Maize silage and maize stubble, strategy for cattle feed in dry seasons

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ABSTRACT
The objective was to estimate the production costs and profitability of maize silage and maize stubble as a feeding strategy for cattle in dry seasons in the southern region of Estado de México.
Methodology: 30 semi-structured surveys with non-probabilistic sampling were applied during the spring/summer 2020 cycle. Socioeconomic variables, the profitability threshold and the benefit/cost ratio were analyzed. The production units were characterized as small, the average age of producers did not exceed 45 years and nine years dedicated to production.
Results: The average production of maize silage and maize stubble was 28 and 7.20 tons with a cost of 1,278.40 and 3,587.23 pesos per ton.
Conclusions: The benefit/cost ratio in maize silage and stubble was 0.46 and 0.16. The conclusion is that both activities were profitable with a predominance of maize silage.

Keywords: economic analysis, production costs, maize silage, maize stubble, benefit/cost ratio.

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INTRODUCTION

Among cereal production in the world, maize is the one with highest production. Annually, it has a volume of 850 million tons in grain cultivated on a surface of 162 million hectares, with an average production of 5.2 tons per hectare (t/ha). Mexico is the second maize importer and it is supplied from the United States and Argentina. Germany and France are the main producers of fodder maize (Cruz, 2021). In Mexico around 70 million tons of agricultural residues are produced, of which the stubble of maize, sorghum and wheat straw represents 58, 12 and 15%, respectively. There are methods to treat the fibrous fodders that allow increasing the consumption, feed digestibility, and animal production (Fuentes *et al.*, 2001). Maize in Mexico is used for human and animal consumption. In the case of animal consumption, it is used as fresh fodder, silage or stubble, with its use mainly during the dry season (Luna *et al.*, 2013).

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The use of maize stubble is common as feed for ruminants, although it has low nutritional value, low digestibility and it is coarse, due to its state of lignification. Interest for the use of agricultural residues in the diet of ruminants has increased their importance in the global scope in recent years, as the availability of grains is reduced. The null competition between monogastric and ruminants over fibrous foods is also important, as well as the ability of ruminants to convert these fibrous materials into useful products for humans (meat, milk, leather, wool, etc.) (Fuentes *et al.*, 2001).

Therefore, the objective was to estimate production costs and profitability of maize silage and maize stubble as feed strategy for cattle in dry seasons in a region of southern Estado de México. The main hypothesis assumes that the use of maize silage and maize stubble as dietary strategy for cattle in the dry season reduces production costs, which makes it a strategy that ensures the economic profitability of cattle producers in the study zone.

MATERIALS AND METHODS

To gather the primary information, the decision was made to use semi-structured surveys that were applied through direct interviews to thirty producers of maize silage and maize stubble in the spring/summer 2020 cycle, and information related to the ensilage process in 2020. Non-probabilistic sampling was used, called intentional sampling or judgement sampling, similar to the snowball method (Goodman, 1961; Vogt & Burke Johnson, 2016). This sampling is applied when the statistical sample to be formed is selected in the environment close to the researcher, without there being specific requirements, although trying to sample at least 10% of the total population.

The secondary information came from various official sources: National Institute of Forestry, Agricultural and Livestock Production Research (*Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias*, INIFAP), Ministry of Agriculture and Rural Development (*Secretaría de Agricultura y Desarrollo Rural*, SADER), Ministry of the Farmland (*Secretaría del Campo*, SC), National Institute of Statistics and Geography (*Instituto Nacional de Estadística y Geografía*, INEGI), and also information contained in different webpages.

Regarding Rebollar (2011) and Rebollar *et al.* (2022), at the private level the costs were classified into fixed and variable. The first do not depend on the production volume, and it must be assumed that even when there is no production, they remain both in the short and in the long term and represent the proceeds (negative) in the absence of production. The second represent the real disbursements linked to the payment for purchase of variable inputs; they happen when there is production, depend on the amount produced, and change when the volume produced changes.

In fixed costs, the useful life of the fixed or immobilized asset was emphasized, as well as its purchase price, years of utility, divided into months of the year and multiplied by the amount of product generated. For the variable expenditures, the cost of the input was multiplied by the amount used. All of this is for each producer surveyed, and then the total cost per producer, its variable, fixed and mean total cost were obtained. Subsequently, an average of the cost was estimated when considering the total of producers surveyed.

