Investment Analysis for Commercial Greenhouse Hydroponically Produced Lettuce and Tomato

By Jeffrey Miller, Pierre Boumtje, and Rachel Johnson

ABSTRACT

This study employs investment analysis techniques to assess the financial feasibility and economic profitability of investments in commercial greenhouse hydroponic farming. Results show substantial net present values (NPV) and internal rates of return (IRR) on greenhouse hydroponics investments for lettuce and tomato. Lettuce however, is the most attractive, with NPVs and IRRs three to four times higher than those in tomato. Also, evidence shows that the potential income and profitability measures are very sensitive to changes in prices. Results provide valuable insights to current and prospective growers, farm managers, rural property appraisers, extension services, and agricultural consultants.

Introduction

Hydroponics is a method of growing plants without soil. Plants may be grown in a nutrient solution only (liquid culture) or they may be supported by an inert medium (aggregate culture). In both systems all of the plants' nutritional needs are supplied through the irrigation water (UK Cooperative Extension Service et al., 2013). Hydroponic farming is not a new idea. Pioneer studies on hydroponics were conducted by Francis Bacon, a British scientist, in the 1620's, William Gericke, Dennis Hoagland, and Daniel Arnon in the1920's. It is reported that American troops that were stationed on infertile Pacific islands during World War II were able to grow vegetables hydroponically to help alleviate the burden of transporting perishable food. After the war, the use of hydroponics spread throughout the world. In the 1960's, soil-less farming on the commercial level was used in many arid regions within the United States, such as Arizona. It has significantly increased in popularity throughout recent years, first with scientists, and then with commercial growers.

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Hydroponics is a highly exacting and demanding system that requires a greater amount of production knowledge, experience, technical skills, and financial investment than many other greenhouse systems. A grower must be committed to meeting the daily demands of production to be financially successful.

Studies on hydroponics are abundant but mainly focus on greenhouse thermal environment and light control, greenhouse ventilation and air conditioning, nutrient uptake and plant physiology, pest and disease control, seed treatment, and plant spacing. Few works if any, have looked into economic and financial aspects of greenhouse hydroponic farming. This study intends to supplement and enrich the literature by providing economic and financial analysis components that need to be taken into consideration. Lettuce (*Lactuca sativa*) and tomato (*Solanum lycopersicum*) which are among the most commonly grown commercial hydroponic vegetables, will be the focus of our study. Therefore, the primary objective of this study is to employ investment analysis (or capital budgeting) techniques as a formal decision method to assess the financial feasibility and economic profitability of investments in commercial greenhouse hydroponic production of lettuce and tomato. Results should provide valuable economic and financial insights to current and prospective growers, farm managers, rural property appraisers, extension services, and agricultural consultants.

Literature Review

Literature on economic considerations of hydroponic farming is not abundant. Ilaslan et al. (2003) studied the economic viability of a greenhouse hydroponic lettuce production. The analysis indicated that given current prices and costs, controlled environment agriculture (CEA) hydroponic lettuce production in northern climates such as Ithaca in upstate New York and Chicago is marginal to negative, in terms of economic viability.

Jose G. Pena et al. (2005) conducted a study comparing production cost differences between field grown and greenhouse tomatoes. Their main conclusion was that greenhouse tomatoes compete at a substantial competitive disadvantage. They must have a price premium of $.17 to $.27 or more per pound to achieve economic survival, yet their profit margin is equal to or below that of field grown tomatoes. The study also identified greenhouse tomato main advantages which are (i) freshness since they are grown close to retail centers and picked ripe, and (ii) higher quality since they are grown in a highly controlled environment. These two advantages can justify the required price premium.

There are other potential advantages that could significantly improve the profitability of CEA and thus hydroponic production. One is that the greenhouse forms a restrictive barrier to insect pressure. As a result, insecticide costs are lowered, and organic production is a real possibility. Also, greenhouses experience less evaporation loss to the outside environment and thus are more efficient water users than non-CE production practices.

Raymond Joe Schatzer et al. (1995) used investment analysis to study economic and financial feasibility of greenhouse production of vegetables. Specifically, they estimated (i) the expected total investment costs, (ii) the expected annual costs, returns, and cash flows, and (iii) the economic feasibility under conditions of yield and price variability. Their results indicated that greenhouse production of tomatoes or cucumbers can provide a

producer with a positive net return in Oklahoma and that the potential income is very sensitive to changes in prices and yields.

