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Irrigation Costs for Tomato Production in Florida* [1]

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Seepage irrigation is the most common method of irrigating tomatoes in Florida today. This method applies water to the field through lateral ditches. From these ditches, water flows horizontally beneath the surfaces to form a perched water table and then moves upward to the plant's root zone by capillary action.

With seepage irrigation, water is sometimes conveyed from the water source to the field through open ditches. Significant water loss may occur due to evaporation and deep percolation. Some growers use underground pipe distribution systems, which reduce these losses; this type of seepage irrigation is known as "semi-closed." Due to the relatively low irrigation efficiencies and high pumpage requirements with both seepage irrigation methods, there is interest in micro (drip) irrigation as an alternative. Microirrigation is the controlled, slow application of water through devices called emitters directly to the plant's root zone from a network of plastic pipes. The term "microirrigation" includes irrigation methods such as drip, trickle, microsprinkler, micro-sprayer, and some forms of subsurface irrigation. Drip irrigation is the form of microirrigation most often used in the production of tomatoes.

The majority of tomatoes grown in Florida are produced for the fresh market. Cultural practices for production usually include raised beds for drainage, plastic mulch, and staking. If drip irrigation is employed with this production system, the lateral tubing used to distribute the water to the plant is placed beneath the plastic mulch and within 12 inches of the plant row. In this publication, the cost of drip irrigation is compared to the irrigation costs of the two forms of seepage irrigation under typical Florida conditions.

IRRIGATION EFFICIENCY

Efficiency is an important factor. It influences the cost of operating an irrigation system. Irrigation application efficiency is the ratio of water stored in the root zone of the plant to the total water pumped. Water losses may occur through conveyance, deep percolation, and runoff (tailwater). Overall irrigation efficiency is affected by many factors, including the method of conveyance, distance from the water source to the field, soil characteristics, age and type of crop, weather conditions, requirements for leaching to prevent salt buildup, method of application, and, perhaps most importantly, how the

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irrigation system is managed. More information on irrigation efficiency is available in IFAS Extension Bulletin 247.

Water-Conveyance Efficiency

Water losses in conveyance from the irrigation pump to the field can be a significant factor in irrigation costs. Efficiencies of various conveyance methods are given in Table 1 for comparison.

Pumping Capacity

The pumping capacity required is a function of the maximum daily evapotranspiration (ET_m), the net area to be irrigated, irrigation system efficiency, and maximum daily hours of irrigation system operation. Pumping capacity was calculated from: where: **P** = Pumping capacity, (gpm) **ET_m** = Maximum daily evapotranspiration (inches) **A** = Area, (net irrigated acres) **Eff** = Overall efficiency, (decimal) **H_o** = Maximum daily hours of operation **C** = 450, (a constant to convert to gpm) The maximum daily evapotranspiration (ET_m) is a function of temperature, relative humidity, day length, crop and cultural practices (such as plastic mulch and row spacings), wind speed, and solar radiation. It can be estimated as 75 percent of pan evaporation or from ET estimation equations.

Table 1. Typical efficiencies of irrigation conveyance methods.

Conveyance Method	Efficiency, percent
Underground Pipe	100[a]
Above-ground Aluminum Pipe	85 to 95
Concrete-lined Ditches	80 to 90
Earth Ditches	40 to 80[b]

[a] assumes no leakage.
[b] depends heavily upon soil properties; values can be very low for Florida's sandy soils.

Water-Application Efficiency

Water-application efficiency is the ratio of the volume of water stored in the root zone (and available to the plant) to the volume of water applied to the field. This efficiency can vary significantly due to the irrigation system, soil type, and management practices.

Seepage irrigation water application efficiencies can range from 25 to 60 percent depending on production system, soil type, and hydro-geological properties including restrictive soil layers, existing water table, size of field, etc. Drip irrigation water application efficiencies are normally much less variable for well-designed and well-managed systems, and typically range from 80 to 90 percent.

