CAN SUBSURFACE DRIP IRRIGATION BE A FEASIBLE AND PROFITABLE PRACTICE FOR GEORGIA COTTON PRODUCTION?

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Situation and Overview

It is estimated that approximately 45% of Georgia's cotton acreage is irrigated (Harrison). The vast majority of this acreage is irrigated with center pivot irrigation. Although non-irrigated production is risky, compared to other crops in Georgia, cotton is considered relatively more drought tolerant. University of Georgia crop enterprise budget estimates assume an expected yield of 700 pounds per acre for non-irrigated production compared to 1,200 pounds per acre for irrigated (Shurley and Smith).

In general, fields in row crop production even on large farms can be small and/or irregular sized. This means it is not uncommon for some fields to be able to accommodate only a relatively small to medium size pivot or for the pivot to not operate a full circle. This increases the investment and fixed costs per acre and thus the yield increase needed to make the system profitable.

There is increased producer and research interest in subsurface drip irrigation (SSDI)—perhaps as an alternative to pivot/overhead irrigation in small-field situations or to irrigate non-irrigated portions of a field that a pivot is unable to reach. There are many factors determining the economics of SSDI and questions from a producer standpoint that need to be addressed before making a decision. These questions include:

1. How do costs compare to center pivot systems?
2. Where and how would SSDI fit in my farming operation?
3. Is SSDI application reliable?
4. Will SSDI yield comparable with pivot irrigation?
5. Is SSDI compatible with different crop row spacing?
6. Is SSDI compatible with my desired crop rotations?
7. What are the implications for tillage practices?

Objectives and Methodology

Research began in 2010 at the University of Georgia Stripling Irrigation Research Park (SIRP) near Camilla, Georgia to investigate the effectiveness and economic viability of SSDI in typical row-crop rotations (Perry). The first full year of data and results was

2011. The purpose of this specific paper is to utilize data from the 2011 study to begin investigating the economic feasibility of SSDI in Georgia cotton production.

The 2011 SIRP study consisted of 22 treatments, 6 replications of each treatment. The 22 treatments are summarized as follows:

SSDI
2 varieties x 2 drip tape depths x 4 application amounts/triggers = 16 treatments

Pivot
2 varieties x 2 application amounts = 4 treatments

Non-Irrigated
2 varieties = 2 treatments

Cotton was planted on 36-inch row spacing. Two varieties were used in the study—DP 1050 B2RF and FM 1740 B2F. For the SSDI portion of the study, drip tape was set on every other row middle (every 72 inches). Drip tape was set at 2 inches (shallow) and 12 inches (deep). For each variety at each depth, irrigation was applied based on 4 triggers or amounts—full, deficit, 40cb, and 70cb. These are as follows:

Full =	100% of the UGA recommendation (Collins, page 113) if adequate rainfall was not received
Deficit =	65% of the UGA recommendation if adequate rainfall was not received
40cb =	100% UGA applied when soil moisture meter reading was 40cb
70cb =	100% UGA applied when soil moisture meter reading was 70cb

For pivot irrigation, only the 40cb and 70cb triggers were used. When triggered, 1 inch of water was applied regardless of the recommendation and growth stage of the cotton.

Yield Results

For the purpose of economic analysis, the main results to be gleaned from the 2011 SIRP study are yield, differences in yield depending on irrigation system type and water application/timing, and irrigated yield compared to non-irrigated.

The average yield for deep drip irrigation (DD) was 1,510 pounds per acre (Figure 1). FM 1740 yielded higher than DP 1050 but the average of both varieties was 1,510 lbs. Shallow drip irrigation (DS) yielded slightly higher at 1,556 pounds per acre average for both varieties. The average pivot irrigated (PVT) yield for both varieties was 1,500 pounds per acre. Statistically, there was no difference in yield between deep drip, shallow drip, and pivot irrigation. The average non-irrigated (NI) yield was 1,071 pounds per acre and was statistically different than irrigated yields.

