PRECISION AGRICULTURE:
VARIABLE RATE TECHNOLOGY AND MANAGEMENT ZONES

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I. Video Film Presentation

Precision Farming Project, Colorado State University.

A multidisciplinary Precision Farming Project was started by a team of scientists (CSU and USDA-ARS), Ag Specialists, and industry personnel in 1997. Two commercially operated center pivot fields were selected near Wiggins, CO for field scale studies. Field evaluation of the various parameters began in Spring 1997.

The overall objective of this project is to assess the technical and economic feasibility of precision farming to make more efficient use of crop production inputs and to protect water quality under irrigation. Specific objectives of this multi-disciplined research which contribute to the overall objective include:

- Provide growers, consultants, and industry with a realistic exposure to and practical interpretation of the application of precision farming to agriculture in the Central High Plains.
- Identify and quantify the factors and their interactions that significantly contribute to yield variability under irrigated conditions that can be modified by management.
- Develop and evaluate various components of precision farming systems(e.g., spatial sampling and analysis, decision support systems, and variable rate water and chemical application equipment) and explore new technologies (remote sensing) for their contribution to the economic feasibility of this technology.
- Assess the impacts and benefits of precision farming on regional environmental quality and economic sustainability of communities in the area.

Copies of the video can be obtained from Dr. Raj Khosla at the above address.
More information about the project is available on internet http://www.wmuinfo.usda.gov/

II. Variable Rate Technology & Management Zones

Application of nutrients such as Nitrogen (N) on farmlands is essential for profitable and sustainable crop production. Practicing nutrient reduction and improving crop yield and profit, while reducing environment damage is challenging. The technology to assist in managing the inherent variability in fertility levels in farm fields has not been available until the recent development of variable-rate computer controllers that can be linked to Global Positioning Systems (GPS). The potential exists to optimize nutrients with variable rate application according to the productivity potential and inherent fertility status of each soil type that exist in each individual field.

One of the impediments in variable rate fertilizer application is intensive grid soil sampling. It involves skilled labor, time and money in procuring and analyzing substantial numbers of soil samples from individual fields (Khosla and Alley, 1999). Several techniques of soil sampling and their comparison have been discussed in the literature (Anderson-Cook et al., 1999; Wollenhaupt and Wolkowski, 1994; Bullock et al., 1994). Grid soil sampling can provide an accurate basis for variable rate (VRT) fertilizer application maps. However, regardless of the technique, grid soil sampling on small grids (i.e. 1 acre or less) is time consuming and cost intensive. Research indicates the cost and labor associated with sampling at the intensity required for accurate mapping may be prohibitive (Gotway et al., 1996). Determining fertility management zones in a field may provide a more economical method of developing VRT application maps.

It is well documented that variation in soil fertility across landscapes affects crop yield (Ortega et al., 1997). Bare soil surface spectral properties are largely influenced by soil organic carbon and moisture (Schreier et al., 1988). Bhatte et al. (1996) found that SOM images strongly correlated with the spatial distribution determined by grid soil sampling. Producers know which areas of a field produce good yield and which areas are low in production. It is logical that nutrient needs are different for these areas. This allows identification of different "management zones" in a field based on past production history. Research at Colorado State University (Personal Communication with Dr. Dwayne Westfall) was conducted to determine if management zone (MZ) maps based on soil color from aerial photographs, topography, and the farmers' management experience can be an effective alternative to grid soil sampling in developing VRT fertilizer maps for N application.

Two VRT N treatments based on MZ and 1 VRT treatment based on grid soil sampling were applied on 3 center pivot irrigated corn fields in northeast Colorado in 1998 and 1999 (Appendix A). Three uniform N treatments (0 lbs/ac, N-recommendation + 50 lbs/ac, and N-recommendation - 50 lbs/ac) were also applied to access if N was a limiting yield factor within MZ. All treatments received N credits for starter N applied and NO_3-N in the ground water. The trial area at each location was sampled using a 250 ft grid for the grid based treatments (GS VRT). Sampling points were located randomly within the grids. The N recommendation was developed for each grid using the University of Nebraska nitrogen algorithm with a common expected yield value of 200 bu/ac. Using these data an interpolated N recommendation surface was then generated.

