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Economic Analysis of Small-scale Greenhouse Tomato Production in Florida

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The number of greenhouse vegetable growers in the United States more than doubled between 2007 and 2012, and total greenhouse vegetable production area increased from 62 million to 98 million square feet. Greenhouses provide opportunities to extend production seasons, increase yields per acre, and reduce production risks. Economic viability of greenhouse vegetable production in Florida can be a challenge, however, and prospective growers seek information on production costs and potential returns for various crops and systems. Based on University of Florida/IFAS tomato production demonstrations, research reports, information from input suppliers, and discussions with growers, we conducted an economic analysis of cluster tomato production in a single-bay, fan-and-pad greenhouse. The analysis includes an annual production budget, 10-year investment analysis, break-even analysis, and sensitivity analysis. These analyses demonstrate that the annualized greenhouse cost, labor costs, and energy costs account for about 60% of total costs and provide the greatest opportunity to find significant cost savings. Also, the tomato selling price must be higher than the average retail price in the southeastern U.S. for small-scale greenhouse tomato production to be profitable.

Greenhouse vegetable production has increased rapidly, and tomatoes are a common greenhouse crop. The number of U.S. growers producing vegetables and herbs in greenhouses increased 115% between 2007 and 2012. The 2012 Census of Agriculture documented 8,750 greenhouse vegetable growers with 98 million square feet under glass or other protection. Of those growers, 90% had less than 10,000 square feet of greenhouse vegetable production. A majority (72%) of greenhouse vegetable producers grow tomatoes, and tomatoes account for more than half (56%) of the total greenhouse vegetable production area in the United States (USDA, 2012).

Greenhouse production offers several advantages. Pest exclusion barriers and soilless media reduce the need for pesticides. Climate controls, such as heating and cooling, shading, and air circulation systems provide opportunities to extend production seasons. Greater control over the production environment can improve product quality, increase yields per acre, and reduce production risks.

Despite the advantages of greenhouse systems, their profitability can be a challenge. Some greenhouse tomato operations in Florida have been successful, but others have closed because of financial difficulties. Basing decisions on appropriate economic analysis can improve the chances of success.

The objective of this study is to assist small-scale greenhouse tomato producers with economic analysis that can help inform management decisions. To achieve that objective we conducted an economic analysis of cluster tomato production in a single-bay (30' × 96'), fan-and-pad greenhouse in Florida. The analysis includes an annual production budget, 10-year investment analysis, break-even analysis, and sensitivity analysis. The analysis provides benchmarks for production yields and pricing needed for profitability, as well as identifying the most expensive aspects of production, which could be viewed as having the greatest opportunity to find cost savings. It can serve as an example framework for growers to conduct their own economic analysis to inform decisions on crop selection, growing practices, product pricing, and long-term investments.

Materials and Methods

Information used in the analysis comes from various sources, including research and extension reports, production demonstrations, input suppliers, commercial growers, and other experts. Research and extension reports provided guidelines on crop configuration and yield expectations, water and nutrient requirements, and hydroponic system and greenhouse design (Hochmuth and Hochmuth, 2001, 2003, 2004; Hochmuth et al., 2001; Hochmuth, 2012). Additional details were drawn from the experience of several years of greenhouse tomato demonstrations at the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) North Florida Research and Education Center, Suwannee Valley, as well as discussions with commercial growers and other experts. Suppliers of greenhouse equipment and growing materials provided input pricing.

Methods of economic analysis were drawn from agricultural economics and farm management literature. Analytical methods

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include enterprise budgeting, break-even analysis, sensitivity analysis, and investment analysis (Kay and Edwards, 1999; AAEA Task Force, 2000; FFSC, 2008).

