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Economics of Satsuma Citrus Production Using Drip Irrigation and Frost Protection in the United States

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Abstract

Citrus belongs to the *Rutaceae* family, which includes oranges, grapefruit, tangerines, mandarins, tangelos, lemons, and many others like finger lime. The US, primarily Florida and California, produce hybrids citrus. Because of its commercial and trade value, different citrus varieties are produced worldwide, such as in Brazil, China, Mexico, the European Union, Egypt, South Africa, Morocco, Argentina, and Turkey. Production practices differ by continent, country, and state. We studied the economics of Satsuma citrus (*Citrus unshiu*) production using drip irrigation and frost protection to determine the financial viability of the industry adopting drip irrigation technology and a sensitivity risk-rated enterprise budget model. We show that the expected net return obtained 50% of the time was $980 per acre. Further, growers could occasionally obtain a profit of $3,726 in the best-case scenario or 7% of the time and a loss of $1,765 per acre with an expected 70% net returns from Satsuma citrus production in its 6th year. Satsuma citrus production using drip irrigation can be a lucrative, but risky investment. Our analysis can be useful to extension professionals, policymakers, and Satsuma citrus growers in the US.

Keywords: Satsuma citrus; Break-even costs; Harvesting and marketing costs; Return on investment; Asian citrus psyllid

Abbreviations: MT: Metric Tons; HLB: Huanglongbing; ACP: Asian Citrus Psyllid; ROI: Return on Investment; BE: Break-Even; P-VC: Pre-harvest Variable or Operating Costs; H&MC: Harvesting & Marketing Costs; VC: Variable Costs; FC: Fixed Costs; AEWR: Adverse Earning Wage Rate; TP-VC: Total Pre-Variable Costs; TFC: Total Fixed Costs; TVC: Total Variable Cost.

Introduction

Spanish explorers brought Citrus to the United States in 1565, notably at Saint Augustine, Florida [1]. The crop was introduced in Arizona and California by 1707 and 1769, respectively. By the 1890s, it had reached the Gulf of Mexico, North Charleston, South Carolina, and the Gulf states. Unfortunately, the crop could not withstand the extreme freezing weather conditions that prompted the development and dissemination of a cold-tolerant resistant variety in Louisiana, Alabama, and North Florida in the 1940s [1-3]. According to FAO [4], citrus is widely grown worldwide, with about 79% grown in the Northern Hemisphere, projected to produce 28.98 metric tons (MT) in 2023 [5]. The Northern Hemisphere's top producers are those in the Mediterranean Basin, while Brazil topped the global and Southern Hemisphere rankings in 2023 [6].

According to Wu et al. [7], citrus has historically been thought to have originated from Southeast Asia, a region rich in biodiversity with a climate influenced by both the East and South Asian monsoons. Through commerce and migration, particularly during the Roman Empire's rule, the crop spread quickly throughout Europe during the Middle Ages and worldwide [8].

Due to several causes, such as advancements in transportation and packaging, rising affluence, and demand for healthy food, the world's citrus production has been rising dramatically. For instance, The Global Citrus Statistic Report (WCO) [9] reveals that the world's total citrus production in 2020 was 158.5 million metric tons (MMT), of which oranges alone accounted for 76 million metric tons (MMT), equivalent to 52.8%. The WCO Report

further revealed that China, Brazil, India, and Mexico were amongst the top five producing countries in 2021 (Table 1). Furthermore, although 51% of citrus was produced in Asia, 52% of the total export came from the Mediterranean region [4,9].

Table 1: The World Top Citrus Producing Countries, 2022.

	Name of Countries	Quantity (Metric Tons)	Percentage of Total Production
1	China	44,063,061	27.8
2	Brazil	19,652,788	12.4
3	India	14,013,000	8.84
4	Mexico	8,756,488	5.52
5	United States	7,230,854	4.56
6	Spain	6,010,050	3.79
7	Egypt	4,638,980	2.93
8	Turkey	4,301,415	2.71
9	Nigeria	4,160,568	2.62
10	Iran	4,073,067	2.57
11	Argentina	3,469,277	2.19
12	Italy	2,895,940	1.82

Source: FAO [4]; WCO [9]

In addition, citrus imports have been stable and Europe, Britain, Norway, and Switzerland being the major importers while the 2021 highest per capita consumption countries were Scandinavia, France, and Germany. The top-ranking China produced 28.1% of world production equivalent to 44.06 MMT compared to the number 5th ranking USA which produced 7.23 MMT tons in the same period [9].

