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MEASURING THE SPATIAL VARIABILITY OF COTTON FIBER PROPERTIES

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Abstract

Development of spatial technologies, in particular yield-monitoring systems, has greatly enhanced our appreciation for the extent of spatial divergence in cotton production fields. Given the importance of fiber quality in determining the value of the cotton, there is considerable interest in understanding the spatial variability of cotton fiber properties and its dependence on underlying field variability. Previous work has relied on hand harvesting of the cotton at intervals throughout the field, and measuring the fiber properties of the harvested lint. While this approach may be suitable for research plots or small-scale production fields, it is not amenable to full-scale production research. Moreover, the hand-harvested cotton has different fiber properties than cotton from the same area that is machine harvested. Both the harvesting and ginning methods alter the cotton fiber, and introduce deviations from the fiber qualities that would be measured by producers. We have developed a system of fiber sampling that removes a portion of the cotton during machine picking. These cotton samples are then ginned in a small research gin, and classed at the USDA-AMS Classing Office. Spatially registered maps are built of the various fiber qualities. Discounts based on the fiber properties and total lint discount are determined according to the Spot Cotton Quotations. Spatially registered maps of fiber discounts are also developed. Fiber value maps are combined with cotton yield and management inputs to determine spatially registered cotton profitability. Management scenarios that optimize profitability are then built for each of the discrete management zones as identified by the response of cotton growth, yield, fiber properties, and profitability.

Introduction

Introduction of a reliable yield monitor (Wilkerson and Moody, 2000) has increased our understanding of factors contributing to spatial divergence in cotton production systems. While yield is important in determining the value of the crop, the fiber quality also contributes to crop value and profitability, as it determines the price of the cotton. Previous studies examined the spatial variability of fiber properties from hand-harvested samples. These studies demonstrated that the development of cotton fiber and final fiber properties is spatially variable, and depends on field conditions (Johnson *et al.*, 1999; 2002).

One limitation of hand-harvesting cotton samples is that the cotton fiber properties for hand-harvested cotton are different than for machine-harvested cotton. Moreover, this method is not amenable to large-scale work, as is needed in a production setting. We developed a sampling system that removes a portion of the cotton as it moves through the picker chute. These samples are then ginned in a research gin, and classed as for production cotton samples. Because cotton fiber properties are dependent on the handling methods, both harvesting and ginning, we compared fiber samples obtained with this method to hand-harvested samples of the controlled research plots. Additional comparisons between research-ginned and production scale ginning on the fiber properties were made.

Materials and Methods

Cotton Production

Cotton was planted in research plots that were 18 rows wide by 67 feet long at the Delta Research and Extension Station at Stoneville as previously described (Pringle 2004). Planting dates and growth conditions varied between the years of the study (2000 - 2004). Agronomic inputs were maintained optimally, and consistent within plots. At final harvest, 100 bolls were handpicked from each plot, and ginned on a 10-saw research gin (Continental Eagle Co., Memphis, TN). Four rows of cotton were harvested from each plot with a John Deere 699 cotton picker that had been modified for plot picking. A small sample of the machine-harvested cotton was removed for ginning with the research gin for comparison of ginning methods on cotton qualities. The remainder of the machine-harvested cotton was ginned on the micro-gin at the USDA-ARS Cotton Ginning Lab in Stoneville. After ginning, the cotton samples were submitted to the USDA-AMS Classing Office in Dumas, AR, for determination of fiber properties by standard determination and HVI classification.

Cotton was planted in a production field at Perthshire Farms, in Bolivar County, MS. At harvest, a 2-row Case IH cotton picker, equipped with a yield monitor (AgLeader, Ames, IA) and fiber sampler (described below) was used to harvest the cotton. The cotton yield monitor recorded the cotton yield, and the geoposition of the harvest. The GPS record from the yield monitor was used to reference the geoposition of the cotton sampled for fiber property determinations. The cotton samples were ginned on the 10-saw research gin, and classed at the Dumas Classing Office, as described above. The remainder of the cotton was transferred to modules, and ginned at the Perthshire gin.

