



ECONOMIC ANALYSIS OF HYDROPONIC LETTUCE UNDER FLOATING ROOT SYSTEM IN SEMI-ARID CLIMATE

ANÁLISIS ECONÓMICO DE LECHUGAS HIDROPÓNICAS BAJO SISTEMA RAÍZ FLOTANTE EN CLIMA SEMIÁRIDO

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Resumen

Los cultivos sin suelo se presentan como una alternativa de cultivo ante la presencia de suelos marginales con escasez hídrica característicos de la provincia de Santa Elena (PSE). La hidroponía presenta a nivel mundial una alta productividad por unidad de superficie, ahorro de agua y cosechas durante todo el año. La lechuga (*Lactuca sativa* L.), especie de estación fría, es la más representativa de un sistema hidropónico, pero no es una especie cultivada en la costa ecuatoriana. El objetivo fue analizar desde el punto de vista económico-financiero la propuesta técnica de un cultivo protegido de lechuga bajo sistema hidropónico de raíz flotante llevado a cabo en el clima semiárido de la PSE. Se realizaron cuatro siembras con el cv. Crespa, utilizando la solución nutritiva Hoagland y Arnon. El rendimiento y los costos se extrapolaron a una infraestructura de 1,000 m² equivalente a una superficie productiva efectiva de 240 m². Se asumen supuestos donde la producción se vende en jornadas laborales de acuerdo a la ley a una proyección de 5 años, con un stock de inventario para una semana, ventas al por mayor y un margen de beneficio en el año 1 de 30% y ascendente en los siguientes períodos. Bajo estos criterios, el costo de producción unitario (en dólares americanos) ascendió a USD 0,49 y el precio de venta a USD 0,70. La inversión total sumó USD 27.077,99, el VAN USD 58.581,07, con una TIR del 40% y un índice beneficio-costado de 1,26; por lo que económica y financieramente el proyecto se consideró viable.

Palabras clave: Cultivos sin suelo, costo de producción, inversión, cultivo protegido, *Lactuca sativa* L.

Abstract

Soilless crops are a farming alternative to marginal soils with limited water availability, which are widespread in the province of Santa Elena (PSE), Ecuadorian coast. This province has semi-arid climate. Hydroponics have worldwide high productivity per unit area, save of water and cultivation cycles throughout the year. Lettuce (*Lactuca sativa* L.) is a cold-season crop, the most representative crop in hydroponic cultivation, but it is not currently cultivated in the Ecuadorian coastal area. The aim of this study was to analyze the economic-financial viability of lettuce cultivation under hydroponic system of floating root. Four lettuce cultivation experiments were carried out with cv. Crespa, using the Hoagland and Arnon nutrient solution. Yields and costs were extrapolated to an infrastructure of 1,000 m² equivalent to an effective productive area of 240 m². The assumptions used in the analysis were: all production is sold, working days were calculated according to the law, 5-year projection, stock of inventory for a week, wholesale selling, and profit margin in Year 1 of 30% and increasing in the following periods. Under these criteria, the production cost (in US dollars) per unit amounted to USD 0.49/unit and the sale price to USD 0.70/unit. The total investment USD 27,077.99, the NPV USD 58,581.07, with an IRR of 40% and a benefit-cost ratio of 1.26; thus, the project was considered viable from an economic point of view.

Keywords: Soilless culture, production costs, investment, greenhouse crop, *Lactuca sativa* L.

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1 Introduction

The increase in the population and the reduction in agricultural soils have caused concern in relation to the food supply. Technology evolves in pursuit of increased productivity and sustainability through genetic improvement, including high-impact technologies on product performance and quality, agriculture, irrigation technologies and nutrition, among others. Soilless protected crops have the same objective, obtaining high yield on less surface area and throughout the year.

Hydroponics with recirculation (closed system) is the most technically, economically and environmentally efficient system by its considerable savings in water and fertilizers, and minimal discharge of residual fertilizer solution into the environment (Urrestarazu, 2015). In the protected crops, hydroponic systems are presented as an interesting option in the face of increased soil and sanitary limitations and the need for short marketing circuits. In Mexico, these already account for 50% of protected crops (INTAGRI, 2017). In the US, in the period 2013-2018, this form of production annually obtained US \$ 891 million, with a rate of 1.2% and it generated an employment increase rate of 10.1% (IBISWORLD, 2018). Hydroponics in the closed system has been more efficient compared to conventional cultivation (in open or greenhouse soil) (INTAGRI, 2017), resulting in better cost-benefit. However, one of the disadvantages of this system is the high initial investment in the infrastructure.

