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WHOLE FARM ECONOMIC ANALYSIS OF PRECISION FARMING PRACTICES

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Introduction

Scientists with the United States Department of Agriculture's Agricultural Research Service in Stoneville, Mississippi began working with Cumbaa Farms in the late 1990s to test, verify and further develop farm level precision agriculture technologies. The past two years (2001 and 2002), all farming operations on a 33-acre test field have incorporated precision farming technologies. This 33-acre field is adjacent to the Delta Research and Extension Center. The field consists of mixed soil types and has been land formed to a .15 feet per 100 feet slope.

The 2001 and 2002 cropping practices and data are based on Veris soil recommendations. Veris analysis is a soil electronic conductivity measure that allows multiple probing and sampling per acre at costs significantly lower than traditional soil probing and lab sampling. The analysis is based on electronic conductivity of the soil, which reveals the clay content of the soil. The Veris analysis revealed three distinct zones within the field (Figure 1**).** The three zones were used to develop precision/variable rate production practices/prescriptions for these two growing seasons.

Aerial photography (airplane) was used to assess the ability of in-season variable rate applications of insecticides, herbicides, plant growth regulators and defoliants. Variable rate defoliation capability was available, however during the 2001 and 2002 growing seasons all zones were managed the same.

This report attempts to establish the total costs associated with a complete precision farming operation based on this 33-acre example. Where possible, any benefits derived from the precision farming practices were also captured by estimating yield differences and associated revenue gains.

Methods

The 33-acre test field was divided into three zones based on soil conditions. These three zones were initially established based on grid soil sampling. The Veris analysis, however, confirmed the three distinct zones. Enterprise budgets were developed for each of the three zones. Enterprise budgets are reported both excluding and including the costs of the precision farming technology. The enterprise budgets were developed using the Mississippi State Budget Generator (MSBG). The MSBG is the budgeting software used to produce the Mississippi State planning budgets (Laughlin and Spurlock). The budgets report costs of production for total specified costs. Total specified costs include all direct and fixed costs excluding land rent, general farm overhead and any returns to management. In order to include the precision farming costs in the enterprise budgets, the capital recovery method was used to establish the annual cost of ownership of the precision farming equipment. This method is consistent with other annual fixed costs calculated in the MSBG and also in the Cotton Yield Monitor Investment Decision Aid (CYMIDA). The CYMIDA was developed by researchers at the University of Tennessee as a tool to help producers determine the amount of cotton lint required for the purchase of a cotton yield monitor to break-even. The framework of the CYMIDA allows the input of purchase prices and other parameters such as interest rates, length of life, etc. and provides annual and per acre costs associated with a specified piece of equipment. Purchase prices for the needed precision farming equipment have wide ranges, thus the median of the price range was used for the annual fixed costs analysis. The CYMIDA was also utilized to determine the break-even lint requirements for the Cumbaa farm based on the incorporation of all the precision farming equipment. Returns in the budgets are expressed at the cotton loan rate of $0.52 per pound of lint and $0.05 per pound for seed. Seed yield is estimated as 155% of the lint yield (Laughlin and Spurlock).

The objective of the precision farming technology was to bring the lower yielding zones (zones 2 and 3) up to the level of zone 1. Savings associated with the precision farming technologies are based on deviations from the inputs used on zone 2, which is considered the "norm." Benefits derived from the total precision farming program are based on yield increases per zone over the five years that yield records exist.

Although a 33-acre test field is large in comparison to standard research test plots, it is small in comparison to actual farming practices. Thus, other larger acreage examples are included in order to help illustrate precision farming costs on a more realistic farm size.

Results

Tables 1a and 1b list the equipment/technologies used on the Cumbaa farm project along with purchase prices associated with the precision farming components. Purchase prices listed in this case are not actual purchase prices for the specified farm since some of the technologies and equipment were provided through research means. The prices shown are a range based on vendors listed in appendix 1. A median of the price range is also shown.

