Factors Affecting the Choice of Irrigation Systems for Florida Tomato Production[1]

Jenna Rogers, Tatiana Borisova, Jeffrey Ullman, Kelly Morgan, Lincoln Zotarelli, and Kelly Grogan[2]

Introduction

Changes in water-use regulations, along with possible reductions in water availability due to saltwater intrusion and periodic droughts, provide incentives for agricultural producers to invest in water-efficient irrigation technologies. In a survey of 31 eastern US states, more than half of the surveyed farms that had improved their irrigation systems between 2003 and 2008 reported improved yield/quality (68%), reduced energy costs (57%), and/or reduced water applied (54%) (Schaible and Aillery 2012). Similar advantages of efficient irrigation systems were reported by researchers at the University of Florida who surveyed Florida vegetable producers in 2013 (see the online presentation by Grogan and van Dijl at http://www.fred.ifas.ufl.edu/outlook-webcasts/).

The objective of this article is to discuss the economic factors that should be considered in selecting an agricultural irrigation system. We used tomato production in Florida as an example, given that tomato is an important agricultural crop for the state, and Florida is the leading state in the nation in the production of fresh-market tomatoes (USDA/ERS 2012). In this article, we compare two widely used irrigation systems for tomato production: seepage and sub-surface drip irrigation.

Irrigation Systems for Florida Tomato Production

Seepage irrigation systems pump groundwater from wells or surface water canals and deliver it to field ditches (also referred to as furrows or lateral canals). Most Florida tomatoes are produced in areas where layers of sandy soils overlay an impermeable layer of clay and organic matter. The water from field furrows seeps down to the

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2. Jenna Rogers, former graduate student, Food and Resource Economics Department; Tatiana Borisova, assistant professor, Food and Resource Economics Department; Jeffrey Ullman, assistant professor, Agricultural and Biological Engineering Department; Kelly Morgan, associate professor, Soil and Water Science Department, Lincoln Zotarelli, assistant professor, Soil and Water Science Department; Kelly Grogan, assistant professor, Food and Resource Economics Department; UF/IFAS Extension, Gainesville, FL 32611.

impermeable layer, and since there is nowhere else for it to go, the water then seeps laterally, reaching the tomato rows or beds. Growers use water retention structures to hold the water back in the furrows and raise the water table in the whole field. The furrows also remove water from the fields during heavy rains (Reyes-Cabrera et al. 2014; Estabrook 2011; Scholberg et al. 2000; Stanley and Clark 1995).

An important characteristic of an irrigation system is irrigation efficiency, which is defined as the percentage of water stored in the root zone of the plant to the total water applied (Pitts et al. 2002). For seepage irrigation systems, irrigation efficiency depends on the system management, and ranges from 20 to 80 percent (Howell 2003; Smajstrla et al. 2002).

Drip irrigation is a system with plastic tubing placed either on the surface of the soil or 4–5 inches below the surface to supply water directly to the root zone of the plants (Reyes-Cabrera et al. 2014; Ozores-Hampton et al. 2012). When the tubing is placed below the surface, the system is referred to as a subsurface drip irrigation system. Drip irrigation seeks to keep the water table low and places only as much water as plants need directly on their roots. Furrows are still required to remove excess water from the fields after rain. The advantage of the system is the significant reduction in water use. Irrigation efficiency for drip systems ranges from 70 to 95 percent (Howell 2003; Smajstrla et al. 2002). These systems also enable application of soluble fertilizer through irrigation systems, referred to as fertigation. Fertigation allows growers to “spoon-feed” fertilizer to the plants, and hence, can reduce fertilizer losses and overall fertilizer use. Among the disadvantages of this system are high maintenance costs because the tubing generally needs to be replaced annually. For more information on drip irrigation, see Dukes et al. (2008a–d).

We found three reports that discuss the costs and benefits of drip irrigation systems, as compared with seepage systems, for Florida tomato production (Table 1). The estimates vary widely, which can be explained by the different specifications of drip systems, different water requirements of various tomato varieties, and various sizes of the farms examined. The differences in the past studies highlight the variability in costs and benefits of alternative irrigation systems, which is important for a producer to consider.

Methods and Data

The objective of this article is to examine the economics of seepage and subsurface drip irrigation systems. We considered the situation for a tomato farm with existing seepage irrigation, where the grower was considering switching to a subsurface drip irrigation system. As a result, we disregarded the costs of installation for the seepage system.

We assumed that the decision about the replacement of the irrigation system was made in 2011. Then, we estimated a ten-year net present value (NPV, $/acre) for seepage and subsurface drip irrigation systems. The NPV was estimated as a sum of annual net returns for ten years (2011–2020), where future returns were discounted to the present value (5% discount rate was used). Annual net returns were based on tomato yields, prices, and production and harvesting costs. Since tomato yield and price varied from year to year, five hundred samples of yields and prices were simulated for a ten-year period, and a distribution of NPV for each irrigation system type was estimated (described below). The estimations followed the procedure described in the Simetar© Excel Add-In User Manual (Richardson 2001).