For the past decade, citrus production in the United States has been declining, and the trees are not being replaced [2,10]. The most prevalent and severe Huanglongbing HLB, also called the greening disease, caused by the Asian citrus psyllid (ACP) has been considered one of the causes of the production decline in Florida and the US in general. The United States produces citrus, which includes oranges, grapefruit, tangerines, mandarins, tangelos, lemons, and their hybrids, in many states, primarily in Florida and California. California, Florida, Texas, and Arizona are the top US-producing states.

For instance, California not only produced 79% of the total production, but they also supply 92% of the country's fresh market. Florida, Texas, and Arizona produce 17%, 4%, and 4% respectively [11-13]. Input prices such as fertilizers, insecticides, and pesticides have increased dramatically, while the producers' price index for fresh fruits has fluctuated and has been challenging to forecast due to the current unpredictability of the global economy and the uncertainty brought on by the Covid-19 outbreak which created farm labor unavailability [11].

Our study assesses the return on investment (ROI) of Satsuma citrus production using frost protection irrigation technology to determine the economic viability of the overall citrus industry. The specific objectives are to:

a. Determine establishment and maintenance costs of a Satsuma citrus field.

b. Determine the sensitivity risk-rated returns over total costs of producing Satsuma citrus, and.

c. Calculate break-even (BE) costs of production.

A recent economic study conducted by Fonsah et al. [10] at the University of Georgia, Tifton, GA, USA, shows that Satsuma citrus yields vary significantly from year to year, and prices vary depending on the quality of the fruits. Singerman et al. [14], who considered the fourth year of production as a full production year, showed that the investment in the new citrus grove was not profitable. More so, Singerman et al. [14] study incorporates the effect of the most severe citrus greening disease infestation also known as Huanglongbing (HLB) disease on the new growers in southwest Florida who were directly affected. In contrast to Singerman et al. [14] study we consider the 6th year as the full production year, a recommendation from the state of Georgia citrus growers and association.

Material and Methods

This study was conducted at the University of Georgia, Coastal Experimental Station, Tifton, Georgia, USA. The study entailed primary data from the growers and secondary data from USDA, FAO, and other scientific and extension publications, respectively [1,4,5,11,12]. We visited Satsuma citrus growers and citrus industry actors in south Georgia to study their agricultural practices, especially the equipment used in production. For additional information and data collection, we organized in-person and telephone interviews with growers and Extension Agents in key Satsuma citrus growing areas in South Georgia, USA.

We collected data on various inputs, land preparation, fertilization, lime, pre- and post-emergent herbicides, fungicides, trees, and tissue and soil analyses following Fonsah et al. [10]. Additional inputs were scouting, labor, fuel, repair, and maintenance. Based on the collected data, we identified pre-harvest variable or operating costs (P-VC), harvesting and marketing costs (H&MC), variable costs (VC), and fixed costs (FC). Variable cost is the sum of pre-harvesting variable (P-VC) plus harvesting and marketing costs (H&MC). We calculated the chances of positive ROI using the costs and returns information. In addition, we derived the break-even point (BE) of producing Satsuma citrus using drip irrigation and a frost protection system. Equation (1) gives the formula to calculate the break-even point as:

$$BE\ \text{point}\left(unit\right) = \frac{FC}{\left(SP - VC\right)} \quad (1)$$

where FC represents fixed costs, SP represents per unit selling price, and VC represents variable costs per unit [15].

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To assess the sensitivity of returns on investment, we calculated risk-rated returns over the total cost of production, adopting a financial management sensitivity analysis approach. To do so, we considered five yields and price scenarios and evaluated the chances of profit (or loss) under each scenario [16-18].

We made several assumptions to assess the economics of Satsuma citrus production using irrigation and frost control technology, which we briefly discuss below. For instance, planting distance and density are essential in good agricultural practices, and they vary from grower to grower due to other factors, such as soil type, climate, weather events, pests, and diseases. We adopted the planting distance of 15 ft x 20 ft, equivalent to 145 plants per acre (Table 2). We used an interest rate of 6.5% annually for long-term loans.

Citrus in general and Satsuma citrus in particular are perennial crops and require at least two years to be established on the field thus requiring major land preparation and maintenance during its first two years. We assumed a citrus field becomes fully productive on and after its 6th year of establishment. Thus, this study estimates the establishment and maintenance costs for the first year, second year and third to fifth year respectively while the 6th is considered full production in this study. The fixed cost (FC) calculation included purchase price, salvage value, the lifespan of the equipment, depreciation, interest rate, taxes, and insurance and was calculated based on five acres because that was the average Satsuma farm size for new entrants [19-21]. Irrigation is an integral part of successful and sustainable Satsuma citrus production. Although several types of irrigation systems are available, this study estimates the costs and returns of citrus production using the drip irrigation system with frost protection measures which require pipe and fittings, tubing, and emitters, a well, pump and motor, and filters.

