THE NATURE AND VALUE OF FIELD EXPERIMENTS

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Types of Experiments

I will in this short paper discuss doing experiments on a small scale, in the garden or on the farm. I believe that experimentation is legitimate and could have a role in developing Bio-dynamics. I would like to focus on two aspects of experimenting: testing different cultivars for their performance under bio-dynamic conditions, and testing the spray preparations.

Why do experiments? Most of the cultivars available to us have been bred sometime during the last fifty years for their yield response to quickly soluble mineral fertilizers. This does not necessarily mean that they will respond with the same yields to compost and manures. A good deal of crop breeding is done with "agronomic performance" (i.e. yield, disease resistance, lodging, etc.) in mind, and generally less attention is paid to more qualitative characteristics such as taste, nutritional value and keeping quality. These may be lost in the wake of a breeding program. What we need to do is to build up a real backlog of comparative work on which cultivars and practices are best for us.

I believe experimentation with the spray preparations is essential, both for ourselves to explore their effects, and for others. I chose them instead of the compost preparations because the spray preparations are more work to apply (on a large scale they demand mechanization), and thus one needs more conviction to actually use them.

There are basic experimental forms in doing field experiments. The one we will concern ourselves with here is called a "randomized block design." Figure 1 shows how the blocks are set up best, on end to each other. The different blocks can be scattered onto different sites if need be. The plots are labelled A, B, C, and D, designating what will be grown or done on those plots. One can have more or fewer plots depending on how much one wants to test. There are many different ways to distribute the plots randomly within the blocks; some use dice, some use tables of random numbers available in the appendices of many books on statistics.

Because there are three blocks shown in Figure 1, there are three replications. One could have four or more blocks, and the greater the number of replications, the easier it is to show

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statistical differences between what one is comparing (i.e. the results are surer).

Why replicate and why randomize? We do this to get away from a central problem of field experiments: soil with uneven levels of fertility. A field can be very uneven in its fertility due to management during previous years. Replicating and randomizing tends to average out the error caused by this uneveness, distributing it over all the things tested. Thus one is surer that the differences one might find between cultivars or spray treatments are not simply due to the patch of ground the crops were grown on.

Statistical analysis of these experiments is by variance analysis. I would be very happy to do such an analysis for any of you who does an experiment. Then one could see if there were any statistically significant differences, and at what level of certainty.

In Figure 1, A, B, C, and D could be the different potato cultivars being compared; say A was Finns, B was Russet Burbanks, C was Kennebecs, and D was White Rose cultivars. One could add on a set of E plots if one wanted to also test Pontiacs, etc. Such experiments could be used to test carrots, squash, beans, tomatoes, wheat, or whatever one had an interest in.

If one wanted to test the spray preparations, A could be a control plot, B might be a plot with preparation 500 treatment, C might be the plot with 501, and D might be a plot with both 500 and 501. One might wish to test only two plots, A and B, one with sprays and one without. Or one might wish to compare several types of sprays such as 500 and 501 with valerian or seaweed extract.

One of the classical experiments done with the spray preparations is to grow plants in shade and light with and without the sprays, which have a light effect. This effect can be observed in the forms of the plants. Radishes and other plants which have an ordered leaf metamorphosis may serve to show this effect clearly. The effect also shows itself in better keeping quality.

To see if one can get this effect oneself, it has been found that hanging fishnet up on poles can give a cheap and good shading effect. A design one could use is shown in Figure 2. It is called a split plot design.

Doing Experiments

Several points: 1) Set up the experiment so that the plants are easy to plant, weed, and harvest. 2) Do things uniformly. By this

I mean plant on the same day; weed the plots in such a way that some plots don't have weeds very much longer than other plots; harvest as much as possible on the same day. Because experiments are comparative, they demand that one follow certain rules of uniformity. Experiments are thus more demanding than ordinary garden work. 3) It is often best not to harvest the border rows on plots, but to only harvest about the central 2/3 area, for the yield and quality measurements. Thus one gets away from border effects of other plots. One must get an accurate measure of the area harvested! 4) The plots can be as big or as small as is practical or wanted, but they must all be the same size. 5) I heartily recommend that if you have effective mechanical equipment for weed control, planting, and harvesting, you plan your experiment so that you can use it and have room to maneuver it between the blocks.

Getting Results

Yields: It is necessary to get the yield, and the area harvested to get that yield, for each plot. One has to get set up with scales and sacks for this.

Storage Losses: If one wants to test storage losses of vegetables and fruits one needs to have a good, dry storage cellar or good facilities. Remember it should be rat, mouse, and child proof! The sacked material should be stored under uniform conditions.

For our purposes three things should be measured: the original storage weight of cleaned material (remember to subtract the weight of the sack or box!); then the weight of the material after the storage period (however long you choose that to be); and a third measurement should be taken, after the second, by sorting out the rotted wares and weighing the rest. Then one can arrive at a fresh weight loss and a loss due to rotting, the sum of which equals the total storage loss. An example of the results of a randomized block experiment comparing the effects of three nitrogen fertilizer levels with one loafing-shed manure level and several spray levels on carrots is shown in Table 1.