The analysis presented here provides reasonable estimates given the assumptions about the enterprise. Actual costs and returns will vary from grower to grower and year to year. Assumptions are that the budget represents production of indeterminant cluster tomatoes in a full 30' × 96' (2880 ft^2) fan-and-pad greenhouse by an owner-managed operation. The tomatoes are grown in lay-flat growbags with coco fiber at a population of 640 plants. Including transplant production, the growing season is 10 months, starting in August and ending in June. The harvest season is 30 weeks, November through June. It is assumed the grower is located close to farmers' markets with sufficient demand to sell all the production from a single greenhouse.

Results and Discussion

Fixed costs

Fixed costs are associated with owning fixed assets or running a business independent of what or how much is produced, over a certain range. This analysis groups fixed costs into three categories: greenhouse and environmental controls, production equipment and durable supplies, and general farm overhead. Fixed greenhouse and environmental control costs include the greenhouse structure and covering, a headhouse, heating and cooling systems, lighting, tables and benches, as well as costs for installation and utility hookup. Production equipment and durable supply costs include the nutrient delivery system, tanks, pumps, valves, tubing, reusable containers, trellises, spray equipment, and other equipment and durable supplies that last multiple years. General farm overhead refers to selling, general, and administrative costs of running the farm business. This includes the business portion of a vehicle expense, office supplies, business services, farmers' market fees, and liability insurance.

Fixed costs may be cash or noncash costs. For example, office supplies, insurance, tangible personal property taxes, repair or maintenance of the greenhouse covering, and farmers' market fees may be paid annually and therefore are considered cash costs. Noncash costs include annual depreciation or capital recovery costs on investments made in previous time periods, as well as any opportunity costs of capital, land, or labor.

The initial investment and annual fixed costs are shown in Table 1. The initial investment is estimated at $58,860. Total annual fixed costs amount to $6,933 in noncash and $3,975 in cash costs. These costs do not include the cost of the land or well.

Variable costs

Variable operating costs vary in proportion to the amount of each crop produced or the length of the growing season. Variable operating costs include materials, labor, equipment operating costs, and interest on operating capital. Those categories are further broken down in Table 2.

Materials used in greenhouse tomato production include transplant production materials, the lay-flat growbags, fertilizers and acid, pest and disease management materials, other growing materials, and packing materials. Total annual material costs are estimated at $3,502.

Labor cost estimates are based on 262 hours per year for growing labor, 180 hours per year for harvesting and packing labor, and 20 hours per year for maintenance and repairs. Average Florida agricultural wage rates (FDEO, 2018) and 9% payroll overhead are used to estimate labor cost. Total labor cost, not including general management and supervision, is estimated at $5,430. If the owner-manager of the greenhouse provides all the labor herself, this labor cost would be considered an opportunity cost or added to the net return to management.

Equipment operating costs are estimated based on the power or energy consumption of the equipment in the greenhouse and estimates of operating time. Electricity costs to run fans, pumps, lighting, and cold storage are estimated at $1,561 for the 10 months of operation. Fuel costs are estimated at $1,680 for propane to run heaters and $656 for gasoline to run a vehicle and limited use of a backup generator. Total energy costs are $3,897 over the 10-month season. Another $802 is estimated for equipment repairs.

Yield, selling price, and gross revenue

Average tomato yields ranged from 15.2 to 21.3 pounds per plant for seven different cluster tomato varieties in trials at the Suwannee Valley Research and Education Center in Live Oak, FL (Hochmuth et al. 1998). Other sources report cluster tomato yields of 20-25 pounds per plant. The starting point for this analysis assumes a total harvest yield of 20 pounds per plant and a 90% packout rate, resulting in actual sales of 18 pounds per plant.

It is assumed the tomatoes are sold directly to final consumers, such as at farmers' markets. The grower receives a retail price and may be able to sell at a premium relative to average supermarket prices.

Table 1. Initial investment and annual fixed costs.

Items	Initial investment	Annual noncash cost	Annual cash cost
Greenhouse & environmental controls	$52,150	$4,597	$1,073
Production equipment & durable supplies	$ 6,710	$1,335	$ 403
General farm overhead	—	$1,000	$2,500
Total	$58,860	$6,933	$3,975

Table 2. Annual variable operating costs.

