Determining the Minimum Acreage for Cost-Effective Adoption of Auto-Guidance Systems in Cotton Production

by

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New agricultural technologies require increased initial investment but tend to decrease variable costs. This article analyzes the minimum acreage needed to adopt auto-guidance technology in cotton production. Ê

With the advent of geographical information systems technology and the availability of global positioning system information to the agricultural sectors, new opportunities in site-specific crop management have become available. One of the most exciting is the new generation of auto-guidance equipment. At a minimum, such systems implement a complex structure of satellites, base stations and portable receiver “rover” units.

In a market dominated by users of conventional technology, such as the market for cotton, an early adopter of a system that reduces marginal cost will experience above-average operating profits in the short run. Such equipment can decrease inputs while increasing output; as more producers adopt the new technology, supply will expand and price will drop. Any profit-maximizing producer must stay abreast of cost-effective technology to remain competitive.

However, not all farms can reasonably expect to benefit from this technology. The purchase of capital such as Real-Time Kinetics Global Positioning System (RTK GPS) receivers and base stations, computer systems and software, potentiometers and hydraulic steering devices, total in the tens of thousands of dollars. Benefits from lower variable costs and higher output can exceed the fixed expense when the technology is used on a farm of sufficient acreage. Before implementation, a cotton farmer needs to know if his farm is large enough to benefit from the technology. An awareness of the minimum cost-effective acreage for new technology is essential to farmers and farm advisors. This article provides a method to determine the minimum cost-effective acreage for use of auto-guided tractors in farming cotton.

Auto-Guidance Technology

Auto-guidance systems are wholly dependent on GPS technology, which requires a base station located on or near the farm, a rover unit for each tractor, a computer and its software. These systems receive a satellite signal every few seconds and employ base station correction signals to improve satellite signal accuracy. The high level of accuracy will allow a great deal of secondary implementation. The uses of the systems go well beyond auto-guidance. This technology is well-suited to cotton production, which requires many cultural practices, including subsoiling, discing, landplaning, bedding, weed control, seeding, fertilizing, irrigating, harvesting, and applying pesticides, growth regulators and defoliators. A farmer with some experience using the computer systems can easily take soil samples, establish drip irrigation, apply material in variable rates and monitor crop yield without another substantial capital expenditure.

The system eliminates human error, such as overlapping and skipping that can lead to excessive or deficient applications of pesticides and fertilizers. A couple of inches skipped per row during bedding can accumulate too many rows per field, resulting in loss of revenue. The main disadvantages of auto-guidance systems include greater capital costs and maintenance and repair expenses. In addition, the value of time expended to learn how to use the system must also be considered. Each component of the system requires significant capital investment and has a limited expected useful life.

The most important advantage is that an auto-guidance system does not require the operator to see, so operations can run at night and in adverse weather conditions. This reduces the time period needed to perform each operation, therefore eliminating bottlenecks and allowing greater outputs to be gleaned from fewer inputs. For example, herbicides such as Staple™ need to be applied within a small window of time; enabling a tractor to run longer hours means that fewer days are needed to apply this type of product to a given area. These

Any profit-maximizing producer must remain abreast of cost-effective technology to stay competitive. This producer uses GPS guided planting.

Photo by Shrini K. Upadhyaya, UC Davis, Department of Biological and Agricultural Engineering

advantages and disadvantages can weigh heavily depending on the size of the operation. A small operation will be more affected by the high capital expenditure required and less able to reap the benefits of the advantages afforded by the technology.

In addition to understanding the mechanisms of cotton production and the advantages and disadvantages of auto-guidance systems, it is important also to note that there are many auto-guidance systems available. The one we will study involves a hydraulic steering mechanism which draws parallel passes in a field, but uses a lightbar that the operator must watch to navigate the turnarounds.

Vigorous competition between companies such as John Deere, Inc., Trimble and Beeline Technologies ensures that any profitability in the market will lead to continued research and development. The technology will become less expensive, easier to use and more accessible. At least one company has begun development of virtual reference systems via cellular channels—a step toward reducing costs by eliminating the need for a base station.

