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ECONOMIC EVALUATION OF THREE FERTILIZATION OPTIONS AND THEIR IMPACT ON THE COMPETITIVENESS OF THE MEZCALERO AGAVE

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ABSTRACT

Given the social and economic importance of the cultivation of Agave mezcalero in Oaxaca, researchers from the Central Valleys of Oaxaca Experimental Field of the National Institute for Agricultural and Livestock Forestry Research (INIFAP) have carried out research over the years on plant nutrition alternatives for a better productivity for the benefit of the producers, arriving to determine several options that consider from the conventional nutrition with synthetic fertilizers to the totally organic nutrition with composts, bovine manure and mycorrhizae; which have been validated on the land of producers in the mezcal region; however, there is no economic criterion on production costs, income, profitability and competitiveness that these fertilization options imply for producers. Therefore, the objective of this work was to know the impact of three fertilization options that have been generated through research, in the profitability and competitiveness of the production of Agave angustifolia raw material considering chemical fertilization, organic fertilization and without fertilization, likewise determine which alternative is more convenient for the producer. For this, the Policy Analysis Matrix (MAP) was used and the economic indicators total cost, total income, net profit cost-benefit ratio were estimated; To determine the competitiveness of the production system, the Private Cost Ratio (RCP) indicator was used. The results showed that the mezcalero agave crop is profitable and competitive, with no significant difference in competitiveness between organic and conventional fertilization, so its application can be recommended in the mezcal region, unlike the option without fertilization, which was less competitive.

Keywords: Agave mezcalero, profitability, competitiveness.

1. INTRODUCTION

Mexico and the southwestern United States are considered the center of origin of the Agavaceae family, which is where the greatest diversity of genera and species is found (García, 2004). Within this family, two subfamilies Agavoideae and Yuccoideae, nine genera and approximately 330 species are recognized, of which 251 are found in Mexico. From some species of the Agave genus, fermented drinks such as mead, syrups, pulque and vinegar, among others, can be made since pre-Hispanic times. Although many other uses and products that can be obtained have been reported, the main product is mezcal, a drink obtained from the cooking, fermentation and distillation of the stems known locally as pineapples; This drink has great historical and cultural significance in the original communities where it is produced, but over time its consumption by other, not necessarily local, sectors has become very important, which has led to a growing demand. In the state of Oaxaca there is a wide tradition and culture around maguey and mezcal, being the most representative state of the Republic in its use (Rodríguez et al., 2018). SIAP (2020) reported for the year 2020 a cultivated area of 10,500 ha with a harvested area of 2,800 ha, a total pineapple production of 153,000 t with an average yield of 62 t/ha. In the case of mezcal, in that same year, more than seven million liters were produced, of which 4.5 million were exported and the rest was destined for national consumption. Although there is a wide diversity of species in the entity, especially wild ones, with which mezcal can be produced, the main species used as raw material to produce this drink is Agave angustifolia Haw, also known as "Espadín", it is a Perennial, viviparous, rigid, rosetteted, rhizomatous plant that is characterized by its radially extended surculose rosette that can reach 2.5 m in diameter, its leaves are thick and fleshy, generally ending in a sharp needle at the apex with spiny margins. The robust woody stem is usually very short, so the leaves appear to emerge from the root (Espinosa et al., 2002). Of the total cultivated area in Oaxaca, 76.3% is occupied by this species, which is endemic to Oaxaca and the south of the country, whose domestication process is more advanced in relation to the other species used to produce mezcal (Rodríguez, 2022). The production of raw material, that is, the pineapple for the production of mezcal is carried out by rural producers, forming the first link in the maguey-mezcal chain, being in most cases, the main productive activity in the production units of the various communities of the mezcal region, for this reason the family's monetary income comes largely from this crop. It is estimated that around 4,000 families depend economically on this primary activity. On the other hand, although the Denomination of Origin of mezcal considers the entire state of Oaxaca as feasible to produce maguey and mezcal (IMPI, 2012), there are regions specialized in production that show a great tradition in cultivation, such as the so-called mezcal region that covers part of the agroecological regions of Valles Centrales and Sierra Sur.

