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Irrigation Preferences of Florida Potato Farmers and the Economic Effects of Cost Share on Subirrigation-Drainage Tile Installation[1]

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Introduction

Improvements to agricultural irrigation systems come with both benefits and costs. Cost-share programs are crucial for Florida potato growers considering updating their irrigation systems from seepage to subirrigation-drainage tile. This publication aims to inform potato growers, Extension agents, crop consultants, representatives of the fertilizer and irrigation industry, state and local agencies, the academic community, and interested Florida citizens of the costs and benefits of drainage tile installation in potato operations, both with and without cost-share programs, and assess the risks involved.

Potatoes are an economically important crop in Florida because of its warmer late winter/early spring temperatures. Florida farmers can grow spuds during the winter-spring season, when temperatures are still too cold in many other potato-producing states (Mwatuwa 2020). In 2022, potatoes were grown on approximately 20,000 acres throughout Florida, resulting in more than $110 million in sales (USDA 2023).

For some growers, irrigation management to enhance operating efficiency is a growing priority, particularly with respect to water usage. Finding the right drainage system is especially important for Florida potato farmers, as potatoes are sensitive to both over- and under-watering (Rens et al. 2022). Understanding the costs of irrigation systems and the cost-share programs available can help potato farmers make informed investment decisions for their farming operations.

Seepage Irrigation vs. Subirrigation-Drainage Tile

Two of the most common types of subirrigation for potato crops are seepage and drainage tile (both classified as subirrigation). Seepage irrigation is a common low-cost method of irrigation that consists of shallow ditches known as furrows (Rogers 2014). The potatoes are planted between the furrows, and water is both irrigated and drained from the fields via controlled water volumes allowed into and drained off the furrows.

Seepage irrigation is relatively inexpensive. The installation cost of the average seepage irrigation system is $206/acre (Mwatuwa 2020). However, because water is easily lost within seepage irrigation systems through evaporation and runoff into canals or ditches, they can have low irrigation efficiency (Rogers 2014). The water application efficiency of seepage irrigation, or how much of the irrigated water is available for use by the crop, is between 20% and 60% (da Silva et al 2018).

As an alternative, subirrigation drainage tile can provide farmers with greater control over irrigation of potato fields. In these systems, three- to four-inch corrugated polyethylene pipes are buried two to three feet deep and spaced 25 to 35 feet apart (Rogers 2014). Water flows through the perforated pipes, which are also used to drain the fields when the water table rises. Potato farms utilizing subirrigation-drainage tile have 11% to 12% more plantable acreage than do farms on seepage fields, as crops can be planted above drainage tile (Rogers 2014). A water application efficiency rate of 60%–80% indicates that drainage tile typically loses less water than seepage irrigation, which decreases water usage and runoff (da Silva et al 2018). Additionally, drainage tile can maintain a more uniform soil moisture level throughout the field than seepage (da Silva et al 2018), which can lead to more uniform potato crop development.

While there are benefits to drainage tile, some farmers are hesitant to adopt it because it can be prohibitively expensive to install, with an average installation cost of $4,508.63/acre (Mwatuwa 2020). Despite the initial installation costs, because of the positive environmental impacts of subirrigation-drainage tile (reduced water loss and water runoff), Florida Water Management Districts are seeking to promote its adoption among farmers.

Cost-share programs are available throughout the state and can assist farmers with the significant capital expenditure associated with installing drainage tile systems. For example, the St. Johns River Water Management District (SJRWMD) can reimburse up to 75% of subirrigation-drainage tile system installation costs with an annual maximum of $250,000 (SJRWMD 2023) for farmers who meet all eligibility requirements.

Limited literature exists comparing crops raised with seepage irrigation to crops raised with subirrigation-drainage tile irrigation in terms of yields and overall economic outcomes. The project described in this publication seeks to better understand farmer irrigation preferences through a survey and to create a model to develop cost evaluation guidelines for growers interested in predicting probable economic outcomes of installing a subirrigation-drainage tile system.

Survey

A survey of potato growers was conducted from March to May 2024. The survey included questions about farmer characteristics, farm operation characteristics, irrigation preferences, and willingness to adopt subirrigation-drainage tile. The development of the survey relied on existing literature within and about the Florida potato industry, as well as the 2021 UF/UGA Crop Producer Survey (Court et al. 2021).