Variable	Annual cash cost
Materials	
Transplant production materials	$ 615
Growing media & disposable containers	$ 880
Fertilizers & acidifiers	$ 794
Pest & disease management materials	$ 182
Other growing materials	$ 600
Packing materials	$ 431
Total materials	$3,502
Labor	
Production labor	$3,468
Harvesting & packing labor	$1,962
Total labor	$5,430
Equipment operating costs	
Electricity	$1,561
Fuel	$2,336
Equipment repairs	$ 802
Total equipment operating costs	$4,699
Interest on operating capital	$ 414
Total variable operating costs	$14,045

Table 3. Enterprise budget summary with moderate yield and price.

Annual revenue, 11,520 pounds sold at $2.00 per pound	$23,040
Annual variable operating costs	$14,045
Annual fixed costs, cash and noncash	$10,908
Net return over variable operating costs	$ 8,995
Net return over total costs	–$ 1,913

Weekly average prices for greenhouse tomatoes on the vine (cluster tomatoes), excluding organic, at retail supermarket outlets in the southeastern U.S. ranged from $1.25 to $2.49 per pound between November 2017 and June 2018. The average weekly average price during that time period was $1.52 per pound (USDA, 2018).

Gross revenue is calculated by multiplying the average selling price for the season by the quantity sold. At a moderate yield and sales of 18 pounds per plant, or 11,520 pounds total, and an average supermarket selling price of $1.52 per pound, gross revenue is $17,510 for the year. Assuming the small-scale grower could obtain a higher price of $2.00 per pound, reflecting a premium for direct-marketed locally grown produce, annual gross revenue would be $23,040. Gross revenue and profitability are highly dependent upon yields and price received.

Enterprise budget and net returns

An enterprise budget estimates costs, revenues, and net returns on an annual basis for a crop enterprise. Table 3 shows an enterprise budget summary based on cost estimates described previously, a sales quantity of 11,520 pounds, and a price of $2.00 per pound. Although revenues more than cover variable costs, the net return over total costs is negative (-$1,913). The return can be interpreted as annual net return to management and land, and profit. If the owner provides all the labor, the labor cost shown in the budget ($5,430) would be counted as a noncash cost or added to the net return. If $5,430 is added to the net return of -$1,913 to show +$3,517, the owner may not consider the enterprise a loss, but would be earning less than the average wage for agricultural employees. Positive net returns over total costs, including unpaid labor cost, could be achieved by finding cost-reducing efficiencies or by obtaining a higher yield or selling price than assumed in this budget.

Break-even and sensitivity analysis

The break-even price is the minimum price needed to make a positive net return, given assumptions about yield and costs. Table 4 shows the break-even price under different yield scenarios, assuming a 90% packout rate. Break-even prices in this analysis range from $1.84 to $2.66 per pound, depending on the yield scenario.

Table 4. Break-even price under different yield scenarios, assuming 90% packout rate.

Yield scenario	Yield per plant (lb)	Sales quantity (lb)	Break-even price
Most pessimistic	16	9,216	$2.66
Pessimistic	18	10,368	$2.38
Moderate	20	11,520	$2.17
Optimistic	22	12,672	$1.99
Most optimistic	24	13,824	$1.84

Table 5. Break-even yield under different price scenarios, assuming 90% packout rate.

Price scenario	Selling price	Break-even yield (lb)	Break-even quantity (lb)
Most pessimistic	$1.50	30.3	17,457
Pessimistic	$1.75	25.4	14,628
Moderate	$2.00	21.9	12,587
Optimistic	$2.25	19.2	11,046
Most optimistic	$2.50	17.1	9,842

Table 6. Annual net return for different price and marketable yield scenarios.

