Analysis of Breakeven Yield Gains and Input Cost Savings for a Cotton Yield Monitoring Information System

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An integral part of precision farming is the advanced computer-based technologies that are used to identify and measure spatial variability of crop yields in a farm field and its causes, prescribe site-specific input applications that match varying crop and soil needs, and apply those inputs as prescribed using variable rate technology (VRT). A popular entry point for farmers interested in precision farming is the installation of yield monitors on harvesting equipment (Lowenberg-DeBoer). Electronic yield monitor technology provides farmers a way to collect detailed information about crop yields. Spatial yield data that have been referenced to specific locations in a farm field using a Global Positioning System (GPS) can then be converted from raw data into a yield map using Geographic Information System (GIS)-based precision farming computer applications. This database of field spatial variability can be combined with other information (e.g., grid soil sample data) to make field maps for VRT input applications.

Evidence about the degree to which farmers have adopted yield monitors is scattered and incomplete. Nonetheless, a few studies provide estimates of yield monitor adoption rates by farmers. In a 1996 USDA personal interview survey of 1,673 corn farms in 16 states, 5.5% of producers reported using yield monitors (Daberkow and McBride). A 1997 mail survey of 1,000 farmers in four North-Central states—Illinois, Indiana, Iowa, and Wisconsin—found that 9.8% of farmers used yield monitors (Khanna et al.). Novartis surveyed 2,366 corn producers and found that 16% had yield monitors in 1998, but only 4.5% had those monitors linked to GPS. Of large farms with more than a thousand acres, 47.5% had yield monitors with 26.2% having the monitor attached to GPS (Novartis). A 2001 mail survey in six southern states indicate that a smaller percentage of cotton farms had adopted cotton yield monitors when compared with grain yield monitor adoption on Midwest crop farms (Roberts et al.). Survey results indicated that

2.8% of 1,373 survey respondents use cotton yield monitors. In contrast to the Novartis survey, nearly three quarters (73.7%) of cotton yield monitor adopters had their monitors linked to GPS.

Most farmers who had adopted yield monitors were using them as a stand-alone technology for making decisions (Lowenberg-DeBoer; Khanna et al.). Khanna et al. found about half the farmers surveyed were using yield monitors to make input decisions but two-thirds of yield-monitor users were not using VRT to apply those inputs. Farmers appeared to be establishing a history of field variability before making variable rate input decisions (Swinton, Harsh, and Ahmad). Yield monitor adopters also appeared to be creating databases for drainage decisions and land rental negotiations (Khanna et al.).

One of the impediments to the adoption of precision farming technology by cotton growers has been the lack of a reliable cotton yield monitor (Searcy and Roades; Valco et al.; Durrence et al.; Sassenarath-Cole et al.). Yield monitors were first developed for grain and oil seed crops in the early 1990s (Mangold). Seed cotton proved to be much more difficult to measure as it flows through the picker, which impeded the development of reliable monitoring technologies. Early models of cotton yield monitors first introduced in 1997 were plagued with numerous problems including poor accuracy, failure to maintain calibration, and sensors that tended to become blocked by dust and other materials (Wolak et al.; Durrence et al.; Roades, Beck, and Serecy). Cotton yield monitor technologies introduced in 2000 appear to be much more reliable and may be more readily adopted by cotton growers (Perry et al.).

Because cotton yield monitors are a relatively new technology, growers lack information about the costs of a yield monitoring information system. This cost information would be useful in estimating the returns required from enhanced management decision making to cover the costs of gathering and analyzing yield data. The general objective of this research was to evaluate the costs of a yield monitor information system for cotton. The specific objectives were: 1) to evaluate cotton yield monitor information costs as a function of cotton and other crop acreage; and 2) to determine breakeven lint yield gains and input cost savings required to cover the fixed costs of the information system.

Methods and Data

System Components

Currently, several manufactures market cotton yield monitors to farmers (Perry et al.). The example yield monitor used to evaluate costs in this study is the PF3000 Precision Farming System manufactured by Ag Leader Technology, Ames, IA (Ag Leader Technology). The equipment compliment includes a general-purpose monitor/controller console, cotton flow sensors on every other chute of a cotton picker, a digital GPS receiver, a PCMCIA memory card, a desktop computer and color printer, and GIS mapping software. These components represent the additional equipment a farmer would need to electronically collect and analyze spatial cotton yield data for management decision making.

