ORIGINAL ARTICLE

Economic Evaluation of the Irrigation System in the Association Avocado-Guava

Evaluación económica del sistema de riego en la asociación aguacate-guayaba

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ABSTRACT: The work was carried out in Sandoval 2 Integral Fruit Farm belonging to Ceiba Citrus Enterprise, with the objective of carrying out the economic evaluation of irrigation system in avocado-guava association, avocado, as main crop, and guava as associated crop. The economic determinations were made based on the productive results achieved on the farm for the association under study. Obtaining in the economic analysis of the association a net profit of $ 1176.9 ha^{-1}, because the associated crop does not cover the production and profitability costs of 0.08 ($·$^{-1}$). The net benefit / total cost ratio was 0.22 ($·$^{-1}$) which is considered low.

***Keywords*:** yields, net benefit/cost, profitability costs.

RESUMEN: El trabajo se realizó en la finca integral de frutales Sandoval 2, perteneciente a la Empresa de Cítricos Ceiba. Los cultivos objeto de estudio fueron el Aguacate, como cultivo principal, y como cultivo asociado la Guayaba. Con el objetivo realizar la evaluación económica del sistema de riego en la asociación Aguacate- Guayaba. Las determinaciones económicas se realizaron a partir de los resultados productivos alcanzados en la finca para la asociación objeto de estudio. Obteniéndose en el análisis económico de la asociación una utilidad neta de 1176,9 $·$ha^{-1}$, debido a que el cultivo asociado no cubre los costos de producción y rentabilidad de 0.08 ($·$^{-1}$), la relación beneficio neto/ costo total fue de 0.22 ($·$^{-1}$) la cuál es considerada de baja.

Palabras clave: rendimiento, relación beneficio/costo, rentabilidad, cultivos asociados.

INTRODUCTION

Currently, agriculture is under heavy pressure to produce more food in the next 40 years, than those produced in the last 10,000 years (Novozymes, 2015).

The deterioration of citrus plantations in the country has forced the Tropical Fruit Group to adopt measures in its future development program. One of these measures is the creation of Integrated Citrus and Fruit Farms, which are those that integrate at least five different species of fruit trees and the intercropping of other crops of short cycle, which allow to incorporating income in less time, in order to increase the purchasing power of workers and of the productive entity (Minag, 2009).

The integral farms of fruit trees are based on the combination and integration of fruit species of long, medium and short preproductive periods in the same row and the use of the streets with crops of low height and short cycles such as fruit, vegetables and other (Farrés *et al.*, 2013).

In this sense, Delgado *et al.* (2011) report that Ceiba Citrus Enterprise deployed a prospective development plan to re-establish its plantations, with the variant of crop diversification, developing Integral Farms. Among the associated crops are avocado and guava, objects of study of this work.

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Avocado (*Persea americana* Mill), is currently produced in almost all countries of warm and temperate climate, although most of their crops are in Latin American countries, this because this species is native to America. Natural distribution of this crop is from Mexico to Chile, through Central America, Venezuela, Colombia, Ecuador and Peru. (Bernal y Díaz, 2005; Gutiérrez *et al.*, 2009).

Guava (*Psidium guajava* L.) is classified as one of the best-known and most estimated fruits in most of the world. The world production of guava is around 1.2 million tons, India and Pakistan contribute 50%, Mexico produces 25% and the rest is provided by other countries such as Colombia, Egypt and Brazil (Yam *et al.*, 2010).

In avocado plantations, it is recommended to associate other fruits of smaller size, such as guava and papaya, in the streets and in the rows. In addition, other short-cycle crops can be used in order to make better use of resources, increase soil efficiency and achieve additional income that allows a quick amortization of the investment. In all these combinations, the vital space of avocado plants should be respected and it should be guaranteed that the technical management of the associated species does not affect its future development. (Minag, 2011).

The plantations of guava can be associated with other crops with the objective to obtain a rapid recovery of the investment. Its use is recommended due to its rapid entry into production and high productivity. The aspects that must be considered for the association with other species are the following: The vital space of each crop. Pests and common diseases. Technological requirements of each of the associated species, especially those of the main crop. (Minag, 2011).

Therefore, the present work has as objective to realize the economic evaluation in the avocado - guava association.

