EVALUATION OF SUBSURFACE DRIP IRRIGATION STRATEGIES FOR THE OPTIMAL USE OF GROUND WATER FOR COTTON PRODUCTION IN THE TEXAS SOUTH-PLAINS

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Abstract

Increased use of groundwater in the Texas Southern High Plains for irrigated agriculture has led to extensive withdrawals from the Ogallala Aquifer. The regional economy relies heavily on the groundwater supply from the aquifer, which recharges at a rate lower than the current withdrawal rate. Subsurface drip irrigation (SDI) has proven an effective technology not only increasing the longevity of water resources, but also offering producers with relatively greater, higher quality cotton yields. The high investment costs of SDI technology makes the analysis of this technology's implementation imperative to the producer as they consider many options to sustain the future of their operations.

This research focuses on evaluating alternative irrigation strategies for subsurface drip irrigation. The data used in the study was obtained from field experiments from 2002-2006 at the Helms Texas AgriLife Research Farm. The main objective of the research was to compare two strategies of applying available irrigation water and other inputs such as fertilizers, seed rate, herbicides, growth regulators and insecticides. The first irrigation strategy, *High Input,* concentrated the irrigation water on a limited area of the field with the rest of the field receiving no applied irrigation (dryland production). The second strategy, *Normal Input,* spread irrigation water over the entire field. The expected outcome will provide the farmers of the region with a comprehensive evaluation of the economic revenue and benefits associated with the implementation of the two alternative subsurface drip irrigation strategies. Overall, the experimental results will offer the producers a range of options to incorporate into the existing cropping systems to maximize net income with reduced water availability. This study concluded that the *Normal Input* strategy was economically preferred compared to the *High Input* strategy.

Introduction

Increased use of groundwater in the Texas Southern High Plains for irrigated agriculture has led to extensive withdrawals from the Ogallala Aquifer. The regional economy relies heavily on the groundwater supply from the aquifer, which recharges at a rate lower than the current withdrawal rate. Past research has shown subsurface drip irrigation (SDI) to be the most water efficient irrigation method available to producers on the High Plains (Bordovsky, 1998, 2001). On average, SDI has produced 10 to 15% more lint than LEPA, and 15-25% more than low elevation spray systems when using identical pumping capacities over the same period.

Past figures have been derived at SDI levels of what is considered "normal"; accounting for the implementation of different application and management processes of SDI technology was simply beyond the scope of previous studies. Management of SDI has a tremendous impact on economic return thus, economic analysis on management procedure is critical to the producer's operation. This study was conducted to determine whether different input strategies could provide an economic advantage in terms of increased revenue from increased quality and yields.

Materials and Methods

In 2001, a 12-acre SDI system was installed with drip lines in alternate 30-inch furrows. Ten 1.2-acre zones were constructed with zone sizes of 1300 ft by 16 rows. Each zone was independently controlled and metered. From 2002 through 2006, two cotton management strategies were compared in this area. The first strategy was *High Input*, high-yield management scenario with the production goal of 3.5 bales per acre and no restriction on input levels. Following this strategy, SDI is applied in a limited area and all available supplemental water resources were used through the SDI system, with the remainder of the area allocated to dryland production. The second strategy *Normal*

Input provided what is considered "normal" input levels with annual yield goal of 2.5 bales per acre. Following this strategy SDI was applied on a relatively larger area to spread available irrigation water, but would be unable to meet 100% of crop water needs during peak irrigation demand periods.

The *High Input* protocol was first defined in SDI experiments in 2001 (Bordovsky, et al., 2001). Nutrients were applied through the growing season with the SDI system based on yield potential and crop development. Fleahoppers, lygus bugs, and aphids were monitored on a weekly basis from emergence through mid-August and controlled at thresholds to prevent fruit loss or plant stresses. Growth regulators were applied to prevent excessive vegetation. Irrigation water was applied daily in quantities that slightly exceed estimated ET using local climatic conditions.

The *Normal Input* protocol had been used in irrigation systems experiments from 1999 to 2001 (Bordovsky, et al., 2001). Irrigations were limited by a pumping capacity of 3.6 gpm/acre; most of the nitrogen applied prior to planting by ground application; limited growth regulators were applied; and insect pests were treated at locally established thresholds.

Gross revenues for both strategies were calculated and analyzed. Loan price was determined for a sub-sample at harvest for *High, Normal,* and Dry yield. Then a collective yield, determined by machine stripping two 30-foot long rows at five locations, for each of the two strategies was applied to its respective loan price to determine gross revenue for each strategy separately.