With the Ag Leader cotton yield monitor, specialized optical flow sensors for cotton on every other row of the picker (two for a 4 or 5- row and three for a 6-row) are used to measure cotton volumetric flow rates in the picker chutes, which move cotton from the picking rotors to the basket of a cotton picker. The monitor console records from the sensors accumulated cotton volume for individual loads within a field and for the whole field and merges these volumetric values with accumulated harvest areas, weight calibration values, and estimated percent lint turnout, to calculate total weights and average yields for fields and loads.

Because of the significant computer resources required by precision farming analysis software, the assumption was made that a farmer would need to purchase a new computer. The new computer equipment was assumed to include a Pentium IV with a minimum of 128 Megabytes RAM, a minimum of a 40 Gigabyte hard-drive, a CD drive with read and write capabilities, a 19-inch color video monitor, and a color printer.

Analytical Framework

A partial budgeting framework was developed to evaluate the potential costs and benefits of the information system outlined above. Partial budgeting, which incorporates marginal analysis techniques, is particularly useful for analyzing the addition of equipment to a farm enterprise (Boehlje and Eidman). Breakeven analysis methods are used to calculate the level of a variable needed to obtain a desired level of profit. When breakeven analysis and partial budgeting are combined, they can provide insight into the potential economic effects of changes in revenues and costs associated with the decision to purchase the yield monitoring system.

Equation (1) summarizes the potential net benefits of a cotton yield monitoring information system:

$$\pi = \sum_{i=1}^{n} \left[\left(p_c \Delta y_i - r_i \Delta x_i - vrc_i \right) \lambda_i - oic_i \right] - \frac{fc_c}{a_c} - \frac{fc_{c+o}}{a_c + a_o}, \qquad (1)$$

where π_i is the net dollar return from the cotton yield monitoring information system (\$/acre), p_c is cotton lint price (\$/lb), Δy_i is lint yield gain (lb/acre) from applying crop input x_i (units/acre) using the yield monitor information system to make VRT input decision i, λ_i is proportion of crop acreage affected by the management decision, r_i is price per unit of crop input x_i, vrc_i is difference in input application costs (\$/acre) for VRT versus uniform rate technology (URT), oic_i is cost (\$/acre) of other information used to make the VRT decision (e.g., grid soil sampling information), fc_c is fixed costs for yield monitoring system equipment components that are specific to the cotton enterprise, and fc_{c+o} is fixed costs for yield monitoring system equipment components that can be used for other crops, a_c is cotton acreage, and a_o is other crop acreage.

Fixed costs (*fc*) for the yield monitoring system include annual expenses for depreciation (*dep*), interest (*int*), taxes (*tax*), insurance (*ins*), and housing (*house*), i.e., $fc=dep+int+tax+ins+house$. The capital recovery method was used to calculate depreciation and interest costs for each piece of equipment:

$$(2) \qquad dep + int = (pc - sv) \times \left[\frac{i}{1-(1-i)^{-n}} \right] + sv \times i \,,$$

where *pc* is the purchase cost of the equipment item, *sv* is its salvage value at the end of its useful life *n*, and *i* is the real rate of interest charged as a opportunity cost on the investment.

Fixed costs for the information system are assumed to be a function of acreage a_c and a_o. Physical limitations on the number of acres a cotton picker can cover in a day and the limited harvest season for cotton as influenced by weather dictate the number of pickers (and thus the number of yield monitors) required to complete the harvest of a given cotton acreage (Cooke, Parvin, and Spurlock). These physical limitations on cotton harvest determine the number of acres over which the cost of the cotton yield monitoring system can be distributed. Another factor influencing per acre costs is that certain equipment components of the yield monitor information system may be used for more than one crop enterprise.

Equation (1) was used to evaluate alternative breakeven yield gains and input savings scenarios from using the information system by solving for Δy_i and Δx_i. Assuming a single crop input decision and solving for Δy_i and Δx_i produces the following breakeven relationships:

$$(3) \qquad \Delta y_i = \frac{r_i \Delta x_i \lambda_i + vrc_i \lambda_i + oic_i + \dfrac{fc_c}{a_c} + \dfrac{fc_{c+o}}{a_c + a_o} + \pi_i}{p_c \lambda_i} \,,$$

and

(4) $$\Delta x_i = \frac{p_c \Delta y_i \lambda - vrc_i \lambda_i - oic_i - \frac{fc_c}{a_c} - \frac{fc_{c+o}}{a_c + a_o} - \pi_i}{r_c \lambda_i}.$$

The partial budgeting-breakeven analysis framework was used to evaluate the per acre costs of the information system and breakeven lint yield gains and input cost savings required to pay for the information system for different farm sizes. Variable rate input application decisions evaluated were nitrogen, phosphorous-potassium, and lime. A zero profit level (π=0) was assumed for estimating yield gains and input savings using equations (3) and (4). Breakeven values were calculated for two fixed cost scenarios: 1) all costs were allocated to the cotton enterprise; and 2) costs for the desktop computer, GIS software, and the general monitor console, all of which can be used for other crops, were allocated across all crop acres. Although not required for this example, ownership costs for the computer were calculated assuming that the computer system was 100% dedicated to yield monitoring information analysis.

