SPATIAL VARIABILITY OF COTTON AND CORN YIELDS IN A CORN-COTTON ROTATION

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Abstract

Precision agriculture has been gaining acceptance and use in some areas of the country and continues to grow across the Cotton Belt. Utilization of Global Positioning Systems (GPS) and Geographic Information System (GIS) make it possible to geo-reference fields which become the framework for multi-layered data that can be used to help explain events occurring in a particular field or management zone. This study on 15-acre field at the Delta Research and Extension Center was initiated in 1998 in an effort to evaluate the spatial variability of corn and cotton yields as well as the soil characteristics measured in the same areas. Corn grown in 1998 had yields which ranged from a low 132 bu/A to a high of 186 bu/A and a field average of 156 bu/A. In 2000, the same area had corn yields which ranged from 151 bu/A to a high of 222 bu/A and a field average of 182 bu/A. The area was rotated to cotton in 1999 following the corn crop of 1998. Yields in general were higher following the corn crop than they had been in previous years and were much higher than surrounding fields of continuous cotton. First harvest yields ranged from 900 to 1439 lb lint/A with an average of 1163 lb lint/A. Second harvest yields ranged from a low of 33 lb lint/A to a high of 208 lb lint/A and a field average of 86 lb/A. Total lint yields ranged from a low of 949 lb/A to a high of 1508 lb/A and an average across the field of 1248 lb/A. The range of 562 lb lint/A represented a range of nearly 60% across the field. In 1999, maturity measured as percent first harvest (PFH) ranged from 81.5% to 96.8% with a field average of 93.1%. With the data collected and analyzed to date, it is apparent that the yield controlling factors are complex and are also not consistent from crop -to-crop or year-to-year. The next step is to look at correlations and relationships between the yield and yield components and soil characteristics which will be the scope of the second manuscript in this set. While the technology is new and shows potential, many questions and concerns are yet to be answered. The new technology does provide many useful tools for examining the variations occurring in the field

Introduction

Site specific management and precision agriculture are just a few of the terms used to describe new technologies that offer promise for incorporation into current agricultural management schemes. Global positioning systems (GPS) have made it possible to geo-reference areas which become the basic framework for multi-layered data that can be used to describe events taking place in a particular field or management zone. Yield monitors which have been introduced on grain harvesters make it possible to measure yield variations in the field while moving across the landscape. The yield data collected can then be related back to the original GPS framework. Since GPS establishes a land-based reference system, the most logical point to begin is the soil and soil nutrient analysis. This on-going study was initiated in 1998 to examine the relationship between soil testing parameters (pH, phosphorus [P], potassium [K], exchangeable acidity, exchangeable cations [K, Ca, Mg, Na], cation exchange capacity [CEC], organic matter [OM], an estimate of sulfur [S], and zinc [Zn]) and yields of corn (1998 and 2000) and cotton (1999). Other data such as harvest moisture, plant stands, bushel test weight, seed weights can also be collected and related back to corn yields. When cotton is grown, seedcotton and lint yields can be measured along with maturity as determined by the percent first harvest (PFH).

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To date, much of the application of technology has been related to the soil variability without actually trying to determine what the relationship between yield and the soil characteristics might be. Variable-rate applicators are proposed for trying to even out nutrients levels in the field while the relationship to yield of that nutrient may not be known. The first objective of this study was to examine the natural variability in a field and build yield maps which show the extent of the spatial variability. The second objective was to determine whether the patterns of variability were consistent from crop to crop and year to year. The second part of the study was was designed to examine the relationship between yield and soil characteristics and determine which factor or factors may explain spatial yield variability in both corn and cotton.

