Socioeconomic impacts on Valencia orange (*Citrus sinensis* [L.] Osbeck) farming in Martínez de la Torre, Veracruz, Mexico

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ABSTRACT

Objective: To analyze the socioeconomic impacts on Valencia orange farming in Martínez de la Torre, Veracruz, Mexico.

Methodology: A study was carried out using semi-structured surveys applied to a sample of 40 Valencia orange producers during the 2023 agricultural cycle. Convenience sampling was carried out, considering demographic, agronomic, socioeconomic and environmental variables. The methodology included the analysis of production costs, profits and profitability. A multiple regression analysis was conducted to evaluate the relationships between the variables, using the statistical SPSS software version 29.0. The variables considered were profitability of the crop (dependent variable), and the independent variables: sowing density, age of the crop, yield, and production cost.

Results: The coefficients of regression show a direct relationship with the dependent variable, which is why the model as a whole is useful to explain the variability in the profitability of the Valencia orange crop.

Conclusions: The current production model highlights key challenges and opportunities for the producers. It is considered that the socioeconomic, agronomic, commercial and environmental variables drive the sustainability and competitiveness of the crop in the region.

Keywords: production, profitability, yield, Valencia orange, costs.

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INTRODUCTION

Globally, orange [*Citrus sinensis* (L.) Osbeck] leads production and trade in the citrus production sector. As a country, Mexico has given high priority to citrus farming because of its competitiveness in the production and export of lemons, limes, grapefruits and oranges, and it is the fourth global producer of grapefruit and fifth of orange (SADER, 2022).

According to the last report from the statistical yearbook of agricultural production in the year 2022, published by the Agrifood and Fishing Information Service (*Servicio de Información Agroalimentaria y Pesquera*) (SIAP, 2023), citrus production in Mexico is concentrated mainly in 10 states, with the following standing out: Tamaulipas, Veracruz, Tabasco, Yucatán, Nuevo León, Puebla, Sonora, Colima, Michoacán and Oaxaca. Among them, Veracruz is the undisputed leader in the production and export of citruses, performing a crucial role in the supply of oranges of varieties as relevant as Valencia, marrs and bitter orange.

In particular, the state of Veracruz has achieved a spillover of more than 7 million pesos through orange farming. With an average annual yield of 14.64 tons per hectare and a surface sown that exceeds 171,719 hectares, the region has proven to be a fundamental pillar in the domestic citrus production industry. The five municipalities that stand out in this region due to their contribution to orange production are: Álamo Temapache with 722,238 tons, followed by Tihuatlán with 200,328 tons, Papantla with 199,030 tons, Castillo de Teayo with 172,176 tons, and Martínez de la Torre with 134,168 tons.

There is special emphasis on Martínez de la Torre, located in the northern zone of the state of Veracruz, Mexico; this municipality has become a key stakeholder in the history of citrus production in the country throughout time. This prominence is due, on the one hand, to its outstanding production and export of Persian lime, and on the other, to the diversification that it presents by hosting the three varieties of orange previously mentioned, in contrast with the other municipalities that are limited to the cultivation of the Valencia variety.

Farmers from Martínez de la Torre, Veracruz, have generally faced a complex environment in constant change that includes fluctuations in the national and international markets that affect the profitability of orange production, as well as challenges related to pests, diseases, and climate change. There are also structural factors such as investment in technology, access to credit, and dynamics in the supply chain that have influenced the capacity of producers to adapt and to respond. In this context, socioeconomic consequences are evidenced in Valencia orange farming in Martínez de la Torre. From the year 2003 until 2022, the surface sown with orange crop has reduced by 11,221 hectares (SIAP, 2023).

Based on this, the socioeconomic impacts on Valencia orange farming were analyzed, taking into account the combination of socioeconomic variables adapted to the specific conditions in the region of study. Semi-structured surveys were conducted during the agricultural cycle corresponding to the year 2023, directed at a sample of 40 Valencia orange producers selected through convenience sampling.

MATERIALS AND METHODS

Characteristics of the study zone

Throughout its rich trajectory in the citrus industry, the municipality of Martínez de la Torre, Veracruz, has stood out as an important producer and exporter of citruses.

