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Determination of production costs of vanilla (*Vanilla planifolia* Jacks ex Andrews) in Huehuetla, Puebla, Mexico

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ABSTRACT

Objective: To identify the production costs of vanilla, as a primary link within the value chain, to determine the profitability of the crop in Huehuetla, Puebla, Mexico.

Design/methodology/approach: The information was obtained from applying N=40 surveys to producers in nine communities, with the methodology of financial evaluation of agricultural projects in the long term.

Results: The diagnosis showed that vanilla is a highly profitable crop, indicating an average production cost of 0.1 ha^{-1} of $54,471.90 and the average total sale price of 0.1 ha^{-1} of $187,500.00 which has an impact on a high profitability (B/C R=2.54), even under conditions of small cultivation surfaces, in addition to farmers combining it with other perennial and annual species that generate income in the short and medium term to support families.

Limitations on study/implications: Vanilla producers are located within a region with characteristics of marginalization due to their geographic location, which makes access to communication difficult; they do not have a government agency to represent them, and therefore, the information of production costs is limited and dispersed.

Findings/conclusions: Vanilla is a crop of great productive potential in the Totonacapan region, and particularly in Huehuetla, due to their high commercial value. It is advisable to promote programs that favor its expansion with improvements in cultivation techniques that reflect higher yields, quality and commercialization to improve the standards of living of the farmers.

Keywords: vanilla, costs, production, profitability, value chain.

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INTRODUCTION

Vanilla (*Vanilla planifolia*) (Orchidaceae) is a tropical crop originally from Mesoamerica and very important commercially. Currently it is one of the most demanded products in the refreshment and culinary industry (Rocha *et al.*, 2018), considered one of the most profitable crops after saffron (Luis *et al.*, 2020). The distribution of vanilla has been reported since colonial times in Mexico, all of Central America, Jamaica, Tobago, Colombia, Venezuela, Guyana, Ecuador and Peru, with Mexico being the place where more studies have been conducted (Gamboa *et al.*, 2014).

Authors like Porras (2013) mention that this orchid is cultivated in many parts of the world, although, the main producing countries are Madagascar, Indonesia, China, Mexico and Turkey. Production of the vanilla with best quality in the world is in Mexico, in the region of Totonacapan, which includes 20 municipalities in the state of Veracruz and 19 in the state of Puebla with a contribution of 76.8% of the production. Its main use is in the food industry and in the cosmetic industry, among others (Damirón, 2004; OMPI, 2009; Díaz *et al.*, 2018).

In the National Agricultural Plan 2017-2030 in Mexico, an increase is estimated in the global demand of 7,307.14 ton to 10,515 t (accumulated growth of 43.9%), while the national production of vanilla has the ability of increasing from 512.78 to 856.71 t, which represents an accumulated growth of 67.07%. To convert vanilla into something useful and finally deliver the finished product to the consumer, it has to go through a process from the acquisition of the plant material, the crop's growth and development, incorporating inputs, cultural tasks and agronomic management, harvest, processing, packaging and commercialization of the product. In terms of production, given the importance of the first link of the production chain, it is necessary to understand which elements are integrated in its analysis process, taking into account key elements that are conjugated in their productive systems, specifically the cost factor, where its use today is not only for transformation and service businesses, but rather for the agricultural business or company (Molina, 2017).

Based on the criterion by Sánchez (2013), the production process is defined as "a series of steps and actions that people take with the help of tools and machinery to achieve the transformation of raw materials into finished products or providing services of a different nature". Therefore, the importance of knowing the profitability margin of a business demands having accurate records about the processes developed, that is, quantifying the activities so that accurate information can be available in quantitative terms, on which decision making could be sustained or supported (Melean and Torres, 2018). As for Ochoa (2015), the author mentions that production costs have become quite a transcendental variable for farmers, considering them as the fundamental basis for planning, control and decision making.

