COTTON YIELD MAPPING

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Abstract

Yield mapping is a critical aspect of a precision management approach to farming. Crop yield is an important feedback parameter when attempting to optimize production inputs on a less than field size basis. However, knowledge of yield variability patterns are not enough to implement a precision management system. Parameters that cause variability should also be measured. No cotton yield mapping systems have been available commercially, but development is underway. Cotton producers, advisors and researchers will be affected by the availability of cotton yield mapping systems, and should prepare for the wide spread availability of such systems.

Introduction

Precision farming is a concept that has captured the interest of many concerned with agriculture. The ability to vary the application rate of agronomic inputs across a field provides the potential for increasing the efficiency of those products and the possibility of reducing the environmental impacts. While variable rate application machines provide the ability to adjust rates, there must be a valid reason for changing applications at a given point in a field. While several different parameters may be useful in making rate determinations, yield is certainly one of the most important. Cotton producers interested in precision management need to have yield mapping capabilities.

The development of yield mapping systems for cotton harvesters has lagged behind the systems for grain combines. Early work on grain yield mapping began in the mid-1980's (Searcy, et al., 1989, Tits, et al., 1989), and commercial systems became available in 1993. Much of the delay between early research and commercialization was due to the lack of a reliable and affordable positioning system. Yield mapping combines the measurement of crop material harvested with the location of the harvester in the field. Without both capabilities, the map creation would be inaccurate. The implementation of the Global Positioning System (GPS) and the availability of differential correction signals for increased accuracy of positioning (the combination is known as DGPS) has provided the ability to locate the harvester in the field. Cotton yield mapping systems can use the DGPS system as currently available. This should reduce the time between research and commercial adoption.

Research on cotton yield measurement technologies has been underway at southern Agricultural Experiment Stations for since 1993 (Wilkerson, et al., 1994). Activities are underway at universities in Tennessee, Texas, Louisiana and Georgia. Cotton yield is difficult to measure because of the low density of the material and the use of pneumatic conveying on cotton harvesters. Most of the research efforts have been focused on techniques either to measure the flow rate of seed cotton through a duct, or to measure the rate of change of cotton mass in the basket. Commercial research and development is also underway. Both Deere and Case have indicated an intention to have cotton yield mapping systems available for their cotton harvesters at some time in the future. Zycom, a company producing precision farming devices, has recently announced the availability of a cotton yield mapping system. Based on the interest of producers, the R&D effort underway and the intention of the harvester manufacturers, it seems likely that cotton yield mapping will be an established technology by the year 2000. The availability of yield mapping, variable rate application machines and the associated data bases will have a significant impact on the entire cotton production system.

Yield Mapping Results

Cotton yield mapping research has been underway at Texas A&M University in 1995 and 1996. The system under investigation is based on weighing the cotton in the basket and determining yield by the change in mass as the harvester moves through the field. This system has been installed on both picker and stripper type harvesters. Figure 1 shows typical data for the weight of the basket as a function of time. As the cotton is harvested, the weight of the basket increases. When the basket is dumped, the weight returns to approximately the weight of the basket alone. There is some variation in the "zero" weight, because a portion of cotton often stays in the basket. The figure also shows the elapsed time for data recording. Discontinuities result when the data logging is disabled. This occurs when the header unit is lifted for turns or to travel for dumping. The yield per acre values are determined from the slope of the weight lines and the distance traveled. Figure 2 is a yield map created using this system. The mass of cotton was determined for a 50 meter travel distance. The data was then smoothed using an interpolation function. The values shown are for the seed cotton as harvested by the machine. In order to examine lint yields, the values shown would have to be multiplied by the turnout ratio. Cotton yield mapping systems currently under investigation do not have a means of determining either moisture or trash and seed content. Averages for the field will have to be used to obtain the lint yield from the variation in the seed cotton.

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Table 1 contains descriptive statistics from three cotton field that were yield mapped in 1996. The data for the fields in the Southern High Plains and the Coastal Bend are for hand harvested and ginned samples. The values are somewhat higher than would be expected for mechanical harvesting and ginning. The data for the field in the Brazos Valley is from the yield mapping system on the cotton picker. This is a summary of the map in Figure 2. In each case, the data show considerable variability. Although the minimum and maximum yield values are shown, the better measure of variability if the coefficient of variation (standard deviation divided by the mean). The lowest variability was in the Coastal Bend field. This was a region that experienced severe drought, and the entire region was well below the average yields. The highest variability was shown in the data for the Brazos Valley field. While this field was quite variable, some of this variation is probably due to inaccuracies in the measurement system.

Implications of Yield Mapping

The availability of yield mapping systems will require a change of thinking on the part of those interested in cotton production. The abilities to measure yield at any point in the field, and to vary applications of production inputs will present significant challenges in the future.