Seepage Irrigation System

This scenario is based on the tomato production budget by IATPC (2008–2009). To account for inflation, the costs in the budget were indexed to 2011 using the Producer Price Index (USBLS 2013). Since the tomato production budget was developed for a drip irrigation system, it needed to be adjusted for the seepage system. Based on the previous studies (Table 1), the seepage irrigation system has lower maintenance costs, but it also has lower yields and higher fertilizer costs compared with subsurface drip irrigation systems. Hence, for the seepage system, we adjusted the IATPC tomato production budget by

- Reducing maintenance costs by $200/acre, approximately equal to the value reported in Simonne et al. (2012)
- Increasing fertilizer costs by 10 percent, half the value reported in IA (2008)
- Reducing average yield by 10 percent, half the value reported in IA (2008)

Note that the yield was projected based on the regression model and 1984–2010 USDA data (Figure 1), with the coefficients of the regression model reduced by 10 percent, and assuming that such changes in the yield did not affect yield variability from year to year.

Subsurface Drip Irrigation System

This scenario is also based on the tomato production budget by IATPC (2008–2009), with the budget costs indexed using the Producer Price Index (USBLS 2013). Simonne et al. (2012) and Pitt et al. (2002) reported installation costs for the subsurface drip irrigation system to range from $176 to $268 per acre. For this study, we assumed that the installation costs were $200/acre (Table 2). To project prices and yields for 2011–2020, we used United States Department of Agriculture (USDA) yield and price data for tomatoes in southwest Florida over the 1984–2010 period (Figure 1) (USDA/ERS 2010). We assumed that these yields and prices reprsented production with subsurface drip irrigation.

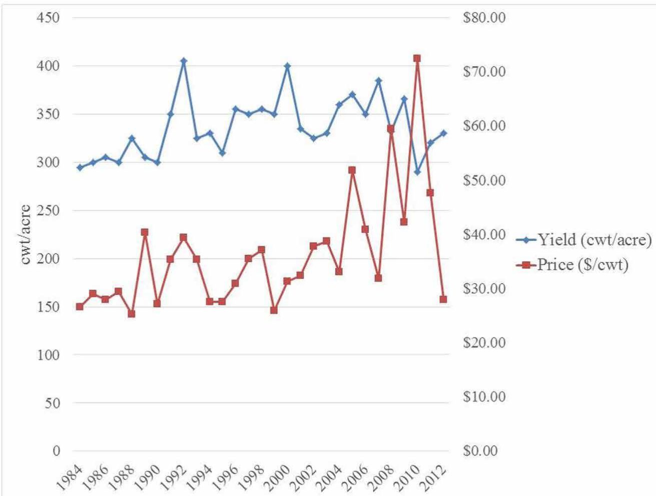

Figure 1. Historical information on yield and nomaimal price for tomatoes in Florida* (USDA/ERS 2010)

Results and Discussion

The estimated ten-year NPV per acre for different irrigation systems is presented in Figure 2.

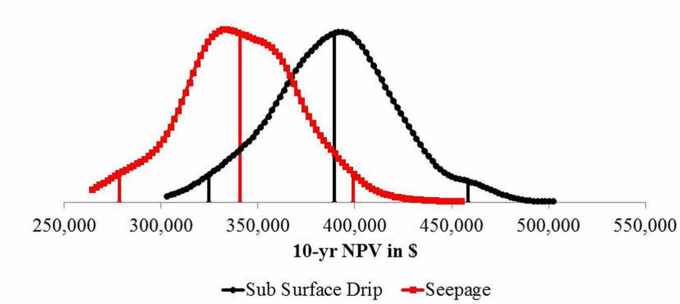

Figure 2. Ten-year NPV distributions of two irrigation systems

For Seepage Irrigation, NPV ranges between $280,000 and $400,000 per acre, and the average NPV is $340,000 per acre.

For Subsurface Drip Irrigation, over ten years, the NPV is expected to be between $325,000 and $460,000 per acre, with an average of $390,000 per acre.

Conclusions

In this article, we used an example of tomato production in southwest Florida to discuss the economics of drip and seepage irrigation systems. Based on the literature review, we identified the following economic factors that producers should consider when selecting an irrigation system:

- Irrigation system installation costs and annual depreciation costs
- Annual maintenance costs such as tubing and labor required
- Changes in water use and associated changes in energy costs
- Changes in fertilizer use and costs due to joint management of fertilizer and irrigation (fertigation)
- Changes in yield that can be associated with increased precision of irrigation and fertilizer use
- Changes in pesticide costs due to reduced disease pressure

Only a few studies report numeric estimates of cost and revenue changes for alternative irrigation systems. These studies report a range of possible costs and benefits, and the difference in the estimates implies that the advantages or disadvantages of the systems depend on each system's specific configuration, the size of the farm, tomato variety produced, and other factors.

