Using Cotton Yield Monitor Data for Farm-Level Decision Making

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Cotton yield monitors were introduced commercially in 1998 and are gaining some acceptance in the U.S. cotton belt. As is the case with grain yield monitors, growers are wondering how to best use cotton yield monitor data. This article compares cotton yield monitor adoption to that of grain monitors, outlines special challenges facing yield monitor data interpretation, and provides an example of yield monitor data analysis using cotton data from Arizona.

History and Adoption of the Cotton Yield Monitor

Because of their relatively recent commercial release, the adoption of cotton yield monitors lags far behind that of corn, soybeans, and wheat in the U.S. Surveys in 2000 and 2001 showed the use of yield monitors for soybeans was approaching 30% and for corn 40% (Figure 1), but projections for the 2004 harvest place those numbers close to 50%. In contrast, the percent of cotton acres harvested with a yield monitor in 1999 and 2000 was below 2 percent (Figure 1). For any crop, yield monitors associated with a global positioning device (GPS) have even lower adoption rates (Figure 2). However, it is expected that cotton yield monitor adoption trends will be similar to those observed with corn, soybean, and wheat.

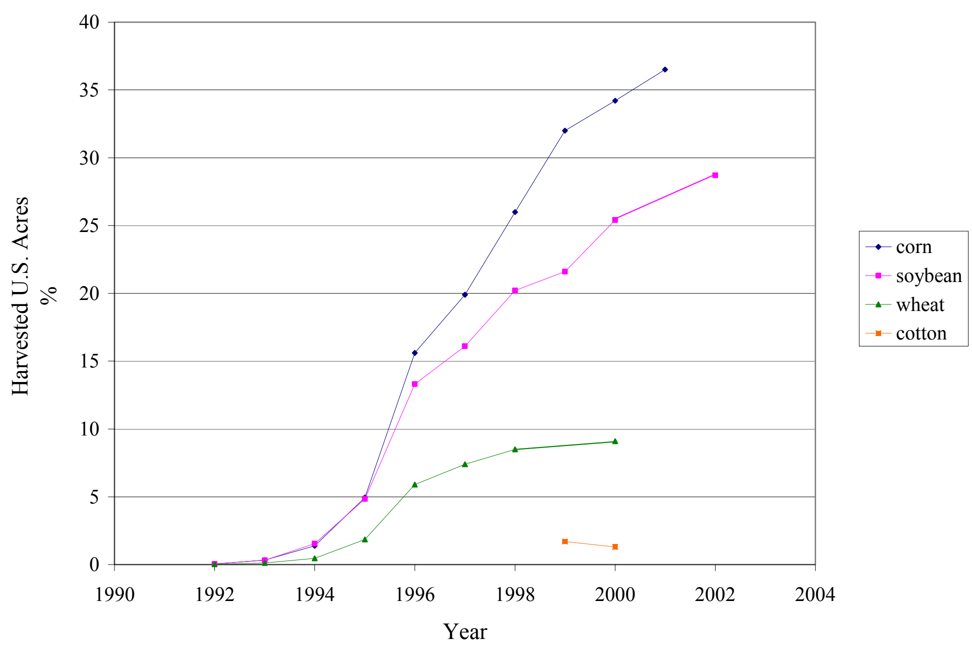

Figure 1: Yield monitor adoption (USDA-ARMS).

