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Artículo Original

Factors that influence the income of avocado (*Persea americana* Mill.) producer in Imbabura and Pichincha, Ecuador

Factores que influyen en los ingresos de los productores de aguacate (*Persea americana* Mill.) en Imbabura y Pichincha, Ecuador

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Abstract

Objectives: Analyze the factors that influence the income of avocado producers in Ecuador, specifically in the provinces of Imbabura and Pichincha. **Methodology:** Surveys were carried out to obtain information from 102 production units (farms). The information from the surveys was analyzed using averages and the percentage was showed in bar graphs for each quantitative variable. A regression model was used to determine the relationship between the variables and their impact on producers' income. **Results:** The majority of farmers in Pichincha and Imbabura are small producers, they use avocado plants grafted on local rootstocks, there are a few physical or digital records on crop management, only a few producers have access to credit and the majority use their own money to finance their crops. The main problems in avocado production were associated with the presence of pests and the low sale price of the fruit. Most farmers use organic fertilizers and perform pruning (training and sanitary) to improve agronomic management; they also sell their production through intermediaries, obtaining low sales prices, being it the main marketing problem. **Conclusions:** The main factors that positively influenced the farmer's income were: land area, implementation of good agricultural practices, training for crop management, sales to the industry, prices and fruit selection; while the factors that had a negative influence were: cultivation in infertile soils, lack of credit and pest problems.

Keywords: Crop management, pests, pruning, training, regression, commercialization.

Resumen

Objetivos: Analizar los factores que influyen en los ingresos de los productores de aguacate en el Ecuador, específicamente en las provincias de Imbabura y Pichincha. **Metodología:** Se realizaron encuestas para obtener información de 102 unidades de producción (fincas). La información de las encuestas se analizó mediante promedios y el porcentaje se representó en gráficas de barras para cada variable cuantitativa. Se utilizó un modelo de regresión para determinar la relación entre las variables y su incidencia en los ingresos de los productores. **Resultados:** La mayoría de los agricultores de Pichincha e Imbabura son pequeños productores, utilizan aguacate injertado en portainjertos locales, los registros físicos o digitales sobre el manejo del cultivo son bajos, solo unos pocos productores acceden al crédito y la mayoría utilizan su propio dinero para financiar sus cultivos. Los principales problemas en la producción de aguacate estuvieron asociados a la presencia de plagas y al bajo precio de venta del fruto. La mayoría de los agricultores utilizan fertilizantes orgánicos y realizan podas (de formación y sanitarias) para mejorar el manejo agronómico; asimismo venden su producción a través de intermediarios, siendo los bajos precios de venta el principal problema para la comercialización. **Conclusiones:** Los principales factores que influyeron positivamente en los ingresos del agricultor fueron: extensión de la tierra, implementación de buenas prácticas de producción, capacitación para el manejo del cultivo, ventas a la industria, precios y selección de frutas; mientras que los factores que influyeron negativamente fueron: cultivo en suelos infértiles, falta de crédito y problemas de plagas.

Palabras clave: Manejo de cultivos, plagas, podas, capacitación, regresión, comercialización.

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Introduction

Agriculture is an activity with multiple biological, economic, social, cultural, human, political and market implications. Obtaining models that manage to encompass, represent and fully relate them as a system is a difficult task, but with great importance to complement the efforts made in different fields to achieve the development of agriculture and improve the socioeconomic level of the peoples (Aldaz et al., 2020).

Avocado cultivation (*Persea americana* Mill.) is appreciated worldwide for its nutritional and nutraceutical characteristics since it is a source of essential elements, bioactive compounds and fatty acids (Viera et al., 2023), which has caused greater demand in the gastronomic and industrial area (Coello, 2017). Although there are several factors that can modify the demand for a food product, Porras Villafuerte (2019) highlights the economic income of consumers, the food preference of buyers and the seasonality of the supply, among other variables that determine the amount of demand for a product. In the particular case of avocado market, from 2017 to 2027 is expected to increase at an annual rate of 6.2% (Sommaruga & Eldridge, 2020).

In Ecuador, this crop offers high expectations for its production, due to its commercialization potential and access to different markets (Enríquez, 2018). The avocado also generates interest in farmers from different areas to establish new producing farms. According to Alvarez et al., (2021) in Ecuador the planted area of avocado was 7,125 ha in 2019. According to Viera et al. (2016), Imbabura and Pichincha are provinces that have a high participation in the production of this fruit in the country.

