1998-02-19

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A. Abstract

On-farm research can be a powerful tool for farmers wishing to establish the true value of new and emerging technology for their own operation. It requires that farmers develop an understanding of how experimental design and data analysis are required to make sound decisions, given the biological variability characteristic of our environment. The development of global positioning systems (GPS) and yield monitors have the potential to significantly improve the ease with which on-farm testing is carried out. The ability to geo-reference the application of treatments, collection of data during the growing season, and align specific landscape positions with topographic variation in the field, will permit the interpretation of data at both the field and landscape element level. While the time required to establish and collect data from the field trials may be reduced, it will likely be more than offset by the time required to organize, analyse and interpret the results prior to making appropriate decisions. There are several issues that should be addressed in the future to facilitate the growth of on-farm testing:

1. There is a need to develop skills amongst farmers involved in on-farm testing, allowing them to efficiently use the technology available. In particular, the use of GIS software to integrate all of the information which will be collected, and methods of extracting data from field maps for analysis.
2. We need to develop a "clearing house" for new and emerging research and methods in the use of Precision Farming technology in Saskatchewan. Research results need to be presented to allow for testing on-farm, and we need a forum where the experience of producers can be shared and further developed.
3. Remote sensing has the potential to have the greatest impact on precision farming through its identification of site specific pest problems. The development and application of remote sensing technology to the expansive agriculture characteristic of Saskatchewan requires immediate attention.

B. Introduction

Farmers have always questioned the application, or "fit", of new technology on their own particular farms. Questions like "will it work on my soils", "what kind of effect will hilly or stony land have", or "do I have an adequate growing season" are frequently asked when new innovations, varieties and technologies are commercialized. As a result, most farmers are interested in having new technology evaluated in their areas. The best example of this occurred with the province-wide support of direct seeding trials in Saskatchewan in the late

1980's and early 1990's. With this local field scale assessment of direct seeding, many farmers made the decision to move from conventional tillage to direct seeding, a decision which is reflected in the 1996 census of agriculture showing 22% of Saskatchewan crop land is now direct seeded.

While commodity prices seem to either be holding the line or declining, crop production inputs are increasing in cost. As a result, there is a heightened interest amongst many farmers in establishing the true benefit of new technology on their own farms. The ability to do this has been significantly improved with the development of combine yield monitors, and more recently, variable rate sprayers and air seeder carts. These tools, all of which are very expensive, provide the farmer with the ability to rapidly conduct and collect data from on-farm experiments, with little hassle associated with down time during the busy seeding, spraying and harvest periods. However, to make effective use of these tools requires that farmers become acquainted with methods of properly establishing a field strip trial so as to allow for an effective interpretation of the results.

In this paper I am going to draw on the experiences of the STEEP (Solutions To Environmental and Economic Problems) program in the Pacific Northwest (Veseth et al., 1997), and our recent experience with the Northeast Agriculture Research Foundation producer group.

C. What is On-Farm Research?

Contrary to popular belief, on-farm research is not research trials conducted by scientists in a farm field. Rather it is the application of a treatment by a farmer using field scale equipment, and using a replicated design to separate the effect of the treatment from the natural variability associated with the field site. Unlike a demonstration, where a single strip of a specific treatment is applied to a field to take a 'look-see' in comparison to the rest of the field, an on-farm research trial is established with the purpose of quantifying the treatment in that specific field, and under the prevailing environmental conditions. While many producers are not comfortable with the use of a scientific approach, experience with field trials quickly raises their understanding of how important quantitative data collection is to making appropriate decisions. On-farm research requires:

- clearly identified treatment strips in the field for treatment application and sample- collection during the growing season and at harvest, and
- access to some form of scale, such as an elevator scale, weigh wagon, or portable scale pads to allow collection of the yield data from strips.

D. Guidelines for an On-Farm Strip Trial

In developing a plan for an on-farm research trial we need to consider the components of a statistically valid experiment, specifically randomization, replication and statistical design. In addition, length of plot used and arrangement of large plot treatments in the field requires careful consideration.

REPLICATION: Experience from the STEEP program in the Pacific Northwest supports the use of four to six replications in field trials, depending on the precision required to answer the question being asked (Veseth et al., 1997). Three replicates are dangerous, as loss of one prevents any statistical analysis of the data.

RANDOMIZATION: To achieve an unbiased distribution of treatments across the experimental layout, it is important to use a random assignment of treatments. This will avoid any consistency in the arrangement of treatments across a slope or naturally occurring characteristic of the field. It is also a useful means of ensuring to yourself that you have not biased one specific treatment.

STATISTICAL DESIGN: The most commonly used experimental design for two to three treatments studies is the Randomized Complete Block Design (RCBD). It focuses on randomization of the treatments being considered within each block, or replicate. The arrangement of each set of treatments within a replicate should be made to minimize variability. In fields with large variability, this may prevent the arrangement of replicates side-by-side. Rather, locations in the field large enough to accommodate the uniform layout of a replicate would be selected.

