Site-Specific Management Guidelines

K.L. Fleming, D.G. Westfall and D.W. Wiens SSMG-21

Field Testing Management Zones for VRT

Summary

Developing accurate variable-rate technology (VRT) fertilizer application maps is critical in implementing precision farming management. Intensive grid soil sampling has traditionally been used to develop application maps. Research at the University of Nebraska found that in many cases where the spatial distribution is rather complex, much finer grid densities than those currently used commercially are required to produce accurate maps of nutrient levels for fertilizer applications (Gotway et al., 1996). However, the cost and labor intensity associated with intensive grid sampling suggests other approaches may be more feasible. Management zone technology may provide a more economical method of developing VRT application maps.

Introduction

It is well documented that variations in soil fertility across landscapes affect crop yield. For example, in northeastern Colorado, winter wheat yields and phosphorus (P) levels were strongly correlated with landscape positions (Ortega et al., 1997). Higher yields on footslope positions were attributed to deposition of soil, organic matter, and nutrients from upslope positions and additional plant-available water.

Bare soil surface spectral properties are largely influenced by soil organic matter (SOM) and moisture. The grey tone pattern in black and white aerial photographs can be a reflection of these soil properties. Bhatti et al. (1991) found that SOM distribution from LANDSAT thematic mapper (TM) images strongly correlated with the spatial distribution determined by grid soil sampling, and the SOM was highly correlated with winter wheat yields. It appears that SOM determined from remote sensing may be effective in determining different productivity zones within a field.

Scientists know that the experiences of farmers have been extremely important in the development of agriculture as we practice it today (Crookston, 1996). Unfortunately, the potential contributions of farmer knowledge to soil and crop research is not being fully utilized. Growers know which areas of a field produce good yield and which areas are low in production. It is logical that nutrient needs are different among these areas. This allows the input of farmers in identification of different “management zones” in a field based on past production history.

Based on the relationships among bare soil color, topography, and farmer production knowledge, a study was initiated to determine if management zone technology could be used to develop VRT application maps that are accurate and cost effective for use in precision agriculture (PA).

Procedures

Management zone identification concept:

Step 1. The PA specialist and farmer used an aerial photograph as an initial template to develop management zones. A gray scale image of a bare soil photograph was enhanced using Adobe Photoshop® to contrast color differences.

Step 2. The PA specialist and farmer drew vector lines, using commercially available software (Agri Trak Professional®), to establish the individual management zones (high, medium, and low productivity areas). They based the zone delineation on soil color, topography, and the farmer’s personal management experience with the field[1].

Management zone testing:

In cooperation with the farmer and PA specialist, we developed management zone maps for two center pivot irrigated corn fields in northeast Colorado (**Figure 1**) and soil sampled each zone. These same fields were sampled using a 1.4 acre grid. All soils were analyzed for nitrate-nitrogen (NO_3-N), SOM, P, potassium (K), zinc (Zn), pH, and texture. Conductivity and yield information were also mapped for both fields.

The Site-Specific Management Guidelines series is published by the Potash & Phosphate Institute (PPI) • Coordinated by South Dakota State University (SDSU) • Sponsored by the United Soybean Board (USB) and the Foundation for Agronomic Research (FAR). For more information, call (605) 692-6280. www.ppi-far.org/ssmg

Figure 1. Example of management zones based on soil color, topography, and farmer's experience with the particular field. (Darkest areas = high productivity, medium areas = medium productivity, and lightest colored areas = low productivity.)

Evaluation of Management Zone Technology

Using the soil and yield data, the management zone procedure was evaluated as a tool to develop VRT maps. Statistical analyses were performed on soil and yield data to determine how well these zones reflected the productivity levels and soil properties. In field No.1, SOM, NO_3-N, K, Zn, and grain yield followed the trends indicated by the management zones (**Table 1**). Generally the highest nutrient levels and yield were in the high productivity zones; intermediate levels were in the medium zones, and lowest levels were in the low productivity zones.

Nitrate-N and SOM were highest in areas that consistently produced the highest yields and lowest in areas that produced the lowest yields. Phosphorus did not follow this trend. Perhaps the immobility of P and less P uptake and removal in lower yielding areas account for this anomaly.

Clay and silt levels were significantly higher in the high productivity zone, intermediate in the medium zones, and lowest in the low productivity zones while sand followed the opposite trend (data not shown). Soils in the field are generally of a sandy nature. Higher productivity would be expected in areas with higher clay levels because of their higher water holding and cation exchange capacities.

