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PLACEMENT OF FERTILIZERS FOR SUGAR BEET

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(With Plate 19)

INTRODUCTION

In England fertilizers are usually broadcast for sugar beet. They may be applied after the last ploughing and worked into the soil to a depth of 3 or 4 in. by the cultivations given in preparing the seed-bed. The more general practice, however, is to broadcast on the seed-bed; subsequent harrowing works in the fertilizer to a depth of 1 or 2 in. In other countries of Western Europe fertilizers for sugar beet are generally broadcast at some stage during the preparation of the seed-bed.

Experiments in the United States described by the National Joint Committee on Fertilizer Application (1932-45) have led to the general recommendation (1949) that 'fertilizer applied at seeding time should be placed in a band at one side of the row not more than 1.5 in. to the side of the seed and at a depth of 1-2 in. below seed level'. Drilling fertilizer in contact with the seed often gave good yields when small dressings of phosphate-rich fertilizers were used, but many experiments demonstrated the dangers of the method when heavy dressings were used and when seed-beds were dry; placing fertilizer in bands to the side of the seed was developed as a safe alternative. Workers in the United States have rarely compared broadcasting and placing of heavy dressings of fertilizers containing high proportions of nitrogen and potash such as are commonly applied in England. In some areas of the United States heavy dressings of fertilizers are now applied for sugar beet; Berger & Truog (1945) state that drilling a small amount of fertilizer along the row is not sufficient to produce high yields, and that a portion of the fertilizer should be broadcast or applied on the plough-sole and the remainder drilled beside the seed.

Lewis (1941) described three experiments on sugar beet where complete fertilizer was broadcast and compared with the same dressing placed in bands in different positions close to the seed. Fertilizer in contact with the seed damaged plant establishment; dressings placed in bands 1.5 in. to the side and 1 in. below the seed gave appreciably higher yields of beet than the same dressing broadcast in one of the three experiments. Recent experiments (Cooke, 1949) carried out in 1947 and 1948 showed that damage to the germination of sugar beet was caused when normal dressings of complete fertilizer were drilled

in the seed zone, below the seed or 1 in. to the side. Bands placed at 3 in. to the side of the seed were generally safe. The yields of sugar were reduced by methods of applying fertilizer which reduced the plant population; there was little difference between the yields given by fertilizer whether broadcast or placed in a safe position to the side of the seed.

The experiments described here were made to continue and extend the comparisons of placed and broadcast fertilizer and to determine whether there was any advantage from broadcasting half the fertilizer and placing half beside the seed.

Scope of the experiments

Ten experiments on sugar beet were carried out in 1949 with the help of the Factory Agriculturists of the British Sugar Corporation. The fertilizer used was a granular phosphate-potash mixture containing 16.0% P_2O_5 and 13.4% K_2O . There are no theoretical or practical grounds for placing the full dressing of nitrogen fertilizer beside the seed of a crop such as sugar beet which has a long growing season. Sulphate of ammonia was broadcast by hand uniformly over all the plots of the experiment at rates which were in local general use.

The methods of fertilizer application tested were:

- (1) Broadcast after the last ploughing and worked into the soil by the normal cultivations given in preparing the seed-bed.
- (2) Broadcast on the seed-bed and harrowed in.
- (3) Placed in one band 3 in. below the soil surface and 2 in. to the side of the seed (duplicate plots).
- (4) Half broadcast after ploughing and half placed beside the seed.
- (5) Half broadcast on the seed-bed and half placed beside the seed.

Each method of application was tested at two rates (3.5 and 7.0 cwt./acre) of phosphate-potash fertilizer. The twelve treatment combinations together with four 'no fertilizer' plots were arranged in four randomized blocks of eight plots, a high-order interaction being confounded.

Broadcast fertilizer was applied both at early and late stages in the preparation of the seed-bed to compare the effect of deep and shallow incorporation with the soil. Early applications were normally made after ploughing; the cultivations given to prepare the seed-bed varied with the weather and the nature of the soil, but at most centres the

fertilizer was worked in approximately 4 in. deep. Late broadcast dressings were applied on the seed-bed on the day of drilling and were worked into the soil to a depth of 1 or 2 in. by harrowing either before or after drilling the seed. In experiments in 1947 and 1948 fertilizer placed 1 in. to the side of the seed had damaged germination; to avoid such injury in 1949 fertilizer was placed in a band 2 in. to the side of the seed and 3 in. below the soil surface. (The seed was normally sown 1 in. below the soil surface.) Combinations of both placed and broadcast fertilizer were tested in 1949 to determine whether there was any advantage in combining the two methods of application. Fertilizer placed near to the seed gives a stimulus to sugar beet in the early stages, but the mature plant with a well-developed root system may be able to utilize fertilizer distributed through the soil more efficiently than fertilizer confined to a single band.

