Bootheel Ag Water Quality and Precise Application Project[1]

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Abstract – In an effort to apply prescription farming techniques in the Missouri Bootheel, the Missouri Ag Water Quality and Precise Application Project, sponsored by the Bootheel Resource Conservation and Development (RC&D) Council, was funded and became operational in September of 1989. In general, the idea of prescription farming is to vary the application rates of inputs (pesticides, nutrients, irrigation, etc.) from point to point within a field, rather than using a single, average rate over the entire field. Applying inputs only where needed maximizes production efficiency and minimizes the possibility that over-applied chemicals (not utilized by crops) may contaminate ground or surface water.

PROGRESS TO DATE

This project was initially a three year project. One of the main goals was to determine whether there is enough variability within fields to warrant variable rate technology (VRT). We are maintaining a large database with information from lab analysis of soil samples from each field. Soil samples are taken on a 330 X 330 ft. grid and the results are loaded into the computer. The field is divided into zones for fertilizer application and the data stored in a digital map. Five fertilizer blends most optimum for the field will be spread by the computer driven spreader truck using this digital map. To date, we have grid sampled 10,000 acres and 9,000 acres have been processed for VRT application. Over 4000 acres have had fertilizer applied using a Soil Teq spreader truck.

It is clear that many of these fields will benefit from variable rate fertilizer application. It is not uncommon to see P levels range from <20 to >200 and K levels range from <100 to >400 in the same field. We believe the same benefits will be evident for VRT chemical application. In fact, much of the data generated in this project affecting fertility recommendations will be important factors when making chemical recommendations. Information about soil type, texture, organic matter, soil pH, and cation exchange capacity (CEC) will be key factors when dealing with many of the soil sensitive chemicals. Other factors will include matching the proper chemical with the pest that exists in various parts of the field. We hope to build on the knowledge and data gained in this project as we move into variable chemical application.

For the project we have incorporated Geographic Information System (GIS) methods capable of utilizing data from infrared photography, aerial photo base maps, and SCS soil survey maps to define differences in soil type, texture, and water holding capacity. This system utilizes several stand alone programs operating under a series of shell scripts. Many operations are integrated but some are not. Much efficiency is lost due to data translations required for data to pass from one program to another. This can be remedied by utilizing a true GIS relational data base environment. We are consulting with the Space Remote Sensing Center (SRSC)[3] located at the Stennis Space Center in Mississippi to develop this type system. We are in the process of converting all data from the project to this format.

Application rates have been recommended for each area of the fields using well established guidelines from the University of Missouri Columbia (UN MO). Recommendations for the project were made based on MU soil testing lab results. The fields were divided into five zone types having similar test values. The average test value for each zone was entered into the standard MU fertilizer recommendation program provided by Dr. Daryl D. Buchholz (MU).

The MU recommendation program will recommend enough fertilizer to grow the crop at the specified yield goal and build the

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soil to an optimal level over an eight year period.

This site specific technology versus the conventional method represents a major shift of plant nutrients within the field. Areas with high test levels receive a lower application rate to avoid an excessive build up of nutrients. These are the parts of the field prone to cause environmental problems (i.e., leaching into ground water or runoff into surface water). The site specific concept also allows for an adequate amount of fertilizer to be applied to the lower testing parts of the field necessary for proper crop development. This will allow for the most efficient use of the plant nutrients that are applied and also the most efficient use of the other resources used to produce a crop.

Plant nutrients represent only a small part of the total resources involved in crop production. Other resources used, such as fossil fuels and raw materials for the production of farm machinery, also weigh heavily on the environment. If plant nutrients are allowed to fall below established optimum levels, the efficiency of all resources involved in crop production will drop. Field passes, fuel consumption, equipment wear, and manpower will not be reduced by lowering the fertility level of any field. Also, there is a point where production will not increase when nutrients are applied at excessive rates.

It is an important point to note that areas of the field that are at or being built to an optimum soil test level do not pose an environmental threat or hazard. In some cases it is possible to have a far worse environmental situation where some or all nutrients are not up to the optimum level for that area.

One such situation would be where some of the nutrients would be at high to excess levels and one or more other nutrients were at very low levels. In this case the crop would be starved from the lack of the deficient nutrients and would not be able to utilize as much of the nutrients that are in high or excess levels. The result would be more of the high level nutrients remaining in the soil subject to leaching or erosion into the ground or surface water. The key to wise and efficient nutrient management from both an environmental and an economic standpoint is nutrient balance at optimum agronomic levels.

Another environmental threat from soils being deficient in particular nutrients is poorer crop growth resulting in less crop residue left to protect the soil from erosion. With more erosion there will be more soil containing nutrients and pesticides entering the surface water.

