Economic Feasibility of Precision Irrigation
in the Northern Texas High Plains

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Abstract:

The benefit of changing to Variable Rate Irrigation (VRI) from uniform application methods needs to be assessed for technology adoption. Precision irrigation involves water application in optimum amounts. Results indicate that feasibility of precision irrigation depends on field variability, crop value, economies of scale, and useful life of the equipment.

Introduction:

Production agriculture is facing significant challenges such as escalating production cost, limited irrigation water, and increased public concern about possible adverse impacts of agricultural production on the environment. Farmers continue to strive to produce high-quality products by using farm technologies that are profitable and environmentally friendly.

Precision farming recognizes variability in soil fertility, water availability, pest concentrations, and crop characteristics within fields and seeks to optimize variable input use to enhance enterprise profitability and minimize environmental impacts. Economic benefits of switching to variable rate application (VRA) from uniform application methods depend on the economic value of assessing and treating within-field variability. Several variables might be responsible for yield variation in a specific field. These variables could include water, especially for water sensitive crops such as corn, fertility, as well as tillage practices. Marek and Cox (2000) assessed potential and future implementation of precision agriculture technologies in the Northern Texas High Plains. Water was assessed to be the most significant factor in production of corn, with plant population and depth of soil also responsible for significant variation in yield.

In the past the emphasis in precision farming research has been on VRA of fertilizers when assessing the profitability of VRA. Swinton and Lowenberg-DeBoer (1998) compared estimates for VRA of fertilizers for 54 sites in nine studies. Babcock and Pautsch (1998) evaluated the profitability of VRA of nitrogen fertilization relative to uniform rate application. Watkins et al. (1998) also performed an economic and environmental analysis of VRA of nitrogen fertilizers for production of seed potatoes. Research on VRA of water is limited. However, in their economics of precision agriculture study, Yu et al. (2000) included a fertilizer and water interaction term in a yield estimation model of irrigated cotton production in the

Southern High Plains of Texas. Results indicated that the interaction of fertilizer and water significantly affected yield. Marek and Cox (2000) in their assessment of VRI potential determined that irrigation water was the most significant factor in the production of corn in the Northern Texas High Plains.

A producer seeking to invest in VRA equipment is faced with the questions, "How much will it cost? How much will yield potential be increased? Will additional returns offset the investment cost?" Knowledge of spatial variability and yield increase can help a farmer make appropriate economic decisions about adopting VRA. In the semi-arid region of the Texas High Plains, research indicates that water is an important production input. In an earlier precision farming study by Marek et al. (2001), analyses of producer yield maps revealed that yield was variable enough to justify investment in precision irrigation technology.

Objectives:

The goal of this research was to assess economic feasibility of alternative VRI controller technology. The specific objectives were to:

- identify and analyze the investment cost of VRI technology in Texas
- evaluate the breakeven variability in the field and estimate the breakeven yields of grain crops to offset the cost of technology.

Methodology:

Studies of site-specific management have often focused on changes in crop input cost, such as fertilizer or herbicide, while ignoring fixed investment costs. Fixed costs represent annualized costs associated with durable capital investment required for VRA and other necessary equipment. The cost estimate data for most of the equipment and technology used in precision irrigation is collected from manufacturers and suppliers. Evaluating the feasibility of

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investing in a new farm technology can be very complicated because of all the factors involved. However, methodology involved in making the decision is relatively simple. First, the gross investment cost should be estimated. Gross investment indicates the amount of capital that will be required. However, net investment that adjusts gross investment by considering tax savings, future salvage value and opportunity cost of investment provides an estimate of the "true" economic cost.

The annual cost of using site-specific tools depends on the useful life of that equipment, software and skill. If site-specific management tools are obsolete in three to four years, the annual cost of use can be expensive. Because a dollar five years from now is not worth the same as a dollar today, all annual costs and benefits need to be discounted to today's dollar. This will allow direct comparison of the costs and benefits of a site-specific management technology. The fundamental analysis for the economic cost of investing in VRI technology and the benefits generated from an increase in potential yield is conducted by applying a standard cost benefit analysis. A farmer will break even if the expected additional returns above the input costs are equal to the cost of VRI depending upon the spatial variability in the field.

