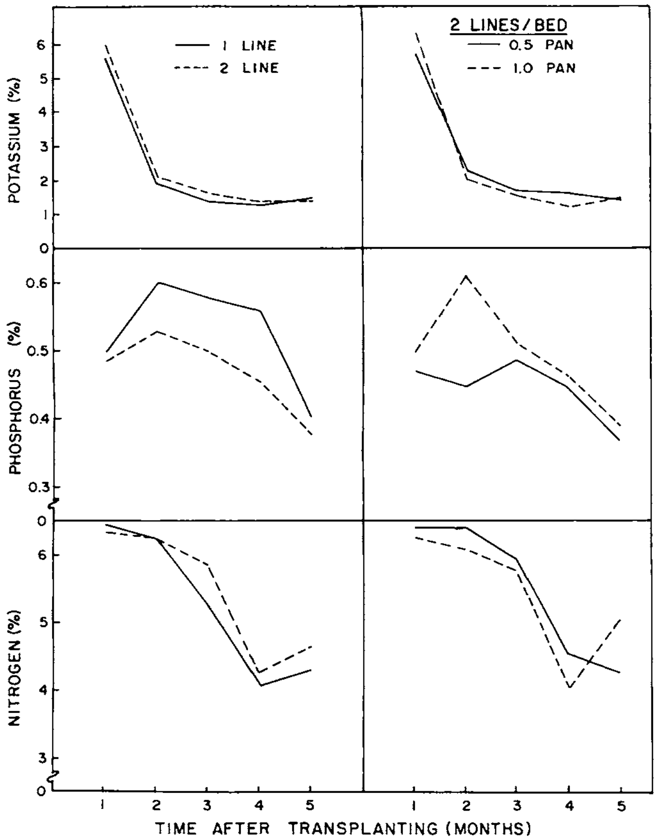

Fig. 2. Effect of number of drip lines/bed (1 or 2/bed) shown on the left and the quantity of water applied with 2 drip lines/bed (on right) on tomato leaf tissue N, P, and K concentration 1978-79.

that the rate of emitter discharge influences water and nutrient flow patterns. However, results from this study indicate that emitter discharge rates of 0.5, 1.0 and 2 gal/hr provided adequate water and nutrient distribution for greenhouse tomatoes to obtain similar plant growth and production parameters. Some effects were noted on movements of nutrients in the soil.

The water quantity associated with the highest yield in both seasons was 1.0-pan. With 1 drip line/bed, tomato production was similar with 0.5 and 1.0 pan. However, with 2 drip lines/bed, yields were significantly greater with 1.0-pan than the 0.5-pan treatment. This indicates that the larger volume of water applied between the plants was more effective in reducing water stress than a smaller amount of water applied near each plant.

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AN ECONOMIC EVALUATION OF THREE IRRIGATION SYSTEMS FOR TOMATO PRODUCTION[1]

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Additional index words. investment costs, variable costs, fixed costs, replacement decision, seepage, subsurface drain, trickle.

Abstract. **Three hypothetical irrigation systems, seepage (modified furrow), subsurface drain, and trickle, were evaluated for soils with naturally high water tables to determine comparative irrigation costs for tomato production. Variable (operating) and fixed (ownership) costs were estimated for each irrigation system. The investment costs of the subsurface drain and trickle systems were significantly larger than the capital requirements for the seepage irrigation system. The variable costs, however, for subsurface drain and trickle systems were less than the seepage system due to the lower volume of water used by these systems. The seepage irrigation system was determined to be the most economical tomato irrigation system under present conditions.**

Increasing demand for water and higher energy costs have prompted many tomato producers to seek irrigation systems that more efficiently distribute and utilize water. Recently much interest has been generated in tomato irrigation systems that supply low volumes of water to designated areas for plant use. The use of these low volume systems would substantially reduce total water use and energy costs incurred in pumping water [1, 6].

The decision to invest in a particular irrigation system is based on whether the system is adaptable to the producer's resource situation and if the capital investment is a feasible alternative. These considerations constitute a man-

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agement decision concerned with evaluating alternative irrigation systems with respect to the costs of each system.

The objective of this study was to compare three different tomato irrigation systems based on the costs of owning and operating each system. The results provide information that describes the potential economic advantages and disadvantages of each system to aid producers in deciding which type of system best compliments their production setting.

