COTTON YIELD MAPS:

TOOLS FOR INCREASING EFFICIENCY & PROFITABILITY

Cotton Incorporated

Edited by:
George Vellidis & Heather S. Brannen
University of Georgia

WHY YIELD MAPS?

George Vellidis[1], Ed Barnes[2], and Heather S. Brannen[1]
[1]University of Georgia, [2]Cotton Incorporated

Precision agriculture is a catch-all term for techniques, technologies, and management strategies aimed at addressing the variability of parameters that affect crop growth. These parameters may include soil type, pH, soil organic matter, plant nutrient levels, topography, water availability, weed pressure, insect pressure, etc. The purpose of implementing a precision agriculture management plan is to address this variability and thereby improve the efficiency and profitability of the farm operation. The most critical component of any such plan is the yield map. Yield maps provide a visual image which shows the variability of yield across a field and can be used to identify high or low yielding areas.

Yield maps can be viewed as both the entrance and the final exam for precision agriculture: as an entrance exam because they can be used to determine if there is enough variability to justify the use of precision agriculture; as a final exam because they can subsequently be used to determine if the investment in precision agriculture was worthwhile. By incorporating production costs, yield maps can be converted to profit maps which provide a vivid image of the least and most profitable areas in the field. Managing these areas individually will typically result in higher overall profitability. Yield maps are created from data collected by a yield monitor – a sensor – or group of sensors – installed on harvesting equipment that dynamically measure spatial yield variability.

HOW COTTON YIELD MONITORS WORK

All commercially available cotton yield monitors are mounted on or behind the ducts of a cotton picker and measure the cotton passing through the ducts during harvest. Depending on the model of yield monitor, sensors may be installed on 2, 4 or 6 ducts. Cables from the sensors on the ducts lead to the cab of the picker where a user interface console is installed. The console receives and processes data from the sensors, displays yield information and yield maps in real time, and stores the data for later use. Yield data are typically stored in pounds of seed cotton harvested per acre although the user can choose to display yield data in many forms including bales per acre. Each yield data point is associated with a unique location (latitude and longitude) provided by a GPS receiver. At the end of the harvest, the yield data can be downloaded to a personal computer and used to create and print yield maps.

USING YIELD MAPS AND PROFIT MAPS TO IMPROVE YOUR BOTTOM LINE

TThe yield map in the Figure 1 is of a 64 acre field in Georgia and is detailed enough to see the tracks of the center pivot irrigation system in the lower portion of the map (arcs). The map also exhibits a high level of yield variability which is typical of many fields. In this field, the variability is attributed to many factors. The lower end of the field is not irrigated and consistently yields less than most irrigated areas. The low wet area at the center right of the field generally produces lower yields in wet years because it receives nutrient-rich runoff from the surrounding slopes which results in rank growth rather than high yields. Conversely, this area produces high yields during dry years. The top center and top right areas of the field are eroded and generally have poor stands and consequently low yields. The top left area of the field was recently brought into production after being in pasture for decades. High soil organic matter and good soil structure resulted in excel-

