PLACEMENT OF FERTILIZER FOR POTATOES

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(With One Text-figure)

INTRODUCTION

There are obvious advantages in concentrating fertilizer close to the seeds of crops, provided that safe methods can be devised. High local concentrations limit fixation processes in the soil and supply adequate nutrient to the plants in their early stages. Superphosphate and modest amounts of mixed fertilizer can be drilled safely with cereal seeds. Other crops are more sensitive to damage by soluble salts, and special techniques must therefore be worked out for the principal classes of crops before controlled fertilizer placement can become general.

Workers in the United States have conducted numerous field experiments since 1930 to determine the best method of applying fertilizer for potatoes planted mechanically. The early experiments showed that localized application in bands was superior to the older practice of mixing broadcast fertilizer with the soil. The more important band-placement methods tested in later experiments were: sideband placement at various distances from the seed; placement in 'broken' bands a few inches long beside the seed; 'Hi-Lo' band placement where one band was placed on a level with the seed and another band 2 or 3 in. deeper in the soil; plough-furrow placement. The earlier work was thoroughly reviewed by Cumings & Houghland (1939), while later experiments have been summarized by Brown (1946). The main conclusions from this American work were:

(1) Fertilizer placed too close to the seed usually caused delayed emergence of the shoots and a reduction in yield.

(2) Consistently high yields were given by bands of fertilizer 2 in. away, and a little below the seed. This method was, on the whole, better than broadcasting the fertilizer, or placing it in bands in other positions.

(3) Placement in a band at one side of the row gave lower yields than bands at each side.

(4) Modifications of side band placement, such as 'broken bands' or 'Hi-Lo' placement, did not give better results than ordinary sideband placement and increased the mechanical difficulty of applying the fertilizer.

(5) Fertilizer applied in whole or part on the plough furrow produced no better results than that applied in sidebands.

American and British potato growers have widely different cultural practices. It may well happen that an outstandingly successful method of applying fertilizer under one set of conditions will have no special merit under quite different ones. Following general local practice the American fertilizer placement experiments were made on seed potatoes cut into smaller pieces and planted mechanically on unridged land in rows 36 in. apart or a little less. Cut sets are particularly liable to damage from fertilizer salts placed close to them; mechanical planting on flat land makes it relatively easy to apply fertilizer in safer and more effective positions; wide spacing would unduly dissipate broadcast fertilizer. As the result of the early experiments a large range of combined potato planters and fertilizer distributors was developed, and it has been stated that 'at the present time practically all of the commercial acreage (in the United States) is planted with the fertilizer placed in bands two to three inches wide and one to two inches to each side of the seed' (Martin & Campbell, 1946). In British practice, potatoes are normally planted by hand as whole seed in furrows about 28 in. apart. Apart from climatic and soil differences there are sufficient differences in cultural practices in potato growing between the two countries to make it necessary to examine the whole question of methods of fertilizer placement for potato growing by the usual methods practised in Britain.

Current British methods of applying fertilizer to potatoes

The common method of planting, by which land is ridged, whole potato sets planted by hand or by machine in the bottoms of furrows and the ridges split back over the seed, allows a variety of techniques with some degree of fertilizer placement. The fertilizer may either be broadcast over the whole surface of the ridge immediately before planting, so that, after planting and splitting the ridges, it is concentrated over and around the seed potato, or it can be distributed along the bottom of the furrow so that fertilizer is placed in contact with the seed. In the more important English potato-growing areas, the first method is usually employed. Many growers have, however, modified their broadcast distributors so that a band of fertilizer is dropped into the bottom of the furrow. Occasionally,

potatoes are planted directly on the band of fertilizer but, more usually, a cultivator is used to pull down a little soil from the side of the ridge to separate the seed potato from the fertilizer. In some areas where potato growing is not practised so extensively, fertilizer is broadcast after ploughing but before the land is ridged up for planting; usually this is done for practical convenience but sometimes in the belief that the fertilizer should be distributed as completely as possible through the cultivated layer of the soil. Again, in some areas where potatoes were not grown before the war and ridging ploughs are not available, seed potatoes are ploughed in with an ordinary plough, the fertilizer being broadcast either before or after planting.