According to the Ministerio de Agricultura y Ganadería (MAG, 2021), Ecuador exported USD 632,000 of fruit in 2021, and the main destination countries were Spain (78%), Colombia (6%) and Hong Kong (6%), this fruit crop is of great economic importance because of its potential to generate around 360 million dollars a year for the country, and its presence in at least 34 potential markets.

The production, marketing and sale of avocados are related to aspects such as the organization of producers, technical production processes, pest management and economic planning (Álvarez & Manosalve, 2019; Álvarez et al., 2021). According to Prada (2015), there is a strong hoarding of production by intermediaries who reduce the profitability of producers and add an increase to the final price. Due to growing global demand and opening of international markets for avocado, this crop can contribute significantly to increased investments, greater foreign exchange earnings, job creation, strengthening agroindustry and improving the quality of life of different people, actors of the productive chain, it is also necessary to transfer technologies that contribute to the integrated production of the crop in accordance with the rational management and use of resources such as soil and water that allow the balance and sustainability of the system (Viteri et al., 2021)

With this background, this research aimed to determine the factors that influence the income of avocado producers in the provinces of Imbabura and Pichincha.

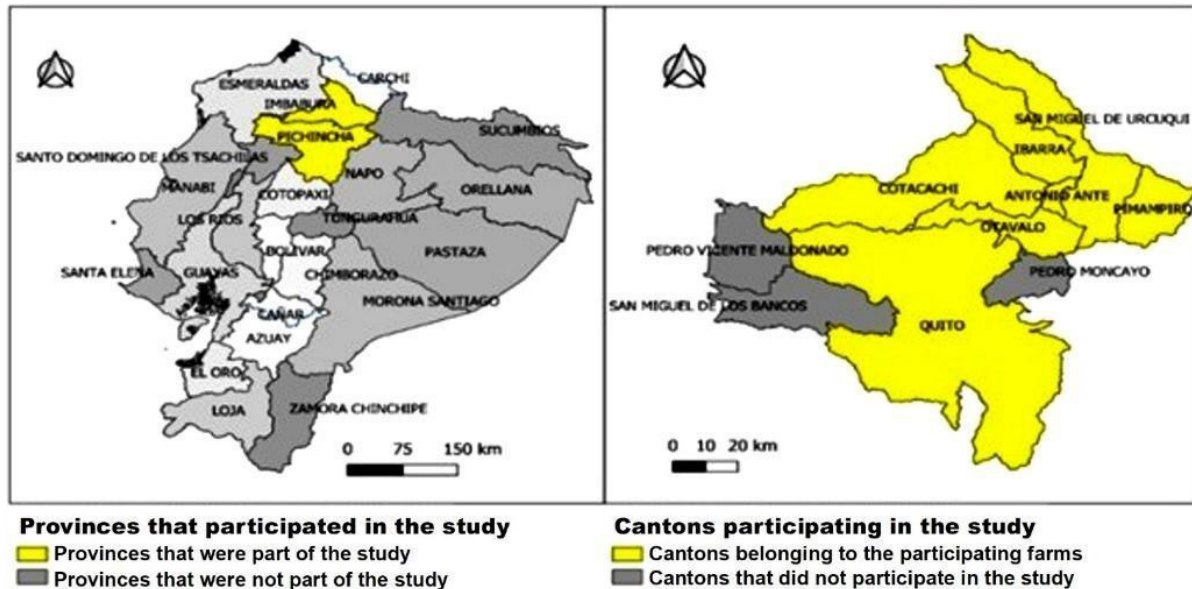
Methodology

Study arean

This study was carried out by collecting primary information in the provinces of Imbabura and Pichincha (Figure 1). For the province of Pichincha, the survey was carried out in the parishes of Puéllaro, Perucho, Chavezpamba, Atahualpa and San José de Minas; sites that have an average of temperature of 16°C, 86% of relative humidity and 535 mm of annual precipitation. In Imbabura, the survey was carried out in Cotacachi, Otavalo, Antonio Ante, Pimampiro, Ibarra and San Miguel de Urcuquí; sites that have an average temperature of 17 °C, 80 % of relative humidity and 1716 mm of annual precipitation.

Figure 1

Geographical location of the study site to determine factors that influence the income of avocado producers in Imbabura and Pichincha, Ecuador



Sampling

For the collection of information, a survey was used as a data collection instrument, to obtain both quantitative and qualitative information related to avocado production and management (Álvarez & Monsalve, 2019).

The sample size (n) was determined using the Levi & Lemeshow (2008) formula:

Where:

N: Total size of the study population (4,449 farms) (MAG, 2021);

Confidence level ($\alpha = 5\%$) to the normal distribution (Maina et al., 2014).