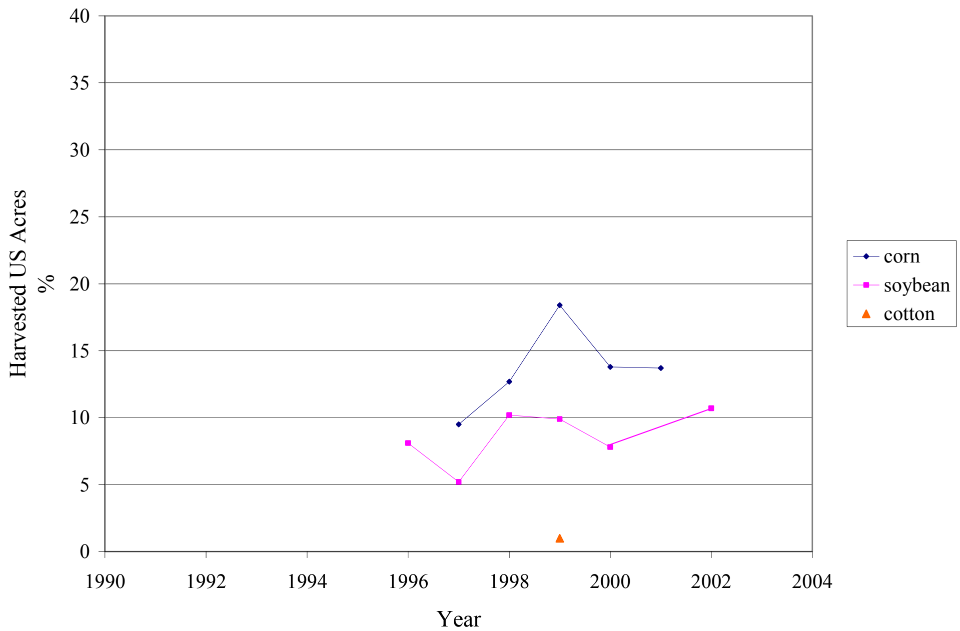

Figure 2: Yield monitor with GPS adoption (USDA-ARMS).

In theory, there should be a greater incentive to use a yield monitor in a higher value crop like cotton. However, the nature of cotton harvesting presented unique challenges developing an accurate on-the-go measure. The first cotton yield monitors were not commercially available until 1998. At this time, more than 20% of the total corn and soybean acres were harvested with a yield monitor. In contrast to the mass flow measures of grain monitors, cotton picker yield monitors use optical sensors to measure the bulk flow of cotton moving from picking rotors to the basket in the vacuum tubes (see AgLeader http://www.agleader.com/docs/cotton-release_2000.htm for more information). A unique feature of cotton monitors is that information can be collected from individual rows.

Fewer economic analyses have been conducted regarding cotton yield monitors compared to grain yield monitors. But now that a substantial number of cotton farmers are collecting site-specific yield data, on-farm experimentation using yield monitor data and cost-benefit analyses of this new technology are possible. Corn, soybean, and wheat growers may assign very little value to yield monitor data until they find a way to use it in decision making. This is likely to be the case for cotton yield monitor data. To help with this, the University of Tennessee, in collaboration with Cotton Incorporated, created an interactive decision aid tool (see http://economics.ag.utk.edu/cymida.html for more information) which allows growers to evaluate adoption decisions before investment. But until data analysis services are widely available, continued adoption of cotton yield monitors may be slow.

Challenges and Opportunities for On-Farm Trials and Precision Cotton Production

The timing and application of inputs for cotton production complicate the implementation of cotton experimental designs. In general cotton farmers apply more inputs for a wider variety of purposes than grain farmers. In addition to the variety, fertilizer, herbicide, and planting time insecticide treatments commonly used by grain farmers, cotton producers might wish to compare mid-season application of insecticide, growth regulator, or defoliant products. Furrow irrigation is not unique to cotton, but it is common, and there can be important differences in the amount of water plants receive from one end of a field to the other. Aerial applications are quite common in cotton, so strip trials are hard to implement. Split-field, paired-field, and large plot designs are more practical to implement than strip trials, but on-farm trial design and analysis has raised questions about the validity of this data because of problems with randomization and replication.