Deep (12") drip irrigation was evaluated for 2 varieties and 4 water application triggers/amounts (8 treatments) (Figure 2). While yield across all treatments averaged 1,510 per acre, the highest yield was for FM 1740 B2F irrigated using the full (100%) UGA recommendation amount as needed. Yields varied by 409 pounds per acre but there was no statistical difference in yield, however, among the top 7 treatments.

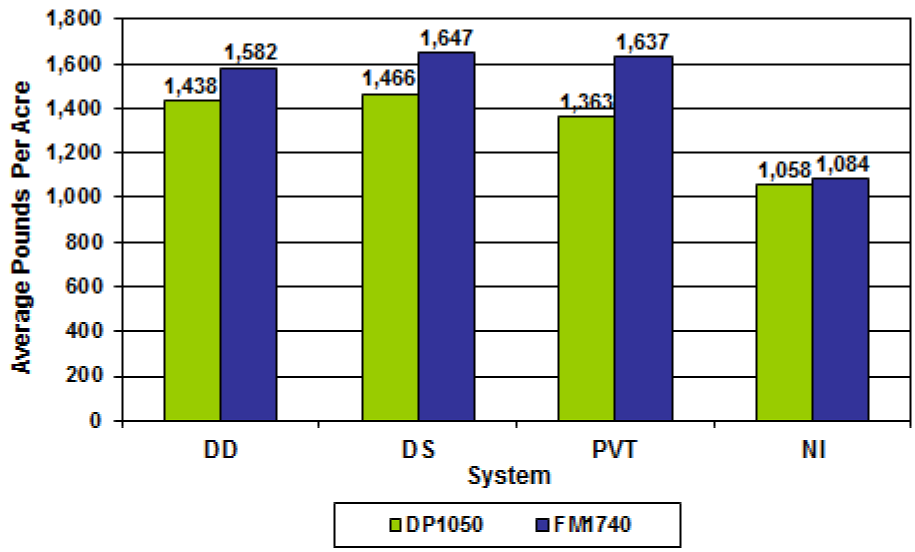

Figure 1. Average Yield of All Applications, By System and Variety

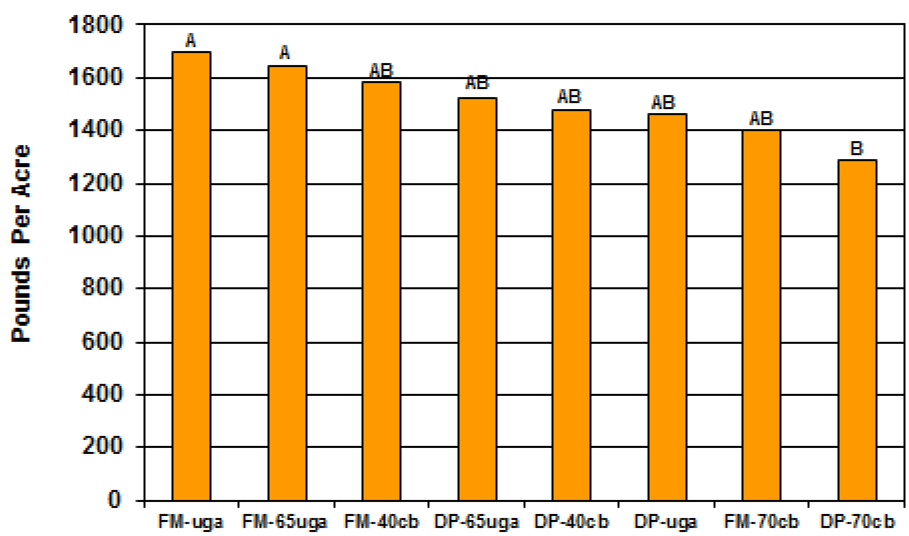

Figure 2. SSDI, 12", By Variety and Application

* Yields with the same letter(s) are not statistically different.

