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XIII. The Technique of Field Experiments

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arise are those which are evolved by the research worker himself and which suit his own particular conditions.

PRACTICAL DETAILS OF EXPERIMENTATION ON ORDINARY COMMERCIAL FARMS

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EXPERIMENTAL plots on the commercial farm call for labour of an unusual kind at busy seasons of the year, and there is sometimes a certain amount of difficulty in inducing farmers to co-operate with experimental stations in field work. Our experience has been that having once accepted an experiment the disturbance of farm routine has proved less than might have been expected, and farmers have been willing to retain experiments for a period of years. This co-operation is beneficial to both parties; for the research institute can test its findings under different soil and climatic conditions, while the farmer has the advantage of the only fertiliser experiments which he can interpret with confidence, namely those carried out on his own soil. Accordingly the aim should be to design experiments which have sufficient practical bearing to appeal to the farmer, while also providing information on more general questions.

Hitherto most experiments on commercial farms have been on single or in some cases on duplicate plots, but more elaborate arrangements involving higher replication are required to bring out small differences. Moreover, the finer points, if definitely established, are well worth the farmer's notice. The purpose of this paper is to describe the methods used in carrying out modern replicated experiments under the ordinary conditions of commerical farming.

The work has been done during the last few years by members of the Rothamsted Staff. The experimental centres cover a wide radius up to 150 miles from headquarters. Transport has been by train and hired car and the equipment no more than can be carried as passengers' luggage. Usually two supervisors have been required.

Co-operation with the Farm Staff.—The essential for the success of experiments of the kind under consideration is the close co-opera-

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tion between the experimenters and the farmer. The nature of the trial should be fully discussed with him, and any modification which he may suggest should be adopted if found to help the main object in view. The interest and help of the farm foreman is equally necessary, for the arrangements with regard to labour and equipment are usually in his hands, and much time can be saved on the farm if this part of the programme is well looked after. Also it will usually rest with him to see that the experimental area is properly drilled and kept free from any manures which are to be applied to the rest of the field.

Choice of Land.—The experimental error is largely determined by soil variation, and great care is necessary in choosing the site for the experiment. Here again the help of the farmer and his foreman is essential, for cross-cropped or cross-manured areas, wet spots, and even the sites of old dung hills are not always apparent to outsiders. Minor soil variations which exist in every field can also be brought to the notice of the experimenters. A simple test for lime over the proposed area is a safeguard where sugar beet or clover is to be grown, and when an experiment is to remain for a series of years a soil analysis is used as a basis of the choice of a suitable site.

Plot Arrangement.—Latin squares involving four, five or six treatments are the forms preferred for soils of a rather variable character. These are sometimes modified by splitting the plots to take in another comparison, thereby doubling the number of plots without increasing the area, or by interweaving the rows or columns with two varieties of the same crop. If a larger number of treatments than six are to be investigated as in "balance" experiments, randomised blocks are used with four replications. The plots may be split in this form also.

Size of Plots.—Usually the main plots are $^1/_{30}$ to $^1/_{50}$ acre for both cereals and root crops. In root crops these are, if necessary, split into halves, for cereal into quarters (for harvesting by the sampling method). Labour considerations make the total area of more account than the number of plots, and for easy handling it should not exceed $^3/_4$ acre; indeed $^1/_2$ an acre is large enough if a heavy crop of roots and tops is likely to be grown. Up to the present, hay plots have been larger, $^1/_{10}$ to $^1/_{15}$ of an acre is the usual size.

Mixing Manures.—The farmer should be consulted about the scale of dressings, for his previous treatment of the land, *e.g.* the application of dung, will affect this question. Fertilisers of known analysis are always used and dressings worked out in terms of N, P_2O_5 and K_2O. When manures can be mixed at home and taken straight to the field this is desirable, though railway officials and taxi drivers seldom regard 5 cwt. of manure as passengers' luggage. The

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alternative is to send the manures in bulk to the farm well ahead of sowing time and weigh, mix, bag and label on the farm. A portable spring balance reading 20 lb. by ounces is quite satisfactory for this work. The caking of manures on storage renders the despatch of ready mixed manures by goods train rather risky, but it is hoped to overcome this difficulty in future.

Laying-out of Plots.—The experimental equipment consists of chain, crosshead, sighting posts, pegs and string. Plots are set out square, with their length parallel to the line of drilling. Pegs are put in all round the outside boundary and the whole strung along and across to define the individual plots for manure sowing.

Sowing Manures.—After checking the bags on the plots—a very necessary precaution—the sowing is done by hand. Farm hands do this job quite well if the nature of the work is explained. The stringing renders the chance of mistakes very small, and the supervisors can usually lend a hand with the work.

Locating the Plots.—Two of the corners of the experimental block are permanently fixed by driving in at each of them a stout peg level with the ground. The distance from these sunk pegs to substantial posts in the field boundary is ascertained. As a safeguard against the loss of these posts, measurements are taken which enable them to be picked up from permanent land-marks (gateposts, trees, etc.). In rootcrops counting the rows from a definite point is an aid to picking up the experimental area. On leaving the experiment it is necessary to define the corners with conspicuous posts in order to avoid the area being run over by the farmer's own manures. The subsequent operations on the experimental area are now carried out exactly as the rest of the field and its presence is no hindrance to the farm.