Table 2: First Year Estimated Establishment and Maintenance Cost Per Acre of Satsuma Citrus Production, 2022.

Pre-Variable Costs	Unit	Quantity	Price	S-Amount[1]
Land prep[2]	Acre	1	525	525
Lime (DOL.)	Ton	1	31.5	31.5
Fertilizer (10-10-10)	Acre	730	0.32	233.6
Herbicides pre-emergent	Acre	2	42	84
Herbicides post-emergent	Acre	2	10.5	21
Insecticides	Acre	4	15.75	63
Fungicides	Acre	0	52.5	0
Trees (15 x 20)	Tree	145	15.75	2283.75
Scouting	Acre	1	78.75	78.75
Tissue analysis	Acre	1	36.75	36.75
Soil analysis	Acre	1	6.3	6.3
Labor	Hrs.	70	10	700
Fuel	Acre	1	31.48	31.48
Repair & Maintenance	Acre	1	38.85	38.85
Irrigation/Frost Protection	Acre	5	222.39	1111.95
Interest on operation	Acre	4133.98	0.065	268.71
Total Pre-Variable Costs (P-VC)	Acre	1	4,989.64	4989.64
Fixed Costs (FC)	**Unit**	**Quantity**	**Price**	**Amount**
Tractor & Equipment	$	554.14	1	554.14
Management Overhead	$	4989.64	0.15	748.45
Irrigation	Acre	1	2,338.85	2,338.85
Total Fixed Costs (TFC)	$	1.00	3,641.43	3,641.43
Total Establishment Costs (TC)				8,631.07

Source: Author's computation, 2024.

[1]There may be rounding errors.

[2]Land prep varies significantly from $0.00 to $1,000 per acre in some cases.

We closely followed Kunwar and Fonsah [18] for the sensitivity risk-rated return analysis where five different yield and price scenarios, i.e., "best," "optimistic," "median" "pessimistic," and "worst" were used to address the five price and yield variation

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among the citrus growers. The "median" is equivalent to the "base" as discussed in Financial Management [22] representing the yields and prices that citrus growers expect to obtain 50% of the time. The best and the optimistic yields and prices are 20% and 10% increase from the "base" or "median" while the worst and the pessimistic yields and prices are 20% and 10% decrease from the "median" respectively. For a comprehensive discussion of this model, see [20,21,23].

The sensitivity risk-rated returns were calculated by assigning probabilities or chances of occurrences of each of the categories. Furthermore, this study assumes that farmers sell 50% of the citrus harvested in the fresh market and 50% as processed; that is, 50/50% fresh and processed markets respectively [24]. The average cull rate was 25%, the price for fresh of $0.60, and $0.25 per pound for processed were obtained from the growers. We used the average price of freshly sold and processed Satsuma citrus. The median price of $0.43 used as median was the average price obtained from both fresh and processed markets adopted to determine the profitability margin [25].

Results and Discussions

Establishment and Maintenance Cost

Sustainable production of perennial crops differs from annual crops as the formers do not need to be planted yearly [26]. As with any other horticultural crop, Satsuma citrus requires inputs such as fertilizers, herbicides, insecticides, fungicides, and irrigation, and their effectiveness is critical to sustainable and prosperous production. Table 1 provides the first-year establishment cost of Satsuma citrus production in our study. The establishment costs or total costs (TC) of $8,631.07 per acre is the sum of total pre-variable costs (TP-VC) plus total fixed costs (TFC). Satsuma citrus planting materials, irrigation, and land preparation costs contribute most to the total pre-variable cost (TP-VC). The total fixed costs (TFC) were estimated at $3,641.43 per acre (Table 2).

Our findings show that the major high-cost components in the consider the 1st year of establishment were land preparation, fertilizers, trees, labor, irritation, and frost protection. For instance, land prep contributed 10.5% of pre-variable cost (TP-VC) which could be more as land prep cost varies significantly from $0.00 to $1,000 per acre depending on where and conditions of the farm to be established. Costs of trees (planting materials) contributed 45.8% of TP-VC which could be more as well depending on the adopted planting distances. Labor costs contributed 14.03% of the TP-VC which could also be significantly higher than the current Adverse Earning Wage Rate (AEWR) or the H-2A labor costs that range from $16.35 to $23.56 per hour across the United States [27]. Our labor cost was $10 because the growers in our study were not participating in the H-2A program. Irrigation and frost protection on the other hand, contributed 22.29% of TP-VC.