Regarding the productive management of the plantations and specifically regarding nutrition, the producers generally do not fertilize their maguey plants and in some sporadic cases they only apply some type of chemical fertilizer before the rains without any scientific-technical criteria, which without It is undoubtedly reflected in the levels of productivity per surface unit, in the sugar content of pineapples, as well as in the duration of the cultivation cycle and therefore in the competitiveness of the productive chain. Although the maguey grows in thin and rocky soils that are not very fertile; For commercial purposes, it is recommended to improve soil fertility to achieve larger pineapples and higher sugar content (Bravo et al., 2007). In this regard, over the years, both experimental and validation research has been carried out with producers in the mezcal region on various alternatives for plant nutrition in order to make them more productive and at the same time shorten the production cycle, generating as a product, several recommendations according to the conditions of the producer (Bravo et al., 2007), however, it is unknown if these recommendations are economically appropriate to increase the profitability and competitiveness of agave production, especially considering the increases in costs of the fertilizers that have been presented in 2021 and 2022. On the other hand, it is also important to know the impact on the profitability and competitiveness of the organic nutrition option compared both with the generalized option of not fertilizing the maguey.

This work was carried out with the purpose of knowing the impact of three fertilization options

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that have been generated through research, in the profitability and competitiveness of the production of raw material of Agave angustifolia considering chemical fertilization, organic fertilization and without fertilization and determine which alternative is more convenient for the producer.

2. MATERIALS AND METHODS

The mezcal region

The scope of the study is the mezcal region of the state of Oaxaca (Figure 1), it is made up of the regions of the Central Valleys (Districts of Tlacolula, Zimatlán, Ejutla and Ocotlán) and the Sierra Sur (Yautepec, Miahuatlán de Porfirio Díaz and Sola of Vega). The first region is located in an altitude stratum of 1,300 to 1,700 meters above sea level, with an average temperature of 20.3 degrees Celsius and an annual rainfall of 644 mm, its predominant climates are Bs and (A)c. In the second region, the altitude stratum is from 800 to 1200 meters above sea level, with an average temperature of 24.9 degrees centigrade and a rainfall of 508 mm, the predominant climates are Bs and Bs0 (García 1973). Research on chemical and organic fertilization has been carried out in various communities of this region, such as those carried out by Arredondo et al., (2001), Espinosa et al., (2005) and Bravo et al., (2007).