Table 2 presents costs of production estimates from the MSBG as well as returns above costs for the each zone for the 2001 and 2002 growing seasons. Additionally, the budgets in table 2 **do not include** costs for the precision agricultural operations. As can be seen in table 2, two of the zones did not have positive returns in 2001, even without the added costs associated with the precision farming technologies.

Table 3 shows annual estimated fixed costs for the precision agriculture equipment used on the Cumbaa farm. The annual fixed costs were calculated using the capital recovery method. The capital recovery method calculates interest and depreciation based on the given parameters specified for a piece of equipment. The parameters that can affect the annual fixed costs are the replacement cost (purchase price), salvage value, interest/discount rate and years of useful life. These parameters are listed in table 3 with the assumed values used in the analysis. Varying these parameters can make significant changes in the annual fixed costs. The values for the parameters used in table 3 were obtained from the Cotton Yield Monitor Investment Decision Aid (CYMIDA).

Table 4 incorporates the added costs associated with the precision farming technologies to the enterprise budgets shown in table 3. As can be seen in table 4, adding the costs of the precision agricultural equipment resulted in only one zone having positive returns. However, if the acreage were expanded to say 750 acres, (i.e., maximize cotton picker capacity) the costs become somewhat more realistic. This is shown in table 5. Additionally, in table 5, the precision agricultural operations are expanded to 2,750 acres. The 2,750 acre column assumes 750 acres of cotton and 1,500 acres of soybeans (i.e. maximize combine capacity). When acreage is expanded to incorporate soybeans, a grain yield monitor is added. As is shown in table 5, on a 750 acre cotton farm, the total cost of a precision farming operation would be approximately $12 per acre. If acreage is expanded to 2750 acres and some grain production is included, the cost drops to approximately $9.00 per acre. There are many other acreage/crop mixes that could be incorporated to spread the fixed costs of these technologies over as many acres as possible.

Table 6 reveals the difference in costs between each of the zones. As can be seen in the table, there were $0.02 per acre seed cost savings associated with precision planting the field. Insecticide costs were also reduced, $1.04 per acre in 2001 and $2.45 in 2002. Plant growth regulator expense was reduced in 2002 by $1.27 per acre. Interest expense is also reduced in each year, $0.11 per acre in 2001 and $0.01 in 2002. Fertilizer costs however increased in each year, $0.19 per acre in 2001 and $0.07 in 2002. The net result of these savings amounts to $0.97 per acre in 2001 and $3.66 in 2002. There are other differences in costs based on the lint yield of each of the zones and thus increased hauling and ginning costs are incurred for those zones that had higher yields. If these cost savings are deducted from the per acre expenses shown in table 5, the net cost of using the precision farming technologies amounts to approximately $9.48 per acre for a 750 acre cotton farm. Since the cost savings shown in table 7 are associated only with cotton production, a realistic comparison cannot be made on the 2,750 acre example shown in table 5 because no grain production data was collected on the farm.

Another way of looking at the analysis is from the perspective of the CYMIDA. If cotton lint is valued at the loan rate of $0.52 per pound, then almost 300 pounds of lint per acre are needed to offset the additional costs of $150.29 per acre on a 33-acre farm. However, if acreage is expanded to 750 acres then only approximately an 18 pound per acre increase is needed for the precision farming technology to break-even.

Conclusions

Table 7 shows cotton lint yields for each of the management zones for the 1998-2002 growing seasons. Table 8 shows the benefits possibly derived from precision farming. Table 8 reveals a 118 pound per acre increase for the two years precision farming was performed. This represents a 16% yield increase over the three previous years. In 2001 and 2002 weather conditions were more favorable for cotton production than the three previous years. Thus, not all of the yield increase may be attributable to precision farming. The Mississippi Agricultural Statistics Service (MASS) reports a 10% yield increase statewide for the years 2001 and 2002 compared to 1998-2000. Therefore the precision farming practices may have contributed to the additional 6% yield increase. A 6% yield increase over a base yield of 727 lbs per acre would result in a per acre increase of 44 pounds. If this yield increase is valued at the loan rate of $0.52 per pound, it would result in increased returns of $23 per acre.

