PRINCIPLES OF EXPERIMENTAL DESIGN APPLIED TO LONG-TIME ROTATIONS

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When this program was planned the idea was that the speaker on this subject would be able to summarize all of the present knowledge on it and present a few standard designs which could be used universally. Letters were sent to the directors of the various state agricultural experiment stations and to a number of research workers in soils and agronomy asking for their views on the principles of experimental design applicable to long-time experiments and the applications being made of them. The answers range all the way from rather blunt rejection of these principles to their full acceptance. I shall draw on these letters rather heavily. In some cases I shall quote directly, in others I shall use my own words. I shall in no case give the name of a man from whose letter I am quoting.

In reading the letters submitted to the committee I found, or so it seemed to me, that not all the men had the same concept of what constitutes research. It might be well, therefore, for me to make clear my understanding of what constitutes research and the aspects of research which I shall discuss. I find it convenient to think of research as consisting of three phases. In the first phase ideas are born, ideas which so occupy the research worker's mind that he forgets to put on his tie, lolls in his bath to the disgust of other members of the household, elevates his feet to his desk and stares off into space, or argues seriously with his colleagues until the idea has been whipped into an hypothesis. He may and frequently does lay out some observation plots without replication to check his ideas before formulating his hypothesis. An hypothesis having been formed the scientist is ready to conduct an experiment to test it critically, the second phase of research. In case the results of the critical experiment lead the experimenter to retain his hypothesis, he, or his readers, will, if the results are of economic value, subject them to rather extensive checks to determine how generally they apply. This is the third phase.

It must be evident that in the first phase research workers will find it very difficult indeed to write up a working plan that will satisfy the powers that be and thus result in money being allotted for the work. It must be equally evident, however, that lack of funds and official sanction can not keep a true scientist from indulging in this phase of research since such a large part of it is the product of his own observation and thinking. It is this phase of research, in which the worker gropes in all directions for leads make the mistake of thinking this research is fundamental because it does lack direction and satisfying all aimless experimentation as fundamental.

I am certain that one of the correspondents to this phase of research in mind when he would like to see developed a school of agronomic research which could believe problems may be solved by acute perception, the pursuit of clues, inductive and deductive reasoning. A good researcher is really a good detective.

Although a very large proportion of a worker's time may and generally should be consumed by this first phase, I shall not discuss it further for the statistician can offer scant assistance at this stage. Some knowledge of that mode of the branch of logic called mathematics will provide to the experimenter. In the second phase, the statistician can render real assistance in planning critical experiments and in analyzing the results from them. I shall spend my time, then, on the second and if I speak as though it were all there is to research, it will be for the sake of brevity and convenience rather than because I do not know do not appreciate the importance of the other phases.

The first essential of an experiment is a question or objective. Many experiments are made without a definite objective in hopes that the answers will furnish both the questions and answers. In discussing the plan for some proposed research which lacked a definite objective, I said, "It is likely that some of these debates can be adjusted after the test gets underway, so that the test will provide certain valuable information."

This attitude is disastrous in long-time experiments for once one of them has been started, amounts to scrapping all or much of what has been done before the change is made in most cases.

For any true experiment with a definite, objective there must be several possible results or possibilities which the accepted interpretation is to be known. This seems to place a heavy responsibility upon the researcher, but a major load may be shunted by using a properly designed experiment. In addition to measuring the