Southeast Climate
EXTENSION | Advancing Climate Extension in Agriculture

Adopting Irrigation to Reduce Climate Risk

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What is the problem?

Climate change and climate variability threaten to increase the uncertainty of water supplies, potentially posing major risks to agriculture due to longer and more frequent droughts, more severe floods, temperature extremes, and unusual shifts in pressure from pests (insects and crop diseases). A recent report from the International Panel on Climate Change (IPCC) indicated that "*there is medium confidence that drought will intensify in the 21th century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration*" and suggested that extreme events will have greater impacts on sectors with close links to climate, such as water, agriculture and food security, forestry, health, and tourism.

Areas with predominantly dryland production systems are particularly vulnerable to drought periods. Such is the case in South Carolina and many other areas of the Southeast USA where irrigation is still very limited. For example, Fig. 1 shows the percent irrigated harvested acreage of major row crops in South Carolina to be quite low compared to dryland production. This reflects on relatively low yields for major crops, which are way below potential yields (Fig. 2). Adoption of irrigation, however, would be an effective way to reduce the potential climate risk expected from future droughts in agricultural production. Irrigation in South Carolina, for example, can double crop yields and significantly increase total agricultural production and income of rural areas. This is particularly true since water in South Carolina and much of the Southeast USA is still plentiful compared to many other agricultural areas of the country.

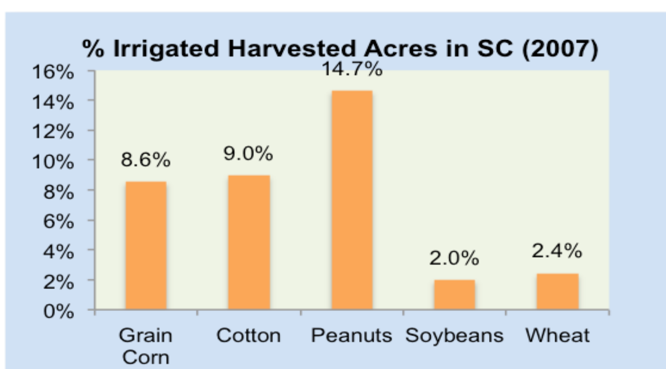

Figure 1. Percent irrigated acres harvested in South Carolina by major row crops.

USDA United States Department of Agriculture National Institute of Food and Agriculture

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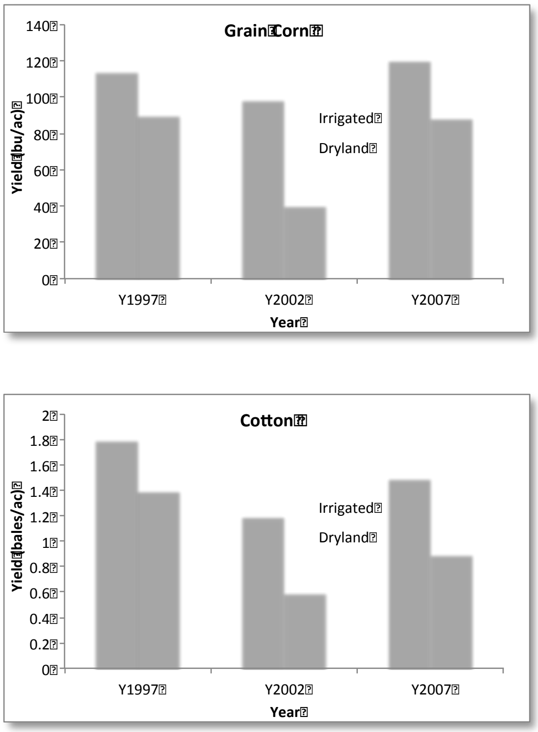

Figure 2. Average irrigated and dryland corn and cotton yields for South Carolina reported in 1997, 2002, and 2007.

How does irrigation reduce climate-related risks?

Drought is the most likely and potentially most devastating climate risk in agricultural production. Irrigation can significantly increase yields over dryland while reducing yield variability and stabilizing production and farm income across seasons. For example, Figure 2 shows the reported average dryland and irrigated yields for corn and cotton in South Carolina during 1997, 2002, and 2007. Even though, the reported irrigated yields were quite low, compared with irrigated yield potential, they were much higher and less variable than the dryland yields.

Similarly, Figure 3 shows dryland and irrigated corn yields for a typical farm in South Carolina simulated using a stochastic method during a 15-year period. It shows that dryland yields are typically much lower, and a lot more variable from season to season compared with irrigated yields. Low yields and yield variability from year to year, make dryland production more risky than irrigated production, especially if droughts become more frequent and severe in the future.