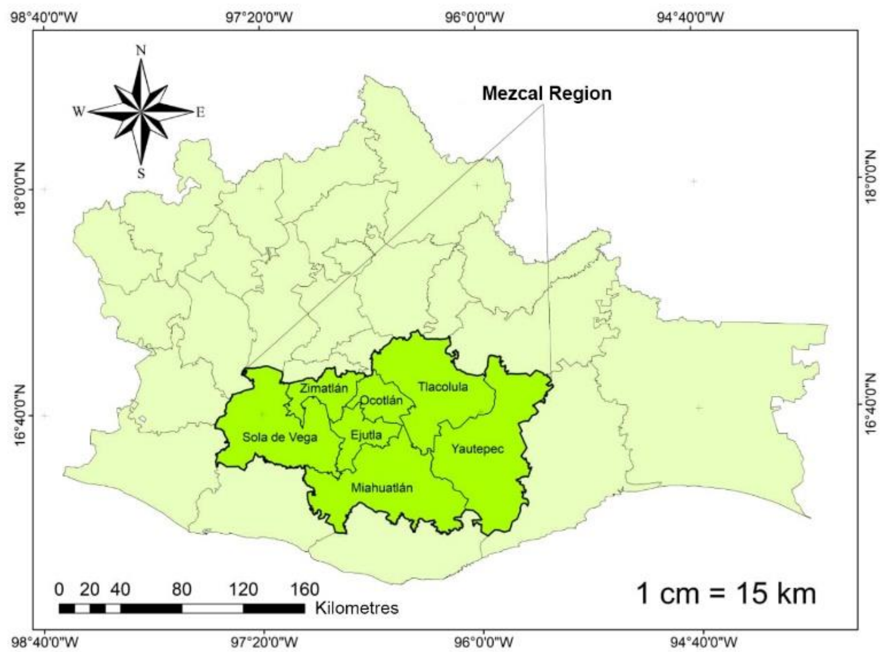

Figure 1. Location of the Mezcal Region in the state of Oaxaca, Mexico

Fertilization alternatives evaluated

The results of the research on fertilization alternatives in mezcalero agave validated in the field of producers were taken, widely proposed by Bravo et al., (2007), which are specified in Table 1. Conventional fertilization considers the use of synthetic fertilizers with a recommended dose for the mezcal region of 60N-30P-30K, which should start its application from the establishment of the plantation. In lands furrowed with a team or tractor, a person deposits the fertilizer at the bottom of the furrow in the place where the maguey will be planted, according to the outline, then it is covered with a layer of soil, then the plant is placed and tamp down the earth. Another way is to place the fertilizer on one side of the plant. In land where stumps were opened, the fertilizer is placed at the bottom, then it is covered with a layer of soil, then the plant is placed, covered and the soil is tamped. To ensure better use of the fertilizer, planting and fertilization must be carried out in moist soil. When the plantation is already established, at the beginning of the rains the fertilizer is deposited around the plant and incorporated. On hillside land, the fertilizer is placed at the top of the slope. With this fertilization, an average yield of 110 t/ha was obtained in six years of duration of the productive cycle from the plantation to the harvest of the pineapples.

Table 1. Mezcal agave fertilization alternatives considered in the economic study (dose per plant per year).

Fertilization type	Products	Unit	Amount
Conventional without fertilizer	Ammonium sulphate	Kilogram	115
	triple calcium superphosphate	Kilogram	25.0
	Potassium sulfate	Kilogram	25.0
organic	bovine manure	Kilogram	1.5
	Compost	Kilogram	0.5
	Mycorrhizae	Gram	2.0
without fertilizer			

Source: Bravo et al., (2007)

Organic fertilization considers the use of bovine manure in an advanced state of decomposition, compost (vermicompost or bocashi-type compost) and microorganisms that promote plant growth (biofertilizers) such as the Glomus intraradix mycorrhiza, which is a fungus that helps the plant to better use of soil nutrients. The form of application is very similar to the application of conventional fertilizers, that is, it must start from the beginning of the plantation and later at the beginning of the rainy season, trying to incorporate the mixture of the products into the soil around the plant and that it have enough moisture for a better use of nutrients. With this fertilization, an average yield of 100 t/ha was obtained with a duration of six years from planting to harvest. The option without fertilization is widespread in the mezcal region, and consists of applying absolutely nothing to the plants, this leads to a longer production cycle (eight years) and lower productivity per surface unit (80 t/ha), this option was considered in the analysis to determine its effects in economic terms for the producer.

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Method to determine profitability and competitiveness

There are various methods to study competitiveness (Magaña, 2014); In this study, the method used was originally proposed by Monke and Pearson (1989), taken up for studies in Mexico by Padilla (1992), Puente (1995), Salcedo (2007), Rodríguez et al. (2013), Rodriguez et al. (2016) and Rodríguez et al. (2019), consists of an accounting system of income and costs of the agricultural system to obtain indicators of competitiveness, profitability and policy effects. For each fertilization option, three data matrices were structured, the first called technical coefficients, which are the quantities of inputs, various materials and labor required per surface unit, including yield; the second data matrix is called the private price matrix, where the unit market prices of inputs, various materials and labor are specified, the prices correspond to the year 2022; the third matrix was formed by multiplying the matrix of technical coefficients by the matrix of private prices, resulting in the matrix of private budget or production costs. In this last data matrix, the primary indicators such as total cost, total income, net profit and Benefit-Cost Ratio were calculated as part of the system. Figure 2 shows the process of structuring the data matrices.

