EVALUATION OF SOIL SPATIAL VARIABILITY IN CALIFORNIA SOILS

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Introduction

Site-specific farming is defined as the management of inputs on a smaller scale than the whole field. Variable-rate fertilizer, lime, and herbicide applications are examples of site-specific farming currently being used in some regions of the USA. The premises behind site-specific farming are (1) that agronomically significant variability in plant growth, yield, soil type, pest pressures, etc. exists within fields, (2) such variability can be measured, and (3) the information obtained can be used to modify management for the betterment of farm profit and the environment. Little research has been done in California's diverse irrigated cropping environment to test these ideas. The initial focus of research must be on collecting and analyzing information that in turn might provide the basis for site-specific farming practices.

In the fall of 1995, a team of U.C. scientists and Cooperative Extension specialists and farm advisors began working with Yolo County grower Tony Turkovich to attempt to relate within-field variation of crop yield and quality to variations in soil chemical and physical properties, pest pressures, plant tissue nutrient content, etc. The team's intent is to relate environmental variables (such as soil drainage class) and manageable factors (irrigation, fertilizer) to crop yield and quality using relatively low-cost information obtained through aerial photography and yield mapping. A key question is: Can variability and its causes be mapped without over-reliance on more expensive information such as grid soil and plant sampling?

The project is supported by a two-year grant from the California Department of Food and Agriculture Fertilizer Research and Education Program and contributions of University California labor resources. Team members bring a wide range of expertise to the project including in crop modeling and plant physiology, agronomy, irrigation, soils and plant nutrition, engineering, remote sensing, and geographic information systems.

Methods and Materials

The team is collecting information from three fields in western Yolo county ranging in size from 77 to 108 acres. These fields were cropped to irrigated wheat in the 1995-96 year and will be rotated into processing tomatoes in 1997. Soil properties, plant nutrient status, and crop/weed/disease visual ratings were collected on a 200 x 200 ft grid -- approximately one sample per acre. Color infrared aerial photographs were taken before crop emergence in December, 1995, at early jointing in March, and during grain fill in May. Photographs were digitized, and a vegetation index was derived for the growing season images. Wheat grain yield was evaluated in June 1996 with a commercial yield monitor/global positioning system package installed on the grower's combine. Yield and grain moisture content were recorded in a data logger once per second, corresponding to two to four feet travel by the combine. All data were compiled, maps produced using Surfer 6.01 developed by Golden Software and color yield maps were generated using ArcView software.

Results and Conclusions

A large amount of data (soil/plant grid sample, yield, and photographic) was obtained from each of the three fields in the project's first year. Analysis of this information is in progress. Collected information from one of the fields (field #5) will be used here to show the potential for obtaining useful results.

The net grain yield in this 77-acre field was 2,944 lb/acre – less than half of a typical "good" wheat yield in the southern Sacramento Valley. The average yield recorded by the yield monitor was 2566 lb/acre. The 13% discrepancy between yields obtained from the truck weights and the yield monitor was probably due to insufficient calibration of the latter. Yield in the southwest corner exceeded 4,000 lb/acre but was less than 1,000 lb/acre in the north-central area of the field. Additional smoothing and processing of yield data -- for example, to remove data noise caused by short-range fluctuations in the flow of grain through the combine-- is still required before an accurate characterization of yield variability can be obtained.

The main factor contributing to low yield was saturated soil conditions resulting from poor soil drainage and heavy winter rains. Apparently, growing the wheat on five-foot beds did not compensate for the slow drainage characteristics of the soil. Yield was highest in the southern one-third of the field where the soil was lower in silt content and higher in sand (Fig. 1). The lowest grain yields were observed in the northeast quarter of the field where the surface soil was higher in silt and clay and where a restricting layer (> 50% clay) was present at a depth of three to five feet. This area of the field also displayed the darkest color in the December bare soil aerial photo (not shown), taken shortly after a rain.

A second cause of low yields was competition from grassy weeds. The density of the weeds varied greatly across the field. In some areas, there were no weeds. In a few areas, there was almost no wheat, only weeds. Weed ratings

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shown in Fig. 2 were obtained by an individual walking the entire field. The weed species that caused the biggest problem were wild oats, canarygrass, and ryegrass. Because these species are equal in height or taller than the wheat and possess a different color seed head, they are easily seen in the May aerial photograph (not shown). We plan to further analyze these data. It may be possible to produce a weed density map from the aerial photograph and -- by comparing that to the yield map -- determine the grain yield and economic loss caused by lack of weed control.

Generally soil chemical properties (pH, phosphorus, potassium, organic matter and zinc) were not spatially correlated with one another. Generally soil sand and clay were inversely related to one another spatially as was sand and soil organic matter. There was no spatial correlation between wheat yield or grain protein and soil chemical properties but there was for leaf nitrogen and chlorophyll content.

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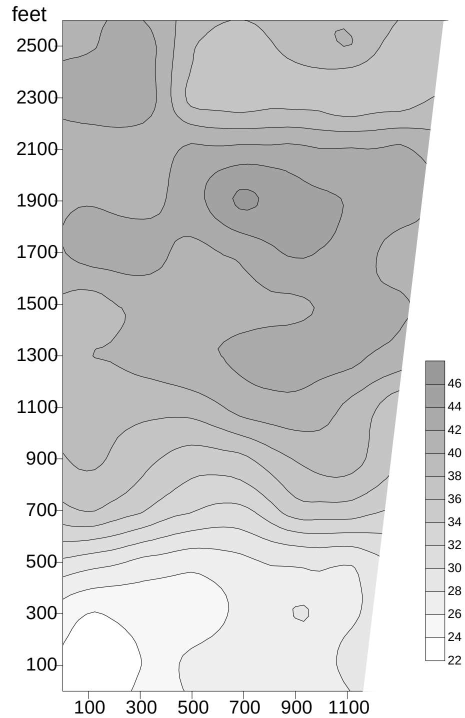

Figure 1. Silt content, 0-6 inch depth, Field #5.

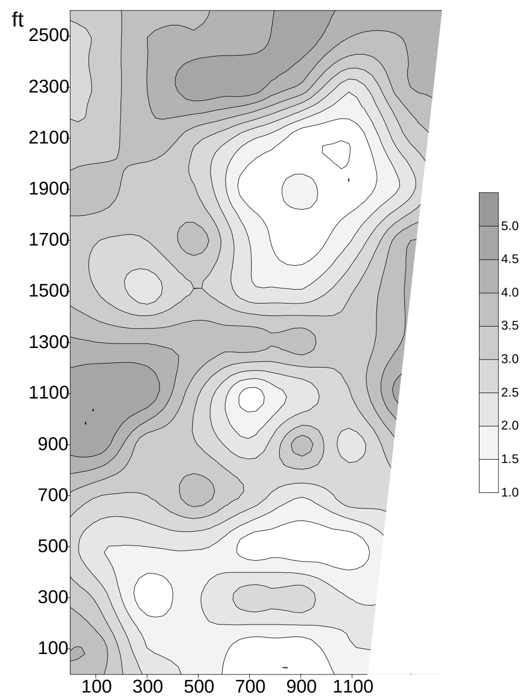

Figure 2. Visual weed rating, 1=low, 5=high, Field #5.