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Research and Extension

Establishing On-Farm Demonstration and Research Plots

On-farm trials are important agricultural decision tools implemented in real-world conditions using farmers' fields for a better and more practical understanding of soil and crop management practices.

On-farm trials can be used for demonstration, such as a wheat variety plot that is not replicated. With proper replication and experimental design to allow statistical analysis, these trials can be used for research. When appropriate, replicated research trials, whether large strips or small plots, can be used for data collection and demonstration purposes. At least three replications should be included in a field for a research trial, with treatments placed randomly among the plots in each replication. Table 1 presents an example of this randomization.

The placement of treatments in plots or strips should account for variability in the field, such that no treatment has an advantage or disadvantage in each replication. K-State Research and Extension personnel can guide plot layout and treatment randomization. Such applied research and demonstration plots are usually designed to compare the performance of two or more agronomic practices, such as seeding rate, pesticide application, variety comparison, fertilizer sources, and different management practices, such as cover crop and tillage.

Figure 1. Three potential randomizations for an on-farm trial with two treatments and three replications. Additional visualizations of plot placement in fields are shown in Figures 1 through 4.

	Plot 1	Plot 2
Replication 1	Treatment A	Treatment B
Replication 2	Treatment B	Treatment A
Replication 3	Treatment A	Treatment B

	Plot 1	Plot 2
Replication 1	Treatment A	Treatment B
Replication 2	Treatment A	Treatment B
Replication 3	Treatment B	Treatment A

	Plot 1	Plot 2
Replication 1	Treatment A	Treatment B
Replication 2	Treatment A	Treatment B
Replication 3	Treatment A	Treatment B

When thoughtfully designed, on-farm plots provide useful, local data. The following guidelines are intended to help define treatments, work with existing in-field variability, and maintain records so the trial is successful and results are reliable.

Treatment Selection

The first step of implementing successful on-farm plots is identifying the question to be addressed and then clearly defining the purpose or objectives to address. An objective can be as simple as comparing yield differences between susceptible wheat variety A and resistant variety B. Objectives should be determined well before necessary field operations to secure the best locations and supplies.

The two practices to be compared are considered treatments. Select treatments that can be directly compared to one another. For example, comparisons could be made between conventional tillage with no-tillage, "commonly known" variety A against "recently released" variety B, or deep placement versus broadcast fertilizer placement. Treatments should vary enough to detect differences by measuring yield or another measurable variable. This means that the change in yield expected from the treatment should be greater than the change in yield that is expected due to natural variability across the field. A difference of 1 or 2 bushels per acre between treatments may not represent a true yield advantage. If a small yield advantage of treatment is observed over several locations or years, more confidence can be placed in that treatment.

Yield differences should be due only to treatments under study. Thus, to avoid confounding effects, it is important to ensure that all other production inputs are the same across all treatments. The comparison is not valid if all treatments have different production inputs such as fertilizer placement, variety or hybrid, or planting date and rate. Observed differences may not be due to the treatments, and conclusions cannot be made.

Plot Design

The sole purpose for establishing demonstration plots is to present visual differences between two or more treatments. Non-replicated demonstration plots are not used for research.

Many producers and most seed companies use check strips beside each entry in variety demonstration plots to measure field variability. Treatments are not replicated with this method, but a standard treatment, such as a common variety, is placed on each side of one or two new varieties (Table 2 and Figure 1). The use of check strips is different than replicating all treatments as with research plots, but it accounts for some of the variability in field conditions.

Plot size will most likely be determined by field length and the practicality of carrying out any special treatment over a large area. Plots should be long enough to allow field equipment to equilibrate but short enough to accommodate each treatment within a reasonably uniform tract of land (See "Crop and Field History" below). The width of equipment used to apply treatments (planter, sprayer, etc.) must be a factor in determining plot width. Plot lengths should be at least 30 feet but could be as long as the entire field. Plots should be large enough that a sample that reflects the treatment area can be collected but not so large that harvesting is difficult.

Since there will be at least two treatments in a demonstration test field, the position of the treatments within the field should be considered. Select a uniform field to ensure that differences are not due to uncontrollable factors. Avoid areas with drainage problems, different soil depths and textures, variable topography, nonuniform weed infestations, border influences such as trees or windbreaks, runoff from neighboring fields, lack of fencing from animals, and other variables. The county soil survey is a valuable aid in assessing soil variability.