Analysis

This study evaluates the initial investment, annual fixed, and variable costs per crop of three tomato irrigation systems. The evaluation of each system is based on the installation, operation and maintenance costs with respect to tomato production in Southwest Florida.

The three tomato irrigation systems include seepage, subsurface drain and trickle irrigation. Seepage is the conventional system which uses a high volume of water, while subsurface drain and trickle are low volume irrigation systems.

Description of Irrigation Systems

This study used a hypothetical 40 acre site measuring 1452 feet X 1200 feet. The site was developed for each irrigation system using a double bed culture which included 4800 row feet per acre. The following irrigation systems were designed for the proposed site.

1. *Seepage irrigation*—A sub-irrigation system which maintains the water table at a desired level under the top of the mulched beds. Water is delivered from the well through PVC pipe to open irrigation furrows that run the length of the field. Flow is controlled for each irrigation furrow with a small valve. Irrigation furrows and/or drainage ditches alternate every 18 feet with the two plant beds between them.
2. *Subsurface drain irrigation*—A sub-irrigation system which maintains a constant water table. Water is delivered from the well through a 6-inch PVC pipe to 4-inch perforated drain pipe that is buried at a depth not greater than 24 inches below the top of the mulched beds and run the length of the field. The perforated plastic drain pipe lines are centered on 36-foot intervals with four rows between them.
3. *Trickle irrigation*—A low volume irrigation system that supplies water to a designated site. Water is delivered from the well through lay flat mains to plastic trickle tubes (running the length of the bed) with emitter sites every 12 inches. This system was designed with four subsystems, each regulated independently. Drainage ditches were located every 36 feet with four beds between them.

After collecting the various technical and cost data on the irrigation systems, a total investment cost is calculated for each system. The investment cost for this study should be interpreted as the amount of capital necessary to purchase the asset ready for operation.

Variable and Fixed Costs

In this study, costs were designated as either variable (operating) or fixed (ownership) costs, which when combined sum to the total costs. Variable costs describe those costs that vary with output and during the production period. These costs are related to the price and quantity of such inputs as fuel, oil, lubricants, electricity and labor. Fixed costs are unrelated to output and do not vary during the production period. The fixed costs considered include depreciation, insurance, repairs, taxes and interest [5].

Variable costs in this analysis, were calculated from operation and maintenance specifications and production requirements. The variable costs of fuel, oil and lubricants were estimated from published engineering data [4]. The cost of electricity was estimated from pumping data which accounted for pump size, volts and amps required, efficiency and quantity of water pumped. Labor cost was estimated for each system from time requirement information furnished by researchers.

The fixed costs of depreciation, insurance, repairs, taxes and interest were calculated for each irrigation system to determine the annual fixed (ownership) costs. Depreciation simply allocates the loss in value due to use of an asset 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 estimated at 2% of investment costs for the irrigation systems, while for wells and pumps these were estimated at 1 and 4% of investment costs, respectively. Interest on investment, however, was calculated at 14% of the average of investment cost and salvage value for each system, well and pump.

Variable and fixed costs were summed to determine the total cost of each irrigation system. Variable, fixed and total costs were used to evaluate the decisions of purchasing a new system and replacement of an existing system with a new system.

Purchase or Replace Decision

The purchase and replace decisions in this analysis involve the annual variable and fixed costs of the systems. Other differences, such as production yields, effectiveness, etc., were not included in this evaluation. Therefore, the purchase decision among new systems is simply the system with the lowest total cost (variable plus fixed costs). The replacement decision, however, compares the variable cost of the existing system and the variable and fixed costs of the new system. The conditions under which a new system would be feasible are when the variable costs of the existing system are greater than or equal to the variable and fixed cost of the new system.

Results and Discussion

Water use, initial investment and annual depreciation varied among the irrigation systems, as shown in Table 1. Reports on water application rate for the subsurface drain and trickle were found to utilize approximately 50 and 83% less water than seepage irrigation, respectively [2, 3, 7]. Initial investment, however, for these lower volume systems was much larger due to the permanent pipe and materials

Table 1. Estimated irrigation water, initial investment and annual depreciation of three irrigation systems for spring tomato production.

Item	Seepage	Subsurface drain	Trickle
Irrigation water[z] (inches)	60	30	10
Initial investment[y] (dollars/acre)	79	950	584
Annual depreciation[x] (dollars/acre)	8	96	153

[z]Quantities of irrigation water were estimated for tomato production during the spring season (120 days) [2, 3, 7]. For simplicity, tomato production yields associated with levels of irrigation water applied were not considered in this evaluation.