The world production of this vegetable is estimated at 26 866 557 t per year with an average yield of 21,89 $T ha^{-1}$ (FAO, 2019). Data from the Food Organization of the United Nations (FAO) indicate that the main producer of this species is Spain, exporting to more than 53 countries, and exceeding 900 000 tons per year. Lettuce occupies 2% in the US in the hydroponic market, while in South America the percentage is 49% (INTAGRI, 2017).

Ecuador's horticulture has increased due to the revival of the peasant economy and exporting agribusiness (Álvarez et al., 2014), as well as the increase in the consumption due to changes in eating habits (Espinoza, 2015). In 2000, the production of 9.770 metric tons was recorded, carried out by smallholder farmers with 58 and 63% of produc-

tion units with less than 1 ha, in cultivation and associated, respectively (INEC, 2002). Meanwhile, FAO (2019) in 2017 recorded an increase of 17 301 t produced. The Survey of Consumption and Household Expenses in Ecuador (INEC, 2013) shows that rural people invest 32% of their income in food and non-alcoholic beverages and only 2% is spent on vegetable purchases in this category. If the value of the Basic Family Basket in the Sierra region is considered to be \$722.44 and the Costa 695.52 value, this expenditure on vegetables would correspond to USD 14 in the coastal area (INEC, 2017). According to (Zaruma, 2009), peasant family farming (AFC) for productive areas is 500 to 2000 m^2 , while for small producers it is 0.25 to 1 ha and for the median 1 to 3 ha. If at the level of Latin America 80% of farms are in the hands of the TFA, in Ecuador this figure rises to 84.5% (Salcedo and Guzmán, 2014). The cultivation and production of vegetables depend on small producers and on peasant family farming. In Ecuador, 83% of this production is destined for domestic consumption. Lettuce culture is traditionally grown in the open field, but also under protected cultivation in soil and hydroponic systems. It is a species that grows during cold season with optimal temperatures of growth and daytime development between 18 and 25 °C and nightly from 10 to 15 °C (Maroto, 2002; Saavedra et al., 2017).

In the province of Santa Elena, a project of agroecological family orchards has been carried out since 2014 in charge of the Ministry of Agriculture (MAG), and since 2017 it has been in charge of the peasant family farming project (AFC) covering the rural and urban sector (Prefectura Santa Elena, 2017; Mateo, 2019). Lettuce occupies an important place among the species produced there. The main problems affecting agricultural productivity in the province are low water availability, semi-arid weather conditions and degraded soils. Barbosa et al. (2015) estimated that this technique manages to increase annual productivity by 10 times with a consumption of only 8% of water, but 87 times higher consumption of energy compared to a conventional crop in the United States (NFT, irrigation, heating, artificial lighting). Treftz and Omaye (2012) indicate positive aspects that point to the sustainability of soilless crops such as saving water, fertilizers and pesticides. They also mention that it can be carried out in arid and urban areas, bringing the product closer to the consumer, and not requiring crop rota-

tion. Soil preparation and weed control are also not required (Resh, 2013). An alternative for agricultural recovery is the hydroponic system for growing vegetables with a nutrient supply adjusted to the needs of each species, obtaining quality plants with high nutritional content. Harvesting can be carried out in a complex or simple infrastructure in small spaces and with low costs of production variables, but with a high initial investment. Resh (2013) states that one disadvantage is the easy proliferation of root diseases in a soilless system with recirculation of nutrient solution.

Lettuce is the main hydroponic crop nationally and worldwide, but due to its status as a cold season plant it is important to evaluate its technical and economic feasibility before recommending its cultivation in the province in this productive system that requires high capital investment. In the literature, there are numerous technical contributions to the topic (Khan et al., 2018; Sharma et al., 2018), but there is little information regarding the economic and financial aspect, and the information available is focused on studies in temperate climates, leading to high heating and lighting costs, which are unnecessary in this case (Barbosa et al., 2015; Quagraine et al., 2018). The objective of the research was to mitigate this gap and perform an economic analysis to determine the profitability of the hydroponic lettuce culture under the semi-arid climate conditions in the province of Santa Elena.