Model Framework

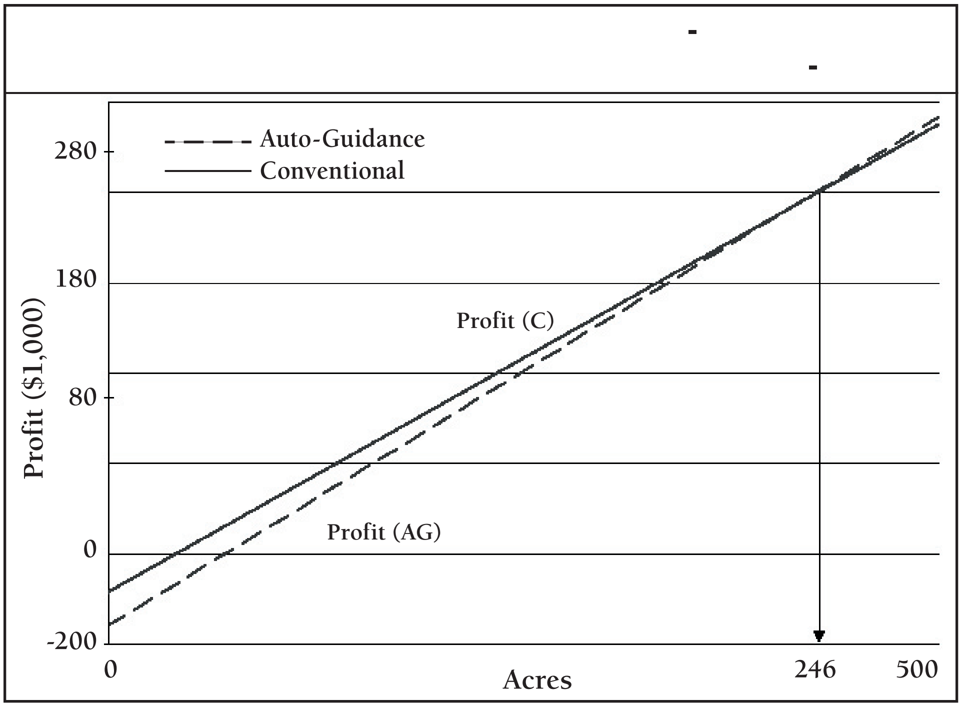
Much of our data is taken from the 2002 Sacramento Valley Sample Cost of Production Study for cotton. If the model is applied to any other area, crop or time frame, numbers such as average yield, pesticide expenses, labor costs and market prices will have to be adjusted. We make the following assumptions:

- ❖ Hourly conventional laborer's wage totals $10.39 after employer's share of payroll taxes. This figure is increased by five percent to $10.90 for workers using auto-guidance equipment.
- ❖ Per-acre fuel, lube, maintenance and repair costs are based on use of one diesel-powered 215-hp crawler and one diesel-powered 130-hp four-wheel drive tractor.
- ❖ Each farmer custom hires a harvester and module builder; these costs are identical for either technology and will not be included in the model.
- ❖ There is no opportunity to purchase used equipment; all purchases related to the auto-guidance system will be considered new.
- ❖ The life of the system is capped at five years due to computer obsolescence and compatibility problems. After this time, the tractor can be retained but new computer equipment, software, GPS receivers, etc., must be purchased. Thus, there is no salvage value.
- ❖ Fixed costs incurred in both the conventional and auto-guidance technologies are offset and thus not included in the model.
- ❖ All farms pay the same interest costs on their capital investments; this term will not be included in the model.