Data

The following yield, lint price, farm size, and input assumptions were used to calculate breakeven values. An expected yield of 656 lb/acre was used as the base from which to calculate the percentage increase in yields required to cover fixed costs. The expected yield was calculated using detrended U.S. Upland lint yields reported between 1960 and 2000 (U.S. Department of Agriculture, Economic Research Service, 2001a). 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, 2001a). 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).

A real rate of interest of 7% for calculating depreciation and interest was calculated using nominal interest rates paid by farmers for capital from Farm Credit Services for 1985 through 2000 (U. S. Department of Agriculture, Economic Research Service, 2001b) and the annual percentage in change in inflation for that period as measured by the Implicit Gross Domestic Product Price Deflator (Congress of the U.S., Council of Economic Advisors). Because most cotton farmers in a six-state survey of precision farming reported owning a 4-row picker, the price of a yield monitor for a 4-row picker was used to evaluate information system costs (Roberts et al.). Yield monitor costs were from a price list published by Ag Leader Technology (Ag Leader Technology). Computer system and software costs were an average of prices gathered in an informal survey by the authors. The expected useful life for each piece of equipment was based on assumptions made by Gandonou et al. A zero salvage value was assumed for each piece of equipment (Gandonou et al.). Tax, insurance, and housing costs were calculated using assumptions from Gerloff. A $500 charge for installation of the yield monitor and a $500 annual charge for training were also assumed when calculating annual fixed costs. The WAAS GPS signal was assumed to be free of charge.

For the purpose of calculating per acre information system costs, one 4-row cotton picker was assumed to harvest up to 712 acres in one season (Cooke, Parvin, and Spurlock). Thus, for each 712-acre increment of cotton harvested, one 4-row picker and yield monitor are required, e.g., if a farmer had 2,136 acres of cotton, three pickers and three yield monitors would be required to complete the cotton harvest. In addition, farm size economies were assumed to influence the per acre costs of the cotton yield monitoring system. For the purpose of estimating information system cost curves as a function of farm size and estimating per acre yield gains and input savings, cotton acreage was evaluated in increments of 356 acres up to 7,120 acres. In addition, each farm size was assumed to have half of its total acreage in cotton. This range of cotton acreage was consistent with the farm size results reported in a mail survey of cotton producers (Roberts et al.). For all farm size scenarios evaluated, only one desktop computer and GIS software package was assumed to be required for data management and analysis.

United States average annual fertilizer and lime prices for 1991 through 2000 were used to calculate breakeven input savings (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues). Average 1991 through 2000 input prices stated in 2000 dollars were \$19.47/ton for lime, \$0.14/lb for phosphorous, \$0.28/lb for potassium, and \$0.32/lb for nitrogen. Differences in variable rate application costs and other information costs used to evaluate lint yield and input cost differences were from a survey of precision farming service providers (Roberts, English, and Sleigh). Cost differences for VRT used to calculated breakeven values were \$0.90/acre for lime, \$1.90/acre for phosphorous and potassium, and \$2.08/acre for nitrogen. A charge of \$1.00/acre for other information costs, oic_i, representing soil fertility information from grid soil sampling was assumed for calculating breakeven values. The \$1.00/acre charge was calculated by amortizing over three years the \$7.00/acre average grid soil sampling charge reported by input suppliers in Roberts, English, and Sleigh. The annualized cost was then dividing by two to obtain separate charges for the lime and phosphorous-potassium decisions. Average fertilization rates for Upland cotton in the United States for 1997 through 1999 (nitrogen, 83 lb/acre; phosphorous, 47 lb/acre; potassium, 58 lb/acre) were used to calculate the percentage reductions in fertilizer rates to pay for the information system (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues).

Results and Discussion

The costs of the information system for a farm with one 4-row cotton picker are presented in Table 1. Total annual ownership costs for the system are $3,995 with yearly costs of $1,874 for the yield monitor, $571 for the computer, $1,049 for computer software, and $500 for training. For a farm with two pickers, the total annual ownership cost of the system rises to $5,860, while the cost for a farm with three pickers climbs to $7,743.

