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A Comparative cost Analysis of Vegetable Irrigation Systems

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Summary. Three vegetable irrigation systems, semi-closed subirrigation (seepage), fully enclosed subirrigation (seepage), and drip irrigation, were evaluated for use on sandy soils with naturally high water tables to determine comparative irrigation costs for tomato production. Investment, fixed (ownership), and variable (operating) costs were estimated for each irrigation system. The investment costs of the drip irrigation system were significantly greater than those for the semi-closed and fully enclosed irrigation systems. The variable costs, however, for the semi-closed system were considerably less than those for the fully enclosed and drip irrigation systems. The semi-closed irrigation system, therefore, was determined to be the least-cost tomato irrigation system under present fuel cost and nonlimiting water supply conditions.

Irrigation is an essential production input for the majority of Florida vegetable growers to achieve adequate yields and suitable crop quality. A large percentage of vegetable production and farm income would not be realized without the aid of irrigation (Sammis, 1980). Therefore, because of the important contribution of irrigation to vegetable production and farm incomes, any major adjustment in irrigation system design, management practices, or use could have a large impact on vegetable profits.

Irrigation is a major cost component of any vegetable enterprise. Irrigation costs of vegetable crops have increased significantly during the past 3 decades, primarily as a result of rising energy costs, higher interest rates, and inflation. In many areas water has become a limited resource due to increased competition among agricultural and nonagricultural users, thus resulting in tighter restrictions on its use by regulatory agencies.

As a result of recent increases in irrigation costs, limited water supplies, and new vegetable irrigation technology, many vegetable growers are considering alternative irrigation systems for new installations and/or the replacement of traditional irrigation systems as they either wear out or become cost-prohibitive. The selection of a vegetable irrigation system is influenced by economic, biological/physical, and institutional/regulatory considerations.

Specifically, this paper evaluates the economics of owning and operating three different irrigation systems for the production of fresh-market vegetables on sandy soils with naturally high water tables in Florida. While changes in irrigation system design and management may affect crop yields, this analysis assumes that recommended management practices are followed for each system design such that yields would not be affected. This assumption is supported by previous studies comparing yields of drip and subirrigated fresh-market tomatoes in Florida (Pitts et al., 1988; Pitts and Clark, 1990; Clark et al., unpublished data).

Two of the irrigation systems (fully enclosed and drip) have been shown to have higher water application efficiencies than the most common irrigation system (semi-closed). The fully enclosed subirrigation system, which achieves water-table control using drip tubing to apply water instead of lateral ditches (which is the case with semi-closed), was developed to improve water conservation while still using subirrigation. In contrast, drip irrigation is a technologically advanced system that requires a commitment to intense management to achieve a higher level of water conservation (application efficiency) and does not use water-table control.

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Cost analysis

This study evaluated the initial investment, annual fixed costs, and variable costs of three vegetable irrigation systems common to southwestern Florida. The evaluation of these irrigation systems was based on installation, operation, andmaintenance costs with respect to fresh-market tomato production on plastic-mulched raised beds. A hypothetical 100-acre (40.5 ha) site measuring 1320 × 3300 ft (402.4 x 1006.1 m) was used to design the irrigation systems and field layout. Perimeter roads, swale ditches, and the well site were included in the layout. Bed rows were constructed on 6-ft (1.83-m) centers with a 13-ft (3.96-m) spray and harvest aisle every three beds, as shown in Fig. 1. Irrigation/drainage ditches were designed in the spray and harvest aisle and spaced every 25 ft (7.62 m). Disposable drip tubing was selected to be used in the fully enclosed and drip irrigation systems (i.e., variable costs).

Description of irrigation systems

The semi-closedirrigation system uses PVC pipe to deliver irrigation water from the pump to the field lateral ditches. Water is applied into lateral ditches that may be spaced from 20 to 30 ft (6.1 to 9.2 m) apart, which are used to maintain a water table at 16 to 20 inches (40.64 to 50.8 cm) below the soil surface [naturally high water table is at 36 to 48 inches (90 to 120 cm) below soil surface]. Peak daily application amounts average 12,000 to 15,000 gal (45,360 to 56,700 liters)/acre (0.405 ha). Extensive water losses are due to runoff, nonuniformity of application, evaporation, and subsurface runoff, resulting in water application efficiencies of 30% to 70% (Smajstrla et al., 1988).

The fully enclosed irrigation system differs from the semi-closed system in that water is applied in the field by a pressurized plastic drip tube (10 mil, 12-inch emitter spacing) buried from 1 to 16 inches (2.5 to 40.64 cm) below the soil surface (Clark et al., 1990). Drip tubes are spaced 20 to 30 ft (6.1 to 9.2 m) apart and operated to maintain a water table at 16 to 20 inches (40.64 to 50.8 cm) below the soil surface. Peak daily application amounts average 7000 to 9000 gal (26,460 to 34,020 liters)/acre (0.405 ha), depending on field conditions and evaporative demand. Water loss is primarily due to evaporation and subsurface runoff, resulting in a higher application efficiency than the semi-closed irrigation system (Stanley and Clark, unpublished data).