Materials and Methods

The research area was a 15-acre field on the Delta Research and Extension Center at Stoneville, MS containing three soil classification units as delineated in the Soil Survey Report for Washington County, Mississippi. The general soil type was Dundee (Aeric Ochraqualfs) with three different textural classes. The classes included very fine sandy loam, silt loam, or silty clay loam. The field was divided into 496 plots (cells) with each cell consisting of four 40-in rows, 82 feet in length (0.025 acres). The 496 cells were arranged in eight tiers and 62 ranges with alleys between tiers. All plots were planted to corn in 1998 (variety: Pioneer 32K61) and maintained uniformly during the entire season with all cultural practices consistent across all cells. The center two rows of each plot were harvested, weighed, and a moisture sample taken so that the yield could be adjusted to a constant moisture. In 1999, cotton (variety: STV-474) was planted and maintained uniformly as in the previous growing season. The two center rows were again harvested with a commercial spindle picker modified for plot harvest. Grab samples were taken at each of two harvest to determine lint percent which was used to calculate lint yields. The area was rotated back to corn in 2000 (variety: Pioneer 3223). Corn samples were taken during the harvest and used to determine the harvest moisture and bushel test weight. The grab samples taken during each cotton harvest were ginned through a 10-saw micro-gin. The lint percent was then used to determine lint yield.

Cells were geo-referenced prior to harvest in 1998 with an ATV-mounted GPS equipped with differential correction. Initial soil samples were taken from each cell following harvest in 1998. Eight to ten subsamples were taken and composited from each cell. The 12-in core was divided into topsoil (0 to 6 in) and subsoil (6 to 12 in) samples. All samples were dried, ground, and mixed prior to leaving the experiment station and were then analyzed by the Soil Testing and Plant Analysis Laboratory at Mississippi State University operated by the Extension Service. Additional 0-6" soil samples were taken following the 1999 and 2000 harvests.

Several tools have been used in the summary and explanation of the data collected. These tools included Lotus 123 spreadsheet and Freelance Graphics, ArcView Geographical Information System (GIS, Environmental Systems Research Institute, Inc.), Statistical Analysis Systems (SAS), and TableCurve 2D (Jandel Scientific). These products made it possible to look at correlations between the yields and measured soil characteristics.

Results and Discussion

Corn Production - 1998 and 2000

The research area described in this study had been in continuous cotton for many years prior to the initiation of the present study. Corn was chosen as the initial crop because it is less influenced by environmental factors, insects, and disease. In the first year of the study, corn yields ranged from a low of 132 bu/A to a high of 186 bu/A with an overall field average of 156 bu/A (Table 1). The actual distribution of yields in the field which have been adjusted to a standard 15.5% moisture is shown in Figure 1998Y.

The yield map did show areas with distinctly higher yield especially in the northwest corner of the field. The west side of the field was the sandiest and graded toward the silt loam and silty clay loam as one moved east in the field.

The crop was allowed to field dry prior to harvest initiation. Because of the size of the study, harvest occurred over a 3-day period . The harvest moisture ranged from a high of 15.7% to a low of 13.9% and an overall field average of 14.6% (Table 1). The field average was well below the grain delivery point requirements. There were no distinct patterns in the field (Figure 1998-HM) and none would be expected under normal harvest conditions. Should harvest begin earlier when moisture content is greater, then harvest may reflect some minute differences in maturity.

The bushel test weights ranged from 55.7 to 60.3 lb/bus with an overall average of 58.6 lb/bu. The field distribution for bushel test weight is shown in Figure 1998-BTW. One should not expect a great deal of change in bushel test weight under optimum moisture conditions. However, the 8% range is more than was expected.

The research area rotated back to corn in 2000 following the cotton grown in 1999. Corn yields in 2000 ranged from 151 bu/A to a high of 222 bu/A and a field average of 182 bu/A (Table 1). The average yield in 2000 was 26 bu/A higher than the average in 1998. This translated to a 17% increase in grain yield. Part of the difference in yield could be reflected in the different corn varieties grown (Pioneer 32K61 in 1998 and Pioneer 3223 in 2000). Certain varieties do better on some soil types with much variation due to the environment, planting dates, and other factors. The range in yields in 2000 (71 bu/A, 47%) was greater than the range found in 1998 (53 bu/A, 40%). The field distribution of grain yield is shown in Figure Y2000. Visual comparisons of the yield maps indicated an apparent difference between the two years. Lower yields were observed on the south side of the field in 1998 while in 2000, the yields in that area were much higher.

