Who wants to be a Researcher? Getting Meaningful Results from On-Site Nursery Research Trials©

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INTRODUCTION

Many nursery growers have been conducting on-farm research trials for years, either independently in order to improve upon current production practices, or in cooperation with university, government or industry entities. By conducting research trials to answer specific questions, growers are able to develop real-world solutions based upon their specific needs at their location. Conducting a research trial in addition to managing normal nursery activities could seem like a daunting task. However, research trials can be designed and specifically tailored to meet a grower's needs in terms of time commitment, resources, space or any other constraint. The objectives of this paper are to outline the benefits of conducting on farm research, provide an overview of how to properly design research trials, and illustrate how to draw meaningful conclusions from research results.

WHAT IS ON-SITE NURSERY RESEARCH (OSNR)?

On-site nursery research (OSNR) is replicated, scientifically valid research conducted by growers - with or without the help of researchers. OSNR is more than applying a new practice to a portion of your crops to make side-by-side comparisons or treating a single block of plants with

a new herbicide to see how it performs. These types of activities would be classified as "demonstrations" which by definition are not valid experiments, but do offer value in observing how a new practice would work at your location. However, demonstrations do not have to be replicated or randomized, and do not sample the variation within a test area (Fishel, 2006; Veseth et al., 1999). It is not possible to make reliable comparisons using demonstrations only, so the best way to make management decisions would be to rely on well-designed research trials.

WHY CONDUCT ON-SITE NURSERY RESEARCH (OSNR)?

The purpose of conducting field research on nursery crops, or any crop for that matter, is primarily to try and help answer questions and solve production issues. Theoretically, applied nursery research is conducted on a small-scale in a somewhat controlled environment. One of the reasons most research is done on a smaller scale (besides funding limitations) is because smaller trials make it easier to reduce background "noise", which is also called experimental error. Background noise (or experimental error) are factors and variables that could influence trial results and may reduce or increase treatment effects such as: pest pressure, weather conditions, media, irrigation uniformity, or countless other factors. Treatment effects are evaluated under controlled conditions and then the results are used to predict outcomes on a larger scale.

Conducting your own research can also be used to confirm that research results and product claims are applicable to conditions and crops at your nursery (Nielsen, 2010). For example, a research report was published indicating that a new substrate amendment was shown to increase growth of *Hydrangea quercifolia* by 15% and reduce irrigation by 10% when added to pinebark and sand substrate. However, a nursery in a warmer climate may produce *Hydrangea microphylla* and use a substrate comprised of primarily pine bark and sphagnum peat moss. In this case, before implementing major, widespread change in your production practices, it would

be wise to conduct a small experiment to confirm that similar results can be achieved under your growing conditions or with different crops. The same would be true for field production nurseries as soil types can vary greatly from place to place. Overall, the major benefit of conducting research at your nursery to determine if a change in chemicals, substrates, growing methods, etc. is going to be effective for YOU – your crops, your environment, and your equipment.

PLANNING AND DESIGNING YOUR RESEARCH TRIAL

Research trials should follow a systematic approach – first, a question or hypothesis is developed that you need an answer to such as: Can I increase crop growth by using a different fertilizer ratio or timing? Can I apply this herbicide to my crops without causing phytotoxicity? Will this plant growth regulator increase flowering? Then the research trial is designed to answer the question/ hypothesis at hand and data is collected, recorded, and analyzed without bias. Before conducting a field experiment, it is best write down the answers to the following questions in order to make the experiment more valid and useful to you:

1. What are my objectives? (Reduce water use, increase crop growth or rooting percentage, utilize a new pesticide, etc.).
2. What is the best way to design the experiment so that my results are most useful?
3. What is the best/most efficient way to arrange my treatments and plots?
4. What variables exist that could impact trial results (pest pressure, differences in field soil characteristics, weather, etc.)?
5. What kind of data will be collected? How often?
6. How will I analyze and use the data?

Once you determine your objective, you would first select one or more treatments to evaluate in addition to a control treatment. In most cases the control treatment would be your normal production practice. A control treatment is used to compare alternative methods (your treatments) to your standard method. Without a control it is difficult to determine if the treatment performed better or worse than your standard method. The most straight forward research goal would be to answer simple yes/no questions such as "Is herbicide 'A' or herbicide 'B' safer to use on my crops?" In this case, a simple trial could be conducted and treatments may only consist of herbicide A vs. herbicide B vs. a control (no herbicide). Depending on available space, you may also choose to investigate various rates of both herbicides to determine optimal rates and margin of safety. If you wanted to determine the optimum rate of fertilizer or a rooting hormone on a certain crop, it would be wise to include a wide range of treatment levels (rates), including a control.

There are many different ways to properly design experiments, but all include the basic components of replication and randomization of treatments. Replication and randomization both function to decrease experimental error, or "noise" and make data valid. A replication could be a large portion of a container growing area or field - or a single container-grown plant. A replication within a trial would be considered an "experimental unit". If treatments in a trial are not replicated, the results are invalid. Without replication there is no way of knowing if a treatment caused an effect, if the effect was due to some other factor or if the results are a due to merely chance. The number of treatment replications you need will depend on the question you need answered and also the magnitude of the differences you want to uncover. Detecting only major differences will usually require fewer replications. The more replications you have the greater the confidence in your results. However, as the number of replications increase so does

time and expense. Often the number of replications will depend on available space, time, and resources. At least three or four replications are needed to be able to analyze the data, but 6, 8, 10 or more is preferred.