Therefore, the total cost per activity (Equation 1).

$$(TC) = VC + FC = PxX + FC \tag{1}$$

where *Px* was the price of the variable input, and *X* the amount used. The total income (*TI*) per sale was obtained when multiplying the amount of final product by the average price current in the local market. Thus, the *TI*=*PyY*, where *Py* was the price per ton of product obtained and *Y* the amount of product that was obtained, for the sale.

In addition, the profit from the process was calculated as the arithmetic difference between the *TI* minus the *TC*; that is (Equation 2):

$$\text{Profit } (P) = TI - TC = PyY - (PxX + FC) \tag{2}$$

Therefore, if the *P* is higher than zero, it will be evidence of the profitability of the process; otherwise, there will be economic loss in the production. Likewise, the value of the profitability indicator known as Benefit/Cost Ratio (*B*/*C R*) was determined as the quotient of dividing the *TI* from sales by the *TC* of production; that is (Equation 3):

$$B/C\ R = (\$TI)/(\$TC) \tag{3}$$

A B/*C R* quotient higher than 1.0 is evidence of profitability per peso invested in the activity. An additional indicator of the activity was the point known as profitability threshold (Rebollar Rebollar, 2011), called minimum economic productive capacity (MEPC), known as the equilibrium point (EP). The expression to be used was (Equation 4):

$$EP(Q) = \frac{\text{Total fixed cost}}{\text{Sale price} - \text{mean variable cost}} \tag{4}$$

and:

$$EP(\text{pesos}) = \frac{\text{Total fixed cost}}{\dfrac{\text{Sale price minus mean variable cost}}{\text{Sale price}}}$$

This indicator helped to deduce whether the activity was profitable or not, based on the methodology that was used in the study (Rebollar, 2011).

RESULTS AND DISCUSSION

Socioeconomic characteristics

Based on the production system of maize silage and maize stubble, the production units (PUs) were characterized as small-scale, because the surface destined to sowing the crop corresponded to less than one hectare; it ranged between 0.9±0.5 ha for maize silage and 1.2±0.6 ha for maize stubble. The average age of producers did not exceed 45 years (44±8.8, 43.3±14.8) and the number of children per producer was 2.0±1.5 and only

28% of them have four children, who support the activities of the system inconsistently; therefore, it is deduced that the production of maize silage and maize stubble is carried out by producers with basic academic education and with an age range that did not exceed 50 years of age (Table 1).

Analysis of the production system of maize silage and maize stubble

The commercial seeds used were D-Kalb 75-00 with 70% of use for maize silage and 83% for maize stubble, Piooner P4039 with 15 and 8.50% respectively, and the remaining producers leaned towards traditional sowing, when using landrace seeds from previous harvests (Table 2).

In relation to the average surface of land sown devoted to the production of maize silage, it was 0.89 ha, and 1.15 ha for production of maize stubble with an average sowing density of 20 and 15.9 kh/ha and average production of 28 t/ha of maize silage and 7.2 t/ha of maize stubble (Table 3).

Variable costs

For maize silage, the average variable cost was 35,345.3 and 25,268.7 $/ha for maize stubble and corresponded to the totality of the activities carried out in the entire productive process (Table 4).

Table 1. Socioeconomic characteristics in the production of maize stubble and maize silage.

Concept	Maize stubble (value)	Corn silage (value)
Age (years)	43.30±14.80	44.00±8.80
Family integration (children)	1.80±1.30	2.00±1.50
Planted hectares	1.20±0.60	0.90±0.50
Time in activity (years)	11.30±8.00	7.00±3.10
Schooling (years)	10.30±3.80	12.90±4.80

Table 2. Seeds used in maize sowing.

Concept	Maize stubble (value)	Corn silage (value)
Dekalb 7500 seed (%)	83.00	70.00
Pioneer P4039 Seed (%)	8.5.00	15.00
Seed of the previous harvest (%)	8.5.00	15.00
Total	100%	100%

Table 3. Production data of maize silage and maize stubble.