δ : Maximum error allowed between the point estimate and the actual value $\delta = 180$;

S^2 : Estimated variance of the variable to be analyzed (estimated from the maximum range of the variable under study: R)

$$R = X_{\max} - X_{\min}$$

In this study, 102 farms were surveyed, 57 farms belonged to the province of Imbabura (55.8%), while 45 farms belonged to the province of Pichincha (44.2%). Currently, the largest avocado production is concentrated in the highlands, precisely in the inter-Andean valleys of Pichincha, Imbabura, and Carchi, this is due to

its diversity in altitudes, climates and soils that allow efficient avocado production (Álvarez et al., 2021). The survey consisted of 56 questions related to general data of the participating farms, family composition, description of agricultural activities and the farm, crop management, use of resources and technology, productive management, negotiation, costs and training. The surveys were carried out from May to September 2021 and were carried out directly to farmers between 24 and 84 years old, small categorized as large (10 or more ha), medium (5.1 to 9.9 ha) and small producers (less than 5 ha).

Statistical analysis

The information from the surveys was analyzed through averages and the percentage was represented in bar graphs for each quantitative variable. Additionally, the relationship between income with a set of variables (Good Production Practices, pest problems, training, land extension, grown in not suitable soil, credit, selection of fruit, sale to the industry and prices), to determine the factors that influence farmers' income, was analyzed using the regression model proposed by Ramírez & Potes (2019) with the following formula:

$$Y = \beta_0 + \beta_1 X_1 + \dots + \beta_p X_p + \epsilon$$

Where Y are the income; β are the regression coefficients; X_p are the independent variables that explain the statistical model. In addition, to comply with the assumptions of the regression model (Marques de Sá, 2007), the dependent variable and land area were transformed into natural logarithm. The data obtained were analyzed using the statistical software R version 4.1.3.

Results and discussion

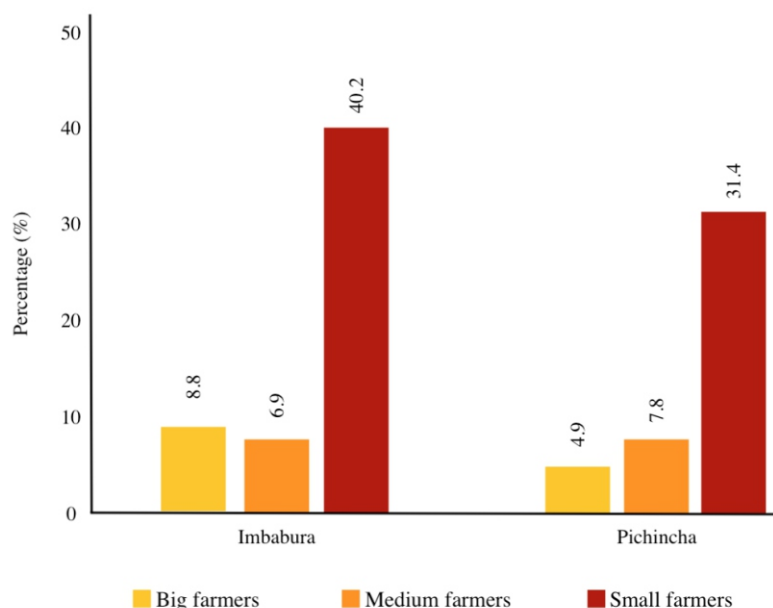
The avocado is highly desired both nationally and internationally, the high demand for this fruit has encouraged producers to increase the number of hectares for the production of this fruit. There is a tendency to increase avocado cultivation in Ecuador (Viera et al., 2016) which is similar to the

trend found by León (2020), who indicates that due to the avocado export boom in Mexico, the area for this agricultural activity increased by up to 60%.

Figure 2 shows that most of producers in Imbabura (40.2%) and Pichincha (31.4%) are within the small producer's category (less than 5 ha); while 6.9% (Imbabura) and 7.8% (Pichincha) are in the medium category (5.1 to 9.9 ha); finally, 8.8% (Imbabura) and 4.9% (Pichincha) are in the large category (>10 ha). In a study carried out on avocado producers in Michoacán Mexico, Steffen Riedemann & Echánove Huacuja (2003), determined that most of the producers had an area of 1 to 3 ha which is similar to this study; whereas some between 4 and 6 ha, and just a few with 7 or 8 hectares.