If the field is uniform, simply arrange treatments to accommodate easy evaluation of each. If the field slopes in one direction, arrange treatment plots with the slope (Figure 2). If the field has two different soil types or conditions, arrange the plots at right angles to these conditions (Figure 3). Harvesting the whole area is appropriate only if the different soil conditions exist to the same extent across treatments and replications. If nonuniform areas exist, treatment observations and yield measurements should be random from the most uniform areas of similar soil conditions within each plot (Figure 4). For example, grain yield in a sandy soil area in treatment A would likely be different than yield from a silt loam area in treatment B. Thus, yield comparisons must be based on data from areas of similar soil texture.

Table 2. Example of using multiple check strips to measure field variability.

Check Strip 1	Treatment A
Strip 2	Treatment B
Strip 3	Treatment C
Check Strip 4	Treatment A
Strip 5	Treatment D
Strip 6	Treatment E
Check Strip 7	Treatment A
Strip 8	Treatment F
Strip 9	Treatment G
Check Strip 10	Treatment A

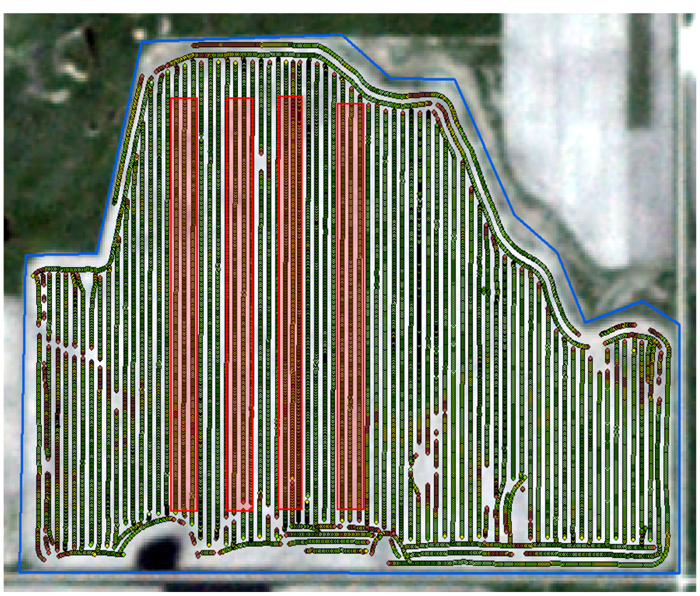


Figure 1. A typical on-farm field trial with four replications of a treatment. A check treatment is placed between each replication for comparison.

Recording Field Information

Create a map of the field showing soil variability, tree lines, terraces, topography, plot location within the field, and intended and actual harvest locations. Precision agriculture equipment and the data it records can generate a

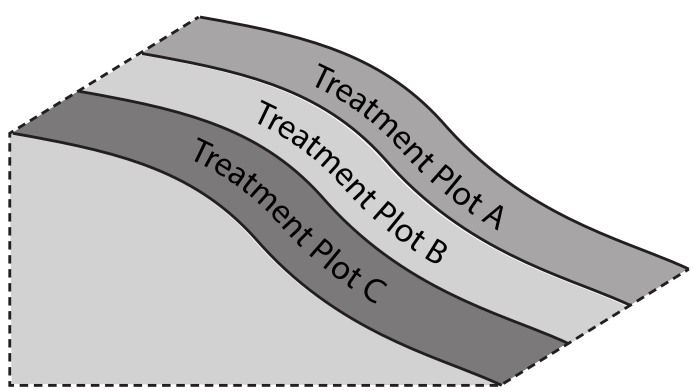


Figure 2. Example of treatments or replications planted with the field slope.

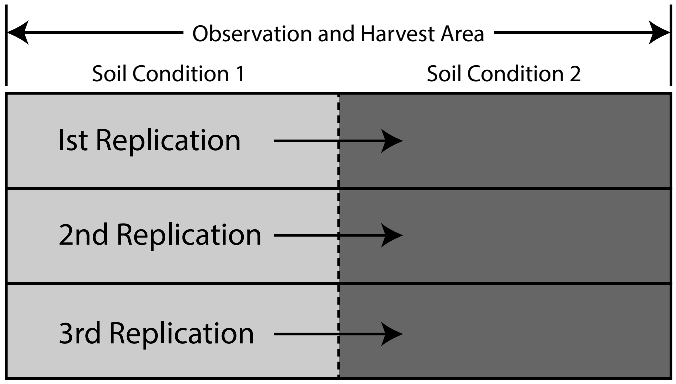


Figure 3. Example of treatments planted perpendicular to the direction of two soil conditions. Observations and harvest samples can be taken from multiple soil conditions, provided the conditions occur throughout a replication.