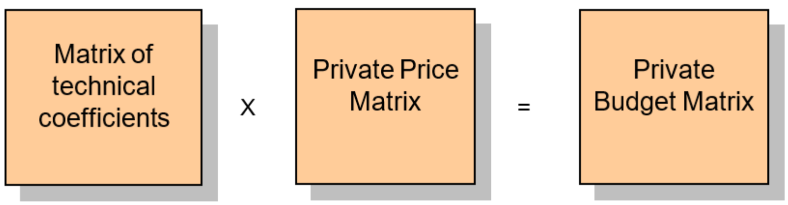

Figure 2. Data matrix structuring process

According to Naylor and Gosch (2005), the preliminary financial indicators were: Total income (IT), known as production value, was the result of multiplying the yield obtained at the plot level (Xi) by the producer's sale price (Pi). IT=PiXi The total cost (CT), which was the result of the sum of the costs of inputs and internal factors, given by the price of the input (Pj) multiplied by the quantity of input (Yj).

Net profit (GN) was the result of the arithmetic difference between total income and total cost.
GN = IT - CT
Benefit Cost Ratio (RBC), is the result of dividing total income by total cost, its interpretation is that for each peso invested in the activity, how many pesos are obtained.

RBC = IT / CT
According to Morris (1990) and Padilla (1992), Value Added (VA) is the difference between the price of a unit of product minus the value of the tradable inputs required to produce said unit of product, or in other words, is the difference between the value of production and the costs of tradable inputs, and is given by the following expression:

$$VA = P_i X_i \sum_{k=1}^{n} P_k Y_k$$

Where:

VA = Value Added
X_i = Quantity produced in tons per hectare
Y_k = Amount of marketable inputs applied per hectare
P_i = Selling price of the product by the producer
P_k = Price of tradable inputs purchased by the producer

To define the RCP, it was first necessary to define the cost of internal factors (CFI), this indicator expresses the part of the costs that refer to the payment of factors that do not have a defined external market or that cannot be exported or imported as easily as labor and land, among others. The CFI is given by the following expression:

$$CFI = \sum^{n} P_r Z_r$$

Where:
CFI = Cost of Internal Factors
Z_r = Amount of internal factors applied per hectare
P_r = Price of internal factors used by the producer

The RCP measures how competitive a crop or production system is in relation to the use of available resources. Producers prefer to make excess profits, which they can obtain if the CFI is less than the VA at private prices; indicates the proportional part of the VA that is destined to cover the CFI (Rodríguez et al., 2016 and Rodríguez et al., 2019). Therefore, what is recommended for an agricultural system to remain competitive is to try to minimize the RCP, keeping the costs of tradable inputs and internal factors low and obtaining a VA as high as possible (Puente, 1995; Rodríguez et al., 2014; Rodriguez et al., 2019). The RCP is given by the following expression:

$$RCP = \frac{\sum_{r=1}^{n} P_r Z_r}{P_i X_i - \sum_{k=1}^{n} P_k Y_k} = \frac{CFI}{VA}$$

Where:
RCP = Private Cost Ratio
CFI = Cost of Internal Factors
VA = Value Added

3. RESULTS AND DISCUSSION

Production costs

Figure 3 shows the production costs per year during the plantation period considering the three plant nutrition options; the alternatives of organic and conventional fertilization presented a production cycle of six years, while without fertilizer the cycle is extended to eight years. The organic option presented the highest production costs throughout the period, while the conventional option was in second place with slightly lower costs than the organic option, while the option without fertilization presented the lowest production costs, this because producers do not make any monetary outlay for fertilization. In general, the three alternatives start from a high initial cost in relation to the following years, from the second year the costs stabilize until the last year in which they increase slightly again due to harvest expenses.

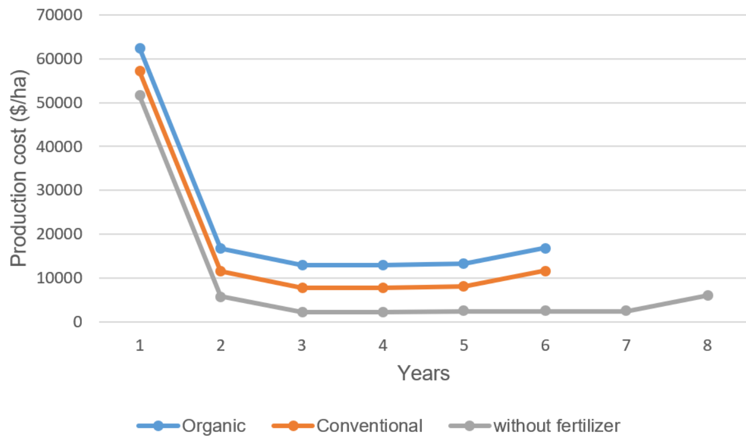

Figure 3. Behavior of the cost of production per surface unit of Agave mezcalero with three fertilization options in the mezcal region, Oaxaca.