However, as illustrated in Figure 1, the per acre cost of owning the yield monitor information system drops dramatically with larger farm sizes. The saw-tooth patterns for the information system cost curves are the result of the discrete acreage sizes examined and the annual picker capacity assumption of 712 acres. The important findings that can be derived from an evaluation of the cost curves are as follows. For a cotton farm with 356 acres of cotton, the cost of the yield monitoring information system is $11.22/acre when all costs are allocated to the cotton enterprise. The cost of the information system declines to $5.61/acre when the expenses of the information system components that can be used for other crops are allocated across all crop acres (712 acres total). Ownership costs per acre fall dramatically for farms with more than 356 acres of cotton. For example, a farm with 712 acres of cotton has information system expenses that are one-half the costs for the 356 acre cotton enterprise. Farms with 2,136 acres or more of cotton (4,272 total crop acres) have yield monitoring costs less than $4/acre when expenses are allocated over cotton acres and average less than $2/acre when costs are distributed over all crop acres. Results indicate that it may be more economically feasible for larger cotton farms to adopt the information system because costs can be spread over more cotton acreage. In addition, most of the farm size cost advantage for the information system is achieved for farms with at least 1,424 acres of cotton (2,848 total crop acres).

Breakeven lint yield gains to pay the ownership expenses of the information system for alternative VRT lime and fertilizer application decisions are presented in Table 2. The required yield gains in the lime, phosphorous-potassium, and nitrogen VRT application decision columns assume that the information system is used only for the specified VRT input decision. For the smallest cotton farm with 356 acres of cotton, a 23 lb/acre lint yield gain is required for the lime VRT decision when all fixed costs are allocated to the cotton enterprise. Assuming a base lint yield of 656 lb/acre, this yield gain represents a 3.6% increase. If the costs of system components not specific to cotton are distributed over all 712 crop acres, the required yield gain to cover information costs is reduced to 15 lb/acre (2.2%). Because of economies of size with the information system for larger farms, the breakeven lint yield gain drops to 10 lb/acre or less for farmers with 2,136 acres or more of cotton when all costs are apportioned to the cotton enterprise. When certain information system ownership costs are distributed over all crop acres, the breakeven yield gain drops from 15 lb/acre for the 356 acre cotton enterprise to 9 lb/acre or less for cotton enterprises of 712 acres or more. Results indicate that using components of the information system to make VRT decisions for multiple crops lowers the required lint yield gain needed to pay for cotton's portion of the information system fixed costs.

Because of the larger VRT application costs for fertilizer, yield gains required to cover the cost of the information system are larger than for the lime VRT decision. For a cotton farm with 356 acres of cotton, the respective yield gains to cover information system fixed costs are 25 and 26 lb/acre for the phosphorous-potassium and nitrogen VRT decisions when costs are allocated over cotton acres (Table 2). The required yield gains for the phosphorous-potassium and nitrogen VRT decisions fall to 16 and 17 lb/acre, respectively, when certain information system expenses are allocated over all crop acres. For both fertilizer inputs, the breakeven yield gains required to pay for the information system decline to 13 lb/acre or less for costs allocated over cotton acres and 10 lb/acre or less for expenses distributed over all crop acres for cotton enterprises of 1,424 or more acres. Results indicate that the economic incentives for adopting cotton yield monitors would be greater for larger cotton farms because the required yield benefits to cover the fixed costs of the information system are not as large as for smaller farms.

The impact of using the information systems for multiple VRT decisions is illustrated in the "All Fertilizer and Lime" columns in Table 2. Estimated yield gains assume that the information system is used for all lime and fertilizer decisions rather than for a single input. The yield gain to pay back the cost of the information system ranges from 34 lb/acre for the smallest cotton farm (356 cotton acres) to 20 lb/acre for the largest cotton farm (7,120 cotton acres) when costs are allocated over cotton acres. When yield information system ownership costs are distributed over all crop acres, the breakeven yield gain falls to 25 lb/acre for the 356 acre cotton enterprise and 17 lb/acre for farms with 7,120 cotton acres. Results suggest that using the information system for multiple VRT input decisions reduces the required yield gain for any one decision, thereby enhancing the economic viability of investing in the information system.

