Conducting Successful Field Demonstrations and Research Plots
Michigan State University Extension Service
R.H. Leep, V. W. Meints, Crop and Soil Sciences
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# CONDUCTING SUCCESSFUL FIELD DEMONSTRATION AND RESEARCH PLOTS

By
R. H. Leep & V. W. Meints
*Department of Crop and Soil Sciences*

## INTRODUCTION

This Ag Fact Sheet answers questions from extension field staff and commercial agronomists about conducting field demonstrations and research plots.

The field demonstration is one of the most useful and productive teaching methods. It generally aims at demonstrating the positive results of research and is especially appropriate in showing growers the value of new varieties or alternative cultural practices. Most demonstrations involve a result which can be seen.

The objective of this bulletin is to outline the principles involved in designing and conducting successful demonstration and research plots. The first part deals with demonstrations, the second with additional considerations for conducting field research. We encourage anyone interested in conducting demonstration or research plots to contact a state Extension specialist or researcher in the appropriate subject matter area for assistance before establishing plots.

Research aims at learning something new or adding to knowledge. Because of natural variation within the plot area, special techniques are used in research plots to prevent errors in conclusions. These include replication, randomization and blocking.

Replication is the repetition of a treatment, usually three or more times, within the experimental area. It reduces the differences in yield which may be attributed to natural variation in soils, plants and environmental factors.

Randomization is the random placement of treatments within the experimental area or within a block in contrast to placement of treatments in some biased order such as increasing rates next to each other.

Blocking is the grouping of all treatments of a replication into a part of the experimental area. The object of blocking is to have the plots within a block as uniform as possible so that observed differences will be largely due to different treatments. In many experimental designs the terms block and replication have the same meaning.

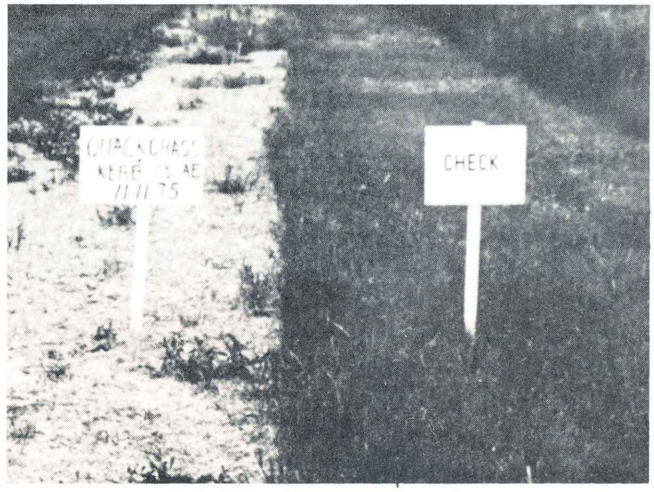
Replication, randomization and blocking permit use of statistical analysis to calculate the probability that treatment differences are real (statistically significant) rather than simply due to chance or random variation. Consider the yields in Table 1 obtained in a uniform trial to measure the natural variation within an experimental area before putting out variety trials. The experimental area was divided into blocks and plots as if different varieties were being compared, but actually only one variety was planted across the entire area. If the entire experiment consisted of one replication (block I) or even if we had two replications (blocks I and II), we might wrongly conclude that variety I was superior to variety II. But looking at the variability between the four blocks of each variety and the average for each variety, we can see that there is no significant difference in yield between the two.


**Research plots can frequently be used for demonstration.**

**Table 1. Yields (bu/A) obtained in a uniformity trial. To illustrate the natural variability in the experimental site, false "variety" designations were assigned to the plot within the trial.[1]**

| | False Wheat Variety I | False Wheat Variety II |
|---|---|---|
| Block I | 75.6 | 70.6 |
| Block II | 76.9 | 74.9 |
| Block III | 77.1 | 83.6 |
| Block IV | 66.8 | 71.3 |
| Variety Average | 74.1 | 75.1 |

[1]From Swearingin, M. L. and D. A. Holt. 1976. Journal of Agronomic Education 5:3-8.