In the following equations, the subscripts "AG" and "C" will denote auto-guidance and conventional techniques, respectively. Where the variable profit lines are equal, the land activity will be at the "breakeven" acreage for the C and AG technologies. Farms with acreage greater than the breakeven level will benefit from adopting the AG technology, while smaller farmers are better off retaining the C technology. Total revenue (TR) is equal to market price multiplied by (lbs/acre) and number of acres and is the sum from total sales of lint and sales of seed. The revenue from the seed yield is a credit obtained from the ginner at harvest time.

$$TR_{AG} = \{[\text{lint\$/lb} * \text{Yield}_{AG}] + [\text{seed\$/lb} * \text{SeedYield}_{AG}]\} * \text{land (acres)}$$

$$TR_{C} = \{[\text{lint\$/lb} * \text{Yield}_{C}] + [\text{seed\$/lb} * \text{SeedYield}_{C}]\} * \text{land (acres)}$$



- "*w*" is the cost of labor per hour; laborers on an auto-guidance system are assumed to make five percent greater wage than those on a conventional system.
- M is the cost of materials applied per acre.
- Ginning costs are \$0.0535/lb. of lint.
- Ginning credits are \$0.07/lb. of seed.
- "F" is the cost of fuel, lube, maintenance and repair per acre; this is the same for both techniques.

Both lint yield and seed yield (lbs/acre) using auto-guidance are generally slightly higher than yields using conventional techniques due to reduction in overlapping and skipping. These percent yield increments are denoted by α and ß, respectively.

$$Yield_{AG} = (1+\alpha) * Yield_{C} = (1+\alpha) * 1{,}250 \text{ lbs/ac}$$

$$SeedYield_{AG} = (1+ß) * SeedYield_{C\,Ê} = (1+ß) * 2{,}300 \text{ lbs/ac Ê}$$

Fixed costs for auto-guidance systems include:

- Base Station: \$20,000
- Two tractors with necessary equipment: \$15,000 each
- Computer system and software: \$3,000
- Annual GPS subscription: \$800
- Total: \$57,000

Conventional farming incurs none of these capital costs.

Variable costs are more complicated. Per-acre data such as fuel and lube, maintenance and repair, rental rates and material costs are taken from the cost of production study mentioned earlier.

The costs are the aggregation of average time spent per acre, cost of labor per hour, cost of materials per acre and other operational costs, for each of fifteen operations.

$$\text{Variable Costs}_{AG} = \text{land (acres)} * [\{(\text{man-hrs/acre})_{AG} * (w_C*1.05) + M_{AG} + F\} + (Yield_{AG} * \$0.0535)]$$

$$\text{Variable Costs}_{C} = \text{land (acres)} * [\{(\text{man-hrs/acre})_{C} * w_c + M_c + F\} + (Yield_c * \$0.0535)]$$

Inputting the data from the 2002 Sacramento Valley Sample Costs of Production Study yields the following expressions for variable cost (VC) per acre:

$$AG: [\{(\text{man-hrs/acre})_{AG} * (w_c*1.05)\} + M_{AG} + F] = \$263.10$$

$$C: [\{(\text{man-hrs/acre})_{C} * w_c\} + M_C + F] = \$273.94$$

$$VC_{AG} = \text{land (acres)} * [\$263.10 + (Yield_{AG} * \$0.0535)]$$

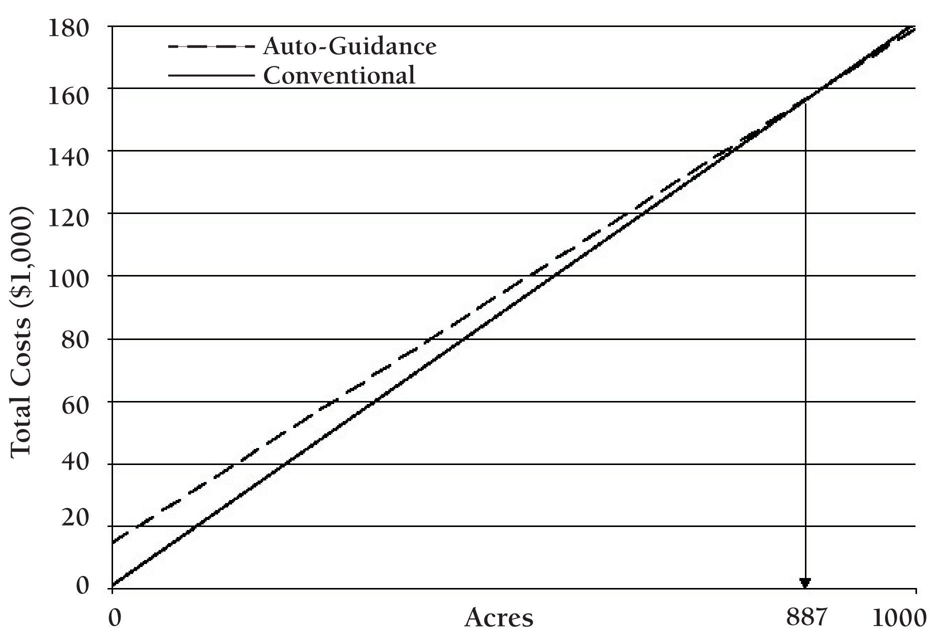
$$VC_{C} = \text{land (acres)} * [\$273.94 + (Yield_{C} * \$0.0535)]$$