The results from the agricultural cycle of the year 2022 by SIAP (2023) reported the cultivation of Persian lime with a harvested surface of 15,579 hectares. Likewise, other citruses such as orange reported a harvested surface of 9,741 hectares, followed by grapefruit with 2,280 hectares, and varieties such as tangerine with 155 hectares and mandarin with 23 hectares harvested, which all contribute to the productive landscape. The value of the joint production of these citrus crops resulted in a total production value that exceeded 2,600 million MX pesos.

These impressive data reflect the continuous importance and success of Martínez de la Torre in the citrus production sphere, consolidating it as a key protagonist in the production and export of citrus at the national and international level.

Location of the study zone

According to the National Institute of Statistics and Geography (*Instituto Nacional de Estadística y Geografía*) (INEGI, 2021) together with the Ministry of Finance and Planning of the government in Veracruz de Ignacio de la Llave (SEFIPLAN, 2021), the geographic coordinates locate the municipality of Martínez de la Torre in the northern area of Veracruz, between parallels 19° 58' and 20° 17' latitude North and 96° 56' and 97° 10' longitude West, with a surface of 402.1 km^2 and an altitude that ranges from 10 to 400 masl. This municipality destines 79.07% of its areas to agriculture, while it only occupies 5.36% for the urban zone, leaving 15.57% to grasslands and rainforest.

Research techniques

A total of 40 semi-structured exploratory surveys were conducted, through convenience non-probabilistic sampling with different Valencia orange producers. The characterization of the crop in study was carried out in the first section, in agreement with the application of the survey with the aim of establishing the relationship between production costs and profitability of the Valencia orange crop; the second section represents the multiple linear regression econometric model. For the data analysis obtained, the IBM Statistical Package for Social Science (SPSS) version 29.0 was used for statistical tests and the multiple linear regression model.

MATERIALS AND METHODS

In the specific context of evaluating the profitability in Valencia orange production, a multiple regression analysis was conducted, where the multiple linear regression model is considered as a model to predict the value of a dependent variable based on the value of two or more independent variables; that is, Y is the dependent variable that it seeks to predict; (β_0), is the constant that represents the expected value of Y when all the predicting variables (X_1, X_2, ..., X_n) are zero; (β_1, β_2, ..., β_n) are the regression coefficients that indicate the relationship between each predictor variable and the dependent variable. For the study case, the dependent variable was profitability, and the following were independent variables: density of sowing, age of the crop, yield, and production cost.

The general equation of the multiple linear regression model is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_n X_n + ... + \varepsilon$$

Production costs of Valencia orange

The key method to evaluate the production costs of Valencia orange implied the conventional approach of economic theory.

This method is based on the relationship between the total production cost and the amount of oranges generated, expressed through the general formula:

$$Unit\ Cost = (Total\ \ Production\ Cost) / (Orange\ Yield)$$

Obtaining an accurate estimation of the total cost requires the meticulous collection of detailed data on fixed and direct costs, classifying them as labor, inputs, agricultural machinery, land, leasing, distribution and financing, among others. The sum of these elements generates the total production cost. The orange yield is measured in tons per hectare.

It is imperative to consider that the costs associated with the production activities and the agricultural inputs were obtained through two different methods: surveys and data about prices provided by commercial houses near the study area in the year 2023. The comparison between these two sources allows a more complete and accurate evaluation of the costs involved in Valencia orange farming.

Production profitability of Valencia orange

Measuring the profitability of the Valencia orange crop for the agricultural cycle 2023 was obtained through the formula:

$$Profitability = \left(Profit - Investment \mid Investment \right) * 100$$

The profit was calculated using the "Margin of Contribution" formula, which represents the difference between total income and the variable production costs:

$$Profit = Total\ Income - Total\ Production\ Cost$$

The "Total Income" refers to what is generated by the sale of Valencia oranges, and the "Total Production Cost" includes the variables of labor, inputs, agricultural machinery, land, leasing, distribution and financing, among others.

For the determination of costs and yields, data from interviews with producers and statistics reported by the SIAP portal for the year 2023 were compared. In order to avoid bias in the information, however, the cost (price) taken into account for the analysis was the one manifested by the producers of Valencia orange through the interview.