Drying conditions were more conducive to field drying in 2000 with field dry down occurring rapidly. Harvest moisture ranged from 11.4% to 13.7% which is well below the allowable moisture for sale to the grain elevator. The field distribution is shown in Figure 2000-HM. The distinctly different areas of the field are related to the time of harvest (early in the day vs late in the afternoon) under extremely hot conditions. As in 1998, three days were required to harvest the entire field.

Bushel test weights in 2000 ranged from 56.3 lb/bu to a high of 59.8 lb/bu with a field average of 58.2 lb/bu. These numbers compare well to those obtained in 1998 with the other hybrid. In 2000, plant stands were also taken at harvest by counting the number of plants in the rows adjoining the harvest rows. Surprisingly, the harvest stand ranged from as few as 18,300 plants/A to more than 28,700 plants/A or a difference of around 10,400 plants/A with an field average of 23,000 plants/A (Table 1). The field distribution is shown in Figure CR00-Stand. Lower stand counts were not necessarily indicative of lower yields.

Cotton Production - 1999

The 15-acre GPS/GIS field was rotated to cotton in 1999 following corn in the 1998 growing season. The summary data is given in Table 2. Lint yields ranged from 900 to 1439 lb lint/A at the first harvest with a field average of 1163 lb lint/A. The actual field distribution is shown in Figure 1999L1. The highest yields at the first harvest were found in the center four tiers of the field from the center to the northern side. This did not correspond to the same high yielding area for corn in either 1998 or 2000. The lowest yielding areas were along the eastern edge. However, at the first harvest, this side of the field was not as mature as other areas of the field.

Second harvest lint yields ranged from 33 to 208 lb/A with an average of 86 lb/A. The yield map for this harvest is shown in Figure 1999L2. As expected, the eastern two tiers had substantially higher yields than the western most tiers. These areas did correspond to changing soil textures across the field. As mentioned earlier, the western tiers are sandier than the eastern tiers.

Total lint yields ranged from a low of 949 lb/A to a high of 1508 lb/A with a field average of 1248 lb/A. The actual distribution of lint yield is shown in Figure 1999LT. Even with the second harvest lint yields added into the total, the easternmost tier had lower yield than the rest of the field. The western tiers were lower yielding than the center of the field indicating possible moisture deficits which could have reduced the yields. In general, one would expect the higher yields on the sandier soils. Drought was a significant event in 1999 making irrigation a necessity for optimum yields. Overall yields in 1999 were much higher than those measured in previous years which was directly related to the rotational benefits of corn in 1998. The 562 lb/A difference represented nearly 60% range in yield in the field and more than a bale per acre.

Maturity of the crop at the time of the first harvest can be illustrated with the calculation of percent first harvest (PFH). The range in 1999, was from a low of 81.5% to a high of 96.8% and an average of 93.1%. This difference of 15% may seem high for some fields but does reflect the variations which occur with different soil textures in the field. Defoliation was triggered based on the majority of the field. The overall field distribution was shown in Figure 1999-PFH_L.

Conclusions

This discussion only touches the tip of the data collected to date but does show how complicated the systems are. When looking at corn and cotton rotation systems, different factors can and do influence growth characteristics of a particular crop. Additional years of data will be needed to obtain a better understanding of what is occurring in the field. The new technologies do provide helpful tools to explain some of the yield variation actually occurring in the field. The next step will be to examine the correlations between the soil characteristics and yield which is the topic of the second paper in the group. While these technologies are new and show potential, many details need to be addressed before they can be utilized consistently and economically.

Acknwledgements

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Table 1. Summary of GIS information for corn component of corn-cotton rotation study. Field 12 GPS/GIS Study. Delta Research and Extension Center, Stoneville, MS. 1998 and 2000

Factor	Range Low	Range High	Difference	Mean
1998 Corn Data				
Yield, lb/A	7412	10405	2993	8728
Yield, bu/A	132.4	185.8	53.4	155.9
Yield, kg/ha	8302	11653	3351	9775
Moisture (%)	13.9	15.7	1.8	14.6
Test Wt., lb/bu	55.7	60.3	4.8	58.6
2000 Corn Data				
Yield, lb/A	8456	12429	3973	10167
Yield, bu/A	151	221.9	70.9	181.6
Yield, kg/ha	9471	13920	4449	11388
Moisture (%)	11.4	13.7	2.3	12.3
Test wt., lb/bu	56.3	59.8	3.5	58.2
Stand, plts/A	18327	28766	10439	23024