COSTS OF IRRIGATION

The costs of drip irrigation for tomatoes are compared to the costs of the two forms of seepage irrigation. Many site-specific factors influence these costs. For this analysis, three 100-acre fields (open-ditch seepage, semi-closed seepage, and drip) were compared. In addition, assumptions were made with regard to pumping capacity, net production acreage, hours of operation, and seasonal pumping requirements.

Maximum hours of operation is a function of soil water-holding capacity, wetted volume of soil, management and labor skills, and reliability of electrical and mechanical systems. Often, seepage systems must be operated nearly continuously during daylight hours to be effective. Drip systems must have the capacity to apply water frequently, more often than once per day if necessary.

Maximum hours of operation for sizing purposes must be less than 24 hours to allow for maintenance and repair of the system. Therefore, the maximum hours of daily operation was assumed to be sixteen for each of the systems.

Net production acreage is less with the open-ditch system than with either drip or semi-closed systems due to the field area allocated to conveyance ditches and to wider lateral ditches. The drip irrigation systems also require field space for drainage ditches and drive lanes for harvesting.

Pumping system capacity for the drip irrigation system is a function of the plant row and emitter spacing and the flow rate per emitter. In this example, the row spacing was 6 feet, the flow rate was 24 gph/100 ft, and there were 5600 ft of row per gross acre. Further, the drip irrigated field was assumed to be divided into four subunits, with only one unit to be irrigated at a time. These assumptions result in a water pumping capacity requirement of 560 gpm. The specific assumptions that were made for this analysis with regard to pumping capacity, efficiency, and field layout are shown in Table 2.

Initial Capital Investment

In addition to efficiency and the availability of water, the initial capital requirement is an essential factor that influences the cost of operation of an irrigation system. In computing the initial capital requirements for the three 100-acre fields, the irrigation systems were separated into two categories: the water supply system and the distribution system.

Economic Analysis

Table 4 provides a listing of the estimated initial capital outlays for the three 100-acre systems. Well depth, pump capacity, and power requirements were assumed based on common water yield characteristics of underground water-bearing formations in Florida. It was assumed that the drip system could be designed in zones, thus the required pumping capacity is 5.6 gpm/acre (based on gross acreage). The drip system must have seepage irrigation capacity since the field must often be wetted to allow for bed formation. In this example, however, there is only sufficient water to wet approximately one half of the field at a time. Total fixed costs for the 100-acre drip irrigation system was estimated at $67,400.

The water supply system consists of the well, and the pump and power unit. The distribution system consists of field conveyance ditches, filter systems, underground PVC pipe and fittings, chemical injection unit, meters, backflow prevention, controllers, and automatic and manual valves. The requirements for these components will vary depending on the system used. In addition, since total pumping head requirements may be different with each system, the assumptions in Table 3 were made.

The seepage systems, because of lower application efficiencies and other factors, would require more pumping capacity than the drip irrigation systems. For example, with the open ditch seepage system, water use is near potential ET over the entire field. This is caused by seepage around ditches and the wet ground surface in the row middles. Therefore, three wells, pumps, and power units were required for this seepage irrigation system. Based on Equation (1), the 100-acre, semi-closed seepage irrigation system required two wells to provide the necessary pumping capacity since conveyance losses were eliminated with this system. Total fixed costs for the seepage irrigation systems were estimated to be $61,140 and $55,500 for the semi-closed and open-ditch systems, respectively.

Table 5 provides a breakdown of the annual fixed costs for the three irrigation systems. Depreciation was computed based on a 10-year loan period. Total annual cost includes depreciation, interest, insurance, taxes, and repairs. Estimated total annual fixed costs for the drip, semi-closed, and open-ditch seepage systems were $11,458, $10,234, and $9,381, respectively.

A summary of annual fixed and variable costs are given in Table 6. Variable costs include pumping and labor. However, for the drip system, the largest component of variable costs is the cost of the disposable lateral tubing that must be replaced each year. Total annual costs for the three 100-acre irrigation systems were $24,344, $13,031 and $12,202 for the drip, semi-closed and open-ditch systems, respectively. Since more net production acres result from the semi-closed than the open-ditch system, the lowest annual irrigation cost per production acre occurred with the semi-closed irrigation system.