In grain yield monitor data, spatial analysis has been used to improve the reliability of farm management decisions. Spatial analysis combines techniques from geography, geostatistics, and regional economics and applies them to yield monitor data. For cotton, spatial analysis can help growers and those that advise them to cope with the large plots required by aerial application and spatial patterns created by irrigation. Individual row data from cotton monitors allow greater flexibility in analysis. Suspect data points, outliers or even entire cotton rows may be removed from analysis leaving an adequate number of observations.

Cotton Yield Monitor Data Spatial Analysis

As an example of the analysis of cotton yield data, yield responses to tillage system treatments were analyzed on a field with varying soil clay content at the University of Arizona's Maricopa Agricultural Center 40 km south of Phoenix in 2002. Large treatment blocks were replicated five times (Figure 3), with the following treatments:

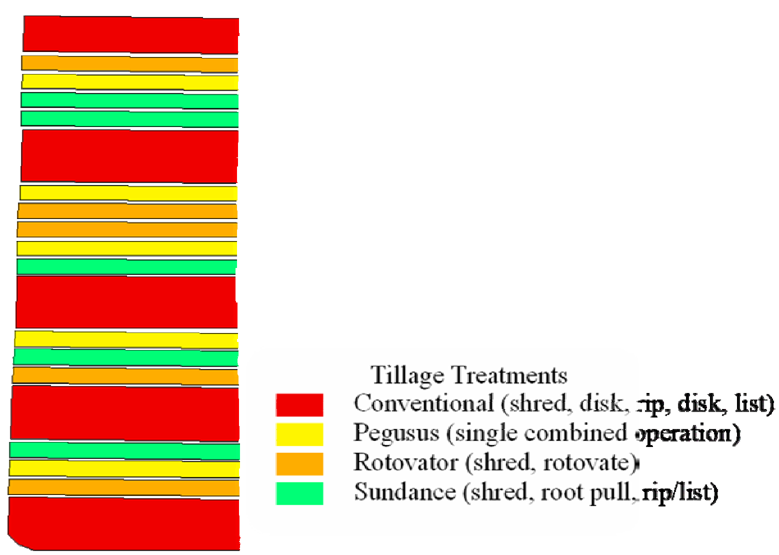

Figure 3: Experimental design of tillage treatments.

Spatial analysis works best when data on soils, topography or other field characteristics are available to help explain patterns. In this case yield was regressed on clay content, the tillage treatments and an interaction term between clay content and treatment using analysis of variance (ANOVA). Inference drawn from ANOVA results is compromised when spatial autocorrelation is present in the data (Griffin et al., 2004). Spatial diagnostics indicated that ANOVA error terms were seriously autocorrelated.

ANOVA indicated the three alternative tillage treatments and the clay by Rotovator interaction term were significantly different from the overall mean yield. When ANOVA was corrected for spatial autocorrelation (SANOVA), all treatments and interaction terms except for the Sundance by clay content interaction were significantly different from the overall mean. Even though treatments were found significant using ANOVA, the effects of Pegasus, Rotovator, and Rotovator by clay content interaction term were reversed between ANOVA and SANOVA.

Importance of Spatial Analysis to Cotton Yield Monitor Data

If only ANOVA was conducted the decision maker would be led to incorrectly believe that Conventional mean and Pegasus by clay content interaction were not significant while Pegasus and Rotovator tillage treatments had a lower and higher than average response for cotton, respectively. Without the use of spatial regression, the grower would not have been provided reliable information to base subsequent management decisions.

Using results only from ANOVA, a grower might decide to use Rotovator on fields where most soils had less than 10% clay content and Conventional systems otherwise (Table 1). Unlike ANOVA, results from SANOVA indicated Conventional tillage systems dominate across all observed clay percentages of the field. The slopes of the four tillage systems are similar under ANOVA (Figure 4), while they are remarkably different when the spatial structure of the yield monitor and crop geographic information system (GIS) layers is correctly modeled (Figure 5).

Table 1: Cotton yield per acre at low, mean, and high clay content by treatment.