Figure 2

Surface of the land and factors that influence the income of avocado producers in Imbabura and Pichincha, Ecuador



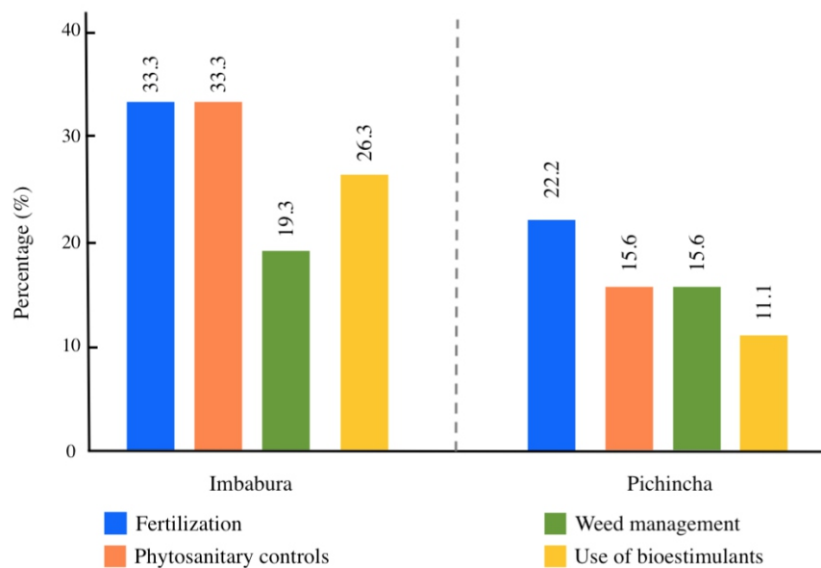
On the other hand, the plant material used by the avocado producers were grafted plants with commercial varieties (Fuerte and Hass), using local rootstocks. These plants were acquired grafted from nurseries or were grafted in the field. This information agrees with López et al. (2022) who recommend the use of grafting in order to guarantee the presence of characteristics of the mother plant in the new plants.

The information on the farm and the organization in crop management is a tool that allows the producer to make appropriate decisions regarding the management of their

crops. According to Figure 3, the producers of Imbabura showed records of fertilization, phytosanitary controls and use of biostimulants (33.33%, 33.33% and 26.32% respectively); in the province of Pichincha, a similar trend is observed in records of fertilization, phytosanitary controls and use of biostimulants variables (22.22%, 15.56 and 11.11% respectively). As recommended by Pedroza et al. (2018), awareness and education of the producer is necessary for the use of records as a traceability tool, allowing an improvement to make the cultivation a more successful business.

Figure 3.

Record of activities and products used by avocado producers in Imbabura and Pichincha, Ecuador

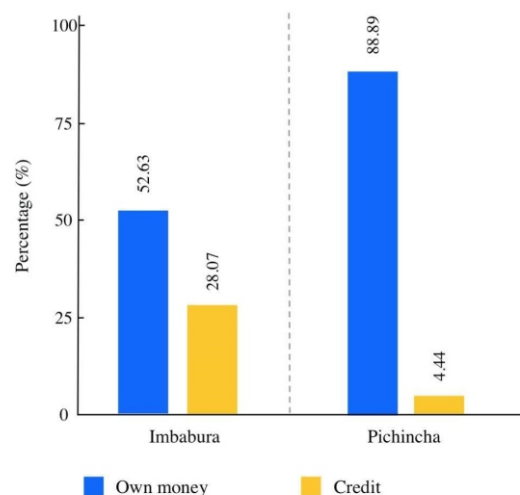


In Figure 4, it can be seen that 88.89% of Pichincha producers and 52.63% of Imbabura producers use their own money to finance their crops. Only 4.44% in Pichincha and 28.07% in Imbabura have access to credit to finance their agricultural activities. Producers are not interested in the financial system because institutions make them go through too many

bureaucratic processes to request a bank loan. In addition, the interest rates are too high (consumer loans in the private financial system are 16.24% per year). Consequently, their production is limited only to the money available from the last harvests and sales of their agricultural products. However, financing is an important basis for crop technification and the acquisition of inputs.

Figure 4

Source of financing for avocado production in Imbabura and Pichincha, Ecuador



Regarding the problems related to avocado production, Figure 5 shows that in Imbabura and Pichincha, the main issues are associated with the presence of pests and the low sale price of the

