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AN ECONOMIC COMPARISON OF VEGETABLE IRRIGATION SYSTEMS[1]

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Abstract. **Seepage (modified furrow), subsurface tile, trickle, walking gun, and center pivot irrigation systems were evaluated to determine comparative irrigation costs (both variable and fixed) for commercial vegetable production. A sensitivity analysis based on water use and crop production (yield) was also evaluated to determine cost per unit relationships. The investment costs of the center pivot, subsurface tile and trickle irrigation systems were significantly larger than the capital requirements for the seepage and walking gun irrigation systems. The variable costs for the subsurface tile and trickle irrigation systems were less than the other systems primarily due to the lower volume of water used by these systems. Substantial variability was observed among irrigation systems for irrigation cost per unit produced, cost per irrigated acre and cost per acre inch of irrigation resulting from various levels of crop production and water use.**

Vegetable production is an important segment of the Florida agricultural economy. Florida vegetable growers harvested greater than 5.7 billion lb. of vegetable products on slightly more than 400,000 acres during the 1982-83 crop year. The farm value of these vegetables accounted for approximately $1.1 billion of Florida's agricultural income (1). A large portion of this production and income, however, would not have been realized without the aid of irrigation.

Irrigation water is an essential production input for a large majority of vegetable growers to achieve adequate yields and suitable crop quality (5, 6). Because of the importance and contribution of irrigation to vegetable production, any major adjustment in irrigation practices could have a large impact on vegetable growers and the Florida agricultural economy.

Recent increases in the investment cost of vegetable irrigation systems coupled with higher interest rates and energy costs have stimulated many vegetable growers to consider alternate irrigation systems for new installations and the replacement of traditional irrigation systems as they either wear out or become cost prohibitive. The consideration of alternate systems requires a comprehensive economic evaluation of the possible irrigation systems.

The objectives of this study were to compare the investment costs and annual variable and fixed costs of five hypothetical vegetable irrigation systems. These systems were designed to grow tomatoes and to evaluate the cost sensitivity of pumping, level of water use and yield per cropped acre. The results should provide information that describes the potential economic advantages and disadvantages of each system to aid producers in deciding which system best complements their production setting.

Methods and Procedures

A cost analysis was performed to compare the investment, annual fixed and variable costs of five vegetable irrigation systems used to grow tomatoes. The cost analysis was based on the installation, operation, maintenance and economic life of the irrigation systems. The 5 irrigation systems included seepage, subsurface tile, travelling gun, center pivot, and trickle. Each system was designed to irrigate 160 acres.

Numerous individuals such as growers, irrigation pipe and pump suppliers, well drillers, researchers, and others who specialize in designing and installing irrigation systems provided information to design the irrigation systems. In addition, several industry representatives, area irrigation dealers and pipe distributors contributed cost data.

Irrigation costs. Costs were designated as either annual fixed (ownership) or variable (operating) costs, which when summed result in the annual total cost of the irrigation system (4). Fixed costs are unrelated to output and do not vary during the production period. The fixed costs include annual expenditures for depreciation, insurance, repairs, taxes, and interest. Variable costs describe those costs that vary during the production period and with output. These costs are related to the price and quantity of inputs used such as fuel, lubricants, electricity and labor.

The fixed costs of depreciation, insurance, repairs, taxes and interest were calculated for each irrigation system to determine the annual fixed costs of the irrigation systems. Depreciation simply allocates the loss in value over the life of the irrigation system to particular time periods. Annual depreciation, investment cost minus salvage value divided by the assets' useful life, was calculated with a straight-line depreciation schedule. Insurance, repairs, and taxes were individually estimated as a percentage (%) or flat rate of the investment costs for the system, well, pump and power unit of each irrigation system (see Table 1). Interest on investment was calculated at 14% of the average of investment cost and salvage value for each system, well, pump and power unit.

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Table 1. Investment and resource data for 5 vegetable irrigation systems.