Data summary over 496 cells in 15-acre field

Table 2. Summary of GIS information for cotton component of corn-cotton rotation study. Field 12 GPS/GIS Study. Delta Research and Extension Center, Stoneville, MS. 1999

Factor	Range Low	Range High	Difference	Mean
1999 Seedcotton Data				
1st Harv., lb/A	2366	3835	1469	3099
2nd Harv., lb/A	98	581	483	256
Tot. Harv., lb/A	2583	4099	1512	3355
PFH , (%)	80.3	96.4	16.1	92.3
1999 Lint Data				
1st Harv., lb/A	899.8	1438.8	539.0	1163.0
2nd Harv., lb/A	33.2	208.5	175.2	85.5
Tot. Harv., lb/A	949.2	1508.2	562.0	1248.4
PFH, (%)	81.5	96.8	15.3	93.1

Data summary over 496 cells in 15-acre field

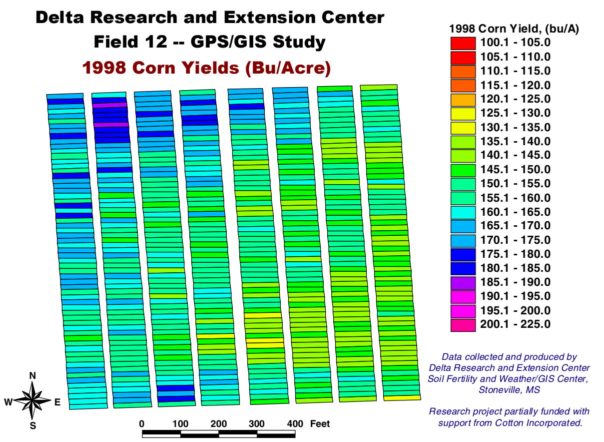

Figure 1998Y: Corn yield (adjusted to 15.5% moisture) GPS/GIS study. DREC Field 12 - 1998

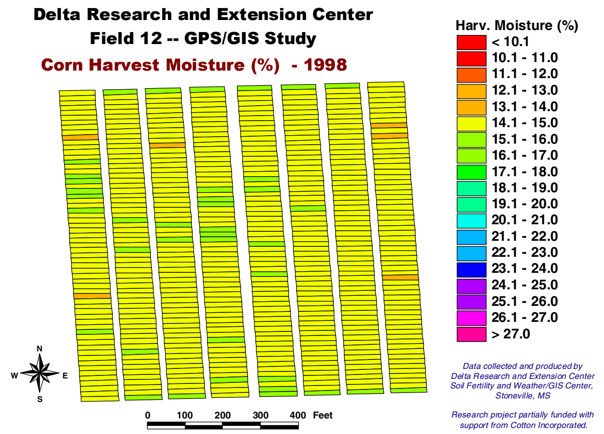

Figure 1998- HM: Harvest Moisture from GPS/GIS study. DREC Field 12 - 1998

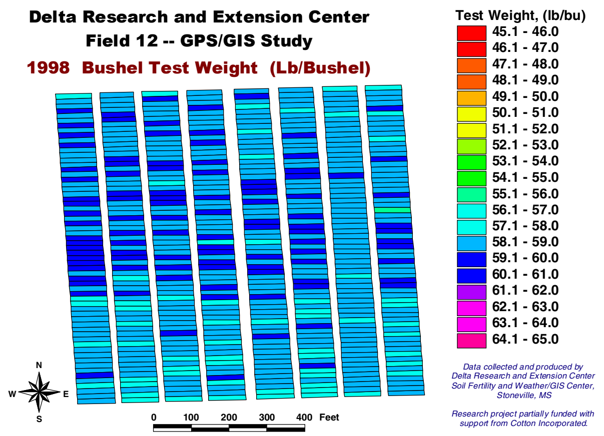

Figure 1998–BTW: Bushel test weight (lb/bushel) from GPS/GIS study. DREC Field 12 - 1998

