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Economic evaluation of the irrigation practice in pineapple cultivation (Ananascomosus L. Merr)

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Abstract: Under tropical conditions, pineapple cultivation requires irrigation, which has been questioned because pineapple's physiological and morphological characteristics determine lower evapotranspiration and drought resistance. This is why, despite international experience, it has not been incorporated into agricultural technology for many years; In order to economically evaluate the response of crops to different levels of water retention, a study was conducted using the results obtained from the irrigation response of red crops in the province of Avila and Spain as a reference. Therefore, the profitability and payback time of the investment have been determined. The results indicate that while ensuring 100% of crop water demand, the economic benefits are highest, and limited irrigation reflects favorable outcomes compared to non irrigated crops.

Key words: necessities of water; yield; quality; investment; expenses

1 Introduction

As is well known, the morphological and physiological characteristics of pineapple cultivation enable it to maintain a certain level of production under the unique climatic conditions of Cuba, without the use of irrigation or limited water levels.

The main producing countries of this fruit use irrigation as a way to compensate for water shortages in areas with insufficient or uneven rainfall, which is a characteristic of tropical and subtropical regions where production is concentrated.

In Cuba, irrigation activities have not been included in the production plan of this crop for many years. According to Bonet et al. (2015) and Bonet (2016), research conducted in the 1980s showed that although it has high resistance to drought, its response to irrigation is positive; these results led to subsequent investments in irrigation technology in the large areas dedicated to its production in the province of Ciego de Avila.

Since then, pineapple plantations in the province have been irrigated unstably using various technologies.

According to Bonet's (2016) study on the Spanish variety Roja of Ciego de Á vila, the evapotranspiration of this crop is less than 3mm d^{-1} and reaches its maximum during the physiological stages of flowering and fruit development.

According to Bonet and Guerrero (2012), the impact of water on crops is not only reflected in the development of agriculture, but also in crop yields; The relationship between yield, evapotranspiration, and irrigation water use is high (Bonet et al., 2010, 2014).

Despite these results, in various situations, people still believe that irrigation is economically unreasonable given the low evapotranspiration and strong drought resistance of pineapple crops; During the study of the impact of water on crop yield, the relationship between these two parameters was demonstrated, and therefore there is an interest in utilizing the climate characteristics of Cuba to evaluate economic standards for pineapple production. These standards have different irrigation water management alternatives, even without the use of irrigation, to ensure that the average annual rainfall exceeds 1,200 millimeters. The purpose of this article is to evaluate the economic effects of irrigation on pineapple cultivation.

2 Method

In order to establish an economic standard for the irrigation feasibility of this crop, profitability and investment payback time were determined, and different water management variants were compared, including production under rainfed conditions, using the information available regarding the water consumed and the production obtained during the experimental phase of the study of the ETc of pineapple in the province of Ciego de Avila (Bonet, 2016). The evaluation was conducted based on the Baca (1993) standard cited by Brown (2000).

The following equation is used for calculation:

$$Cr=Csr+Ci+Co+Cm+Ca \quad (1)$$

$$Bb=Re \times Pe \quad (2)$$

$$In=Bb-CT \quad (3)$$

$$CT=Cr+Cc \quad (4)$$

$$TRI={}^{CT}/_{In} \quad (5)$$

$$RF={}^{UNDI}/_{I} \quad (6)$$

$$RI={}^{UNDI}/_{(I+Cr)} \quad (7)$$

$$UNDI=(Bb-Cr) - [(Bb-Cr) \times Iu] \quad (8)$$

$$\frac{B}{C} = {}^{Bb}/_{Cr} \quad (9)$$

Among them:

Cr - Irrigation cost ($/ha); Csr - Irrigation System Cost ($/ha);

Ci - Irrigation system installation cost ($/ha);

Co - Common operating costs of irrigation systems ($/ha);

Cm - Irrigation system maintenance cost ($/ha);

Ca - Amortization cost of irrigation system ($/ha);

Bb - Marginal gross profit ($ha^{-1});

Re - Expected yield (t/ha); Pe - Expected price ($/t);

Annual net income ($ha^{-1});

CT - Annual total cost ($ha^{-1});

C^{C} - Annual production cost of non irrigated crops ($ha^{-1});

TRI - investment payback periods (years); RF - Financial profitability;

UNDI- net profit after tax ($ha^{-1});

I-Initial investment ($ha^{-1}); RI - Return on investment;

Iu - Profit tax (%);

B/C - Profit cost ratio.