Treatments	Clay content Level		
	8% (low)	23.2% (mean)	32% (high)
--------------------------------------ANOVA--------------------------------------			
Conventional	2468	4551	5757
Pegasus**	2027	3824	4865
Rotovator***	2631	4126	4991
Sundance*	2091	3888	4929
--------------------------------------SANOVA--------------------------------------			
Conventional***	4300	5179	5687
Pegasus**	3241	3291	3320
Rotovator***	2656	3792	4450
Sundance***	2550	3244	3646

* intercept shifter coefficient significantly different from mean yield at the 10% level
** intercept shifter coefficient significantly different from mean yield at the 5% level
*** intercept shifter coefficient significantly different from mean yield at the 1% level

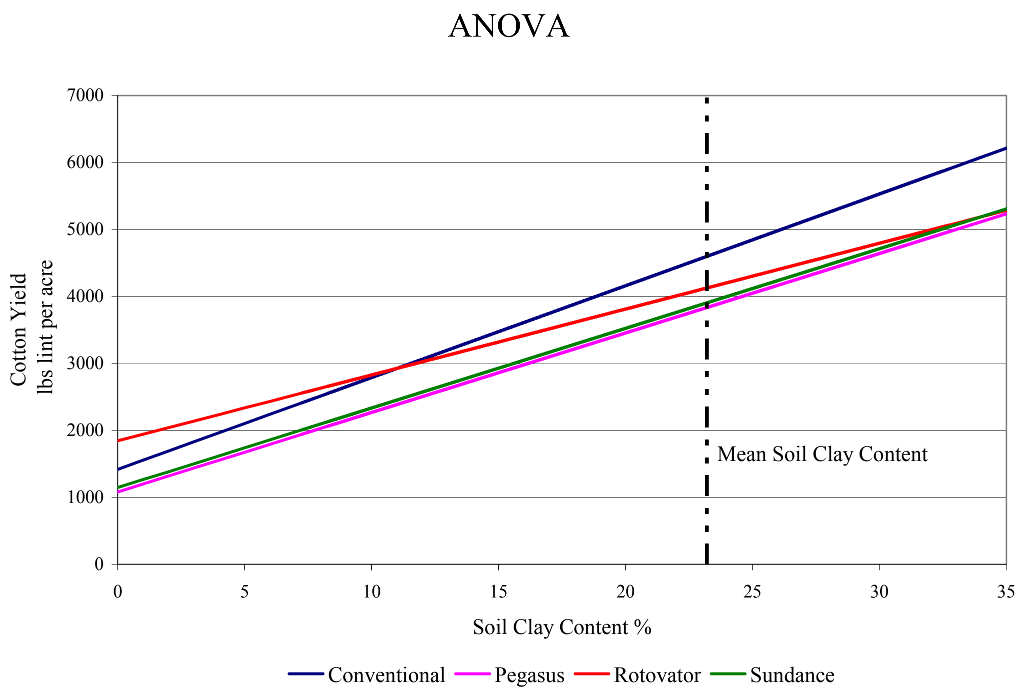

Figure 4: Predicted cotton yields using estimated ANOVA coefficients.

If the grower were considering adoption of one of the alternative tillage systems, their decision would differ depending upon soil clay content and the analysis method utilized. Over the observed range of clay content percentages of the field and ANOVA results, the decision maker would choose Rotovator (Figure 4). However, when SANOVA is used for decision making, Rotovator would be chosen for fields with over 16% clay content and Pegasus system chosen for fields with less than 16% clay content (Figure 5). In addition, Sundance dominated Pegasus for soils with more than 24% clay content, which is near the mean soil clay content of the field (23.2%). This can be contrasted to ANOVA where Pegasus never dominated any other tillage system at any soil clay content. At the mean soil clay content, Conventional dominates Rotovator which dominates Pegasus and Sundance.