Besides potential yield benefits, the yield monitoring information system may help farmers reduce input costs. Breakeven input cost savings for lime and alternative fertilizer decisions are presented in Tables 3 and 4. Results in the two tables assume no changes in lint yields with the VRT decision and the yield and input price assumptions stated previously. The first column in each table presents the required input cost savings for the lime application decision, assuming that the yield monitoring system is not used for any other VRT input decisions. For a cotton farm with 356 acres of cotton, a $13.12/acre savings in lime input expenses, or a 0.67 ton/acre reduction in lime applied, is required to pay for the cost of the yield monitoring system when expenses are allocated over cotton acreage only (Table 3). Dividing yield monitoring costs over all crop acres decreases the breakeven lime cost savings to \$8.22/acre (0.42 ton/acre reduction). As with breakeven yields, the required lime savings to pay for the system decline with increasing farm size. The breakeven lime savings drop to \$4.83/acre for information system costs distributed over 7,120 cotton acres and \$3.72/acre for expenses distributed over 14,240 total crop acres.

The input savings required to pay for the information system are slightly larger for the phosphorous-potassium and nitrogen decisions because of higher VRT application costs. For the phosphorous-potassium decision, the required fertilizer savings declines from \$10.12/acre for the 356 acre cotton enterprise to \$5.62/acre for the 7,120 acre cotton enterprise when information system expenses are distributed over all crop acres (Table 4). The required phosphorous-potassium fertilizer savings compared with the base application rate of 105 lb/acre is substantial, ranging from 43% (46 lb/acre) for the 356 acre cotton enterprise to 24% (26 lb/acre) for the 7,120 acre cotton enterprise (Table 4). Similar fertilizer input savings are required for the nitrogen VRT decision compared with the base nitrogen application rate is 83 lb/acre—44% (36 lb/acre) for the 356 acre cotton enterprise and 23% (19 lb/acre) for the 7,120 acre cotton enterprise (Table 4). When the information system is used to make multiple fertilizer decisions, the breakeven percentage changes in fertilizer usage are smaller than when the system is used for only one decision. The required total reduction in fertilizer usage is 25% (47 lb/acre) compared with the base level of 188 lb/acre of total fertilizer applied when costs are distributed over all crop acres for a 356 lb/acre cotton enterprise farm. The required input savings drops to 17% or less (33 lb/acre or less) for farms with 1,424 or more acres of cotton (Table 4). The fertilizer savings results suggest that a farmer may not be able to pay for the information system using fertilizer cost savings alone. These cost savings in combination with yield gains from applying fertilizer more efficiently or yield gains and input cost savings from other input decisions (e.g., pesticides) may be needed to pay for the information system.

Summary

A partial budgeting and breakeven framework was developed to evaluate the yield benefits and input cost savings required to cover the cost of a cotton yield monitor information system. Because of farm size economies with certain components of the information system, breakeven increases in lint yields and input cost savings to cover the fixed costs of the yield monitor information system for alternative cotton acreage sizes were calculated using the partial budgeting framework. Fixed costs for the yield monitoring system included annual expenses for depreciation, interest, taxes, insurance, and housing. The capital recovery method was used to calculate depreciation and interest costs for each piece of equipment. The information system equipment compliment include a general-purpose monitor/controller console, cotton flow sensors on every other chute of a cotton picker, a digital GPS receiver, a PCMCIA memory card, a desktop computer and color printer, mapping and application recommendation software, and training in data management and analysis. Results indicate that it may be more economically feasible for larger cotton farms to adopt a cotton yield monitoring information system because costs can be spread over more cotton acreage. Purchasing a general monitor/controller console that can be used for multiple crop enterprises can reduce the per acre cost and the required yield gains and input savings to pay for the fixed costs of the information system. Most of the farm size cost advantage for the information system is achieved for farms with at least 1,424 acres of cotton (2,848 total crop acres). Spreading the cost of the system over multiple VRT input decisions reduces the required yield gains and cost savings for any one input decision.

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Table 1. Ownership Cost Data For the Cotton Yield Monitoring Information System for a Farm with One Cotton Picker

Item	Purchase Cost ($)	Useful Life [a] (Years)	Annual Capital Recovery [b] ($)	Taxes Insurance Housing [c] ($)	Annual Fixed Cost ($)
Cotton Yield Monitoring System [d]					
PF3000 Monitor/Controller Console	2,010	8	336.61	12.06	348.67
PF3000 Cotton Sensors	2,395	8	401.09	14.37	415.46
GPS 3100	3,995	5	974.34	23.97	998.31
PCMCIA Memory Card	100	5	24.39	0.60	24.99
Monitor Installation	500	8	83.73	3.00	86.73
GPS Signal Subscription	0	----	----	----	0
Office Computer [e]					
Desktop Computer and Color Printer	1,376	3	524.33	8.26	532.58
PC Card Reader	100	3	38.11	0.60	38.71
GIS Mapping Software [f]					
Field Mapping Software	2,186	20	206.34	13.12	219.46
Annual Software Update	825	1	825.00	4.95	829.95
Annual Training Charge	500	----	----	-----	500.00
Total Cost	13,987	----	3,913.94	80.92	3,994.86