In terms of agricultural production cost, it is conceptualized as the cost in which they incur to convert seeds and inputs into finished products (Molina *et al.*, 2009); the author describes the basic elements (direct raw material, direct labor, and indirect production costs) as a fundamental part for the quantification of costs. Barrera *et al.* (2011) and Espinosa *et al.* (2015) suggest that it is necessary to conduct studies about profitability and productivity for decision makers, as well as for producers; therefore, performing an analysis of technical and economic viability of an agricultural activity is important. Therefore, the objective was to identify the production costs of vanilla as primary link within the value chain to determine the profitability of the crop in Huehuetla, Puebla, Mexico.

MATERIALS AND METHODS

The study was carried out in Huehuetla, Puebla, which benefits from the denomination of origin of vanilla (20° 02' 10" N and 97° 35' 97" W) of the Northeastern Sierra in Puebla, located at an altitude of 517 masl, in the climate transition zone of the temperate Northern

Sierra to the warm zone of the Gulf slope, with a single climate that is semi-warm subhumid with rain throughout the year, and where there are around 18,803 inhabitants (SNIM, 2015). Huehuetla is eminently rural, reporting that 89% of the population, in addition to having a broad traditional agricultural knowledge, conserves the native language, which is the dialect variant known as Totonaca from the Sierra (Mackay and Trechsel, 2015). It is one of the rural populations characterized by presenting a very high degree of marginalization, and currently it occupies the first place in the state (SNIM, 2015).

The target population was made up of n=40 farmers, based on the list of beneficiaries from the program "Productive reconversion for crops of high commercial value" of the Ministry of Rural Development in the state of Puebla. Through the key informants, the nine communities devoted to vanilla production were located: Cinco de Mayo, Putlunichuchut, Kuwikchuchut, Xonalpu, Huehuetla, Leacaman, Putaxcat, Lipuntahuaca and Chilocoyo El Carmen. A study with qualitative and quantitative approach was conducted. The technique used for the application of the instrument in the field is sampling by reference chain or snowball (Mendieta, 2015). The field work was carried out in the month of May, 2022, and consisted in the application of a structured survey for the diagnosis of the vanilla production system in the municipality, specifically the production costs emphasizing the cost of preparing the land (cleaning, cutting or felling trees, weeding, establishing tutor trees, treating soil or substrate, and boxing), establishing the crop (planting, cuttings, replanting, organic and inorganic fertilizers, pest and disease control, and live tutors), farming tasks (tying cuttings, safety pruning, pruning for vines and tutors, channeling, pollination, and manual weeding), organic and inorganic fertilization, application of insecticides and fungicides, irrigation, harvest, gathering and commercialization.

Each of the members of the sample was surveyed directly on his plot with the aim of corroborating and complementing the information from the interview respondents. The profitability of the crop was determined by applying the methodology of financial evaluation of agricultural projects in the long term (Gittinger, 1982). In the financial evaluation, the flow of production costs (*CF*) and flow of income (*IF*) were estimated for a time horizon of 10 years, since this is the period when the plantation achieves stable production. To estimate production costs, the following formulas were applied (Espinosa *et al.*, 2015):

$$FC = TCoE_1 + \left(\sum_{i=1}^{N=10} FPCo + VPCo \right)$$

Where: *TCoE*=Total cost of establishment of the plantation on year 1, calculated by the sum of the amount of inputs used for the establishment of a surface of 0.1 ha of vanilla by its respective market average in 2021; *FPCo*=Fixed production cost of year 1 to year 10, calculated by the sum of the depreciation costs of the plantation (*TCoE* minus the rescue value, divided by the 10 years of useful life); and *VPCo*=Variable production cost from year 1 to year 10, calculated by the sum of the different amounts of inputs for the operation and

maintenance of the plantation for its respective average market price. The Income flow was estimated using information about the sale price of the vanilla producer (*Px*) and the yield obtained from the pod (*Rx*) in a surface of 0.1 ha. Mathematically, it is obtained with the following formula:

$$FI = \left(\sum_{i=1}^{N=10} Px * Rx \right)$$

The production and income costs correspond to the useful life of the project, which is why they were taken to present value by applying an updating rate of 12%. Finally, the Net Present Value (NPV), the Internal Return Rate (IRR) and the Benefit-Cost Rate (B/C R) were estimated.

