ESTABLISHING ON-FARM DEMONSTRATION AND RESEARCH PLOTS

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INTRODUCTION

Farmers, Extension and industry personnel, and researchers have a common interest in on-farm demonstration and research plots for studying various soil and crop management practices. Demonstration and research plots usually are designed to compare differences in tillage methods, herbicide treatments, varieties or hybrids, fertilizer sources or rates, methods of chemical application, and other crop production inputs.

Properly designed plots can satisfy wide interests, and conceivably yield more useful information, if planners consider the guidelines that follow. These guidelines are for establishing on-farm demonstration or research plots, recording site characteristics and observations, and evaluating results. Depending on treatments or management practices, all or some of these guidelines should be considered.

TREATMENT SELECTION AND PLOT DESIGN

Define clearly in advance of actual field work the purpose or objective of the on-farm plots. An objective can be as simple as comparing yield differences between soil-borne mosaic susceptible wheat variety A and resistant variety B.

Select treatments which represent a specific practice or principle, such as a standard compared to a new practice. For example, one could compare conventional tillage with no-tillage, or common variety A with "new" variety B, or deep placement with broadcast placement of fertilizer. Treatments should vary enough to detect differences visually and/or by measuring yield. For example, observing a visual or yield response between 40 and 50 pounds of nitrogen per acre may not be possible. The difference between 0 and 40 pounds of nitrogen per acre, however, may be more obvious.

Some comparisons of treatments may result in little or no difference. When this occurs, it is difficult to conclude which treatment is superior. A difference of one or two bushels per acre between treatments does not represent a true yield advantage. If the small yield advantage of a treatment continues for several years, more confidence can be placed on that treatment.

Visual or yield differences should be due only to treatments under study. It is important to ensure that all other production inputs are the same across all treatments. If production inputs such as fertilizer placement, the variety or hybrid, and planting date and rate are not the same for all treatments, the comparison is not valid. Observed differences may not be due to the treatments.

Usually the sole purpose for establishing demonstration plots is visual observation of differences between two or more treatments. However, to collect meaningful measurements of differences between treatments, replication is necessary. Replication is used to increase precision in identifying treatment differences. It allows a statistical analysis of field variation. This analysis will help determine whether detected differences in treatments are real or due to random chance. In some cases, different farms can serve as replicates or a producer can use several replications of each treatment on a single farm. The number of replications necessary depends on the number of farms in the demonstration. For example, with 5 to 10 farms two replications are adequate, but with fewer farms, 3 to 6 replications are recommended. If only one farm is used, a minimum of 4 replications is necessary. Treatments within each replication must be randomized. Figure 1 shows examples of randomizing two treatments in three replications. Randomization within each replication prevents one treatment from being favored.

The concepts of replication and randomization are important considerations in establishing strip tests requiring more precision. Randomization involves advance planning and may require a small amount of extra work for the producer. Contact research and Extension personnel for assistance.

Many producers and most seed companies use check strips beside each treatment 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. In Figure 2, for example, Variety A is the check variety and is on both sides of pairs of new varieties—varieties B and C, D and E, and F and G.

Treatments

	1	2	3	4	5	6
PLOT 1	A	A	A	B	B	B
1st Replication	B	B	B	A	A	A
PLOT 2	B	A	A	A	B	B
2nd Replication	A	B	B	B	A	A
PLOT 3	A	A	B	A	A	B
3rd Replication	B	B	A	B	B	A

Figure 1. An example of treatment replication and randomization. There are six possible randomizations using two treatments and three replications.

These check strips are used to adjust the yields of the new varieties for productivity gradients across the field. The average of all check strips is determined, as well as the average of each pair of check strips. The average of all check strips is divided by the average of the first pair of check strips. To adjust the yield, that number is then multiplied by the yield of the new varieties between the first pair of check strips.

For example, the average of all check strips for variety A is 56 bu/a [(50 + 52 + 58 + 64) ÷ 4 = 56] and the average of the first pair of check strips is 51 bu/a [(50 + 52) = 102 ÷ 2 = 51]. The overall average of variety A is divided by the average of the first pair of check strips of Variety A (56 ÷ 51 = 1.09); and 1.09 is multiplied by Variety B (1.09 X 54 = 58.9 bu) and Variety C (1.09 X 53 = 57.8 bu) to adjust their yields. Repeat with each pair of treatments across the demonstration plot.

Use of check strips is not the same as replicating all treatments as with research plots, but it accounts for some of the variability in field conditions.

Plot size most likely will be determined by field length and practicality of carrying out any special treatment over a large area. Limit the plot length to accommodate each of the treatments within a reasonably uniform tract of land (See “Crop and Field History” below). Width of equipment used to apply treatments (planter, sprayer, etc.) is a factor in determining plot width.

