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Designing, Conducting, and Evaluating On-Farm/Ranch Tests

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A growing number of producers are realizing the benefits of testing new technology on their farms or ranches. As federal and state support for applied research is scaled back, producers will obtain more information for making important decisions from tests conducted on their own fields, pastures, meadows, and feedlots. On-farm / ranch testing is a valuable part of the technology transfer process that will supplement, rather than replace, testing at research and extension centers.

Value of on-farm/ranch testing

Proper testing procedures make the farming or ranching enterprise more efficient and / or profitable by providing information that is tailored to the concerns of individual producers, such as:

1. Am I over-fertilizing?
2. Is there a better variety than the one I am presently using?
3. Will a newly advertised soil additive improve my soil?
4. Can a trap crop be grown in lieu of nematicide to control the sugar beet cyst nematode?
5. Will leaving meadow hay windrowed for winter grazing cut livestock production costs over haying and feeding?
6. Will a particular implant improve steer performance?

On-farm / ranch testing differs from experiment station testing in several ways. Treatments (variables) are tested on a larger scale, fewer variables are evaluated, farm-size equipment is used, animals are selected from the on-farm / ranch herd, and there may be less control of environmental variables.

There are several advantages to on-farm / ranch testing. Some pests of economic interest are not found in research centers; therefore, pest control methods need to be evaluated on producers' infested fields. Because of the differences between research centers and area farms and ranches in soils, weather, and management, testing provides site-specific information for the farm or ranch where it takes place. This type of testing allows the producer to verify or fine tune recommendations such as soil fertility recommendations, possibly reducing production costs. Additionally, the potential of new products can often be evaluated at the farm or ranch level more quickly than they can be evaluated at research centers.

Many producers own or have access to a computer. Inexpensive software can be used to perform statistical operations, providing a way to interpret the results of on-farm / ranch tests. Alternatively, cooperative extension personnel can assist with analysis of data.

Demonstrations or research?

Demonstrations are observational and are used to illustrate well-known and usually obvious practices such as tillage, seeding or harvest methods, cover crops, and other erosion control methods. Treatments or variables demonstrated are usually not replicated, and yields and / or animal performance are not always measured. Demonstrations do not always include a control (comparison with normal practice).

Research plots (testing) involve replication, comparisons, and other methods in order to accurately measure differences, particularly in yield and / or animal performance. Varieties, pesticide use, and seeding-rate comparisons, for example, do not usually produce visually obvious differences; therefore, differences need to be measured, multiple comparisons must be made, and the data can then be subjected to statistical analysis. Testing is designed to answer questions. Some of the variables that can be tested are:

Varieties	Seeding rates
Fertilizer rates	Fertilizer sources
Herbicide rates	Need for pesticide
Method of forage utilization	Grazing method
Forage hay type	Animal supplement

Variables such as planting dates and other timing events, crop rotations, and irrigation methods are difficult to evaluate on the farm. Optimum fertilization and pesticide application rates are also difficult to evaluate since several rates are required.

Important principles for designing tests

Establish objectives

Objectives can be in the form of specific questions (see above). They should be related to one or more goals such as improving forage, crop or animal production, reducing pesticide use, or reducing erosion. For example, will a newer variety of dry bean produce higher yields than the variety I currently grow? Will winter grazing of forage kochia (not weedy kochia) provide adequate cow performance?

Include controls

Controls are the standard or normal practices against which the results of field tests are measured. Producers decide whether to adopt or reject a change in practice by comparing test results to control results. The control must be treated as closely as possible to the way the new practice or technology is treated.

Select field, pasture, or animal group

Not every field, meadow, or pasture will be suitable for testing. It is easier to measure true differences in treatments when tests are conducted on relatively uniform fields. Soil maps and previous soil tests are also helpful. Fields that have had different management within the same field should be avoided. Fields with irregular shapes are difficult in that treatments are usually planted in strips. If the length of strips vary, measurement of harvested grain, hay, beets, or other products will be difficult.

Fields that vary in topography can be used and will be discussed later. Groups of animals used in treatment comparisons need to be as uniform as possible.

Plan to repeat (replicate)

All fields, no matter how uniform in appearance, are variable. This can be demonstrated by planting a whole field uniformly with one variety. Sub-dividing and measuring the yield on each block will reveal differences in yield (see Figure 1). Barley yield on this field varied from 66.8 to 83.6 bushels per acre among the 16 blocks. Differences in yield can reflect variations in soil quality, unintentional overlaps, or gaps in fertilizer or herbicide applications, for example. This variation can be thought of as “background variation.” One important technique for dealing with this variability is replication (repeated plots of treatments studied). Variation among animals means that a number of animals and / or groups of animals needs to be used.