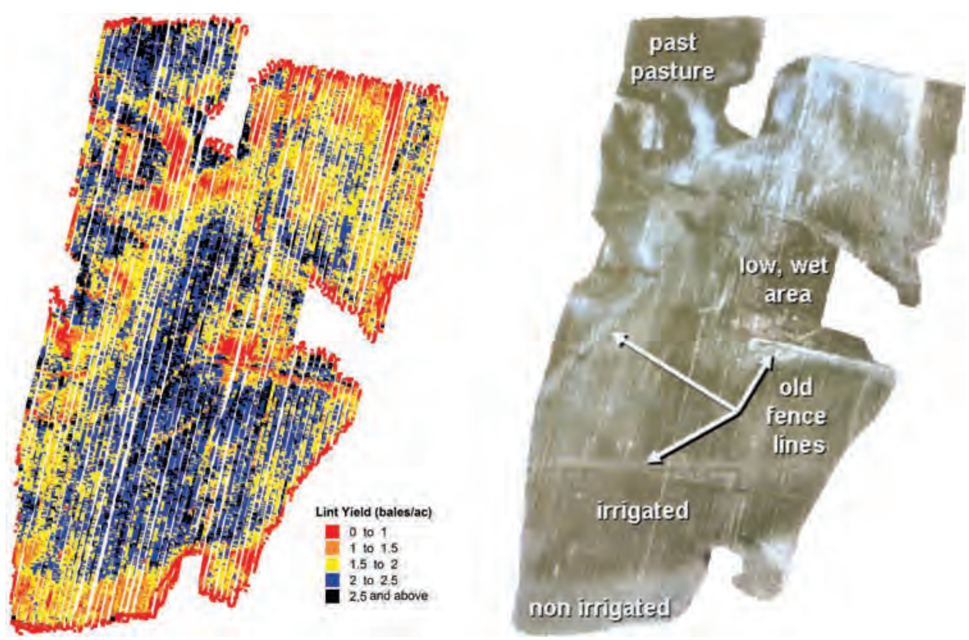

Figure 1: Yield map (left) and aerial photo (right) of the 64 acre field in southern Georgia.

lent yields. With a yield map, a producer can compare the yields between highly productive and less productive areas and make appropriate management decisions and answer questions such as: Is intervention a good investment?

Figure 2 presents profit maps created from the yield map shown in Figure 1. The profit maps were created by multiplying the yield data by the market price of cotton lint and then subtracting the production costs. The result is a map of net revenue in terms of dollar per acre commonly referred to as a profit map. The profit map on the left uses the 2011 Georgia estimates for the price of lint and irrigated production costs – $1.00/lb and $528/ac, respectively. With these figures, 9.7% of the area resulted in a net loss of income, 21.9% of the field provided a net return of between $0 and $250 per acre, 41.1% provided a net return of between $250 and $500 per acre, 27.4% provided a net return of greater than $500 per acre. When nearly 10% of a field results in net loss of income even under relatively high cotton prices, it provides the opportunity for management changes that should lead to increased profitability. The profit map on the right uses the 2012 Georgia estimates for the price of lint and irrigated production costs – $0.75/lb and $577/ac, respectively. With these figures, the profit map is dramatically different and 29.9% of the field results in net loss of income. When yield patterns don't vary much from year to year within a given field, it is relatively simple to evaluate scenarios with different levels of yield, price, and production cost and identify areas of the field which are chronically unprofitable.

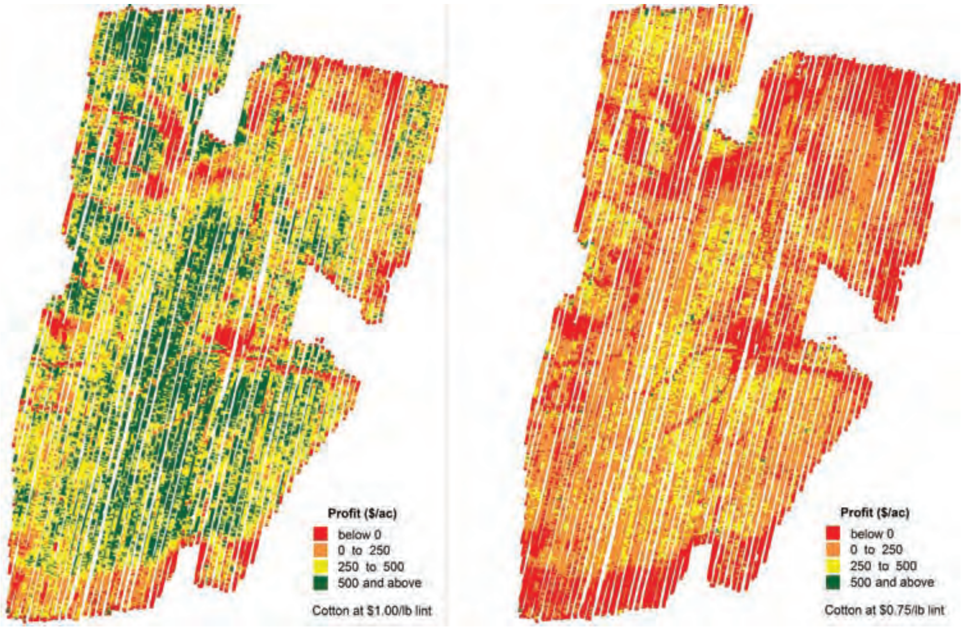

Figure 2: Profit maps of the field in Figure 1 created using the 2011 Georgia estimates for the average price of lint and irrigated production costs ($1.00/lb and $528/ac, respectively) (left) and the 2012 Georgia estimates for the averages of $0.75/lb for price of lint and $577/ac for irrigated production costs (right).