To assess the economic feasibility of VRI, investments of $10,000, 15,000 and 20,000 are assumed as possible bases for a VRI control setup on a center pivot systems. These values are assumed for irrigation systems ¼, 3/8 and ½ mile long, respectively, and correspond to 125, 284 and 500-acre systems, respectively. Life expectancy of the system is assumed to be 5 years with a discount factor of 4.2124 at the discount rate of 6%. This yields an additional investment cost of $69.89, $46.30 and $34.94 per acre for each of the systems, respectively. (As new generation control systems are developed, a 10- to 15- year life could be expected, improving the feasibility prediction.)

Prices used in the economics portion of the analysis were based on 5-year average values obtained from local markets. The average prices for the respective crops within the region are as follows: corn - $2.78/bushel, sorghum **-** $4.36/cwt, soybeans- $5.66/bushel and wheat - $3.51/bushel. Yield variability used in the respective economic analyses varied from 20 to 50%.

The future streams of returns over five years were discounted to present value (PV) using a discount rate of six percent and compared with the initial cost for investing in the technology. If PV is greater than the investment, adopting precision agriculture will be profitable. However, if PV were less than the investment, precision agricultural technology would not be feasible to implement. Given the average prices of the major crops grown in the area, corn, sorghum, soybean, and wheat, and field variability assumption, breakeven additional yields were also estimated for three center pivot irrigation systems.

Results and Discussion:

Before investing in variable rate irrigation technology, yield maps for each crop in each field under each crop need to be reviewed carefully because not all fields are suitable for implementation of variable rate irrigation on center pivot systems. A field with a center pivot not suitable for VRI is presented in Figure 1. It indicates a nozzling problem rather than yield deviation problem down the lateral and the problem could be corrected without using VRI. However, the field represented by Figure 2 is considered more appropriate for use of VRI. Figure 3 exhibits a corn yield map illustrating a production system that is a good candidate for VRI. Such a field shows a potential for improvement with VRI. However, Figure 2 is considered the best candidate for VRI because sectoring alone cannot fully solve the variable yield problem. As an example, the breakeven requirement procedure using yield maps for center pivot field can be illustrated in Figure 3 by outlining the sub level production area(s) within the

histogram bins by using the polygon tool available with most yield mapping software packages. These tools compute the respective sub area(s) and associated yield. The 82-acre area represented in Figure 3 is outlined by the black line polygon and indicates the improvement area required for breakeven by using a VRI system. The outlined region, which is relatively small, would require only 15 bushels per acre gain to breakeven with a VRI system cost of $20,000. This improvement would have to be sustained for five years.

Breakeven additional yield levels required for justifying additional investment in VRI for corn ranged from 12-30 bushels per acre for the ¼-mile and 6-15 bushels per acre for ½-mile center pivot system depending on the variability in the field (Table 1). For soybean, the breakeven yield ranged from 3-15 bushels per acre for the various systems (Table 2). For irrigated wheat, the expected breakeven yield ranged from 5-24 bushels per acre for the three sizes of center pivot systems (Table 3). For sorghum, additional yield ranged from 380-1,900 pounds per acre for the three center pivot systems at various levels of field variability (Table 4). The sensitivity analyses were conducted for each crop by varying the output prices. The breakeven yield results at those output prices were also included in the respective tables.

Additionally, greater yields might be obtained from fields with much variability in amounts of irrigation applied to different areas than from fields where irrigation was uniform. Also, VRI would be feasible for crops of high value but low-value crops require substantially greater yields to breakeven. Hence, substantial field variability and high crop prices are required for VRI to be profitable.

Variable rate irrigation could be feasible and represent an important tool in the technologies associated with precision agriculture in the northern Texas High Plains. This

feasibility is more apparent with higher value and more water-use sensitive crops. It seems that

VRI would be feasible for most crops grown in the region.

