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A CASE STUDY ANALYSIS OF A PRECISION FARMING SYSTEM FOR COTTON

J.A. Larson, R.K. Roberts, B.C. English, and R.L. Cochran
Department of Agricultural Economics
The University of Tennessee
Knoxville, TN
T. Sharp
Jackson State Community College
Jackson, TN

Abstract

Cotton farmers lack information on costs and required returns to pay for investment in precision farming technologies. This research evaluated the breakeven yield gains and input savings required to cover the cost of investment in a precision farming system for gathering site-specific information and applying crop inputs using that information and variable rate technology.

Introduction

Precision farming has the potential to improve profitability by increasing yields and lowering input costs for farmers while providing environmental benefits to society. These benefits are potentially very important in input intensive cotton production. One of the impediments to the adoption of precision technology by cotton farmers has been the lack of a reliable yield monitoring system. Cotton yield monitors, first introduced in 1997, had poor accuracy and were not reliable (Searcy and Roades, 1998; Valco et al., 1998; Durrence et al., 1999). Subsequent cotton yield monitor technology introduced in 2000 appears to be more reliable and may facilitate the adoption of precision farming practices by cotton farmers (Perry et al., 2001). Because precision farming has not been as widely adopted in cotton production as in other crop production, information about the yield gains and input savings required to pay for a precision farming system would be useful for farmers considering an investment in the technology. The objectives of this study are: 1) to evaluate the per acre cost of investing in precision farming system for gathering site-specific information and applying crop inputs using that information and variable rate technology (VRT), 2) to determine the breakeven yield gains and input savings needed to pay for the precision farming system, and 3) to compare the breakeven levels with estimated costs and returns from a West Tennessee precision farming demonstration.

Data and Methods

The following breakeven equation was used to evaluate the effects of changes in revenues and costs associated with the decision to invest in a precision farming system:

$$\sum_{i=1}^{n} \Delta y_i = \frac{\sum_{i=1}^{n} (r_i \Delta x_i \lambda_i + oic_i) + \frac{fc}{ca} + \pi}{p \sum_{i=1}^{n} \lambda_i} \qquad [1]$$

where Δy is the gain in lint yield (lb/acre) from applying a crop input using site-specific information to make the VRT decision for input i (lb/acre), r is price per unit of crop input x ($/unit), Δx is the difference in the input application rate for VRT versus uniform rate technology (URT) (units/acre), oic is the cost of other information used to make the VRT decision ($/acre), fc is the ownership costs for the precision farming system ($), π is a profit goal on investment in precision farming ($/acre), ca is cotton enterprise acreage, p is cotton lint price ($/lb), and λ is proportion of cotton acreage affected by the VRT decision ($0 \le \lambda \le 1$). Fixed costs include annual charges for depreciation, interest, taxes, insurance, and housing.

Equation (1) was used to estimate the breakeven yield gains and input savings required to pay for the precision farming equipment set used on several West Tennessee precision farming demonstration fields (Table 1). Ownership costs were calculated for an Ag Leader Technology PF 3000 cotton yield monitor (Ag Leader Technology, 2002). Computer hardware and GIS field mapping software costs were an average for several software vendors. A Rawson variable rate controller and a Micro-Trak® MT-9000 controller make up the equipment set for variable rate application of inputs (Rawson Control Systems, Inc., 2003; Micro-Trak® Systems, Inc., 2003). Depreciation and interest were calculated using the capital recovery method, a zero salvage value, and a real rate of interest of 7% (U. S. Department of Agriculture, Economic Research Service, 2001; Congress of the U.S., Council of Economic Advisors, 2001). Taxes, insurance, and housing were calculated as 2% of purchase cost (ASAE Standards, 2000). An expected lint price of 56 ¢/lb was used to calculate breakeven values. The expected price was calculated using detrended Upland farm prices reported between 1970 and 2000 (U.S. Department of Agriculture, Economic Research Service, 2001). Nominal prices were inflated to 2000 dollars by the Implicit Gross Domestic Product

Price Deflator before detrending (Congress of the U.S., Council of Economic Advisors). Fixed costs per acre were calculated for different farm sizes and the assumption that one four-row picker can harvest 712 acres in one season (Cooke, Parvin, and Spurlock, 1991). In addition, an expense of \$2.50/acre was assumed for remote sensing using aerial photography and a charge of \$20/acre was assumed for precision farming consultation services. Yield gains and input savings to pay for the precision farming system were calculated for different farm sizes and input savings scenarios ranging from 0 to 30% below the base URT input level.

The estimated yield gains and input savings were compared with those obtained from a precision farming demonstration conducted on four paired farm fields (8 Fields total) near Sommerville in Fayette County, Tennessee. One of the paired fields at each site was managed using the site-specific information VRT application of inputs. The other field was managed conventionally using Ag Extension Service recommended rates. Each field classed into five productivity zones via NDVI classing. The five zones were consolidated into three for VRT application of inputs. For the VRT managed fields, input usage was reduced in the low and medium productivity zones. VRT was used to manage seed, in-furrow fungicide, insecticide, growth regulator, and harvest aid inputs.