Treatment comparisons can be replicated in several ways. Treatments or variables can be repeated in the same field, compared on different fields, or compared over more than one year (Figure 2). They can be compared through a coordinated effort among several producers. If several fields are used, they do not need to be comparable; in fact, fields that differ in yield potential may be desirable. When testing the same treatment comparisons over more than one year, it is important that inputs and management be as similar as possible.

The minimum number of replications (reps) in field studies is usually three. If fewer are used, it will be difficult to determine whether variation is due to treatments studied or to background variation. More replications will improve the measurements of treatment differences in some cases; however, more work will be required to complete the test. More replications are desirable in the event of unexpected disasters and the need to eliminate one or more replications. Animal replication is discussed later.

Randomization and blocking

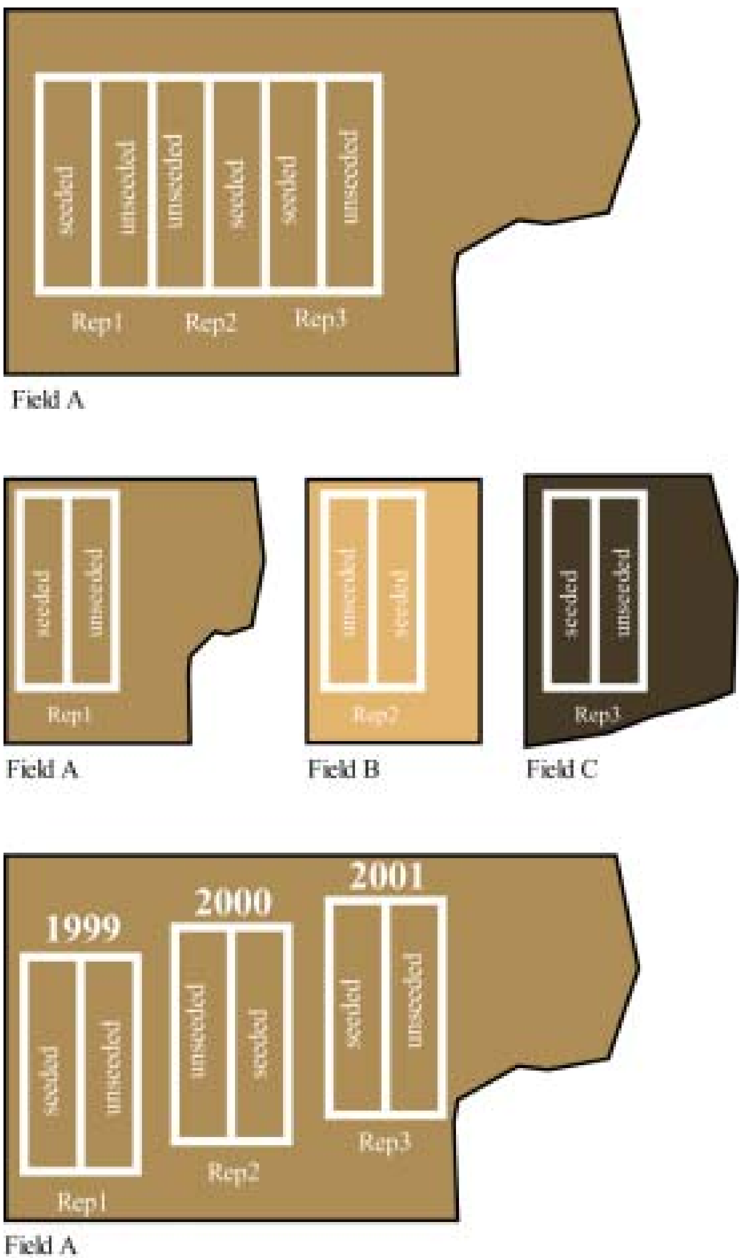
Because even fields that appear uniform are variable, it is important that each treatment tested have a chance to be on the most favorable or the least favorable locations of the field. As seen in Figure 1, a variety planted on the left and right strips will have an advantage over a variety tested on the two center strips. The center

Figure 1. Variations in a uniform field are illustrated by barley yields (bu/a) measured on 16 sections of the field. The same variety was planted on the whole field.