The results on crop yield under different water retention conditions, as well as its composition by quality according to NC 7726:12 (2012), obtained under experimental conditions (Bonet, 2016), were used as a basis for information. The results are shown in Table 1 and Table 2.

Table 1. Irrigation area yield

Variant	Irrigation water guarantee level (%)	Potential yield (t ha^{-1})
80% Wmax	100	92.0
70% Wmax	65	82.8
Not watering	0	64.4

Table 2. Composition of production by quality category during the experimental phase of the ETc study of pineapple in Ciego de Avila province

Treatment	Category (%)		
	1ª.	2ª.	3ª.
80% CC	82	16	2
70% CC	79	17	4
Dry	70	22	8

The following information can be used to calculate the total cost of irrigation:

• The production cost is calculated as three production cycles, while aspects related to seeds and sowing are only carried out at the beginning of the production process.

• Irrigation system costs (IAgric, 2009a, 2009b).

• Installation costs (layout, excavation, installation, hydraulic testing and refitting).

• Operating costs, determined from the irrigation regime calculated for the predominant soils in the pineapple areas of the province.

• Irrigation system efficiency: 80%

• The sprinkler irrigation system used has a rainfall intensity of 5.0 mm · h^{-1}.

• Electricity and water bills (Cuba - Ministry of Finance and Prices, 2012).

With the sales price established for the different categories according to the *Official Gazette of the Republic of Cuba (2016)*, the expected price of the production is calculated and considering the potential yield according to Bonet (2016), the value of the production is obtained.

The calculations have been made on the basis of an irrigation schedule for an average year in the conditions of the province of Ciego de Avila.

The following software is used for development work: Microsoft Office Word 2007, Microsoft Office Excel 2007, Corel Graphics Suite 11, MapInfo Professional 9.0, and Auto CAD 2007, as well as the statistical program Viewer SPSS (11.5).

3 Results and discussion

Table 3 reflects the marginal gross profit of different irrigation management alternatives.

Table 3. Gross profit of different water management alternatives

Variant	Expected returns (t ha^{-1})	Expected price (\$ t^{-1})	Marginal gross profit (\$ ha^{-1})
80% W max	92.0	2738.15	251,910.00
70% W max.	82.8	2703.50	223,849.80
Not watering	64.4	2615.40	168,431.76

Based on the existing information, the irrigation hours for three cycles were determined, and the consumption expenses for water, electricity, and wages were calculated. Considering the characteristics of the irrigation system and the irrigation standards (Minag 2006), the useful life span was assumed, resulting in rates of 6.7% for depreciation and 1% for maintenance respectively (Table 4).

Table 4. Total cost of different water management alternatives (\$$ha^{-1}$)

Details	80% W max	70% W max	Not watering
Production cost without irrigation	33,624.50	33,624.50	33,624.50
Irrigation system cost	6974.31	6,974.31	-
Installation cost	300.00	300.00	-
Operating costs	6671.28	5,125.95	-
Maintenance costs	244.09	244.09	-
Amortization costs	1611.06	1,611.06	-
Total Costs	49,425.24	47,879.91	33,624,50

Figure 1 reflects the net income generated by implementing irrigation. It is worth noting that the maximum economic benefits have been achieved by ensuring the maximum water demand of crops throughout the entire cycle, both due to increased yield and improved quality composition. However, the application of limited irrigation and even production under rainfed conditions also produces satisfactory results. This result is justified by the crop's ability to withstand periods of drought and its low evapotranspiration, as well as by the country's climatic conditions that guarantee a high rainfall regime during several months of the year (Bonet and Guerrero, 2016).

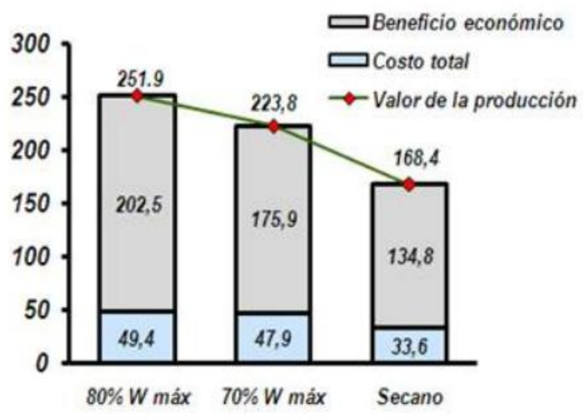

Figure 1. Net revenue of different water management alternatives (\$ha-1).