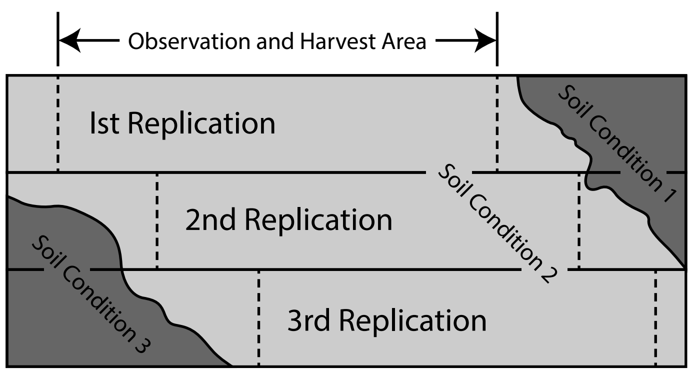


Figure 4. Example of treatments planted across three soil conditions. Observations and harvest samples should be taken from similar areas in the most uniform soil conditions. The harvest area is shown between the dotted lines in each replication.

substantial amount of this information; however, sensors in the equipment should be well calibrated, and data recorded must be downloaded from the monitor for storage and analysis. All field information and observations should be stored in one location for easy access when it is time to analyze the results.

Previous soil and crop management practices can cause field variability and influence treatment response. If possible, record crop history for at least the last three to five years. Note previous crops, crop rotations, fertility programs, and pesticide applications. Old soil test reports can be useful sources for this information. Also, indicate any differences in primary tillage operations. Locate the plots within an area of the field with a uniform management history.

Separate soil samples from each treatment area are valuable when establishing uniformity between treatment areas. Follow prescribed procedures to sample soils from the plot area and send the composite sample to a reputable laboratory for analysis. Record soil test results and soil series of the plot area on a worksheet (see example at the end of this document).

Planting conditions are critical to the interpretation of results involving crop growth. Record preplant (fall or spring) tillage practices and the extent of residue cover from the previous crop. Also, record the seeding rate/date, row spacing, hybrid, planting depth, soil moisture, and soil surface conditions. List the sources and rates of fertilizers and pesticides as well as the application methods. Also, indicate any other production inputs used during planting and equipment used.

Growing Season Observations

Detailed data are desirable. The most important observations are factors influenced by the treatments applied. For example, note the difference in emergence or date of heading between conventional and zero-tilled plots in a tillage comparison test.

Observe weather conditions during the growing season. Place a simple rain gauge at the test site. After each rain, record the rainfall with the date and empty the gauge. Record how the crop in each treatment responds to weather conditions such as freeze, rain, or drought. Other weather variables can be downloaded from the closest weather station. Check *https://mesonet.k-state.edu* for more weather-related information.

Take note of any weeds, insects, or diseases present. Record the date of infestation and extent of damage and note any differences between treatments due to the pests. If comparing pesticide treatments, record more detailed data to evaluate the differences between treatments.

Record various growth characteristics of the crop from germination to harvest. Various precision agriculture technologies, such as drone-collected imagery at different crop growth stages, can also be used as non-destructive methods to scout and understand crop growth patterns. For example, drone imagery collected before planting can help assess soil characteristics such as soil moisture, organic matter, nutrients, minerals, and crop residue variability within the field. Similarly, imagery collected after seed germination can provide information on seed emergence and stand count. The drone image collected during the mid-growth stage can map weeds or disease presence in the field. In the same way, drone imagery collected at the late maturity stage can be used to estimate crop maturity and yield. Overall, the following growth parameters are recommended for observation, but your particular objectives may require other observations:

1. Date of emergence and/or spring green-up (small grains)
2. Extent of tillering, grazing potential (small grains)

3. Height at 4- to 8-leaf stage (coarse grains and legumes)
4. Plant population
5. Dates of percentage of canopy coverage
6. Any abnormal growth, such as nutrient deficiency, herbicide injury, etc.
7. Any weeds, diseases, or insects
8. Date and plant height at silking, heading, or flowering
9. Date of maturity
10. Cutting dates (forages)
11. Lodging
12. Grain moisture and test weight at harvest
13. Yield of grain or forage

Yield estimates are the only means of making total production and economic comparisons between treatments. For validity, take them from comparable areas in each plot to avoid unequal effects of soil variability. If nonuniform areas exist in the plot, only harvest the areas that are the same size with similar soil conditions in each treatment. Several soil conditions may be included, provided they occur to the same extent in each treatment (see Figure 3).