**Label plots with appropriate signs.**

## DEMONSTRATION PLOTS

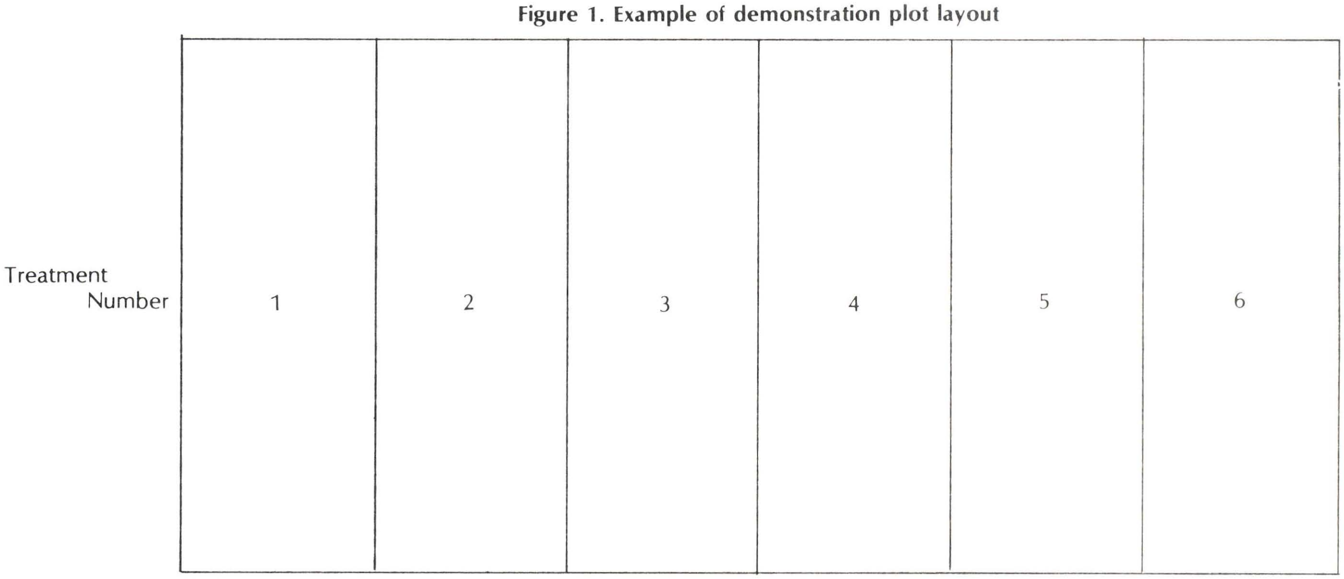
**Plan Ahead.** Field plots should be set up to demonstrate specific principles, so set up objectives well ahead of time. Plan in detail, making arrangements for plot location, equipment, seed, fertilizer, herbicides and pesticides. Provide all cooperators with detailed plot plans. The responsibility of each person should be clearly defined and written down to avoid any misunderstanding. Plan to mark all plots, and outline when various operations and observations are to be made so plots are not prematurely plowed, cultivated or harvested.

**Location.** Select a field which will allow good production with soils uniform in type and topography. The plots do not necessarily need to be restricted to flat land. Use soil maps, soil tests and past field history before deciding on a site. Locate plots across tile lines and not parallel or between them. The field should be accessible, preferably along a well-traveled road.

**Plot Size.** Demonstrations will vary in size depending upon available planting and harvesting equipment and space. If space is available, the following plot sizes should serve as a general guide. Small grain demonstration plots might be 1 drill width wide by 30 feet long, row crop plots 4 or 6 rows wide by 30 feet long and forage plots 10 to 15 feet wide by 30 feet long. The plots should be laid out to facilitate easy planting and harvesting.

Figure 1 shows how a demonstration plot can be laid out. The treatments might be varieties or herbicide treatments. Perhaps one or more of the treatments might be a combination of chemical and mechanical weed con-

**Figure 1. Example of demonstration plot layout**




Variety or treatments - 1, 2, 3, 4, 5, 6.

trol. The size of each plot is not critical as long as soil and environmental variability are kept to a minimum within the plot area.