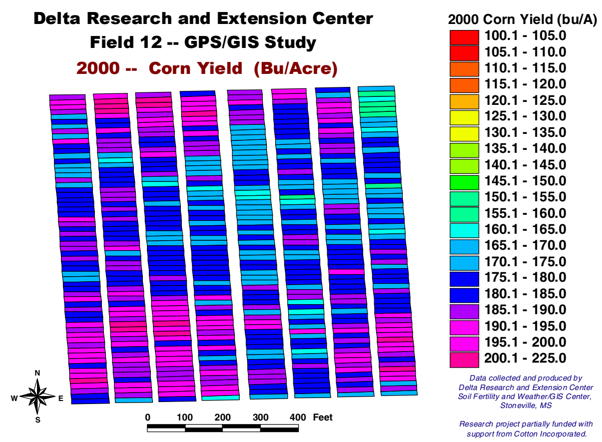

Figure 2000Y: Corn yield (adjusted to 15.5% moisture) GPS/GIS study. DREC Field 12 - 2000

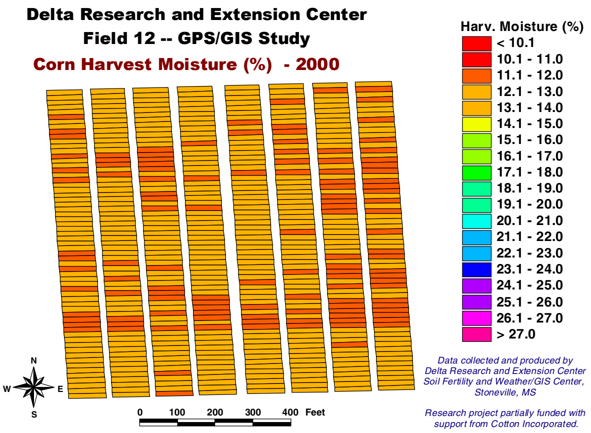

Figure 2000 HM: Corn Harvest Moisture from GPS/GIS study. DREC Field 12 - 2000

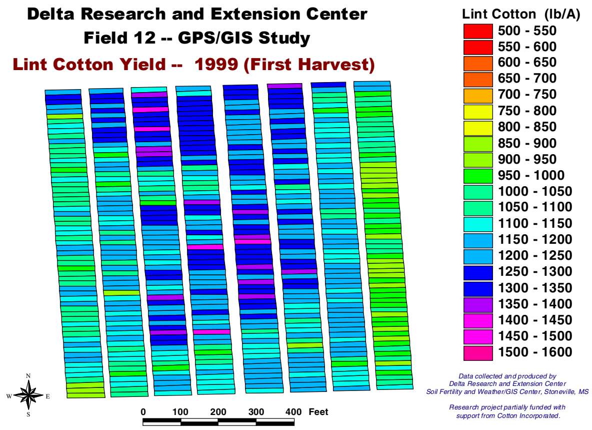

Figure 1999L1: Lint Cotton Yield from First Harvest from GPS/GIS study. DREC Field 12. 1999

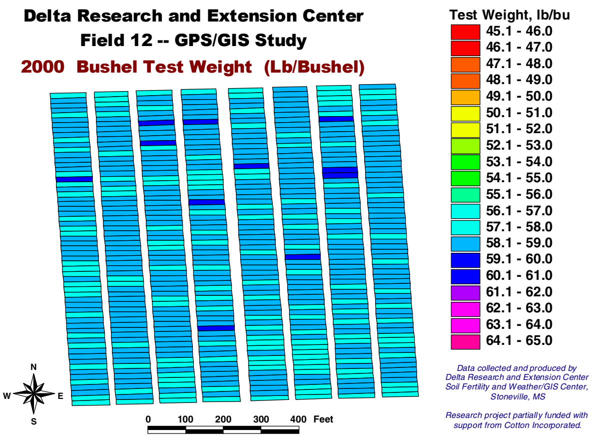

Figure 2000–BTW: Bushel test weight (lb/bushel) from GPS/GIS study. DREC Field 12 - 2000

