

# DESIGN, WRANGLING AND ANALYSIS OF AN ON-FARM STRIP TRIAL. IOWA SOYBEAN ASSOCIATION METHODOLOGIES

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## INTRODUCTION

Iowa Soybean Association (ISA) has conducted over 4,500 replicated on-farm trials over the past 15 years. During this time, we have developed our own methodologies and approaches to on-farm research. In this talk we review step by step ISA approaches to a replicated strip trial involving 5 nitrogen rates including trial design, data wrangling, data analysis and machine learning approaches. The talk concludes with discussion on some difficulties in on-farm research with an appeal to the science community to work on these gaps.

## WHY CONDUCT ON-FARM RESEARCH?

While on-farm research is gaining acceptance among the scientific community, there remain many skeptics of on-farm research approaches to science. Most of these objection's stem from a lack of controlled environments where there is less confounding of experimental treatments with soil types, textures, landscape positions and other extraneous factors. Some major institutions still classify on-farm research as not research but "demonstrations". While these objections provide clear warnings to on-farm research approaches, we would argue that replicated strip trials can be sub-set in such a fashion that experimental units are as uniform as any small plot experiment, with the benefit that on-farm research can capture heterogeneous treatment responses across landscapes, yield levels and soil types, providing even more relevance to farmers.

The chart below lists what we believe are the most important benefits and limitations for on-farm research.

Benefits	Limitations
<ul style="list-style-type: none"><li>• Farmers find on-farm research more credible.</li><li>• <b>Use Commercial Equipment.</b></li><li>• Insight into fertility by soil types and landscape position interactions.</li><li>• Sometimes less expensive compared to small plots.</li><li>• <u>Participatory Learning!</u></li></ul>	<ul style="list-style-type: none"><li>• Designs must be simple and fit into logistics of commercial operation.</li><li>• Analytics are different from small plot research.</li></ul>

While difficult to accept, much previous work has shown that farmers find results from on-farm research more credible than small-plot research from distant locations (Radatz, et. al, 2018; Baumgart-Getz et. al, 2012, Kyveryga, 2019). Farmers, being risk averse, want field-scale research results from their local geographies before they will implement improved practices. This does not imply that small-plot research is not an important aspect in the development of improved practices, but rather that small-plot research is not enough to drive adoption. On-farm research must be included as a companion or spoke of any program that seeks to drive adoption of improved practices.

A less appreciated advantage of on-farm research is that it utilizes commercial farming equipment. Over the past decade, farmers have made very large investments in planter, spraying, and harvesting technology. These investments usually far exceed small plot equipment at research stations providing more uniform stand establishment and treatment applications.

### ON-FARM EXPERIMENT DESIGNS

Much too common in the industry is the use of split-field comparisons as “on-farm research”. Split field designs are subject to sometimes extreme heterogeneity in experimental units due to different soils, landscape positions, pest incidence and base soil fertility. This heterogeneity in experimental units leads to spurious results and this practice should be discontinued immediately. The only exception being where it is logistically infeasible to conduct the experiment as a replicated strip trial and there are very competent statisticians available to mine the data.

In ISA research, we favor replicated strip trials where each treatment in the experiment is compared to the control in replicated strips across the field. In some cases, we use a “Two Blocks” design where the farmer will apply treatments to two large blocks in the field separated by untreated controls. This simplifies logistics for some tillage, manure, or cover crop experiments while maintaining more uniform experimental unit comparisons.



A growing on-farm research design is learning blocks where smaller experimental units are embedded in a variable rate application. The advantages of these learning block designs are that costs are reduced as the amount of land area dedicated to research is very much reduced. Further, it can sometimes be easier for a farmer to establish several treatments or rates compared to a replicated strip trial. However, in our experience in Iowa, it can sometimes be difficult to find enough land area in uniform soils or yield potential to set up uniform experimental units. Further, since so much of ISA efforts are to understand heterogeneous treatment responses, we prefer replicated strip trials whenever feasible.

## **DATA WRANGLING**

A potential pitfall in on-farm research is the amount of data wrangling required. Practitioners of on-farm research must be equipped with specialized GIS software to read and map as-applied, as-planted, and yield monitor data. This data usually has outliers, and this data must be removed to reduce systematic noise in the experiments. Opinions on best approaches for removal of outliers in on-farm research data vary tremendously among scientists. There is a tremendous need for standardization in approaches to removal of outliers, especially with yield monitor data. Something that ISA urges is for academic and industry scientists to develop generally accepted protocols for outlier detection and removal. In the ISA approach, we use crop images to identify areas in the field where confounding factors such as wind damage, flooding or lodging have impacted the strips non-uniformly. Other than this, we don't generally remove any data from the analysis unless the data is not in the range of the yield monitor calibration.

## **HETEROGENEOUS TREATMENT EFFECTS**

The promise of precision agriculture is that farmers can improve profitability and stewardship via variable rate applications of inputs at the sub-field level. To date, this promise has largely not been fully achieved. Limiting this promise has been a lack of understanding of where and what rate to apply inputs. Replicated strip trials and on-farm research will be very important to the future of crop production as it is able to differentiate heterogeneous treatment effects such as how soils, yield levels and landscape positions interact with fertilizer rates. The data science community is making large progress in developing approaches and computer codes to understand and predict heterogeneous treatment effects through cubist and causal forest analysis. We foresee step change advances in agronomic science via the combination of on-farm research combined with recent advances in statistics and computing.

Radatz et. al (2018)

1.

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