Item	Seepage	Subsurface tile	Travelling gun	Center pivot	Trickle
System investment ($)	18,000	167,200	48,000	72,000	136,900
Economic life (yr)	15	15	15	15	10
Well investment ($)	13,200	9,075	9,075	9,075	9,075
Economic life (yr)	20	20	20	20	20
Pump investment ($)	9,350	8,100	8,100	9,350	6,800
Economic life (yr)	20	20	20	20	20
Power unit investment ($)	10,780	8,500	8,500	9,800	7,200
Economic life (yr)	10	10	10	10	10
System: Repairs (% of new costs)	1	1	2	2	2
Taxes (millage-ex. 14 mills)	14	14	14	14	14
Insurance ($/$1,000 new cost)	10	10	10	10	10
Pump: Repairs (% of new costs)	1	1	1	1	1
Taxes (millage-ex. 14 mills)	14	14	14	14	14
Insurance ($/$1,000 new cost)	10	10	10	10	10
Power unit: Repairs (% of new costs)	1	1	1	1	1
Taxes (millage-ex. 14 mills)	14	14	14	14	14
Insurance ($/$1,000 new cost)	10	10	10	10	10
Irrigation water use/crop (acre-inches)	55	40	36	36	30
Pumping cost ($/acre-inch)	1	0.9	6	4	.75
Labor requirements (man-hr/acre-inch)	0.04	0.08	0.04	0.05	0.15
Acres irrigated	160	160	160	160	160
Cropped acres	100	100	100	100	100
Yield per cropped acre (units)	1,000	1,000	1,000	1,000	1,000
Long term interest rate (%)	14	14	14	14	14
Labor ($/hr)	4	4	4	4	4

Variable costs were calculated from operation and maintenance specifications and production requirements (2, 3). The pumping variable costs were estimated on a dollar per acre-inch basis for each irrigation system. Labor costs were estimated for each system from time requirement information furnished by growers and researchers.

Resource data. A 160-gross acre site was proposed for each irrigation system. The cropped acreage was assumed to be 62.5% (100 acres) of the total acreage. Tomato yields were assumed to be 1,000 boxes per cropped acre for each irrigation system. Irrigation water to produce a tomato crop was assumed to be 55, 40, 36, 36 and 30 inches per acre for seepage, subsurface tile, travelling gun, center pivot and trickle irrigation systems, respectively. These estimates of yield and level of water use to produce a tomato crop were used in the absence of comparative research data or grower experience.

Results and Discussion

Initial investment costs and annual fixed costs for the 5 irrigation systems are shown in Table 2. The trickle and subsurface tile irrigation systems were the most expensive with annual fixed costs amounting to $33,029 and $32,733, respectively, while the seepage irrigation system had the lowest annual fixed cost at $8,479.82. Annual depreciation and interest on investment represented the major expenses for annual fixed costs.

Annual variable cost is the sum of labor and pumping costs, as presented in Table 3. The highest annual variable cost was the travelling gun irrigation system ($35,481.60) followed by the center pivot system ($24,192.00). The annual variable cost of the trickle irrigation system was the lowest at $5,130. Pumping cost and quantity of water use contributed significantly to the annual variable cost for each system except the trickle irrigation system. The trickle system required a lesser quantity of water to produce a crop with relatively lower pumping cost per acre-inch. Labor cost represented slightly more than half of the annual variable cost for only the trickle irrigation system, while labor costs for the other irrigation systems were much smaller.

Annual total cost is the sum of fixed and variable costs, as shown in Table 4. The seepage irrigation system revealed annual total cost of less than one-half of the other irrigation

Table 2. Annual fixed costs of 5 vegetable irrigation systems.

Item	Seepage	Subsurface tile	Travelling gun	Center pivot	Trickle
Initial investment[z]	51,330.00	192,875.00	73,675.00	100,225.00	159,975.00
Investment cost/acre	320.81	1,205.47	460.47	626.41	999.84
System depreciation	1,200.00	11,146.67	3,200.00	4,800.00	13,690.00
Well depreciation	660.00	453.75	453.75	453.75	453.75
Pump depreciation	467.50	405.00	405.00	467.50	340.00
Power unit depreciation	1,078.00	850.00	850.00	980.00	720.00
Annual depreciation[y]	3,405.50	12,855.42	4,908.75	6,701.25	15,203.75
Interest on investment[x]	3,593.00	13,501.00	5,157.00	7,016.00	11,198.00
Other fixed costs[w]	1,481.22	6,376.25	2,514.45	3,946.15	6,626.65
Annual fixed cost[v]	8,479.82	32,733.00	12,580.00	17,663.00	33,029.00
Annual fixed cost/acre	53.00	204.58	78.63	110.39	206.43
Annual fixed cost/cropped acre	84.80	327.33	125.80	176.80	330.29

[z]Initial investment includes the capital cost of the system, well, pump and power unit for each irrigation system.
[y]Annual depreciation is the sum total of system, well, pump and power unit depreciation schedule.
[x]Interest on investment is the total interest expense for the initial investment of each irrigation system.
[w]Other fixed costs include insurance, repairs and tax expenditures described in Table 1.
[v]Annual fixed costs is the sum total of annual depreciation, interest on investment and other fixed costs.