The 44 pounds per acre lint increase is more than the 18 pounds needed for the precision farming technology to break-even. In fact, it could represent a net revenue increase of approximately $13.40 per acre ($22.88 – $9.48). Without the ability to

adequately quantify the yield increases, it is difficult to make an absolute statement on revenue increases. However, MASS data for Washington county shows only a .7% increase in county yields for period 2001-2002 compared to the 1998-2000 period. Thus, some yield increase is most likely attributable to the management practices on the Cumbaa farm.

The emphasis thus far on the Cumbaa farm has been primarily to implement a total precision farming program and determine the cost associated with the implementation. This process has taken the approach of trying to bring uniformity to an otherwise variable field. In the future, efforts possibly should be made to "rearrange" the precision farming input levels in an effort to maximize net revenue. For example, "higher" yielding zones may need "more" inputs and "lower" yielding zones may need "less" inputs. Additionally, experiments need to be designed to quantify benefits (i.e. yield) from precision farming not just cost savings.

References

Larson, Jim, Rebecca Cochran, Burt English, Roland Roberts and Bradley Wilson. "Cotton Yield Monitor Investment Decision Aid." Department of Agricultural Economics. University of Tennessee.308 B Morgan Hall. 2621 Morgan Circle. The University of Tennessee. Knoxville, TN 37996-4518.865-974-7482 (voice). 865-974-4829 (fax)

Laughlin, David H. and Stan Spurlock. "Mississippi State Budget Generator User's Guide 5.5." Department of Agricultural Economics. Mississippi State University. Available on the web. http://www.agecon.msstate.edu/laughlin/msbg.php

Mississippi Agricultural Statistics Service. Available on-line at http://www.nass.usda.gov/ms/cot1.pdf. Accessed August 18, 2003.

Table 1a. List of Conventional Equipment Used in Cumbaa Project.

150 hp Tractor
420 gal 60 ft Hi-Clearance Sprayer
8-row planter
Coulter –Type fertilizer applicator
4-row cotton picker
8-row post –direct lay-by applicator

Table 1b. Precision Farming Equipment Used in Cumbaa Project.

Precision AG Equipment	Purchase cost/additional cost	Median of the Range
Computer	$1,000-$2,000	$1,500
Variable Rate Planter Adapter	$3,500-$5,000	$4,250
Spray/Fertilizer Controller (GPS compatible)	$1,500-$2,500	$2,000
Yield Monitor	$5,200-$9,000	$7,100
GPS unit	$1,200-$3,500	$2,350
GIS Software	$1,500-$3,000	$2,250
Veris soil analysis	$1.50-$6.00/acre	$3.75
Aerial Photos	$1-$7 an acre	$4.00

Table 2. Total Specified Costs and Returns above Specified Costs.

Zone	2001 Cost of Production	2001 Returns Above Specified Costs	2002 Costs of Production	2002 Returns Above Specified Costs
Zone 1	$451.91	$67.90	$449.56	$182.59
Zone 2	$464.45	-$24.69	$453.21	$116.81
Zone 3	$441.03	-$53.25	$449.30	$81.25

Table 3. Median Prices, Salvage Value, Years of Useful Life and Annual Fixed Costs of Specified Precision Ag Equipment.

Equipment	Median Price	Salvage Value	Interest/ Discount Rate	Years of Useful Life	Annual Fixed Cost	Per Acre Annual Costs (33 acre example)
Computer	$1,500	0	0.07	3	$571.58	$17.32
Variable Rate Planter Adapter	$4,250	0	0.07	8	$711.74	$21.57
Spray/Fertilizer Controller (GPS compatible)	$2,000	0	0.07	8	$334.94	$10.15
Yield Monitor	$7,100	0	0.07	5	$1,731.62	$52.47
GPS unit	$2,350	0	0.07	5	$573.14	$17.37
GIS Software	$2,250	0	0.07	3	$857.37	$25.98
Veris soil analysis	$3.75	0	0.07	3	$1.43	$1.43
Total					$4781.82	$146.29
Aerial Photos	$4.00					$4.00
Total						$150.29

Table 4. Total Specified Costs Including Precision Ag Equipment – 33 acre Farm.