**Replication.** When observations only are involved in a demonstration plot, it is not necessary to replicate. Occasionly it may be useful to provide two replications to increase credibility of observations or as insurance in case poor stand or another such disaster unrelated to treatment occurs in one of the replications. If data are to be collected, refer to the discussion of research plots.

**Randomization.** In most cases, randomization is not necessary for demonstration plots. If data are to be collected, refer to research plot section.

**Equipment.** Equipment such as planters, grain drills and combines could be provided by the farm cooperator. Other equipment such as 100-foot measuring tapes, scales, stakes, buckets, hand sprayers and planters may also be required depending upon the type of demonstration.

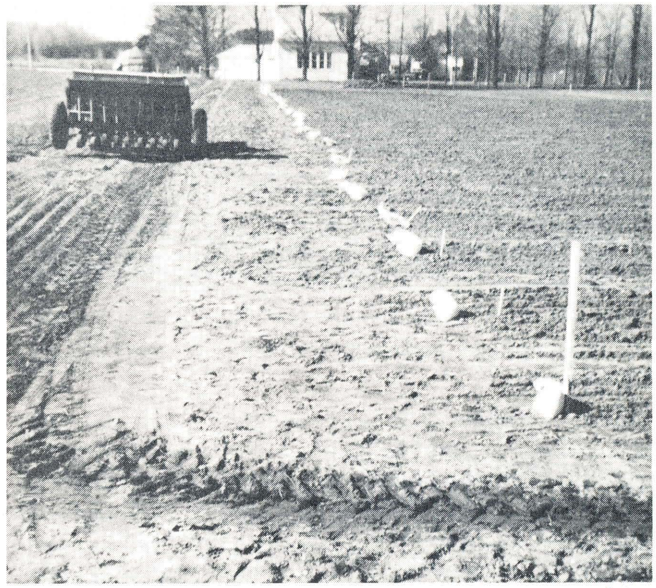
**Planting and applying treatments.** Calibrate all equipment accurately before any treatments are applied. The entire plot area should be marked out before applying treatments. Border rows along the edges and ends of the plot area should be provided to eliminate border effects. With small grain and forage plots, run the drill wheel on the wheel track in planting the next plot. This will leave extra space between the plots making plot identification easier. After the crop has emerged, cut alleys around the plots or provide some other means to delineate the edges of the plots so observers will be able to see where treatments begin and end. Provide signs labeling treatments.

**Publicity.** Twilight meetings, crop tours and newsletters are good ways to publicize demonstrations. Put up a sign visible from the road identifying the type of demonstration, cooperators, etc. Don't forget to take plenty of photographs to extend and preserve the demonstration's usefulness.

## RESEARCH PLOTS

**Plan Ahead.** In addition to the items mentioned under the **Plan Ahead** section **(DEMONSTRATION PLOTS)**, have a plan for data analysis before setting up the experiment. Cooperators will be particularly interested in the results of an experiment since they have donated land, materials and/or labor. They should receive a copy of the data from the experiment as well as an interpretation of the data as soon as possible.

**Location.** Selection of a location for a research plot is even more important than for a demonstration plot. Soils should be as uniform as possible. Use a soil map to determine the approximate soil boundaries. Then if the soil is



**The entire plot should be marked out prior to applying treatments.**

likely to be a major factor in determining response to the treatment, as in fertilizer or soil amendment plots, use a soil probe and look at soil profile characteristics to determine exact soil boundaries. All plots within a block should have the same soil type, although sometimes the blocks can be put on slightly different soil types as long as all blocks belong to the same soil management group. This may mean that not all the blocks are contiguous.