Table 3. Annual variable costs of 5 vegetable irrigation systems.

Item	Seepage	Subsurface tile	Travelling gun	Center pivot	Trickle
Water use (acre-inches)[z]	55.00	40.00	36.00	36.00	30.00
Labor	1,408.00	2,048.00	921.60	1,152.00	2,880.00
Pumping	8,800.00	5,760.00	34,560.00	23,040.00	2,250.00
Annual variable cost[y]	10,208.00	7,808.00	35,481.60	24,192.00	5,130.00
Annual variable cost/acre	63.80	48.80	221.76	151.20	32.06
Annual variable cost/cropped acre	102.08	78.08	354.82	241.92	51.30

[z]Water use was assumed to be applied at the indicated rate per season on the entire acreage for each irrigation system except the trickle irrigation system which was assumed to use the indicated rate per season only on the number of cropped acres.
[y]Annual variable cost includes labor and pumping costs.

Table 4. Annual fixed and variable costs of 5 vegetable irrigation systems assuming, one crop per year.

Item	Seepage	Subsurface tile	Travelling gun	Center pivot	Trickle
Fixed cost	8,480.00	32,733.00	12,580.00	17,663.00	33,029.00
Variable cost	10,208.00	7,808.00	35,481.60	24,192.00	5,130.00
Annual total cost[z]	18,688.00	40,541.00	48,062.00	41,855.00	38,159.00
Annual total cost/acre	116.80	253.38	300.39	261.59	238.49
Annual total cost/cropped acre	186.88	405.41	480.62	418.55	381.59
Annual total cost/acre-inch	2.12	6.33	8.34	7.27	7.95
Annual total cost/unit of yield	0.19	0.41	0.48	0.42	0.38

[z]Annual total cost is the sum of fixed and variable costs.

systems. The irrigation system with the highest annual total cost was the travelling gun. Minor percentage changes in pumping cost, level of water use and yield, however, could dramatically change the annual total cost of these irrigation systems.

The seepage irrigation system is presently the most economical system for vegetable growers to use depending on their production conditions. This system has the lowest annual total cost per irrigated acre, per acre-inch of water use and per unit of yield. Growers contemplating installing new irrigation systems or replacing existing systems should consider the annual total cost relationships of the systems. However, when conditions allow lower investment costs, lower pumping costs, lower levels of water use, increased cropped acres per given site and/or increased yields, other irrigation systems may become more economical. In addition, this analysis does not account for improvements in product size, consistency and quality. If a given irrigation system could contribute one or more of these factors, it could prove to be a profitable investment.

Furthermore, if irrigation water in the future should become limited and/or regulated, the low-volume irrigation systems could easily be cost competitive with the other irrigation systems or they may become the only feasible alternatives if normal crop yields cannot be maintained. Cost comparisons associated with limited water use should include the evaluation of the cost per irrigated acre, cost per acre-inch and cost per unit of yield. The same cost relationships do not remain consistent among irrigation systems when yields and pumping costs are significantly changed. For instance, if yields for a particular system were 25% higher than another system which incurred 150% increase in pumping cost, as was realized during the last decade, the higher yielding irrigation system could prove to be more economical.

This paper addresses the economics associated with vegetable irrigation system selection. Other factors such as overall management, trained personnel, water source and quality, pest and disease control, land preparation, plant establishment, and others must also be taken into consideration when selecting a vegetable irrigation system.

Based on the results of this study, growers will select those irrigation systems that complement their production setting and produce favorable returns over costs. Vegetable growers that evaluate the fixed, variable and annual total cost per cropped acre, acre-inch of water use and unit of yield will likely plan more economical irrigation systems.

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