Figure 3 shows how a yield map can have an immediate management benefit. This 53 acre field is irrigated by a center pivot. The two dark green circles of higher yield were caused by leaks in the center pivot. As a result, the cotton immediately under the leak received more water than was applied to rest of the field. In addition to pointing out that the leaks should be repaired, the yield map clearly indicates that there is opportunity to increase yields by irrigating more. The question then becomes is the cost of additional irrigation exceeded by the income provided by the increase in yield?

In the remainder of this publication, we present a series of case studies from across the U.S. cotton belt which illustrate how cotton yield maps were used to take management actions or make management changes that resulted in increased profitability.

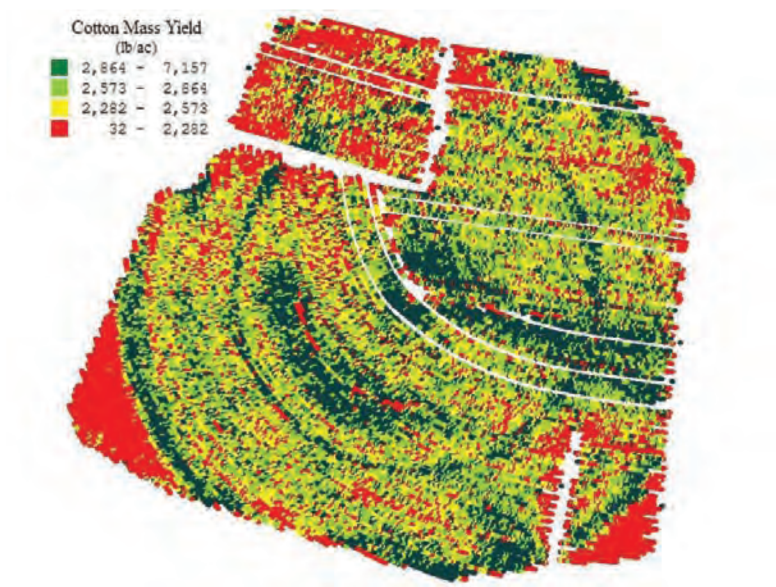

Figure 3: Yield map of a 53 acre field showing the effectsof leaks from a center pivot irrigation system.

O K L A H O M A

OKLAHOMA CASE STUDY

1. Location: Altus, Oklahoma
2. Field size: 63 acres
3. Crop: Cotton
4. Management problem identified from yield maps: Yield loss due to blocked drain tile.
5. Cost of yield monitor and associated mapping software: Approximately $10,000.
6. Number of years yield monitoring was needed to establish spatial trends: 2 years.
7. Management response to identified problem: Invested approximately $1,500 for drain tile and leveling.
8. Return from management response: $7710 during the following year.
9. Case study contributed by Wesley Porter, Randy Taylor and CNK Farms.

From the Producer's Perspective:

The yield maps really helped to know exactly where the high and low yields were in the field. The yield maps also matched very well with the soil electrical conductivity (soil EC) maps created with a Veris 3100. Because soil EC can sometimes be used as a surrogate for soil texture, this helped confirm the patterns we saw in the yield maps. From the yield maps we identified an area approximately 5 ac in size in which cotton yields averaged only 480 lb/ac lint cotton -- much lower than the field average which typically exceeds 2000 lb/ac (see map on the left side of Figure 4). We attributed the lower yields to poor drainage so we installed drain tile under the 5 ac area. The following year, the average yield in this area was 2022 lb/ac – a 1542 lb/ac gain in lint yield. At $1/lb, this resulted in $7710 in additional income.