Randomization is needed for the same purpose, to reduce "noise". For example, if a field trial was designed with two treatments ('A' and 'B'), and all of the 'A' treatments were located on the west side of a nursery pad and all the 'B' treatments were located on the east side of a nursery pad, we could not be certain of treatment effects because all the treatments were grouped together (one treatment may have received more water, sunlight, pest pressure, etc.). By replicating and randomizing, we can be more certain of trial results.

EXPERIMENTAL DESIGNS

The simplest design is the completely randomized design (CRD). In a CRD, treatments (and controls) are assigned completely at random to a previously determined set of experimental units (plants, field plots, etc.). For example, if someone wanted to test 4 treatments (A, B, C, D) and a control (E) a completely randomized design could be set up (Figure 1). Completely randomized designs might be useful in testing a large number of treatments. A CRD is also appropriate when plant material is uniform and the environmental conditions are similar across the entire experimental area (such as in a greenhouse). While CRD are simple, they can create more "noise" than other types of designs, especially if it is conducted in nursery field soils (due to variability) or if there are differences in experimental units (plant size, health, etc.). In those cases, a randomized block design may be yield better results.

A randomized complete block design (RCBD) is used to account for natural variability among treatments that might impact treatment differences. In RCBD, treatments are assigned at random to a group of plots (called blocks). Each block will contain one replication of each treatment

(Figure 2). This design is useful in the field or if there is a lot of variability among plants used as experimental units. For example, if part of a field was poorly drained, plants in a research trial might also grow poorly which would impact trial results. One way to alleviate this issue would be to place a "block" of treatments in that area so that one replication of all treatments was in the poorly drained area (in addition to having other replications in more favorable areas). Another scenario where blocking would be useful is in an experiment that test the impact of a pesticide on crop growth, but your experimental units (plants) were not of uniform size. In this case, you could "block" the largest plants together and then have subsequent blocks of plants of similar sizes. Blocking according to plant size insures groups of plants with similar sizes received all treatments. There are several other ways to design experiments including split-plot designs, split-block designs, Latin square designs, and factorial designs, all with advantages and disadvantages. The easiest way to determine which type of design is best for your needs is to consult with university researchers, county extension agents, or others who conduct research regularly.

ELIMINATING VARIABILITY

It is important to eliminate as many factors as possible that could influence trial results. Often times in weed science, we test different herbicides at different rates to determine if the herbicide causing injury or growth reduction to an ornamental plant. When controls are included, they usually receive no herbicide – and consequently may be filled with weeds within a few weeks which could impact crop growth, and thus trial results. A way to reduce this noise would be to regularly hand pull weeds from the controls so that any growth reduction could be attributed to the herbicide treatment, not weed competition. Treat all treatments as similarly as possible. If you had to move some plants from a shade house or greenhouse in order to treat them, move the controls also and not just the ones you are going to treat. Noise can be reduced by using the

correct experimental design, using adequate number of replications, carefully selecting experimental units, and by treating all treatments as uniformly as possible.

DATA COLLECTION AND NOTE TAKING

Growth (height and width, caliper, etc.), flowering, substrate pH/EC, weed counts, and rooting percentage would all be forms of quantitative data – data that is measurable and recordable. Qualitative data, such as injury/phytotoxicity ratings, health ratings, or marketability ratings is subjective but can also be very valuable. The data that needs to be collected, and how often it needs to be collected will depend on the questions you need answered and what you are trying to achieve with the trial.

In addition to collecting data at set intervals, taking plenty of notes throughout the trial is invaluable. Pest pressure, unusual weather patterns, field operations, and other factors that could influence trial results should be documented throughout the trial. Regularly monitoring the trial would be ideal as you could correct any issues that may occur before they ruin the trial.

DATA ANALYSIS

Eliminating background "noise" or experimental error entirely is impossible, but statistical analysis allows us to identify background noise so we can more clearly detect these factors and better determine true treatment differences. The easiest way to analyze data would be to compare averages across treatments using a program like Excel®. Statistical packages are available but are complicated, expensive and can take years to master. Some statistical software packages are available online for free, but are also difficult to use. A professional analysis using statistical software will provide you with more reliable results. Most university and extension personnel are happy and willing to collaborate with you on your trial and typically have access to statistical software. Most ONSR trials can be analyzed fairly quickly.

Is it always necessary to analyze your data statistically? Maybe not depending on your needs and the trial results. If your trial was properly designed and one treatment consistently outperformed the others in terms of size, flowering, or other parameter important to you, there is a good chance your results were statistically significant and you will know which treatment was most effective. Analyzing the data statistically just helps you to make your conclusion with more certainty. However, it should be noted here that poorly designed trials cannot be saved by statistics. If you are unsure if your design is going to provide useful results, do not hesitate to ask for help.