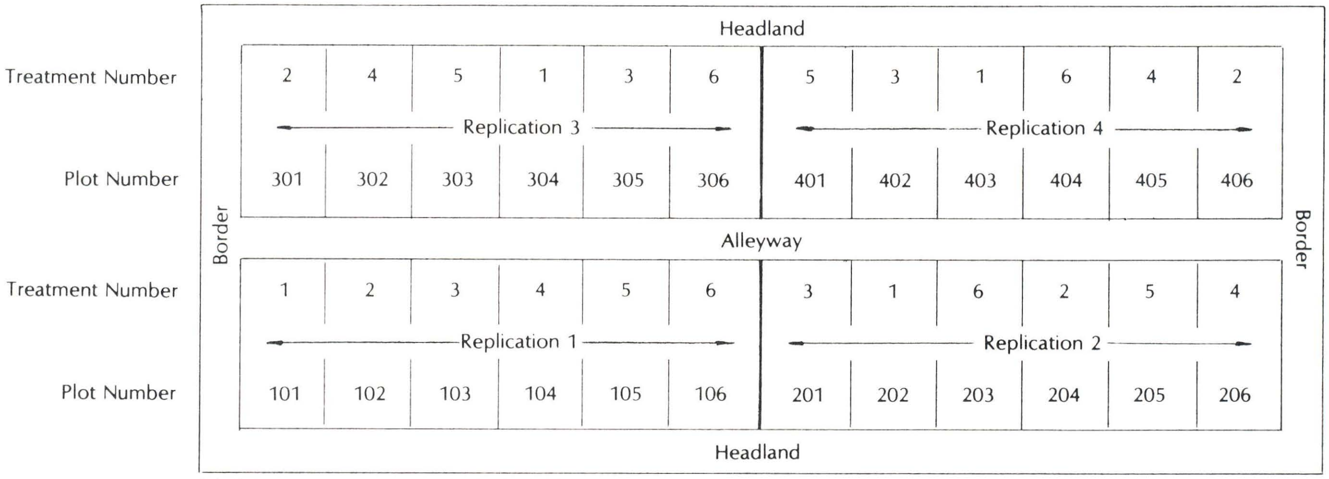
Generally the area should be more nearly square rather than long and narrow so that soil variablility is reduced. If tile drainage is present, lay out plots across the tile lines rather than parallel to them.

All areas of the plot should have identical history. Legumes and manure often influence yields for more than one year. Avoid dead and back furrows. Avoid field edges because snow and weed seeds may accumulate near a fence row. Headlands should also be avoided because these areas may have received overlapping applications of fertilizers and pesticides in previous years. Since competition for water, light and nutrients influences plant growth, make sure the borders are as equal to the conditions in the center of the plot as possible.

**Plot size.** Because of the difficulty in finding a large area with uniform soils, research plots frequently need to be smaller than demonstration plots. This may necessitate the use of small plot equipment or more hand labor. The size of the plot will depend on the type of experiment, equipment and the area available. All research plots should be measured carefully so that yields per acre can be precisely determined.

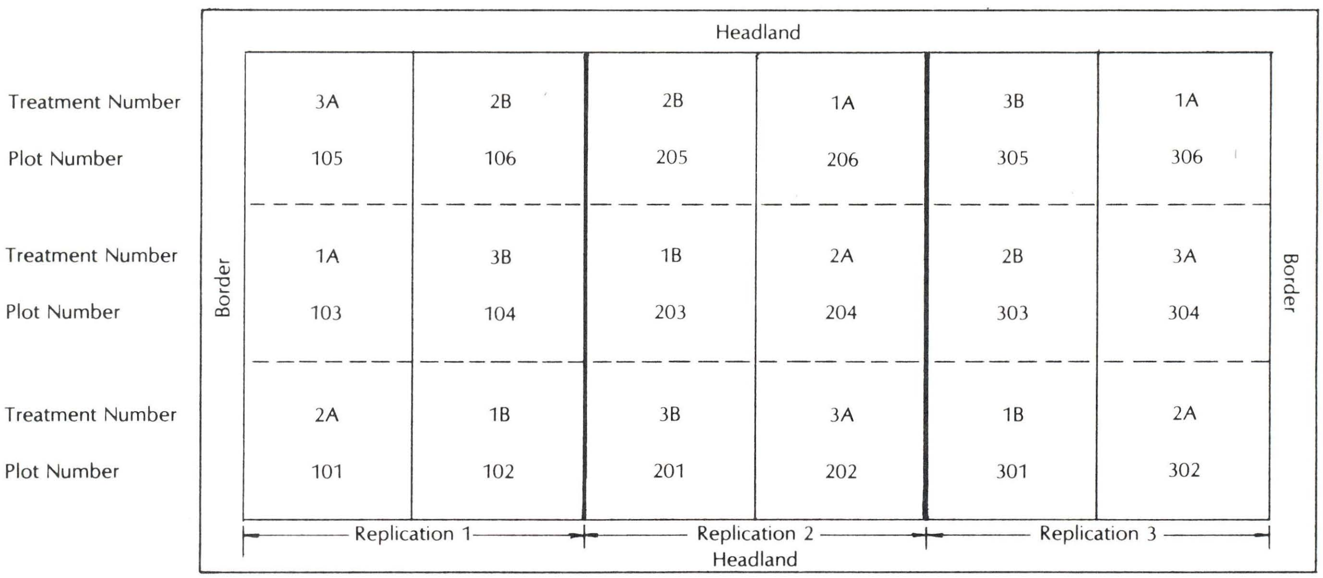
Figure 2 provides a plot layout example for a research plot. This type of plot layout might be used for evaluation