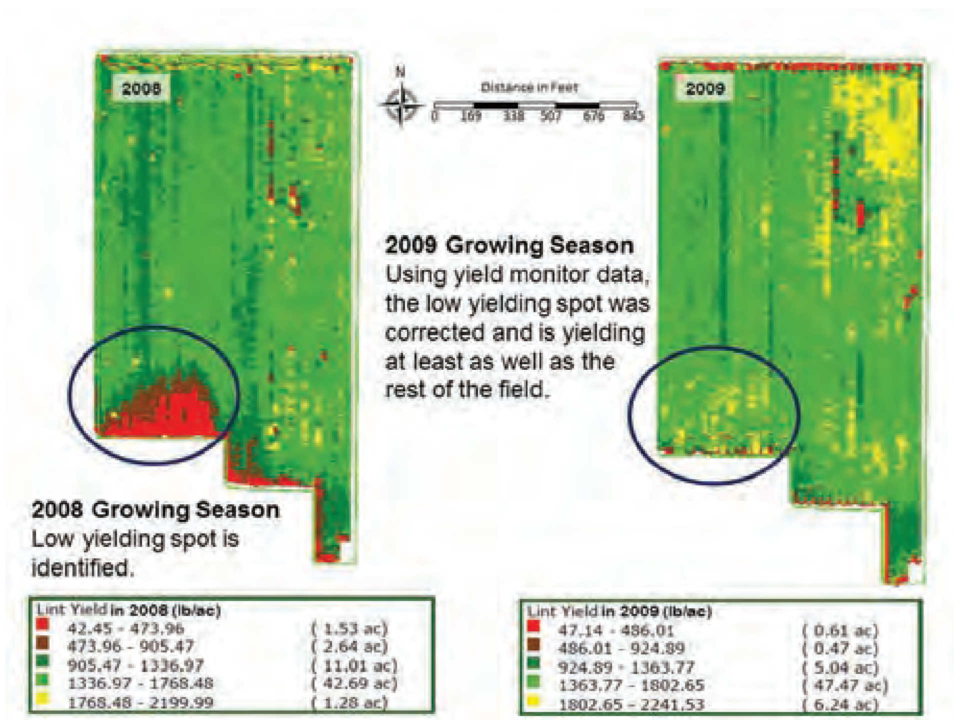

Figure 4: Yield maps of the 63 ac field near Altus, Oklahoma, before and after drain tile was installed to improve yields.

A L A

ALABAMA CASE STUDY

1. Location: Courtland, Alabama
2. Field size: 58 acres
3. Crop: Corn in rotation with cotton or soybeans
4. Management problem identified from yield maps: Low-yielding area was taken out of production and amended for 4 years. Variable rate seeding was used in the field.
5. Cost of yield monitor and associated mapping software: Approximately $10,000.
6. Number of years yield monitoring was needed to establish spatial trends: 3 years.
7. Management response to identified problem: Applied chicken litter and gin trash and planted grass to low-yielding area. Invested approximately $2000 for variable rate seeding equipment.
8. Return from management response: Most of the low-yielding area is producing higher yields
9. Case study contributed by John Fulton and Paul Clark Farms.

From the Producer's Perspective:

We identified a low yielding area approximately 5 ac in size in a 58 ac field from cotton yield maps created during 2003 and 2005 (Figure 5). After the 2005 growing season, we decided to take this area out of production (Figure 5) and apply chicken litter and gin trash to it for four years. The area was also planted to grass. We also used the yield maps to develop a variable rate corn seeding map for the field (Figure 6). For variable rate seeding, we use three rates (25,000, 27,000 and 29,000 seeds/ac) and plant fewer seeds in areas with lower yields and more seeds in areas with higher yields. Our normal seeding rate is 26,000 seeds/ac. We brought the 5 ac area back into production during 2010. The 2010 corn yield map (Figure 6) shows that most of the 5 ac area produced about the same yield as the rest of the field. The field was in cotton during 2011 but we were not able to collect yield data.