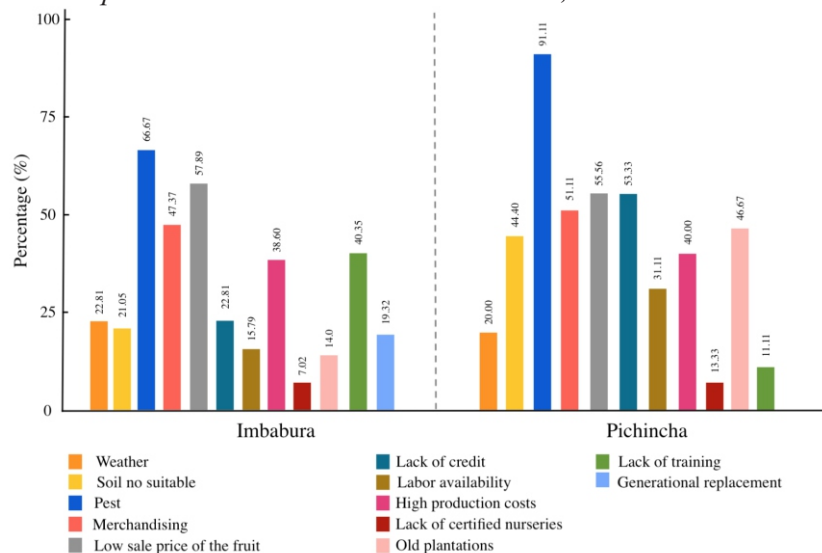
fruit. In Pichincha, 91.11% of producers say that pests are the main problem in their avocado crops, while 11.11% of producers say the lack of training is the main problem in their crops. In Imbabura,

66.67% of producers say that pests are the main problem in their avocado crops and 7.02% say that the lack of nurseries that provide quality plants is their main problem. Urrea & Cardona (2020) say that avocado pest management should be focused on having quality fruit, although the

quality requirements depend on the client or the destination country, there are some pests that are limiting at the level of international trade and their presence in fruit implies the closure of markets at the local level.

Figure 5.

Problems for avocado production in Imbabura and Pichincha, Ecuador

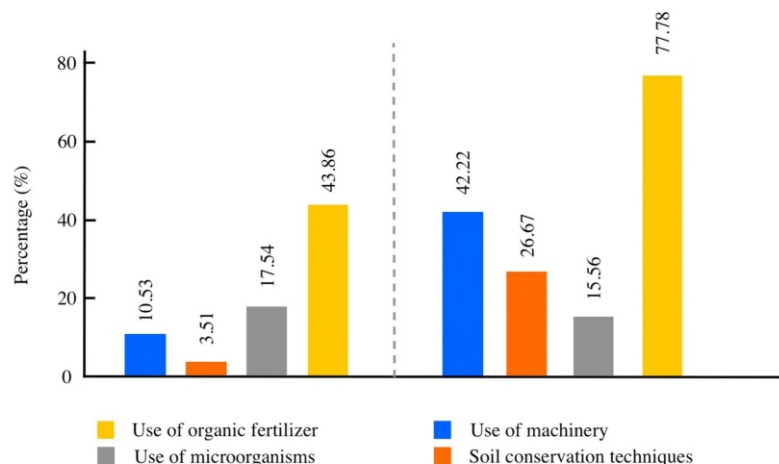


For the use of technology variable, Figure 6 shows that the high use of organic fertilizer is a common denominator in both provinces. In Pichincha, 77.78% of avocado producers use organic fertilizers while 15.56% use microorganisms in their crops. In Imbabura, 43.86% of producers use organic fertilizers in their crops and only 3.51% use techniques to prevent erosion. The main organic fertilizers are those of both vegetable and animal origin,

highlighting compost, bocashi, humus and bioles. Díaz (2011) mentioned that the key in the fertilization and soil improvement processes is the balance of nutrients where there is neither an excess nor a deficiency, with the use of organic resources as essential. On the other hand, elements such as agricultural machinery, microorganisms, and soil conservation techniques are very little implemented for use on farms in both provinces.

Figure 6.

Use of agricultural machinery and technology by avocado producers in Imbabura and Pichincha, Ecuador