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

If the field is uniform, simply arrange treatments to accommodate easy observation of each. If the field slopes in one direction, arrange treatment plots with the slope (Figure 3). If the field has two different soil types or conditions, arrange the plots at right angles to these conditions (Figure 4). Harvesting the whole area is appropriate only if the different soil conditions exist to the same extent across treatments and replications. If non-uniform areas exist, treatment observations and yield measurements should be random from the most uniform areas of similar soil condition within each plot (Figure 5).

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. Provide a sketch of the field showing soil variability, tree lines, terraces, topography, plot location within the field, and intended and actual harvest locations.

Separate soil samples from each treatment area would be valuable in 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 the worksheet below. Unless fertilizer rates are the treatments, apply uniform fertilizer rates across the treatment area.

Check Strip 1	**Treatment A**	**50 BU/A**
Strip 2	**Treatment B**	**54 BU/A**
Strip 3	**Treatment C**	**53 BU/A**
Check Strip 4	**Treatment A**	**52 BU/A**
Strip 5	**Treatment D**	**55 BU/A**
Strip 6	**Treatment E**	**58 BU/A**
Check Strip 7	**Treatment A**	**58 BU/A**
Strip 8	**Treatment F**	**60 BU/A**
Strip 9	**Treatment G**	**62 BU/A**
Check Strip 10	**Treatment A**	**64 BU/A**

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

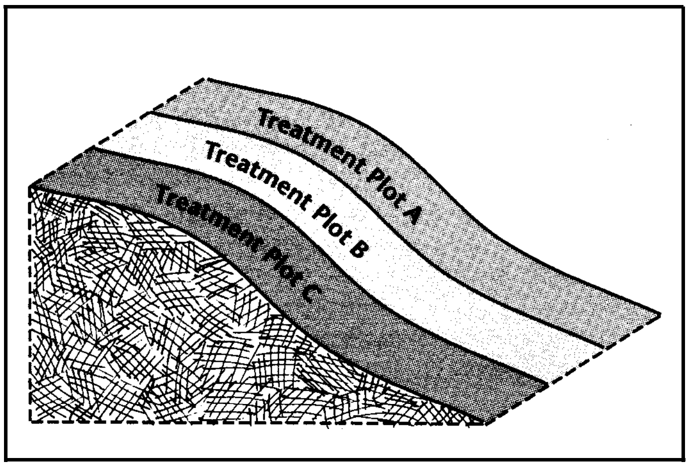

Figure 3. Example of treatments or replications planted with the field slope.

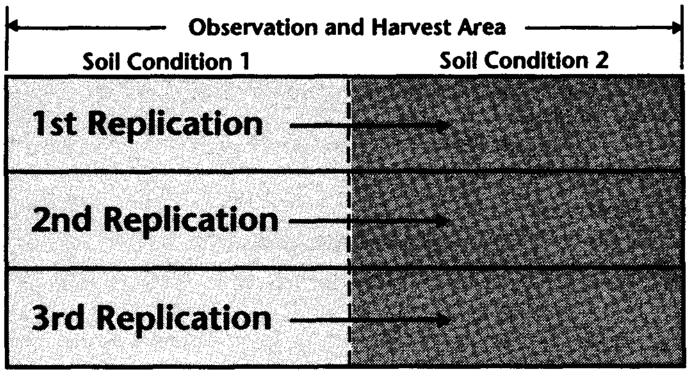

Figure 4. Example of treatments planted perpendicular to direction of two soil conditions. Observations and harvest samples can be taken from both soil conditions provided the two occur across all treatments or replications sufficient to allow observations.

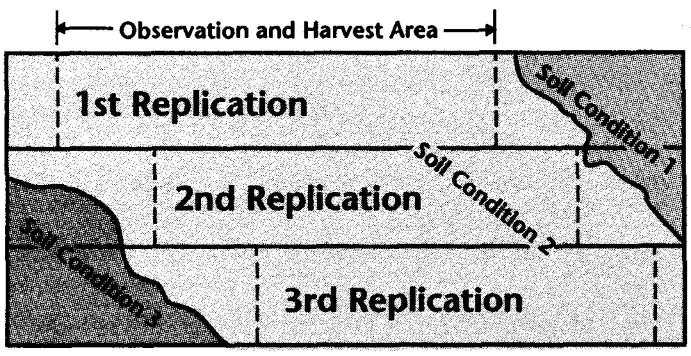

Figure 5. Example of treatments planted across three soil conditions. Observations and harvest samples should be taken from similar areas in the most uniform soil condition. Harvest area is shown between the dotted lines in each replication.