Sampling System

The sampling system has been described in detail elsewhere (Sassenrath *et al.*, submitted). The system was constructed of sheet metal, and attached to the outer chute of the cotton picker. A paddle gate inside the sampling mechanism diverted the cotton from the picker chute into the sampler chute for collection in sacks attached to the sampling platform. The sampling platform was built on the outside of the picker cab, above the front wheels, and included a seat with seat belt for operator safety. The sampling operation was triggered when the operator opened the paddle gate. Samples were collected for 10 s, after which time the gate was closed, and a new bag was put on the collector. Location in the field was determined from the GPS signal from the yield monitor.

Data Analysis and Map Production

Data were analyzed using Excel, SigmaPlot, and SAS. Spatial maps were generated in ArcView, using Spatial Analyst. Grids were built from the data using IDW method, with a fixed radius, power of 2, no barriers.

Results

Most biological events result in a standard normal, or Gaussian, distribution of events. Deviations from the standard normal distribution are indicative of the presence of discrete populations, or responses. The greater the population of samples, the more accurate is the distribution.

In this manner, the spatially registered yield (Figure 1) can be distributed between bins based on the quantity of cotton harvested per pixel. Plotted as the frequency of pixels for each range of yield amount, the individual yield measurements show a standard normal distribution, with small population both above and below the average (Figure 2). These nonconforming populations can be directly tied to specific portions of the field using ArcView, and correlate well with the observed yield map (data not shown). Examining the distribution of a population gives indications of potential deviations from normal, much the same as statistical calculations such as mean, median, and standard deviation.

Certain fiber properties, such as micronaire, are distributed nearly normally from within a population (Figure 3). Other fiber properties, such as color, do not show a normal distribution, due to the discrete nature of the grading scale. Distinct differences between cotton fiber properties result from methods of handling, including both the picking method and gin used. This difference is apparent as a shift in the distribution of the values recorded for the cotton. While the ginning method only slightly affected the micronaire distribution, a greater influence is observed for other fiber properties, such as length (Figure 4). In general, because of the absence of any cleaners on the 10-saw research gin, cotton ginned in the research gin had significant discounts due to lint color, leaf, and extraneous matter (data not shown). Hand picking the cotton improved the leaf and extraneous matter, but altered cotton properties associated with maturity and strength, apparently from a predilection of humans to thoroughly remove the cotton from the plants, even though not of the best quality.

To circumvent the error introduced into the cotton fiber properties from hand harvesting, and to allow more rapid and consistent sampling of cotton fiber properties for delineation of spatial variability, we built a cotton sampler onto a commercial cotton picker (Figure 5). The cotton sampler allowed us to sample a portion of the harvested cotton approximately every 20 seconds during the picking operation. The system was found to be sufficiently reliable and easy to use to allow consistent sampling in a large-scale production setting.

To better compare the fiber properties with value of the lint, we determined the discounts for each of the fiber properties, and the overall lint discount, from the Spot Cotton Quotations for the Lower Delta. These discounts were used to determine the overall cotton value. Preliminary corrective values were used to better fit the research-ginned samples to values observed by producers. These corrective values compensated for the poorer grades resulting from the absence of lint cleaners on the research gin. The spatially registered cotton value was linked with information on management costs and yield information using Spatial Analyst in ArcView. The resulting map gives the spatially registered profitability of the cotton for that year (Figure 6).

Conclusions

The cotton sampling system retrieves small samples of cotton from the picker chute during the harvest operation. The system is reliable, and reasonably accurate in sample position location. Future advances to the sampling mechanism will allow triggering of the sampling operation based on geoposition, as recorded by the GPS on the yield monitor. This will further improve the accuracy of the sampling position. Because the system uses machine-harvested cotton, it eliminates the error in fiber qualities introduced in hand-harvested lint. However, the small sample size requires ginning on a 10-saw research gin, which introduces errors due to the absence of lint cleaners. Work in progress is implementing a neural network to translate the information from the 10-saw research gin to the large-scale production gin, eliminating the biases of ginning method. The information gained from using the current system allows development of spatially registered information on all fiber parameters, and the total fiber value. This information is then coupled with the yield and financial management records for development of profitability maps. Future research is underway to explore co-dependencies between fiber quality and yield parameters, and interrelationships with environmental and edaphic stressors.