In their study of greenhouse financial analysis, Wen-fei, Steve Richards, et al. (2000) found that the most profitable greenhouse businesses are not necessarily the largest greenhouses. The top 20 percent rate of return on asset (ROA) of wholesale greenhouses generally had higher annual sales, lower operating costs, higher sales per full-time worker equivalent, lower debt-to asset ratio, and higher asset turnover ratio. The top 20 percent ROA of retail greenhouses generally have average annual sales, low operating and overhead costs, high labor efficiency, no debt, and high asset turnover ratio.

Models and Data

Investment analysis (or capital budgeting) is a formal decision method used to assess the financial feasibility and economic profitability of investments. Three most commonly used models to evaluate returns on investment options include (1) the net present value method, (2) the internal rate of return methods, and (3) the payback (or breakeven) period methods. The first two account for the time value of money, and all together, they provide the most meaningful decision making information in investment analysis and capital budgeting situations. Bierman et al. (1992) indicated that the capital budgeting practices employed most by large firms to make decisions were the internal rate of return (IRR) method (88%) and net present value (NPV) method (63%). Hydroponics farming is suitable for such analysis because most capital assets such as equipment, building structures, and land last many years, with revenues and costs occurring over a number of years.

As a recall, the model used for this study is shown in the equation below.

$$(1) \quad NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \cdots + \frac{C_T}{(1+r)^T}$$

where:

C_0 is the initial investment

C_i is net cash flow in period i

r is the discount rate

and T is the final year of the planning horizon.

or in summary,

$$(2) \quad NPV = -C_0 + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i}$$

The acceptability of each investment depends upon the comparison of its NPV with the investor's required NPV. Ranking of investments is based on the relative sizes of the NPVs, with the largest favored the most.

The payback period is the length of time required for an investment to recover the initial outlay of funds. This method does not consider cash flows after the payback date or account for differences in timing of cash flows prior to the end of the payback period. It measures the speed of recovery of the initial investment, but does not measure the investment's total profitability. The investment with the shortest payback period is ranked the best, while all investments with payback periods less than the investor's required payback period are acceptable.

There are many types of hydroponic greenhouses and the economic and financial feasibility of greenhouse production of vegetables depends upon the type of greenhouse operation (Wen-Fei, Uva, et al., 2000). All data used in this study are based on the Ohio State University Quonset style house. Individual bay dimensions are

24'x128'. With a total of 4 bays, total producing area is 12,288 square feet, corresponding to 64 square inches per plant for lettuce, and 4 square feet per plant for tomato.

When using the NPV and IRR methods, information needed to evaluate investments generally include (i) the initial investment, (ii) the expected net cash flows for the investment by period including a salvage value if any, (iii) an appropriate interest rate or discount rate, (iv) the length of planning horizon, (v) terms of financing if borrowed funds are used, and (vi) the marginal tax bracket of the borrower, as well as the taxability status for each cash flow.

The initial investment for commercial hydroponic lettuce and tomato production includes the cost of setting up of the greenhouse structure, the greenhouse environmental control equipment cost, and the greenhouse production equipment cost. Cost estimates of these initial outlays are shown on Table 1 for lettuce and Table 2 for tomato.

The Ohio State University (2011) estimates receipts on greenhouse hydroponic lettuce to be based on 23,638 marketable heads per turn and 10 turns per year, and those for tomato on about 2764 plants per year, with 30 pounds of marketable fruits per plant. We use the same estimates in this study.

Greenhouse hydroponics variable costs include expenses on supplies labor, packaging, utility, professional services, and miscellaneous costs. Ownership costs for greenhouse hydroponics include greenhouse structure ownership costs, environmental control equipment ownership costs, and other equipment ownership costs. Estimates of both variables and ownership costs are shown on Table 3 and Table 4 for lettuce and tomato respectively.

The expected net cash flows used in this study are from the 2011 Ohio State University hydroponic enterprise budgets. The gross margin, which is the before-tax return over fixed and variable costs for lettuce and tomato as shown in Table 3 and Table 4 respectively, is used. A 20-year planning horizon which reflects the lifespan of this type of greenhouse structure will be used. An interest rate of five percent reflecting a mortgage rate for a similar length of time will be used to discount the cash flows.

Results and Discussions

Net present values and internal rates of return of these greenhouse hydroponic investments are substantial for both lettuce (Table 5) and tomato (Table 6). Comparing the two, lettuce is by far the most attractive, with NPV and IRR values three to four times higher than those in tomato. Potential greenhouse hydroponic growers must recognize that the potential income is very sensitive to changes in yields and prices that they receive. In a controlled growing environment however, variability in yield may be considerably reduced. So, growers may worry only about price variability. We conducted a sensitivity analysis and used prices five and ten percent lower than the expected price. Results show NPVs that decrease by hundreds at all levels of discount rates for both lettuce and tomato. IRRs also prove to be very sensitive to price changes. For lettuce, IRRs fall from 98 to 70 percent and then to 50 percent when the expected price is reduced by 5 and 10 percent respectively. For tomato, IRRs fall from 26 to 16 percent and then 7 percent when the expected price is reduced by 5 and 10 percent respectively. Also, payback periods of two and almost five years for lettuce and tomato respectively are quite attractive for this type of investment.