We present Satsuma citrus production's year-2 establishment and maintenance costs in Table 3. The inputs required in year-2 are like the first year's. However, there was no land preparation cost in year 2, thus reducing the total establishment cost (TC) to $6,120.25 per acre. The second-year establishment costs are 29.10% less than the year-1 costs. Labor, irrigation, and frost protection are the most expensive inputs in year-1 total establishment and maintenance costs (TC). Note also that labor cost in this study was $10 per hour which is significantly lower than the adverse effects wage rate (AEWR) of $16.35 - $23.56 per hour across the United States [27]. The cost of planting materials or satsuma trees also reduced considerably from year-1 to year-2 because we assumed a replacement of five trees (Table 3).

Table 3: Year-2 Estimated Establishment and Maintenance Cost Per Acre of Satsuma Citrus Production, 2022.

Pre-Variable costs (P-VC)	Unit	Quantity	Price	$-Total[1]
Fertilizer (10-10-10)	Acre	219	0.32	70.08
Micro-nutrient sprays	Acre	1	10.5	10.5
Pre-emergence Herbicides	Acre	2	42	84
Post emergent herbicides	Acre	5	10.5	52.5
Insecticides	Acre	4	15.75	63
Fungicides	Acre	0	52.5	0
Trees replacement (15 x 20)	Tree	5	15.75	78.75
Tissue Analysis	Acre	1	36.75	36.75
Soil Analysis	Acre	1	6.3	6.3
Scouting	Acre	1	78.75	78.75
Labor	Hours	104	10	1,040.00
Fuel	Acre	1	31.47	31.47
Repair & Maintenance	Acre	1	38.85	38.85
Irrigation/Frost Protection	Acre	5	222.39	1,111.95

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Interest on operation	Acre	1,590.95	0.065	103.41
Total Pre-Variable Costs (P-VC)	$	1	2,806.30	2,806.31
Fixed Costs	**Unit**	**Quantity**	**Price**	**$-Total**
Tractor & Equipment	Acre	1	554.14	554.14
General Overhead	Acre	2,806.31	0.15	420.95
Irrigation	Acre	1	2,338.85	2,338.85
Total Fixed Costs (TFC)	$	1	2,228.02	3,313.94
Total Costs (TC)	$	1	5,034.34	6,120.25

Source: Author's computation, 2024.

[1]There may be rounding errors.

Production practices and the total cost (TC) of establishing and maintaining a typical Satsuma citrus field in its 3rd to 5th years are the same (Table 4). The TC of establishment and maintenance from the 3rd to the 5th was $7,394.71 per acre. Similarly, labor, irrigation and frost protection contributed most to the total pre-variable costs (TP-VC) during these years, where the former is estimated at $2,000 per acre and the latter at $1,111.95 per acre (Table 4). As earlier mentioned, labor costs would have been higher if the current H-2A (AEWR) rate had been adopted.

Table 4: Year 3-5 Estimated Establishment and Maintenance Cost Per Acre of Satsuma Citrus Production, 2022.

Pre-Variable Costs (P-VC)	**Units**	**Quantity**	**Price**	**$-Total[1]**
Fertilizer (10-10-10)	Acre	438	0.32	140.16
Micro-nutrient sprays	Acre	2	10.5	21
Pre-emergence Herbicides	Acre	2	42	84
Post emergent herbicides	Acre	5	10.5	52.5
Insecticides	Acre	4	15.75	63
Fungicides	Acre	0	52.5	0
Trees replacement (15 x 20)	Tree	5	15.75	78.75
Tissue Analysis	Acre	1	36.75	36.75
Soil Analysis	Acre	1	6.3	6.3
Scouting	Acre	1	78.75	78.75
Labor	Hour	200	10	2,000.00
Fuel	Acre	1	31.48	31.48
Repair & Maintenance	Acre	1	38.85	38.85
Irrigation/Frost Protection	Acre	5	222.39	1,111.95
Interest on operation	Acre	2,631.54	0.065	171.05
Total Pre-Variable Costs (TP-VC)	Acre	1	3,914.54	3,914.54
Fixed Costs (FC)	**Unit**	**Quantity**	**Price**	**$-Total**
Tractor & Equipment	Acre	1	554.14	554.14
General Overhead	Acre	3914.54	0.15	587.18
Irrigation	Acre	1	2,338.85	2,338.85
Total Fixed Costs (TFC)	$	1	2,394.26	3,480.17
Total Costs (TC)	$	1	6,308.80	7,394.71

Source: Author's computation, 2024.

[1]There may be rounding errors.