Results

Total annual ownership cost of the precision farming system for a farm with one four-row picker was estimated to be \$5,891 (Table 2). Annual ownership costs per acre range from \$16.55/acre for a farm with 356 acres of cotton to \$3.90/acre for a farm with 3,560 acres of cotton (Table 3). Ownership cost results indicate that most of the farm size cost advantage for the precision farming system was achieved for farms with over 1,000 acres of cotton. Ownership costs per acre would be less for cotton if some of the expenses for the computer, software, and VRT equipment were allocated to other crop enterprises. The yield monitor console could also be used for other crops, which can further reduce the per acre ownership costs when its cost is allocated over all crop acres.

Required lint yield gains to pay for the information system for different VRT input saving scenarios are presented in Table 3. The breakeven values were calculated assuming expenditures of \$20/acre for precision farming consulting services and \$2.50/acre for remote sensing. If no input savings are realized, the required yield gains to pay for the precision farming system range from 70 lb/acre for a farm with 356 acres of cotton to 47 lb/acre for a farm with 3,560 acres of cotton. The required yield gains to pay for the precision farming system are considerable less for the 30% input savings scenario—varying from 20 lb/acre for a farm with 356 acres of cotton to −2 lb/acre for a farm with 3,560 acres of cotton. The largest factor influencing the required yield gains was the \$20/acre precision farming consultant fee. Breakeven yield gains are considerable lower when the precision farming consultant fee is cut in half to \$10/acre.

The estimated average input savings from the precision farming demonstration average \$24.09/acre. Results indicate that the input savings alone do not pay for costs of the system used in West Tennessee precision farming demonstration when assuming a \$20/acre consulting fee. Lower expenditures for consulting services improve the relative profitability of the system. Allocating some of the ownership costs to other crops would also improve the relative profitability of the system for cotton. Using the precision farming system for other input decisions such as fertilizer and lime could result in more input savings that would also improve the relative profitability of the precision farming system. Another factor influencing the input cost savings with precision farming was the relatively low proportion of acreage in the low productivity zone. More acres in the low productivity zone would also improve the relative profitability of the system. Yields in the low and medium productivity zones did not appear to be negatively impacted by reduced input usage with VRT application of inputs.

Conclusions

Farmers who invest in precision farming need particular levels of lint yield gains and input savings to pay for their investment. Results indicate that it is more economically feasible for larger cotton farms to adopt the precision farming system because costs can be spread over more cotton acreage. Results also indicate that input savings alone do not pay for costs of the system used in West Tennessee precision farming demonstration when all ownership costs are allocated to cotton. Allocating some of the ownership costs for certain equipment to other crops improves the relative profitability of the precision farming system for cotton.

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Table 1. Cotton Precision Farming System Equipment and Other Costs.

Item	Purchase Cost	Useful Life	Salvage Value
Yield Monitor			
Monitor/Controller	2,295	8	0
Sensors (Cost per Sensor)	3,185	8	0
GPS Unit	2,995	5	0
Flash Card	100	5	0
Installation	500	8	0
Total	9,075		
Computer Hardware and Software			
2 iPAQs	800	3	0
Site-Mate	750	20	0
Desktop Computer and Printer	1,890	3	0
PC Card Reader	25	3	0
GIS Field Mapping Software	2,186	20	0
Annual Software Updates	825		
Annual Training Allowance	500		
Total	6,976		
Variable Rate Application			
Micro-Trak MT-9000	1,750	8	0
GPS Unit	2,995	5	0
Rawson ACCU-RATE (single)	3,925	8	0
Installation	500	8	0
Total	9,170		

Table 2. Cotton Precision Farming System Annual Ownership Costs.

Item	Capital Recovery Charge	Taxes, Insurance, Housing	Total Annual Cost
Yield Monitor			
Monitor/Controller	384	46	430
Sensors	533	127	661
GPS Unit	730	60	790
Flash Card	24	2	26
Installation	84	10	94
Total	1,756	245	2,001
Computer and Software			
2 iPAQs	305	16	321
Site-Mate	71	15	86
Desktop Computer and Printer	720	38	758
PC Card Reader	10	1	10
Field Mapping Software	206	44	250
Annual Software Update	0	17	17
Annual Training Allowance	500		500
Total	1,812	130	1,941
Variable Rate Application			
Micro-Trak MT-9000	293	35	328
GPS Unit	730	60	790
Rawson ACCU-RATE (single)	657	79	736
Installation	84	10	94
Total	1,765	183	1,948
Total Annual Cost	5,333	558	5,891

Table 3. Required Yield Gains to Pay for a Precision Farming System for Alternative Input Savings Scenarios Assuming Consulting Services and Remote Sensing Cost of $22.50/Acre.

	Ownership	Yield Gains for Alternative Input Savings Scenarios			
Cotton	Cost/Acre	0%	%10	%20	30%
Acreage	$/Acre	---------------Lb/acre-----------			
356	16.55	70	53	37	20
712	8.27	55	38	22	5
1,068	7.39	53	37	20	4
1,424	5.54	50	34	17	1
1,780	5.56	50	34	17	1
2,136	4.63	48	32	15	−1
2,492	4.77	49	32	16	−1
2,848	4.18	48	31	15	−2
3,204	4.34	48	31	15	−2
3,560	3.90	47	31	15	−2