Problems of Potato Growing

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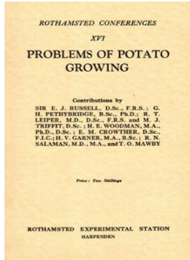

Results of Recent Fertiliser Experiments

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RECENT FERTILISER EXPERIMENTS ON POTATOES

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The art of field experimentation has now reached the stage of development at which it may be applied with confidence and with advantage to examine the behaviour of fertilisers on crops grown commercially on ordinary farms. It is no longer necessary to treat the results of properly conducted field trials with the cautious reserve with which one examines the photographs in the seedsman's catalogues or on the trade stands at agricultural shows. Only the more striking of the older trials and demonstrations received publicity. In many of the trials at experiment stations the conditions were made abnormal, as *e.g.* in the continuous crop experiments at Rothamsted, in order to make the results clear enough to swamp accidental irregularities of soil, season and pests. Farmers were naturally suspicious of applying the results of such experiments and demonstrations to their own land and they tended to rely on compound fertilisers which had proved their value for many years over a variety of soils. One or other of the constituents in these mixtures could generally be relied on to push up the yield and the belief grew up that there was some special virtue in a "properly balanced fertiliser" over and above the obvious one that it covered the risk of making mistakes by one-sided manuring. It must, however, be realised that experience and rough trials with compound fertilisers fail to show which ingredient is in fact effective. They therefore fail to give information which can be used to relate manuring practice to the results of soil survey or analysis.

The modern field experiments, which were first used on several commercial farms in 1927, have the supreme advantage that they show their own accuracy and reliability. Failure to get a significant response does not in any way mean that the experiment has failed, for it is always possible to say how large the effect would need to be before it could be detected. Insignificant responses in accurate experiments suggest that economies could be effected by reducing the amount of the ineffective fertiliser.

The present paper reviews the results of some fifty experiments conducted in the years 1927 to 1933 on ordinary commercial main-crop potatoes on a wide variety of soils—sands, silts, loams, clay loams, light and heavy fenland peats, acid peats, etc. The detailed results of all of the experiments are in the Rothamsted Reports for these years. In rather less than half of the experiments dung was used as a basal dressing, but it is not possible from this series of experiments to assess the value and effects of the dung in these

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basal dressings. Dung was used where it was available and where experience showed that it was needed. It was not used on many of the richer fenland soils.

Frequency of the Responses in Yield

The experiments varied greatly in size, complexity and accuracy. Many were simple 16- or 25-plots experiments testing different amounts of superphosphate. More complex ones had 36 or 81 plots to test different amounts and combinations of nitrogen and potash and a few had 27, 36 or even 162 plots to test all three nutrients. It is not possible therefore to give any satisfactory general average of the responses. The most concise summary is obtained by setting out (a) the numbers which gave signficant responses (or depressions) for each fertiliser and (b) the numbers in which the effect was not larger than could easily have occurred purely by chance variations.

The results are shown for the experiments as a whole and also for a special group of highly organic fenland soils. Every experiment undertaken is included ; there has been no selection or elimination

Significant responses to fertilisers

Nutrient	*Soil*	*Negative*	*Insignificant*	*Positive*
Nitrogen	Fen . .	—	2	11
	Others	—	3	16
	Total (32)	—	5	27
Phosphoric Acid . .	Fen . .	—	—	8
	Others	2	17	13
	Total (40)	2	17	21
Potash	Fen . .	—	5	9
	Others	—	14	8
	Total (36)	—	19	17
INTERACTIONS :	N and P_2O_5	1	9	6
	N and K_2O	—	19	4
	P_2O_5 and K_2O	—	16	1

In 90 per cent. or more of the trials there was a definite response to sulphate of ammonia. Fenland soils, which are rich both in total and in available nitrogen, responded to sulphate of ammonia just as frequently as the mineral soils.