Concept	Maize stubble (value)	Corn silage (value)
Area for corn silage (hectares)	1.15	0.89
Planting density (kilograms/hectare)	15.90	20.00
Production (tonnes)	7.20	28.00

Table 4. Variable production costs in maize silage.

Performed activities	Maize stubble (value)	%	Corn silage (value)	%
Soil preparation	(13 500,00±1 587)	5,50	(16 500±836,50)	5,50
Sowing	(11 300,00±794,10)	4,50	(13 100±668,40)	4,30
Fertilization	(81 045,00±4717,30)	32,70	(108 870±4 465,30)	35,90
Seed used	(11 387,30±525,20)	4,60	(24 295.3±1 027,10)	8.00
herbicide and insecticides	(25 380,00±2359,90)	10,20	(16 995±732)	5,60
Silage Process	(80 185,00±4335,80)	32,40	(99 565±3 165,70)	32,90
Indirect Inputs	(24 620,00±1898,20)	9,90	(23 900.0±946,20)	7,80
Average variable cost	35 345,30	14,20	25 268,70	8,30
Total	247 417,30	100	303 225	100

Fixed costs

The fixed costs reached to produce maize silage averaged $450.4/ha, product of the use of various agricultural tools, while for the case of maize stubble the fixed cost was $559.3/ha.

Total cost (TC)

The total costs reached for production of maize silage were 35,795.7±(11,725.1) $/ha, while the total costs for maize stubble were 25,828.1±10,158.8 $/ha. The mean total cost (MeTC) or cost per producer was $35,795.7±(11,725.1). If average production of silage was 28 tons, then each producer disbursed $1278.4/t.

The mean total cost (MeTC) or cost per producer to produce maize stubble was $25,828.1±10,158.8. If the average production was 7.2 tons, then during the period of analysis the producer paid 3,587.2 $/t produced.

Total income per sale

The total income (TI) is all the money that the enterprise obtained from the sale of products. The total income from the sale of maize silage in relation to the tons produced was (Table 5 and 6):

Table 5. Total income in the production of maize silage.

	Yield (t)	Sale price ($/t)	Total income ($/t)
Average	28.0 (±18,7)	2 000.00 (±360.5)	52 500.00

Table 6. Total income in production of maize stubble.

	Yield (t)	Sale price ($/t)	Total income ($/t)
Average	(7.20±3,2)	(4 233.3±249.8)	(30 013.3±12 364.5)

Income, cost and profit per ton of maize silage. On average, for this activity during the period of analysis, the producers generated positive profits, which reached 16,704.3 $/t (Table 7). The average B/CR in the production of maize silage was 1.5 and meant that for each peso that the producer paid as total production cost per ton of maize silage, he recovered that peso and obtained a profit of 50 cents. In addition, based on the result of the B/CR the producer could sustain an increase in costs of up to 50% in order not to lose or win; however, when considering the reciprocal of the B/CR, then the average income of the producer, from sale of maize silage, would resist a reduction (caused by the sale price) of up to 33.3% and stay in equilibrium.

As for production of maize silage, the producer paid on average 25,821.1 $/t, received from the sale of the product 30,013.3 $/t and earned 4,185.2 $/t. That is, after paying fixed costs and total variable costs inherent to this activity, the profit was positive and the activity was considered as profitable (Table 8). Producing maize silage in that time of the year had an effect on the total and average B/CR of 1.2, and therefore for each peso of the total cost that the producer disbursed to pay for the activity, he received 20 cents as benefits, and with that, the activity is profitable.

In addition, the producer could face up to 20% of increase in the total production cost and remain in a situation of equilibrium with the income from sales, or else, when taking the reciprocal of this indicator, a reduction of 16.6% in the income in order to be equal to the total production cost of maize silage.

Equilibrium point (EP): Maize silage

The equilibrium point (EP) in pesos was calculated as follows:

$$EP(\text{pesos}) = \frac{\text{total fixed cost}}{\dfrac{\text{sale price} - \text{mean variable cost}}{\text{Sale price}}} = \frac{450,40}{\dfrac{2000-1488,17}{2000}} = \frac{450,40}{\dfrac{511,83}{2000}} = \$1759,5$$

$$EP(Q) = \frac{\text{total fixed cost}}{\text{sale price} - \text{mean variable cost}} = \frac{450,40}{2000-1488,17} = \frac{450,40}{511,83} = 0,9$$

The equilibrium point (EP) or profitability threshold is where total production costs are equal to the total income from sales; the total costs include fixed costs plus variable

Table 8. Income, cost, and profit of maize silage.