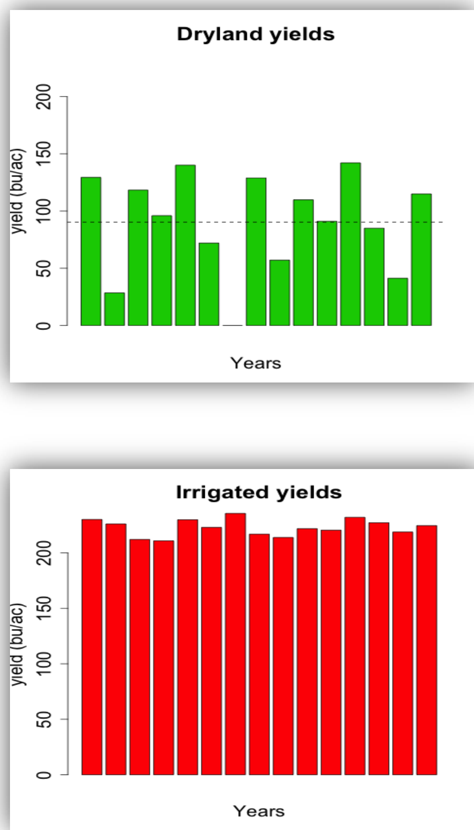

Figure 3. Simulated typical irrigated and dryland corn yields during a 15-year period in South Carolina.

What are the agronomic benefits?

Irrigation prevents crop water stress, which can significantly reduce crops yields and profits. Irrigation also provides water to activate herbicides and dissolves and transports crop nutrients so that they are available to the plant. In some cases, irrigation can also be used to prevent crop damage by freezing temperatures.

What are the impacts on production costs?

Irrigation requires considerable investment over dryland production, but it can also result in considerable increase in yields and profits. Since the farmer can target higher yields with irrigation, crop input requirements, like fertilizer, will need to be higher. Also, irrigation will require investing in irrigation equipment (like a center pivot and pumping station), which represents a significant initial investment and on-going operating costs, such as irrigation labor, water permits, fuel/electricity, equipment repairs and maintenance, etc.

What is the investment cost?

The investment cost of irrigation can be significant and depends on each particular situation. Factors such as the field size, shape, and topography, labor cost and availability, soil type, characteristics of the water source (quality, quantity, depth…), power supply, etc, all affect the type of irrigation system that can be used and the cost of purchasing and operating the system.

For example, Fig. 4 shows a 15-year simulation of irrigation cost (investment + operating cost) from investing on a center pivot to irrigate 100 acres of corn in South Carolina. This assumes that: (1) the irrigation system (center pivot) costs $2,000/acre (including the pump and well), (2) a loan that needs to be repaid in seven years is taken to purchase the system, (3) the current price of electricity is used, and (4) irrigation is applied to meet crop water needs and optimize crop yield. In this case, the cost is relatively high during the first seven years, while the loan is being repaid, but drops significantly afterwards.

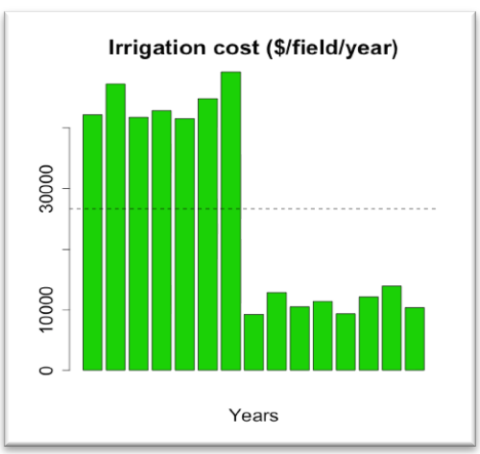

Figure 4. Simulated yearly irrigation cost for a 100-acre corn field in South Carolina.

What are the economic benefits?

Although the cost of irrigation can be significant, it can also be a very profitable investment. For example, we have taken the dryland and irrigated yields shown in Fig. 3 and the irrigation costs in Fig. 4, and calculated the potential economic benefit of investing on irrigation to grow corn, assuming an average corn price of $5.00/bu. Results in Fig. 5 show that net revenue for the irrigated and dryland corn are similar for the first six years, but considerably higher revenues are obtained with irrigation during the following years. Figure 6 shows that during the 15-year period, the average net revenue for the irrigated corn is $860/acre/year compared with $467/acre/year for the dryland corn. This is an advantage of $393/acre/year for the irrigated corn. Figure 7 shows that this difference would accumulate to a total of $5,900/acre during the 15-year period, for a total of $590,000 of additional revenue for the 100 acre field (an average of $39,333/year).

Increased yield and economic benefits of irrigation over dryland production have also been demonstrated by local field research and by local farmers. For example, in a three-year cotton study conducted during 1997 to 1999 in South Carolina, irrigation increased lint yield by an average of 494 lb/ac (65%), which represented an average yearly increase in income of $395 per acre (Table 1).