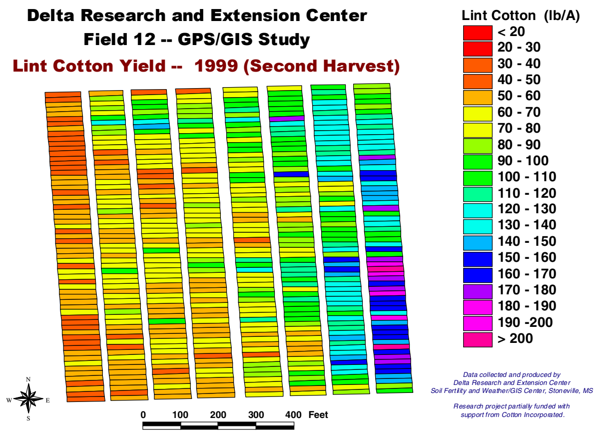

Figure 1999L2: Lint Cotton Yield from Second Harvest from GPS/GIS study. DREC Field 12. 1999

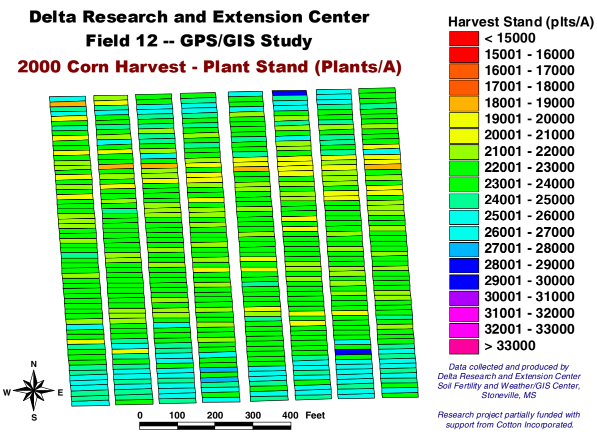

Figure CR00-Stand: Plant Stand at Harvest for Corn from GPS/GIS study. DREC Field 12 - 2000

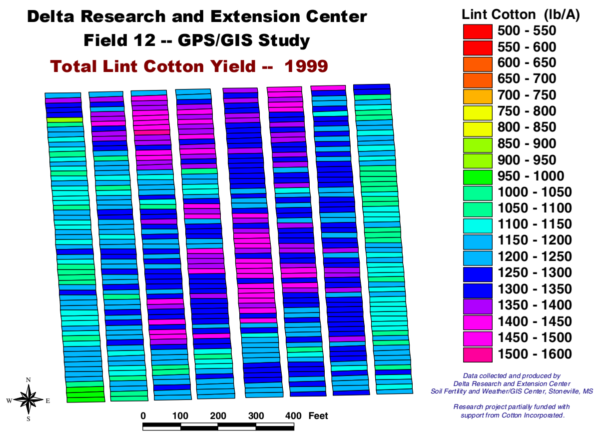

Figure 1999LT: Total Lint Cotton Yield from Two Harvests from GPS/GIS study. DREC Field 12. 1999

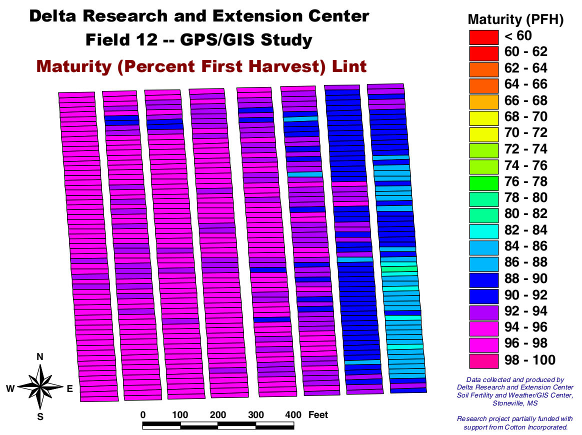

Figure 1999 PFH_L: Maturity as Measured by Percent First Harvest from GPS/GIS study. DREC Field 12 - 1999