[a] Based on assumptions made by Gandonou et al. (2001). A zero salvage value was assumed for each piece of equipment (Gandonou et al., 2001).
[b] Calculated using a real interest rate of 7% (U. S. Department of Agriculture, Economic Research Service, 2001a; Congress of the U.S., Council of Economic Advisors, 2001).
[c] Tax, insurance, and housing costs were calculated using assumptions from Gerloff (2001).
[d] Yield monitor equipment costs were from a price list published by Ag Leader Technology (Ag Leader Technology, 2001).
[e] Computer system costs were an average of prices gathered in an informal survey by the authors
[f] GIS software costs were an average of prices gathered in an informal survey by the authors

Table 2. Breakeven Lint Yield Gains for Alternative Fertilizer and Lime Variable Rate Input Decisions Required to Cover Cotton Yield Monitoring Information System Fixed Costs

	Required Yield Gains When System Costs are Allocated Over Cotton Acreage Only for Different VRT Decisions [a]								Required Yield Gains When Certain System Costs are Allocated Over All Crop Acres for Different VRT Decisions [b]							
	Lime		Phosphorous And Potassium		Nitrogen		All Fertilizer and Lime		Lime		Phosphorous And Potassium		Nitrogen		All Fertilizer and Lime	
Cotton Acres	(lb/acre)	(%)	(lb/acre)	(%)	(lb/acre)	(%)	(lb/acre)	(%)	(lb/acre)	(%)	(lb/acre)	(%)	(lb/acre)	(%)	(lb/acre)	(%)
356	23	3.6 [b]	25	3.8	26	3.9	34	5.2	15	2.2	16	2.5	17	2.6	25	3.9
712	13	2.0	15	2.3	16	2.4	24	3.7	9	1.4	11	1.6	11	1.7	20	3.0
1,068	13	2.0	15	2.3	15	2.3	24	3.6	9	1.4	11	1.7	11	1.7	20	3.0
1,424	11	1.6	13	1.9	13	2.0	21	3.3	8	1.2	9	1.4	10	1.5	18	2.8
1,780	11	1.7	13	2.0	13	2.0	22	3.3	8	1.2	10	1.5	10	1.5	19	2.9
2,136	10	1.5	12	1.8	12	1.8	21	3.1	7	1.1	9	1.4	9	1.4	18	2.7
2,492	10	1.6	12	1.8	12	1.9	21	3.2	8	1.2	9	1.4	10	1.5	18	2.8
2,848	9	1.4	11	1.7	12	1.8	20	3.1	7	1.1	9	1.3	9	1.4	18	2.7
3,204	10	1.5	12	1.8	12	1.8	20	3.1	7	1.1	9	1.4	9	1.4	18	2.7
3,560	9	1.4	11	1.7	11	1.7	20	3.0	7	1.1	9	1.3	9	1.4	18	2.7
3,916	9	1.4	11	1.7	12	1.8	20	3.1	7	1.1	9	1.4	9	1.4	18	2.7
4,272	9	1.4	11	1.6	11	1.7	20	3.0	7	1.0	9	1.3	9	1.4	17	2.7
4,628	9	1.4	11	1.7	11	1.7	20	3.0	7	1.1	9	1.3	9	1.4	18	2.7
4,984	9	1.3	11	1.6	11	1.7	20	3.0	7	1.0	9	1.3	9	1.4	17	2.7
5,340	9	1.4	11	1.7	11	1.7	20	3.0	7	1.1	9	1.3	9	1.4	18	2.7
5,696	9	1.3	11	1.6	11	1.7	19	3.0	7	1.0	8	1.3	9	1.3	17	2.6
6,052	9	1.4	11	1.6	11	1.7	20	3.0	7	1.0	9	1.3	9	1.4	18	2.7
6,408	9	1.3	10	1.6	11	1.6	19	3.0	7	1.0	8	1.3	9	1.3	17	2.6
6,764	9	1.4	11	1.6	11	1.7	20	3.0	7	1.0	9	1.3	9	1.4	17	2.7
7,120	9	1.3	10	1.6	11	1.6	20	3.0	7	1.0	8	1.3	9	1.3	17	2.6

[a] Fixed costs for the desktop computer, GIS software, and the general monitor console, all of which can be used for other crops, are allocated across all crop acres when calculating lint yield gains.