2 Materials and methods

2.1 Infraestructure

The method for the development of the proposal is based on the production results of real experimental crops, which were carried out at La Libertad, Santa

Elena provinces, in greenhouses belonging to the project "P06 System of hydroponic production, alternative to the change of the agroproductive matrix in Santa Elena" located in the Faculty of Agricultural Sciences of the State Santa Elena University (UPSE). The geographical location of the place is south latitude $2^{\circ}13'56,46''$, longitud oeste $80^{\circ}52'30,097''$, altura de 44 msnm. Dentro de la clasificación climática, la provincia de Santa Elena posee un clima semiárido, las precipitaciones anuales registran un promedio de 200 mm, humedad relativa de 81.6% y temperatura media anual de 24.5° (CLIRSEN-MAGAP, 2011; INAMHI, 2017). The study was carried out in a galvanized iron greenhouse of 20 m long, 10 m wide and 4 m height, with a cover of the polyethylene roof of UV/IR 6, side walls and fronts covered with a white net of 50% shaded.

The production obtained and the costs were projected for a production area equal to 1000 m^2 . The growing bed at 90 cm of height had a width of 1 m, a height of 10 cm, of which 8 cm are occupied with water and 2 cm correspond to the thickness of the foam plate held by the plants. The length was 3 m and was coated with 0.2 mm thick black polyethylene in which the floating root system maintained the roots of the plants submerged in water with dissolved minerals according to the formula of Hoagland and Arnon (Beltrano and Gimenez, 2015). In the case of short-lived leaf crops such as lettuce, the fertilizer solution covers the daily requirements of the plant and does not need to be modified. In previous trials, this was identified as the best formulation among three evaluated. This requirement was subtracted from the ion inputs of the irrigation water (drinking water), resulting in the doses indicated in Table 1. The crop was supplied from a fertilizing tank (500 liters of capacity) with a system of recirculation pipes with the fertilizer solution using a submersible pump Pedrollo Top II of 0.5 HP (Figure 1).

Table 1. Nutrient content of the nutrient solution and irrigation water used for a lettuce culture, based on the Hoagland and Arnon solution.

Macronutrient solution (mMolL ⁻¹)	Chemical elements									
	NO ₃ ⁻	SO ₄ ⁼	H ₂ PO ₄ ⁻	HCO ₃ ⁻	Cl ⁻	Ca ⁺⁺	Mg ⁺⁺	K ⁺	Na ⁺	NH ₄ ⁺⁺
Requirement	15	2	1			4	2	6		1
Irrigation water	0	0.05	0	0.88	1.28	1.15	0.65	0.18	0.3	0
Real supply	15	1.948	1	0.37	1.28	2.85	1.35	5.82	0.3	1
Micronutrient solution (mgL ⁻¹)	Fe	Mn	Cu	Zn	B	Mo				
Real contribution	2.47	0.50	0.02	0.05	0.42	0.01				

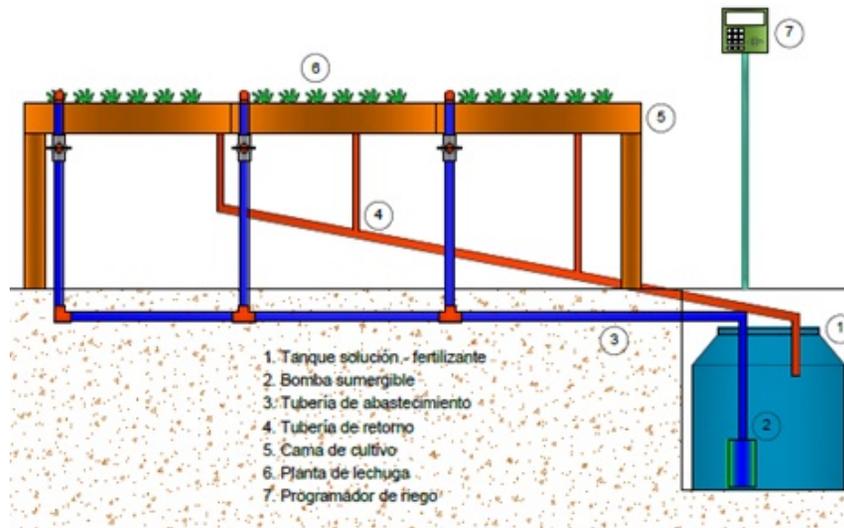


Figure 1. Diagram of bed construction and fertilizer solution supply controlled by the irrigation programmer in a protected culture of lettuce under a floating root system.