Field Observations.—A detailed plan of the experiment is sent to the farmer and his notes and comments on the action of the manures are of great value. Special observations may require a visit from headquarters.

Harvest.—More help is required from the farm at this stage than at any other. A few days' notice of the approach of harvest is necessary in order to enable the plots to be separated from the rest of the field and also separated from each other. Swedes and sugar beet are separated by strings, and the farm staff allowed to pull and top them on the plots. Here again little supervision is necessary when the job is understood. Potato plots are separated by digging 3-foot lanes across the rows and one picker for each plot along the frontage is made responsible for the potatoes spun or ploughed out in his area (defined by stakes). If potatoes are hand dug only stringing across the rows is necessary. Potatoes are sacked up and weighed on

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a corn scale. Beet and swedes are weighed in a pignet on a tripod roughly constructed on the farm, using a 200 lb. spring balance.

Cereals are harvested by the sampling method, which is the subject of a paper by Mr. Watson. Hay is cut by the farm methods when $^1/_{10}$ acre plots are used and separated on the ground by strings. It is made and cocked by hand on the plots and weighed as described for sugar beet.

Sampling.—Soil samples are taken from the unmanured plots in case analytical work seems desirable from the yield data. Sugar beet is sampled for sugar, and hay for dry matter, every plot being treated independently. This is quite an appreciable addition to the labour of harvesting.

Labour Considerations.—The amount of work entailed by replicated experiments is regarded as a serious matter not only by farmers but also by many experimenters. The operations on the experiments carried out in the last few years have been timed in order to obtain a rough idea of the labour involved. The data are only to be taken as a very rough guide, for weather and crop conditions give rise to big variations. Since an experiment is seldom less than 32 plots, times have been worked out on this basis. The figures refer to time spent actually on the operations. An allowance must be made for the necessary preparations for starting and for clearing up.

AVERAGE TIMES REQUIRED FOR AN EXPERIMENT OF 32 PLOTS

Mix manures	2 men	1½ hours	Plots $^1/_{50}$—$^1/_{100}$ acre
Mark out plots	2 ,,	1¼ ,,	,, ,, ,, ,,
Apply Manure	2 ,,	2 ,,	,, ,, ,, ,,
Locate Plots	2 ,,	½ ,,	,, ,, ,, ,,
Hay Harvest—			
Weigh out of cock, and sample	4 ,,	9 ,,	,, $^1/_{15}$ acre
Cereal Harvest—			
Sample barley	2 ,,	6 ,,	,, $^1/_{200}$,,
Potato Harvest—			
Sack on plots; plough and 8 pickers		7 ,,	,, $^1/_{50}$—$^1/_{70}$ acre.
Sack on plots; 6 forks and 9 pickers		8 ,,	,, ,, ,, ,,
Weigh sacks on plots	4 ,,	2½ ,,	,, ,, ,, ,,
Sugar Beet Harvest—			
Weigh roots and tops and sample on plots	3 ,,	10 ,,	,, ,, ,, ,,

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Standard Error obtained.—The feature of replicated experiments is the reduction of experimental error and its valid estimation. It may be of interest to summarise the magnitude of the significant differences between treatments as found in recent experiments on the above lines. By the usual convention a significant difference is one exceeding three times the standard error. The figures are as follows :—

MAGNITUDE OF A SIGNIFICANT DIFFERENCE (3 TIMES THE STANDARD ERROR) BETWEEN TREATMENTS IN RECENT REPLICATED EXPERIMENT ON ORDINARY FARMS.

	Number of Experiments	*Significance Difference. Cwt. per Acre*	*Per cent. of Mean Yield*	*Approximate cash value of the Significant Difference*
Hay [1]	11	3·8	13·7	6s. 6d.
Barley Grain	3	2·9	18·8	20s.
Barley Straw	3	2·5	15·7	3s.
Swedes	2	23	8·0	17s. 6d.
Sugar beet roots	5	20	12·1	40s.
Sugar beet tops	2	21	13·2	8s.
Potatoes	10	20	8·3	80s.

[1] By sampling methods.

It is sometimes urged against replicated experiments that they are needlessly complicated for ordinary purposes, though they may reveal points of academic interest. The cash value of the above detectable difference are in most cases quite considerable and represent returns which would cover any reasonable expenditure on manures.

The technique is certainly not too precise for ordinary purposes, and it is doubtful whether a cruder one could give results that could not be obtained equally well by observation.

Scope of the work.—With the limited staff available the amount of work which can be undertaken is small, the chief difficulty being its seasonal character and the fact that the farms are widely scattered. To obtain information over a wider area suitable schemes having a common basis and involving the co-operation of workers at other centres are required. A beginning has been made in this direction, but much remains to be done before the soil types of England will have been carefully examined in their responses to manurial treatment.

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