Each of eight fenland soils responded to superphosphate, but only in 13 out of 32 trials did the mineral soils give significant responses to superphosphate. In two experiments superphosphate definitely reduced the yield. In three experiments on acid peat—" moss " soils in Lancashire—there was no phosphate response. It is clear then that fenland soils stand out quite distinctly from other soils in their need for phosphate, as is, of course, well recognised in practice.

In 36 potash trials one half gave definite responses, with some indication that fenland soils were more responsive to potash than mineral soils. In so far as the soils tested in these experiments were typical, they show that sulphate of ammonia is almost always effective and that superphosphate is effective on fenland soils. Superphosphate on mineral soils and potash on all soils are much less consistently successful in increasing yield.

Some evidence on " balance " in fertilisers may be obtained from experiments where two fertilisers were tested both alone and together. If one fertiliser increases the effectiveness of a second fertiliser, then the response to the mixture should be greater than the sum of the responses to the separate fertilisers. It is unlikely that any such interaction will be detected unless one or other has a marked effect when used alone. If a soil is acutely deficient in potash it may not show a nitrogen response until the potash deficiency is corrected ; nitrogen and potash might then show a positive interaction. If, however, both fertilisers have marked effects then it is unlikely that the two together will have a much greater effect than the sum of the two separate effects, for yields cannot be pushed up indefinitely. The experiments show that sulphate of ammonia and superphosphate quite often " interact positively," i.e., they frequently reinforce each other's effect. Thus in 6 out of 16 trials the response to sulphate of ammonia in the presence of superphosphate was significantly greater than that in the absence of superphosphate, or, alternatively, the response to superphosphate was greater in the presence of sulphate of ammonia than in its absence. This harmonises with the striking effects of superphosphate on fenland soils, for these are known to be rich in available nitrogen. The interactions of nitrogen and potash and of potash and phosphate were much less frequent. Positive significant effects were obtained 4 times out of 23 for nitrogen and potash and only once in 17 trials for potash and phosphate.

Size of the Responses in Yield

So far no notice has been taken of the sizes of the response. Field experiments are rarely accurate enough to detect as significant responses which would be too small to be profitable but, on the other hand, apparently large and profitable increases in small experiments may be essentially accidental results. In most of these experiments the standard error per plot was about 15 cwt. per acre and a response of 1 ton per acre would be detected as significant in an experiment with 16 or 25 plots. The size of the responses in the present series of experiments may be illustrated by setting out the responses to certain standard dressings which occurred in most of the experiments:

N=0.4 cwt. N per acre or 2 cwts. of sulphate of ammonia per acre.
P=0.6 cwt. P_2O_5 per acre or 4-5 cwts. of superphosphate per acre.
K=1.0 cwt. K_2O per acre or 2 cwts. of sulphate of potash per acre.

		Decrease		*Increase*						
Response in cwt. per acre ..		20-10	10-0	0-10	10-20	20-30	30-40	40-50	50-60	*Over* 60
Nitrogen ..	Fen Soils	—	1	1	1	1	6	2	—	1
	All Soils	—	3	3	5	7	9	3	1	1
Phosphoric Acid	Fen Soils	—	—	—	1	2	2	1	2	—
	All soils	3	9	8	7	4	5	2	2	—
Potash	Fen soils	1	3	1	3	2	—	—	2	2
	All soils	1	7	11	7	4	—	—	3	3

The comparisons are restricted to plots which received the other two nutrients with and without the one under test. The results are set out by showing the number of experiments in which the response in cwts. of potatoes per acre was from 0 to 10, 10 to 20, and so on. The actual responses are subject to large and unequal errors but the results as a whole are clear enough to illustrate the main features.

The responses to 2 cwts. of sulphate of ammonia per acre were between 1 and 2 tons of potatoes per acre in just one half of the experiments, and the other results are grouped round these values, some above and some below, in such a way as to make it possible to speak of a general nitrogen response at the rate of about 15 cwts. of potatoes per cwt. of sulphate of ammonia.