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One of the major challenges in growing citrus and other fruit trees in general is freeze damage [28,29]. With climate change, it has been difficult to forecast temperature accurately, so farmers must bear the severe loss. For instance, the Georgia blueberry and peach industries lost over 50% of their crops to frost damage in 2017 [29] and in the past two consecutive years. South Carolina and Georgia peach production fell by 66% and 78% respectively due to spring freezing temperature [28]. While the US citrus production did not only decrease by 12%, it was also the lowest production in the past half a century at 4.9 MMT [28].

The alarming decline in citrus production is also blamed on the persistent Presence of HLB, also called citrus greening disease, that have taken an unpleasant negative toll on the Florida citrus industry. The overall decline in citrus production is also blamed on Hurricane Irma which touched down in September 2017 and Hurricane Ian in September 2022 [28]. With these perceived potential dangers, citrus growers need to include frost control protection in their agricultural practices even though it is costly. For instance, the total investment for frost protection is $104,200 is calculated based on five acres because it does not make economic sense to invest such a huge amount on one acre. After amortizing the total investment taking into consideration the cost of irrigation inputs, lifespan, depreciation, interest, taxes and insurance, the total annual cost per five acres was $11,694. We divided this amount by five to obtain the total fixed cost (TFC) of $2,33.85 and an operating cost of $222.39 per acre, thus a total cost (TC) of $2,561.25 per acre (Table 5).

Table 5: Annual Investment and Operation Costs of Irrigation and Frost Control System in Satsuma Citrus Production System Calculated based on Five Acres, 2022.

Description	New Cost	Life Span	Depreciation	Interest	Tax & Insurance
Pipe & Fittings	5040	20	252	164	38
Micro Sprinklers system	1470	10	147	48	11
Well (8") (600 Gals/min)	52,500	25	2100	1,706	394
Pump & Motor (3-phase electric hook-up)	16,800	15	1,120	546	546
Check valve	1,050	10	105	68	8
Filter	2,100	5	420	68	68
Meter base	2,205	5	441	72	72
Cut off valve	2,730	5	546	89	89
Water tank	4,305	20	215	140	32
Misc	5,000	5	1,000	163	38
Installation	11,000	20	550	358	83
Total Investment	104,200		6,896	3,421	1,377
Total Annual Fixed Costs					$11,694
Annual Fixed Costs per Acre					$2,338.85
Operating Costs					
Motor Size (HP)			8		
Repairs			207		
Annual Pumping Hours			1,820		
Electricity					
Demand (standby charge) per Year			90		
Rate $ per KWH			0.08		
Annual Energy Cost			905		
Annual Energy Cost per Acre					181
Operating Cost Per Acre per Year					$222.40
Total Annual Costs Per Acre[1]					$2,561.25

Source: Author's computation, 2024.

[1]There may be rounding errors.

The yield and price data were obtained from primary data. In order words, this data was the average of the information gathered from the Satsuma citrus growers and Extension Agents interviewed. The "Best", "Optimistic", "Pessimistic" and "Worst" case scenarios were determined by the researchers. After obtaining the average "Median" or "Base" yield and price from the Satsuma citrus actors, we determined the "Pessimistic" and "Worst" as 10% and 20% decrease from the "Base" or "Median". Similarly, we assumed the "Optimistic" and "Best" yields and prices of 10% and 20% increase in yields and price respectively (Table 6).

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Table 6: Sensitivity Yield and Price of Producing Satsuma Citrus in the 6th Years, 2022[1]

Items	Best	Optimistic	Median	Pessimistic	Worst
Yield (lbs.)	42,000	38,500	35,000	31,500	28,000
Price per lb.	0.52	0.47	0.43	0.39	0.34

Source: Author's computation, 2024.

[1]There may be rounding errors.

Table 7: Sixth Year Estimated Cost of Producing Satsuma Citrus at 50/50 Fresh and Processed Markets, 2022.

