the minimum participation in the generation of employment of this crop in the region, that percentage was used to remunerate the internal factors of production (value of land, credit and water), as well as producer profit. This value quantifies the effect of the production system within the agricultural sector itself (Table 3).

Conclusions

By scale of production, the large producers of sorghum grain in the north of Tamaulipas of each analyzed technology presented the best profitability indicators, with a positive net private gain and a private profitability ratio greater than 0. This was also corroborated with the indicator of the ratio of private cost (CPR), which in the three types of technologies was less than 0.4642%, which means that they generated a higher income received from the sale of their product and a lower cost in agricultural activity, so therefore, a future expansion in the production of sorghum grain can be expected in the northern region of Tamaulipas.

When considering land rent, the producer results in unfavorable gains, mainly for small and medium producers. Therefore, it is important that the producer of this grain consider whether it is convenient to resort to land rent.

The low added value (PVAP) that is generated in the region is evident, since just over 62% of the value of the production of sorghum grain was destined for intermediate consumption, a percentage that the producer dedicates to the payment of inputs and services from other sectors of the national and international economy. Situation that reflects high costs in tradable and indirectly tradable inputs, so it is important to analyze and reduce costs, since it is essential in determining the profitability for sorghum production in the northern region of Tamaulipas. Because it is a technified region, the minimum use of labor, among other factors within the internal factors, translates into the lowest percentage of value added in total income.

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