[y]Initial investment is the amount of capital necessary to purchase the irrigation system. Does not include pump and well investment.

[x]Annual depreciation reflects the decline in value of the irrigation system over time.

Table 2. Well and pump initial investment and annual fixed costs, 1981.

Item	6″ Well: Well	6″ Well: Pump	8″ Well: Well	8″ Well: Pump
Output capacity	300 gpm	300 gpm	500 gpm	gpm
Initial investment	$6,500	$2,600	$10,000	$3,500
Life (years)	15	10	15	10
Salvage value	0	0	0	0
Annual depreciation	433	260	667	350
Interest on investment[z]	455	182	700	245
Other fixed costs[y]	65	104	100	140
Total fixed costs	953	546	1477	755

[z]Interest on investment was calculated at 14% of the average of initial investment and salvage value.
[y]Repairs, taxes, insurance were estimated at 1% of initial investment on wells and 4% of initial investment on pumps.

used to convey the water. Annual depreciation varied in the same manner as initial investment costs.

Associated with each irrigation system was a well and pump. Table 2. describes the initial investment and total fixed costs for the 6″ and 8″ wells and pumps. The 6″ well and pump was used with the trickle and subsurface drain systems, while the 8″ well and pump was used by the seepage irrigation system. The total fixed costs of the 6″ and 8″ well and pump summed to $1499 and $2232, respectively.

The annual fixed costs of the three irrigation systems including the respective well and pump are reported in Table 3. The annual fixed costs of the low volume systems, subsurface drain and trickle, were three times greater than the annual fixed costs of the seepage system. The low volume systems had high initial investment requirements which when coupled with high interest rates (cost of borrowing money) resulted in large annual fixed costs.

Table 3. Annual fixed cost of three tomato irrigation systems for a 40 acre site, 1981.

Item	Seep	Subsurface drain	Trickle
Depreciation	$ 320	$3,840	$6,120
Interest	221	2,660	1,635
Other fixed costs	63	760	467
Well & pump fixed costs[z]	2,232	1,499	1,499
Annual fixed costs	2,836	8,759	9,721
Annual fixed costs/AC	71	219	243

[z]Well and pump fixed costs include a 8″ well and pump for the seepage system and 6″ well and pump for the subsurface drain and trickle irrigation systems.

The variable costs of the three tomato irrigation systems are presented in Table 4. Labor costs to maintain the trickle system are 100% and 400% larger than those required by the seepage and subsurface drain systems, respectively. Electricity costs, however, reflect the lower costs for the systems pumping lower quantities of water. Electricity costs for the subsurface drain and trickle systems are approximately one-half and one-eighth of the costs for the seepage irrigation system. Total variable costs, though, for the subsurface drain and trickle systems are approximately one-half and one-third, respectively, of the total variable costs for the seepage system.

The variable and fixed costs of the three irrigation systems are summed to determine the total costs of each system, as shown in Table 5. The total costs indicate the seepage irrigation system is the least expensive system to own and operate when one crop per year is produced. The

Table 4. Estimated variable costs of three tomato irrigation systems, 1981.

Item	Seep	Subsurface drain	Trickle
Labor[z]	$ 300	$ 150	$ 600
Electricity[y]	2,832	1,437	375
Ditches[x]	229	0	55
Total variable costs	3,361	1,587	1,030
Total variable costs/AC	84	40	26

[z]Labor costs ($5.00/hr) include only the time required to maintain the system.
[y]The cost of electricity was estimated to be $.07/kwh.
[x]The cost to plow the ditches includes fuel, oil, lubricants and labor.

lower volume systems, subsurface drain and trickle, were more costly to own, due to their large capital requirements and the high cost of money (interest), which more than offset their lower operating costs and resulted in larger total costs when compared to the seepage irrigation system.

In the event that the irrigation systems are used for two crops per year the magnitude of the difference in total cost between the systems lessens (Table 5). Nonetheless, the seepage system in this situation is also the least expensive to own and operate. However, the low volume systems increase in competitiveness as use of the systems are intensified (more water being pumped). In addition, rising energy costs and/or lower interest rates coupled with adequate use could easily make the low volume irrigation systems economically attractive.

Table 5. Estimated total variable and fixed costs of three tomato irrigation systems for a 40 acre site, 1981.