USING THE DATA

Before wide-scale recommendations are made, researchers typically repeat studies several times at different locations to validate results. OSNR is slightly different because these results are specific to your own situation. Repeating OSNR may be necessary if results are inconclusive due to unknown factors or noise. Repeating experiments may also provide further validation of previous results. Further validation is always important before making major and potentially costly production changes. Repeating trials may be limited due to time and resources.

CONCLUSION

Conducting OSNR can be enjoyable part of the nursery management process and may lead to significant improvements at your nursery. It can also be a time consuming, difficult (and possibly expensive) process. Do not hesitate to contact your local extension office or state extension specialist to ask for guidance. Most will be more than happy to assist you in any way possible and the process can be mutually beneficial.

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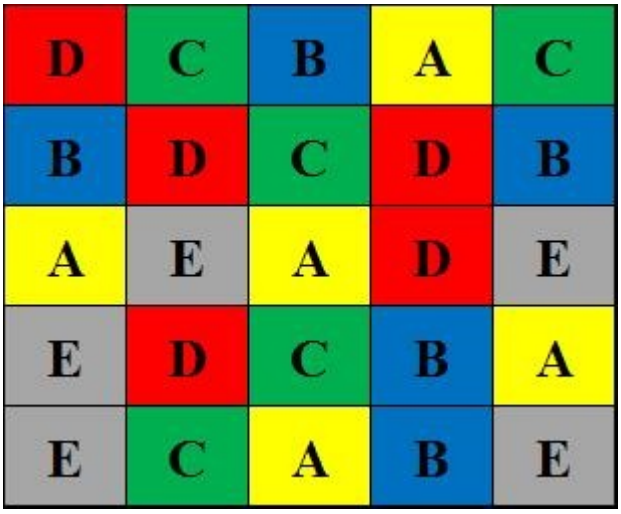
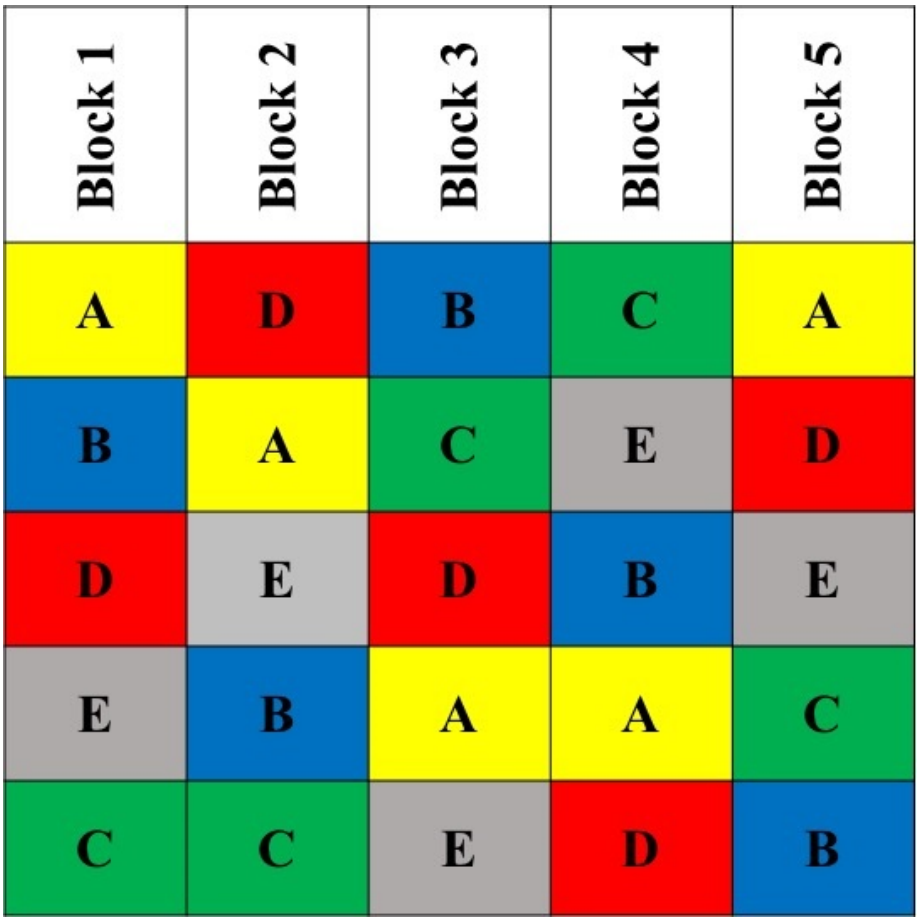


Fig. 1. A completely randomized trial with four treatments (A, B, C, D) and a control treatment (E). Each treatment is replicated five times and treatments and controls are assigned at random.



Block 1	Block 2	Block 3	Block 4	Block 5
A	D	B	C	A
B	A	C	E	D
D	E	D	B	E
E	B	A	A	C
C	C	E	D	B

Fig. 2. A completely randomized block design with four treatments (A, B, C, D) and a control treatment (E). Each of the five blocks contains one replication of each treatment and treatments are randomly assigned within each block.