A yield map presents the cotton producer with the ability to document and analyze the extent of problems that may exist in a field. Producers have long know that problem areas exist, but have not had the tools necessary to evaluate the true cost of those areas. With recent changes in federal farm policy, producers can no longer rely on government payments to aid in profitability. If an acre of land produces at a loss consistently, the producer will need to question the wisdom of continuing to farm that ground in the same way. Conventional wisdom has suggested that 3-5 years of yield mapping will be necessary before making management decisions based on those maps. Experience with yield mapping in other crops suggests that producers will find two sources of yield problems. Natural variation due to soils or topology will affect crop yield, and the producer may or may not be able to affect these causes. These natural variations will have important interactions with weather in a given year, and the effects may be difficult to predict. Man made variations often are evident in yield maps and these can be quickly corrected. Examples have included incorrect irrigation practices, weed escapes and planting errors.

Yield mapping will also have an impact on cotton advisors and consultants. The most immediate impact will likely be requests by clients to explain the variability that is seen in a given field. These will not be easy requests to fulfill. Interpretation of yield maps will require knowledge of the field, the cultural practices used in a given year, the weather for a growing season and any insect, weed or disease problems that might have existed. In short, much more detailed knowledge will be required for clients fields. This need for information represents both a challenge and an opportunity. Obtaining and handling this detailed, site-specific information will mean that new technologies will be needed by crop consultants. They will have to learn to use or hire services for geographic databases and positioning systems. There will likely be more reliance on remote sensing or aerial photography to view the entire field. A significant challenge will be to provide useful site-specific information at a reasonable cost to the producer.

Cotton research and extension activities are also likely to be affected by yield mapping capabilities. The ability of measure yield variability over large areas means that research may not have to be limited to small plots. Suggested cultural practices could be investigated over large areas, and the interactions with various field parameters analyzed. If several producers have yield maps available, this could represent a significant resource for investigation. However, yield maps by themselves will have limited utility. Other important parameters will also have to be known in order to extract useful knowledge from a collection of yield maps. Perhaps the greatest impact on research and extension personnel will be the change in producer focus on management units. Today, the management unit is commonly the entire field. With yield maps, variable application maps and remotely sensed images, the focus will change from fields of 50 to 250 acres to subfield areas of a few acres. This detailed focus will change the way recommendations are made.

Summary

Cotton yield mapping systems will be commercially available and widely adopted in the near future. The availability of this detailed information will change the management focus from the field as a single unit to the field as a collection of management units. Professionals interested in the cotton production system will be impacted by this change. Yield mapping will likely serve as an impetus for the development of technologies and services that provide the producer and his advisors with detailed site-specific information. A major challenge for all involved will be to obtain and handle this detailed information in a cost efficient manner.

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Table 1. Yield mapping statistics for harvested lint at three locations in Texas.

Location	Mean (lbs/ac)	Coefficient of Variation (%)	Minimu m (lbs/ac)	Maximum (lbs/ac)
Coastal Bend [1]	474	18	290	615
Southern High Plains [1]	1271	26	536	2090
Brazos Valley [2]	376	51	2.7	1310

[1] hand harvested and ginned [2] lint calculated as 33% of harvested seed cotton

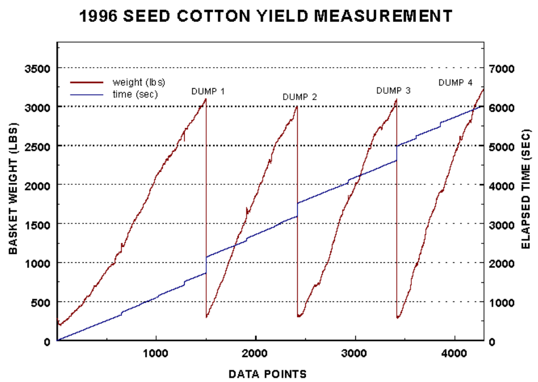

Figure 1. Change in basket weight as cotton is harvested and dumped. Elapsed time of data logging is shown also (diagonal line from lower left to upper right).

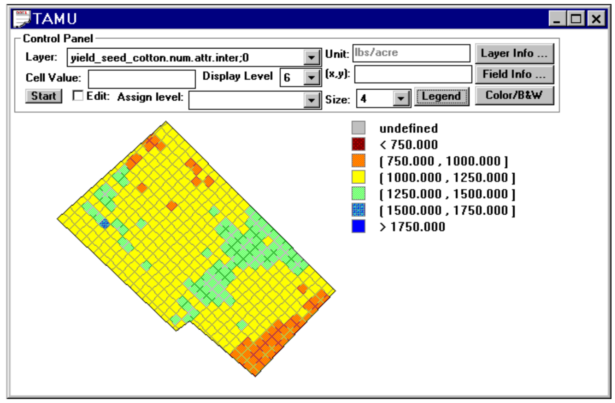

Figure 2. Interpolated yield map of seed cotton for a field in the Brazos Valley of Texas.