RESULTS AND DISCUSSION

Characterization of Valencia orange farming

During the observations, various activities have been identified in the farmland, classifying them into two categories: farming tasks to maintain the orange plantation and work associated to the process of fruit cutting.

The farming tasks for maintenance are carried out by day laborers and they are divided into two sub-categories: those carried out with their own tools, such as machetes and scissors, and those carried out with tools provided by the owner, such as clearers and tractors, which are handed out at the beginning of the workday and returned at the end. Payment for these tasks is weekly. In contrast, the work of orange cutting is paid daily, with workdays that begin between 6:00 am and 7:00 am, and conclude around noon or 1:00 pm.

An approach to maintaining the plantation has been observed, with practices such as periodic clearing and pruning of Valencia orange trees. This implies the elimination of unproductive branches and parasite vines that affect the tree development.

Soil fertilization is also conducted to improve the quality and presentation of the fruit. When it comes to the harvesting process, day laborers use cloth *ayates*, baskets and ladders to cut the oranges. While some cut and deposit the oranges in baskets, others transport these baskets to fill the transport truck with the fruit that has already been cut.

Finally, the transport process of the Valencia orange for its trade is divided into three markets, each subdivided into juice and fruit. The sale of oranges for juice is done through the sale on the scale or at the *juguera* (juice-maker). The sale of oranges as fruit is carried out in central markets destined to domestic trade.

Qualitative analysis: demographic, agronomic, economic, commercial and socio-environmental aspects

Evaluation of the field data about the Valencia orange producers has made it possible to offer a meticulous vision of many variables related to production. The interpretation is presented next.

Age: the average age of Valencia orange producers is 58 years old, suggesting an older population. This characteristic can be beneficial due to the accumulated experience and deep knowledge in crop management. In addition, age could influence the planning of succession in the operations of orange farming.

Sex: the participation of men predominates among producers, with 72.5% compared to 27.5% of women.

Marital status: 70% of the survey respondents declared being in domestic partnership, 20% are widows, 7% married and only 3% single.

Education: the educational disparity is evident, with 57.5% of the producers who only completed primary school, 30% secondary school, and only 12.5% with high school education.

In Martínez de la Torre, the management system for Valencia orange farming continues to follow a conventional approach, although the income generated does not satisfy the basic needs of producers.

Although it is not imperative to obtain credits, the annual production costs on average were the following:

Leasing of a hectare was $9,200; farming tasks around $1,400; soil fertilization $5,585.63; and weed control, $890.75. Thus, this represents an economic challenge.

The total annual production cost per hectare is $17,076.38 MX pesos, with an average unit cost per ton of $965.

Meanwhile, the average annual profit reaches $28,305.73, highlighting the absence of leaf fertilization and the use of heavy machinery. The average profitability is 1.41, indicating that a yield of 1.41 is obtained for each investment unit.

The sale price of conventional plants is $17.00 pesos, in contrast with $35.00 pesos for certified plants. The producers devote on average two hectares to Valencia orange cultivation, with a density of 267 trees per hectare and a mean age of 32 years. A single

cut is carried out per year, with an average yield of 14.9 t ha^{-1}. In terms of trade, 45% is sold to intermediaries, another 45% through auctions, and only 3% is destined to the sale to juice-makers, with the collection center known as "sale at the hole". Environmental changes include 55% soil erosion and 45% contamination of water sources due to ill management of agricultural residues. The climate challenges are notable, with 95% facing drought and only 5% affected by torrential rainfall. The main threats are *Diaphorina citri*, mites, woodlouse, aphids, leaf miner, and diseases such as Huanglongbing, citrus tristeza, alternaria, antracnosis and canker.

Results from the econometric multiple linear regression model

Results were obtained based on the multiple linear regression model, which considers profitability as dependent variable and density of sowing, age of crop, yield and production cost as explicative independent variables. They are declared in the following way:

$$Profitability = \beta_0 + \beta_1 * Density\_Sowing + \beta_2 * Age\_Crop + \beta_3 * Yield * \beta_4 * Production\_Cost$$

Coefficients of correlation (R) and determination (R^2)

Table 1 shows the summary of the model in the context of the R and R^2 test where both values are significant, of R: 0.935 and R^2: 0.875. These values indicate that 87.5% of the variability in the profitability can be attributed to the independent variables incorporated in the model. A high R^2 points to a solid capacity of the model to explain the variation observed.