Aerial photographs were used as an initial template in developing the management zones. Producer's experience was used to draw vector lines (management zone lines) using Agri Trak Professional (Software) on a MapInfo software (GIS platform) to establish individual management zones (high, medium, and low productivity areas) based on soil color, topography and management experience on the field. One MZ treatment used the farmer's philosophy of applying more N on the low productivity zones and less on the high productivity zones (MZ VRT). The other management zone treatment used the soil sample data to generate an N recommendation for each zone (MZSS). Nitrate and SOM samples were averaged within each zone and rates were generated using the University of Nebraska N algorithm. Expected yields were 220 bu/ac, 200 bu/ac and 180 bu/ac in the high, medium, and low productivity zones respectively.

Each treatment strip was 80 ft wide corresponding to the applicator width and ran the length of the field (approximately 2600 ft). Treatment strips were laid across the management zones. Treatments were applied with a commercial Terragator applicator equipped with a Raven controller.

Data from the 1999 growing season will be presented in this paper. No significant differences in corn yields were observed across the 3 VRT treatments indicating MZ based VRT is as effective as grid based VRT.

However, the cost of implementing the MZ VRT program is much less making it a profitable alternative to grid soil sampling. No significant advantage was observed between the two MZ approaches evaluated for VRT application. We did see significant zone effects indicating that the management zones reflected distinct sub-regions within the field. Other research on near by fields found similar results (Fleming et al., 1998). Soil organic matter and soil texture are probably the major factors defining the management zones. The high productivity zones were consistently highest in SOM and clay while the low productivity zones were lowest in SOM and highest in sand across all three fields. Higher clay and SOM levels would lead to higher water holding capacity and cation exchange capacity resulting in higher productivity.

References:

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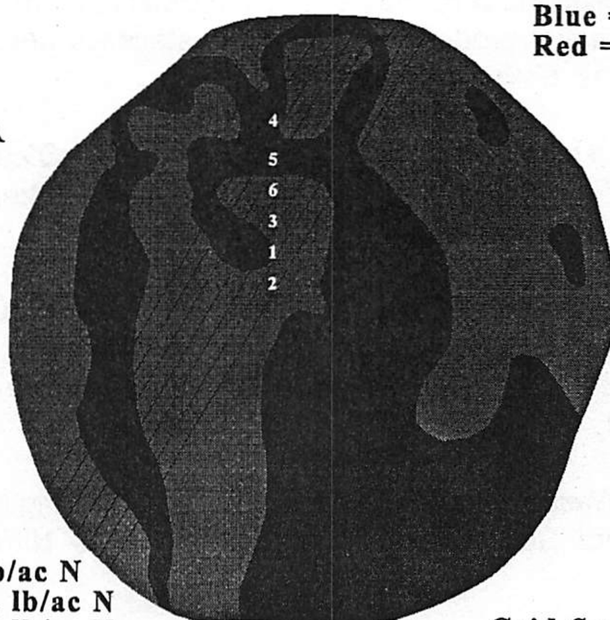
Appendix A:

Green = High Productivity
Blue = Med. Productivity
Red = Low Productivty

Pivot A



Management Zone N Rates

Treatment 4
High = 150 lb/ac
Med. = 175 lb/ac
Low = 200 lb/ac

Treatment 6
High = 168 lb/ac
Med. = 165 lb/ac
Low = 146 lb/ac

Treatments

1 Uniform 0 lb/ac N
2 Uniform 121 lb/ac N
3 Uniform 221 lb/ac N
4 Management Zone VRT
5 Grid Sample VRT
6 Management Zone Smart Sampling VRT

Grid Sample N Rates
150 lb/ac
161 lb/ac
172 lb/ac
183 lb/ac