The drip irrigation system uses buried PVC pipes to deliver irrigation water to the field (Clark et al., 1988). In the field, water is distributed to plants via a plastic drip tube (15 mil, 24-inch emitter spacing) placed in each plant bed. Irrigations are scheduled to meet crop water requirements with peak daily application amounts averaging 5000 to 7000 gal (18,900 to 26,460 liters)/acre (0.405 ha).

Investment, fixed, and variable costs

Making the correct irrigation system selection based on costs requires an understanding of how different types of costs affect total irrigation costs. The information needed to develop a cost analysis includes investment, fixed, and variable costs (Osburn and Schneeberger, 1978). Investment cost may be interpreted as the amount of capital necessary to purchase the irrigation system ready for operation. Fixed costs are unrelated to output and do not vary during the production period. The fixed costs considered include depreciation, interest, repairs, taxes, and insurance. Variable costs are those that vary with output during the production period. These costs were determined by the price and quantity of inputs such as fuel, labor, chemicals, drip tube, etc.

The investment costs of the irrigation systems were based on a 100-acre (40.5-ha) site. The basic components of each system included a well, pump, power unit, and distribution system. Agribusiness representatives and university research and extension personnel furnished price and quantity estimates for the design, materials, and installation of the irrigation systems.

The fixed costs of depreciation, interest, repairs, taxes, and insurance were calculated for each irrigation system to determine the annual fixed costs (Osburn and Schneeberger, 1978). The investment cost, salvage value, and useful life (years) of the many different inputs of an irrigation system determine the level of depreciation. Depreciation (a non-cash expense) simply allocated the loss in value over the life of the irrigation system to particular time periods. Annual depreciation was calculated with a straight-line depreciation schedule (investments cost minus salvage value divided by the asset's useful life). Interest costs were calculated at 12% of the average of investment cost and salvage value for each item. Repairs, taxes, and insurance costs were estimated at 4.0%, 1.6%, and 0.6% of the investment costs, respectively.

The variable costs of pumping fuel, labor, drip tubing, and chemicals were calculated from operation and maintenance specifications and production requirements. The pumping variable costs were estimated based on supplying 66, 46, or 24 inches of water for the semi-closed, fully enclosed, and drip irrigation systems, respectively (Harrison and Choate, 1969). Labor costs were estimated for the three irrigation systems from time requirement information furnished by growers and university personnel. Drip tube and chemical treatment costs were obtained form agribusiness representatives. The opportunity cost of operating capital was assumed to be 10% annually for 6 months.

Table 1. ***Investment costs of vegetable irrigation systems, 1991.***[z]

Item	Semi-closed	Fully enclosed	Drip irrigation
Investment costs[y]	$61,820	$65,846	$84,355
Investment costs/acre[x]	$1,005	$1,071	$1,372
Investment costs/TLBF[w]	$138	$148	$189

[z]*The basic components of each irrigation system include a well, pump, power unit, and distribution system. Drip tubing costs were not included in the investment cost estimates since its useful life was consider to be 1 year or less. Drip tubing costs were assumed to be variable costs as shown in Tables 4 and 5.*

[y]*Investment costs of each irrigation system are based on a 100-acre (40.5-ha) site.*

[x]*An acre (0.45 ha) is 7260 linear bed feet (2213 linear bed m).*

[w]*TLBF denotes thousand linear bed ft (304.9 linear bed m).*

Results and discussion

The initial investment costs for the three irrigation systems are shown in Table 1. The drip irrigation system was the most expensive at $84,355 for the 100-acre (40.5-ha) site. The investment costs for the semi-closed and fully enclosed systems were $61,820 and $65,846, respectively. Investment costs per acre (7260 linear bed ft or 2213 linear bed m) and investment costs per thousand linear bed ft (TLBF or 304.9 linear bed m) also are provided in Table 1.

The annual fixed costs of the three irrigation systems are reported in Table 2. The drip irrigation system had the highest annual fixed costs ($15,926), while fixed costs for the semi-closed and fully enclosed systems were $11,257 and $12,117, respectively.

The variable costs of the drip, semi-closed, and fully enclosed irrigation systems are shown in Table 3. The drip irrigation system had the highest variable costs at $20,148, followed by the fully enclosed ($15,237) and the semi-closed ($9255) systems. The variable costs of the fully enclosed and drip irrigation systems were larger than those for the semi-closed primarily due to the cost of the drip tubing. The chemical variable cost associated with drip tube maintenance (to prevent clogging) is influenced by operation time and system flow rate. Hence, the fully enclosed system, which used less drip tubing, incurred a chemical variable cost similar to the drip irrigation system due to the increased quantity of water used for irrigation.

