MISSISSIPPI

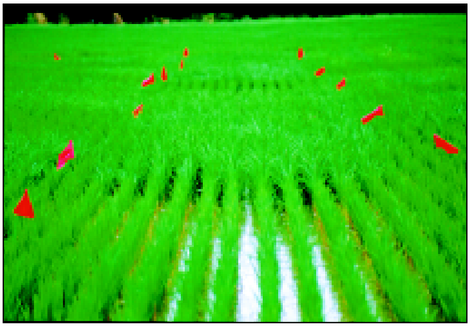
Defining and Managing Yield Zones for Rice and Soybeans—A Case Study

By T. Walker, M. Cox, W. Kingery, S. Martin, L. Oldham, and J. Street

Temporal yields, recorded with precision farming tools, in leveled fields can help define management zones. Low yields were associated with low soil phosphorus (P) and compaction in cut areas. Variable rate (VRT) P application increased the whole field yield and reduced yield variability.

Approximately 1.1 million acres of soybeans and 250,000 acres of rice were produced in Mississippi's Delta region in 2003. Because of the alluvial nature of Delta soils, the variability in soil properties can be extensive. In addition to this natural variability, the practice of precision land-leveling fields for irrigation purposes can significantly contribute to soil and crop variability. Soil and crop variability that results from the land-leveling process is now being more accurately quantified by using precision farming (PF) tools such as differential-corrected global positioning systems (DGPS), yield monitors, and geographical information systems (GIS).

The implementation of PF tools is not just beneficial to researchers. If used correctly, PF tools have the ability to help producers operate more efficiently, which often increases cash-flow. The use of PF tools has increased since the technologies became commercially available in the mid-1990s. One important PF tool used by many rice and soybean producers in the Mississippi Delta is DGPS yield monitors. DGPS yield monitors allow producers the ability to collect enormous amounts of data each year. However, after having collected multiple years of yield data, many producers have begun to experience difficulties in data management and synthesis, which can limit the implementation of site-specific production practices into their crop management program. This implementation inability has caused many producers to question the feasibility of this technology. The objectives of this research were to use PF tools to: 1) define zones within a rice/soybean production field where yields were consistently high, average, or low; 2)



Phosphorus deficiencies affect rice production by decreasing tillering, delaying maturity, and decreasing yield and milling quality.

Rice maturity differences caused by P-deficiencies. Plot on left had sufficient P applied prior to flooding. Plot on right had P applied at ½in. internode elongation.

determine the factors that caused the yield variability and address those factors; and 3) determine the economical feasibility of implementing these technologies in a production environment.

Approach

A 35-acre field in Bolivar County, MS, was selected in the spring of 2003 to test the ability to couple historical field data and soil sampling to determine crop management zones. The predominant soils in this field were Forestdale (Fine, smectitic thermic Typic Endoaqualfs) silty clay loam and Dundee (Fine, silty, mixed, active, thermic Typic Endoaqualfs) silt loam.

This field was precision land-leveled in the summer of 2000. 'Cocodrie' rice was planted in April of 2001 and harvested in September. Glyphosate-resistant soybeans were planted in April of 2002 and harvested in September. DGPS yield monitor data were collected for both crops. These yield data were normalized using the Multi-Year Yield Analysis technique which defines crop management zones based on 1) actual yields relative to the whole field yield average; and 2) the stability of these yields across years, crops, and varieties. Three crop management zones were defined for this study: high, average, and low. The high yielding zone was defined by yields that were greater than 120% of the field average with a coefficient of variation (CV) less than 30%. The average yielding zone was defined by yields that ranged from 80 to 120% of the whole field average and had a CV of less than 30%. Low yielding zones were defined by yields that were less than 80% of the field average and had a CV of less than 30%. The field was then soil sampled on a 2-acre grid in which each yield zone was represented.

The soil samples were analyzed for Lancaster-extractable…Mississippi State University (MSU) method…nutrients and soil pH. Management zones were initially defined based on yield. Further definition of the management zones was accomplished using soil sample analyses and a topographic map that identified areas where the topsoil was either 'cut' or 'filled' in the land-leveling process. Soil test P concentrations ranging from very low (VL) to high (H), according to MSU Extension Service (MSU-ES) recommendations, were used to develop a VRT-P application strategy in 2003. 'Cocodrie' rice was planted in April of 2003 and harvested in September.