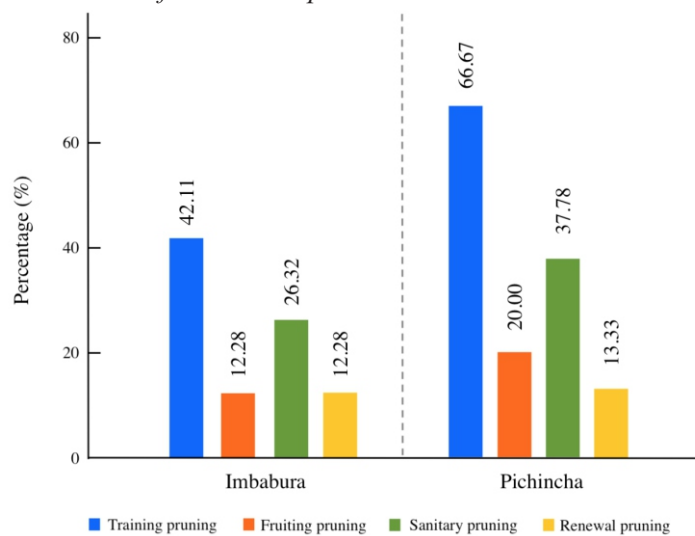


Regarding pruning (Figure 7), it was observed that training pruning is the most used in the two provinces, followed by sanitary pruning. In Pichincha, 66.67% use training pruning, 37.78% sanitary pruning, 20% fruiting pruning and 13.33% renewal pruning. While in Imbabura, 42.11% use training pruning, 26.32% sanitary pruning, 12.28% fruiting pruning and the same percentage use renewal pruning. About 37% of interviewed agricultural producers from both provinces do not perform any type of pruning at

any stage of avocado production, seriously affecting the quality and quantity of the fruit obtained. According to Viteri et al. (2021), pruning is one of the most important techniques to take care of the quality of the avocado crop, allowing sunlight to enter all the branches. It also contributes to the renewal of branches that have been affected with the passing of the productive cycles, generates optimal management for pest control, and maintains an appropriate size on the tree, which facilitates the harvest of the fruit.

Figure 7

Types of pruning carried out use for avocado producers in Imbabura and Pichincha, Ecuador

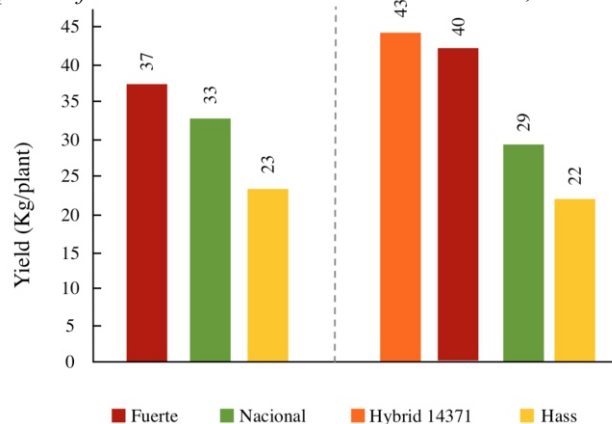


According to Figure 8, in Pichincha the 'Híbrido' cultivar shows the highest fruit yield per plant (43 kg) followed by the 'Fuerte' variety with 40 kg per plant, the 'Nacional' cultivar shows 29 kg per plant; and, finally Hass variety shows the lowest harvested fruit yield per plant (22 kg). In Imbabura 'Fuerte' variety shows the highest fruit yield per plant (37 kg), the 'Nacional' variety

shows 33 kg per plant; and, finally 'Hass' variety shows the lowest harvested fruit yield per plant (23 kg). The low yield of the 'Hass' variety in this study is since the plants were relatively young from 3 to 6 years old and they have not yet expressed their productive potential; while the 'Fuerte' and 'Híbrido' were plants of 10 to 15 years old.

Figure 8

Average yield (Kg) per plant of avocado in Imbabura and Pichincha, Ecuador

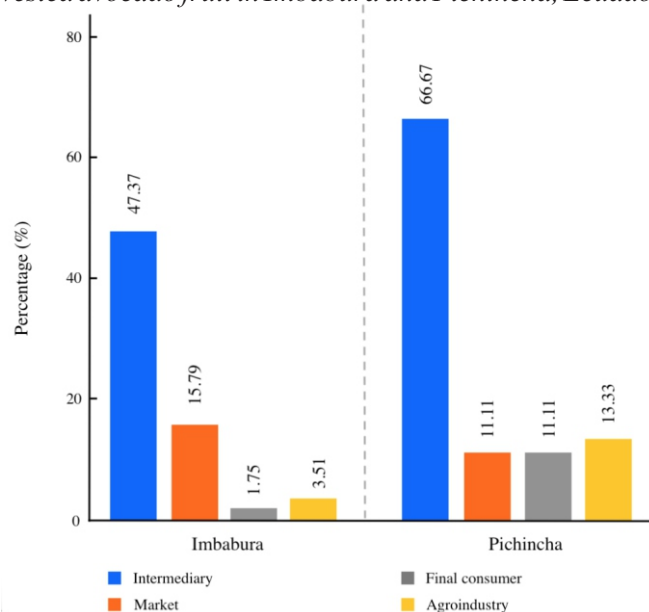


Regarding the destination of the production, Figure 9 shows that in both Imbabura and Pichincha (47.37% and 66.67% respectively), the production is sold by an intermediary to later make it available to the final consumer. Bishelly (2014) mentions that in agricultural goods, the

initial link is rural and the final link is urban, in this commercial chain it is difficult to connect directly between the first (producer) and the last link (consumer), generating an excessive profit for a third party (intermediary) and a price manipulation for the final consume.