METHODS

The research was developed in an area of fruit production of 12.0 ha. in the integral fruit farm Sandoval 2, belonging to the UBPC 24 de Febrero of the Ceiba Citrus Enterprise, Caimito Municipality, Artemisa Province. Located at coordinates 335800 North latitude and 335500 West longitude, at an altitude of 41.0m above mean sea level.

The crops object of study were the avocado (*Persea americana* Mill.), Julio variety as the main crop, with a planting frame of 7.0 x 6.0 m for a density of 238 plants·ha^{-1}. As an associated crop the guava (*Psidium guajava* L.), Enana roja E.E.A 18-40 variety, established two plants in the rows between avocado plants (476 plantas·ha^{-1}).

The economic determinations were made based on the productive results obtained in the farm for the association object of study, quantifying all the expenses, involved in the determination of the costs of the initial investment of the irrigation system and the sowing, as well as the total production costs. Calculated and analyzed according to the prices of fruit trees in force in the commercialization of the company. With these values, the indicators described below were calculated:

- Production value: It was calculated from the marketing price of the ton for the total production obtained ($·ha^{-1}).
- Total cost of production: It was determined by adding the costs of agricultural activities, salary, maintenance to the irrigation system, water and fuel ($·ha^{-1}).
- Net profit: It was determined by the difference between the value of production and the total cost ($·ha^{-1}).
- Net benefit / total cost ratio: It was determined by the relationship between the net profit and the total cost of production ($·$$^{-1}$).
- Recovery period of the investment of irrigation: It was determined by the relation between the investment in irrigation and the net profit (years).
- Profitability: It was calculated based on the capital invested ($·$$^{-1}$).

RESULTS AND DISCUSSION

Table 1 summarizes the elements that make up the gross income ($·ha^{-1}) of production in the study area. The yields obtained were low for the cultivation of guava (9.44 t·ha^{-1}) with respect to those reported by Minag (2009) up to 37.0 t·ha^{-1}. Hernández *et al.* (2010), who, in urban agriculture conditions obtained 36.7 t·ha^{-1} and

Sangerman *et al.* (2013), for Mexican conditions achieved between 13.01 t·ha^{-1} and 28.56 t·ha^{-1} and for avocado (0.94 t·ha^{-1}), considered acceptable according to (Hernández *et al.*, 2009). They report for this variety and under similar conditions, yields between 0.9-1.2 t·ha^{-1} for the second year of production and Sánchez *et al.* (2018), report yields between 7 and 30 t·ha^{-1} for Mexico's conditions. It is observed that the crops have high income values with respect to these yields, which is given by the high prices with which the fruits are commercialized according to the destination of placement, among which are tourism, industry and others.

Tables 2 and 3 shows the different concepts that make up the production and irrigation costs ($·ha^{-1}). It is observed (Table 2) that, the salary cost represents 60% of the direct costs, and 54.1% of the total production costs, due to the payment system established in the integral farm. It establishes the salary cost is composed, for an advance for the practice of all manual activities in the attention to associated crops and a profit for the income obtained in the month for the production, which can reach up to 30% of it.

On the other hand, (Table 3) the maintenance component of the irrigation system, reached a value representing 48% of the costs of irrigation, provided by a pipe replacement (20 mm) that was made due to the deterioration of the field system. The cost of water consumption as observed is negligible, since its rent is made by installed capacity and not by the volume of water extracted.

TABLE 1. Gross income of production

Concept	Income ($·ha^{-1})
Guava sale	3438.57
Avocado sale	3113.70
Total	6552.27

TABLE 2. Production cost

Concepts	Income ($·ha^{-1})
Phytosanitary care (chemical product)	430.61
Fertilizer	29.70
Weed control in the row (chemical)	7.72
Weed control in the street (4 passes with CH-60)	59.00
Maintenance, lubricants and greases (EBD)	55.50
Diesel fuel (Irrigation)	458.00
Water consumption for irrigation	8.77
Maintenance of the irrigation system	734.88
Salary	2906.12
Mechanized activity	179.30
Harvest ($ 0.21 * QQ stocked)	17.16
Total direct costs	4886.76
Indirect costs (10% of direct costs)	488.70
Total	5375.36

TABLE 3. Irrigation costs

Concepts	Monto ($·ha^{-1})
Maintenance, lubricants and greases (EBD)	55.50
Diesel fuel (Irrigation)	458.00
Water consumption for irrigation	8.77
Maintenance of the irrigation system	734.88
Amortization of irrigation investment	263.65
Total	1520.80

Tables 4 and 5, shows the elements of expense, which intervene in the investment costs of sowing and the irrigation system ($·ha^{-1}). It is observed (Table 4) that the cost of the fruit tree seedlings, represents 84% of the value of the investment cost of sowing, due to the prices of commercialization of the seedlings, which are 10.0 $ for avocado and $ 6.50 for guava.