Pre-Variable Costs (P-VC)	Unit	Quantity	Price	$-Amt/Ac[1]
Fertilizer (10-10-10)	Acre	1,000.00	0.32	320
Micro-nutrient sprays	Acre	2	10.5	21
Pre-emergence Herbicides	Acre	2	42	84
Post emergent herbicides	Acre	5	10.5	52.5
Insecticides	Acre	5	15.75	78.75
Fungicides	Acre	2	52.5	105
Trees replacement (15 x 20)	Tree	5	15.75	78.75
Tissue Analysis	Acre	1	36.75	36.75
Soil Analysis	Acre	1	6.3	6.3
Scouting	Acre	1	78.75	78.75
Labor	Hours	200	10	2,000.00
Fuel	Acre	1	31.48	31.48
Repair & Maintenance	Acre	1	38.85	38.85
Irrigation/Frost Protection	Acre	1	222.4	222.4
Interest on operation	$	3,154.53	0.065	205.04
Total Pre-Variable Costs (P-VC)	Acre	1.00	3,359.57	3,359.57
Harvesting & Marketing Costs (H&MC)	**Unit**	**Quantity**	**Price**	**$Amt/ac**
Harvesting & hauling	Acre	26,250.00	0.16	4,121.25
Packing & cooling	Acre	26,250.00	0.01	262.5
Total Harvesting & Marketing Costs (TM&HC)	$	1	4,383.75	4,383.75
Total Variable Costs (TVC)	$	1	7,743.32	7,743.32
Fixed Costs (FC)	**Unit**	**Quant.**	**Price**	**$Amt/Ac**
Tractor & Equipment	Acre	1	554.14	554.14
Irrigation	Acre	1	2,338.85	2,338.85
Recaptured Establishment Costs	Acre	1	1,504.02	1,504.02
Overhead and Management	Acre	3,360	0.15	503.94
Total Fixed Costs (TFC)	Acre	1	4,900.95	4,900.95
Total Costs (TC)	Acre	1	12,644.27	12,644.27

Source: Author's computation, 2024.

[1]There may be rounding errors.

In this study, the sixth year is considered full production. The most high-cost components are fertilizer and micro-nutrient spray, ($341), fungicide ($105), and labor ($2,000) respectively. Our labor cost of $10 is because the growers in our study were not part of the H-2A (AEWR) wage rate program discussed earlier (Table 7).

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What distinguishes the 6th from the previous establishment years is the harvesting and marketing costs (H&MC). Harvesting and hauling cost is $4,121.25 per acre obtained by multiplying the quantity of 26,250 lbs. by $0.16 hauling price per lb. The quantity 26,250 lbs. per acre is obtained by deducting 25% cull. After adding packing and cooling fees of $262.50, the total harvesting and marketing cost (TH&MC) is $4,383.75 per acre. The total variable cost (TVC) which is the sum of P-VC of $3,359.57 plus TH&MC of $4,383.75 equal $7,743.32 (Table 7).

On the other hand, irrigation cost was $2,338.85 while recaptured establishment costs of $1,504.02 were the high-costs items respectively. Overhead and management cost was 15% of pre-variable costs (P-VC), while the total fixed cost (TFC) was $4,900.95 per acre. Total cost (TC) of production of $12,644.27 per acre is the summation of total variable cost (TVC) and total fixed cost (TFC) (Table 7).

Sensitivity risk-rated returns over total costs

Table 8 shows the sensitivity risk-rated returns over the total costs of producing Satsuma citrus using drip irrigation and frost protection technologies. The sensitivity risk-rated returns analysis is based on the five yield and price scenarios presented (Table 8). The estimated average citrus marketable yield from a fully productive sixth year of production obtained from sampled growers was 35,000 lbs. which is the most likely base yield. The most likely price is $0.43 per pound of citrus during our study period in 2022 was the average price of citrus sold fresh ($0.60 per lb.) and processed ($0.25 per lb.).

Table 8: Sensitivity Risk-Rated Returns of Producing Satsuma Citrus over Total Costs, 2022.

Description	Best	Optimistic		Expected	Pessimistic		Worst
Returns ($)[1]	5,151	4,236	3,321	2,406	1,491	575	-340
Chances (%)[2]	7%	16%	31%	50%			
Chances (%)[3]				50%	31%	16%	7%
Chances for Profit =		91%	Base Budgeted Net Revenue ($) =				$2,406

Source: Author's computation, 2024.

[1]Net return level (Top row).

[2]The chance to obtain this level or more (Middle row).

[3]The chance to obtain this level or more (Bottom row).

In the best-case scenario, the chance of getting $5,151 per acre in a full production year is 7%, while in the worst-case scenario, there is a 7% chance of losing $340 or less per acre. In the optimistic scenario, there is a 31% chance of gaining $3,321 or more per acre. The table shows that growers can still get a positive net return of $1,491 in the pessimistic scenario, where the chance is 31% of the time. Finally, we observed a 91% chance of positive net returns in a full productive year from Satsuma citrus production using irrigation and frost protection technologies with a net return of $2,406 (Table 8).

Break-Even Analysis

Table 9: Break-Even (BE) Costs of Producing Satsuma Citrus, 2022.

Description	Amount
BE pre-harvest variable cost (TP-VC) per lb.	$0.10
BE harvest & marketing cost (TH&MC) per lb.	$0.13
BE fixed costs (FC) per lb.	$0.14
BE Yields per Acre.	29,405 lbs.
BE Total cost (TC) per acre	$0.36

Source: Author's computation, 2024.