Shallow (2”) drip irrigation was also evaluated for the same 8 treatments (Figure 3). The yield across all 8 treatments averaged 1,556 pounds per acre but ranged from 1,768 pounds per acre to 1,336 pounds per acre. The highest yield was again for FM 1740 B2F, irrigated at the full (100%) UGA recommendation but there was no statistical difference among the top 7 of the 8 treatments.

Shallow (2”) drip out-yielded deep (12”) in 6 of the 8 treatments (Figure 4). The only exceptions were both varieties with irrigation applied at the “deficit” amount (only 65% of the UGA recommendation). Statistically, there was no difference in yield among the top 12 of the 16 treatments. Also, statistically there was no difference in the worst yield and the 6th highest yield.

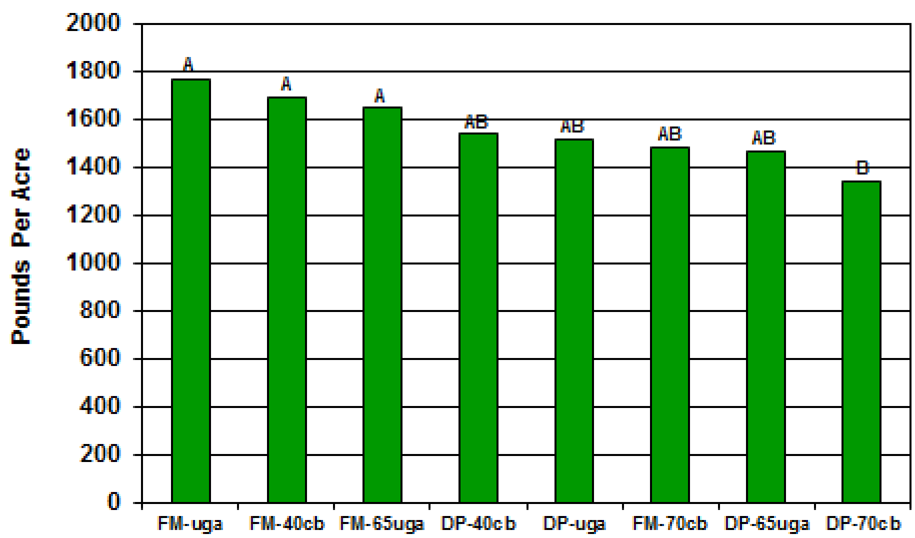

Figure 3. SSDI, 2”, By Variety and Application

* Yields with the same letter(s) are not statistically different.