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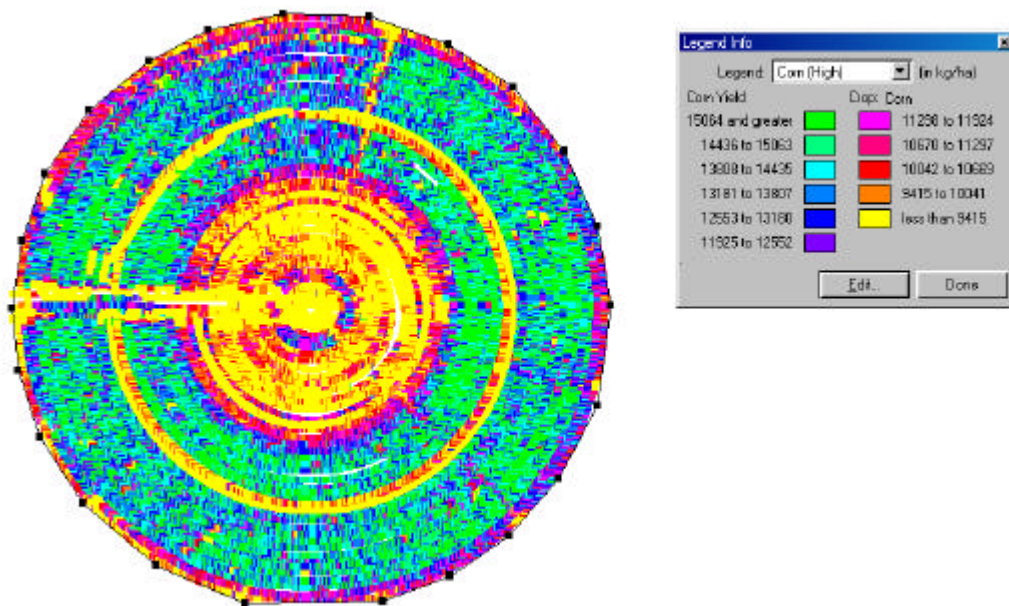
Figure 1. Corn yield map illustrating a center pivot irrigation system that is not a suitable candidate for VRI.

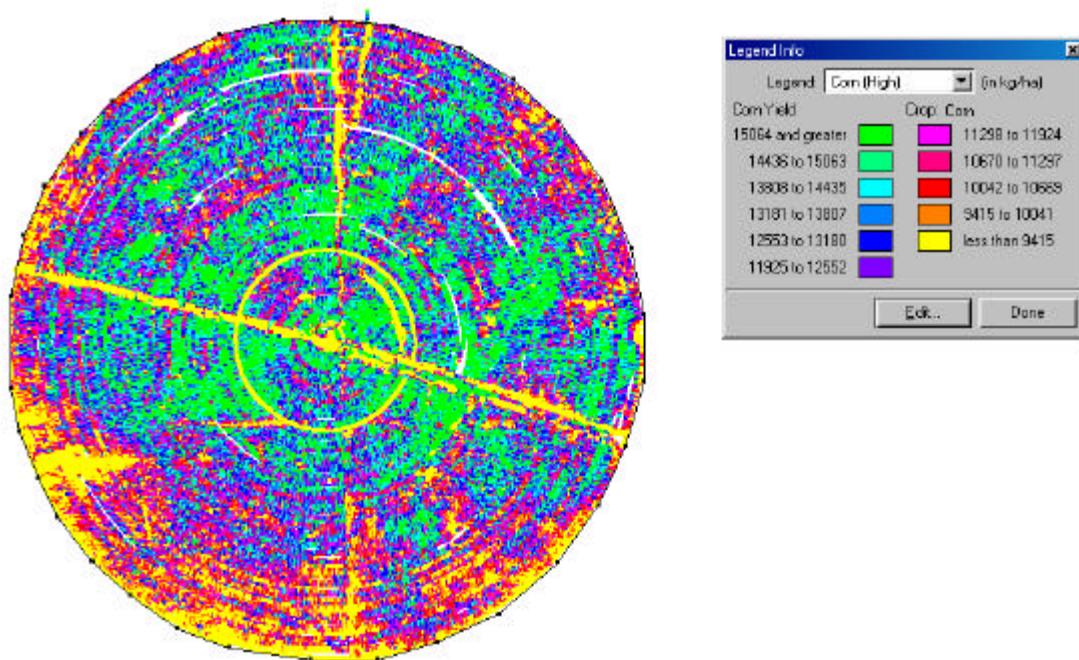**Figure 2. Corn yield map illustrating a center pivot irrigation system that is an excellent candidate for VRI**
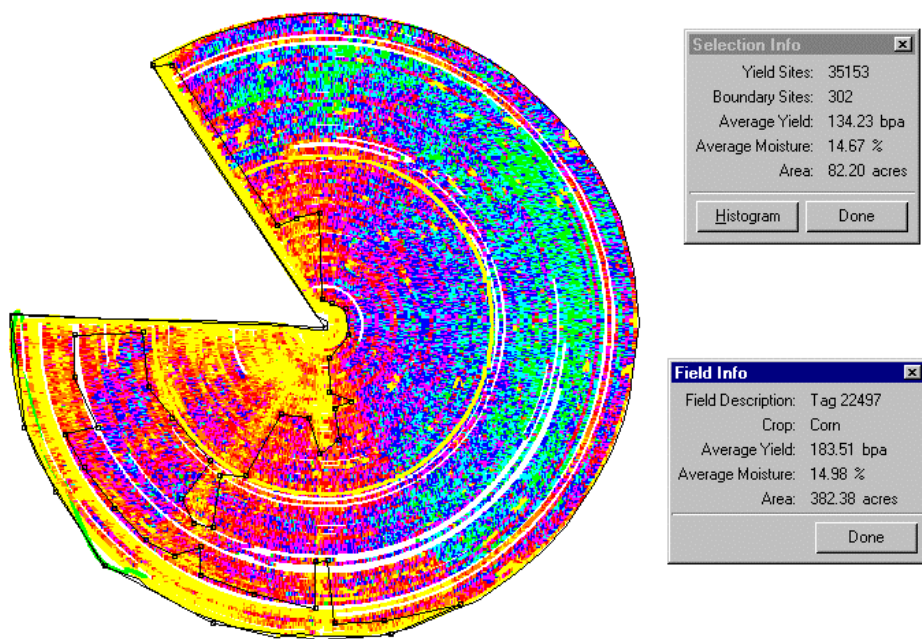
Figure 3. **Corn yield map illustrating a center pivot irrigation system that is a good candidate for variable rate irrigation.**