2.2 The crop

The seeds of lettuce cv. Crespa (*Lactuca sativa* var. *acephala*), a plant of loose leaves, oak type, with light green color were purchased in an agro-store in Manabí (Jipijapa, Ecuador). The seedbed was performed in situ in a growing house parallel to that of the test in PVC trays of 128 alveoli. They were watered daily and no sanitary applications were needed. From the emission of the first leaf it was fertilized with the same fertilizer solution tested at a concentration of 50%, in volumes of 0.5 liters per tray. The transplant was performed four times during the first half of 2018: January 18, February 6, March 6 and May 17; with seedlings with 3 true leaves on the described beds, at a density of 32 m^{-2} plants.

The oxygenation of the nutrient solution was performed daily for 30 minutes, twice a day (morning and afternoon), in order to provide enough oxygen in the roots and facilitate the absorption of nutrients needed for the growth and development of the plant. This work was carried out automatically by an irrigation programmer and the feeder pipes located at the head of each experimental unit. The water consumption, mainly due to perspiration, determined the time of replenishment of the nutrient solution. This consumption was determined by measuring daily the height of the water sheet of each bed (experimental unit or 1 m^2 replica).

The consumption of each repetition was averaged throughout the growing cycle and it was projected to one consumption per plant.

The health status of the crop was assessed daily for control actions. The chemical quality monitoring of the nutrient solution in the growing beds was carried out using an OAKTON ECTester11 (for salinity) and a pH-meter, Milwaukee brand Ph55 (for pH). The chemical parameters of fertilizer solutions were measured daily to establish timely correction measures in agronomic management. The fresh weight of lettuces was measured at harvest using the BOECO BWL 61 digital balance. The fresh weight of leaves and roots corresponded to yield per plant, as hydroponic lettuce is commonly marketed complete (with roots).

The harvest criterion was the size and weight of the product and the absence of floral buds. In Spain and Panama, the rules require a minimum of 100 g for the marketing of loose-leaf lettuce from protected cultivation, without specifying whether it is harvested in soil or hydroponics systems (Junta de Andalucía, 2013). Conversely, the Colombian Technical Standards (1994) require that a container of hydroponic lettuce must contain at least 150 g of product, including roots. In Ecuador, there are no standards in this regard, but on the domestic market there are packaging of hydroponic lettuce of 100

and 200 g.

For the purposes of this study, which has an economic approach, only the weight of full lettuce, averaged of the four planting dates, was considered as the only relevant agronomic variable (Table 2). The results were statistically analyzed with the Infostat v2018e program. Parametric variables were analyzed with the F test and nonparametric variables with the Kruskal Wallis test.

2.3 Economic analysis

A budget was developed based on the model proposed by Díaz et al. (2012), where the initial balance is first identified and operational processes are then determined in order to quantify them in time and currency. The calculation of the investment of the galvanized iron and polyethylene cover was for an area corresponding to 5 sheds covering 1000 m² of surface, each shed was 30 m long, 7 m wide and 3.5 m height. This area had an efficiency of 24%, i.e., it implies 240 m² of effective productive area. The number of annual harvests was estimated according to the duration of the plantings carried out in the project. 32 plants were obtained per m² and a product loss of 20% was assumed. Whereas the production is sold in its entirety and a week's inventory is planned with 1 418 lettuces, relative to the annual production of 73 728 units per year.

The costing process was carried out *in site* by

quantifying everything related to the project. For the cost projection, an average inflation of 2.40% Banco Central del Ecuador (2018) and a discount rate of 15.40% were considered. As a comparison point for expected prices, a value was determined based on the analysis at 9 outlets of the province of Santa Elena, which sell a wide variety of vegetables. A token was applied for each sale point selected in Salinas, La Libertad and Santa Elena provinces (Ecuador). The instrument allows to obtain product information regarding quality, specifications according to the brand, quantities, prices and grams per pack. The budget was done using Excel.