Table 1. Crop yield average and coefficient of variation (C.V.) over time.

Year	Crop	Average, lb/A	C.V., %
2001	Rice	6932	38.9
2002	Soybean	2662	23.6
2003	Rice	7159	22.2

Results and Discussion

Yield. Rice yield in 2001 was highly variable **(Figure 1 and Table 1)**. Though the yield variability was much less in the subsequent soybean crop, the apparent yield zones appear to be consistent with what was seen in the previous rice crop **(Figure 2)**. The yield zone consistency was confirmed by performing a Multi-Year Yield Analysis **(Figure 3)**, in which three management zones where defined: high yield, average yield, and low yield. Soil test P results indicated that a P application was warranted over the majority of the field, but the southern portion of the field had a greater probability of obtaining a yield response **(Figure 4)**. Analyses of the yield data collected from the 2003 rice crop indicated a substantial decrease in variability compared to the 2001 rice crop **(Table 1)**. **Figure 5** indicates a definite increase in rice yield in the P-limiting area of the field, as a likely result of VRT P application. Weather differences or other factors may also be involved.

Combining the topographic map **(Figure 6)** with **Figure 3** indicates that P fertility may not be the only source of yield variability. The 'fill' area in **Figure 6** is consistent with the high-yielding area in **Figure 3**. In addition, the 'cut' area…except for where P is limiting…is consistent with the average yielding area. One hypothesis that could be proposed

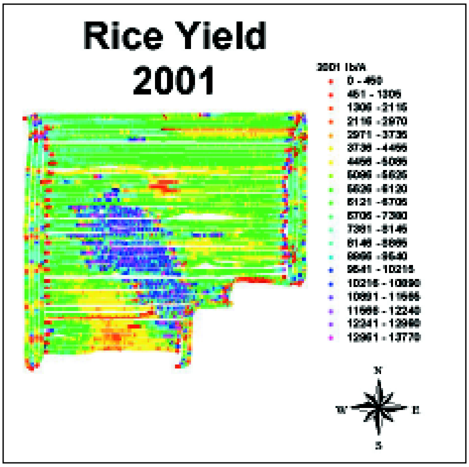


Figure 1. 2001 rice yield map.

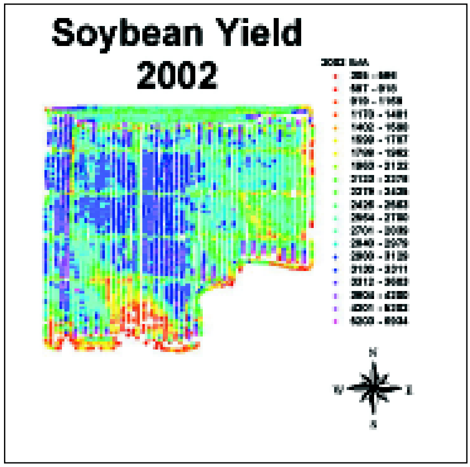


Figure 2. 2002 soybean yield map.

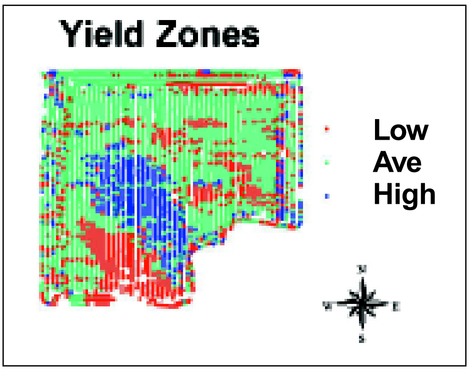


Figure 3. Normalized yield from 2001 and 2002.

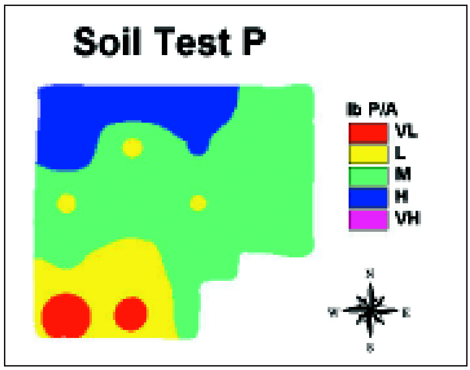


Figure 4. Spring 2003 extractable-P levels.