The number of potato-planting machines increased markedly in the last decade and 7120 were in use in England and Wales in 1948. Some have a fertilizer attachment designed to place fertilizer either in the same furrow as the seed or in a band separated from the seed by a layer of soil. The machines are usually built to work on flat unridged land, planting the seed and covering it over with a ridge of soil.

The present investigation was undertaken primarily to determine the best way of applying fertilizer to potatoes planted in furrows, but it brings out some of the principles to be embodied in combined fertilizer distributors and potato-planting machines.

Scope of the experiments

For satisfactory field experiments on fertilizer placement it is essential that the amount of fertilizer applied should be known accurately, and that the machine should deliver fairly constant rates from day to day. A far higher precision in rates of application is needed in experimental work on contrasted methods than would be required in a commercial machine of any one pattern. The delivery rates of most commercial distributors depend very much on the condition of the fertilizer and the humidity of the atmosphere (Mehring & Cumings, 1930). For this investigation, the National Institute of Agricultural Engineering designed and constructed a two-row fertilizer distributor having a positive displacement top delivery hopper. The machine, which has been described elsewhere (National Institute of Agricultural Engineering, 1946–7), was designed to work in land already ridged, the potatoes being afterwards planted by hand in the usual way. An account has been given of the performance of the delivery system of the machine (Cooke, 1947), special attention being given to consolidation of fertilizer by upward pressure of the piston, jolting on rough land and the condition of the fertilizer. Laboratory tests and subsequent experience on other crops showed that granular fertilizers gave more constant rates of delivery, but all potato experiments described in this paper were carried out with powdered fertilizer.

The methods of application chosen for investigation were:

A. Fertilizer was broadcast on the cultivated land before it was ridged up for planting.
B. Fertilizer was broadcast evenly over the ridges before planting.
C. Fertilizer was placed in the bottom of the furrows in a band so that after planting it would be in contact with the seed.
D. Fertilizer was placed in two bands, each 2 in. below the bottom and 2 in. from the centre of the furrow.
E. In four experiments in 1945, a test was made of a band of fertilizer 2 in. below the bottom of the furrow.

There are many ways of applying fertilizer which will give varying degrees of concentration around the seed. It is impossible to test all the local variants of any one practical method in a series of experiments carried out in several counties and in this investigation only two well-defined methods of broadcast application have been tested. Local practices and refinements of the various techniques can be tried best by investigators working in their own areas.

The methods chosen for testing cover the main conditions of practical importance and show the effects of the maximum dilution of fertilizer with soil (broadcasting before ridging) and the maximum concentration (single band in contact with the seed). The approximate position of the fertilizer is shown diagrammatically in Fig. 1 for each method before planting, and also after the ridges have been closed after planting.

Fertilizers used

In each year a uniform batch of the National Compound Fertilizer recommended for potatoes was used in the powdered form. The analyses varied slightly, according to the supplies of potash available, and were:

	% N	% P_2O_5	% K_2O
1945	7	7	12
1946	7	7	9
1947	7	7	10·5

Design and layout of the experiments

In four experiments laid down in 1945 broadcasting before ridging was not tested, the fourth treatment being placement below the seed (E). This proved to be an inefficient method of applying fertilizer and was not tested further. The first four methods listed above (A, B, C, D) were tested in fifteen experiments in 1946 and ten experiments in 1947. The individual plots were generally of six rows and 22 yards long. Each experiment had

thirty-two plots and the most convenient arrangement was found to be a strip of 88 yards along forty-eight rows, giving four lines of eight plots. Each method of fertilizer application was tested at three rates (approximately 5, 10 and 15 cwt. per acre) with unmanured plots corresponding to rate nil for each method. In 1945 and 1946, but not in 1947, the machine ran over the land with the coulters in position on the unmanured plots to measure cultivation effects as such, but the differences were negligible. The arrangements of plots were restricted in some of the earlier experiments, but with increasing experience and after modifications in the machine the 1947 experiments were laid out as two blocks of sixteen randomized treatments. In two of the 1945 experiments there were two blocks of four plots for methods, each plot being split along its length for the four rates. In the other two experiments of 1945 and in all fifteen experiments of 1946, one degree of freedom from methods by rates was confounded to give four blocks of eight plots.