Economic indicators

According to the information presented in Table 2, in terms of the total income per surface unit, the alternative that contributed to a higher average annual income was with conventional fertilization due to the higher yield obtained with $127,500.00 and the lower income was obtained with the alternative without fertilizer, the organic option provided an income of $117,500.00. Regarding the average annual production cost per surface unit, the highest cost was presented for the organic option, which is due to the fact that the cost of compost and manure is significant due to the volumes that must be applied and the dragging of these materials to the plots; the lowest production cost was for the option without fertilizer. The annual average net profit, which is an important indicator for the producer to make decisions, was higher for the option with chemical fertilization, with $110,164.17 per year, while the lowest profit was for the option without fertilizers. It should be noted that this analysis does not consider the possible implications of the three alternatives on the soil, such as the effects of synthetic fertilizers on health, microfauna, pH, among other aspects. The Benefit-Cost Ratio (CBR) is a first indicator of profitability and can be interpreted as the pesos obtained for each peso invested in the activity. In this regard, the good profitability of agave production in Oaxaca can be verified, since the CBR they were high; the best option was for the non-application of fertilizers because no

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fertilization cost is incurred, however it should be noted that the profit is obtained up to year 8 of the plantation, the opposite case of the other two options that generate the gain at six years, due to the effect of plant nutrition; the lowest index was for the organic system. It is important to note that it could be considered that there are no significant differences between the options without fertilizer and with fertilizer.

The added value as a deeper indicator in the analysis of competitiveness, understood as the contribution of the activity to the economy and above all as an economic benefit in the region, was very significant and the values demonstrate the high competitiveness of the production, being the option conventional that provided the highest value with $115,597.50 and the option that provided the lowest added value was without fertilizer. The Private Cost Ratio as the main indicator of competitiveness was significantly appropriate, indicating that agave production under any of the three nutrition options is highly competitive, with the option without fertilizer having the lowest competitiveness, while organic and conventional did not present differences in competitiveness.

Table 2. Average economic indicators per year obtained with three nutrition alternatives for agave mezcalero

	Organic	Conventional	Whitout fertilizer
Total income ($/ha)	117500.00	127500.00	72187.50
Total cost ($/ha)	22573.33	17335.83	9355.00
Net Income ($/ha)	94926.67	110164.17	62832.50
RBC ($)	5.21	7.35	7.72
value added ($/ha)	100360.00	115597.50	66832.50
RCP	0.05	0.05	0.06

In Figure 4, a comparison of the basic economic indicators, total income, total cost, net profit and added value of the three nutrition alternatives can be made, where it is confirmed that the conventional fertilization option showed the best levels of the indicators.

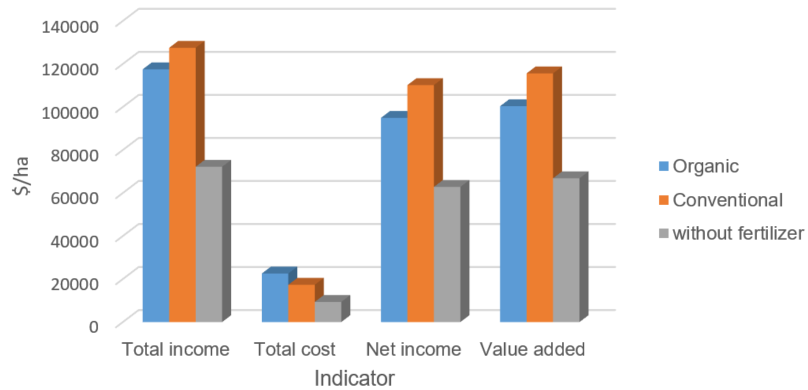

Figure 4. Preliminary economic indicators

In Figure 5, the RCP obtained for the three fertilization options can be observed, where it is observed that there was no difference in competitiveness between the organic and conventional options (RCP = 0.05), while without fertilizers it showed the least competitiveness (RCP = 0.06).