Prior to launch, the survey instrument was reviewed by subject matter experts such as Extension agents and water management stakeholders. After the survey received final approval, potato growers were invited to complete it at industry stakeholder events, such as field days and workshops.

The survey recorded data from six North Florida farmers with a total of 3,000–3,950 acres of potatoes. This represents approximately 15%–19.75% of Florida's 20,000 acres of potato farmland (USDA 2024). Four respondents had been farming for over twenty years, one had farmed for ten to fifteen years, and the other five to ten years. Respondent potato marketable yields, simply referred to as "yield," ranged from 251 to 351+ hundredweight per acre (= 100 pounds per acre, hereinafter abbreviated as cwt/acre).

A significant section of the survey measured farmer preferences for fifteen different irrigation system factors. The questions were posed using a Likert Scale Methodology, with responses ranging from "Not at all Important = 1" to "Extremely Important = 5." The results of this section are presented in Table 1.

According to the survey responses, the most important factor for Florida potato farmers when choosing an irrigation system was improved crop/yield quality, with an average score of 4.83. The least important factor was low initial cost, with an average score of 3.50. This result was surprising and inconsistent with a later question in the survey, where cost was the most frequently mentioned barrier to irrigation improvement.

Costs for irrigation system installation can range significantly, as the average installation cost for seepage in Florida potato farms is approximately $206/acre, compared to the more substantial $4,509/acre of drainage tile system (Mwatuwa 2020).

Subirrigation-drainage tile adoption may appeal to Florida potato farmers because it will increase crop yield/acre by at least 10%–12% due to the increase in the number of potato plants that can be planted per acre. Additionally, recent studies show improved potato yield, better potato quality, and reduced water application using subirrigation-drainage tile as opposed to seepage (da Silva et al 2023).

While farmers agreed on the importance of improved crop yield and quality, there was a wide range of responses on the price/acre they would be willing to pay to adopt drainage tile. Responses ranged widely, with some farmers expressing a willingness to pay $1,200/acre for drainage tile installation and others unwilling to pay anything at all to install drainage tile.

While subirrigation-drainage tile can help farmers meet important goals such as increased crop yield, even those who do consider low initial cost to be less important than other factors may still have concerns regarding high installation costs. However, when taking into consideration a 75% cost-share program, farmers with average installation costs would be responsible for paying approximately $1,127/acre ($4,509 x the farmer's share of 25%), which could be economically feasible for some growers.

However, the Saint Johns River Water Management District's cost-share program is a reimbursement program, meaning that the farmer is still responsible for paying full installation costs up front, with cost-share money being repaid later. The financial burden of the initial costs may discourage farmers from installing drainage tile.

Model

A model was created to assist farmers' understanding of their farm's economic situation and to help them decide whether converting some or all of their potato acreage from seepage to subirrigation-drainage tile would make economic sense for their farm.

This model uses Microsoft Excel and Lumivero @Risk software. The @Risk software allows the user to create input distributions, which are then simulated to determine the average values and the likely spread of potential outcomes for different economic situations.

@Risk is an appropriate software for this analysis because it can visualize projected financial outcomes based on data inputs. Similar risk management software such as ModelRisk, another Excel plug-in, may also be used.

This model spans over 10 years, which can be adjusted as needed. The model assumes a farm will transition 75 acres a year to drainage tile, as that is optimal for benefiting the most from SJRWMD cost-share programs with current drainage tile installation costs of $4,509/acre (Mwatuwa 2020). The standard model assumes a farm size of 750 acres, which was within the most common farm size range according to the survey.

Two potato yield simulations were considered within the model. Simulation 1 “High Projected Yields” is based on the marketable yields from field trials conducted by Zotarelli et al. (2022) comparing seepage and drainage tile potato plots. Simulation 1 seepage irrigation has an average marketable yield of 249.87 cwt/acre. Subirrigation-drainage tile’s average yield is 265.12 cwt/acre.

Simulation 2 “Low Projected Yields” uses the marketable yields based on field trials conducted by Mwatuwa et al. (2020). The seepage irrigation average yield is 207.12 cwt/acre. The subirrigation-drainage tile average yield is 255.17 cwt/acre.

These studies’ averages are at the lower end of the Florida grower survey result’s average yields, which were reported to range from 250 cwt/acre–350 cwt/acre.