The total cost of the irrigation system is simply the sum of the fixed and variable costs associated with each irrigation system, as shown in Table 4. The semi-closed system had the lowest total cost at $20,512 for the 100-acre (40.5-ha) site, while total cost for the fully enclosed and drip irrigation systems were $27,354 and $36,064, respectively.

The results of this analysis clearly indicate the semi-closed irrigation system would be the least-cost choice for a new installation. Therefore, assuming all other parameters (interest rates, energy costs, water permits, yield, quality, etc.) are held constant among irrigation systems, growers will choose the irrigation system with the lowest total costs.

The information developed here represents the estimated average annual total costs of the new systems. You should be aware that the actual costs incurred by the grower over time (yearly) will most likely be different. However, the estimated average annual total costs described here should approximate the weighted average of the actual costs incurred by the grower.

Table 2. ***Annual fixed costs of vegetable irrigation systems, 1991.***

Item	Semi-closed	Fully enclosed	Drip irrigation
Annual fixed costs			
Depreciation	$3,715	$4,084	$5,634
Interest	$3,709	$3,951	$5,061
Repairs	$2,473	$2,634	$3,374
Taxes	$989	$1,054	$1,350
Insurance	$371	$395	$506
Total annual fixed costsz	$11,257	$12,117	$15,926
Total annual fixed costs/acre[y]	$183	$197	$259
Total annual fixed costs/TLBF[x]	$25	$27	$36

[z]*Annual fixed costs of each irrigation system are based on a 100-acre (40.5-ha) site.*
[y]*An acre (0.45 ha) is 7260 linear bed ft (2213 linear bed m).*
[x]*TLBF denotes thousand linear bed ft (304.9 linear bed m).*

Table 3. ***Variable costs of three irrigation systems, 1991.***

Item	Semi-closed	Fully enclosed	Drip irrigation
Variable costs			
Chemical treatment	NA	$1,476	$1,476
Drip tube	NA	$3,864	$10,500
Drip trube installation	NA	$404	$716
Irrigation maintenance labor	$1,120	$560	$1,120
Irrigation manager (acres/day)	$371	$395	$506
Pumping (diesel fuel)	$7,135	$7,088	$2,247
Operating interest	$441	$726	$959
Total variable costs/season[z]	$9,255	$15,237	$20,148
Total variable costs/season/acre[y]	$151	$248	$328
Total variable costs/season/TLBF[x]	$21	$34	$45

[z]***Annual fixed costs of each irrigation system*** are ***based on a 100-acre*** (40.5-ha) site.
[y]*An acre (0.45* ha) is 7260 *linear bed ft (2213 linear bed* ***m).***
xTLBF denotes thousand linear bed ft (304.9 linear bed m).

Table 4. ***Total costs of three vegetable irrigation systems, 1991.***

Item	Semi-closed	Fully enclosed	Drip irrigation
Total annual fixed costs	$11,257	$12,117	$15,926
Total variable costs/season	$9,255	$15,237	$20,138
Total irrigation costs[z]	$20,512	$27,354	$36,064
Total irrigation costs/acre[y]	$334	$445	$587
Total irrigation costs/TBLF[x]	$46	$61	$81

[z]*Total irrigation costs are based on a 100-acre (40.5-ha) site.*
[y]*An acre (0.45 ha) is 7260 linear bed ft (2213 linear bed m).*
[x]*TLBF denotes thousand linear bed ft (304.9 linear bed m).*

Other factors affecting irrigation system selection

Frequently, other economic, biological/physical, and institutional/regulatory variables also affect the irrigation selection decision. The semi-closed irrigation system was found to be the least-cost irrigation system while other variables were held constant. However, should changes in these variables occur, growers should examine irrigation cost per unit of output. Small changes in some of the variables may result in dramatic adjustments in the total cost relationships of the irrigation systems. Some of these variables include crop yield, product quality, level of water use, efficiency, etc. For instance, the expanded use of the water resource may allow an individual to farm more acres due to the use of a water-conserving irrigation system or to use an irrigation system more intensely in a multiple-cropping program, thereby distributing costs over multiple crops.

In addition, a grower may want to consider options other than a new installation. The modification of an existing irrigation system may be a desirable alternative to a new installation. This evaluation and the replacement decision of an existing system with a new installation require a time-value analysis of costs.

Traditionally, growers have adopted those irrigation systems that are easily combined in their production system and that produce favorable returns over costs. Given the results of this study under the prevailing conditions (holding all others factors constant) and assuming no yield difference between systems, the well-informed producer would choose the semi-closed system for a new installation.

The use of water for irrigating vegetable crops certainly will continue to be a major input in any vegetable production system. Therefore, growers who understand clearly the factors affecting irrigation costs will likely plan an economical irrigation system.

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