**Figure 2. Example research plot layout (randomized block design). Treatments randomized within blocks (replications).**




Variety or treatments - 1, 2, 3, 4, 5, 6

**Figure 3. Example research plot layout (split-plot design). Subplots randomized within whole plots. Whole plots randomized within replications.**




Variety or Treatments
Whole Plots = A, B
Subplots = 1, 2, 3

of several new corn varieties. The design could be expanded to incorporate more than six varieties. The design could also be used for comparison of fertilizer rates. An additional plot design that is frequently used where two or more variables are being studied is a split-plot design. An example is shown in Figure 3. A split-plot design is particularly useful where it is impossible to treat a unit as small as a plot but where it would be possible to treat several plots as a unit. The assignment of one variable to whole plots (A and B) and the other variable to the subplots (1, 2 and 3) has the effect of creating large plots (whole plots) out of adjacent small ones (subplots). The natural variation among the whole plots is usually greater than among the adjacent subplots because of the distance that separtates the whole plots. This is particularly true if there are more than three treatments as the whole plots. Therefore, it usually takes a larger difference between the whole plots to be statistically significant than it does for the subplots. There is a trade-off between the convenience of applying treatments to strips of plots and the treatment differences needed to be statistically significant.

In irrigation studies, where it is impractical to apply irrigation treatments to ordinary small plots, the split-plot design can be useful. As another example, the whole plots might be varieties and the subplots nitrogen fertilizer treatments. A split-plot design may be useful in such an experiment because if we had randomized the varieties within each replication we would have to clean the drill and change seed between every plot or risk extra compaction by driving across certain plots to catch all the plots with variety A at one time. By using the split-plot design with varieties in a strip, we could plant variety A in all replications, doing our turning in the headlands before cleaning the drill to plant variety B.

**Replication.** Replication is not only desirable but absolutely necessary in research plots. Frequently three or four replications are used, but the final number depends on the magnitude of treatment differences expected and the amount of natural variation in yields, weed control, etc. Occasionally, the researcher will use only one replication at a location, but will use locations and years as replications. Use of locations and years as replications usually makes it more difficult to interpret the data than if all the replications had been in the same experimental area in one year. An Extension specialist or researcher can provide some guidelines as to the number of replications needed.

**Randomization and blocking.** All plots must be randomized within research plots. One of the most commonly used plot layouts is the "randomized block" design, illustrated in Figure 2. The selected site is divided into replications. Each replication is considered a block. The blocks (replications) are further subdivided into sufficient plots so that each treatment can be represented in each replication. Variability due to factors other than treatment would normally be less for plots within a block than between plots in different blocks. The assignment of treatments to the plots is determined by chance (randomization). An easy method of randomizing a set of plots is to assign each treatment a number and draw numbers from a box for each replication to match with the plot area already assigned.

When a "split-plot" design is used (Figure 3) whole plots are randomized within each replication. Then all subplots are randomized within each whole plot.

**Equipment needed.** Some of the equipment needed for research plots may be supplied by the farmer, but because of the smaller plots the researcher may need to supply more equipment than for larger demonstration plots. Harvesting will frequently need to be done with a special research plot harvester or by hand.