3 Results and discussion

3.1 Yield of hydroponic lettuces

The duration of transplant to harvest at the different dates of establishment varied from 21 to 25 days (Table 2), the longer period corresponded to the time with lower temperatures (Ecuador). This allowed to project 12 harvests annually, considering the staggered elaboration of seedlings to avoid downtime. Therefore, no matter the time of the year (winter or summer), the duration of the growing cycle is similar due to the small variation in the climatic conditions of the Ecuadorian coast. Unlike a country with a temperate climate such as Spain, where the same variety has growing cycles between 31 (hot season) and 81 days (cold season) (Sábada et al., 2007).

Table 2. Dates of establishment of four planting cycles of hydroponic lettuce cv. Crespa cultivated in floating root system during 2018 in the province of Santa Elena and the associated climate.

Transplant	Harvest	Duration of the Cycle (days)	Average of temperatures Max. - Min. (°C)	Average of relative humidity Max. - Min.
18-Jan	06-Feb	22	37.31 - 24.34	88.20 - 25.35
06-Feb	27-Feb	21	35.94 - 24.10	91.59 - 29.19
06-Mar	25-Mar	22	36.59 - 23.43	84.90 - 27.46
17-May	08-Jun	25	32.01 - 21.55	83.74 - 36.00

Hydroponic lettuce can be marketed with roots, which demonstrate the production method used and the freshness of the product. Based on the four crops carried out between January and May 2018,

harvest weights (parametric variable) were obtained between 115.8 and 150,1 g *plant*⁻¹, with an average of 139.0 g (Figure 2).

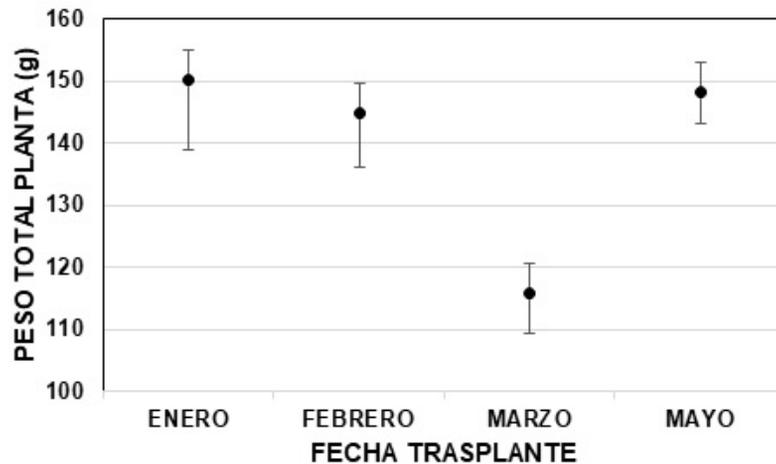


Figure 2. Full plant weight to lettuce cv. Crespa on four transplant dates (2018), cultivated in the province of Santa Elena under floating root system and nutritive formula of Hoagland and Arnon.

The variation coefficient in the data did not exceed 11.7 %, so the plant weights obtained were assumed to be highly reliable. The harvest weights obtained in January, February and May crops were similar. Only the March harvest was significantly smaller, moving away from an optimal commercial weight.

These weights were associated with an average for the four 22-leaf crops per plant. Solís (2017) working in the province of El Oro reported four weeks of hydroponic culture lettuces with 10.5 leaves, and a total unit weight of 64.32 g, probably due to adverse weather conditions. In other studies, plant weights with ranges from 80.10 to 271.02 g were reported with hydroponic lettuce in other latitudes (Defilipis et al., 2006; Barrientos, 2011, 2014; Tarqui et al., 2017). Maboko and Du Plooy (2009) propose planting density increases of up to 50 *units/m²* to improve performance, depending on climate and variety. Mandizvidza (2017) suggests modifying, depending on the variety, the cation ratios in the nutrient solution to improve the performance and quality of postharvest in lettuces.

3.2 Water resource

The consumption of nutrient solution in recirculation (water + fertilizer) was estimated at 7,7 *m³* per growing cycle in 1000 *m²* of greenhouse, which would amount to 92,4 *m³* for the 12 annual growing cycles. At the end of the crop, the remaining ferti-

zer solution was applied to an ornamental garden. This represents a marginal cost of production and considerable savings of the water resource if the values reported in the literature between 52 to 125 *m³* of irrigation water consumption are considered in 1000 *m²* for each cycle of lettuce growing in low soil greenhouse conditions (Defilipis et al., 2006). The consumption represented 8,7 % of water consumption under a protected crop. In open field, the water requirement can rise up to 411 *mm ha⁻¹*, depending on the weather, the time of the year, the variety and irrigation system; which is equal to 411 L 1000 *m²* (Tarqui et al., 2017). In this case, water savings would be even more evident, representing hydroponic consumption by only 1.9 % compared to an open field crop.