The 2002 Sacramento Valley Sample Costs of Production Study reports the average market price as \$0.65 per pound; yield as 1,250 pounds of lint per acre and 2,300 pounds of seed per acre, using conventional technology. Yield using auto-guidance is assumed to be five percent greater in both cases: 1,312.5 and 2,415 pounds per acre, respectively.

$$VC_{AG} = \text{land (acres)} * [\$263.10 + \$70.22] = \$333.32 * \text{land (acres)}$$

$$VC_{C} = \text{land (acres)} * [\$273.94 + \$66.88] = \$340.82 * \text{land (acres)}$$

Figure 2. Cost Comparison for Cotton: Auto-Guidance versus Conventional Technology



Combining this information results in the following expression, in which we allow land to vary and equate the two variable profit equations to find the breakeven acreage to adopt the auto-guidance and conventional technology.

$$[\{(\$0.65/lb * 1{,}312.5\ lbs/acre) + (\$0.07/lb * 2{,}415\ lbs/acre)\} * land(acres)] - FC_{AG} - VC_{AG}$$

$$=[\{(\$0.65/lb * 1{,}250\ lbs/acre) + (\$0.07/lb * 2{,}300lbs/acre)\} * land(acres)] - FC_{C} - VC_{C})$$

where:

FC_{AG} = ($57,000 at 7% interest, 5 years) = $13,794/year

FC_{C} = $0

VC_{AG} = land (acres) * $333.32

VC_{C} = land (acres) * $340.82

This model is very flexible in the case that new data are introduced. New parameters α and ß, different market prices for cotton, ginning costs and credits, material cost savings due to technological improvements and auto-guidance laborers' wage premium all can be easily inputted without changing the basic form of the model.

The variable profits are equal at 246 acres of land planted to cotton (Figure 1). This number is the minimum breakeven acreage to adopt AG technology, assuming the current parameters and variables. If the increased lint and seed yields from AG technology are ignored, the minimum farm size required to adopt an auto-guidance system is 887 acres (Figure 2). This latter figure seems more consistent with current adoption patterns. This outcome may be explained by short-term inefficiencies in learning and using the technology.

Conclusion

For farms of sufficient size, the implementation of an auto-guidance system will reduce inputs while increasing yield, resulting in increased profits for those farmers who employ the technology ahead of their competitors. Analysis based upon a linear programming model reveals a breakeven acreage of 246 acres for the revenue and cost parameters defined in the model. If these parameters were to change, the breakeven acreage would change accordingly. This model can be adapted to calculate the same information for a different crop.

A decrease in marginal production costs increases the supply of cotton, increasing both producer and consumer welfare. This welfare increase depends on the share of cotton in the total economy and the percent of cotton acreage farmed using auto-guidance systems but, ultimately, the appropriate implementation of such technology benefits the economy in its entirety.

The 2002 Sacramento Valley Sample Costs of Production Study for cotton is among over 125 studies available for downloading in pdf format from the UC Davis Department of Agricultural and Resource Economics Web site at: www.coststudies.ucdavis.edu

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