To compile data, an Excel registry format was designed on the costs of establishment and the costs of maintenance for a surface of 0.1 ha of vanilla; likewise, information was gathered about the sale prices of the producer and yield for that surface.

RESULTS AND DISCUSSION

The producers surveyed have surfaces of less than 0.5 ha, which is why 95% have surfaces of 100 to 1000 m^2, which agrees with what experts from Universidad Autónoma Chapingo, Colegio de Postgraduados and the Sistema Producto Puebla describe, who mention that 79% of the vanilla producers from the Totonacapan region devote surfaces of less than 0.5 ha (smallholding) for vanilla production (Santillán *et al.*, 2019). Of the farmers, 93% sow under rainfed conditions and 100% have the type of land tenure of private property, which is a result similar to that obtained by Torres (2020), where the author mentions that in the municipality of Huehuetla, land tenure obeys the scheme of private smallholding, reason why some peasants opt for having lands for other basic crops such as corn and bean.

The vanilla production system in Huehuetla shows that 77% manages the crop using the *cocoite* tutor (*Gliricidia sepium*) intensively. Under this system of high-density plantation, the distance between tutors recommended for plantations is 2×1 m, and two cuttings per tutor, so that the plant density is 1000 plants 0.1 ha^{-1}, compared to the production system in shade mesh characterized by having 1862 cuttings 0.1 ha^{-1} on average compared to another mean of 123 cuttings 0.1 ha^{-1} in production systems under orange trees (Barrera, 2009). As Sánchez (2001) mentions, the number of tutors in a vanilla plantation will depend on the tutor canopy, since the regulation of shade is very important, so that the vanilla is left exposed to the sun in 50%. Of the farmers, 75% use the commercial variety that is *Vanilla planifolia* J., as mentioned by Herrera *et al.* (2022) who describe that vanilla production in Mexico is through *V. planifolia*, with the Totonacapan region being one of the most profitable.

This orchid is planted in the spring-summer cycle and fall-winter cycles under the system mentioned before. Land preparation for sowing is diverse, it takes place in two periods or dates; it begins with weeding, cleaning, in the months of January and March. After these activities, cutting or felling trees is done, the establishment of live tutors, the

treatment of land or substrate, some cleaning activities and some other task to prepare the land, although all the farmers do not necessarily carry out the activities or in the order mentioned.

Once the land is in optimal conditions for the establishment of the cuttings and their good growth and development, there is a period of four months for sowing, which happens in the months of May and August. An activity called auxiliary irrigation is carried out, generally performed in the flowering season or in the month of May when the temperature is intense and higher than 35 °C.

In the study region, only chemical fertilization is applied based on the formulation N46-P00-K00 (urea). In the case of organic fertilization, it is based on the use of organic fertilizers such as bokashi (1 kg plant^{-1}) and manure (1 kg plant^{-1}) applied each year.

Weed management in vanilla cultivation is of great importance, and their control is carried out since the moment when the crop is established, twice per year. Among the main weeds found there are *Simsia amplexicaulis* (*acahual*), Commelinaceae (*oreja de ratón*), *Ipomoea purpurea* (*quiebraplatos*) and *Bidens odorata* (*aceitillo*). Regarding the impact of pests and diseases, there are *Tentecoris confusus* (red bug) and diseases from *Fusarium oxysporum* (basal rotting), *Puccinia* sp. (rust), and *Colletotrichum* spp. (canker), which agrees with Mata *et al.* (2007) cited by Barrera *et al.* (2011), who mention that the red bug, *Fusarium*, and canker are the most common in the vanilla crop, so farmers resort to applying chemical and natural products for their prevention and control such as copper sulfate, cypermethrin pyrethroid, calcium hydroxide, extract of chili pepper, onion, garlic and soap (FAOSTAT, 2017).