4 Economic analysis

The cost of unit production consisting of direct labor costs (four operators), direct raw material (seedlings, fertilizers and agrochemicals) and the indirect costs of direct labor (four operators), direct raw material (seedlings, fertilizers and agrochemicals) and the indirect costs of production (field supervisor, beds and plastic covers), were determined for 1000 *m²* of infrastructure, without considering outsourcing costs. The initial investment amounted to USD 27 027.99, of which 17,00% was for working capital and the remainder for fixed asset investment. This consisted of: (a) the galvanized iron greenhou-

se shed, which was estimated at the market price of Quito companies that offered it a price of USD 10 m⁻²; b) the infrastructure of wooden beds with a height of 90 cm (Table 3); c) the irrigation system

(input and recirculation pipes, programmer and its installation) (Table 4); d) additional ones such as irrigation pump, beds, balance and plastic bags.

Table 3. Construction costs of 240 m² wooden beds for the floating root system for 1000 m² of greenhouse (in US dollars, values as of September 2018).

Detail	Quantity	Measured Unit	Unit cost (USD)	Total Cost (USD)
Wooden bed construction				
Boards of 20 cm × 4m, semi-hard	580	Unit	4.00	2 320.00
Black Plastic Sleeve 1.5 m wide	m ²	1.19	297.50	
Foam of 2.5 cm thickness (1 × 1m)	270	Unit	5.29	1 428.30
6 × 6 cm sticks	90	Unit	3.00	270.00
Accessories (nails, cardboard, foam, pond outlet, etc.)		Unit		372,30
Flex hose	10	Unit	0.80	8.00
TOTAL (USD)				4 696.10

Table 4. Construction costs of a recirculating irrigation system for the floating root system for 1,000m² of greenhouse (in US dollars, values as of September 2018).

Detail	Quantity	U. Unit	Cost Measure (USD)	Total Cost (USD)
Pipe 3/4 inches (6 meters)	90	Unit	3.34	300.60
Pipe 1 inch (6 meters c/u)	20	Unit	6.76	135.20
63 mm 0.8 mpa (6 m)	100	Unit	15.81	1581.00
Flex hose 1"	120	M	0.80	96.00
1 000-litre tank	10	Unit	250.00	2500.00
Irrigation accessories (T, elbows, etc.)		Unit		580.88
Electrovalves	5	Unit	52.00	260.00
Mesh filter	5	Unit	12.80	64.00
TOTAL (USD)				3438.73

Under these conditions, the cost per unit produced amounted to USD \$0.49 (Table 5). The units to be produced for the second year decreased by the inventory that has been considered at the end of

the first year (2019). The unit cost of production decreased in the second year because the installation cost of irrigation equipment only applies for the first year.

The price paid to the hydroponic lettuce producer in the domestic market (supermarket chains) is approximately USD 0.50. The final sale price on the same chains is around USD 1.00 per bag, based on a survey conducted on supermarkets in the province of Santa Elena (Figure 3). The unit cost obtained would only be sustainable with a direct sale to the consumer, without intermediaries. According to the same survey, weekly sales of these su-

permarkets in the province of Santa Elena increase in approximately 2 000 units. The weekly sales (1 418) would correspond to 70% of that value, exceeding the capacity of the local market. The product is commercialized in surrounding provinces such as Guayas, Manabí and Los Ríos. Currently the market is co-produced by the provinces of the Ecuadorian mountains, mainly three companies, but there is plenty of place to grow (own data).

Table 5. Total and unit production cost budget for 1000m² of greenhouse (in US dollars, as of September 2018) of hydroponic lettuce cv. Crespa cultivated in floating root system in the province of Santa Elena.