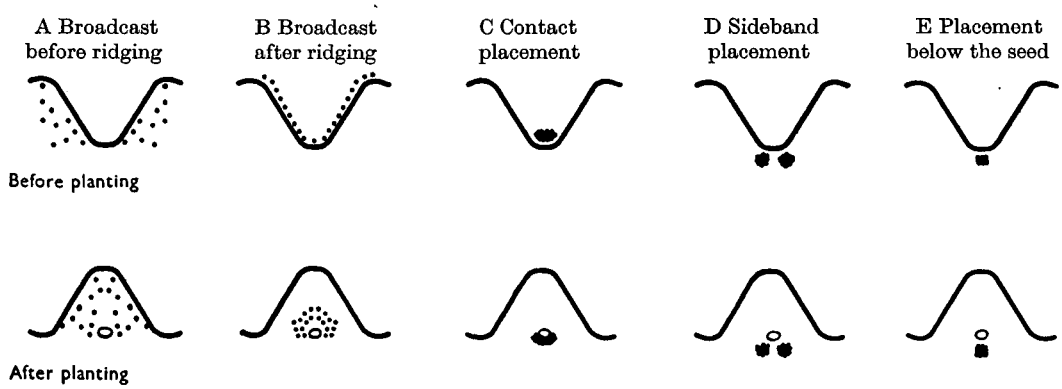

Fig. 1. Diagrammatic representation of five methods of fertilizer placement for potatoes.

The area was marked out as soon as preliminary cultivations for the crop were complete, and applications were made to plots having fertilizer before ridging. The land was then ridged and the placement machine was used to apply fertilizer in the bottom of the furrow (contact placement), and in sidebands below the furrow bottom. Fertilizer was deposited in the furrow bottom by raising the coulters and arranging the feed tubes so that they applied a band of fertilizer about 2 in. wide. For sideband placement, the coulters were set at the appropriate spacing and depth and were lowered on entering the plot. The bands of fertilizer deposited in the soil were about 1·5 in. wide. As the machine fertilized two rows at once and the tractor drawing it covered three rows, work was started on the centre line of the experiment and proceeded clockwise to avoid disturbance of fertilized plots by the outside tractor wheel. The machine started on the left hand of the centre line of the experiment and worked to the other end of the field applying fertilizer to the appropriate plots. It then made a right-hand turn into the first two rows on the right-hand side of the centre line. The experimental area was worked through in this way. As the machine passed from plot to plot, the coulters were raised or lowered as was necessary, while the rates of application were varied by altering the ratios in the gearbox. For each experiment, the rate of application of placed fertilizer was determined by a field calibration in each gear. The machine was run over a measured distance, and the flow of fertilizer was diverted into collecting boxes and weighed. Small variations in delivery rate which occurred from centre to centre have already been discussed elsewhere (Cooke, 1947). Finally, on appropriate plots, fertilizer was broadcast over the ridges by hand at a predetermined rate which was constant from centre to centre. The potatoes were planted by hand as soon as possible and ridges were split back in the usual way. Using this procedure it was possible to lay out randomized block experiments and eliminate the edge rows of plots. In much earlier experimental work with machinery it had been found necessary to use long single-row plots, often in systematic arrangement. After planting, each experimental area was treated in the same way as the rest of the field. Cultivations and spraying were done by the farmers in accordance with local practice. During the growing season, periodical observations were made on each experiment to assess any checks to growth caused by fertilizer placed too near the seed. At harvest, the centre four rows of each plot were lifted by hand, a short length of row being discarded at each end of the plot. The potatoes were weighed and graded into ware and seed sizes.

RESULTS OF THE EXPERIMENTS

Total yield of potatoes

The mean unmanured yields and mean increases in yield given by fertilizer for all experiments in each year are set out in Table 1.

In the mean of four experiments in 1945, contact placement was superior to sideband placement and broadcasting after ridging at the low rate of application; at higher rates, there was little to choose between the three methods. Placement directly below the seed was less efficient at higher rates than the other three methods tested. American results confirm that placement below the seed is less efficient than sideband placement and this method was not tested in subsequent years.