Seasonal irrigation value was calculated for both strategies. In the case of *High Input* irrigation value was the revenue from all high-input cropland and dryland yield divided by the acre-inches of the applied irrigation area. The *Normal Input* seasonal irrigation value was derived by calculating the revenue from all normal-input cropland (entire area) divided by the acre-inches of irrigation applied to that area.

Results & Discussion

Table 1. Cotton lint yield, loan values, and water use efficiency from *Normal* and *High Input* treatments irrigated by SDI at TAES, Helms Farm: 2002-2006

	Normal Input	High Input	Difference
Yield (lb lint/ac)			
2002	1055	1197	143
2003	1015	1050	35
2004	1655	1346	-309
2005	492	610	118
2006	1852	1294	-557
Loan Value (lb/ac)			
2002	0.443	0.482	0.039
2003	0.519	0.538	0.019
2004	0.510	0.530	0.020
2005	0.474	0.474	-
2006	0.558	0.553	-0.005
Gross Revenue ($/ac)			
2002	467	574	107
2003	529	568	39
2004	818	642	-176
2005	231	301	70
2006	1036	712	-324
Seasonal Irr. Value ($/ac-in)			
2002	28.47	27.95	-0.52
2003	44.75	39.89	22.9
2004	33.62	14.34	-19.28
2005	-60.38	-21.23	39.15
2006	66.64	31.06	-35.58

Table 1 shows lint yield, loan values, gross production values and seasonal irrigation water use efficiencies for the 2002, 2003, 2004, 2005 and 2006 test years. Until 2004, the *High Input* methodology resulted in higher lint yield, better fiber quality resulting in higher loan values, and higher seasonal irrigation value than the *Normal Input* treatments. However, in 2004, the *High Input* treatment produced 309 lbs/ac less than the *Normal* treatment with respective yields of 1346 and 1655 lb/ac. In 2005, the High Input treatments resulted in numerically higher yields than the normal treatment, with a difference of 118 lbs/ac. In 2005, estimated gross lint value was slightly higher in the *High Input* treatment than the *Normal* treatment; however, this was due to the slightly high yields and not due to differences in fiber values as in previous years. In 2006 cotton lint yields were substantially high in all *Normal Input* treatments. *High Input* treatments produced 557 lb/ac less than *Normal Input* treatment with respective yields of 1294 and 1852 lb/ac. This may have been due to the application of an early season growth regulator on *High Input* treatments, which appeared to have severely slowed plant development in June. This data highlights the importance of finding appropriate management inputs to achieve maximum returns for available water inputs.

Table 2 shows that the average yield difference between the two management treatments over the five-year test period is 41 lb lint/ac/yr in favor of the *Normal Input* treatment. The difference in the average gross revenue over the five-year test was $55/ac/yr in favor of the *Normal Input* treatment. Based on the results to date, in terms of gross revenue and yield, the *Normal Input* strategy is economically preferred to the *High Input* SDI strategy on the Southern High Plains of Texas.

Table 2 Average of the *differences* in *High Inputs* and *Low Inputs* from 2002 - 2006

	Average	Favored Treatment
Average Yield Difference (lb lint/ac/yr)	41 lbs.	*Normal Input*
Average Gross Revenue Difference ($/ac/yr)	$55	*Normal Input*

Figure 1 shows the average lint yields for the *High Input* and *Normal Input* treatments from each year of the test period. Shown in 2002 and 2003 *High Input* treatment yielded more cotton lint pounds per acre. In 2004, *Normal Input* yielded 309 more lbs/ac. There was a *High Input* preference during the hail year in 2005. Finally, in 2006 a substantial difference of 557 lbs/ac was calculated favoring the *Normal Input* strategy