These results indicate that irrigation investment is recovered in one crop cycle (3 crops), and the value of irrigation investment is most favorable among variables that fully meet crop water demand.

Comparing the water management criteria yields the results shown in Table 5.

Table 5. Economic comparison of water management variants in pineapple planting

Parameter	Water management		Difference
	80% CC	70% CC	
Net profit after tax ($ ha^{-1})	50,621.19	43,992.47	6,628.72
Cost-benefit ratio	5.10	4.67	0.43
Financial profitability	7.26	6.31	0.95
Return on investment	1.02	0.92	0.10

A rate of 0.75 was used to determine the profit tax (National Tax Administration Office, 2012). The results confirm the economic effectiveness of the crop's response to irrigation; in the two water management alternatives the results are satisfactory, but it is observed that by guaranteeing the maximum water demand of the crop throughout its cycle, the greatest economic benefit is obtained.

These results are reflected in higher water productivity, reflecting the effective water yield ratio of the crop, which is consistent with other crops studied under Cuban conditions (González et al., 2013). However, limited irrigation and even production under drought conditions have produced satisfactory results. According to Segura (2008), this result is reasonable because this crop has the ability to withstand periods of drought and its low evapotranspiration, and the country's climate conditions ensure high precipitation for several months of the year.

For the three main soil types in the planting area, the calculated irrigation frequency to ensure the water demand of pineapple in three cycles is between 89 and 95 (Figure 2).

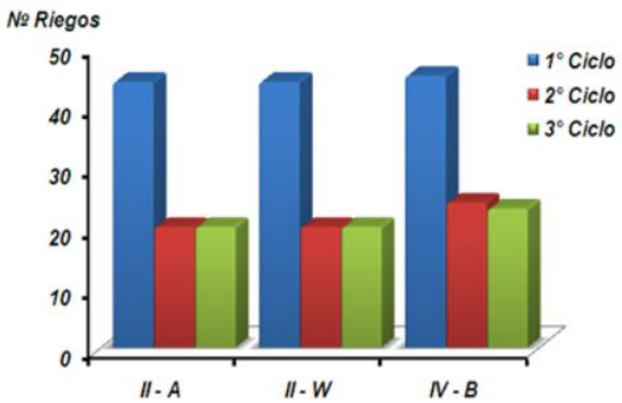

Figure 2. Number of irrigations applied to the crop during the three cycles

Using the average of a series of rainfall in the research area over the past 20 years, the available rainfall was calculated, and an annual value of 725.6 millimeters was obtained, which proves that the standard for evaluating the irrigation demand of pineapple crops is reasonable; according to Bonet et al. (2013), this confirms the possibility of this crop, which can ensure a certain level of yield even under drought conditions if appropriate water management is implemented; in this regard, the treatment of pineapple seedlings obtained through in vitro propagation is particularly important, as it has been shown that by effective preparation during the domestication stage, plants can better adapt to drought conditions after transfer to plantations (Rodriguez et al., 2016a, 2016b).

The report submitted by authors Bonet et al. (2014) shows the water use efficiency of this crop, which, combined with the results of economic evaluations, can diagnose changes in irrigation management under water supply constraints. For example, according to Planas (2014) and Duarte et al. (2017), future changes can be predicted due to the expected impact of climate change. In the driest year, the difference between the optimal irrigation system and the limited irrigation system will be even greater.

It should also be considered the additional economic benefit for the national producers that the availability of irrigation systems allows them, taking advantage of the compatibility of the climate with the requirements of the crop, to carry out sowings throughout the year without depending on rainfall. The results justify the application of a controlled deficit irrigation programme for pineapple cultivation based on:

• Ensure maximum crop demand during the establishment, flowering, and formation stages of the fruit.

• During the stages of nutritional development and harvest, irrigation plans can be adjusted to maintain a water balance of over 70%, for which effective use of rainwater is necessary.

• One recommended practice during pineapple irrigation is to use coverings to reduce the evaporation rate on the soil surface.

4 Conclusion

Irrigation pineapples under the conditions of Ciego de Á vila province is economically appropriate, achieving the best results while ensuring 100% of crop water demand.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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