				Row avgs.
76.0	66.8	71.3	72.7	71.7
77.1	77.0	76.8	83.6	78.6
73.8	76.9	74.9	81.8	76.9
75.6	73.6	74.3	79.4	75.7
Column averages				
76.0	66.8	71.3	72.7	

strips are likely to produce lower yields as they did with the barley. With a minimum of three strips (replications) each, it is unlikely that one variety will end up on the three best strips of the field. It may be tempting to alternate two treatments across a field, however this should be avoided in favor of a randomized arrangement. Blocking is the grouping of treatments studied so that they are placed side by side in a replication (Figure 3). Comparing treatments in a relatively small area will result in less soil and other variation.

Figure 2. This test design evaluates trap crops. Three replications are located on one field, on three separate fields, and over three years on one or more fields.



As with crop testing, it is important that animals be selected at random for different treatments. Sorting 10 lambs from a large flock for Treatment A and then sorting 10 more lambs for Treatment B may seem random, but the tester may be inadvertently selecting groups based on vigor and / or size. Assigning animals to treatments, particularly in feeding trials, requires randomization with regard to an animal's age, sex, genetics, number of days pregnant, lactation stage, and previous management, among other factors.

Decide on strip size (field studies)

Generally, size is not critical; however, if the field strip is too wide, the block on which all treatments are compared can vary considerably from one side to the other. The width of the strip should be chosen to accommodate equipment. Strip length is usually the distance from the front to the back of the field. There will always be a border effect in which one treatment will influence, positively or negatively, the adjacent treatment, but the border effect usually involves only a few rows or feet. Therefore, it is desirable to make strips slightly wider than the width covered by one or two passes with harvesting equipment.

Studies involving animals

Animal testing can be especially challenging on a farm or ranch. In some cases, each animal can represent a replication. For instance, 40 calves can be identically managed in one pen or pasture with 20