Break-even (BE) analysis is useful in economics, business, and accounting in determining profitability margins for a business enterprise. BE is the point where the business enterprise is neither gaining nor losing money. It is the equilibrium point where the total cost equals the total revenue. For instance, the BE total cost per acre is $0.36, which is the unit cost divided by the medium yield. Therefore, if a Satsuma citrus enterprise' BE total cost (TC) is more than $0.36 per acre, it will receive a negative investment return, and the reverse is true as well. Similarly, any yields less than the BE yield of 29,405 lbs. per acre would translate to negative net returns and vice versa (Table 9).

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Total Annual Fixed Machinery Costs Analysis

The estimated fixed machinery costs analysis was based on five acres because that was the average farm size for Satsuma citrus growers. Some of the fixed costs items included a tractor, herbicide strip sprayer, bush hog mower, dump wagon, and truck. We also assumed 33% of the use of these equipment because most farmers grow at least three crops on average per season. Even Satsuma growers in the state of Georgia, USA, cultivate other types of citruses at every given time (Table 10). Although the total investment is $73,815, the total fixed cost per five acres per year which is the average farm size is $2,771 while to total fixed cost (TFC) per acre is $554.14 after dividing by five (Table 10).

Table 10: Estimated Total Annual Fixed Machinery Costs for Satsuma Citrus. Calculation is based on 5 Acres, 2022[1].

Description	% Use for Crop	Purchase Price	Salvage Value	Life Span	Depreciation	Interest	Tax & Insurance	FC/ Acre
Herbicide strip Sprayer	33%	315	63	10	8	4	1	2.65
Bess Sprayer	33%	15,750	3,150	10	416	203	44	132.43
Bush Hog Mower (20')	33%	4,200	840	10	111	54	12	35.32
Dump wagon	33%	2,100	420	10	55	27	6	17.66
Tractor 5095M (hp 80)	33%	25,200	5,040	20	333	324	70	145.36
Truck (1/2 ton)	33%	25,200	5,040	10	665	324	70	211.89
Grinder (hand tools etc.)	33%	1,050	210	10	27.72	13.51	2.91	8.83
Total Investment		$73,815	14,763		1,616	950	205	554
Total Fixed Costs Per 5 Acres		$2,771						
Total Fixed Costs Per Acre		$554.14						

Source: Author's computation, 2024.

[1]There may be rounding errors.

Conclusion

An economic analysis was conducted to assess the returns on investment (ROI) and break-even points of producing Satsuma citrus using drip irrigation and frost protection technologies. Satsuma citrus yield, input and output quantities, and price data were obtained from primary and secondary sources for the analysis. The estimated average Satsuma citrus marketable yields from a fully productive citrus farm were 35,000 lbs per acre. We defined five different price and yield scenarios using the base yield and price for sensitivity risk-rated returns over total cost analysis. Our results depicted that although the expected net return was $2,406 per acre, growers could obtain as high as $5,151 per acre under the best price and yield scenario. They could lose up to $340 per acre under the worst scenario [30].

Our analysis is limited in that we considered only five price and yield scenarios from twenty-five possibilities for the simple purpose of the analysis. Considering all the possible combinations of price and yield scenarios can give the detailed distribution of net returns, which we plan to incorporate in the future extension of this analysis.

Satsuma citrus production using irrigation and frost protection technologies entails enormous capital investment for at least six years when a positive ROI can be obtained. Positive ROI depends on several factors, including adopted agricultural practices, yields, the price received for produce, overall cosmetic quality appearance of the fruits, and target market and percentage of fresh citrus sold compared to processed. With price volatility, growers should aim to increase the percentage destined for the fresh market, which commands a premium price. It is also essential for growers to adopt good agricultural practices that would increase the quality of the product and eventually increase the percentage of fruits for the fresh market. This study adopted 50/50% fresh and processed fruit markets and still obtained profit. Adopting good agricultural practices could significantly reduce the average 25% cull, thus significantly increasing profitability. With continuous research funding, the greening disease also called Huanglongbing (HLB) disease which continues to affect productivity may be reduced, thus rendering the southeast United States citrus industry sustainable. With disease pressure, price fluctuation, and massive capital investment, Satsuma citrus production is a risky business, however, with the potential to provide huge returns.