Planting conditions are critical to 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 and the methods of application. Also indicate any other production inputs used at the time of planting and equipment used.

CROP AND FIELD HISTORY

Previous soil and crop management practices can cause field variability and influence treatment response. If possible, record crop history for at least the last 3 to 5 years. Note previous crops, crop rotations, and fertility programs. Old soil test reports can be useful sources for this information. Also indicate any differences in primary tillage operations. Locate the plots on a field with a similar management history.

GROWING SEASON OBSERVATIONS

Observe weather conditions during the growing season. Place a simple rain gauge at the test site. After each rain, record the rainfall (in inches or centimeters) with the date and empty the gauge. Note rainfall effects on soil erosion. If drought conditions persist, note the difference in plant growth or response between treatments. For example, grain sorghum leaves will curl and/or turn pale green under drought stress. Note any differences between treatments in this curling effect.

Observations of the insects and diseases present, date of infestation, and extent of damage are sufficient if these infestations do not interfere with treatment effects. Record similar observations for persistent weeds and note any differences between treatments due to the pests. If comparing herbicide treatments, record more detailed data to evaluate the differences between treatments.

Record various growth characteristics of the crop from germination to harvest. The following observation points are recommended:

1) Date of emergence 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) Any deficiency symptoms, diseases or insects (i.e., chlorosis, etc.)
5) Date of silking, heading or flowering (also plant height)
6) Date of maturity
7) Lodging
8) Plant population
9) Grain moisture at harvest
10) Grain yield

Detailed data are desirable, but not necessary. Observations should be relative to the treatments applied. For example, the farmer might note the difference in emergence or date of heading between conventional and zero-tilled plots in a tillage comparison test.

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 the plot area is uniform, the entire plot

Demonstration Plot Worksheet

Name ______________________________ Field location ______________________________

Address ______________________________

______________________________ T ________ R ________ SEC ________ ¼ ________

Study objectives ______________________________

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Site Characteristics

Soil series ______________________________ Soil Texture ______________________________

Soil test: Nitrogen ____________________ pH ____________________

Phosphorus ____________________ Organic matter ____________________

Potassium ____________________ Micro-nutrients ____________________

Sample depth (inches) ____________________

Cropping History

Previous crops (last 5 years)	**Fertilizers**		**Chemicals**		**Other**
	rate	source	type	rate	
1					
2					
3					
4					
5					

Climatic Conditions

Month	**Moisture**		**Temperature**	**Month**	**Moisture**		**Temperature**
	Rain	Irrig.	days above 90°		Rain	Irrig.	days above 90°
January				July			
February				August			
March				September			
April				October			
May				November			
June				December			

Planting and Cultural Practices

Preplant tillage ______________________________

Soil conditions at planting ______________________________

Residue cover at planting (%) ____________________ Planting depth ____________________

Planting date ____________________ Planting rate ____________________

Variety/hybrid ____________________ Plant population ____________________

Type of planter ____________________ Plants/row ft. ____________________

Fertilizer rates, dates, source ______________________________

Method of application ______________________________

Topdressing fertilizers: rates, dates, source ______________________________

Manure ______________________________

Herbicides/insecticides: rate and compound ______________________________

Method of application ____________________ Dates applied ____________________

Cultivation dates ______________________________

Other practices ______________________________

Other comments ______________________________

____

Demonstration Plot Worksheet

List of treatments	Emergence	Heading/Flowering		Harvest	Yield	Other
	Date	Date	Height	Height		
1						
2						
3						
4						
5						
6						

Plot Description

Plot length ____________________

Plot width ____________________

Number of rows ____________________

Harvest date ____________________

Grain moisture ____________________

Harvest weight ____________________

Harvested length ____________________

Harvested width ____________________

No. of rows harvested ____________________

Harvest population ____________________

Method of harvest ____________________

Harvest date ____________________

Plot Diagram

can be harvested for yield. If non-uniform areas exist in the plot, harvest only 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 5).

Machine harvesting the middle rows from each treatment to determine yields of row crops reduces a border effect. Harvest whole plots or representative areas of small grain cereals and grass plots to determine yields. Measure grain weight in a weigh wagon or on a 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 simple formula:

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

GW is grain weight per acre, which is 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 in 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 X 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 X 20 = 10,000 square feet. If 551 pounds of wheat grain were harvested at 14 percent moisture, GW = (551 X 43,560) ÷ 10,000 = 2,400 pounds grain per acre at 14 percent moisture.

In the above example, the bushels per acre of wheat if the moisture were 14 percent 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. Keep records for all locations. Differences in results between locations may be explained by the variability in weather, soils, planting conditions, pests, or any of the parameters previously discussed. Contact your Extension agent or specialists for assistance in organizing data sheets.

SUMMARY

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

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