A Primer for On-Farm Experiments Using Yield Monitor Data

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INTRODUCTION

Analyzing yield monitor data as an aid in farm decision-making is a computer-intensive and knowledge-intensive process. Detailed analysis protocols have been posted to the SSMC website (Griffin et al., 2005; Griffin et al., 2007), but for the novice a more general guide is needed. Once the overall process is understood, the more detailed documents can be referenced.

The overall process involves the following steps:

- Planning the Experiment
- Applying Treatments
- Calibrating Yield Monitor
- Preparing the Data
- Assimilating Data into a Geographic Information System (GIS)
- Performing Statistical Analysis
- Comparing Results
- Making Farm Management Decision

Although a single farm mapping software package to be capable of the steps described above may be available in the near future, the current process involves moving files between software packages. We have used software that is free to the general public as well as farm mapping software, professional geographical information system (GIS) software, and professional statistical software. The specific software mentioned in this article is in the public domain and are free to users.

STEPS IN THE PROCESS

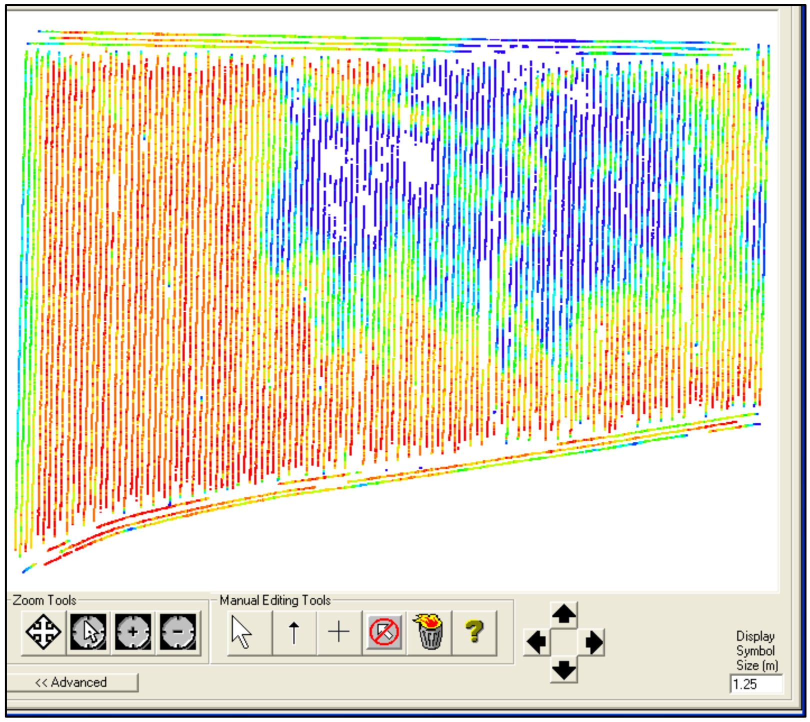
Plan the Experiment The experimental design should be chosen based upon the treatments tested, the field, and the farmer--one size does not fit all field research purposes. Most on-farm trials are implemented as strip-trials or split-planter trials although many farmers opt for split-field trials due to constraints of treatments to be applied, i.e. tillage. Elaborate experimental designs such as randomized blocks are rarely implemented due to time requirements; therefore simpler designs are preferred.

Yield monitor calibration (photo Kansas State Univ.)

Apply Treatments Typically, categorical experiments are simpler to set up than rate trials. Categorical trials include treatment(s) of each product that the researcher desires to test. Rate trials include a range of rates that include a very low or even zero rate and a very high rate in addition to two or three rates that are in what is expected to be the "adequate range." The very low and very high rates are expected to be extreme enough to reduce crop yield in order to properly estimate the crop response curve.

Calibrate Yield Monitor It is recommended that the combine yield monitor be properly calibrated prior to harvesting the on-farm experiment.

Prepare the Data In nearly all cases, yield monitor data must be rectified before use in spatial analysis. The term "filtering" is used to describe the process of removing erroneously measured observations and relocating data to the appropriate location. Yield Editor filtering software can be downloaded free from USDA-ARS (Drummond, 2006). From research conducted at Purdue (Griffin, 2006), it was determined that filtering yield monitor data prior to analysis led to different production recommendations being made.



