Financial feasibility of an aquaponic system with Pacific white shrimp (*Penaeus vannamei*) and vegetables using two sources of low-salinity water

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INTRODUCTION

Aquaponics is an integrated system of aquatic animals and vegetables, where the waste from aquaculture units is used in the production of vegetables. The effluents enriched with nutrients from aquaculture are used for plant growth, while the plants purify the water, thus allowing it to be reused in the aquaculture units. Aquaponics has been tested successfully with different species of fish; however, there are other species of aquatic organisms with the potential for their integration into aquaponics. With the development of shrimp farming in fresh water and low salinity, the effluents from these farms could be used in the production of vegetables with commercial importance, improving the income of shrimp farmers. It is essential to generate scientific information to help determine the financial feasibility of aquaponics scenarios, especially when the aquatic organism involved in the aquaponic system is shrimp. Therefore, the objective of this study was to determine the financial viability of a white shrimp aquaponic system with basil and lettuce using two low-salinity water sources in northwestern Mexico.

MATERIAL AND METHODS

The technical and financial data were obtained from the field work carried out in the experimental module "YK", located in Mazatlán, Sinaloa, Mexico. From the technical and financial data, two scenarios were projected: groundwater scenario (GW) and diluted seawater scenario (DSW). Each model scenario was projected with four 6-m diameter circular tanks for shrimp culture and 12 hydroponic DFT systems for basil and lettuce crop. The effluent from the shrimp culture flows by gravity to the filtration system and DFT systems. The dimensions of the DFT systems are 2-m wide, 30-m long and 0.2-m high, constructed with concrete blocks and covered with plastic. At the end of the DFT systems, three 450 L tanks recover the excess water and then pump it to the shrimp culture tanks with a ¼ HP submersible pump. The cultivation of basil and lettuce are carried out under shade house with a production area of 576 m^2 (1506 m^2 including corridors between DFT systems) while the area for shrimp cultivation is carried out in 87 m^2 (272 m^2 including corridors between tanks). A total area of 0.17 ha was required for the project. The growing cycle is described in the Table 1.

Table 1. Production scheme of the two model scenarios.

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Shrimp	X	X	X	X				
Basil		X	X	X				
Lettuce					X	X	X	X

Table 2. Production parameters of the shrimp-vegetable aquaponic system by scenario.

Production parameters	GW scenario	DWS scenario DSW
Shrimp		
Stock density (PL m^{-2})	75	75
Final weight (g)	9.1-8.9	8.7-8.5
Survival (%)	89.5-73.6	85.0-73.6
FCR	1.6-1.7	1.6-1.7
Yield (kg m^{-2})	0.6-5.0	0.5-.04
Basil		
Stock density	16	16
Annual production	3,570.0	2,847.5
Yield	8.4	6.7
Lettuce		
Stock density	16	16
Plants per year	20,400	20,400

The financial feasibility of both model scenarios was carried out through the following indicators: production break-even point (PEP), net present value (NPV), internal rate of return (IRR), benefit-cost ratio (RBC) and payback period (PP). Sensitivity analyzes were performed to find key points where the feasibility of the proposed system could be improved. The variables evaluated were: sale price, fuels and lubricants, labor and land rent. The indicator used in the sensitivity analyzes was the IRR.

RESULTS

Investment costs amount to US $ 26,580 for each scenario. Vegetable crops represent 65.7% of total investment costs, while shrimp farming represents the remaining 34.3%. Civil works is the highest asset, with 58 and 79% of the total investment costs of shrimp farming and vegetables, respectively.

Table 3. Investment costs of the aquaponic system shrimp-vegetables for each scenario.

	Shrimp (US $)	Percentage of the total (%)	Vegetables (US $)	Percentage of the total (%)
Civil work	5,326	58	7,404	79
Service equipment	797	9	531	5
Auxiliar equipment	556	6	324	3
Transport equipment	1,225	13	817	7
Deferred assets	1,225	13	817	7
Total	9,130	100	17,450	100

Variable costs represent 88.1 and 87.6% of operating costs for the GW and DSW scenario, respectively. Salaries are the highest operating cost while seedlings/seeds are the lowest operating cost.

Table 4. Operational costs of the aquaponic system shrimp-vegetables by scenario.

	Category	GW scenario Cost (US $)	GW scenario Percentage of total (%)	DSW scenario Cost (US $)	DSW scenario Percentage of the total (%)
Postlarvae	Shrimp	46	0.2	46	0.2
Feed/fertilizer	Shrimp	97	0.5	96	0.5
Seed/seedlings	Vegetables	14	0.1	14	0.1
Agricultural supplies	Vegetables	79	0.4	79	0.4
Fuels and lubricants	Shared	1,022	5.1	1,022	5.3
Vehicle maintance	Shared	82	0.4	82	0.4
Salaries	Shared	15,816	78.8	15,102	78.1
Incidentals	Shared	515	2.6	495	2.6
Administrative expenses	Shared	1,307	6.5	1,307	6.8
Land rent	Shared	817	4.1	817	4.2
Depreciation	Shared	279	1.4	279	1.4
Total		20,074	100	19,339	100

The income from sales of the harvested products is summarized in Table 5. Vegetables contribute most of the profitability, as shrimp only generate 1.1-1.2% of total sales revenue. On the other hand, the sale of basil is the main income input with 58.2 and 52.7% for the GW and DSW scenarios, respectively,

Table 5. Sales incomes,operational cost and net profit by crop and scenario.