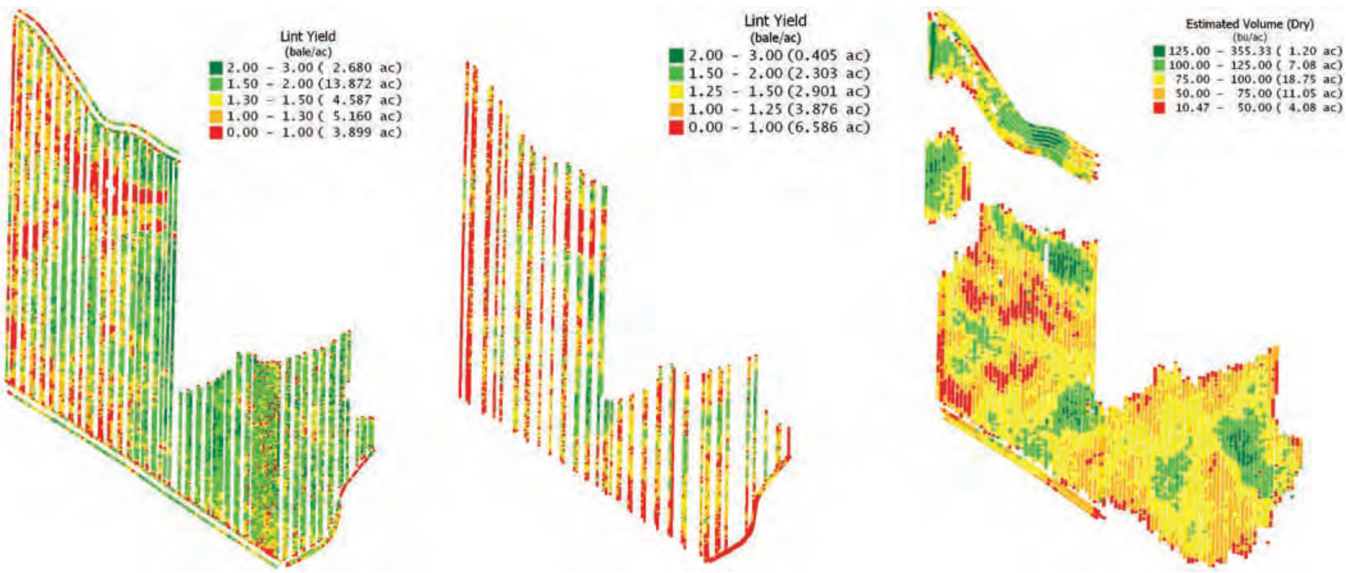

Figure 5: Yield maps from cotton in 2003 (left), cotton in 2005 (center), and corn in 2006 (right). The low-yielding area appears in the top of the two cotton maps. The 2006 corn map shows the area which was taken out of production.

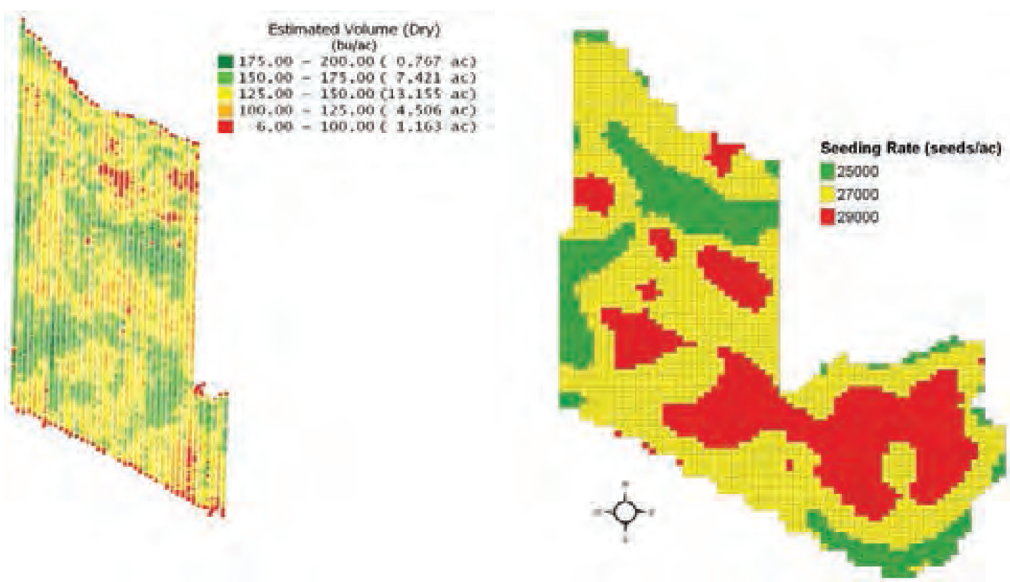

Figure 6: Corn yield map from 2010 showing improved yields in the treated area (left). Variable rate corn seeding map (right) was created largely from the yield maps. The treated, formerly low-yield area, was assigned the lowest seeding rate.