Analysis of variance test (ANOVA)

Another result obtained by the multiple linear regression (Table 2) is the ANOVA test, whose results reveal that the F statistic is high, reaching a value of 61.058. This substantial

Table 1. Summary of the model[b].

Model	R	R square	R square corrected	Typical error of the estimate
1	.935[a]	.875	.860	.11968

[a] Predictor variables: (Constant), Production_Cost, Crop_Age, Sowing_Density, Yield

[b] Dependent variable: Profitability

Source: Prepared by authors using Software SPSS v. 29.0, field research 2023.

Table 2. Analysis of variance (ANOVA).

Model		Sum of squares	gl	mean square	F	Sig.
1	Regression	3.498	4	.874	61.058	.000[b]
	Residual	.501	35	.014		
	Total	3.999	39			

[a] Dependent variable: Profitability

[b] Predictor variables: (Constant), Production_Cost, Crop_Age, Sowing_Density, Yield

Source: Prepared by authors using Software SPSS v. 29.0, field research 2023.

value indicates that the model has statistical significance, confirming that the predicting variables exert a significant impact in the Profitability of the Valencia orange crop. The degree of Signification (Sig.) associated to the F statistic is equal to 0.000, evidencing that the model is highly significant. When Sig. is lower than the conventional significance of 0.05, it suggests the rejection of the null hypothesis.

Interpretation of coefficients

Table 3 presents the coefficients corresponding to the independent variables, revealing the following relationships:

Density_Sowing: An increase of one unit in the density of sowing results in a reduction of 0.001 units in the profitability, keeping the other variables constant; Age_Crop: An increase of one unit in the age of crop translates into an increase of 0.001 units in profitability, keeping the other variables unchanging; Yield: An increase of one unit in the yield is associated with an increase of 0.162 units in profitability, keeping the other variables constant; Production_Cost: An increase of one unit in the production cost is related to a decrease of 9.21E-005 units in profitability, keeping the other variables constant.

Ultimately, the model is revealed as significant, offering a substantial explanation of the variability in profitability. The individual coefficients provide information about the relationship of each independent variable with the dependent variable. In other words, the model as a whole is a valuable tool to explain the variability in profitability. Next, the expression of the multiple linear regression model:

$$Profitability = 1.005 - 9.21 \times 10 - 5 \times Production\_Cost + 0.001 \times Age\_Crop$$
$$- 0.001 \times Density\_Sowing + 0.162 \times Yield$$

Table 3. Coefficients[a].

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Typical error	Beta		
1	(Constant)	1.005	.309		3.247	.003
	Seeding_Density	−.001	.001	−.055	−.906	.371
	Age_Crop	.001	.004	.016	.261	.796
	Performance	.162	.016	.674	9.850	.000
	Production_Cost	−9.212E-005	.000	−1.032	−15.248	.000

[a] Dependent variable: Profitability

Source: Prepared by authors using Software SPSS v. 29.0, field research 2023.

CONCLUSIONS

A demographic profile mostly composed by experienced producers is revealed, with an average age of 58 years, which indicates deep knowledge in crop management. However, educational disparity stands out.

From an agronomic and economic perspective, a conventional orientation is seen in the crop management, with significant annual costs and a lack of implementation of sustainable practices, which contravenes the growing global demand for agricultural sustainability, especially if the significant relationship between socioeconomic variables and profitability is taken into account. In terms of opportunities and challenges, the importance of training programs stands out, as well as access to financial resources, exploration of new markets, and diversification of products to increase competitiveness. Investment in research and development, together with innovative agronomic practices, becomes essential to approach challenges and improve perspectives in the long term. Environmental sustainability is perceived as a central worry, with soil erosion and water pollution identified as critical aspects. The multiple regression model applied to evaluate the profitability shows a robust explicative capacity, with R^2 of 87.5%, which suggests that the variables selected are key elements to understand the variability in profitability. In sum, the study provides an integral and balanced view of the landscape of Valencia orange farming in the region, highlighting both the positive aspects and the challenges, and offering orientations to improve the sustainability and competitiveness of the citrus industry in Martínez de la Torre.

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