Item	Seep	Subsurface drain	Trickle
	One Crop/Year		
Variable cost	$3,361	$ 1,587	$ 1,030
Fixed cost	2,836	8,759	9,721
Total cost[z]	6,197	10,346	10,751
Total cost/acre	155	259	269
	Two Crops/Year		
Variable cost	6,722	3,174	2,060
Fixed cost	2,836	8,759	9,721
Total cost[z]	9,258	11,933	11,781
Total cost/acre	116	149	147

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

The purchase decision, based on the results of this analysis, indicate the seepage system is currently the most economical tomato irrigation system. The decision to change from an existing system to a new system is dependent on the variable and fixed costs of the new system and variable costs of the existing system. For example, a grower will not save money by abandoning a seepage system (40 acres) with variable costs of $3,361, assuming fixed costs have been expended, and replacing it with a low volume system that has a total variable and fixed costs of either $10,346 or $10,751.

Growers contemplating installing new tomato irrigation systems or replacing an existing system should evaluate the variable and fixed costs of the systems under comparison. The use of these costs in the evaluation of irrigation systems will certainly aid the producer in making an informed decision.

In the event that a producer was restricted by regulatory agencies to use substantially less water per season, the production of vegetable crops would most likely become unprofitable using seepage irrigation. In this situation, the use of a low volume irrigation system would provide a viable alternative for tomato production. Therefore, producers should thoroughly evaluate their individual situation and potential economic circumstances before committing themselves to any tomato irrigation system.

Traditionally, producers have adopted those irrigation systems that are easily combined in their production system and produce favorable returns over costs. Given the results of this study under the prevailing conditions a producer would not abandon an existing seepage system unless lower interest rates and/or extremely high energy costs are realized.

The use of water for irrigation tomato crops will certainly continue to be a major input in the vegetable production system. Therefore, producers who understand that irrigation is an essential production input requiring management, large capital expenditures and continuous cost evaluations will more likely plan an economical irrigation system.

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BLACK BEAN PRODUCTION POTENTIAL IN SOUTH FLORIDA[1]

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Abstract. **A large market for black bean (**Phaseolus vulgaris **L.) exists in south Florida. This is primarily due to an increased population of Latins in the region. Black beans are currently being shipped from New York to meet Florida's increasing demands. The purpose of this investigation was to measure the production of several black bean genotypes grown under south Florida's environmental conditions. Genotypes were evaluated for seed yield and growth characteristics during several seasons at the ARC, Fort Pierce and AREC, Homestead. Seed yields ranged from 433 to 1,389 kg/ha at Fort Pierce and 976 to 2,914 kg/ha at Homestead. No statistical differences in seed yield occurred among genotypes except for the fall 1977 planting at Homestead and the F_8 (Tui x Guali) trial during spring 1981 at Fort Pierce. In two trials at Homestead, four rows/bed had significantly higher seed yield than with two rows/bed. 'Arbolito', 70002, and 70003 were significantly more lodging resistant than 'Black Turtle Soup' or 'Strain 39' in two trials at Fort Pierce.**

Results suggest that black beans can be grown in south Florida, with optimum seed production on four rows/bed. Our seed yields were comparable to those obtained in New York State.

New kinds of vegetables could provide a viable and economically profitable alternative to south Florida's vegetable growers. This would result in a more diverse vegetable industry in south Florida. Prior to large-scale plantings, suitable cultivars, planting and harvesting dates, cultural practices, and pest management programs must be determined. Adequate local, interstate, or foreign markets, and transportation modes must be established to provide a proper distribution chain. Cost analysis must be made to insure growers an economic profit.

A sizable black bean market has existed for several years in south Florida. This market has increased rapidly over the past several years, primarily due to the large and increasing population of Latins into this region. New York state, a major black bean production area (5), has supplied much of Florida's black bean demands. If Florida's grower can economically produce black beans, a local market in south Florida and foreign markets in Central and South America, and the Caribbean are already established. The purpose of this investigation was to evaluate several black bean genotypes for growth and yield characteristics under south Florida's environmental conditions. In addition, disease resistance was also evaluated at Homestead.

Materials and Methods

Fort Pierce, Florida: Several black bean genotypes were evaluated for yield and growth characteristics during fall 1980 and spring 1981 at the Agricultural Research Center. Dolomite limestone (2.24 mt/ha) was preplant incorporated into an Oldsmar fine sand soil. Raised beds were spaced at 2.1 m centers with a 105 cm width. A fertilizer application

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