ARKANSAS CASE STUDY

1. Location: Manilla, Arkansas
2. Field size: 2 fields, 300 acres total
3. Crop: Cotton
4. Management problem identified from yield maps: High variability in cotton yield.
5. Cost of yield monitor and associated mapping software: Approximately $10,000.
6. Number of years yield monitoring was needed to establish spatial trends: 2 years.
7. Management response to identified problem: Soil electrical conductivity (soil EC) maps were created and used to develop variable rate seeding maps. Invested approximately $3500 for variable rate planter. Variable rate seeding was tested in replicated field strips.
8. Return from management response: Average savings of 8000 seed per acre or average savings of $20 per acre. Yield response on entire field not yet measured.
9. Case study contributed by Terry Griffin, Tom Barber, and Wildy Family Farms.

From the Producer's Perspective:

Cotton yield maps created in two fields following the 2010 growing season (Figure 7) indicated a wide range of yield variability. We decided that variable rate seeding would be the best way to address this variability.

We used the Veris 3100 to create soil EC maps (Figure 8) and used the soil EC values to determine the seeding rate. The criteria for seeding rates were lower seeding rates for lighter soil textures with higher seeding rates on heavier soil types (Figure 8). The end result was an average seeding rate of 40,000 seed per acre across the 300 acres. Our regular seeding rate was 48,000 seed per acre. To gain confidence in our variable rate seeding plan we conducted a replicated strip test in one of the fields during 2011 (Figure 11). We alternated variable rate seeding strips with uniform rate strips to compare the yield results.

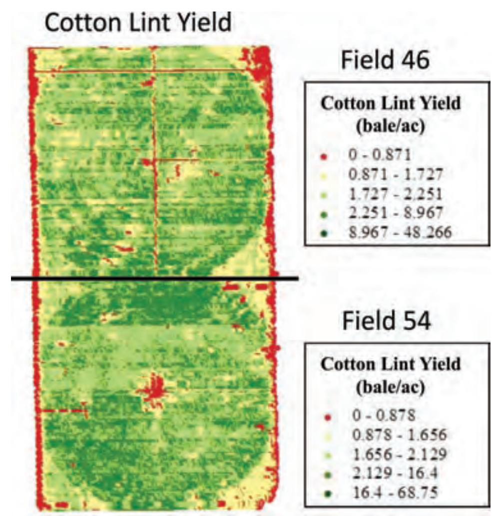

Figure 7: Cotton yield maps form two fields created during the 2010 growing season show high variability in yield.

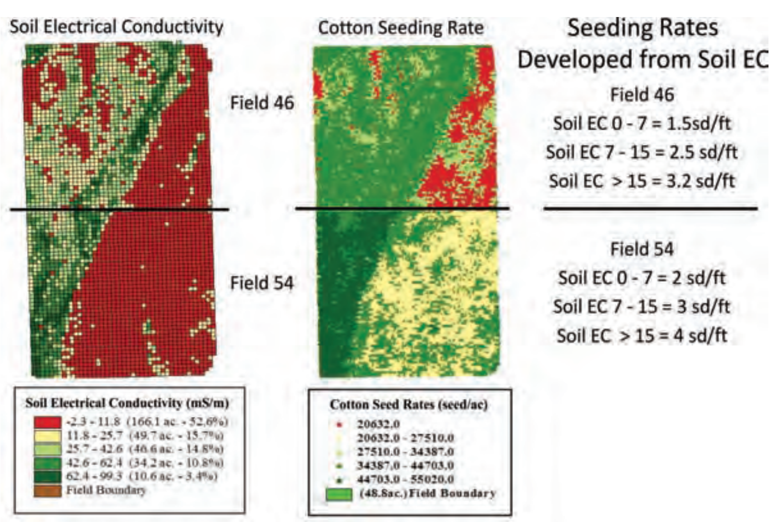

Figure 8: Veris 3100 soil EC map (left) and proposed seeding rates (right).

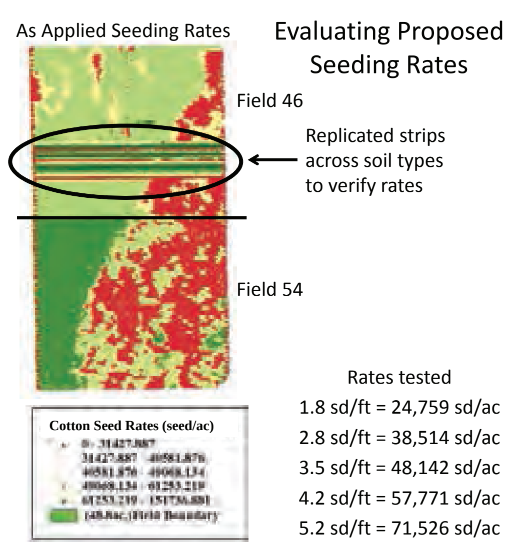

Figure 9: Replicated strips were used to evaluate the feasibility of the proposed seeding rates. Strips alternated between the conventional seeding rate and variable rate seeding.