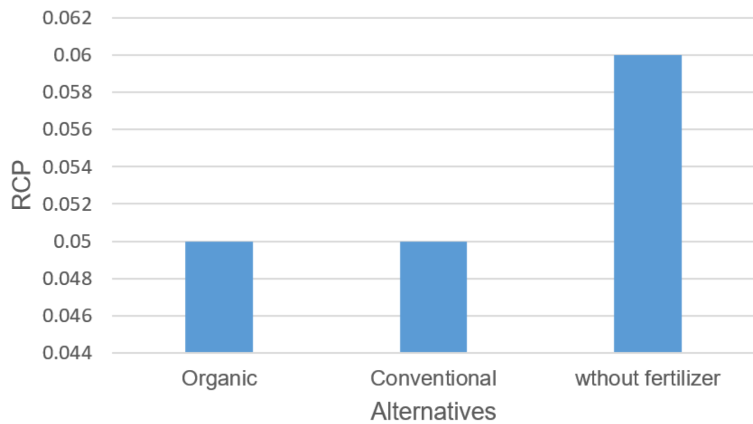

Figure 5. Private cost ratio of Agave production

Regarding the results of the sensitivity analysis of the RCP before possible changes in the sale prices of the raw material for the production of mezcal, the curves in which the RCP is a function of prices presented a behavior as proposed by Rodríguez et al., (2015) and Rodríguez et al., (2019) with an inverse relationship, that is, the lower the sale price, the lower the competitiveness and vice versa. Figure 6 shows that, under a sales price range of one peso per kilogram up to eight pesos per kilogram, production is competitive, even if the price drops considerably, competitiveness remains positive since the added value covers the internal factor costs and generates monetary gains for the producer. However, according to the behavior of the curves, it is possible to identify the option that is more convenient as it better withstands downward price changes, thus it is observed that the conventional option presented less sensitivity. When the price was the lowest of one peso per kilogram, the organic option is more susceptible to losing competitiveness, while with synthetic fertilizers there is greater security in maintaining competitiveness even with low sales prices. At high sales prices, the three options showed excellent levels of competitiveness, with no differences between the evaluated options.

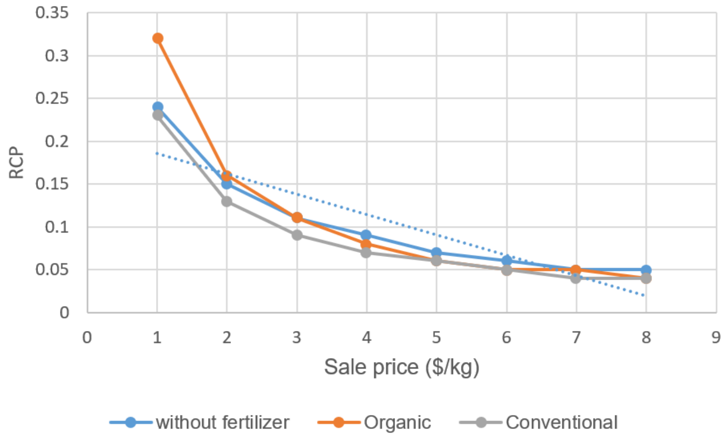

Figure 6. Sensitivity analysis of the RCP to changes in the sale price

4. CONCLUSION

The production of mezcalero agave, with the three fertilization options and under the current economic conditions of prices, is highly competitive, generating important profits and added value to the regional economy, for which it constitutes an important activity in the local economy, generating value. and employment in marginalized rural areas; no difference was observed in the level of competitiveness between conventional and organic fertilization, while the option without fertilizer proved to be less competitive, therefore, organic fertilization can be considered as an economically viable option, in addition to the benefits that its use entails as more sustainable production. Competitiveness did not show significant sensitivity to changes in sales prices, so this activity will continue to be competitive and profitable even in a scenario of low prices.

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