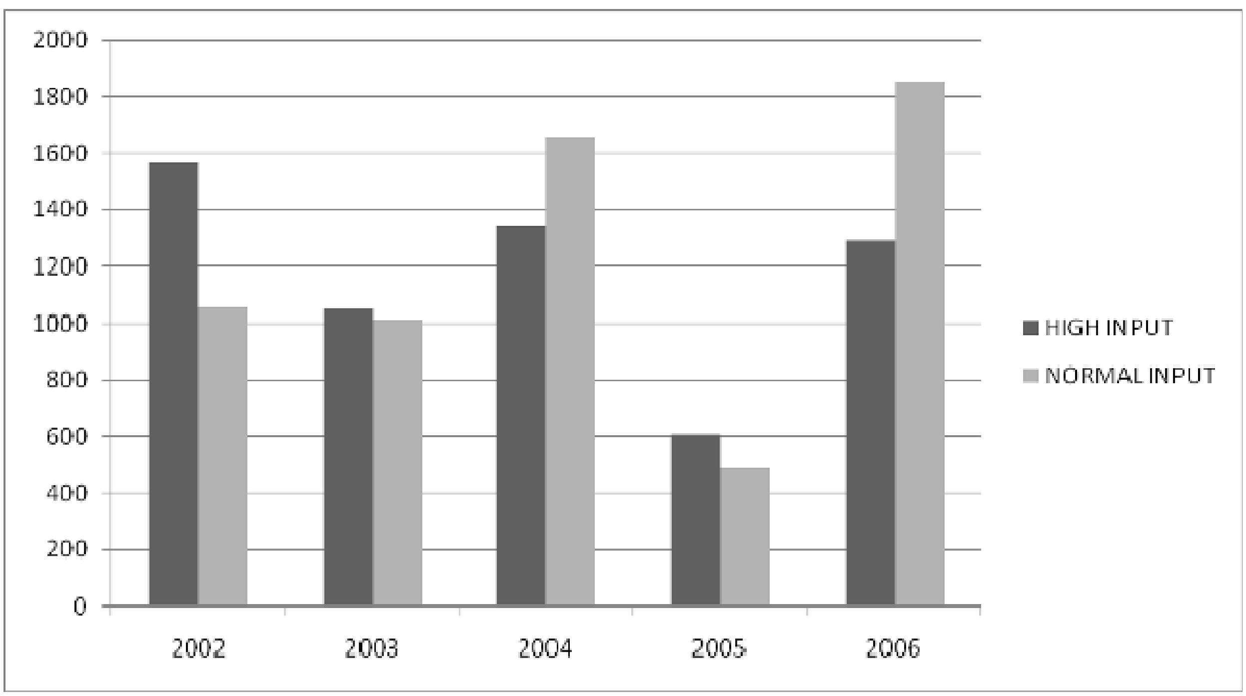

Figure 1. Yearly average cotton lint yield for *High* and *Normal Input* treatments in lbs./ac.

Figure 2 reveals the yearly average seasonal irrigation value for the five-year test period. In 2002 and 2003 numerical differences favored *Normal Input* strategies. There were slightly higher preferences towards *Normal Input* in 2004. In 2005 during the hail year, irrigation was considered of negative value to the crop, even so the *High Input* strategy was less negative. Finally, in 2006 the largest difference out of the five years was in favor of the *Normal Input* strategy.

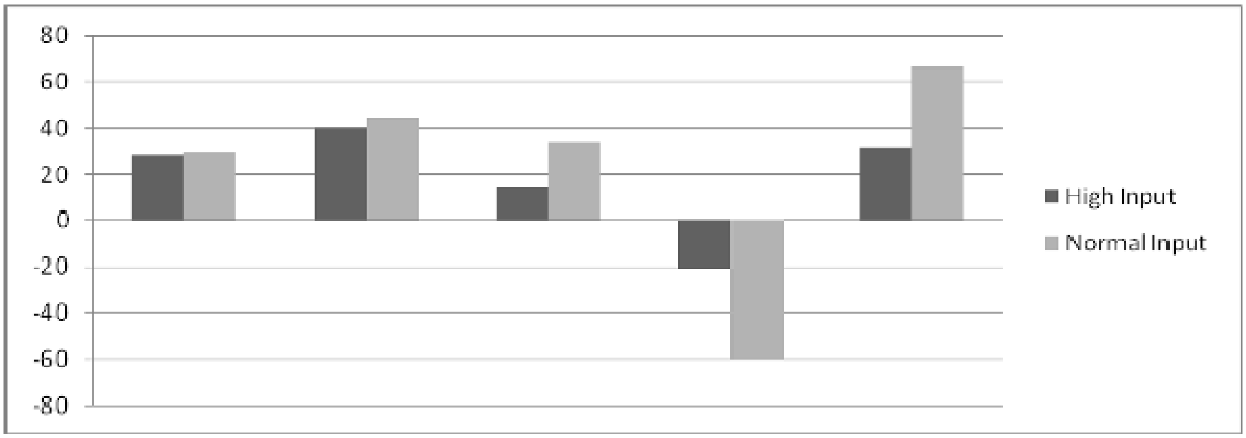

Figure 2. Yearly average Seasonal Irrigation for *High* and *Normal Input* strategies in $/ac-in.

Figure 3 indicates the respective average loan values for each treatment per year. In 2002, the *High Input* strategy brought about $0.03/lb. more than the *Normal* strategy. There was a slight numerical difference in 2003 favoring the *High Input.* In 2004, the *Normal Input* strategy brought about $0.014/lb. more than *High Input.* A difference of $0.018/lb. was evident in 2005 where the *High Input* strategy was favored. Finally, in 2006 the *Normal Input* strategy was favored over the *High Input* strategy by bringing $0.017/lb. more.