Detail	2019	2020	2021	2022	2023
Cost Materials	3 628.50	3 645.40	3 732.80	3 822.30	3 914.00
Costs work	24 003.60	25 503.20	25 548.40	25 593.60	26 731.90
Costs CIF	9 073.00	2 856.80	2 856.80	2 856.80	28 566.80
Total Cost (USD)	36 705.10	32 005.40	32 138.00	32 272.70	33 502.70
Units produced	75 146.00	73 728.00	73 728.00	73 728.00	73 728.00
Unit Cost	0.49	0.43	0.44	0.44	0.45

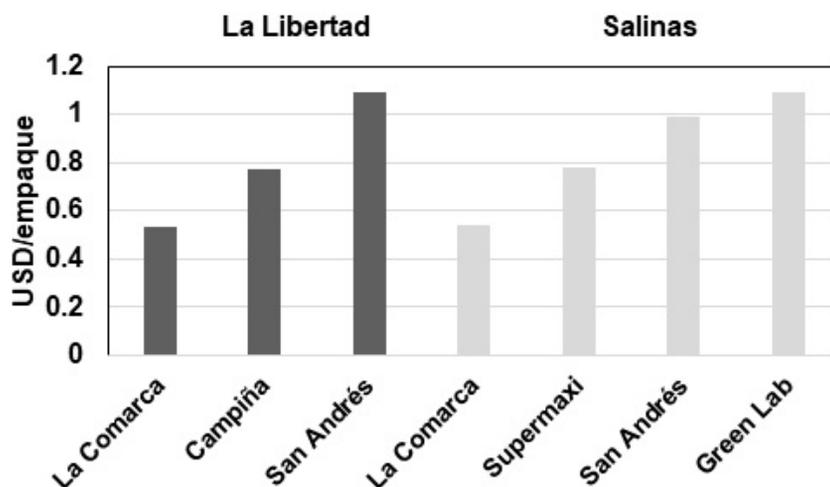


Figure 3. Comparison of unit sales price between brands of hydroponic lettuce in bags of 100 to 200 grams, in supermarkets in the province of Santa Elena (black bars= La Libertad province; gray bars = Salinas province). U.S. Dollar Values as of September 2018.

To be competitive in this scenario, an initial profit margin of 30% was considered, allowing a sale price of USD \$0.70 per marketing package. From the second year onwards, a profit margin of 45% was established for the package with one unit. According to Álvarez et al. (2014) in Ecuador the marketing of tomato (similar for all vegetables) presents three modalities (channels): a) collector - wholesaler- retail, b) supplier -wholesaler - supermarket and c) producer - supermarket. The third model is aimed to be without intermediaries, but considering the costs and existing market players for the purchase of the product (Zaruma, 2009) super/hypermarkets would be excluded, leaving as potential customers families (who buy in specialized local markets), restaurants, hotels and casinos (HORECA). This decision would allow the producer to move from the category of self-consumption and temporary to that of permanent producers, obtaining a position in the market.

Projected revenue and production costs allowed calculating the net value (VAN), the internal rate of return (TIR), and the profit-cost index (B/C). A discount rate of 15.40% has been determined, taking into account that there is financing and market risks by being a new project. Therefore, the risk has been estimated at 25% and the average inflation in recent years is 2.40% per year. The VAN obtained was USD 31 101.62 with a TIR of 40% and a B/C of 1.26; therefore, economically and financially the project was considered viable (Table 6). This index indicates that for every dollar invested, USD 0.26 of net gain is obtained.

Ríos (2013) by doing a financial analysis for a 700 m² hydroponic greenhouse with hydroponic lettuces in NFT system achieved a TIR of 50.91% and a profit/cost ratio of 0.7, indicating the project as unviable. Ortega et al. (2016) reported in tomato hy-

droponic variations in the benefit/cost ratio (C/B) between 0.7 (coconut fiber) and 1.8 (tezontle). Therefore, the hydroponic system with inert substrate (coconut fiber) was not profitable, while in agricultural soil the B/C ratio was 1.5. Quagraine et al. (2018) determined in their inert substrate lettuce assay VAN, TIR and B/C values of USD 73 872, 48.7% and 1.3, respectively. The return on investment was achieved over the third year. In hydroponic tomato the return on investment is also achieved in the second or third year, according to the Red Agrícola (2017).