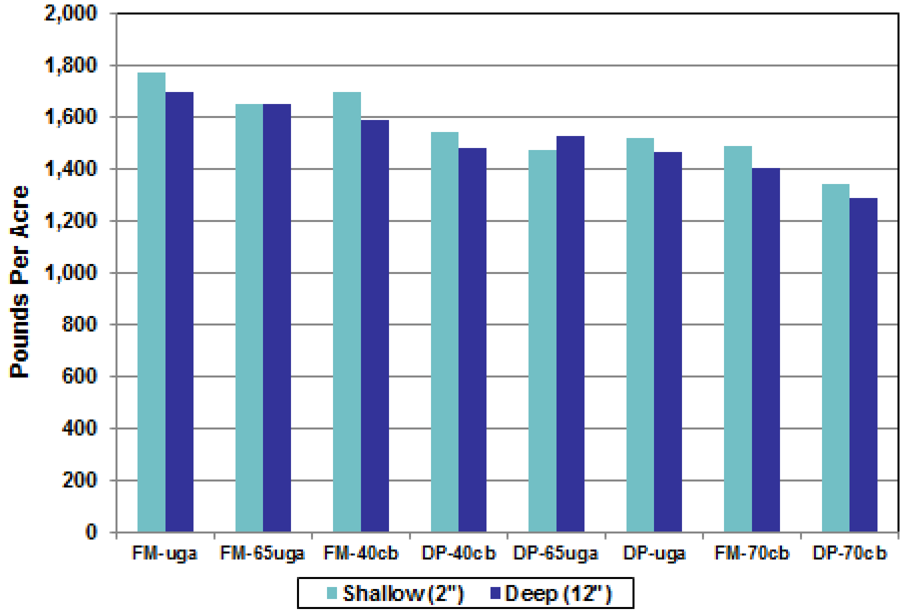

Figure 4. SSDI, By Depth and Variety and Application

Regardless of irrigation method, the lowest yields occurred when irrigation was not applied until the soil moisture sensor reading was 70cb (Figure 5). This resulted in the least number of applications and the least amount of water applied. The remaining yield observations were all within less than 150 pounds per acre of each other regardless of the irrigation type and amount of irrigation applied. The yields shown are the average of both varieties for each treatment.

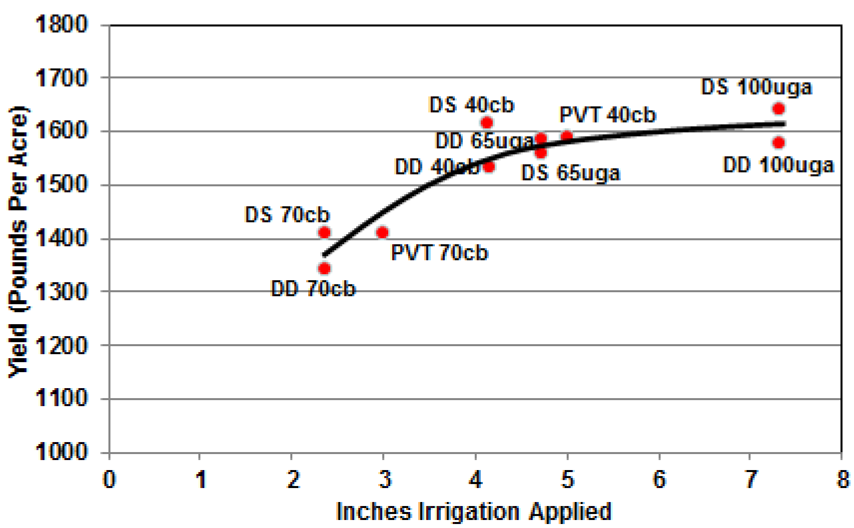

Figure 5. Yield By Treatment and Amount of Irrigation Applied

From these yield results, several conclusions could be made that are relevant to economic analysis:

- Subsurface drip irrigation (SSDI) can result in yield comparable to pivot irrigation.
- SSDI can possibly yield as well as pivot but with less water applied.
- Numerically, shallow drip tends to yield better than deep drip but the yield difference was not statistically significant in this study.
- Irrigated yield averaged 42% higher than non-irrigated yield. Non-irrigated treatment yields were very high, however-- averaging 1,071 pounds per acre.

Economic Comparisons

Where is subsurface drip irrigation (SSDI) likely to be a feasible and potentially profitable production practice? This research analyzes 3 scenarios considered typical of decisions in which using SSDI might need to be evaluated:

1. A well and center pivot (full circle) already exists. Add SSDI to adjacent non-irrigated acres not reachable by the pivot due to field size and/or shape.
2. Smaller, irregular field where a full circle is not possible. A partial pivot (less than a full circle) with remaining area left un-irrigated compared to SSDI for the entire field.
3. Small area not feasible for pivot. SSDI compared to non-irrigated.