The responses to superphosphate were much less consistent. In over one-quarter of the trials the superphosphate plots yielded less than those without superphosphate. Only in one-third of the trials did the response exceed 1 ton per acre ; these more responsive centres included 7 of the 8 fenland trials and only 6 of the 32 trials on other soils. Phosphate response obviously depends on the soil.

The responses to potash were even less consistent than those to superphosphate. At half of the centres the responses were less than 10 cwts. of potatoes per acre. 30 of the 36 trials fall into a consistent group with small responses but the other six centres (4 on light fenland soils and 2 on light sands) show enormous responses of about 3 tons per acre. In isolated soils potash fertiliser doubled the crop. Some soils have an acute potash shortage whilst the majority of potato soils show only slight effects in yield. The common recommendation of potash for potatoes would appear to be mainly an insurance against the chance of acute shortage of potash, but the general use of compound fertilisers provides no opportunity for detecting the soils which are acutely deficient in potash.

Although responses to sulphate of ammonia are general, responses to superphosphate and potash obviously vary greatly from soil to soil. Efficient manuring must take account of these soil differences.

It may be noted that the Rothamsted experiments of 1927 to 1932 which are included in the above summary gave much smaller res-

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ponses to potash fertilisers than had been obtained on the same farm from 1921 to 1926. The explanation may be that in the earlier years little stock was kept and little dung was used on the farm. Further, in several years of the earlier period the experiments on potatoes had no dung but received large dressings of fertilisers. In the later years the potatoes always had a basal dressing of dung and the experimental dressings of fertiliser were smaller. The results of the earlier experiments are given in Sir John Russell's Bulletin 28 of the Ministry of Agriculture, Second Edition, 1933, page 154.

Potato Quality and Composition

In this country there have been few systematic studies of the effect of fertilisers on potato quality. On the Continent, where potatoes are used as industrial raw materials for starch or alcohol production, it is customary to quote "starch percentages" in fertiliser trials or to express the yields as starch per acre instead of as tons of fresh tubers per acre. Actually the data express only densities or dry matter contents ; they are determined not by chemical analysis but by weighing the samples in air and then in water and using standard tables. The results have little bearing on "cooking quality" and in any case "cooking quality" is a matter of taste which varies from country to country. There is some evidence that good boiling or steaming quality depends on a high ratio of starch to protein or alternatively on a low nitrogen percentage on the dry matter.

In 1929 Rothamsted had an opportunity of collaborating with Dr. Lampitt of Messrs. Lyons who undertook careful cooking trials and chemical analyses on the produce of all of our experimental plots. Rothamsted continued the analytical work in the subsequent years.

Marks for Quality of Steamed Potatoes (1929)

Cwts. K_2O per acre	*Woburn*	*Rothamsted*	*Cwts. N per acre*	*Woburn*	*Rothamsted*
0	32.6	28.5	0	34.4	29.2
0.5	33.6	29.5	0.3	33.3	29.3
1.0	34.5	29.6	0.6	32.9	29.1

Effect of Potash Fertilisers on Dry Matter Contents of Tubers

	No Potash	*Sulphate*	*Muriate*	*30 per cent Potash Salt*	*Rate of Dressing cwts. K_2O per Acre*
Woburn 1929	27.5	26.7	26.2	24.8	1.0
Rothamsted 1929	26.1	25.9	24.9	24.2	1.0
,, 1930	23.1	23.3	22.7	22.1	0.8
,, 1931	20.9	20.5	20.2	20.2	0.8
,, 1932	22.6	22.1	—	—	0.8

Effect of Sulphate of Ammonia on Nitrogen Content of Dry Matter of Tubers

Rate of Application, cwts. per acre	0	1	1.5	2	3	4
Woburn 1929	1.44	—	1.49	—	1.54	—
Rothamsted 1929	1.52	—	1.58	—	1.65	—
,, 1930	1.34	1.40	—	1.47	—	—
,, 1931	1.40	1.41	—	1.46	—	—
,, 1932	1.28	—	—	1.35	—	1.43

Unfortunately 1929 was a drought year and our yields were low and irregular. The cooking quality tests were probably more irregular than would be obtained in more normal years. They showed that fertilisers had no effect on quality for frying and that sulphate of ammonia slightly decreased and potassic manures slightly increased quality for steaming. The effects of fertilisers were, however, small by comparison with the effects of different soils. It was impossible by manures to raise the quality of our Rothamsted potatoes to the level of our Woburn potatoes. There were no clear results on the relative values of sulphate and chloride of potash.