At the national level, family farming has a small-holding structure with an average of 3.48 ha per farm, which supports food in general and contributes to 9.9% of the agricultural production and 43% to the value of sectoral production (Salcedo and Guzmán, 2014). FAO y CAF (2009) offer a credit contribution of around 70% to high-investment projects presented by chambers of agriculture, trade union associations, agricultural centers, peasant organizations. It emphasizes that credit must be reimbursable for projects that offer the best guarantees and signs of sustainability from three criteria: economically profitable, environmentally func-

ional and socially viable. They also suggest that working capital, marketing and training requirements should not be excluded from the investment.

Conventional crops require large areas to become profitable, while horticulture and even more protected crops, including hydroponics, operate efficiently on small surfaces. Therefore, it is more effective to contribute to sector policies that stimulate investment in high-efficiency areas of soil and water resources. Hydroponics meets this criterion and in a closed system (with recirculation) no polluting drains are emitted into the environment, complying with the criterion of environmental functionality.

On the other hand, the profits with a hydroponic project can go beyond the economic. Castiblanco (2016) evaluated a 10-year hydroponic project in a women's prison, estimating a social discount rate (TSD by its acronym in Spanish) of 12%. While, as in this case, annual operating costs exceeded the initial investment, and despite the high costs of investment, operation and maintenance, the economic net flow was positive by making this proposal economically and socially profitable.

Table 6. Cash flow with funding for a hydroponic project with cv lettuces. Crespa under floating root system, in the province of Santa Elena (values as of September 2018).

Detail	2018	2019	2020	2021	2022	2023
Initial Balance		5 003.70	1 594.81	9 066.99	16 461.70	31 603.36
Sales Revenue		54 249.69	58 191.56	58 432.68	58 677.62	60 913.97
Loan	20 202.93					
Total Income	20 202.93	59 253.40	59 786.38	67 499.68	75 139.32	92 517.33
Investment	28 861.33					
Payment providers		3 628.47	3 645.37	3 732.78	3 822.30	3 915.39
MOD Payment		24 003.62	25 503.15	25 548.35	25 593.55	26 731.89
CIF Payment		8 427.99	2 211.84	2 211.84	2 211.84	2 211.84
Payment Expenses Sales		10 160.90	10 891.32	11 077.30	11 263.27	11 449.25
Payment of fee		7 822.70	7 822.70	7 822.70		0.00
Outflow total	28 861.33	54 688.68	50 719.38	51 037.97	43 535.96	44 953.37
Cash Flow	-8 658.40	1 594.81	9 066.99	16 461.70	31 603.36	47 563.97
Capital Contribution	8 658.40					
Accumulated Cash Flow	0.00	1 594.81	10 661.81	27 123.51	58 726.87	106 290.84

Likewise, these productive systems can be activated in urban or rural community orchards, with training and strengthening of the society. In the province of Santa Elena, people work massively in these orchards (Prefectura Santa Elena, 2017), but hydroponic systems have not yet been implemented. With regard to social viability in this low-scale proposal, four direct and indirect jobs associated with the transportation and marketing of the product were achieved, thus improving the living conditions of those involved. Additionally, it would enrich the basket and the family diet, generate employment and savings in the purchase of fresh products.

5 Conclusions

The total weight of lettuces obtained on four transplant dates under the agroecological conditions of the province of Santa Elena, meets the minimum commercial weight, is relevant to the current offer in shopping centers and it is competitive in the market as long as it is sold without intermediaries.

The consumption of nutrient solution (fertilizing water) was estimated at 7.7 m^3 per growing cycle in 1000 m^2 of greenhouse, representing 8.7 % of the consumption of water under protected crop, and only 1.9% compared to an open field crop.

With the established assumptions and the technical-economic evaluation, a unit production cost of USD 0.49 was obtained. A VAN of USD \$ 31 101.62, was obtained with a sale price of each package of USD 0.70 (higher than zero), a TIR of 40%. This value was higher than the discount rate. The profit-cost ratio obtained was 1.26.

The sustainability of the proposal was evident in the economic and financial viability, the considerable savings of the water resource, the non-pollution of the environment as a closed system and the social viability shown in the generation of employment and improvement of quality of life of those involved, as well as being a contribution to the local diet.

It will be a future task to evaluate other genetic materials of lettuce that have a higher tolerance to high temperatures, with the aim of obtaining better yields and exploring with other horticultu-

ral, aromatic or medicinal species, baby vegetables or fourth-range products that have an economic activity. On the other hand, an increase in productivity can occur by increasing plant density or by applying biostimulants that allow lettuce to cope better with abiotic stress.

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