In conducting economic analysis for each of these typical on-farm scenarios, several assumptions are made. These include:

- A 450 pound per acre yield difference is assumed between irrigated and non-irrigated production. This would be consistent with 750 pounds and 1,200 pounds per acre for non-irrigated and irrigated production respectively and also consistent with the average yield difference (451 pounds) between all irrigated treatments and the non-irrigated treatments in the SIRP study.
- SSDI is assumed to yield the same as pivot irrigation.
- Fiber quality is not considered. Quality is assumed the same for SSDI, pivot irrigation, and non-irrigated.
- Pivot irrigation is assumed to be 81% as efficient as SSDI (Amosson). For example, if 1" of water were applied by pivot, only .81" of water would need to be applied through SSDI to provide the same benefit to the crop due to less transpiration loss and runoff.
- An average or typical season total application by pivot is assumed to be 8".

For each of the three irrigation scenarios, system costs were actual irrigation dealer bid estimates. These three SSDI scenarios were developed in consultation with producers and irrigation dealers and actual dealer estimates developed for each situation. Each system and each estimate is an actual farm/field situation.

Economic Results

<u>Scenario #1</u>

In this example, there is an existing well and 114-acre pivot (full circle). SSDI is added to 4 adjacent non-irrigated areas (totaling 62 acres) not reachable by the pivot. The SSDI system cost $102,700 or $1,656 per acre.

Annual fixed costs include depreciation, interest, insurance, and taxes. These costs total $137.69 per acre (Table 1). Variable (application) costs include diesel and/or electricity, maintenance and repairs, and labor. These costs are estimated at $11.00 per acre inch of water applied (Shurley and Smith, Amosson). Application is assumed to be 6½ inches per year-- 81% of what is assumed typically applied (8 inches) through center pivot.

In this scenario, SSDI is added to an existing well and pivot system and compared to what would otherwise be non-irrigated cotton not reached by the pivot. Assuming a 450-lb per acre yield increase and applying 6½ inches of water SSDI, net income is estimated to increase by $113.81 per acre (Table 1).

Table 1. SSDI Added to Existing Pivot, Compared to Non-Irrigated, 62 Acres.

Income Gained		**Additional Variable Costs[2]**	
Additional Yield Per Acre	450 lbs	Irrigation Application	$71.50
Net Price Per Lb[1]	$0.80	Other Inputs	$37.00
Additional Income Per Acre	**$360.00**		
		Additional Fixed Costs[3]	
		Depreciation	$62.12
		Interest	$67.29
		Tax and Insurance	$8.28
		Total Additional Cost Per Acre	**$246.19**
Per Acre Net Income Gain or Loss			**$113.81**

1/ Price should include the net gain or loss on cottonseed-- the value of cottonseed minus the cost of ginning, storage and warehousing, classing, and promotions. For this example, this value is assumed to be zero.

2/ Application is 6½ inches at $11 per inch. Other inputs include higher cost under irrigation for fertilizer, etc.

3/ Based on SSDI system cost of $102,700 ($1,656 per acre), average operational life of 20 years with salvage value of 25%, interest rate of 6.5%, and taxes and insurance totaling .8% of average value.

The analysis also assumes an additional cost of $37 per acre for other inputs such as increased fertilizer, defoliation, etc. in irrigated production compared to non-irrigated (Shurley and Smith). In practice, however, since the non-irrigated areas where SSDI is to be installed are adjacent to an area already irrigated, there may be no difference in inputs and production practices between irrigated and non-irrigated.

A net cotton price of 80 cents per pound is assumed but prices are highly variable from year to year. Assuming a 450-lb yield gain, the “breakeven price” needed to cover all additional costs would be 55 cents per pound ($246.19 / 450 lbs = $0.547).

<u>Scenario #2</u>

In this example, a 48-acre rectangular field can be partially irrigated by center pivot. The pivot can cover only a partial circle and irrigate 37 acres. The remaining 11 acres would be non-irrigated. This is compared to using SSDI to irrigate the entire 48 acres.

The 37-acre pivot would cost $52,100 or $1,408 per acre. Alternatively, SSDI on all 48 acres would cost $62,900 or $1,310 per acre.

The cost of the well, pump, and motor are not considered in this analysis because these costs would be incurred and are assumed the same with either pivot or SSDI. In practice, however, SSDI may require less horsepower and less GPM per acre and thus may be cheaper.