The harvest is carried out during the fall, once the pods reach their state of physiological maturity; the indicator to perform this activity is when the apex or tip of the fruit changes from a green to a yellow color, description that is similar to what was exposed by Cervantes *et al.* (2019), and it happens six or eight months after pollination (March and May). The harvest is carried out manually and up to two workdays are considered for this activity. The production costs for the establishment of vanilla under the production system in cocoite (*Gliricidia sepium*) and in high densities with the variety *Vanilla planifolia* Jacks Ex Andrews were $48,920.00, including auxiliary irrigation which is applied four times per month with a total of 48 irrigation events per year, tools and other activities of workforce (Table 1).

Table 1. Initial production costs and maintenance of the *Vanilla planifolia* Jacks Ex Andrews crop produced with cocoite tutors in high densities in Huehuetla, Puebla.

Concept	Vainilla
Establishment of the plantation	$ 0.1 ha^{-1}
Module maintenance	$ 48,920.00
Variable costs	$ 49,378.90
Fixed costs	$ 5,093.00
Costs of production	$ 54,471.90

Source: Prepared by the authors with information obtained in the field 2022.

On average, the total production cost to produce vanilla in a surface of 0.1 ha is $ 54, 471.90, where all the activities or practices recommended for the management of vanilla are contemplated.

To estimate the Income flow, the yield and sale price of the green pod was required. Under the production system in high densities with *Gliricidia sepium* tutors, the yield was 250 kg, which contrasts with the research carried out by Barrera *et al.* (2011) who evaluated the shade mesh system and estimated a yield of 100 kg on a surface of 6000 m^2. The increase in yield is one of the indicators of the crop's productivity, but when the unitary cost is analyzed this is confirmed, as shown in Table 2. For a farmer, it costs $191.2 to produce one kg of green vanilla, which means that the yield obtained allows covering the production costs. The gross income obtained was $187,500.

Regarding the indicators of the profitability of the vanilla crop, under this production system in high densities under the cocoite tutor (*Gliricidia sepium*), a NPV higher than zero was obtained, which indicates that the vanilla production generates profits, so it can be deduced that it is a good investment since it generates economic benefits. The IRR was higher than the discount rate of 12%, which indicates that the investment is convenient and profitable (Table 3).

To calculate the profitability, it is necessary to take into account the benefit/cost (B/C) rate as indicator of its economic viability. In this sense, the profitability analysis of the vanilla crop revealed that the B/C rate was 2.54 (Table 3), so that vanilla production in Huehuetla is considered a crop of commercial value, highly profitable, since the investment is recovered and there is a result of nearly double of the profits compared to the investment made; that is, for each peso that is invested in this crop, a utility of 1.54 is expected.

Table 2. Unitary cost and income from vanilla in the municipality of Huehuetla, Puebla.

Variable	Vanilla
Unit cost ($ 0.1 t)	192.2
Yield (kg 0.1 t^{-1})	250
Sales price ($ kg)	750
Gross income ($ 0.1 t^{-1})	187,500
Net income ($ 0.1 t^{-1})	139,450

Source: Prepared by the authors with information obtained in the field 2022.

Table 3. Indicators of profitability and economic feasibility of the vanilla crop in Huehuetla, Puebla.

Indicator	Vanilla
GO	515,391
B/C ratio	2.54
IRR (%)	88

Source: Prepared by the authors, 2022.

According to Borja *et al.* (2016), when the benefit/cost rate is higher than the unit, it indicates that there is profitability. Other authors such as Herrera *et al.* (2022) mention that the value of the vanilla value chain is important both in general and in the profitability of each link, so it is an opportunity in employment and welfare for local communities.

CONCLUSIONS

Vanilla is a crop of very high productive potential in the Totonacapan region, and quite importantly in the municipality of Huehuetla, which has the denomination of origin in addition to its great diversity and uses, and because it is a crop with high commercial value, it is a profitable alternative for the farmers. It is recommended to firmly support with programs that promote its expansion, to support the development of strategies and technologies that improve cultivation techniques which result in higher yields and better quality, and to ensure a commercialization that benefits producers in these vanilla-producing zones of the northeastern region of the state of Puebla and surrounding area, in order to detonate regional development through crops that are potentially profitable such as vanilla.

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