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References

1. Krewer GW, Powell AA, Westerfield R (2015) Citrus Fruits for Southern and Coastal Georgia. UGA Cooperative Extension Bulletin 804: 1-12.
2. Andersen PC, Ferguson JJ (1996) The Satsuma Mandarin. Gainesville, FL: University of Florida, IFAS Extension, #HS195.
3. Mahr AP (2018) Simulated net income for Georgia grown satsuma mandarins, MS dissertation, University of Georgia, Department of Agricultural and Applied Economics, Athens, GA.
4. FAO (2020) Citrus Fruit Fresh and Processed Statistical Bulletin 2020.
5. World Citrus Organization (WCO) (2023) Northern Hemisphere Citrus Production to Rise.
6. World Citrus Organization (WCO) (2024) Forecast for Southern Hemisphere Citrus Production.
7. Wu GA, Terol J, Ibanez V, López-García A, Pérez-Román E, et al. (2018) Genomics of the origin and evolution of Citrus. Nature 554(7692): 311-316.
8. Webber HJ, Reuther W, Lawton HW (1967) History and Development of the Citrus Industry. In History, world distribution, botany, and varieties. Essay, University of California.
9. World Citrus Organization (WCO) (2022) Global Citrus Statistics Released.
10. Fonsah EG, Price J, Cantrell B (2020) Economic Analysis of Producing Satsuma Citrus in Georgia Using an Enterprise Budget. J Food Distribution Res 51(1): 43-49.
11. Kramer J, Simnitt S, Calvin L (2021) Fruit and Tree Nuts Outlook, FTS-372, USDA, Economic Research Service.
12. USDA (2022) Citrus: World Markets and Trade. Foreign Agricultural Service.
13. Munch D (2023) US. Citrus Production - An Uphill Battle to Survive. Market Intel.
14. Singerman A, Burani-Arouca M, Futch SH (2019) The Economics of Planting New Citrus Groves in Florida in the Era of HLB. University of Florida. Publication #FE1050.
15. Hayes A (2023) Break-Even Analysis: Formula and Calculation. Investopedia.
16. Fonsah EG, Hudgins JE (2007) Financial and Economic Analysis of Producing Commercial Tomatoes for Fresh Market in Georgia. J ASFMRA pp. 147-154.
17. Fonsah EG, Chen Y, Diffie S, Srinivasan R, Riley D (2018) Economic productivity and profitability analysis for whiteflies and Tomato yellow leaf curl virus (TYLCV) management options. J Agric Environ Sci 7: 1-9.
18. Kunwar SR, Fonsah EG (2022) Economic Analysis of Southern Highbush Blueberry Production Using Drip Irrigation and Frost Protection in Georgia, USA. J Extension 60(1): 11.
19. Fonsah EG, Ferrer MC, Escalante C, Culpepper S (2012) Financial Analysis of Methyl Bromide and Mulch Alternatives for Bell Pepper in Georgia. UGA Cooperative Extension Bulletin pp. 1411.
20. Fonsah EG, Krewer G, Harrison K, Bruorton M (2007) Risk-rated economic return analysis for southern highbush blueberries in soil in Georgia. HortTechnology 17(4): 571-579.
21. Fonsah EG, Krewer G, Harrison K, Stanaland D (2008) Economic returns using risk-rated budget analysis for rabbiteye blueberry in Georgia. HortTechnology 18(3): 506-515.
22. Brigham EF (1982) Financial management theory and practice (3rd edn). Dryden Press, New York.
23. Fonsah EG, Kunwar SR, Diaz-Perez CJ (2023) Economic evaluation of bell pepper production under colored shade nets system in the southeast region of the USA. Afr J Agri Econom Rural Dev (JAERD) 11(1): 1-7.
24. USDA, Economic Research Service (2022) Fruit and Tree Nuts Outlook, FTS-375 p. 13.
25. Fonsah EG, Price J, Cantrell B (2022) 50/50 - Year-6+ Satsuma Citrus Budget. University of Georgia, Department of Agricultural & Applied Economics.
26. Kreitzman M, Toensmeier E, Chan K, Smukler S, Ramankutty N (2020) Perennial staple crops: yields, distribution, and nutrition in the global food system. Front Sustainable Food Systems 4: 216.
27. Rosasco Law Group (2024) H2A Wage Rate.
28. USDA, Economic Research Service (2023) Fruit and Tree Nuts Outlook, FTS-377 p. 10-16.
29. Fonsah EG (2018) Fruit and Nuts In: 2018 Georgia Ag-Forecast. Farm to Port: Maximizing the global impact of Georgia agriculture, Department of Agriculture and Applied Economics, College of Agriculture and Environmental Sciences, University of Georgia, pp. 23-24.
30. Fonsah EG, Dawson J, Price J, Cantrell B (2023) 50/50 6th Year+ Satsuma Citrus Budget. University of Georgia, Department of Agriculture & Applied Economics.

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