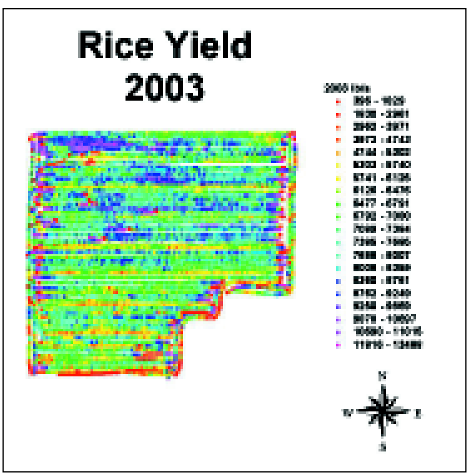


Figure 5. 2003 rice yield map.

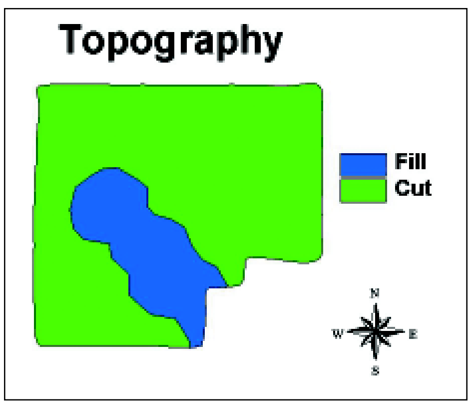


Figure 6. Topography map defining areas of cut and fill.

from these data is that compaction may be limiting yields the first two years after precision land-leveling.

Research that was recently published by the authors indicated a strong correlation between the total volume of soil that was cut and the difference in yield compared to the fill area. A second hypothesis that may further define the decrease in in-field variability from 2001 to 2003 is that organic matter additions (e.g. crop stubble) from the previous cropping years aided in the restoration of the disturbed microbiological ecology that was caused by the land-forming process.

Economics. A question that is asked often by producers when discussing the implementation of PF is: "Will this technology pay for itself?" A cost-analysis was conducted for the field from which these data are reported. When comparing the whole field average rice yield in 2001 to that of 2003, the net increase in grain of 227 lb/A would amount to a net return of $21.44/A. The cost of applying these PF technologies would be approximately $16.57/A. The MSU-ES recommends that when fields have been recently land-leveled, soil samples should be randomly collected and composited based on whether the area has been 'cut' or 'filled'. If this method had been used, based on the soil samples that were collected from areas of 'cut' and 'fill', it is highly probable that a blanket application of 30 lb P_2O_5/A would have been recommended. This would have cost $12.96/A , or $453.60 for the 35-acre field. That is less than the cost of the VRT-P treatment. However, studies by MSU scientists indicate that if P had been uniformly applied at the recommended rate, maximum rice yields would not have been obtained in the area of the field where soil test P was in the VL to L range. That theoretically would have resulted in a lower whole-field yield average.

Conclusions

Use of PF tools (i.e., DGPS yield monitors, GIS, grid soil sampling, and VRT), coupled with topography maps (i.e. "cut" and "fill" maps), successfully defined management zones, determined yield limiting factors, and addressed one of the key limiting factors: inadequate P fertility. These tools decreased whole-field yield variability and increased total rice production. Although there was an added expense of applying P with VRT, this method was more agronomically appropriate. More precise application of P to areas of need helped to maximize yield and resulted in more consistent production of rice within management zones. Higher crop yields and potentially greater uptake of applied P should also result in reduced environmental P risks. BC

Research Project No. MS-10F.

Dr. Walker is Assistant Professor of Agronomy, located at the Delta Research and Extension Center in Stoneville, Mississippi; e-mail: twalker@drec.msstate.edu. Dr. Cox is Associate Professor, Dr. Kingery is Professor, and Dr. Oldham is Associate Extension Professor, all in the Dept. of Plant and Soil Sciences at Mississippi State University. Dr. Martin is Associate Extension Professor of Agricultural Economics and Dr. Street is Extension Rice Specialist at the Delta Research and Extension Center in Stoneville.

Acknowledgments

Sincere appreciation is expressed for research funds provided from the following sources: Advanced Spatial Technologies for Agriculture, Mississippi Rice Promotion Board, and the Foundation for Agronomic Research (FAR). Also, sincere appreciation is expressed to Mr. Delbert Dean, who was the cooperating producer, as well as Mr. Scott Lanford and Mr. Grady Jackson for their technical support.