Zone	2001 Cost of Production	2001 Returns Above Specified Costs	2002 Costs of Pro-duction	2002 Returns Above Specified Costs
Zone 1	$598.20	-$78.38	$595.85	$36.31
Zone 2	$610.74	-$170.98	$599.50	-$29.47
Zone 3	$587.32	-$199.55	$595.59	-$65.03

Table 5. Median Prices, Annual Fixed Costs, and Per Acre Annual Fixed Costs of Specified Precision Ag Equipment for Selected Acreages.

Equipment	Median Price	Annual Fixed Cost	Per Acre Annual Costs 33 acres	Per Acre Annual Costs 750 acres	Per Acre Annual Costs 2750 acres
Computer	$1,500	$571.58	$17.32	$0.76	$0.18
Variable Rate Planter Adapter	$4,250	$711.74	$21.57	$0.95	$0.22
Spray/Fertilizer Controller (GPS compatible)	$2,000	$334.94	$10.15	$0.45	$0.10
Yield Monitor	$7,100	$1,731.62	$52.47	$2.31	$0.53
GPS unit	$2,350	$573.14	$17.37	$0.76	$0.18
GIS Software	$2,250	$857.37	$25.98	$1.14	$0.26
Veris soil analysis	$3.75	$1.43	$1.43	$1.43	$1.43
Total		$4781.82	$146.29	$7.80	$3.96
Aerial Photos	$4.00		$4.00	$4.00	$4.00
Total Grain Yield Monitor	$6,500	$1585.29			$0.79
Total			$150.29	$11.80	$8.75

Table 6. Costs Savings Associated with Precision Ag Equipment.

	Seed Expense		Fertilizer Expense		Insecticide Expense		Interest Expense		Plant Growth Regulator Expense	
Zone	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**
Zone 1	$34.16	$34.16	$23.41	$17.54	$40.98	$41.42	$1.61	$1.54	$6.08	$7.60
Zone 2	$39.84	$40.25	$25.54	$18.31	$40.45	$39.62	$1.97	$1.60	$6.08	$6.08
Zone 3	$43.92	$43.92	$27.67	$19.07	$38.07	$35.87	$1.76	$1.59	$6.08	$0.00
Total Cost Savings	$0.54	$0.54	-$6.18	-$2.15	$34.09	$80.25	$3.68	$0.41	$0.00	$41.80
Savings per Acre	$0.02	$0.02	-$0.19	-$0.07	$1.03	$2.43	$0.11	$0.01	$0.00	$1.27

	2001	**2002**	**2001-2002 Average**	**Total Per Acre Annual Costs 750 acres (from Table 5)**	**Average Net Per Acre Annual Costs (750 acres)**
					$11.80
Net Savings	$32.13	$120.85	$76.49		-$2.32
Net Savings per acre	$0.97	$3.66	$2.32	$11.80	$9.48

Table 7. Cotton Lint Yields.

Zone	**1998**	**1999**	**2000**	**2001**	**2002**
Zone 1	605	789	786	870	1058
Zone 2	605	789	786	736	954
Zone 3	605	789	786	649	888
Weighted Average	605	789	786	736	954

Table 8. Revenue Improvements Associated With Precision Ag. Equipment.

	1998-2000 Average Yield	**2001-2002 Weighted Average Yield**	**Yield Difference/ Pounds per Acre**	**Percentage Increase in Yield**	**Additional Revenue @ $0.52 per pound**
All Zones	727	845	118	16	$61.36
	Mississippi Statewide Yield Average 1998-2000	**Mississippi Statewide Yield Average 2001-2002**	**Yield Difference Pounds per Acre**		
	694	764	70	10	
	1998-2000 Average Yield	**2001-2002 Average Yield assuming 6% Yield Increase from Precision Farming**			
	727	771	44	6	$22.88

(Zone 1-Red; Zone 2-Green; Zone 3-Blue)

Figure 1. Management Zones in Cumbaa Field.

Appendix 1

Price Sources

Bubba Bailey
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662-754-5901

Cotton Yield Monitor Investment Decision Aid
University of Tennessee
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