TENNESSEE CASE STUDY

1. Location: Selmer, Tennessee
2. Field size: 108 acres
3. Crop: Cotton and corn
4. Management problem identified from yield maps: High soil and yield variability.
5. Cost of yield monitor and associated mapping software: Approximately $10,000.
6. Number of years yield monitoring was needed to establish spatial trends: One year.
7. Management response to identified problem: The field has high soil variability. The producer decided to address this soil variability by using variable rate application of nitrogen and variable rate seeding. Yield maps and soil samples (analyzed for cation exchange capacity – CEC) were used to create yield potential maps. The producer purchased a planter with factory installed variable rate drives at a cost of $6,700. Hydraulic control of the seeding drive enabled the producer to do on-the-go seeding rate changes right from the display mounted inside the tractor cab. The farm already owned variable rate fertilizer application equipment.
8. Return from management response: $24/ac reduction in production costs.
9. Case study contributed by Mike Buschermohle and Fullen Family Farms.

From the Producer's Perspective:

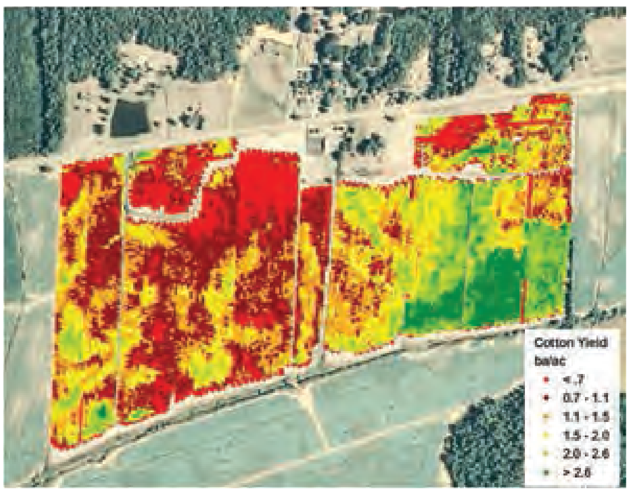

Figure 10: Cotton yield maps of the case study field from 2009 showed high cotton yield variability. This information was used to create management zones in the field.

Due to the wide range of soil variability in many of the fields on the farm, we adopted variable rate technology. Our production management strategy is to vary the rates of crop inputs based on management zones in our fields. We established yield potentials for low-, medium- and high-yielding management zones in these fields using a combination of cotton yield maps (Figure 10) and soil cation exchange capacity (CEC) maps. These management zones were used to establish variable rate nitrogen (Figure 11) and seeding rates (Figure 12) for the crops in our rotation. For this 108 acre field, the low, medium, and high-yielding management zones received 154, 175 and 196 lb N/ac for corn. The corn seeding rates were 22,000, 26,000 and 30,000 seeds/ac for the low, medium, and high-yielding management zones, respectively. Not only did we reduce production costs by $24/ac compared to our traditional blanket nitrogen fertilizer application and seeding rate, but the field still achieved its long term yield potential average of 150 bushels per acre.

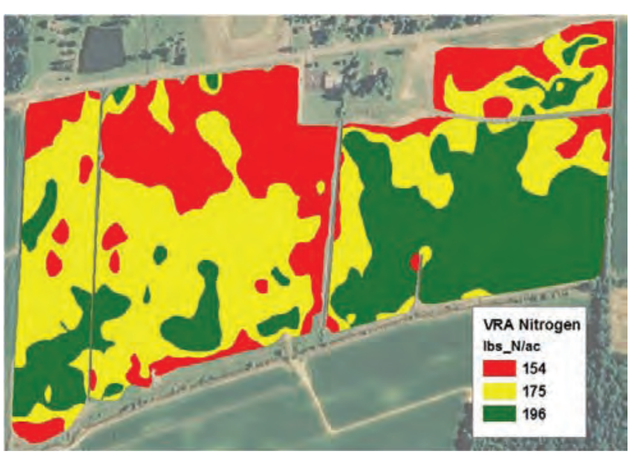

Figure 11: Variable rate nitrogen application map for 2010 corn crop.

