Principles of Field Experimentation.

THE science of field experimentation has developed rapidly during the last decade, and its ever-widening importance justified a Rothamsted conference devoted entirely to its principles and technique.[1] As was only fitting, the first paper was contributed by Dr. R. A. Fisher, who detailed the three principles of modern field experimentation—replication, randomisation, and local control—and showed how these three are necessary in order to reduce, and to give a valid estimate of, the error which must always loom largely in this type of inquiry. Following this, Dr. J. Wishart illustrated the calculations appropriate to randomised blocks and Latin squares, which have proved the most serviceable forms of lay-out.

Later speakers enlarged on a variety of subjects. It is clear from a perusal of the papers that the need is often felt for inquiries carried out at a number of centres simultaneously, so that different conditions of soil and weather may be encountered, and hence that the conclusions may be of general applicability; if each centre adopts the same form of lay-out (though with separate randomisation of treatments) then it is possible to combine all the results in one calculation and attain considerable precision, and still not lose the individuality of the results. Details were given of the methods which experience has shown to be the best for experiments located at a distance from the research station. In these cases a sampling method has proved satisfactory, not only as a means of making developmental studies but also to provide a reliable estimate of the final yield.

Particular cases necessitate special technique. Horticultural experiments introduce difficulty through the longevity of the plants concerned, with the concomitant danger of accident, and the problem of measuring the vigour of the plant. In the case of variety trials, the National Institute of Agricultural Botany still prefers the well-known 'Beaven's half-drill strip' method. The only paper on grass experiments was contributed by Prof. Stapledon, who described the methods adopted at Aberystwyth: he laid much less stress on the statistical adequacy of the technique than on botanical analyses and the problem of how the result should be measured and converted into terms of nutritive value. The papers deal fully with all the working details, and together they provide a most valuable compendium of experience.

A number of examples of the precision and type of results which may be expected from modern field experiments is contained in the Rothamsted Report for 1930.[2] The majority of problems attacked are manurial ones, and the complex lay-outs used give very detailed information. The response of the crop to two or three plant foods, each in varying amounts, can be tested in one and the same experiment, and, if occasion arises, this can be combined with inquiry into the different forms in which any nutrient can be supplied, or the responses of different varieties of the crop plant.

The reader is soon convinced of the necessity for complex experiments, for it is evident in nearly all cases that incomplete inquiry might give misleading results. As an example, it was found that potatoes only responded appreciably to potash and to large doses of nitrogen when a sufficiency of phosphate was supplied, and that superphosphate provoked more than three times as much response in the presence of plenty of nitrogen and potash as it did in the absence of dressings of these two nutrients. Relations of this type appear again and again, making the conclusions difficult to state in a simple manner: there is always a danger in these intricate cases that the reader may 'miss the wood for the trees', but in general the report is admirably and lucidly expressed.

The height of complexity is reached in two rotation experiments which were initiated in 1930: these will yield results year by year, but for their full completion they need twenty years and thirty years, respectively. The Report also contains a brief description of the work proceeding in the laboratory, and summaries of papers recently published by the staff; it is a valuable volume to workers in agriculture and the allied sciences.

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[1] "The Technique of Field Experiments": being the Report of a Conference held at Rothamsted on May 7, 1931, under the chairmanship of Sir A. D. Hall; with contributions by Sir A. D. Hall, Sir John Russell, Dr. R. A. Fisher, Dr. J. Wishart, Prof. R. G. Stapledon, S. F. Armstrong, A. H. Lewis, T. N. Hoblyn, H. V. Garner, D. J. Watson, T. H. J. Carroll, and others. Pp. 64. (Harpenden: Rothamsted Experimental Station, 1931.) 1*s*. 6*d*. net.

[2] Rothamsted Experimental Station, Harpenden: Lawes Agricultural Trust Report for 1930. Pp. 172. (Harpenden: Rothamsted Experimental Station, 1931.) 2*s*. 6*d*.

The Coal Measures of Belgium.

IN several Continental countries the geology of the coal measures has for long received great attention. This is especially true of those coalfields where the rocks are highly disturbed and the interpretation of the geological structure is often a matter of great difficulty.

In Belgium a succession of brilliant workers has applied palæontological methods to the elucidation of the sequences and structures in the coalfields. Lately this work has been carried out under the direction of Prof. A. Renier, of Brussels, whose contributions to the geology of the Carboniferous of Belgium have been widely known for many years. In a recent memoir, Prof. Renier has summarised the development of these investigations, and has given a concise account of his views concerning the mode of deposition of the rocks and of their correlation, while Prof. Pierre Pruvost, of Lille, has contributed to the memoir a very valuable account of the fauna.*

Prof. Renier asserts that in the coal measures of Belgium the floor of every seam is full of the rootlets of *Stigmaria*. The plant remains of these fossil soils are of very monotonous aspect, *Stigmaria ficoides* being present at every horizon throughout the sequence. Renier emphasises that the tracing and recording of such fossil soils, even when they are, locally, not overlain by coal seams, is of great assistance in the investigation of the strata. This is in marked contrast with the general practice in many mining areas in Britain, where frequently there have been no records of any of the strata passed through excepting the coal seams.

Renier directs attention to the wide lateral extent of many coal seams, while at least one marine bed in the coal measures he recognises in areas so far apart as the Pas de Calais, Holland, and Westphalia. This wide extent of at least some beds in the Upper Carboniferous strongly supports the view that there was at times continuous deposition over wide areas. The views formerly held by some geologists regarding the deposition of the coal measures in small isolated basins,

* Considérations sur la stratigraphie du terrain houiller de la Belgique, par Armand Renier; La Faune continentale du terrain houiller de la Belgique, par Pierre Pruvost. *Mém. Mus. Roy. d'Hist. Nat. de Belg.*, No. 44, 1931.