Disclaimer

Mention of specific trade names is for information purposes only, and does not constitute a recommendation at the exclusion of other systems that may also be available.

Acknowledgements

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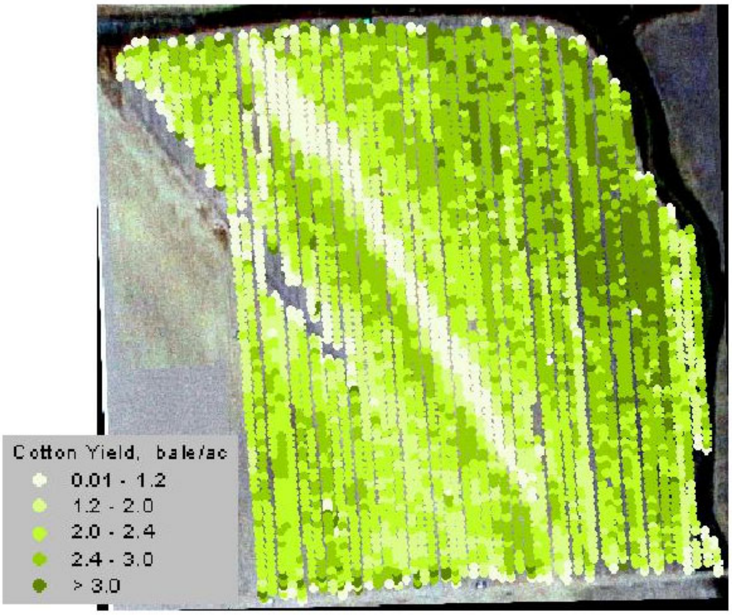

Figure 1. Spatially registered cotton lint yield as determined by a cotton yield monitor.

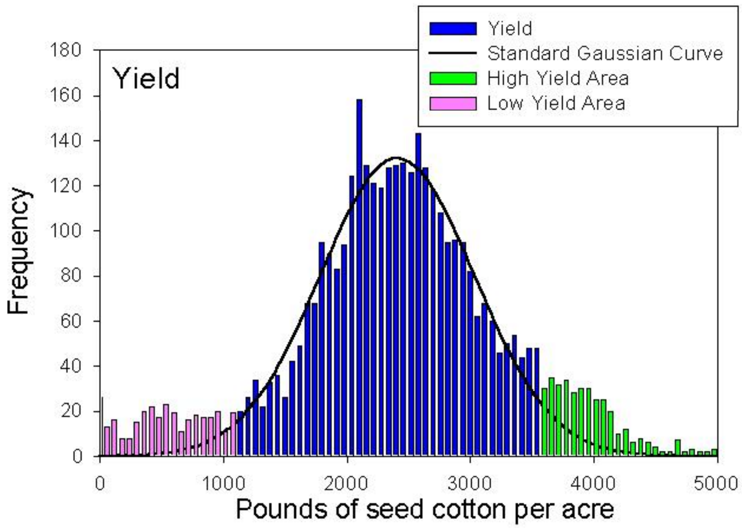

Figure 2. Frequency distribution of cotton lint yield.