Table 1. Corn breakeven yield required for implementation of VRI on various lengths of center pivot irrigation systems assuming different output prices and field variability.

	Field Variability (%)	10	20	30	40
Output Price ($/bu)	System Length (mile)	Breakeven Yield (bushels/acre)			
	¼	33.18	22.12	16.59	13.27
2.50	3/8	21.98	14.66	10.99	8.79
	½	16.59	11.06	8.29	6.64
	¼	29.84	19.89	14.92	11.94
2.78	3/8	19.77	13.18	9.88	7.91
	½	14.92	9.95	7.46	5.97
	¼	27.65	18.43	13.83	11.06
3.00	3/8	18.32	12.21	9.16	7.33
	½	13.82	9.22	6.91	5.53

Table 2. Soybeans breakeven yield required for implementation of VRI on various lengths of center pivot irrigation systems assuming different output prices and field variability.

Field Variability (%)		10	20	30	40
Output Price ($/bu)	System Length (mile)	Breakeven Yield (bushels/acre)			
5.32	¼	15.59	10.40	7.80	6.24
	3/8	10.33	6.89	5.17	4.13
	½	7.80	5.20	3.90	3.12
5.66	¼	14.66	9.77	7.33	5.86
	3/8	9.71	6.47	4.85	3.88
	½	7.33	4.88	3.66	2.93
6.00	¼	13.83	9.22	6.91	5.53
	3/8	9.16	6.11	4.58	3.66
	½	6.91	4.61	3.46	2.76

Table 3. Wheat breakeven yield required for implementation of VRI on various lengths of center pivot irrigation systems assuming different output prices and field variability.

Field Variability (%)		10	20	30	40
Output Price ($/bu)	System Length (mile)	Breakeven Yield (bushels/acre)			
3.25	¼	25.53	17.02	12.76	10.21
	3/8	16.91	11.27	8.45	6.76
	½	12.76	8.51	6.38	5.10
3.51	¼	23.63	15.76	11.82	9.45
	3/8	15.66	10.44	7.83	6.26
	½	11.82	7.88	5.91	4.73
3.75	¼	22.12	14.75	11.06	8.85
	3/8	14.66	9.77	7.33	5.86
	½	11.06	7.37	5.53	4.42

Table 4. Sorghum breakeven yield required for implementation of VRI on various lengths of center pivot irrigation systems assuming different output prices and field variability.

Field Variability (%)		10	20	30	40
Output Price ($/cwt)	System Length (mile)	Breakeven Yield (cwt/acre)			
4.00	¼	20.74	13.83	10.37	8.30
	3/8	13.74	9.16	6.87	5.50
	½	10.37	6.91	5.18	4.15
4.36	¼	19.03	12.68	9.51	7.61
	3/8	12.60	8.40	6.30	5.04
	½	9.51	6.34	4.76	3.80
4.72	¼	17.58	11.72	8.79	7.03
	3/8	11.64	7.76	5.82	4.66
	½	8.79	5.86	4.39	3.51