	GW scenario Shrimp (US $)	GW scenario Basil (US $)	GW scenario Lettuce (US $)	DSW scenario Shrimp (US $)	DSW scenario Basil (US $)	DSW scenario Lettuce (US $)
Incomes	338	17,500	12,222	308	13,958	12,222
Costs	6,756	6,659	6,659	6,510	6,414	6,414
Net profit	-6,418	10,841	5,563	-6,202	7,544	5,808

Both scenarios resulted to be financially viable. However, the GW scenario presented the best indicators with a lower PEP and PP, and a higher NVP, IRR and RBC than the DSW scenario.

Table 6. Financial analysis of the two scenarios projected for the aquaponic system shrimp-vegetable.

Financial indicators	GW scenario	DSW scenario
PEP (%)	40.9	49.7
NPV ($)	23,913	8,994
IRR (%)	31.4	19.8
RBC	3.4	2.4
PP (years)	2.5	4.0

Sensitivity analysis indicates that both scenarios showed higher sensitivity to sales prices, followed by salaries.

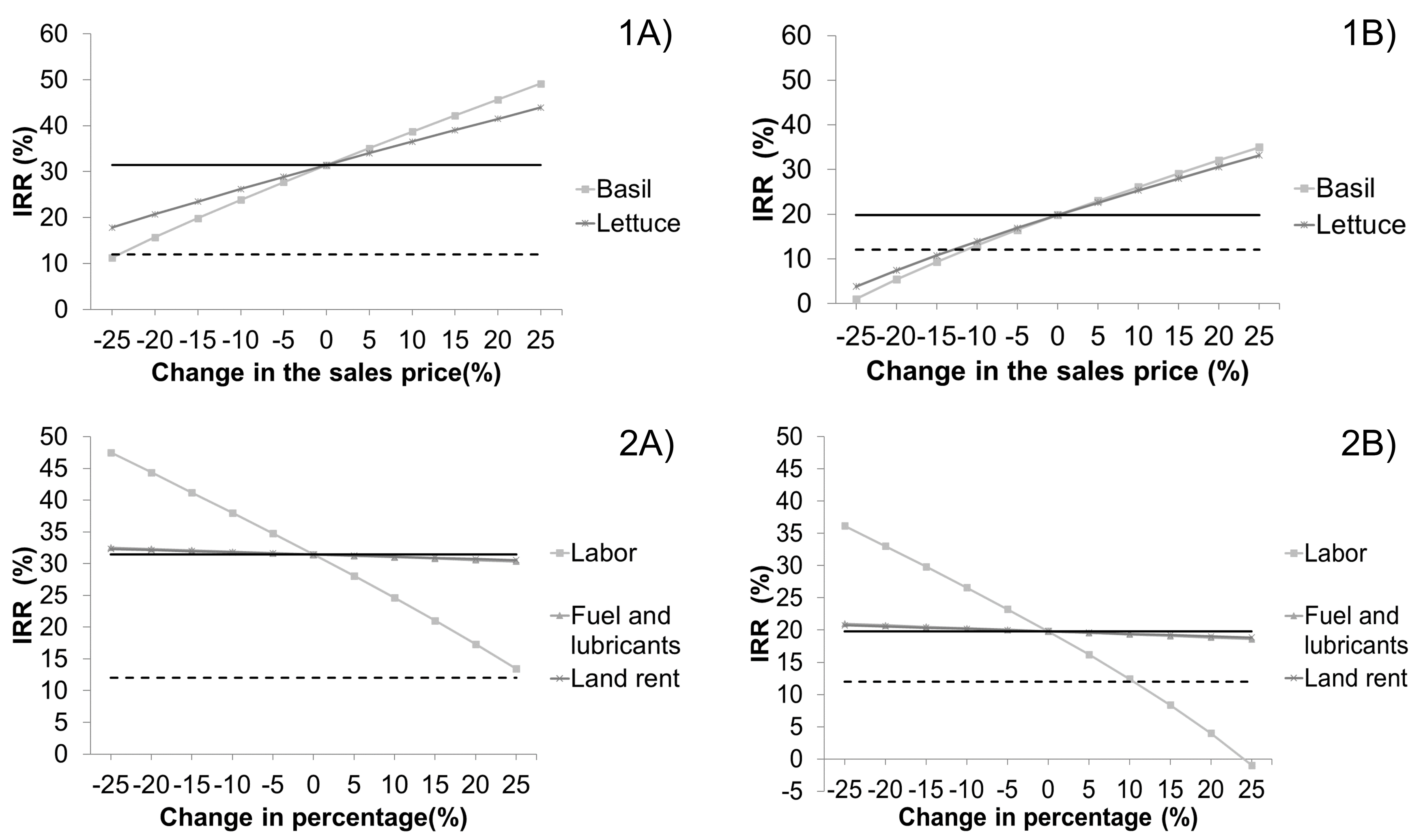

Figure 1 and 2. Effect of the change in the sales price (1), labor, fuel and lubricants and land rent (2) on the IRR calculated for aquaponic system scenarios using groundwater (A) and diluted seawater (B).

CONCLUSION

The results obtained suggest that the two small-scale commercial aquaponic scenarios for shrimp and vegetables are profitable. However, the GW scenario showed better financial indicators than the DSW scenario. The integration of vegetables through hydroponic systems to shrimp farming could be a good alternative to improve the profitability of shrimp producers.

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