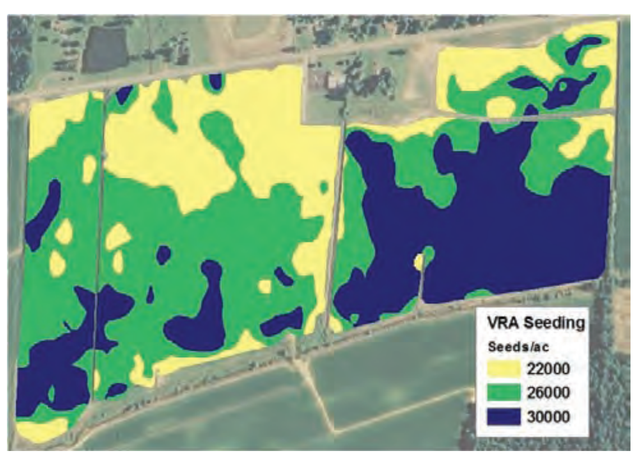

Figure 12: Variable rate seeding prescription map for corn during 2010 growing season. The management zones used for seeding are the same as used for variable rate nitrogen application.

SOUTH CAROLINA CASE STUDY

1. Location: Estill, South Carolina
2. Field size: 204 acres across several fields
3. Crop: Cotton
4. Management problem identified from yield maps: Low yield from nematode damage.
5. Cost of yield monitor and associated mapping software: Approximately $3,500.
6. Number of years yield monitoring was needed to establish spatial trends: Between 3 and 5 years depending on field.
7. Management response to identified problem: Yield maps and soil samples (analyzed for nematodes) were used to create on/off nematicide maps. Invested approximately $3500 for variable rate nematicide applicator and related hardware and software. Invested approximately $1200 in sample and data analysis (consultant).
8. Return from management response: Reduction in Telone use, improved control of nematodes, and an increase in yield.
9. Case study contributed by Will Henderson, Jr.

From the Producer's Perspective:

We have been yield mapping our cotton for 5 years. We have between 3 and 5 years of yield maps depending on how we rotate our peanuts. This year we worked with our consultant to create yield stability maps from our yield maps. This helped us determine which areas in the fields had repeatable yields – whether high or low. This was done in the fields where we suspected the most severe nematode infestation. From the yield stability maps we created nematode sampling zones (Figure 13). Samples collected within a zone were averaged to estimate the nematode population of that zone. Based on the soil sample results, we created nematicide application maps. Zones with nematode counts above our threshold received nematicide while zones below the threshold did not (Figure 14).

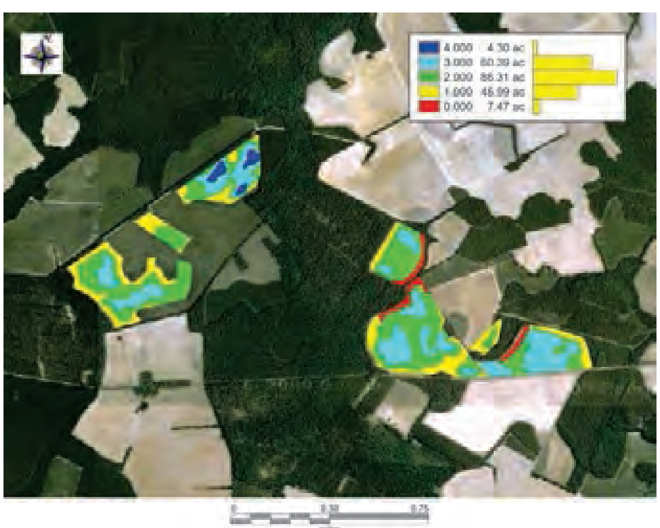

Figure 13: Nematode sampling zones created from yield stability maps. Samples collected within a zone were averaged to estimate the nematode population of that zone.

Figure 14: Nematicide application maps – zones with nematode counts above the threshold received nematicide while zones below the threshold did not.

Funding for this publication provided by Cotton Incorporated

Cotton Incorporated