Site-Specific Management Guidelines

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SSMG-17

Setting Up On-Farm Experiments

Summary

The ability to perform on-farm experiments has been greatly improved with the advent of yield monitoring and differentially-corrected global positioning system (DGPS) equipment. However, care should be exercised when planning a particular experiment to remove sources of variation that might confound the interpretation of the data. In addition, the use of yield monitor data may require more observations or larger loads to adequately capture the random variation in the field. Simple statistical tests, like the t statistic, are appropriate when analyzing paired data such as the side by side split-planter design or strip data from yield monitors.

Introduction

The availability of on-the-go yield monitors can help producers conduct on-farm experiments. Advantages for on farm experimentation include: many more locations and crop-years can be evaluated, and research is performed at the same scale farmers use. Some examples of this type of experimentation might include:

1) evaluating different hybrids for yield potential,

2) crop response to different levels and formulations of fertilizer,

3) and the influence of soil type on yield potential.

The ability to accurately measure yield presents many unique opportunities to producers, but producers must also be aware of pitfalls that accompany this type of field experimentation. The purpose of this Guideline is to describe some of these pitfalls and offer some methodologies that could be used to lay out and evaluate on-farm experiments.

Laying Out the Experiment

Critical to laying out the experiment is the hypothesis to be tested. For example, if the hypothesis is to determine the yield potential difference between two corn hybrids, then care should be taken to eliminate other factors that might confound the results. An ideal way to test such an hypothesis is with a side by side split-planter design. Ideally, the width of the combine harvest head should be exactly one-half of the planter width. In this case, two hybrids are each randomly assigned to one-half of the planter before planting the field or strips and the appropriate seed placed in the planter boxes. The field is then planted as normal, resulting in pairs of adjacent hybrid strips across the field. To guard against any bias toward one hybrid or another, consider making at least six passes through the field with the split-planter configured one way, then switching hybrids to the alternate side of the planter for a similar number of passes (Peterson, 1997). In addition, the hybrid strips should be laid out in such a fashion so that other sources of variation are minimized. The following factors should be as uniform as possible across strips:

Planting date	Stand count
Similar maturity	Percent grain moisture at harvest
Soil fertility	Tillage
Previous crop management	Weed, insect, and disease pressure
Soil type	Drainage
Compaction	Topography

Of course, the experiment could be laid out such that any of the above factors could be tested for their effect on yield. It is quite common for soil type and topography to change across a given field. If it is not possible to find an area where the soil and topography are uniform, strips should be side by side and should run perpendicular to the maximum sources of variation (**Figure 1**). If slope is uniform across the field, strips should run up and down the slope. By laying out the experiment in this fashion, variation of known properties, such as topography, can be removed or accounted for systematically.

Collecting the Data

Yield monitors are a valuable tool in gathering data at harvest time. Commercially available systems can keep

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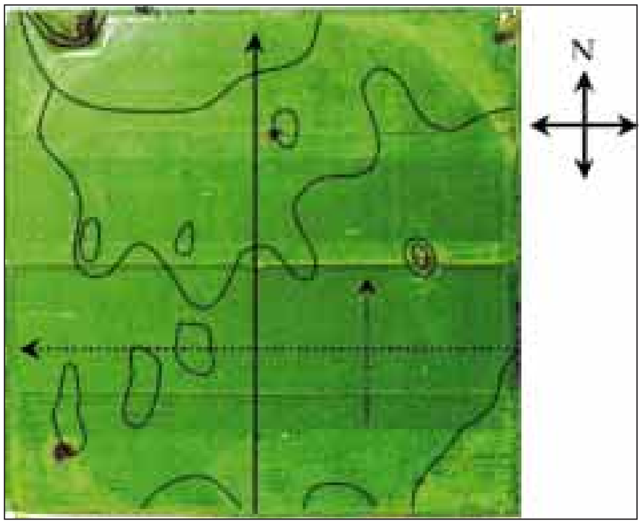

Figure 1. Aerial photo of quarter section illustrating soil boundaries. Strips are laid out perpendicular to maximum soil variation (north-south solid line). In areas where soil properties are uniform, strips can be laid out in either direction (dashed lines).

track of individual "loads" determined and defined by the operator. Each strip or section of a strip in the experiment is assigned a unique load number, and the monitor records data such as total pounds of grain harvested, average grain moisture, area harvested, and calculated bu/A for each load. The quality of the data collected by the yield monitor is a function of proper plot design and harvest technique (see Guideline #9). When collecting side by side strip data traversing a slope, the two strips to be compared should be harvested in the same direction. This eliminates any systematic variation that might occur due to ground speed of the combine and also allows for paired comparisons of measurements if the yield monitor is connected to a DGPS receiver. Spatial yield data also allow for the creation of yield maps (**Figure 2**). Yield maps provide information on spatial differences and can be used in conjunction with other data layers, such as soil properties, to help interpret yield variations (Gardner and Doerge, 1998).