For SSDI on the 48 acres, Net Income (return above irrigation costs only) is estimated at $779.57 per acre (Table 2). Alternatively, if 37 acres were irrigated by pivot and 11 acres remained non-irrigated, Net Income is estimated at $727.39 per acre. Net Income is $52.18 per acre higher with SSDI.

Table 2. SSDI Compared to Partial Pivot and Non-Irrigated, 48 Acres.

SSDI (48 Acres)		Pivot (37 Acres)	
Yield Per Acre	1,200 lbs	Yield Per Acre	1,200 lbs
Net Price Per Lb[1]	$0.80	Net Price Per Lb[1]	$0.80
Income Per Acre	**$960.00**	**Income Per Acre**	**$960.00**
Irrigation Application[2]	$71.50	Irrigation Application[2]	$88.00
Fixed Costs[3]		Fixed Costs[4]	
Depreciation	$49.14	Depreciation	$45.06
Interest	$53.24	Interest	$54.92
Tax and Insurance	$6.55	Tax and Insurance	$6.76
Total Irrigation Cost Per Acre	**$180.43**	**Total Irrigation Cost Per Acre**	**$194.74**
Net Income Per Acre	**$779.57**	**Net Income Per Acre**	**$765.26**
		Non-Irrigated (11 Acres)	
		Yield Per Acre	750 lbs
		Net Price Per Lb[1]	$0.80
		Income Per Acre	**$600.00**
		Average Net Income Per Acre[5]	**$727.39**
Per Acre Net Income Gain or Loss			**$52.18**

1/ Price should include the net gain or loss on cottonseed-- the value of cottonseed minus the cost of ginning, storage and warehousing, classing, and promotions. For this example, this value is assumed to be zero.

2/ Pivot application assumed to be 8 inches and SSDI 6 ½ inches. Both systems are assumed to be $11 per inch.

3/ Based on SSDI system cost of $62,900 ($1,310 per acre), average operational life of 20 years with salvage value of 25%, interest rate of 6.5%, and taxes and insurance totaling .8% of average value.

4/ Based on center pivot system cost of $52,100 ($1,408 per acre), average operational life of 25 years with salvage value of 20%, interest rate of 6.5%, and taxes and insurance totaling .8% of average value.

5/ Weighted average of pivot and non-irrigated.

Annual Fixed Cost for the partial center pivot is estimated at $106.74 per acre. This compares to Fixed Cost of $108.93 for SSDI. Because the pivot is not operating a full circle, fixed cost per acre will be high but the difference was expected to be more than this example showed. Fixed Cost per acre for the partial pivot was actually slightly less than for SSDI. The Net Income gain for SSDI was due to yield difference on the non-irrigated portion of the field and lower amount and cost of application in SSDI.

Scenario #3

In this situation, there are adjacent fields unfeasible for pivot due to size and/or shape. SSDI is analyzed as an alternative to non-irrigated production totaling 38 acres.

SSDI for this 38 acres would cost $56,000 ($1,474 per acre). Well, pump, and motor would cost $25,000.

Compared to non-irrigated production, SSDI was estimated to increase net income by $79.13 per acre (Table 3). Additional Income is estimated at $360 per acre and Additional Variable and Fixed Costs are estimated at $281 per acre.