	Total income ($/t)	Total cost ($/t)	Profit ($/t)	RB/C
Average	30 013.30	25 828.10	4185.20	1.20

Table 7. Income, cost, and profit of maize silage.

	Total income ($/t)	Total cost ($/t)	Profit ($/t)	RB/C
Average	52 500.00	35 795.70	16 704.30	1.5

costs. Thus, based on the EP, the producer would have to have sold and/or produced 0.87 t of maize silage for the production cost to be equal to the income from sale, situation that makes the system viable, which constitutes a source of income and a form of subsistence.

Equilibrium point (EP): Maize stubble

The equilibrium point (EP) in pesos was calculated as follows:

$$EP(\mathrm{Q}) = \frac{\text{total fixed cost}}{\frac{\text{sale price} - \text{mean variable cost}}{\text{Sale price}}} = \frac{559{,}38}{\frac{4233{,}33 - 3665{,}3}{4233{,}3}} = \frac{559{,}38}{\frac{568{,}03}{4233{,}33}} = 0{,}4$$

$$EP(\mathrm{Q}) = \frac{\text{total fixed cost}}{\text{sale price} - \text{mean variable cost}} = \frac{559{,}38}{4233{,}3 - 3665{,}3} = \frac{559{,}38}{568{,}03} = 0{,}9$$

Under the conditions suggested, these results mean that during the period of analysis, the producer would have to have produced and/or sold 0.9 t of maize silage for the production cost to become equal to the income from sale, situation that makes the system viable, in addition to being a source of income and form of subsistence.

The education of producers was not an obstacle for the production of maize silage, which agrees with the statement by Gutiérrez (2018), where age and schooling as socioeconomic variables linked to maize production did not represent any difference with the activity. However, there were limiting factors for the production such as sufficient availability of land, financial solvency, and machinery available, similar to what was found by Field (2013).

The production costs can also vary from the type of silo used, since, according to Villalobos-Villalobos *et al.* (2015), there are differences between each type of silo, with the one of horizontal pile being the one of lowest elaboration cost; this is the specific reason why producers from the study zone prefer the use of the horizontal silo.

With relation to the utility and importance of maize silage as dietary strategy for animal production, the results found are similar to those reported by Garcés Molina *et al.* (2004) and Gutiérrez (2018) which conclude that the use of maize silage is useful and important for the diet of the herd in addition to being financially profitable (Muñoz *et al.*, 2013).

The yield per hectare of maize stubble (7.2 t/ha) was lower than the one found by Salinas and Gutiérrez (2000) where the authors mention that the production of maize stubble generated by one maize crop (reeds, leaves and cobs), fluctuates between 20 and 35 t/ha, and of stubble only (reeds and leaves) it varies between 16 and 25 t/ha; however, it was higher than the finding by Muñoz *et al.* (2013) in a study for the high valleys in Mexico. Regarding the use of maize stubble as alternative for animal feed, the results obtained agree with those from Asmud and Lars (1983), which argue that promoting the optimal use of maize stubble allows to reduce production costs derived from animal feed. The perception of producers about the utility, importance and ease of use of maize silage plays an important role in the decision for its adoption, which indicates that they are fundamental factors in decision making of the producer, for the adoption or rejection of new innovations in their production unit, as was observed by Martínez-García *et al.* (2016).

CONCLUSIONS

The economic activities of production and use of maize silage and maize stubble, as feeding strategy for animals during the period of study, are sustained under the strategy of substituting the use of commercial feeds for animal diet, and they reduce production costs and improve profitability in agriculture and livestock activities. The economic analysis of production and use of maize silage and maize stubble allows stating that both activities are economically profitable given that the income from sale was higher than the total production cost. The financial activity of maize silage production presented a higher profitability index compared to the use of maize stubble.

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