

LESSONS AFFORDED BY
THE ROTHAMSTED EXPERIMENTS.

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In directing attention to the published report of the course of lectures delivered in the United States in 1893 by Sir J. Henry Gilbert, LL.D., F.R.S., on Agricultural Investigations at Rothamsted, England, during a Period of Fifty Years,¹ the *Experiment Station Record* (vol. vii. No. 5, 1896), published at the Government Printing Office, Washington, makes the following observations :

The account of these investigations, presented in concise and systematic form, with résumés of the progress of agricultural science along special lines, constitutes a most valuable contribution to the literature of agricultural investigation.

In reviewing the work done at Rothamsted the casual reader can hardly fail to be impressed with the permanency and thoroughness of the work ; the limited number of lines undertaken, although the work extends over fifty years ; the close coöperation between the work in the field and stable and in the laboratories ; and the completeness of the records.

The Rothamsted investigations probably furnish the best examples of what may be accomplished with field experiments continued over a series of years and supplemented by laboratory work ; and they have probably taught more than any other set of experiments as to the best methods for such work. It should be remembered that the work was commenced at a time when agricultural investigation was in its infancy, and the methods were in very crude form. By patient plodding the effort has been to develop these methods gradually, and to establish principles which would bear the test of subsequent investigation.

The field work is unique. Land especially adapted to experimental purposes was selected, and permanent plots laid out. A plan was developed for each set of experiments, which was only varied as experience suggested. Experiments thus inaugurated were continued through thirty, forty, and even fifty years without interruption. The shortest experiment reported upon lasted five years, and fully two-thirds of the experiments lasted over twenty successive years.

¹ U. S. Dept. Agr., Office of Experiment Stations Bul. No. 22.

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Except at the very first, there is no evidence of a vacillating policy or an inclination to abandon one line of work in order to take up some new one. The belief was in the final effectiveness of continued effort along a given line. Once organised and entered upon, the investigation was continued without interruption until definite, well-established results were attained. Whether in the investigations of questions in animal or plant nutrition, in nitrification, or in the study of the soil and drainage waters, this commendable policy is evident. We know now that such long periods are not always necessary in order to secure reliable results, and we have found shorter methods for studying many phases of the question of plant nutrition. But the spirit of thoroughness and the perseverance which led to the continuation of a single experiment through forty or fifty years are well worthy of emulation. It is only by adhering to a definite policy for a number of years that an agricultural experiment station can expect to work out problems of importance so that the results will have a permanent value. The importance of this element of permanency in station work can hardly be overestimated, and too frequently it seems not to be appreciated by those in charge of the work. It is not that the Rothamsted experiments are works of unusual genius, but that they have been carried out with that close attention to details and that persistency of effort which are so essential in all work of this nature. A knowledge of the methods pursued has inspired a widespread confidence in the Rothamsted work hardly bestowed upon any similar set of experiments. The results secured have become a part of our agricultural science, and have been incorporated into text-books the world over.

"By far the greater part of the laboratory investigations, whether chemical or botanical, have had for their object the solution of problems suggested by the field and feeding results." The work in the field and stable was constantly supplemented by that in the chemical and botanical laboratories; and it was by attacking questions from different sides that results of such permanent value were attained. Thus in field experiments not merely the growing of crops with different fertilisers and determining the yield was undertaken, but the soil and the drainage waters were studied, the meteorological conditions were observed, and the composition of the crops was determined. In selected series of the experiments more than seven hundred ash analyses were made of the crops, which is believed to be "the finest series of ash analyses yet executed and the most instructive, the results exhibiting the influence upon the composition of the ash of wide differences both in the supply of mineral food and in the character of the season." Again, in connection with a series of experiments with fertilisers on meadows, botanical analyses of the herbage on the experimental plots have been made systematically since 1857. In feeding experiments with growing animals, not only the food eaten and the gain in weight were recorded, but animals were slaughtered at different stages of

growth or fatness, and analyses, including those of the ash, made of the carcasses.

The united efforts of the station have thus been concentrated upon one or two lines of work at a time. The permanent work has been the experiments with fertilisers for different field crops grown continuously and in rotation. The investigation of special subjects, largely suggested by these experiments, has been taken up from time to time. At one time we find questions of animal nutrition and the composition of the increase in fattening animals occupying a part of the attention, at another time studies of the rain and drainage waters, and again the soil, nitrification, &c. But the field experiments have gone on without interruption and have remained a prominent feature of the station's operations.

Recent visits to a considerable number of experiment stations in this country (the United States) have confirmed the impression that in too many cases the stations are scattering their efforts on a variety of comparatively unimportant investigations. There is need of much greater concentration of work and of more efficient co-operation among the different workers in the planning and carrying out of important lines of work. In many cases it would be far better for the station to select some line of investigation suggested by its environment and make this the central feature of its work, grouping other inquiries about this in such a way that they might contribute to the securing of the most productive results along this line. In some cases the organisation of the station seems to stand in the way of proper co-operation. Each department is so far independent that it not only determines its own line of work, but even considers that it is doing a favour to other departments if it aids in their investigations. This is obviously a bad arrangement. It is the duty of boards of control to see to it that the organisation of the station shall be such as will facilitate the carrying out of thorough investigations on some well-considered plan. Unity in organisation and work is absolutely essential to the successful conduct of an experiment station.

Not of the least importance in the eyes of those in charge of the Rothamsted work is the keeping of detailed records of every experiment or investigation undertaken. For this purpose and for tabulating and computing the data ample clerical force is provided. Lately this has included three clerks; and an effort is made to keep duplicate copies of the tabulations in different places to avoid the risk of loss by fire.

Care is taken, furthermore, to preserve samples of the soils, crops, and feeding stuffs, and the ashes of crops and animals, so that at any future time the results obtained can be verified, or studied from a new point of view suggested by the progress of science. In several instances this has already been done. Any new hypothesis advanced can be tested by the records and samples collected at Rothamsted. These remain a mine of information for the agriculturist and are the starting-point for many an investigation.

The importance of systematic records and of sufficient clerical

force to keep them properly is too frequently unappreciated by our stations. The pocket notebook kept by the person in charge of the experiment as a temporary record until the results are published frequently constitutes the only record the station has of the experiment. Such a method of record keeping seems to be wholly inexcusable. It is unscientific, and it provides the station with no satisfactory record of its work. The published account should not be relied upon for the permanent record. Many of the data incident to an experiment may be omitted from publications of the nature of station bulletins and reports. But these data should be kept in proper form so that they will be available for a reconsideration of the results at any time, or for comparison with other experiments that may be made. In a number of instances in which additional data of feeding experiments have been requested for comparison, the reply has been that the station had no permanent record of the experiments except that published in the bulletin. Reference to the bulletin showed only general summaries and averages, with no statement of the quality or composition of the feeding stuffs used, the amounts of food fed daily, or the details of the gains or losses in weight of the animals fed. It was in fact only a meagre account of the conditions and results of the experiment. As far as permanent value is concerned, these experiments might as well not have been made, and the time and money expended on them might better have been used in completing and putting into permanent form the records of other experiments.

The Rothamsted experiments teach many lessons, but they teach no more important one for the American stations than that of permanent persistent effort along a few special lines, with the exercise of all the precautions suggested by scientific investigation, and the keeping of detailed records of the conditions and results of the work. A few experiments carefully planned and supervised, with full permanent records, carry more conviction and are of greater benefit to both the practice and science of agriculture than any number of carelessly conducted, incomplete trials with fragmentary records.