LENGTH OF PLOTS: The length of plot needed to provide an accurate assessment of treatments is dependent of the variability in the field. STEEP work found that plots 300 ft in length were adequate on uniform fields, and when using four replicates (Wuest et al., 1994). However, a plot length of 750 ft or longer was the best means of achieving accuracy in data collection on fields with variable landscapes.

EXPERIMENTAL LAYOUT: Positioning of replicates in the field so as to minimize variation may require that the study be assigned to various parts of a field. While arrangement of the replicates side-by-side may appear the most convenient, field variability could result in highly variable data, preventing any estimate of treatment effect.

E. Combine Yield Monitors, GPS, and GIS Software for On-Farm Research

The development of GPS and yield sensors for combines should significantly improve the opportunity for data collection in on-farm research trials. Grain yield data from replicated strips applied to a field could be collected without having to harvest the strips separately from the remainder of the field. Once the location of the treatment strips are geo-referenced within the field, the data from the yield map can be selected to give the final yield result. When combined with a topographic map, the producer should be able to identify similar land form elements along the length of a treatment strip, allowing for the interpretation of a treatment response at each specific slope position in the field, simply through comparison with the adjacent control strip. While some problems continue to persist regarding the accuracy of the yield sensor in combines, and the precision of GPS units in accurately locating yield information with its exact collection position, these technologies should significantly improve the ease with which on-farm testing is carried out. To make this system work effectively several tools and information sources would be required by the producer.

Topographic Maps

To date, most GPS units are not capable of providing an accurate topographic map. As a result, detailed survey may be required to establish the amount of relief in a particular field. Once a topographic map is available for a field, identification of upper, mid and lower slope positions can be determined. In addition it will become a useful tool in determining the best position to assign the treatment strips in the field so as to ensure that all landscape elements are covered.

Management Units

Dr. Dan Pennock, Soil Science Department, University of Saskatchewan, has developed a method of classifying a rolling landscape into specific landscape units. This involved the description of primary landform element groups, including shoulders, backslopes, footslopes and level elements, which were further subdivided into convergent (high catchment areas) and divergent (low catchment areas) for overland water flow. Due to the influence of landscape on soil formation and change due to cultivation and erosion, these individual landscape elements were found to demonstrate common soil and crop productivity characteristics. Continued work with graduate students has led to the development of aerial photo based interpretation of field landscape elements which are closely related to those classifications established with topographic survey. This innovation of using image analysis of black and white photographs to establish soil management units has great potential to rapidly develop management unit maps for precision farming application.

Replication

One aspect of using long strips in a field is that each treatment may cover several similar landscape management units, producing a form of replication within the treatment strip. As long as the landform element covers all of the treatments within a replicate, one could argue that it is providing the same type of effect as randomly positioned replicates within the field. This could be of great advantage to a farmer, particularly in the case of applying a treatment series which is going to have an effect on grain yield (ie. unfertilized or unsprayed check). The aspect (direction it faces) of a particular landscape element would also have to be considered, however, may not be as significant a factor in influencing crop response.

GPS and Benchmark Sites

Global positioning systems have the unique ability to navigate you back to a specific location in a field, without any physical locating marker. In addition, when linked with a data logger, the GPS unit can be used to map weed, disease, tissue samples, and other observations to specific sites in a field. As a result, one can return both throughout the growing season, or year-after-year, to an exact sampling site. This could prove to be invaluable for sample collection, particularly in hilly terrain. Once finished in the field, the map and data collected can be down loaded into the GIS program, and saved for future overlay onto other maps for that particular field.

F. Data Management and Interpretation

As with any data collection, organizing, analysis and interpretation of the results can be equally as challenging as running the field trial. The collection of data now linked with a map, or field, position provides us with the means of increasing our interpretation of the yield results. Soil samples, weed and disease maps and other data collected during the year, and in previous years, can now be layered for interpretation. This will be no small feat, and will require that the farmer develop strong skills in the use of GIS software. Deciding whether a measured variation in grain yield is due to soil nutrients, pest infestation, soil salinity, or any number of variables will require the experience and judgement of the producer, and in many cases the assistance of resource specialists. It will be interesting to observe and monitor the progress of farmers as they develop these skills, and determine the training they will require to become proficient in use of the technology.

G. Summary

While the future of on-farm testing will have its principle focus on evaluating new equipment and positioning technology, there is going to be a great need to attempt to make some sense of the ‘chaos’ associated with environmentally driven biological systems. It is the work of individual farmers, and producer groups, which has illustrated to many of us the current gulf which exists between *precision technology* and *precision information.* We are in the infancy of characterizing and quantifying the role and impact that precision application, measurement and positioning technology will have on our farming systems. What we can all agree on is that never before has there been so much involvement of North America’s “high-tech” science and technology community in an agricultural issue.

The question is often asked are things moving too slow with PF technology? I would think that we are likely moving as fast as possible given the ability of electronic technology to explain the diversity characteristic of biological systems.

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