Other economic factors were identified, with average values shown in Table 2 below. These values were found in Mwatuwa et al. (2020) using data collected in Northeast Florida from 2010–2016. All factors can be adjusted to meet the known or assumed values for each grower’s unique operating characteristics.

Production costs include all farm activity costs excluding water pumping and harvesting labor costs, which are considered separately from general production costs. General farm labor is included in production costs, while harvesting labor is separately defined as “Labor Costs” in the model. Harvesting labor needs to be evaluated separately because it fluctuates significantly given that it is generally priced by weight of harvested product instead of by acreage.

Prices can fluctuate over time due to many factors. Instead of using a normal distribution, a triangle distribution is used. Triangle distributions use a minimum, average, and maximum value. Normal distributions were used for yield because the data included averages and standard deviations; triangle distributions were used for the remaining variables because for these, maximum, average, and minimum could be identified.

This study used $18/cwt as the average price for potatoes because that was the average according to the survey results. The minimum used in the study was $14.50/cwt because that is the standard price according to Mwatuwa as of 2020. The maximum, $22.10/cwt, was based on the 2022 USDA Potato Summary (USDA 2023).

Using simulations with 10,000 iterations, the study considered multiple economic situations. In Figure 1, the red pattern represents simulation 1, “High Projected Yields,” while the blue pattern represents simulation 2, “Low Projected Yields.”

Net Present Value (NPV)

The NPV represents the profitability of the drainage tile investment over the 10-year time period. An NPV greater than zero generally means that an investment is profitable and therefore “worth it” to invest.

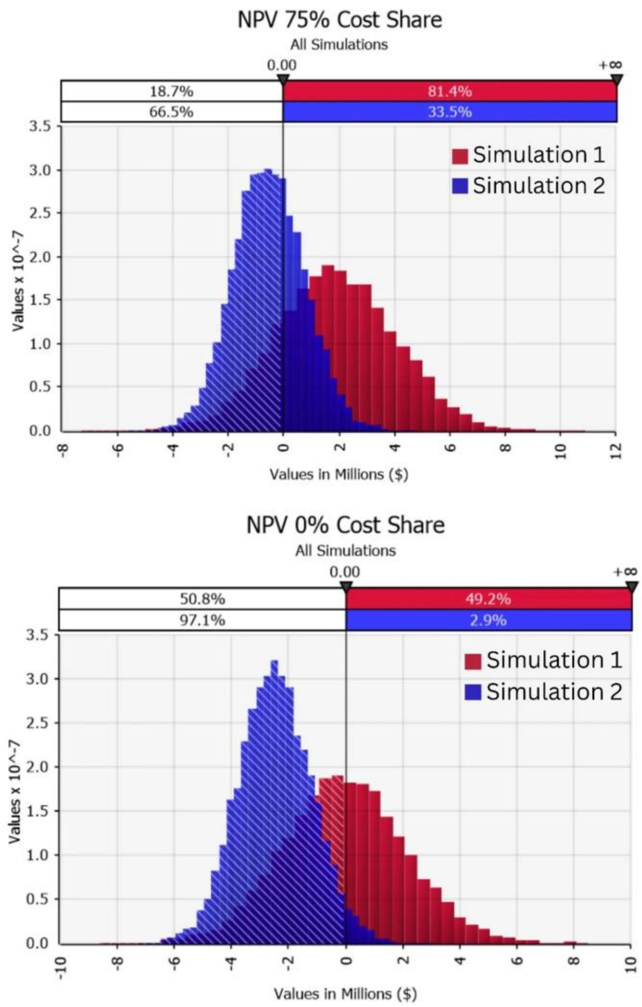

Figure 1. Cost Share NPVs of 75% and 0% Cost Share.
Credit: Created using @RISK software.

A discount rate of 5% is used in the NPV calculation. This reflects the relatively low risk of potato farming (Potato Business 2023), but a higher discount rate may be used instead to reflect greater risks faced by individual growers, or if they would need to borrow money to finance investment into drainage tile installation (Cruz and Singerman 2019).

With 75% cost-share assistance, farmers with high projected yields investing in drainage tile have an 81.4% likelihood of profiting from the investment over 10 years. Farmers with low projected yields have a 33.5% likelihood of positive cash flows over the same 10-year time period.