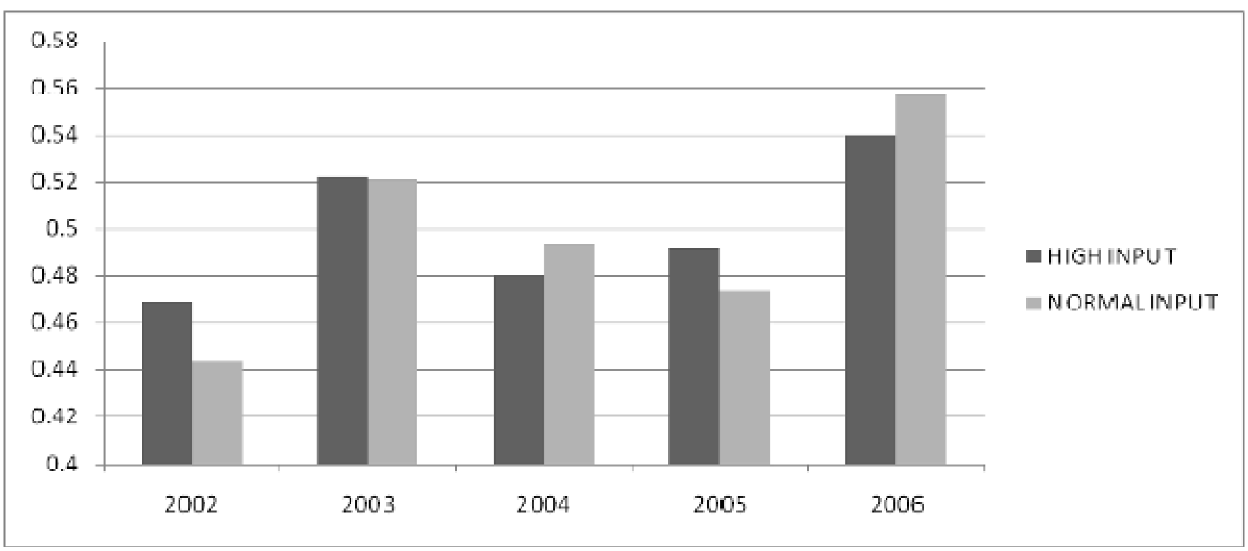

Figure 3. Yearly average loan values for *High* and *Normal Input* strategies in $/lb.

Conclusion

The intent of this study was to determine whether concentrating SDI in a smaller area allocating remaining area to dryland (*High Input* treatment), or the spreading of water resources and other inputs over the equal amount of land (*Normal Input* treatment) was economically preferred. This allows producers to manage their SDI strategies in favor of larger cotton lint yields coupled with higher gross revenues. As water availability decreases in the Southern High Plains of Texas, more SDI systems will be utilized and it is imperative that producers implement the optimal economic SDI strategy. The results of this study show that a producer who is faced with an option to allocate available water resources should spread the resource over the entire field opposed to focusing irrigation on a smaller area of the field with the remainder of the area non-irrigated. Implementing the *Normal Input* strategy will yield more high quality pounds of lint per acre and thus provide higher gross revenue. This study also suggests that the *Normal Input* strategy will bring more dollars per acre-inch per acre than the *High Input* strategy. Thus, the results indicated by this study show that given an area of land under SDI treatment, the *Normal Input* strategy is economically preferred to the *High Input* strategy.

Acknowledgments

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References

Bordovsky, J.P. 1998. Evaluation of high frequency cotton irrigation for planned soil water depletion with LEPA and subsurface drip systems. Project 96-286TX. 1998 Final Report to Cotton Incorporated and the Texas State Support Committee.

Bordovsky, J.P., W. M. Lyle, and E. Segarra. 2001. Economic evaluation of Texas High Plains cotton irrigated by LEPA and subsurface drip. Texas Journal of Agricultural and Natural Resources, 13(1): 67-73.

Bordovsky, J. P., M. Parajulee, J. Gannaway, D. Porter, and E. Segarra. 2005. Subsurface drip irrigation design and management for cotton production. Project 02-210 TX. 2004 Annual Report to Cotton Incorporated.

Bordovsky, J. P., M. Parajulee, J. Gannaway, D, Porter, and J. Johnson. 2006. Subsurface drip irrigation design and management for cotton production, Phase II. Project 02-210 TX. 2006 Annual Report to Cotton Incorporated.