How Much Data to Collect

In general, it is best to randomly replicate a treatment in an experiment. The side by side split-planter treatment discussed earlier does not lend itself to replication in the traditional sense. If the yield monitor is set-up to take yield measurements every second, the number of observations within a strip is based on the ground speed of the combine. A secondary complication is that these observations are not random. The observations are collected in a non-random order, that is to say, one after the other in the direction the combine is moving. A random sample usually requires fewer samples to estimate the statistical distribution (mean and variance) of the property being sampled. A non-random sample, therefore, requires more observations to adequately estimate the mean of a strip. To illustrate this point, two strips of yield data, running from west to east, collected from the southern half of the

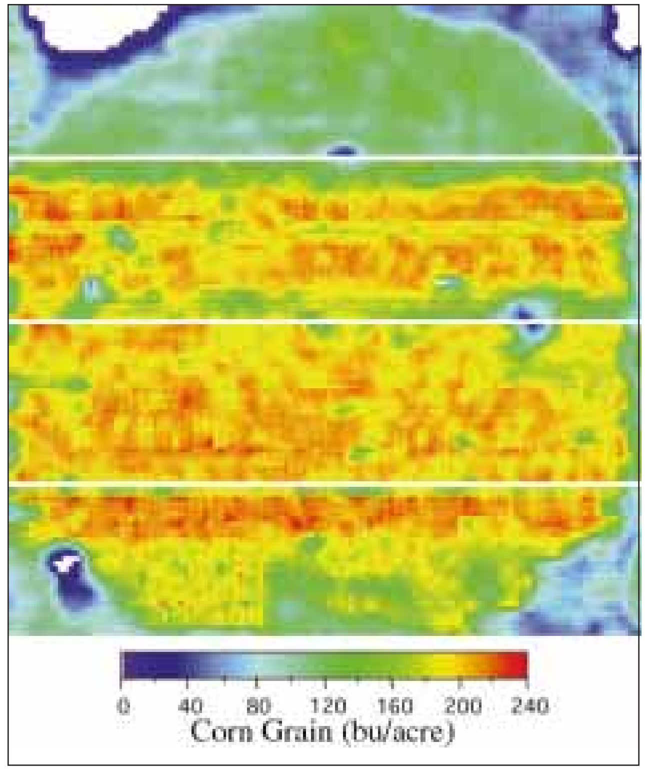

Figure 2. Yield map generated with yield monitor data and differentially-corrected GPS data.

field on uniform soil (dashed arrow) shown in **Figure 1** are compared. In this part of the field uniform nitrogen (N) management was applied. Each strip contains 80 observations. The means or averages of all 80 observations in the two strips are virtually identical (**Figure 3**). The statistical distributions of two strips taken from different soils are much different, and average yields are almost 20 bu/A different. This illustrates the importance of removing sources of variation that could confound the experimental results.

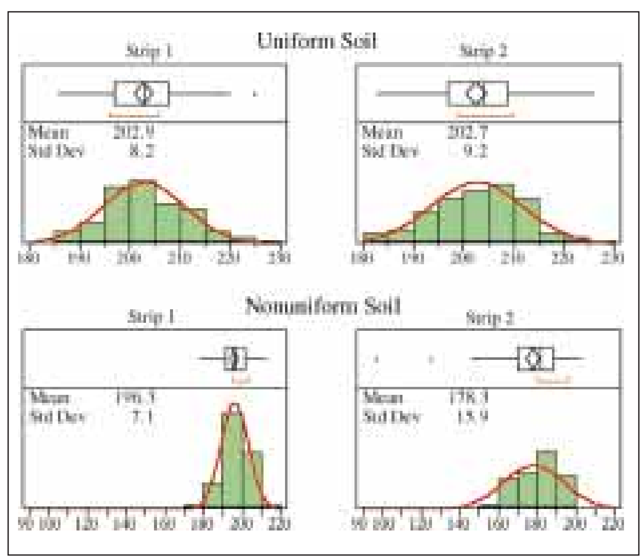

Figure 3. The statistical distribution of yield data for two pairs of strips of 80 observations each with similar N levels on uniform and nonuniform soil.