[b] A lint yield of 656 lb/acre was used as the base from which to calculate the percentage increase in yields required to cover fixed costs.

Table 3. Breakeven Fertilizer and Lime Cost Savings Required to Cover Information System Fixed Costs Allocated Over Cotton Acreage Only

	Lime		Phosphorous and Potassium			Nitrogen			All Fertilizer		
	Costs	Inputs	Costs	Inputs		Costs	Inputs		Costs	Inputs	
Acres	($/acre)	(tons/acre)	($/acre)	(lb/acre)	(%)[a]	($/acre)	(lb/acre)	(%)[b]	($/acre)	(lb/acre)	(%)[c]
356	13.12	0.67	14.12	64	61	14.30	45	54	17.20	66	35
712	7.51	0.39	8.51	39	36	8.69	27	33	11.59	45	24
1,068	7.40	0.38	8.40	38	36	8.58	27	32	11.48	44	23
1,424	6.02	0.31	7.02	32	30	7.20	23	27	10.10	39	21
1,780	6.25	0.32	7.25	33	31	7.43	23	28	10.33	40	21
2,136	5.53	0.28	6.53	30	28	6.71	21	25	9.61	37	20
2,492	5.76	0.30	6.76	31	29	6.94	22	26	9.84	38	20
2,848	5.28	0.27	6.28	29	27	6.46	20	24	9.36	36	19
3,204	5.49	0.28	6.49	29	28	6.67	21	25	9.57	37	19
3,560	5.13	0.26	6.13	28	26	6.31	20	24	9.21	35	19
3,916	5.31	0.27	6.31	29	27	6.49	20	24	9.39	36	19
4,272	5.03	0.26	6.03	27	26	6.21	19	23	9.11	35	19
4,628	5.19	0.27	6.19	28	27	6.37	20	24	9.27	36	19
4,984	4.96	0.25	5.96	27	26	6.14	19	23	9.04	35	18
5,340	5.10	0.26	6.10	28	26	6.28	20	24	9.18	35	19
5,696	4.90	0.25	5.90	27	25	6.08	19	23	8.98	35	18
6,052	5.04	0.26	6.04	27	26	6.22	19	23	9.12	35	19
6,408	4.86	0.25	5.86	27	25	6.04	19	23	8.94	34	18
6,764	4.98	0.26	5.98	27	26	6.16	19	23	9.06	35	18
7,120	4.83	0.25	5.83	27	25	6.01	19	23	8.91	34	18

[a] A base phosphorous rate of 47 lb/acre and a base potassium rate of 58 lb/acre were used to calculate the percentage reductions in fertilizer rates to pay for the information system (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues).

[b] A base nitrogen rate of 83 lb/acre was used to calculate the percentage reductions in fertilizer rates to pay for the information system (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues).

[c] A base total fertilizer rate of 198 lb/acre was used to calculate the percentage reductions in fertilizer rates to pay for the information system (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues).

Table 4. Breakeven Fertilizer and Lime Cost Savings Required to Cover Information System Fixed Costs Allocated Over Cotton and Other Crop Acreage [a]

	Lime		Phosphorous and Potassium			Nitrogen			All Fertilizer		
Acres	Costs ($/acre)	Inputs (tons/acre)	Costs ($/acre)	Inputs (lb/acre)	(%)[b]	Costs ($/acre)	Inputs (lb/acre)	(%)[c]	Costs ($/acre)	Inputs (lb/acre)	(%)[d]
356	8.22	0.42	10.12	46	43	9.40	36	44	12.30	47	25
712	5.06	0.26	6.96	32	30	6.24	24	29	9.14	35	19
1,068	5.12	0.26	7.02	32	30	6.30	24	29	9.20	35	19
1,424	4.31	0.22	6.21	28	27	5.49	21	25	8.39	32	17
1,780	4.50	0.23	6.40	29	27	5.68	22	26	8.58	33	17
2,136	4.07	0.21	5.97	27	26	5.25	20	24	8.15	31	17
2,492	4.23	0.22	6.13	28	26	5.41	21	25	8.31	32	17
2,848	3.94	0.20	5.84	27	25	5.12	20	24	8.02	31	16
3,204	4.09	0.21	5.99	27	26	5.27	20	24	8.17	31	17
3,560	3.87	0.20	5.77	26	25	5.05	19	23	7.95	31	16
3,916	3.99	0.20	5.89	27	25	5.17	20	24	8.07	31	16
4,272	3.82	0.20	5.72	26	25	5.00	19	23	7.90	30	16
4,628	3.93	0.20	5.83	26	25	5.11	20	24	8.01	31	16
4,984	3.78	0.19	5.68	26	24	4.96	19	23	7.86	30	16
5,340	3.88	0.20	5.78	26	25	5.06	19	23	7.96	31	16
5,696	3.75	0.19	5.65	26	24	4.93	19	23	7.83	30	16
6,052	3.84	0.20	5.74	26	25	5.02	19	23	7.92	30	16
6,408	3.73	0.19	5.63	26	24	4.91	19	23	7.81	30	16
6,764	3.81	0.20	5.71	26	24	4.99	19	23	7.89	30	16
7,120	3.72	0.19	5.62	26	24	4.90	19	23	7.80	30	16