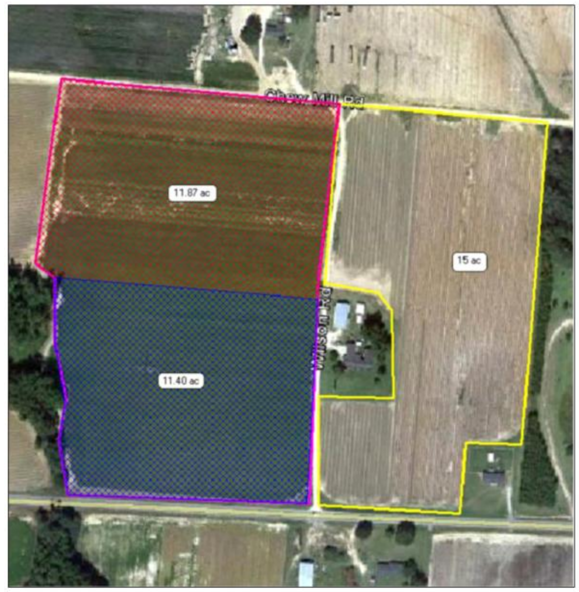

Table 3. SSDI Compared to Non-Irrigated, 38 Acres.

Income Gained		**Additional Variable Costs[2]**	
Additional Yield Per Acre	450 lbs	Irrigation Application	$71.50
Net Price Per Lb[1]	$0.80	Other Inputs	$37.00
Additional Income Per Acre	**$360.00**		
		Additional Fixed Costs	
		SSDI[3]	$122.50
		Well, pump, and motor[4]	$49.87
		Total Additional Cost Per Acre	**$280.87**
Per Acre Net Income Gain or Loss			**$79.13**

1/ Price should include the net gain or loss on cottonseed-- the value of cottonseed minus the cost of ginning, storage and warehousing, classing, and promotions. For this example, this value is assumed to be zero.

2/ Application is 6½ inches at $11 per inch. Other inputs include higher cost under irrigation for fertilizer, etc.

3/ Based on SSDI system cost of $56,000 ($1,474 per acre), average operational life of 20 years with salvage value of 25%, interest rate of 6.5%, and taxes and insurance totaling .8% of average value.

4/ Based on well/pump/motor cost of $25,000, average operational life of 25 years with salvage value of 20%, interest rate of 6.5%, and taxes and insurance totaling .8% of average value..

The analysis assumes a 450-lb yield increase due to irrigation and a net cotton price of 80 cents. Analysis also assumes 6½ inches of water applied and an additional $37 per acre in other variable inputs. The breakeven net price of cotton needed to cover Total Additional Cost of SSDI compared to non-irrigated production is approximately 63 cents per pound ($280.87 / 450 lbs = $0.624 per lb).

Summary and Conclusions

There is increased interest in subsurface drip irrigation (SSDI) as an alternative to pivot/overhead irrigation. There are many factors determining the economics of SSDI compared to pivot irrigation and/or non-irrigated production.

Based on 2011 research conducted at the Stripling Irrigation Research Park (SIRP) near Camilla, SSDI can yield equivalent to pivot irrigation and, further, may be able to do so with less water applied. Numerically, shallow drip irrigation yielded higher than deeper drip but results were not statistically different.

Three on-farm scenarios were identified that were believed to be representative of situations where SSDI might be considered and the types of decisions cotton producers would have to make. Economic analysis (budgeting) of each of these scenarios suggest that SSDI can be profitable to reach adjacent areas not reached by an already existing center pivot but profitability depends on the distance and cost of reaching the non-irrigated area and the amount of area to be irrigated.

Analysis also suggests that SSDI could be a profitable alternative in a situation where a pivot cannot operate a full circle due to field size or shape. In the situation budgeted in this study, the advantage for SSDI was much less than anticipated, however. Every farm situation will vary and economies of scale come into play.

SSDI was also compared to non-irrigated production where a pivot is not feasible. SSDI provided increased net income.

Depending on yield, price, costs, and economies of scale, SSDI can be profitable. Success with SSDI, however, may have as much to do with management as it does with economics. Questions still exist concerning proper depth of the drip tape—2 inches may too shallow and 12 inches may be too deep depending on soil type (texture, depth to B horizon, etc.), slope or erodibility of the field, and other crops in rotation with cotton. How is the feasibility and profitability of SSDI impacted by different row spacings, various crop rotations, and different tillage systems? SSDI may also require use of GPS and auto steer.

Related References

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