**Planting and applying treatments.** In addition to the items mentioned in the demonstration section, extra care should be taken in identifying the corners of the experiments. Stakes in the experiment have a tendency to be moved or removed by field equipment or vandals. More permanent markers should be located at the field edge and distances measured so that the corners can be accurately located in case all stakes in the field are removed before harvest.

For variety, fertilizer or herbicide trials, make one treatment for all replications; then clean the sprayer, fertilizer applicator or planter and repeat with the second treatment.

**Publicity.** Frequently, research plots can be used for both demonstration with visual observations throughout the growing season and for research with collection of data such as yield, quality and weed, insect and disease control throughout or at the end of the season. Don't forget to label plots with the treatment used and/or supply observers with plot diagrams.

If the possibility exists that observers could damage plots by walking through them, some researchers use an extra observation replication along the roadside of the site for spectators to make their observations. If rates are used as treatments, it is sometimes useful not to randomize the treatments but to put increasing rates adjacent to each other in the observation replication to facilitate visual comparison of rates.

**Harvesting and collecting data.** Considerable care must be exercised in collecting data from research plots. A sloppy job of data collection will make it impossible to tell whether differences between treatments are due to treatment effect or to natural variation. Harvesting or data collection should only be done on a carefully measured area in the center of the plot away from the influence of adjacent plots. Yields or other measurements should be made on each plot of each replication separately. Don't forget to record information such as stand counts, lodging, moisture percentage, test weight, weed population, etc., that may be useful in explaining the data.

If a harvester or thresher is used, harvest a strip of grain beside the plots before harvesting the plots themselves as the harvester will always retain a small amount of grain. Empty the harvester after each plot and wait a set amount of time with the machine running before starting on the next one. It is important to be consistent in both harvesting and data collection to reduce errors.

**Handling data.** The yields per acre should be calculated for each replication separately. Calculations of yield per acre can be done as follows:

$$\frac{\text{43,560 (sq ft per acre)} \times \text{yield per harvested area (lb)}}{\text{harvested area (sq ft)} \times \text{standard bushel weight of crop (lb per bu)}} = \text{bu/acre}$$

Adjustments for mositure can be calculated as follows on either weight or yield:

$$\text{Weight of grain at harvest moisture} \times \frac{100\% - \text{moisture at harvest}}{100\% - \text{desired moisture}} = \text{Weight of grain at desired moisture}$$

For example, if we wanted to adjust a corn yield of 120 bu/acre at 20% mositure to 15% moisture:

$$120 \text{ bu/acre} \times \frac{100\% - 20\%}{100\% - 15\%} = 113 \text{ bu/acre}$$

If the experiment has been properly designed, it can be submitted for statistical analysis. (Consult the appropriate reseacher or Extension specialist before laying out the experiment to make sure the design is appropriate for statistical analysis.) After the data have been collected, the researcher or Extension specialist may be able to help with the statistical analysis because he has ready access to a computer.

Statistical analysis allows us to calculate a statistical probability that a treatment difference is real or "significant." Scientists frequently use a "probability level" of 5 percent. A treatment difference that is significant at the 5 percent level means that there are 5 chances in 100 that the treatment difference is not real but is simply due to random variation; or said another way, there are 95 chances in 100 that the difference is due to the treatment. Occasionally, researchers will use a 10 percent probability level, meaning that chances are 9 in 10 that the yield difference was due to treatment and not to random variation.

Sometimes the term "least significant difference" or "L.S.D." is used. Least significant difference refers to the magnitude of yield differences needed to be significant at a given probability level. For example, if the L.S.D. for a set of treatments in a corn experiment is 6 bu/acre at the 10 percent probability level, then the difference in yields between treatments must be at least 6 bu/acre to be sure 9 times out of 10 that the yield difference is due to treatment and not to random variation.

Statistical significance says nothing about economical significance. A 3 bu/acre yield difference may not be statistically significant but could be economically significant to the farmer. However, it makes little sense to advocate a treatment that appears economically significant to a farmer but can't be repeated with a fair degree of certainty.

## SUMMARY

We have outlined some principles used in conducting successful field demonstration and research plots. Differences between demonstration and research plots have been described. For help in conducting these plots, contact an Extension specialist or appropriate researcher.

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