[a] Fixed costs for the desktop computer, GIS software, and the general monitor console, all of which can be used for other crops, are allocated across all crop acres when calculating lint yield gains.

[b] A base phosphorous rate of 47 lb/acre and a base potassium rate of 58 lb/acre were used to calculate the percentage reductions in fertilizer rates to pay for the information system (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues).

[c] A base nitrogen rate of 83 lb/acre was used to calculate the percentage reductions in fertilizer rates to pay for the information system (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues).

[d] A base total fertilizer rate of lb/acre was used to calculate the percentage reductions in fertilizer rates to pay for the information system (U.S. Department of Agriculture, National Agricultural Statistics Service, Various Issues).

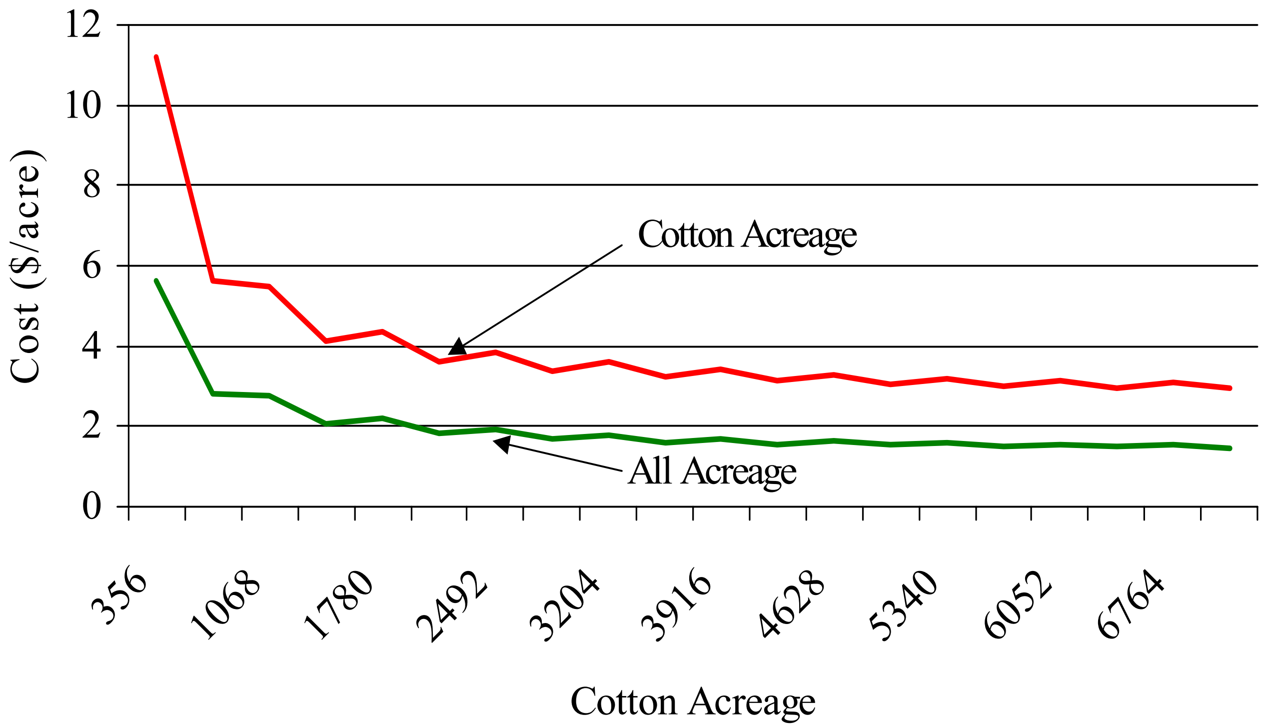

Figure 1. Cost Per Acre of the Cotton Yield Monitoring System