The NPV of 0% cost-share assistance shows significantly more risk to the farmer. About 49.2% of farmers are likely to have positive cash flows without any cost-share assistance with high projected yields (simulation 1), while only 2.9% of farmers with low projected yields (simulation 2) can expect to see positive cash flows without cost-share assistance.

Payback Period

Payback period measures the number of years required for the farmer to pay off their 10 years of investment into drainage tile, assuming that all profit goes towards installation cost payback.

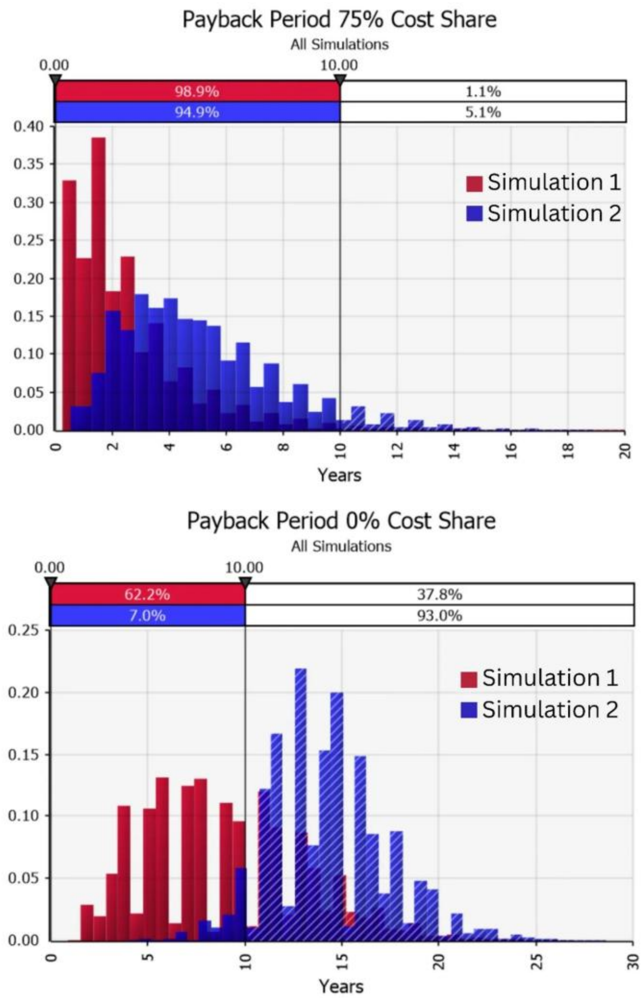

Figure 2. Cost Share Payback Periods of 75% and 0% Cost Share.
Credit: Created using @RISK software.

With the current program providing 75% cost share and $250,000 annual maximum, there is a 98.9% likelihood that a farmer with high projected yields would be able to pay back installation costs in five years. Farmers with low projected yields have a 94.9% likelihood of paying back installation costs in five years.

Farmers without access to cost-share programs are likely to have a much longer payback period. Farmers with high projected yields have a 62.2% likelihood of paying back the costs of installing 75 acres/year of drainage tile in ten years without cost share. Farmers with low projected yields have only a 7% likelihood of being able to pay off the costs of 75 acres/year of drainage tile installation in that same ten-year period.

This model not only shows the economic benefit farmers gain from cost-share programs, but it also serves as a useful decision-making tool for farmers considering investment into drainage tile irrigation.

Yield Improvement

While overall yield is an important factor, farmers should also consider yield increase after drainage tile installation. Simulation 1 has a higher yield overall after drainage tile installation, with a drainage tile yield of 265.12cqt/acre, but a lower increase from seepage, gaining 15.5 cwt/acre. Simulation 2 has a lower overall drainage tile yield of 255.17 cwt/acre, but it experiences an increase of 48.05 cwt/acre after drainage tile installation.

Farms with more significantly increased yields after drainage tile installation will have an increase in cash flows compared to farms with smaller yield gains. Using the average values from the model, annual cash gains can be calculated.

Simulation 1's gain of 15.5 cwt/acre leads to an increase in $274.50/acre (at average price of $18/cwt). Drainage tile incurs an increase of $281.02/acre in production costs on average, a decrease of $25.21/acre in water pumping costs, and an increase of $11.63/acre in labor costs. Overall, this results in an increase of $7.16/acre after drainage tile installation.