Yield monitor data that is not filtered—note zig-zag patterns in center of field and at end rows where data has not been properly geo-referenced.

Assimilate Data into a GIS
Once data has been filtered, the data are assimilated with supporting data such as treatments, soils, elevation, and other yield affecting factors with professional GIS software. In order for data to be analyzed by the statistical software, it must be in a single file format.

Perform Statistical Analysis With all of the data in a single dataset, it is ready for spatial statistical analysis with software such as GeoDa (Anselin, 2003) or R (R Core Development Team, 2007), both of which can be downloaded and used free. Although several statistical analysis methods exist, we suggest using one of the spatial statistical methods. Any appropriate statistical analysis of a spatial dataset can be thought of as spatial statistics. We typically use regression analysis which can be thought of as a functional relationship between correlated variables that can be estimated from a given dataset. Regression can be used to predict values of one variable when given values of other variables. Spatial statistics expands upon traditional regression to address the problems of spatially dependent data. Once statistical results are available, the interpretation and economic analyses are conducted in order to make production recommendations and farm management decisions.

Compare Results It is our practice to take the regression results and graph them in a spreadsheet so that the results can be easily communicated with decision makers. Using the estimated coefficients from the statistical analysis, we calculate the dependent variable, typically yield, over a range of the covariates such as soil clay content, elevation, or other continuous variables for each treatment and/or other discrete categories such as soils in a spreadsheet. From these calculations, we create a scatterplot. These graphs are useful in intermediate interpretation of the results of the planned comparison with the farm management decision-maker.

Categorical Trials and Partial Budget Analysis For economic analysis of side-by-side or categorical treatments, a partial budget is sufficient. A partial budget includes only the costs and revenues that differ between alternatives, while an enterprise budget is exhaustive. For field-scale experiments, the difference in revenue may only include the difference in revenue for each treatment (Equation 1). The difference in costs may include the seed costs if a hybrid trial or the machinery costs if a tillage trial.

Equation 1: *Revenue = yield x market price*

Rate Trials and Economic Analysis For rate trials such as nitrogen rates or seeding rates, the functional form estimated in the regression analysis and equation derived from the regression model is used. The model coefficients are used to calculate yield maximizing levels of input, or what is commonly known as agronomic maximum. However, yield maximized levels are not profit maximization levels unless the input is free, an unlikely situation. To calculate profit maximization levels, or economic optimal levels, the profit function (Equation 2) must be used. Each planned comparison may have a completely different model, costs, and treatments and the analyst should be prepared to adjust their own protocol accordingly.

Equation 2: *Profit = (yield x market price) – input cost*

Many farmers and field researchers suggest that economic analysis is missing from their studies. In a large proportion of on-farm or field-scale trials, the economic analysis is straight forward even to non-economists although other types of trials require advanced techniques and calculus. Although the economic analysis of categorical trials may only include partial budgeting techniques, partial budgeting is also useful for economic analysis of rate trials. From the response function or curve, economic analysis can be conducted.

Make Decisions We have stressed that the result of a spatial analysis is a production recommendation and not just a map. Some farmers, consultants, and researchers have concluded that precision agriculture is simply a map. Our conjecture is that analysis of precision agriculture data must result in a farm management recommendation that the farm can feasibly implement in a timely manner. We sometimes use maps for communication and validation purposes, but never as the ultimate end product of a spatial analysis.

Although appropriate spatial analysis is sometimes difficult and time consuming, it is imperative to provide the farmer with a production recommendation in a timely manner. A "timely manner" may be defined in a variety of ways based upon the season and the input tested. For instance, seed corn is typically ordered near the end of harvest for the following year to secure early order discounts. If a production recommendation based upon spatial analysis of a corn hybrid trial was provided to the farmer sometime in early spring or even late winter, the value of the recommendation has diminished.

CONCLUSIONS

Although performing spatial analysis requires more time, effort, and human capital than other analysis procedures, it is our experience through research and practice that spatial analysis leads to more reliable decisions. It has also been our experience that well planned out on-farm experiments have a better chance of being used for farm management decisions.

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