Apparent electrical conductivity, as measured by EM38® and Veris® 3100, showed similar relationships and were highest in zone MZ 3 and lowest in zone MZ 1 (data not shown). Higher clay and water contents of soils in MZ 3 may be responsible for these results.

In field No. 2 (data not shown) soil and crop parameters differed by management zone, but did not always follow the expected productivity indexes. The area we classified as the medium productivity management zone had the highest SOM, NO_3-N , P, K, Zn, conductivity, clay, and yield values, while areas classified as high productivity zones had intermediate values for these parameters. The low productivity zone had the lowest values for the parameters listed above and were highest in sand.

Our results illustrate that this approach can identify production land management zones. However, ground truthing needs to be performed to determine productivity levels. Conductivity data appear to be a cost effective and efficient tool to ground truth the management zones.

Practical Implications

Grid soil sampling to the intensity required to generate accurate VRT application maps may not always be feasible because of the time and expense required. Management zone technology may be a more economical method of developing VRT application maps. It is well documented that landscape position correlates well with soil parameters and crop yield. It is equally well documented that soil color correlates with SOM, and this relationship can be captured in aerial photos. Producers know which areas in a field produce high yield and which are low in production. Integration of these data sets aids in the identification of different management zones based on past production history. Management zone technology based on these relationships were compared to soil nutrient, texture, conductivity, and crop yield. Statistical analysis showed that different management zones had different yields, nutrient concentrations, apparent electrical conductivity values, and textures. Our initial analysis indicates this method may be effective in identifying different management zones. However, ground truthing is needed to develop accurate VRT maps from the management zones. Conductivity maps appear to have potential for cost effective ground truthing. Because these studies were conducted only on sandy soils in semi-arid environ-

Table 1. The relationship of farmer identified management zones with SOM, NO_3-N, P, K, Zn, and grain yield in field No.1. (MZ 1 = Low prod., MZ 2 = Medium prod., MZ3 = High prod.)

Management zone (MZ)	SOM, %	NO_3-N	P	K	Zn	Yield, bu/A
		ppm	ppm	ppm	ppm	
1 (Low)	0.8 a	17 a	16 a	140 a	3.8 a	156 a
2 (Medium)	0.9 b	20 a	11 b	161 b	4.1 a	170 b
3 (High)	1.2 c	25 b	14 a	208 c	4.4 b	172 b
Prob > F	0.0001	0.0014	0.0006	0.0001	0.037	0.0001

ppm= parts per million

Means followed by a different letter are significantly different at $p<0.05$.

ment of Colorado, further testing over a broader scope of fields and crop production systems is needed to confirm these results. ■

[1]Mention of a trade name, proprietary product, or specific equipment does not constitute an endorsement, guarantee or warranty by Colorado State University.

References

Bhatti, A.U., D.J. Mulla, and B.E. Frazier. 1991. Estimation of soil properties and wheat yields on complex eroded hills using geostatistics and thematic mapper images. *Remote Sens. Environ.* 37: 181-191.

Crookston, R.K. 1996. Using decision cases to enhance technology transfer in precision agriculture. *In Proc.3rd Inter. Conf. On Site-Specific Management for Agricultural Systems*, pp.1117-1122. Am. Soc. Agron., Madison, WI.

Gotway, C.A., R.B. Ferguson, and G.W. Hergert. 1996. The effects of mapping scale on variable-rate fertilizer recommendations for corn. *In Proc.3rd Inter. Conf. On Site-Specific Management for Agricultural Systems*, pp.321-330. Am. Soc. Agron., Madison, WI.

Ortega, R.A., D.G. Westfall, and G.A. Peterson. 1997. Variability of Phosphorus over landscapes and dryland winter wheat yields. *Better Crops with Plant Food.* No. 2. Published by the Potash & Phosphate Institute.

This Site-Specific Management Guideline was prepared by:

Mr. K.L. Fleming
Research Associate
Colorado State University/USDA-ARS
CSU-AERC
Fort Collins, CO 80523-1325
Phone: (970) 491-8663
E-mail: fleming@wmu.colostate.edu

Dr. D.G. Westfall
Professor
Department of Soil and Crop Science
Colorado State University
C16 Plant Science Building
Fort Collins, CO 80523
Phone: (970) 491-6149
E-mail: westfall@lamar.colostate.edu

Mr. D.W. Wiens
Sales Manager
CenTrak LLC
Fort Morgan, CO 80701
Phone: (970) 542-0200
E-mail: agritrak@henge.com

Ref. # 99091 / Item # 10-1021