Simulation 2 has a more significant gain of 48.05 cwt/acre, leading to an increase in $864.9/acre. After applying the aforementioned input prices, the resulting increase after drainage tile installation is $597.56/acre.

Simulation 2's gain in revenue from drainage tile indicates that drainage tile investment is more favorable in fields that have high increases in yield post-installation. These farms have greater potential to pay off the $1,127/acre installation costs after cost share, compared to farms that, although they may have greater total revenues, do not see significant yield change from drainage tile installation.

Conclusion

Subirrigation-drainage tile installation is a significant investment for farmers. Though the initial cost may be high, the benefits of drainage tile such as increased yield and reduced water runoff are important factors to farmers. These factors may influence farmers to implement drainage tile irrigation when possible. However, while drainage tile can reduce some costs, such as water pumping, it can also increase other production costs, including labor, which may be a barrier to adoption.

Growers interested in subirrigation-drainage tile should consider the total revenue of their potato operation, as well as the additional revenue from increased yield after drainage tile installation. Since it is difficult to predict the exact effect of drainage tile on potato yield, growers may convert a small portion of their land to drainage tile, then measure the resulting yields. After harvest, they can determine if the increase in revenue makes it "worth it" for further investment.

The economic model created for this project simulates an economic situation that can be adjusted to meet individual farms' yields and costs. Farmers with potato yields higher than 251 cwt/acre (simulation 1) are more likely to have better financial outcomes, such as higher yearly profit, cumulative profit, and NPV, after investment into drainage tile installation compared to farmers producing less than 250 cwt/acre (simulation 2). However, farmers with these lower total yields but higher yield increase will have lower profits overall but see greater financial benefits from drainage tile.

The model results show that cost-share programs are economically impactful for farmers looking to invest in drainage tile irrigation. Without cost share, current drainage tile installation costs are higher than most farmers' willingness-to-pay range. When cost share is considered, the installation costs enter the willingness-to-pay range and increase the farmer's likelihood of obtaining a return on their investment in a reasonable time period, depending on individual yield circumstances.

Detailed instructions on how to use the @Risk Model are available at the UF/IFAS Department of Food and Resource Economics potato reports page at fred.ifas.ufl.edu.

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Tables

Table 1. How important are each of the following factors when choosing an irrigation system?

Factor	Mean	Std. Dev.
Improved crop/yield quality	4.83	0.41
Ease of operation	4.50	0.55
Reliability	4.50	0.55
Serviceability	4.50	0.55
Cost share programs	4.33	0.82
Reduced maintenance costs	4.20	0.84
Increasing capacity	4.20	0.84
Reduced water runoff	4.17	0.75
Automation	4.17	0.75
Compatibility with existing equipment	4.17	0.75
Low labor costs	4.00	1.22
Reduced fertilizer/pesticide loss	3.83	0.75
Reduced water applied	3.83	0.98
Reduced environmental impact	3.67	0.82
Low initial cost	3.50	0.55

Table 2. Economic Model Inputs.

Initial Acreage and Transition Amount			
Total Starting Acreage	750 acres		
Yearly Acres of Transition to Drain Tile	75 acres		
Potato Marketable Yield		**Average**	**St. Dev.**
Yield under Seepage (cwt/acre)	Simulation 1	249.87	85.8
	Simulation 2	207.12	34.72
Yield under Drain Tile (cwt/acre)	Simulation 1	265.12	68.8
	Simulation 2	255.17	43.98
Potato Price	**Minimum**	**Average**	**Maximum**
Price ($/cwt)	$14.50	$18.00	$22.10
Production costs	**Minimum**	**Average**	**Maximum**
Seepage Production Cost ($/acre)	$2,164.02	$2,667.40	$3,003.24
Drain Tile Production Cost ($/acre)	$2,472.02	$2,948.42	$3,747.44
Seepage Water Pumping Cost ($/acre)	$54.32	$60.36	$66.40
Drain Tile Water Pumping Cost ($/acre)	$30.00	$35.05	$40.50
Seepage Labor Cost ($/cwt)	$2.75		$3.25

Drain Tile Labor Cost ($/cwt)	$3.50		$4.00
Drain Tile Installation Cost & Cost Share			
Drain Tile Installation Cost ($/acre)		$4,508.63	
Cost Share (%)		75%	
Cost Share Maximum Cap ($)		$250,000.00	
Inflation Factor		2%	

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