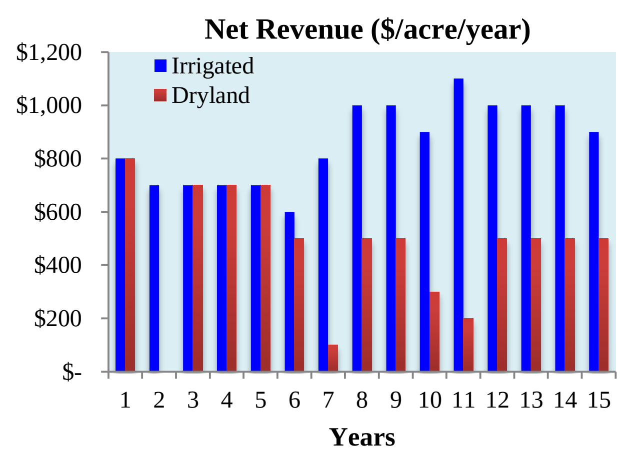

Figure 5. Simulated net revenue for irrigated and dryland corn.

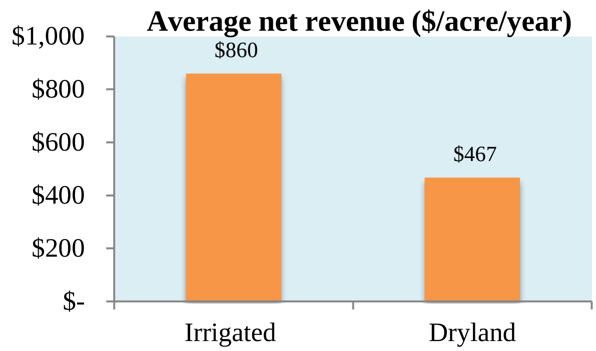

Figure 6. Average simulated net revenue for irrigated and dryland corn over a 15-year period.

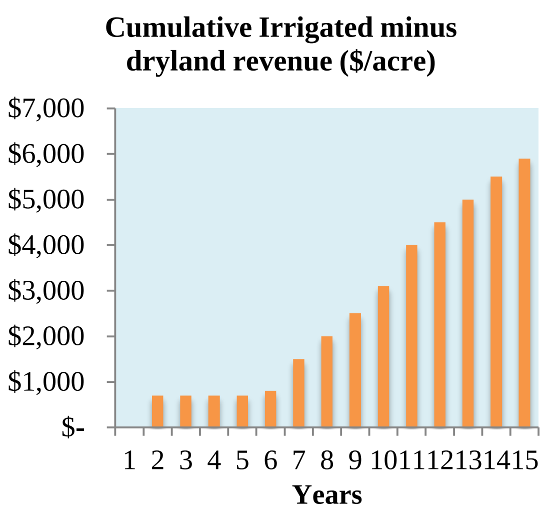

Figure 7. Simulated cumulative net irrigated minus dryland corn revenue during a 15-year period.

Table 1. Cotton production with SDI compared to dry land during three years in South Carolina (cotton price = $ 0.80/lb).

Year	Yield Increase	Income Increase
1997	370 lb/ac (37%)	$296/ac
1998	534 lb/ac (56%)	$427/ac
1999	577 lb/ac (103%)	$462/ac
Average	***494 lb/ac (65%)***	***$395/ac***

Similarly, Table 2 shows an economic comparison between irrigated and dryland production in a commercial farm in South Carolina during a five year period. Irrigation increased yields by 100%, 74%, and 23% and increased net revenue by $235.50, $135.00, and $34.50 per acre for corn, soybeans, and wheat, respectively.

Table 2. Average increase in yield and economic return from irrigation over dryland obtained by a farmer in South Carolina during a five-year period (2009 to 2013).

	Corn	Soybeans	Wheat
Dryland yield (bu/ac)	81.9	27.0	59.0
Irrigated yield (bu/ac)	164.0	47.0	72.5
Yield increase (bu/ac)	82.1	20.0	13.5
Yield increase (%)	100%	74%	23%
Crop Price ($/bu)	$5.00	$11.50	$7.00
Income increase ($/ac)	$410.50	$230.00	$94.50
Irrigation cost ($/ac)	$175.00	$95.00	$60.00
Revenue increase($/ac)	**$235.50**	**$135.00**	**$34.50**

What are the barriers to adoption?

Irrigation requires significant initial investment, which can be a problem for many growers. Also, since irrigation is a long-term investment, its profitability in humid environments depends on uncertain future weather conditions and crop prices.

What are the incentives to adoption?

Incentives to adoption include the potential for significantly higher and less variable yields and farm profits, which significantly decreases farming risk.