SITE-SPECIFIC MANAGEMENT RESEARCH IN MISSOURI: SWAMPED IN SPATIAL DATA

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MAPS, MAPS, AND MORE MAPS

With a maturing GPS technology, we have over the past couple of years become very enamored with producing maps on crop production fields. It wasn't long ago that the only map available was the soil map from county soil surveys. Continued sensor development and aerial photography and sensing, along with decreasing costs to store and manipulate spatial data, will mean that in the future measuring and mapping data will be the rule. There have been a lot questions raised regarding the minimum amount of data needed to generate a quality map, how to interpolate between data points to create the map, and even how many colors (classes) a map should have. These questions should be addressed. However, equal if not greater in significance is the need to develop procedures and tests to interpret maps.

The over-all goal of measuring for maps in crop production systems is to understand what variability exists and what impact that variability has on crop production. It is a "cause and effect" investigation. In times past using small-plot research, we managed our variability in favor of our treatments of interest. Experimental areas were selected on the basis of homogeneity. Treatment variables were few, and thus interactions were limited. As such, the interpretation of "treatment 'A' causes this effect" was a short jump.

In contrast, the cause and effect search is quite different with field-scale mapped data. Generally, variability is not controlled. The area of interest is much larger with no control on whether the area is uniform. Usually there are no treatment variables with predetermined mechanisms. In short, the rules for concluding cause and effect at the small plot scale do not hold for field-scale maps. In one hand we have a map(s) of grain production and in the other hand we have a multitude of potential other maps (soil nutrient availability, soil types, topsoil depth, elevation, aspect, pest pressure, crop stand, etc.). The step from demonstrating *association* to demonstrating *cause-and-effect* between the two hands is a difficult one. Correlation methods give an association test only and therefore the potential for misinterpreting cause and effect is real.

Maps from a field in north-central Missouri will illustrate this point. Figure 1 shows the weighted three-year average yield map for a 70-acre field obtained from two years of soybean (1992 and 1994) and one year of corn (1993) production; along with potassium (K) and phosphorus (P) availability maps, from sampling taken on a 80-ft soil grid in the spring of 1995. Grain yield has been slightly depressed (about 5 to 10%) in an east-to-west strip marked "A" on the yield map. Yield depression in strip "A" is interrupted by a narrower north-to-south strip that corresponds to the field drainage channel with depositional soil. The relevant

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question to the producer is "what is causing the yield reduction?" Both K and P maps show lower availability over strip "A". So with just two maps to go along with the yield map there are three possibilities for what is causing the yield depression: K, P, or K and P. Without other observations/measurements of plant growth, nutrient deficiency symptoms, tissue sampling, or supplemental fertilizer treatments as a "check", we are left unsure of the cause and effect relationship for strip "A".