The number of observations or plots used to calculate the mean of a treatment is also very important. If a random sample of four observations is taken from each strip on the uniform soil (**Figure 3**) and averaged, a different estimate of the mean could be calculated. The average of four random observations would be 199.8 bu/A and 203.8 bu/A for strips 1 and 2, respectively (**Figure 4**). A minimum number of random samples need to be drawn from the population to adequately describe all the variation in the population of 80 observations. If a non-random sample is drawn, as in the yield monitor data, where the observations are taken from left to right, more observations will be needed to calculate the mean before the random variation of the population is captured (**Figure 5**).

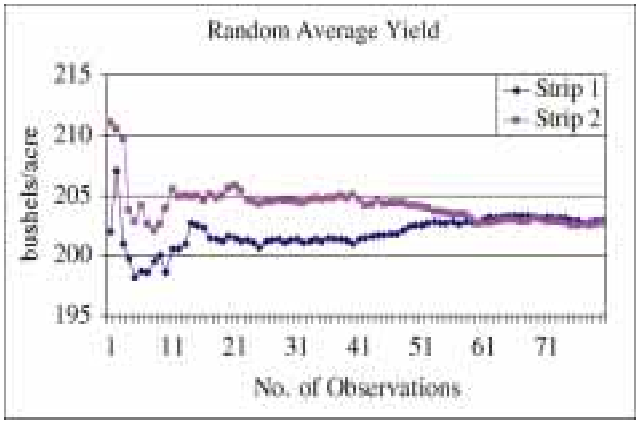

Figure 4. **Successive averages over 80 random observations taken from two side by side yield strips. Approximately 15 random observations at this sample size are required for the estimated average yield to become stable.**

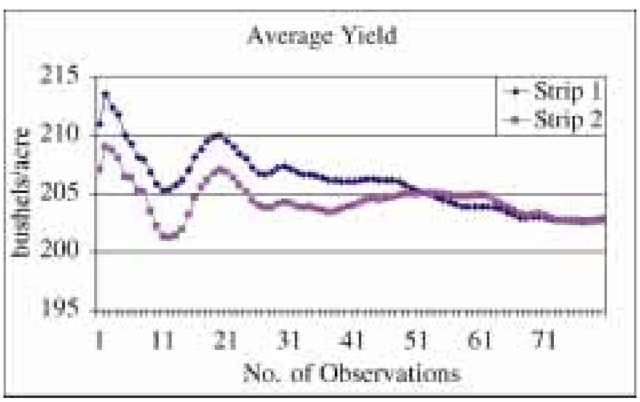

Figure 5. **Successive averages over 80 observations of two side by side yield strips. Approximately 25 observations (500 ft. of row) are required to capture the yield variability when non-random samples are taken.**

Analyzing the Data

Once a representative sample is drawn from the data, statistical analysis needs to be performed to determine if there are any differences in the treatments. Since data taken from a yield monitor are difficult to randomize, the types of statistical analysis that can be performed are limited. A simple statistical analysis can be performed with paired data such as the side by side split-planter experimental design. The means of the two paired data sets can be tested to see if they are statistically different from each other using a paired t-test (see Guideline #18).

Figure 6 illustrates how the calculated t statistic changes based on the number of observations using paired observations from two pairs of adjacent yield strips. If the calculated t statistic is above the solid line (comparing strips from two different soil types), then 95 out of 100 times we would expect a difference in the two yield strips. For the t statistic below the solid line (side by side strips on the same soil), there is no difference between the two yield strips. In these cases, the more observations or the longer the strips the greater the difference between the t statistic and the critical value used to determine statistical difference.

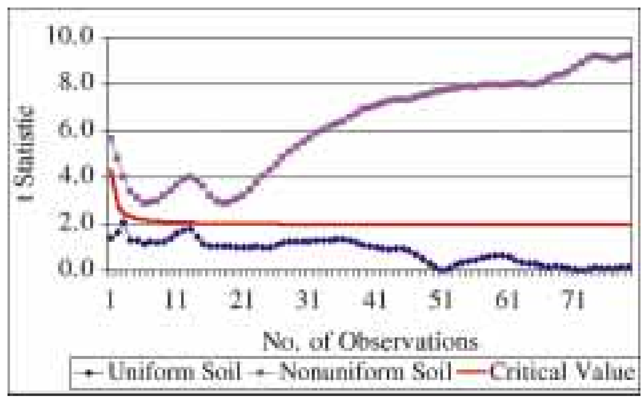

Figure 6. **A paired t-test of yield monitor data from two different paired yield strips and the effect of number of observations on the statistic.**

References

Gardner, D. and T. Doerge. 1998. Creating yield difference maps from split-planter fields. Precision Farming: Precision update, Issue 3, Pioneer Hi-Bred International, Inc.

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Ref. # 99087 / Item # 10-1017