Annual sales	Average selling price ($/lb)				
quantity (lb)	$1.50	$1.75	$2.00	$2.25	$2.50
9,216	($10,650)	($8,346)	($6,042)	($3,738)	($1,434)
10,368	($9,161)	($6,569)	($3,977)	($1,385)	$1,207
11,520	($7,673)	($4,793)	($1,913)	$ 967	$3,847
12,672	($6,184)	($3,016)	$ 152	$3,320	$6,488
13,824	($4,695)	($1,239)	$2,217	$5,673	$9,129

The break-even yield is the minimum yield needed to make a positive net return, given assumptions about selling price and costs. Table 5 shows the break-even yield under different price scenarios, assuming a 90% packout rate. Break-even yields in this analysis range from 17.1 to 30.3 pounds per plant, depending on the price scenario.

A sensitivity analysis changes key parameters or assumptions and demonstrates the effect on net returns. The sensitivity analysis in Table 6 shows annual net return over total costs for five different sales quantities and five different selling prices. The annual sales quantities represent total harvest yield of 16, 18, 20, 22, and 24 pounds per plant, and a 90% packout rate. The selling prices start at $1.50 per pound, just slightly below the average supermarket retail price, then consider a range from $1.75 to $2.50 per pound in $0.25 increments.

The analysis shows the importance of obtaining a premium selling price for a small-scale tomato grower to be profitable. Even at an optimistic sales quantity of 12,672 pounds, the grower needs to receive a selling price of at least $2.00 per pound to earn a profit. If the grower can obtain a selling price of $2.50 per pound, the enterprise turns a profit in all but the most pessimistic yield scenario.

Investment analysis

Investment analysis compares the initial investment of $58,860 in the greenhouse, equipment, and durable supplies with an alternative investment that earns a set rate of return. The investment analysis is based on annual cash flow over a 10-year period (Table 7). Assumptions include a 2% inflation rate on costs and revenues, a 2.5% risk-free nominal discount rate, and a risk premium of 3%.

Table 7. Ten-year investment analysis at two different average prices.

	Average selling price	
	$2.00/lb	$2.50/lb
Net present value	– $23,611	+ $23,517
Internal rate of return	– 4%	+ 13%
Payback period	> 10 years	6 years

At a moderate yield of 20 pounds per plant and moderate selling price of $2.00 per pound, there is a negative net present value and negative internal rate of return. Even without the risk premium, the net present value is negative, which means the investment in the greenhouse, equipment, and supplies performs worse than an alternative investment that earns a 2.5% rate of return.

The results of the analysis change drastically with just a $0.50 increase in selling price. At the most optimistic price assumption ($2.50/lb), but still at the moderate yield assumption (20 pounds per plant), the net present value over ten years is $23,517. The rate of return is 13%, and the payback period is 6 years. At that price, the investment looks favorable.

Discussion

Production of tomatoes in greenhouses offers advantages of season extension, increased yields per acre, and reduced need for pesticides. Greenhouse tomato production is now common in the United States and several other countries. Investment costs are substantial however, and financial viability is uncertain. This analysis of costs and returns demonstrates that to be successful a grower must either find cost efficiencies to reduce costs below the estimates in this budget or access high-value markets that pay better than average retail prices. Increasing the scale of operation has the potential to decrease average cost through economies of scale, but could also require a lower selling price to move larger volumes.

This budget shows that the most expensive cost groups are the annualized cost of the greenhouse and environmental controls, the annual labor cost, and the annual energy cost. Together those costs account for 60% of total annual costs. Finding ways to cut costs in those areas without sacrificing yield has the greatest potential impact on total costs and profitability.

The analysis also shows that it is difficult for a greenhouse tomato grower at this scale to be profitable at average supermarket selling prices. Direct marketing to final consumers through farmers' markets or other outlets and promoting locally grown or other quality attributes offer the potential to obtain a higher price for tomatoes. Effective marketing and obtaining a price premium is critical for the success of small-scale greenhouse tomato production in Florida. Based on cost estimates in this analysis and a moderate yield of 20 lb per plant, the grower needs to sell at an average price above $2.17 per pound to achieve a positive net return.

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