Conclusion

This study shows that investment in greenhouse for hydroponic commercial lettuce and tomato is economically and financially sound, with very promising NPVs, IRRs, and pay-back periods. Comparing the two vegetables, lettuce is by far the most attractive with NPVs and IRRs three to four times higher than those in tomato. Controlled environment agriculture has the advantage of reduced variability in yields. However, current and prospective growers, farm managers, rural property appraisers, extension services, and agricultural consultants must be aware that the potential income and profitability measures are very sensitive to changes in prices.

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Table 1. Initial investment for a hydroponic greenhouse for lettuce

Component	Cost
Greenhouse structure set up	$48,976
Greenhouse Environmental Control Equipment	$52,000
Other growing and delivery equipment	$58,786
Total Initial Investment	$159,765

Source: Adapted from OSU Department of Agricultural, Environmental, and Developmental Economics

Table 2. Initial investment for a hydroponic tomato greenhouse

Component	Cost
Greenhouse structure set up	$50,387.04
Greenhouse Environmental Control Equipment	$52,000
Other growing and delivery equipment	$18,855
Total Initial Investment	$121,242.04

Source: Adapted from OSU Department of Agricultural, Environmental, and Developmental Economics

Table 3. Greenhouse hydroponic lettuce budget

Receipt description		
1	Percentage of greenhouse area utilized	90%
2	Crop harvest per turn	24,883 heads
3	Number of turns per year	10
4	Marketable heads per turn	23,638 heads
5	Marketable heads per year	236,380 heads
6	Expected price	$1.10/head
7	Total annual revenue	$260,018
Cost description		
Variable costs		
1	Production supplies costs	$12,506
2	Production labor costs	$60,192
3	Packaging costs	$45,000
4	Utility costs	$27,570
5	Miscellaneous costs	$2,870
6	Professional services	$750
7	Total Variable costs	$148,928
Fixed costs		
1	Greenhouse structure ownership costs	$9,795
2	Environmental control equipment ownership costs	$10,400
3	Other equipment ownership costs	$11,757
4	Total fixed cost	$32,052

Source: Adapted from OSU Department of Agricultural, Environmental, and Developmental Economics

Table 4. Greenhouse hydroponic tomato budget

Receipt description		
1	Percentage of greenhouse area utilized	90%
2	Number of plants per year	2,764
3	Number of pounds of fruit per plant	30 lb.
4	Marketable pounds per year	78,774 lb.
5	Expected price	$1.80/lb.
6	Total annual revenue	$141,793.20
Cost description		
Variable costs		
1	Production supplies costs	$13,658.86
2	Production labor costs	$25,703.30
3	Packaging costs	$15,253.70
4	Utility costs	$2,870.00
5	Miscellaneous costs	$2,870
6	Professional services	$750
7	Total Variable costs	$92,479.96
Fixed costs		
1	Greenhouse structure ownership costs	$10,077.41
2	Environmental control equipment ownership costs	$10,400
3	Other equipment ownership costs	$3,771
4	Total fixed cost	$24,348.41
Total costs		$116,828.37

Source: Adapted from OSU Department of Agricultural, Environmental, and Developmental Economics

Table 5. Lettuce capital budgeting results

	Net Present Values		
Interest rate	At the expected price of $1.10/head	At the expected price of $1.045/head (5% lower)	At the price of $0.99/head (10% lower)
5%	832818.58	670792.87	508778.66
4%	920518.43	743825.64	567145.48
3%	1020759.33	827331.81	633918.2
2%	1135735.88	923144.85	710569.18
Internal Rate of Return	98%	70%	50%
Payback Period			2 Years

Table 6. Tomato capital budgeting results

	Net Present Values		
Interest rate	At the expected price of $1.80/lb.	At the price of $1.71/lb. (5% lower)	At the price of $1.62/lb. (10% lower)
5%	19564.835	107324.1	18971.21
4%	222701.3	126379.36	30028.57
3%	253702.91	148255.81	42779.57
2%	289346.01	173449.33	57523.22
Internal Rate of Return	26%	16%	7%
Payback Period			4 Years 9 Months