The analytical data for experiments in four years at Rothamsted and one year at Woburn show that potash fertilisers reduce the dry matter contents of the fresh tubers, especially in dry seasons. Sulphate of potash had little effect, muriate of potash had more and 30 per cent. potash salt much more.

Sulphate of ammonia consistently increased the nitrogen content of the dry tuber. Superphosphate reduced the nitrogen content of the dry tuber in those years in which it greatly increased the yield. Potash had no effect on the nitrogen content of the dry tuber.

Although the potato is essentially a carbohydrate food it is interesting to observe that it is an efficient crop for converting inorganic nitrogen—sulphate of ammonia—into vegetable protein. The recoveries in the potato tuber of the nitrogen added as sulphate of ammonia in the Rothamsted experiments of 1929 to 1932 were 21, 43, 29, and 36 per cent. respectively ; in addition 20 per cent. may be recovered in the haulm.

The results already available suggest that the effects of fertilisers on potato composition are relatively small and unimportant unless there is a wide price range for quality or unless fertilisers are used in very heavy dressings.

Future Experiments

The experimental data presented are admittedly incomplete and need to be supplemented by very many more field experiments, both by simple experiments on the direct effect of fertilisers on commercial farms and by more complex experiments at research stations and colleges. Farmers with heavy fertiliser bills might find that an adequate fertiliser trial would point the way to considerable economy and to greater efficiency. Other farmers might find that comparatively small outlay on the proper fertilisers would greatly

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increase their returns. It is possible that our tests were made on land of more than normal fertility and that in practice good responses would be obtained more frequently. Now that there is to be a national body to effect economies in marketing it would be well to consider whether there is not room for more systematic enquiry on economies in production. Each good field experiment has general as apart from purely local value, for up to the present little headway has been made on the old and fundamental problem of relating fertiliser practice to the results of soil examination. The problem can only be studied seriously where there is a mass of reliable field information to provide standards for testing the value of methods before they are used for advisory work. If the results are to have value in practice they must be standardised in practical terms on typical commercial land.

Analytical results for readily soluble potash in soils from some of the **1932** and **1933** potato experiments already discussed may be quoted to illustrate the possibility of detecting acute deficiences by analysis.

Amount of Potash Soluble in one per cent. Citric Acid
(parts per 100,000 of soil)

	Mineral Soils	*Fenland Soils*
Soils with large potash responses (2 tons per acre or more)	4	8, 10, 12, 15
Soils with small or no potash response ..	12, 17, 19	21, 28, 34, 38

Although there is a certain amount of overlapping there can be no doubt that this or some other improved method of soil analysis could be used with advantage to detect cases of acute potash shortage.

The experiment stations need to concentrate on more complicated experiments which are at present beyond the resources of the commercial farm. Thus, they must study not merely the effects of fertilisers and organic manures in a single year but also the residual effects over several years. Again, they should provide standard experiments which should run year after year to ascertain how far the responses to fertilisers on a single soil vary from season to season. We have already experiments of both of these types at Rothamsted with one of the latter type running parallel at Woburn. The results of the first four seasons are already interesting. Thus, potatoes responded to potash on heavy land at Rothamsted in three of these four seasons but not in any one on light land at Woburn. On the other hand both barley and sugar beet responded in two seasons at Woburn but not in any one at Rothamsted.

A number of such standard experiments would provide a basis for interpreting the results of isolated experiments on ordinary farms and, in addition, they would throw light on the still more important problem of discovering the conditions under which fertilisers act and the way in which the plant feeds.