Our analysis shows that the potential increase in yields is a primary determinant of the profitability of water-efficient irrigation systems. Given the assumptions about the costs and benefits of subsurface drip irrigation systems, our financial analysis shows that tomato farmers in southwest Florida can benefit from switching from a seepage irrigation system to a subsurface drip system. The increase in average yield that we assumed for the subsurface drip irrigation system offsets the relatively low installation cost for the system, as well as the increase in operation and maintenance costs. Although not explicitly discussed in this paper, a significant part of the system installation costs can be covered by USDA/NRCS cost share as part of the federal Environmental Quality Incentive Program (EQIP) that addresses natural resource concerns (http://www.nrcs.usda.gov/wps/portal/nrcs/main/fl/programs/financial/eqip/).

Changes in the regulatory framework regarding water use (such as water-use monitoring requirements or changes in water-use permits), along with a possible reduction in available water due to weather conditions, can provide additional incentives for producers to invest in water-efficient irrigation technologies. Furthermore, salts in the soils and irrigation water have become a significant issue for Florida growers over the past few years. Tomato yield can be decreased considerably in response to a small increase in soil or irrigation-water salinity, which can reduce producer profits to zero or even lead to losses (Dukes et al. 2012; Grattan 2002). Pumping of excessive amounts of groundwater can increase saltwater intrusion from deeper aquifer levels. Efficient irrigation systems, such as subsurface drip systems, could be beneficial for reducing saltwater intrusion, and hence, reducing or delaying the effect of salinity on yields.

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Table 1. Summary of existing studies related to drip irrigation for Florida vegetable production

Source	Irrigation system, crop, and acreage	Installation costs ($/acre)	Disadvantages	Advantages
Simonne et al. 2012	subsurface drip; small vegetables; 10-acre farm	268.30	$179.0/acre increase in variable costs due to annual maintenance	reduction in water use and pest problems, reduction in pumping costs, increase in yield, and increase in the efficiency of irrigation and fertilizer use (not quantified)
Pitts et al. 2002	subsurface drip; tomato; 100-acre farm	176.33*	$558.62/acre* increase in variable costs due to tubing, and additional labor requirements	reduction in pumping costs, increase in irrigation efficiency (double that of seepage), and reduction in water usage (not quantified)
IA Drip-Micro Common Interest Group Market Development Subcommittee, 2008	drip; tomato; farm acreage is not specified	1,093.14*	50% increase in energy costs; 20% increase in harvest costs	20% increase in yield, 50% reduction in costs of cultural practices and irrigation labor, and 20% reduction in fertilizer and chemical costs

* Estimate indexed to 2012 value using Producer Price Index for new construction (USBLS 2013)

Table 2. Estimated cost for tomato production in southwest Florida under subsurface drip and seepage irrigation systems ($/acre*)

	Subsurface drip system	Seepage system
Pre-harvest variable costs		
Transplants	$680.79	$680.79
Fertilizer mixed and lime	$1,581.14	$1,739.25
Fumigant	$802.98	$802.98
Herbicide	$23.35	$23.35
Insecticide and nematicide	$489.70	$489.70
Fungicide	$427.90	$427.90
Tractors and equipment	$2,054.41	$2,054.41
Farm trucks cost (driver cost/overhead and mgmt expense)	$36.77	$36.77
General farm labor	$153.43	$111.84
Tractor driver labor expense	$233.78	$233.78
Scouting	$49.10	$49.10
Level land	$158.20	$158.20
Plastic mulch	$360.03	$360.03
Drive stakes	$88.71	$88.71
Prune plants	$87.13	$87.13
Stakes	$98.19	$98.19
Plastic string	$31.37	$31.37
String and stake eisposal	$134.65	$134.65
Pull and bundle mulch	$198.02	$198.02
Cross ditch	$29.68	$29.68
Tie plants	$158.41	$158.41
Trickle tube	$158.41	$0.00
Interest expense on variable costs per acre	$434.84	$434.84
Total pre-harvest variable costs	$8,470.97	$8,429.08
Total pre-harvest fixed costs (interest and overhead expenses)	$4,735.35	$4,735.35
Total pre-harvest costs (total fixed and variable expenses)	$13,206.31	$13,164.43
Total harvest and marketing costs	$5,130.88	$5,130.88
Total costs per acre	$18,337.20	$18,295.31
Irrigation system installation costs	$200	
Irrigation system depreciation	$20	

* Baseline tomato production budget for 2008/09, indexed by multiplying unit cost estimates by 1.091, adjusting for inflation, and representing average ten-year production costs (USBLS 2013).