Fifteen experiments in 1946 and ten in 1947 tested the same methods of application and gave concordant results. In both years, broadcasting before ridging was much inferior to the other methods tested. There were no appreciable differences between broadcasting over the ridges and the two methods of placement, except that in the 1947 experiments fertilizer placed in contact with the seed at the high rate depressed the yield. This effect, which is discussed later, was caused by the very dry spring.

Table 1. *Unmanured yields and yield increases from fertilizers applied in different ways, in tons potatoes per acre*

Year	No. of exps.	Mean yield without fertilizer	Approximate rate of dressing* (cwt. per acre)	Mean increase in yield from fertilizer: Broadcast before ridging (A)	Broadcast after ridging (B)	Placed in contact (C)	Placed as sidebands (D)	Placed below seed (E)
1945	4	4·80	4	—	2·06	3·34	2·44	2·46
			8	—	4·21	4·88	4·92	4·00
			12	—	5·37	4·88	5·30	4·45
			Mean	—	3·88	4·37	4·22	3·64
1946	15	6·75	5	1·24	1·91	2·35	2·05	—
			10	2·85	3·62	3·47	3·73	—
			15	3·46	4·34	4·50	4·02	—
			Mean	2·52	3·29	3·44	3·27	—
1947	10	7·09	5	0·90	1·48	1·73	1·82	—
			10	1·84	2·15	2·36	2·44	—
			15	2·38	2·70	2·13	2·85	—
			Mean	1·71	2·11	2·07	2·37	—
				Broadcast			Placed	
		*Actual rates (cwt. per acre)	1945	4·0, 7·9, 11·8			4·0, 7·9, 11·8	
			1946	4·8, 9·6, 14·4			5·2, 10·5, 14·5	
			1947	5·0, 10·0, 15·0			6·0, 12·3, 17·1	

Differences between methods assessed by response to a standard quantity of fertilizer

There were inevitable irregularities in the amounts of fertilizer applied by the placement machine at different centres. The yields for exactly 5, 10 and 15 cwt. per acre of fertilizer were estimated graphically for each method by straight-line interpolation between points on either side of the desired rate. The mean of the responses to 5, 10 and 15 cwt. per acre was taken as an estimate of the response to 10 cwt. per acre of fertilizer. This method was preferred to assuming the form of the response curve because there was no reason to expect the curvatures to be the same for different methods of application, especially where there might have been damage by certain methods at the high rate.

The estimated responses to 10 cwt. of fertilizer per acre are given in Table 2 for each of the experiments in 1946 and 1947, together with mean values for all the experiments in each year. Standard errors of the annual means were estimated from the interaction between centres and methods. These standard errors provide drastic tests of the consistency of the differences as they include not merely all the local soil and other irregularities, but the contrasts between centres in the relative effects of the different methods. Significant differences established in this way would be expected to recur over a wide range of soil conditions.

In 1946, broadcasting after ridging, contact placement and sideband placement were all significantly superior to broadcasting before ridging, but there were no significant differences between the three methods of applying fertilizers after ridging. In 1947, broadcasting before ridging again gave lower responses than any of the methods of applying fertilizer after ridging, but the differences were not statistically significant. The responses for the 2 years are summarized in Table 3 with the mean responses and standard error for the 2 years' results treated as a single set without eliminating any differences due to the year in which the experiments were made. Broadcasting before ridging was significantly inferior to the other three methods, which showed no appreciable differences between themselves.

The advantage of applying fertilizers after ridging was determined by comparing the mean responses

for the three methods of application after ridging with the response given by broadcasting before ridging. Broadcasting before ridging was significantly inferior to applications of fertilizer after ridging in each year and on the mean of the two years. The difference was large in 1946 and small in 1947.

yields given by 5 and 10 cwt. per acre obtained by straight-line interpolation from the yield curves for each experiment (Table 5). The three methods gave very similar results. There were no significant differences between methods in any one year or in the mean results for the 3 years.