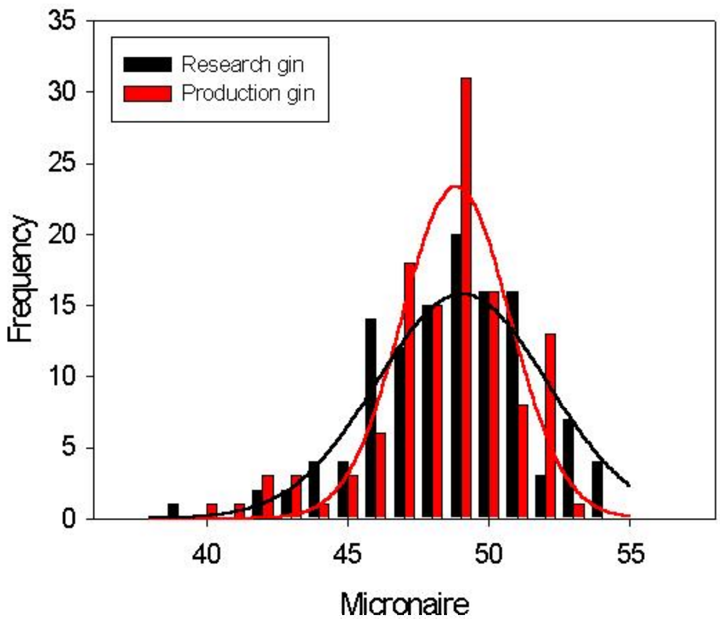

Figure 3. Distribution of micronaire from machine-harvested cotton, ginned on a 10-saw research gin or a production gin.

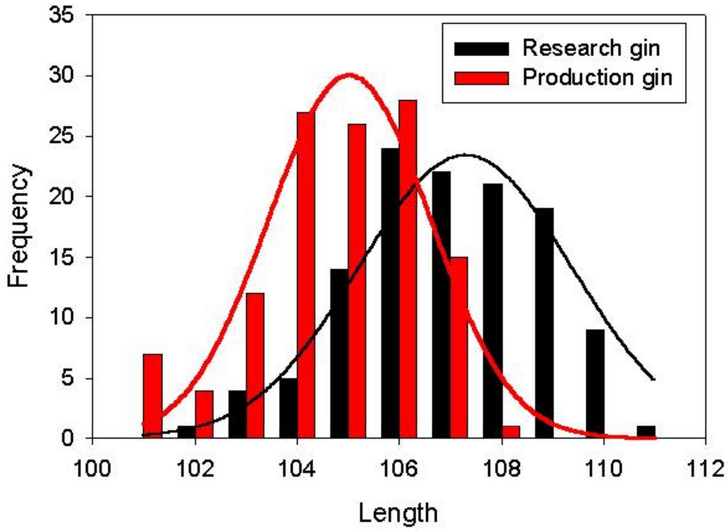

Figure 4. Comparison of length of machine-harvested cotton with ginning methods.

Figure 5. Sampling chute attached to the outer chute of a commercial cotton picker.

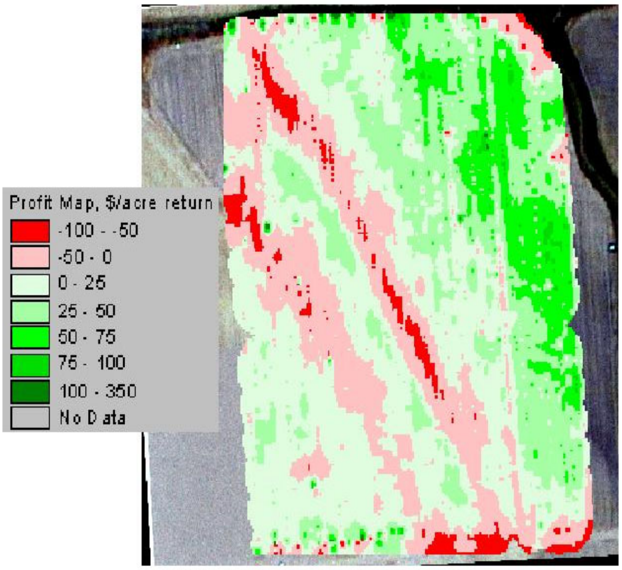

Figure 6. Profit map of the cotton production field, derived from the spatially registered yield and lint quality, coupled with total management inputs.