Taste: One of the impressive moments for me when I was studying in Europe was taking part in a taste test at the bio-dynamic research center in Darmstadt, Germany. Carrots had been grown with different fertilizations and with and without spray preparations. The co-workers at the lab were asked to rank grated carrot mashes, made with carrots taken from the different treatments, according to their taste. We didn't know which mash belonged to which treatment, but the unanimous opinion of the group, which showed itself by the ratings given without any consultation among us, was that the preparation-treated carrots were "head and shoulders" above all the others.

Otherwise I have little experience on how to do taste tests, but I can foresee taste-testing parties with friends might be a lot of fun! If one had a more absolute taste scale, such as 4=excellent, 3=good, 2=mediocre, 1=poor and 0=awful, one could perhaps use it for a couple of tests to see how quickly stored products lose their taste.

The Benefits and Pitfalls of Experiments

Experiments of this type have a form directly meant to answer certain questions. The form is valid for these questions, and is not meant to stifle observational skill, but rather to encourage objectivity and to build up a solid basis of knowledge. One must always be conscious of one's inputs into experimental situations. A common reaction to bio-dynamic experimental results is: "those who did the experiments wanted to get certain results, and that force manifested itself physically or nonphysically to produce the results." The only answer to this lies with the individual researcher. The one who experiments must encourage a feeling of objectivity rather than his own feelings, wishes and thoughts. His singlemost goal must be the coming forward of that which should show itself in the experiment, whether or not it is what he or she expects or wants to come forward. The results of the experiment are not the responsibility of the researcher; his primary responsibility is setting up and carrying out the experiment. Evaluation of the experiment follows, with the help of statistical methods which are impartial enough. If experiments show no differences, this is just as much to be marvelled at as if they do show differences.

Field experiments have an artifical nature, but I believe their results are valid for others in a way that general observations may not always be. In any case they help to satisfy the skeptical part of ourselves which demands systematic comparisions.

One thing I've noticed about doing experiments is that they can quickly generate interest among people in the surrounding community and can contribute a real part to the common culture. On the other hand, the community can play an irritating role in the form of children (who have probably been told repeatedly not to disturb the plots), and other people who may suddenly decide that your radish experiment looks good to eat! Another pitfall is animals running amok. I had a pig root in my carrot experiment when I was working on a farm in Norway.

A guideline for the wise is to get a special notebook just for the experiment, and to keep careful notes on all the details.

Please feel free to write me if I can help in the design, or just for my general thinking and support, if you want to try an experiment. I am surely no expert on the technical aspects of experiments, but at present I can easily contact scientists and statisticians who are.

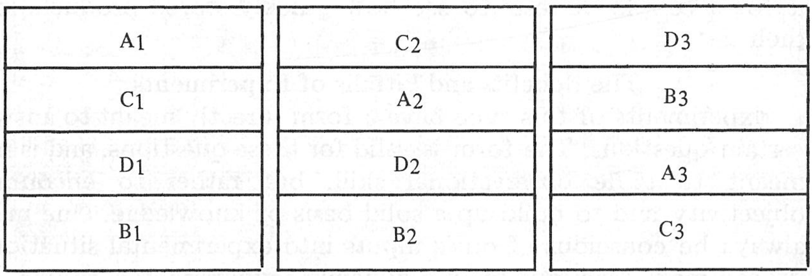

Figure 1 Randomized Block

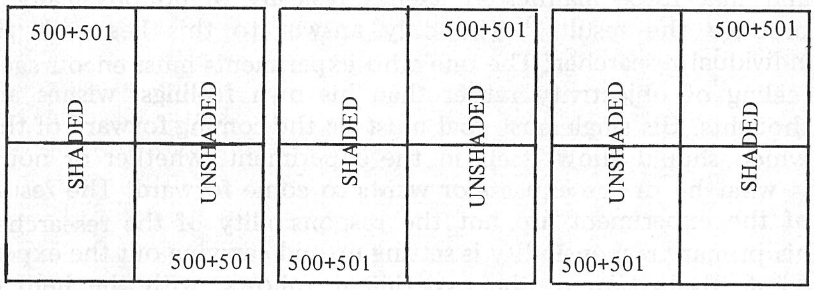

Figure 2 Split Plot

Table 1. Fertilization experiment complexed with b.d. sprays. (after Spiess)

N1 25 kg nitrogen, 70 kg phosphorus, 130 kg potassium
N2 50 kg nitrogen, 70 kg phosphorus, 130 kg potassium
N3 75 kg nitrogen, 70 kg phosphorus, 130 kg potassium
B1 30 t/ha loafing shed manure
B2 30 t/ha loafing shed manure + 3X spraying with 500
B3 30 t/ha loafing shed manure + 3X spraying with 500, 4X with 501
B4 t/ha loafing shed manure + 6X spraying with 500, 4X with 501

Storage losses of carrots (Rothilde) grown under the fertilizations, (analyzed by Samaras). Losses in %.

	N1	N2	N3	B1	B2	B3	B4
Fresh wt. loss	26.0	27.0	29.5	33.5	28.9	28.5	26.2
Rotting loss	23.5	30.5	58.8	28.2	23.0	20.4	16.6