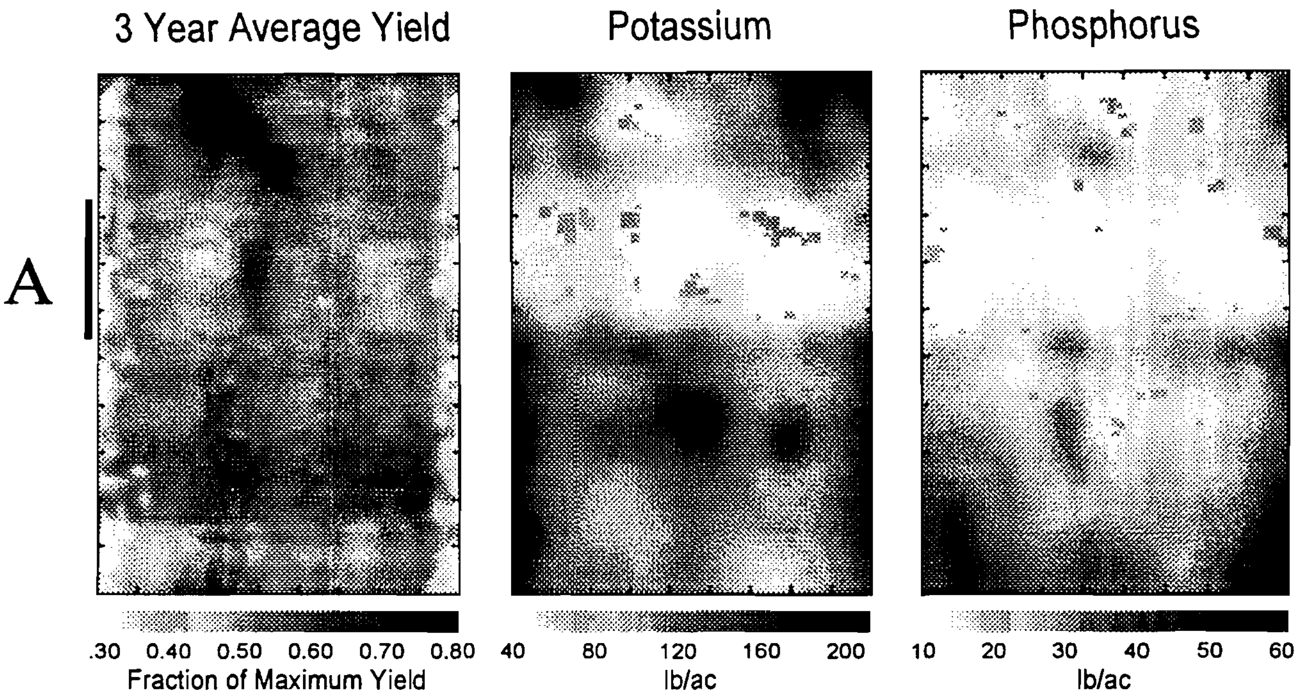

Figure 1. Three-year weighted average yield map and potassium and phosphorus availability maps for a claypan soil field in north-central Missouri.

Are there some rules or guidelines to follow for making cause and effect conclusions for all these maps? Mosteller and Tukey (1977) suggest that an association may reflect a cause and effect relationship if all three of the following conditions hold: (1) the data is consistent, (2) the data is responsive (one variable will change if another variable is changed), and (3) the data is mechanistic (chemical, physical, and biological linkages that fit). For the maps in Figure 1, the data may be consistent (multiple years included) and the mechanism proven (P and K are essential elements for crop growth), but since the low P and K areas are somewhat aligned, we are unable to state the data is responsive. The search continues.

IMPLICATIONS FOR FERTILIZER RECOMMENDATIONS

The current approach for site-specific fertilizer recommendation and application in crop production is to map fields by soil type or by grid-soil sampling. A whole-field map of nutrient needs for a crop is generated from this. Fertilizer rates are based on a generalized response relationship between the soil test, fertilizer additions, and yield increase, developed for a state or region. Figure 2 illustrates the approach.

This approach has some limitations when compared to the diversity of variability that exists within fields. Previous research has demonstrated that nutrient availability is only one of many factors that controls yield. For claypan soils in Missouri, limited plant-available water will result in yield variability within fields for many years. Topsoil depth above the claypan is a good indicator of how much plant-available water within the growing season there will be, or how productive the soil is. Other factors that will vary yields within fields include, but are not limited to, soil pH, soil organic matter, soil compaction, nutrient toxicity, weed and insect pests, crop population, tree hedges along field edges, and poor surface drainage. (For the yield map in Figure 1, we have assessed that there are probably at least four or five factors controlling yield.)

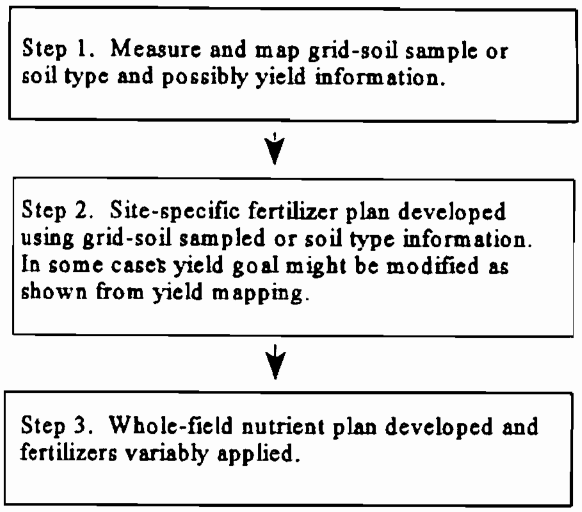

Figure 2. Current method for site-specific fertilizer recommendations.