This analysis assumes equal production per acre from each system which may not occur. For example, flooding the field with seepage irrigation provides some frost protection; this is not possible with the drip system. On the other hand, the capacity to provide fertilizers to the plant through the drip irrigation system may reduce fertilizer costs and increase production over the seepage systems.

SUMMARY

The cost of irrigation is a function of the initial capital outlay for the irrigation system, irrigation requirements, availability of water, market interest rates, and fuel costs plus the costs associated with labor and other site-dependent variables. Assuming common Florida conditions and current interest rates and fuel costs, annual irrigation costs were estimated at $363, $195 and $214 per net irrigated production acre for the drip, semi-closed and open-ditch irrigation systems, respectively.

Table 2. Assumptions used in the economic analysis.

Assumption	Open-ditch	Semi-closed	Drip
ET_m (inches)	0.25	0.25	0.22
Net Production Area (acres)	56	67	67
Irrigated ET area (acres)	100	88	67
Efficiency (percent)	35	45	85
Daily Hours Operated	16	16	16
Pump Capacity (gpm)	2000	1375	560
Number of Wells	3	2	1
Season Pumpage (ac-in)	3850	2650	1050

Table 3. Irrigation pumping head required[a].

Assumption	Open-ditch	Semi-closed	Drip
Drawdown[b]	27	28	22
Static Water level	6	6	6
Friction (pumping)	4	4	4
Operation Pressure	5	20	46
Total pumping head	42	58	78

[a] given as feet of head, where 2.31 ft= 1 psi.
[b] assumes specific yield of 25 gpm/ft of drawdown.

Table 4. Initial capital investment($) for 100 acre Tomato Drip, Semi closed and Seepage Irrigation Systems.

Item	Drip	Semi-closed	Open-Ditch
Water supply system	1 well	2 wells	3 wells
Well(s) 10-inch, 140ft deep[a]	8,000	16,000	24,000
Pumps(s)	6,000	12,000	18,000
Power Unit(s)	3,500	6,000	9,000
3-inch PVC pipe	4,500	8,000	
4-inch PVC pipe	6,000	6,000	
6-inch PVC pipe	9,000	7,500	
8-inch PVC pipe	13,500		
Fittings	4,000	2,000	
Conveyance ditches			3,000
Valves	4,500	2,240	300
Filtration	2,000		
Chemical injection	1,000		
Meters	2,400	800	1,200
Backflow prevention	1,000	600	
Controller	2,000		
Total[b]($)	67,400	61,140	55,500

[a] well diameter and specific yield will vary with location.
[b] does not include the costs of land forming.

Table 5. Annual Fixed Cost ($) for 100 acre Drip, and Semi-closed and Open ditch Seepage Irrigation Systems for Tomatoes.

Item	Drip	Semi-closed	Open ditch
New cost	67,400	63,140	55,500
Average cost[a]	33,700	31,570	27,750
Years of life[b]	10	10	10
Depreciation[c]	6,740	6,314	5,500
Interest[d]	3,370	3,157	2,775
Insurance[e]	337	316	278
Taxes[f]	337	316	278
Repairs[g]	647	631	550
Total	11,458	10,734	9,381

[a] new cost - salvage value divided by 2 (assumes no salvage value).
[b] based on 10 year loan.
[c] new cost divided by years of life.
[d] average cost x 10 percent
[e] new cost x 0.5 percent
[f] average cost x 1 percent
[g] new cost x 1 percent

Table 6. Annual Fixed, Variable and Pumping Costs ($) for 100-acre Drip and, Semi closed and Open ditch See age Irrigation System for Tomatoes.

Item	Drip	Semi-closed	Open ditch
Fixed cost[a]	11,458	10,734	9,381
Variable Costs:			
Irrigation tubing[b]	10,750	0	0
Pumping Costs[c]	859	1,568	1,664
Labor Costs[d]	1277	729	1157
Total annual costs[e]	24,344	13,031	12,202
Total per acre[f]	363	195	214

[a] from Table 5
[b] 560,000 ft @ $19/1000 ft
[c] at $0.08 per KWH
[d] at $5.00 per hour
[e] based on 90-day growing season.
[f] net production acres.