ANALYZING FIELD-SCALE, ON-FARM EXPERIMENTS FOR FARM MANAGEMENT DECISION MAKING

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Abstract

Precision agriculture is information technology. Data collection may be sufficiently dense that each observation can have nearly immeasurably small cost. However, many agriculturalists recognize that the collective sum of the nearcostless, individual site-specific observations has great potential value. They also recognize that lacking a proper means to use these data, the conversion of these data into information, may elude them. With respect to data that can be collected using precision agriculture applications, economists attribute the chasm between the data collected and the capacity for decision-making based on the data to be due to the lack of qualified, third-party analysts, e.g. in economic terms, network externalities applied to agriculture.

Agricultural research is conducted in the environment. As such, the results are subject to variations caused by time and space. Repetition in time is necessary to evaluate the effect of seasons. Spatial effects are attributable to some combination of site aspect, slope, soil chemical and physical properties, microclimatic and other factors. Classically, variation due to space is estimated by replication, typically by spatial blocking, and consequent partitioning of variation attributable to spatially separate replications (Cochran and Cox, 1950). With the advent of technologies that can measure parameters at discrete intervals on whole fields, data may be collected from large-scale, twodimensional matrices and the effects of space and treatment may be estimated separately by analysis of variance of all the within-field data. The latter case describes site-specific experimentation and the basis for its analysis. With an appropriate understanding of how to manage and analyze field-scale data matrices, researchers or growers can perform experiments at field scale. Frequently, field-scale experiments are easier to treat and manage than are smallplot experiments; especially for such practices as tillage, irrigation, or aerial application. Critical requisites for interpreting the effects of treatments applied at field scale is properly designing and conducting the experiments and understand the basis for statistically estimating the effect of space, and employing necessary mathematical techniques to estimate them. We address the basic field-scale experimentation procedures including design, implementation, data collection, analysis and interpretation.

Several documents provide advice on conducting on-farm research, although most extrapolate small-plot methodology to landscape scales. Focusing on individual field experiments misses the opportunity to maximize the utility inherent in communities of datasets. Such sets may comprise similar experiments conducted across different environments and farm practices. In addition to the deliberate interventions, i.e. experimental treatments, at each specific field, the community dataset becomes substantially richer when individual field characteristics are considered as observations in a community network similar to meteorological mesonets, or an aggregation of field experiment datasets that collectively constitute a landscape-scale experiment. From such a perspective, fixed factors of the field may serve as variables from which to conduct an aggregate analysis. For instance, when 50 farmers desire to participate in a seeding rate study, the deliberate intervention is the seeding rate, while additional observational data may include farm-specific characteristics such as row spacing, planting depth, latitude, and other factors that can be evaluated as covariates. As more farmers participate, the fixed factors of each farm can be utilized as variables, albeit with uncontrolled sample size. Each individual field experiment in the community network, a MesoTrial, requires a minimum level of data quality; therefore strict controls must be followed.

Plan and Design Experiment

The most common designs used by farmers include strip trials and split-field designs. Rarely do farmers use experimental designs based on small plot methodology such as randomized complete block designs. A natural extension of the split-field approach will sometimes entail the replication of one or more treatments in different areas of the field such that each treatment is present on each major production zone within the field. Strip-trials are

useful for treatments applied with the planter such as varieties and seed treatments. In such experimental systems, treatments applied using a division within a 12-row planter that are harvested with a 4-row cotton picker could provide 3 harvester passes. Whereas with a 6-row picker the number of harvester passes would be reduced to 2. We recommend using at least three harvester pass widths for any given treatment in the event that 1) a single harvester pass is unusable and 2) enhance utility of Yield Editor.

Certain types of hypotheses are more accurately tested at field-scale than are others. When a yield monitor is used for collecting on-farm research data variety comparisons cannot be made directly without determining the characteristics of the harvested grain or cotton. Different varieties of grain crops typically differ in moisture content and test weight. Differences in seed size between cotton varieties may preclude the use of yield monitors to precisely determine yield differences among varieties. Although variety trials are the most common tests performed by growers, seeding rate, tillage practices, and other systems approaches may provide more reliable information from investment in field-scale experimentation.

Telematics have enhanced experimentation by transmitting prescriptions to application equipment, time and motion data from equipment to computers, and other applications. These capacities allow imposing experimental designs by means of prescriptions to controllers that can automatically implement experiments. An embedded design that places replicated plots within fields at appropriate locations is the logical experimental design for this technology.

Data collection

All aspects of the experiment should be electronically recorded using geo-referenced information. Experiments are often not implemented as planned due to weather, miscommunication, and equipment malfunctions. Trusted advisors must document whether the experiment was properly conducted, i.e. to include the data or exclude the data from the database. Telematics are also able to transmit as-applied data directly to computer servers.

Use of spatial data to estimate spatial effects require dense data sets. Rather than use spatially sparse data, the preferred method to explain inherent soil variability is high-resolution continuous data. A common technique to assess soil properties, although the measure is indirect, has been apparent electrical conductivity. Although electrical conductivity has no direct interpretation with respect to crop growth, it proxies for one or more factors that do.

Yield monitor data is best gathered while the harvester is operated under the range of conditions that it was calibrated. As when recording experimental design, telematics can retrieve yield monitor data and transmit directly to the server without transferring data by physically moving data cards, thus reducing the risk of human error.

Data Management

The current best management practices for handling yield monitor data include an objective editing of data to remove erroneously measured points and reposition observations (Drummond, 2011). Assembling disparate spatial data layers should follow the procedures described by Griffin et al. (2007). It is not uncommon for one or more people to modify data while in their possession, either intentionally or unintentionally. In order to protect data integrity, original datasets must be available to the analyst, rather than only subsets or otherwise modified versions. In addition, the original dataset must be logged and secured for future reference.

<u>Data analysis</u>

Griffin et al. (2007) provided insights to manage and analyze data based on spatial statistical theory and experience. More than one approach may be used to analyze site-specific data. In some cases observations have been treated as population statistics, while in others as replicates. In other cases classical small-plot methodology was used with the invalid assumption that small-plot statistical analysis was appropriate at landscape scales. The advantages, disadvantages, and dangers of invalid assumptions were reviewed by Griffin et al. (2005).

Investments in the human capital, i. e. the training or professional services needed to perform spatial analysis of yield monitor data are relatively large but scalable. Since education is a recurring resource, once an investment in training has been made, the techniques may be used across many datasets. Spatial analysis, who are expert in the analysis of field-scale data sets, consider the spatial error process model (Anselin, 1988) the most appropriate approach for analysis and interpretation of site-specific agriculture data.

References

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