When considering these other factors, the current approach as shown in Figure 2 is really only a beginning. Such use of grid-soil sample maps as the basis for site-specific fertilizer plans will not likely improve utilization of fertilizer nutrients in areas of a field where factors other than nutrients are controlling grain yield. Continued reliance on this strategy may actually hinder adoption of the site-specific management when positive returns are not realized by farmers investing in this type of site-specific management.

With multiple factors controlling crop growth and productivity within fields, spatial data needs to be sorted and interpreted in a sequence of decisions that will allow for isolation, evaluation, and fertilizer prediction by those areas within a field that are alike in the factor(s) controlling yield. While this requires more analysis and careful examination of mapped information, such a process is necessary in order to recognize and manage the complexity of

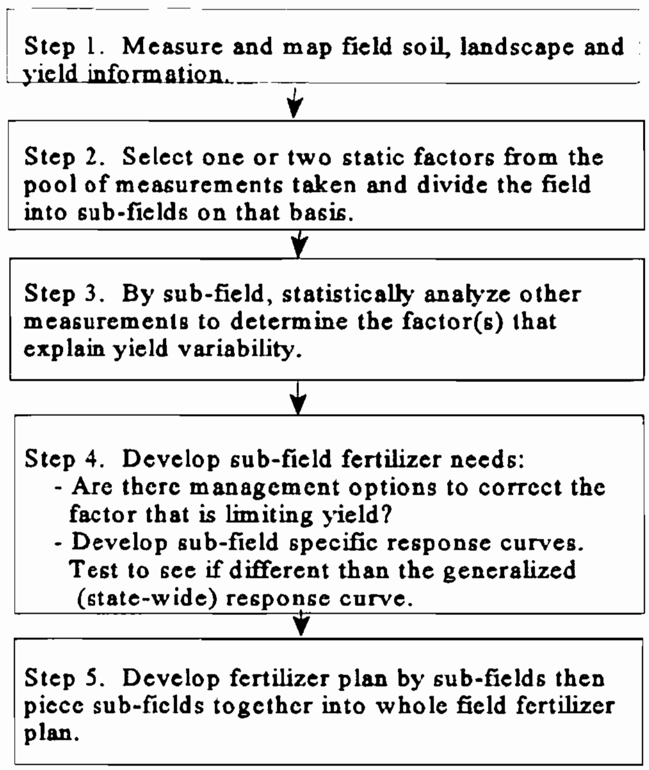

Figure 3. Improved site-specific fertilizer recommendation method under development.

field variability in a true site-specific management manner. Presently we are developing a method that will interpret field-mapped information in a way in which multiple factors controlling yield within a field can be isolated and analyzed for developing site-specific fertilizer plans. The five steps of this new method are shown in Figure 3.

Two concepts are used as guidelines in formulating the new method: (1) A specific soil, yield, or landscape measurement needs to be analyzed and used for developing variable nutrient applications based upon whether or not it relates to a crop-growth or yield-controlling factor(s) that can be corrected with management, and (2) mapped information needs to be sorted and analyzed in a way to give field-specific sensitivity for predicting fertilizer input needs. With this new method, good quality yield maps from combine yield monitoring are necessary.

The goal of this new method is to develop and validate a procedure for site-specific fertilizer recommendations that is agronomically, economically, and environmentally precise. The method we are working on provides a framework for systematic analysis of soil and landscape variations and their impact on crop production. A site-specific fertilizer plan derived from using this method will refine fertilizer recommendations and result in improved crop nutrient utilization.

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