Table 2. *Unmanured yields and responses to* 10 *cwt. per acre of fertilizer, in tons potatoes per acre*

	Yield without fertilizer	Response to fertilizer broadcast		Response to fertilizer placed	
		Before ridging (A)	After ridging (B)	In contact (C)	As sidebands (D)
	1946 experiments				
Dunstable, Beds	2·50	2·47	3·83	3·50	3·97
Silsoe, Beds	7·87	3·77	4·20	4·20	4·03
Horseheath, Cambs	7·16	3·66	3·85	1·83	4·09
Swaffham Prior, Cambs	5·78	1·54	4·12	4·32	2·31
Hemel Hempstead, Herts	3·99	4·40	5·41	5·93	5·72
Leverstock Green, Herts	9·04	0·76	1·88	1·12	1·33
Little Berkhamsted, Herts	5·99	3·81	3·89	4·46	4·16
Rothamsted, Herts	7·25	3·94	4·91	5·40	5·63
March, Isle of Ely	7·46	0·82	1·94	2·01	1·66
Amber Hill, Holland Division, Lincs	7·87	3·40	3·48	3·39	3·27
Kirton, Holland Division, Lincs	9·76	2·48	2·16	2·26	2·48
Leverton, Holland Division, Lincs	12·26	2·53	2·57	3·53	2·57
Caistor, Lindsey Division, Lincs	8·45	2·05	3·82	3·42	3·73
Lewes, Sussex	1·12	0·85	0·90	2·07	1·48
Salisbury, Wilts	4·80	1·45	2·52	3·53	1·68
Mean (15 experiments) ±0·166	—	2·53	3·30	3·40	3·21
	1947 experiments				
Silsoe, Beds	4·91	2·55	2·67	2·43	3·51
Stapleford, Cambs	7·43	0·88	1·90	1·04	1·67
Swaffham Prior, Cambs	3·99	1·93	2·02	3·70	2·64
Harpenden, Herts	4·32	0·78	1·52	1·54	1·08
Rothamsted, Herts	6·88	2·09	2·42	1·50	2·57
Mepal, Isle of Ely	11·79	1·12	1·93	1·15	0·75
Holbeach, Holland Division, Lincs	9·29	2·14	2·24	2·63	3·17
Leverton, Holland Division, Lincs	8·19	0·86	1·60	1·55	2·14
Branston, Kesteven Division, Lincs	7·78	1·82	2·32	1·83	1·74
Caistor, Lindsey Division, Lincs	6·34	2·86	2·46	2·06	1·97
Mean (10 experiments) ±0·153	—	1·70	2·11	1·94	2·12

Table 3. *Response to* 10 *cwt. fertilizer per acre, in tons of potatoes per acre*

Year	No. of exps.	Mean	Broadcast: Before ridging (A)	Broadcast: After ridging (B)	Placed: In contact (C)	Placed: Side-bands (D)
1946	15	—	2·53	3·30	3·40	3·21
1947	10	—	1·70	2·11	1·94	2·12
Both years	25	±0·111	2·20	2·82	2·82	2·77

Table 4. *Response to* 10 *cwt. fertilizer per acre applied before and after ridging, in tons of potatoes per acre*

	1946 (15 exps.)	1947 (10 exps.)	Both years (25 exps.)
Before ridging	2·53	1·70	2·20
After ridging	3·30	2·06	2·80
Difference	0·77	0·36	0·60
Standard error	0·192	0·176	0·128

In the first year of these experiments (1945) the methods tested were broadcasting after ridging, contact placement, sideband placement and placement below the seed. The first three methods were identical with those tried in 1946 and 1947. As the rates used in 1945 were lower (approximately 4, 8 and 12 cwt. per acre), the results for the 3 years have been brought together by calculating the response to 7·5 cwt. per acre of fertilizer from the

Relative efficiencies of methods of applying fertilizer

The mean results of the experiments for each year given in Table 1 were used to estimate the relative efficiencies of the methods of application, taking the common practice of broadcasting over the ridges as the standard. For each method the yield of potatoes was plotted against the amount of fertilizer applied. A smooth curve was drawn for broadcasting over the

ridges and the efficiencies of broadcasting before ridging, contact, and sideband placement were determined by reading off the amounts of fertilizer applied broadcast over the ridges required to give yields equal to those given by the other methods of application. The values found are expressed in Table 6 as percentages of the amount of fertilizer actually applied.