On the other hand, (Table 5) the value of the irrigation system costs represents 67.4% of the total investment of the system, which is due to the high investment costs of a drip irrigation system (Pizarro, 1996; Carrazón, 2007).

Although the crops have high income values with respect to their yields and high marketing prices (according to Table 1), the economic results in the avocado-guava association are related in Table 6, referring to the total cost of production. It is appreciated that the values of income from production ($·t^{-1}), created by the associated crop from its obtained yields, and the average marketing prices applied in the company, are lower than the total production costs, that induces losses to be assumed by the main crop.

Therefore, it is suggested to realize a maintenance of the irrigation system, with the objective of recovering it, to then re-evaluate it and adjust the irrigation times according to the actual expense and the application efficiency obtained. That guarantees the increase of agricultural yields and with it the economic sustainability of the association.

Table 7 shows the economic results of Sandoval 2 Integral Fruit Farm, observing that the cost of irrigation represents 28.3% of the production costs, with a yield of 0.44 ($·$$^{-1}$), recovering the investment of the system in 2 years and nine months.

The net profit is 1176.91 ($·ha^{-1}), a profitability in the association of 0.08 ($·$ $^{-1}$) based on the capital invested and the net benefit / total cost ratio of 0.22 ($·$ $^{-1}$), these results are classified as very low. On the other hand, Hernández *et al.* (2009), for the cultivation of guava in conditions of urban agriculture, obtained a value of B/C 5.02 with greater humidity in the soil. Martínez and Cisneros (2016), when evaluating, from the economic point of view, an localized surface irrigation technology suitable

TABLE 4. Cost of planting investment

Concepts	Income ($·ha^{-1})
Dismantling and conditioning	627.44
Preparation of soil for planting	406.56
Plantation (seedlings)	5474.00
Total	6508.00

TABLE 5. Investment cost of the irrigation system

Concepts	Income ($.ha^{-1})
Irrigation system	1776.67
Booth of the DPS	16.73
Water well	33.12
Bomb	809.93
Total	2636.45

TABLE 6. Economic results of the association

Concepts	Guava	Avocado
Yield (t·ha^{-1})	9,44	0.94
Sale price ($·t^{-1})	1535.07	3312.45
Production value ($·t^{-1})	3438.57	3113.70
Total cost ($·ha^{-1})	5375.36	-1936.79
Unit cost ($·t^{-1})	1946.02	
Net profit ($·ha^{-1})	-1936.79	1176.91

TABLE 7. Economic results of the association

Concepts	Amount
Irrigation Cost ($·ha^{-1})	1520.80
Production cost ($·ha^{-1})	5375.36
Cost of irrigation investment ($·ha^{-1})	2636.45
Irrigation cost ratio/ Production cost (%)	28.3
Net profit ($·ha^{-1})	1176.91
Net benefit / total cost ratio ($·$$^{-1}$)	0.22
Profitability of the total capital invested ($·$$^{-1}$)	0.08
Profitability of the irrigation investment ($·$$^{-1}$)	0.44
Recovery period of irrigation investment (years)	2.24

for coffee cultivation, obtained B/C ratios (4.19), benefits generated in relation to long-term capital spent (32.36), to total irrigation costs (2.45), as well as higher net profits (67. 377.7 pesos/ha). On the other hand, De Oliveira *et al.* (2016), when using drip irrigation and exudation, in vegetables, obtained relationship B/C for lettuce and broccoli crops, 4.5 and 3.8, respectively with dripping and 5.9 for the cultivation of cabbage with exudation. That corroborates the profitability of localized irrigation.

CONCLUSIONS

- Profitability on Sandoval 2 Farm for the crop association was 0.08 ($·$$^{-1}$) based on the capital invested and the net benefit/total cost ratio of 0.22 ($·$ $^{-1}$). These results are classified, as of very low.
- The net profit was 1176.9. $·ha^{-1} , lower than planned, because the associated crop does not cover production costs.

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