Machine harvesting the center of each treatment reduces border effects. Combine yield monitors, if properly calibrated, can provide reasonable estimates of grain yield; however, an accurate measure of grain weight should be recorded for each plot using a weigh wagon or farm scale. Determine the moisture content at harvest from a sample for each treatment. If machine harvesting is not possible, hand harvest the same length of two or more rows at two locations in each treatment. Again, make sure the harvest area covers similar soil conditions. Grain yield in bushels per acre can be calculated using this formula:

$$\text{bushels per acre} = \frac{GW}{TW} \times \frac{100 - GM}{100 - SGM}$$

GW is grain weight per acre, calculated from the pounds of grain removed from the plot area. TW is the official grain test weight expressed as pounds of grain per bushel. GM is the grain moisture content at harvest, expressed as a percent. SGM is the standard grain moisture content. TW and SGM for common Kansas crops are listed below.

Crop	TW	SGM
Wheat	60	12.5
Grain Sorghum	56	14.0
Soybean	60	13.0
Corn	56	15.5

Thus, GW = (pounds of grain × 43,560 sq ft per acre) ÷ plot area in square feet. If a harvested treatment or plot area were 500 feet long and 20 feet wide, the plot area would be 500 × 20 = 10,000 square feet. If 551 pounds of wheat grain were harvested at 14% moisture, GW = (551 × 43,560) ÷ 10,000 = 2,400 pounds of grain per acre at 14% moisture.

In the above example, the bushels per acre of wheat, if the moisture were 14% at harvest, would be:

$$\text{bushels/acre} = \frac{2{,}400}{60} \times \frac{100 - 14}{100 - 12.5} = 39.3 \text{ bushels per acre}$$

Data Sheets

Keep data sheets for all plot work, including as much of the above information as possible. An example worksheet is included at the end of this publication. Keep separate records for all locations. Differences in results between locations may be explained by the variability in weather, soils, planting conditions, pests, or any previously discussed parameters. Contact your local extension agent or specialists for assistance in organizing data sheets.

Summary

The value of research or demonstration plots increases with these guidelines. Increasing the number of locations within a geographic area to allow observations of treatment effects under several environments will increase the usefulness of the data through more precise and reliable comparisons.

Demonstration Plot Worksheet Before and In Season

Project Title:______________________________________

Project Objective:__________________________________

Treatments: ______________________________________

Replication	Treatment	Emergence Date	Plants/ row ft						

Planting and Cultural Practices

Planting date: ___________________________________

Tillage: ____

Variety/Hybrid: __________________________________

Seeding rate: ____________________________________

Soil conditions at planting: _________________________

Residue cover at planting:__________________________

Planting depth: ___________________________________

Type of planter: __________________________________

Fertilizer rates, dates: ____

Fertilizer source and application method: ____

Herbicides, rates, dates applied: ____

Fungicide rates, dates applied: ____

Insecticide rates, dates applied:____

Irrigation dates, amounts: ____

Precipitation dates, amounts: ____

Other comments: ____

Demonstration Plot Worksheet End Season

Plot/Treatment Number	Harvest Date	Harvest Method	Plot Length	Plot Width	Harvested Length	Harvested Width	Number of Harvested Rows	Harvest Population	Harvest Moisture	Harvest Weight
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

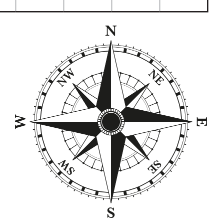
Cropping History

Previous crops (last 5 years)	Fertilizers		Chemicals		Other
	Rate	Source	Type	Rate	
1					
2					
3					
4					
5					

Plot Diagram

Scale: ¼ inch = ______________________________

GPS coordinates of plot 101 (front, left) __________



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