Table 5. *Response to 7·5 cwt. of fertilizer per acre applied in three ways, in tons of potatoes per acre*

Year	No. of exps.	Broadcast after ridging	Placed: In contact	Placed: As sidebands	Standard error
1945	4	3·70	4·26	4·07	0·214
1946	15	2·76	2·84	2·75	0·124
1947	10	1·81	1·76	1·84	0·160
Mean of all years	29	2·56	2·66	2·62	0·089

Table 6. *Relative efficiencies of four methods of application taking broadcasting after ridging as the standard*

Year	No. of exps.	Approximate rate of fertilizer applied cwt. per acre	Broadcast: Before ridging (A)	Broadcast: After ridging (B)	Placed: In contact (C)	Placed: As sidebands (D)
1945	4	4	—	100	158	117
		8	—	100	122	125
		12	—	100	82	97
		Mean	—	100	121	113
1946	15	5	67	100	113	99
		10	76	100	87	97
		15	63	100	116	81
		Mean	69	100	105	92
1947	10	5	54	100	113	125
		10	76	100	95	100
		15	79	100	57	105
		Mean	70	100	88	110

In 1945, both placement methods were, on the whole, more efficient than broadcasting over the ridges, and there was a pronounced tendency for them to be more efficient at low than at high rates.

In both 1946 and 1947, broadcasting before ridging was very inefficient, the mean efficiencies for the 2 years agreeing closely. Ten cwt. of fertilizer applied broadcast before ridging will be required to give yield increases equal to those given by 7 cwt. of fertilizer broadcast after ridging. Over the 2 years, contact and sideband placement had approximately the same average efficiency as broadcasting after ridging, except that in 1947 contact placement was very inefficient at the heavy dressing through damage to early growth during the very dry spring.

Yields of ware potatoes

In each year the yield of ware potatoes was determined at most experiments using a 1½ in. riddle. There were no over-all effects of the different methods of fertilizer application on the percentage of ware tubers. The mean results for the 3 years are given in Table 7.

Emergence and early development of the crop

In 1945, observations on the crops soon after emergence and during the growing season revealed no checks to growth due to fertilizer placed near to the seed. Plant counts made at three centres soon after emergence was complete showed no differences due to any of the methods of application. In 1946, observations were again made on the growing crops and showed that contact placement had no harmful effect on early development at any of the centres.

In 1947, there was a long dry period in the late spring and in three of the ten experiments growth was seriously checked by certain treatments. At Stapleford (Cambs) the high rate of fertilizer applied by both broadcasting methods and by contact placement depressed growth seriously in June, but a month later the crop had largely recovered. At Silsoe (Beds) contact placement at the high rate retarded growth in early July, and this effect persisted through the growing season. At Rothamsted growth in late June was seriously retarded by contact placement, but a month later the check had almost disappeared. In each of these three experiments, contact placement gave poor results at harvest time.

Table 7. *Percentage of ware tubers in total crop*

Year	No. of exps.	Broadcast: Before ridging	Broadcast: After ridging	Placed: In contact	Placed: As sidebands
1945	3	—	73	75	73
1946	14	94	94	95	95
1947	8	92	92	93	92

Inspections were made in 1947, during the growing season and at harvest, to determine if the plant population had been damaged by fertilizer application. Only one experiment (Silsoe, Beds) showed

variable plant establishment and a count was made of the number of plants harvested. Fertilizer applied by broadcasting over the ridges, and by contact or sideband placement gave a significantly greater number of plants than no fertilizer. Fertilizer placed in contact with the seed at 17 cwt. per acre depressed the plant seriously although the method was safe at low and intermediate rates.