Figure 9

Destination of the harvested avocado fruit in Imbabura and Pichincha, Ecuador

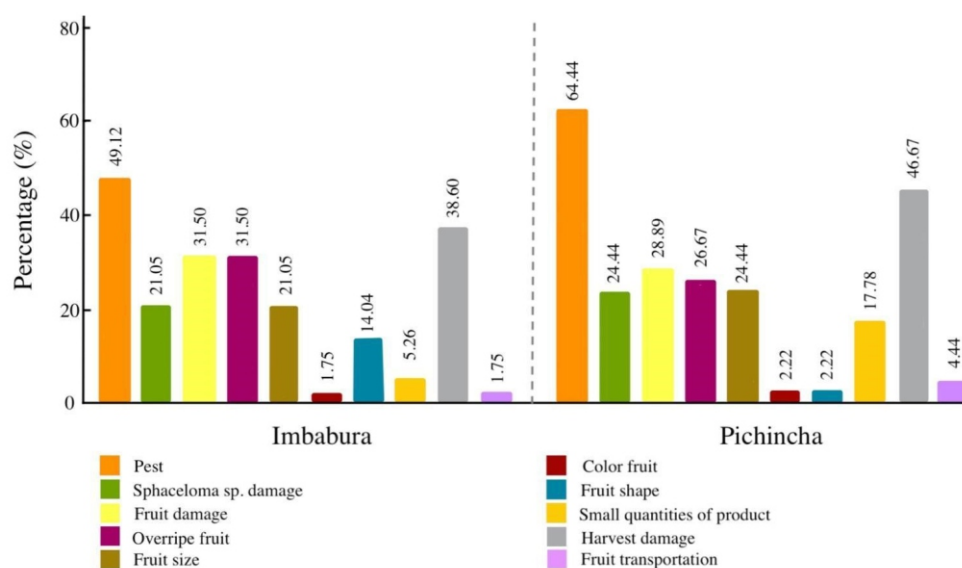


Regarding the main causes of fruit loss or rejection, Figure 10 shows that in Pichincha, small quantities of product (64.44 %) is the main cause, while in Imbabura, pests (49.12%) are the main causes of fruit loss or rejection. This information is corroborated by De Oleo (2010),

who estimated that avocado losses are largely related to the lack of control of insects and diseases, inadequate harvesting and fruit handling, as well as lack of practices such as pruning.

Figure 10.

Main causes of loss or rejection of the avocado fruit in Imbabura and Pichincha, Ecuador

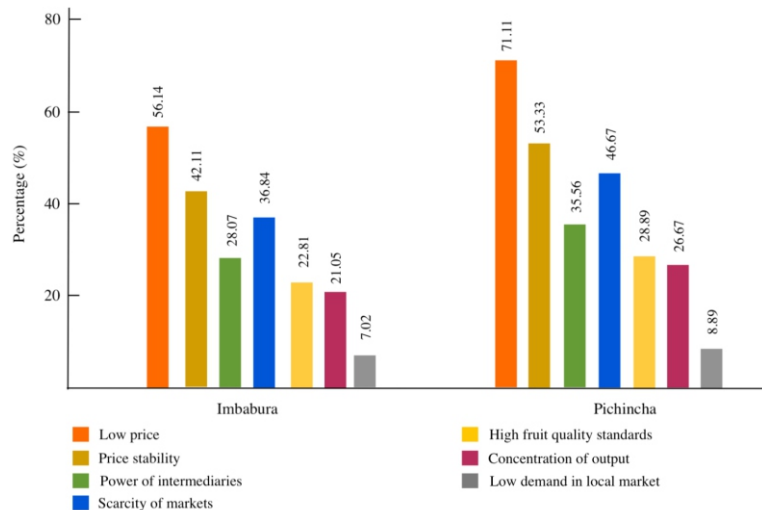


According to Figure 11, in Pichincha, 71.11% say the low sale prices are the main problem for the commercialization; 53.33 % price instability; 46.67% lack of market alternatives; 35.56 % high bargaining power of intermediaries; 28.88% high market demands; 26.67% production concentration; and, 8.89% low demand for varieties. The main problems for the commercialization of the fruit were the low sale price and high price instability in both provinces. In Ecuador in 2021, the price varied between USD 1.30 USD per Kg to 1.60 USD per Kg. These two problems are the most frequent when negotiating, because medium and small

producers in the agricultural sector still have a deficient organizational administration, fostering problems in introducing their production in the market, this does not allow them to generate positive revenues for their growth (Zambrano & Camping, 2015). The implementation of State policies such as the incentive to export fruit, training, technical training and advice, and low-interest loans, among others, would allow the promotion and improvement of avocado production, to promote associativity and ensure that producers can achieve greater advantages in negotiation and marketing.