If the relationships in the 2002 data were confirmed in subsequent seasons, a grower who wanted to use alternative tillage systems for soil conservation or other reasons might decide on a field-specific tillage plan. Varying tillage within fields is unlikely with current equipment because it would complicate logistics. But fields where soil clay content is low may be managed differently from those which are mostly higher clay content soils. Tillage effects may also be related to other soil and landscape properties such as slope, aspect, or organic matter.

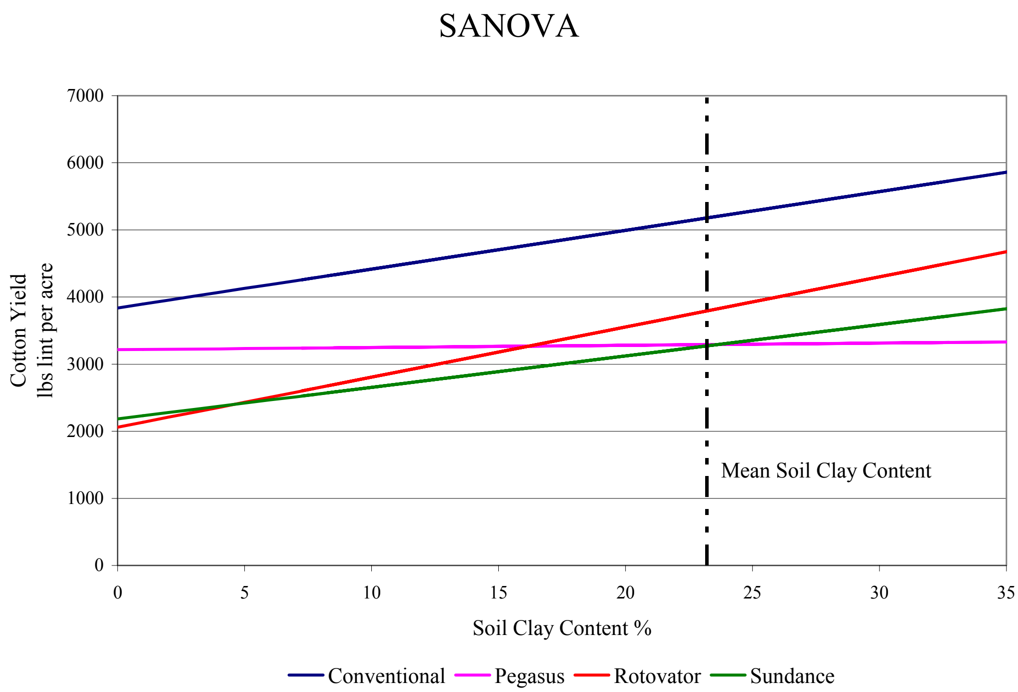

Figure 5: Predicted cotton yields using estimated spatial model coefficients.

Conclusions

Similar alternative experimental designs and spatial analysis techniques for yield monitor data are being evaluated on-farm in five states. If more reliable information can be gleaned from the limited replication experiments that growers are already conducting with yield monitors, they will be able to make better farm management decisions. These analyses have been conducted on corn and soybean in Indiana, Illinois, and Kentucky, cotton from Arizona, and rice in the Mid-South. Further testing and demonstrations of these types of analyses are being identified in other crops across differing regions.

References

Griffin, T.W., D.M. Lambert and J. Lowenberg-DeBoer, 2004. Testing For Appropriate On-Farm Trial Designs And Statistical Methods For Precision Farming: A Simulation Approach. Proceedings of the 7th International Conference on Precision Agriculture and Other Precision Resources Management, ASA/SSSA/CSSA, Madison, Wisconsin.

Disclaimer - *The purpose of this newsletter is to compare traditional ANOVA analyses to SANOVA methods in evaluation of treatments from farm-level field trials. Results are from a single year at a single location, therefore tillage system rankings are not intended to be used as generalizable knowledge across regions, growers, or tillage systems, but rather as a demonstration into alternative methods of on-farm experimenation.*