Weather

Rainfall data recorded at Rothamsted for the spring and summer months of 1945, 1946 and 1947 are given in Table 8. In 1945, the potatoes on the experiments described here were not planted until early in May. From then until harvest time the monthly rainfall was fairly close to the average for 1930–9 except that August was a dry month. In 1946, planting on the experiments started at the end of March and continued through April and early May. Rainfall was deficient in April but was above

Table 8. *Rainfall in* 1945, 1946 *and* 1947 *at Rothamsted*

	1945		1946		1947		Average
	Rain (in.)	No. of rain days	Rain (in.)	No. of rain days	Rain (in.)	No. of rain days	1930–9 rain (in.)
April	1·35	12	0·98	8	2·07	14	2·24
May	2·23	13	2·32	15	1·16	12	2·21
June	2·19	17	2·49	21	2·40	12	2·01
July	2·68	11	2·03	11	1·53	11	2·25
August	1·27	11	3·74	21	0·07	4	2·04
September	2·10	15	3·75	18	1·35	10	2·68
Total	11·82	79	15·31	94	8·58	63	13·43

average in May, June, August and September. The 1947 season was most abnormal. After severely cold weather in February and early March there was heavy rain in the second half of March. It was impossible to work the soil at most centres in early April and potato planting was delayed until late April and early May. At planting time there was adequate moisture in the soil, but at several centres the seed-bed tilths were very poor. There was little rain during late April, May and the first 3 weeks of June while periods of high temperature must have accentuated damage by fertilizer at the three centres mentioned above. At the end of June, heavy storms brought the rainfall up to average for the month. In 1946 and 1947, June rainfall was almost identical, but whereas in the earlier year it fell on 21 days, in 1947 there were only 12 rainy days. July rainfall was below average and there was no measurable rain at Rothamsted between 6 August and 10 September. The check to growth caused by high dressings of fertilizer must be associated with the long dry period from mid-May until the end of June (from 8 May to 26 June, Rothamsted rainfall was only 1·34 in.)

The 3 years show considerable seasonal variation, 1945 may be regarded as a fairly normal year, 1946 was abnormally wet, and 1947 abnormally dry. Taking these major seasonal differences into account, the results given by the different methods of applying fertilizer are remarkably consistent from year to year.

DISCUSSION

Where potatoes are planted by the traditional British method of drawing out ridges, planting the seed in the furrows, and splitting the ridges to cover the seed, there appears to be no advantage in special placement methods. Fertilizer should be broadcast over the ridges immediately before planting. When the ridges are split back the fertilizer will be concentrated over and around the seed. This method of planting and manuring potatoes on ridged land secures, in fact, the advantages of controlled placement which have been obtained in American experiments and practice by using combined fertilizer distributors and potato planters on unridged land.

Most potato planting machines are designed to work on a flat seedbed. With such machines, unless a fertilizer attachment is fitted, there is no alternative to applying the fertilizer before the potatoes are planted. This procedure is equivalent to broadcasting before ridging with ordinary planting methods and makes inefficient use of the fertilizer.

The results of the present investigation are in accordance with the American findings that the best use is made of fertilizer if the planting machines for unridged land are fitted with an attachment to deposit bands of fertilizer about 2 in. away from the seed and a little below it. Fertilizer should not be deposited in contact with the seed owing to the risk of damage to growth in a dry season. Where planting machines are designed to work on ridged land the fertilizer should be broadcast over the ridges before planting.

SUMMARY

In twenty-nine experiments conducted in 1945, 1946 and 1947 placement of fertilizer in contact with the seed or in two bands each 2 in. away and 2 in. below the level of the seed gave average yields similar to those given by the standard practice of broadcasting after ridging but before planting. Placement in one band 2 in. below the seed was tested in four experiments and proved inferior to other placement methods and to broadcasting over the ridges.

Broadcasting fertilizer before ridging was compared with broadcasting after ridging in twenty-five experiments in 1946 and 1947. Applications made after ridging were consistently superior to those made before ridging. The general relationship was that 10 cwt. per acre of fertilizer broadcast before

ridging were required to produce average increases in yield equal to those given by 7 cwt. per acre broadcast after ridging.

Observations on the growing crops revealed no harmful effects of fertilizer placed in contact with the seed in 1945 and 1946. In 1947, however, at several centres growth was severely checked by heavy dressings placed in contact with the seed and the final yields were below those from fertilizer placed in sidebands which caused no early check.

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