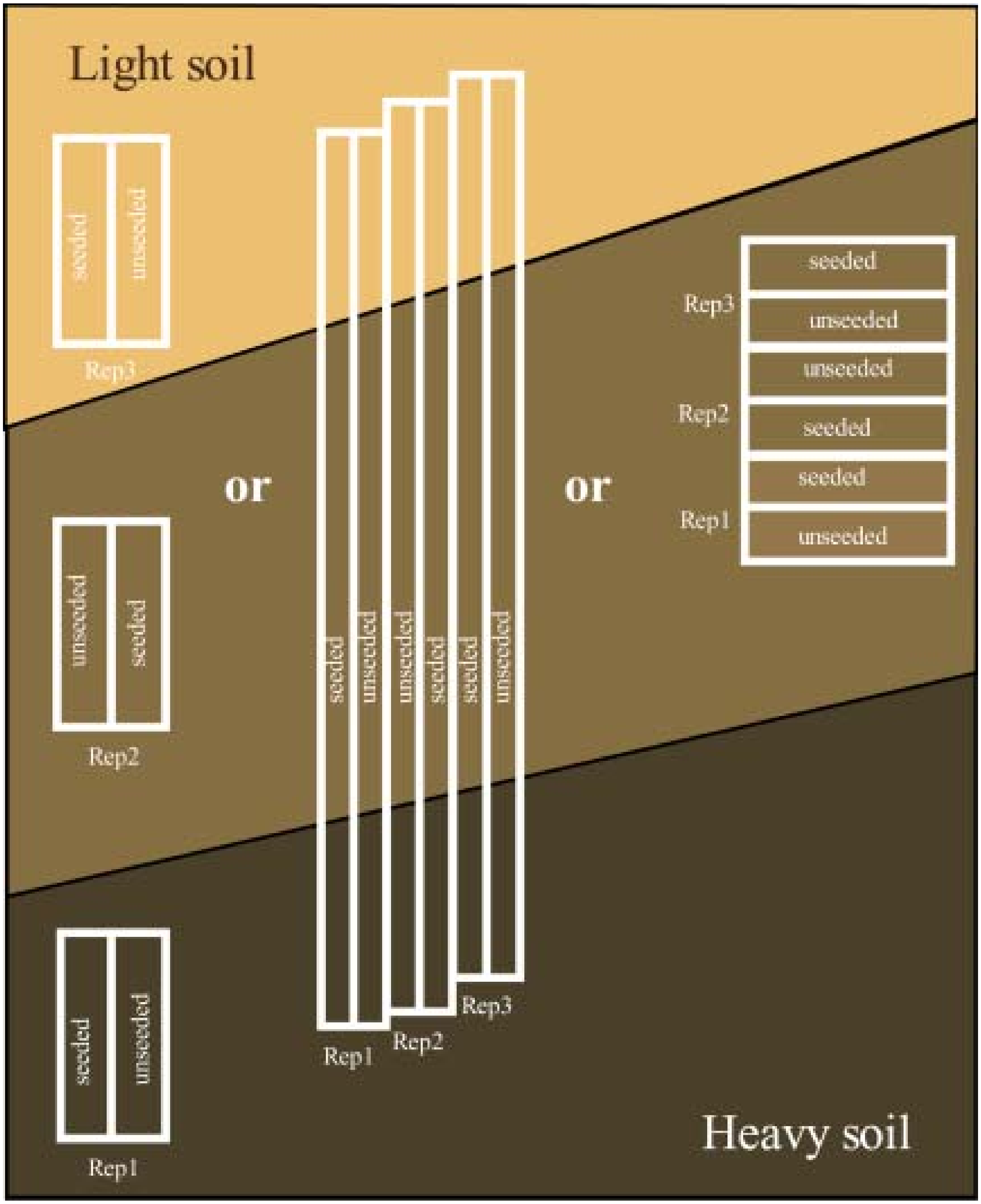


Figure 3. These are three examples of treatment blocking. On the left, each rep is established in a separate but uniform area; in the middle, each rep spans across the variation but encompasses each area equally; and on the right, each rep is confined within a single uniform area.

Figure 4. Shown is a randomized complete block design with side-by-side comparison of two corn varieties. The plots are strips planted the length of the field and 20 feet wide. Each variety is replicated four times.

calves receiving a vitamin injection and 20 receiving no vitamin. Here there are two treatments with 20 replications per treatment.

In other studies, groups of animals in separate pens or paddocks can become the experimental units replicated. One study can be to compare weight gains of heifers grazing stockpiled (uncut) meadow grass in the fall versus grazing windrowed meadow hay cut earlier in the summer when the nutritional quality of the forage was higher. On a 60-acre meadow, one can swath three 10-acre blocks in the summer. The next step can be to establish six paddocks (three paddocks of stockpiled meadow grass and three paddocks of windrowed hay). Although one can place 20 heifers in each paddock (120 heifers total), the 20-heifer group in each paddock remains the experimental unit, leaving three replications for each treatment. To save resources, another technique is to conduct the same experiment with just 40 animals. In this case, two groups of 20 animals are allocated to the two treatments. At the completion of grazing of the first set of paddocks, these same animals are moved into the next set of paddocks and finally on to the third set of paddocks. Here again there are three replications, but now the replications are done with the time variable a consideration when the statistics are conducted. Careful weight measures are recorded at the beginning and end of each paddock-grazing period.

Plan measurements and records

For yield comparisons in field studies, one will need to know the weight and area of each plot harvested. It is very important to measure yields on each strip. If all strips are harvested and only one weight determined, it will not be possible to subject a test treatment to statistical analysis. In grazing or other studies involving animals, it is important to weigh animals under conditions as nearly similar as possible at the beginning and the end of the study in order to accurately measure performance. Differences in stomach fill can mask more permanent weight gains. Mature cattle, for example, can ingest 300 pounds or more of feed and water in a short period of time. Researchers commonly bring animals into a drylot the last two evenings of a study, each time withholding feed and water overnight and weighing the next morning. The two morning weights are averaged. If pen or group weights are recorded, care must be taken to account for one or more animals that may perform poorly due to sickness or other reasons. Because of this, individual animal weights are helpful. Usually a minimum three-week study period is needed in order to accurately measure animal performance differences.

As part of a study, one should record observations on such things as inadvertent grazing by a neighbor’s cows, wildlife grazing, or pest attacks, all of which will likely not be uniform across the field. The more records kept, the easier it will be to interpret results. Also, differences in emergence, seedling vigor, or maturity rate may help explain any final differences observed in the yield of field treatments.

Calibration of measuring equipment

Yield monitors, moisture sensors, weigh wagons, and portable scales are used to measure treatment results. Since they are subjected to rough physical treatment during transport and use and to inclement weather, they need to be monitored and calibrated fairly frequently. Changes in empty weight of weigh wagons, for example, can result in false results.

Statistics

Replication, randomization, and blocking are all important in statistical analysis of data from strip testing, grazing, or feedlot studies. Statistical treatment is necessary in order to separate the background variation from the variation created by the treatments tested. An accurate decision cannot be made based on field, pasture, or feedlot testing alone. Statistics provide the odds or probability of one treatment being superior to another. A 5% level of probability is commonly used. If the difference measured, for example, in the yield of two varieties is greater than the statistically-calculated value, it can be concluded with 95% certainty that the one variety is higher yielding.

References

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*(This publication shows examples of on-farm / ranch studies conducted across the U.S. It is available at: www.sare.org / san / htdocs / pubs / .)

**(This publication is available at: www.asas.org / jas / papers / 1999 / am / am017.pdf.)

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