Figure 11

Main problems regarding the commercialization of the avocado fruit in Imbabura and Pichincha, Ecuador



Factors influencing farmer income

The factors that determine the income from agricultural production are diverse and complex and vary according to the economic, social and environmental conditions of each region. In general, aspects related to the supply and demand of agricultural products, productive and technological conditions, public policies and the institutional context can be identified (Effendy et al., 2019; Barrett & Carter, 2013; Dorward et al., 2004).

In the case of South America, studies have been carried out that explored the factors that determine the income of producers. Market access can be a key factor affecting producer income, as well as supply and demand changes influence prices (Alston et al., 2009). In addition, it is pertinent to consider the advantages of

production and marketing because they affect the capacity of small producers to face market demands and volatility (Steffen Riedemann & Echánove Huacuja, 2003).

Access to technology and training are factors that can improve crop quality and yield (Foster & Rosenzweig 2014). In Peru, the cultivation area, climate change, water scarcity and the level of technology were identified as determinants for income in farm families in the Amazonas region of Peru (Chávez et al., 2022). In the case of Ecuador, in the two studied provinces, the regression analysis ($R^2=0.512$) (Table 1) detected that aspects related to access to knowledge of technologies such as the implementation of good production practices (0.700**), accompanied by training (0.696**) and the sale to the industry (1.068**) which pays better prices (0.602**) favorably influence the improvement of the

producer's income. Another relevant variable was the land extension (0.205**), thus the size of the cultivated area positively influences the income of the producers, which infers that the scale of production is an important factor in obtaining better economic results (Steffen Riedemann & Echánove Huacuja, 2003). These results also showed that the commercialization of the fruit to the industry is a good alternative, however, it should be noted that this type of market requires compliance with quality criteria which can affect the amount of sales, especially if technological aspects are not considered during the production process.

On the other hand, the establishment of the plantations on soil not suitable for cultivation (slope, organic matter content, texture, depth) (-1.124***) and the presence of pests (-0.931***) significantly affect the income of the producer, because it will require a greater investment in inputs and practices to achieve adequate productivities (Anacona et al., 2023). Access to financing is an important factor for investment in technology and improvement of production (Anacona et al., 2023), which will also enhance the producer's income. The results indicated that the lack of credit is decisive at -0.481*; therefore, it has a negative impact on the income of the producer.

Table 1

Regression analysis of factors influencing the avocado producer's income in Imbabura and Pichincha, Ecuador.

| Variable | Regression coefficient | | Standard error | t-statistic |
|---------------------------------------|------------------------|----|----------------|-------------|
| Learn about good production practices | 0.700 | ** | 0.231 | 3.03 |
| Pest problems | -0.931 | ** | 0.315 | -2.96 |
| Receive training | 0.696 | ** | 0.292 | 2.38 |
| Land extension (expressed in ln) | 0.205 | ** | 0.098 | 2.10 |
| Grown in not suitable soil | -1.124 | ** | 0.296 | -3.80 |
| Lack of credit | -0.481 | * | 0.266 | -1.80 |
| Selection of fruit | -0.335 | NS | 0.297 | -1.13 |
| Sell to the industry | 1.068 | ** | 0.436 | 2.45 |
| Fruit prices | 0.602 | ** | 0.295 | 2.04 |

Conclusions

The results showed that most of the farmers in Pichincha and Imbabura are small producers, they use grafted avocado plants for their plantations, using local rootstocks. The organization in Imbabura and Pichincha, in terms of physical or digital records, is low. Most farmers use their own money to finance their crops, and only a few producers have access to credit to finance their agricultural activities. In Imbabura and Pichincha, the main problems are associated with the presence of pests and the low sale price of the fruit. Most of the producers use organic fertilizers and pruning to improve agronomic crop management. The production is sold by an intermediary, and low sale prices are the main problem for commercialization.

According to the results of this study, the

main factors that positively influenced the farmer's income were: knowledge of the technology (good agricultural practices), training, land extension, sale to the industry and fruit prices. On the other hand, the factors that negatively influenced incomes were: pest problems, grown in not suitable soils for cultivation and lack of credit.

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