So, what's all the talk about nutrient utilization, optimum agronomic levels, and poor crop growth? Let's get to the point. What most folks want to know is "If I use this technology how much can I reduce my fertilizer application this year".

The point is that success measured by pounds of nutrients not **applied to a field alone** is not a good assessment of this technology for reducing non-point source pollution or generating profits. In some fields we had a reduction of 35% and in others a 20% or 15% reduction. But in other fields we applied the same and in some cases even more than previous management had applied. So how can we say this site specific management is so great for the environment?

The main consideration is how much did we change the management of plant nutrients, pesticides, and all other inputs that will have a positive impact on non-point source pollution and my economic situation. On fields where we applied the same amount of total nutrients per field as the previous management, we redirected 30% to 40% of those nutrients from areas where nutrients were high or excessive to other parts of the field where nutrients were lower than the optimum level for good crop growing conditions. The fertilizer would have been applied to areas of the field that were already at high or excessive levels and prone to cause more environmental problems. On the other hand they were redirected to areas of the field that had low test levels and would pose no additional environmental problem and could enhance crop growth, better utilization of other nutrients, produce more crop residue to protect the soil, and add more profit for the producer.

In the SP53[4] program, we calculated the difference between the previous rate the producer was applying and any point where the application was re-

[4] This was a pilot project sponsored by ASCS to implement Integrated Crop Management (ICM) practices. Five counties in the state were selected and twenty farms in each county were allowed to participate. A cost share of $7.50 per acre was paid to offset the cost to producers for participating.

duced. This amount of fertilizer was either not **applied to the field** or redirected to other parts of the field where nutrients were lacking. Following is a list of the different nutrients and the percent they were either reduced or redirected for all fields.

N	4%
P	47%
K	40%
Z	85%
S	88%
Lime	38%
All Nutrients	26%

The P, K, and lime redistribution seem to be in a range that we would expect to be very typical for the area. The Z and S show being reduced or redirected by 85% - 88%. This seems to be a high number and indicates that the producer was over applying these nutrients for some reason and this situation is probably not typical of the region. The N on the other hand represents only a small change in management due to the way the recommendations were made. The N recommendation was varied based on the differences in organic matter only. Since the biggest factor affecting the N recommendation is the yield goal only small changes in N recommendations were made across the fields. In the fall of 1991 we collected about 400 hand harvested yield samples of corn using GPS to locate the sites. The sample sites were taken about the same spacing as the previous soil samples. In 1992 the Agricultural Engineering and USDA ARS group from MU collected continuous yield data with sensors and GPS equipment mounted on their plot combine. Stewart Burrell (MU) is currently analyzing this data for correlation with other field variables. Dr. Steve Borgelt with Agricultural Engineering at MU will be working with us in 1993 to mount a yield-o-meter provided by CLAAS and interface this unit to a GPS unit and moisture sensor. We hope to collect yield data on most of our crops this year. As more data about yields and yield potential is gathered and understood, a reduction and or redirection of N in the range of 25% will be a reasonable expectation.

EXISTING CHALLENGES

One of the big problems we face is managing the massive amounts of data that are generated by prescription farming. Being able to interpret the amount of data and make good agronomic and environmental recommendations is difficult. The collection and organization of data is time consuming and expensive. In the future, many types of data will be collected passively from sensors on farm equipment for automated input into decision aid systems. Also if data that is routinely collected by the normal activities of the Soil Conservation Service (SCS), Agriculture Stabilization and Conservation Service (ASCS), and other government agencies can be utilized by a compatible GIS, the cost will be reduced and the technology will be adopted by a larger number of producers for prescription farming purposes.

Now and in the future, SCS is and will be developing layers of data with the Geographic Resources Analysis Support System (GRASS), which is the GIS that will meet their needs. Some of this data will be invaluable for the purpose of prescription farming (if in a compatible format) and will reduce the cost of implementing prescription farming for the producer.

Another valuable source of information could be utilized from the ASCS activities. These include accurate field boundaries, crop history, and a universal method of naming (i.e., farm #, tract #, and field #) fields. Additional layers of data will need to be developed that may not be available from other sources, but will be critical for prescription farming recommendations.

ADOPTION CONSTRAINTS

How fast and to what degree this technology and these systems are utilized will depend upon several factors.

1. The ability to automate data collection.
2. The development of VRT equipment to apply prescriptions.
3. The user friendliness of these systems.
4. Cost of systems per unit served.
5. The extent of shared data by government agencies.
6. Economic factors affecting agriculture and the economy.
7. Technology transfer and education to agribusiness.