Method of laying down the experiments

The plots used were six rows wide and 22 yards long. Each block contained eight plots arranged side-by-side. The first visit was made to each centre before the seed-bed was prepared; the site was marked out and phosphate-potash fertilizer was broadcast on the appropriate plots. When the seed-bed had been prepared by the farmer, a second visit was made. Nitrogen fertilizer was broadcast on all plots, the late dressings of phosphate-potash fertilizer were broadcast and the seed-bed was harrowed to work in the fertilizers. The special drill which has been described previously (Cooke, 1949) was used to sow the seed and place fertilizer beside the seed on appropriate plots. The drill was stopped on plot boundaries while adjustments were made to the fertilizer coulters and to the gearbox governing delivery rates. The fertilizer delivery mechanism of the drill was calibrated at each centre by running over a measured distance and diverting the flow of fertilizer into collecting boxes. Broadcast fertilizer was applied at exactly 3.5 and 7.0 cwt./acre. The differences between the rates of application of broadcast and placed fertilizer as determined by the field calibrations were small, and direct comparisons of the two methods of application were possible.

After sowing each experiment was treated in the same way as the rest of the field. Periodic observations were made to assess the effects of the treatments on germination, establishment and growth of the crop. At harvest the central four rows of each plot were lifted after discarding a length at each end of the plot. The harvested roots were weighed and counted in the field; samples of the beet were taken from each plot for the determination of dirt-tare and sugar percentage. The tops were weighed on each plot.

RESULTS OF THE EXPERIMENTS

Ten experiments of identical pattern were carried out in 1949. The mean yields of sugar and of tops and the plant populations for all the experiments are set out in Table 1. The increases given by broadcast fertilizer, comparisons of early and late broadcasting and comparisons of broadcasting and placing fertilizer were examined for each centre by averaging the two rates of dressing. The effects of different methods of applying fertilizer on the yields of sugar and of tops and on plant population are discussed separately. In stating the results of individual experiments only those effects which were significant ($P = 0.05$) are considered.

Yields of sugar

The overall effect of fertilizer on the yield of sugar was small (Table 1). The average increases in yield for the ten centres given by 5.25 cwt. of phosphate-potash fertilizer were similar whether the fertilizer was all placed beside the seed, broadcast early or late or half was broadcast early and half placed beside the seed. Half the dressing placed and half broadcast late gave slightly higher yields of sugar than the other methods of application. Broadcast fertilizer increased the yield of sugar at the Felstead, Kidderminster and Peterborough centres. There were no consistent differences between the yields given by early and late broadcasting; when half the dressing was placed and half broadcast, late broadcasting was superior to early dressings at Bury St Edmunds. There were no differences between the yields given by placed and broadcast fertilizer.

Yields of tops

On the average of all the experiments all methods of applying fertilizer increased the yield of tops (Table 1). Similar yields were given by placing and early broadcasting of the whole dressing, and by half the dressing broadcast late and half placed. Late broadcasting, and half the dressing broadcast early and half placed, were slightly superior to the other methods of application. Broadcast fertilizer increased the yield of tops at Felstead, Kidderminster, Peterborough and Spalding. Late broadcasting was superior to early broadcasting at Kidderminster. When half the dressing was placed and half broadcast, early broadcasting was superior to late dressings at Felstead. At Spalding broadcasting gave more tops than placing both when half and when the whole dressing was broadcast. At Bury half the fertilizer placed and half broadcast gave more tops than the whole dressing broadcast.

Plant population

Observations during spring and summer showed no check to germination at any centre caused by the

heavy dressing of fertilizer placed 2 in. to the side of the seed. The different methods of applying fertilizer had only small and irregular effects on the plant population at harvest (Table 1). Broadcast fertilizer increased the plant at Kidderminster. There were no differences between the plant establishment given by placed and by broadcast fertilizer at any centre.

Early development

All the experiments were visited several times during the spring and summer and eye observations were made on the growth of the crops. At Ely and Spalding there was little visible response to fertilizer. At the other centres phosphate-potash fertilizer caused marked increases in growth early in the season. Marks were assigned to the crop on each plot for vigour of growth. At seven of the eight centres early broadcasting caused better growth of tops during the summer than late broadcasting. In most

phate or potash the increases in yields of sugar and of tops caused by dressings of phosphate-potash fertilizer were generally small. This was due in part to very dry weather during the growing season. At Rothamsted rainfall was below average in every month except October and November. June, July, August and September were very dry months, and growth of the crops was restricted at many centres. Heavy rain in October made the beet grow rapidly on experiments which had not been lifted; this late growth was accompanied by a decrease in the percentage of sugar. Infection of virus 'yellows' was general in 1949, and may have been responsible for reductions in yields and sugar contents of the beet. The crops at Bury St Edmunds, Ely, Kelham, Spalding and Peterborough were severely attacked by virus disease.

Although at sowing seed-beds were dry and the rainfall during the period from sowing to singling

Table 1. Mean yields of sugar and of tops and mean plant populations in ten experiments on sugar beet in 1949

Fertilizer (cwt./acre)	Without phosphate- potash fertilizer	All placed	All broadcast		Half placed, half broadcast	
			Early	Late	Early	Late
Yield of sugar in cwt./acre						
3.5	—	37.5	39.5	37.5	37.6	38.6
7.0	—	38.8	36.8	38.7	38.9	39.3
Mean of rates	37.0	38.2	38.1	38.1	38.3	39.0
Yield of tops in tons/acre						
3.5	—	13.1	13.0	13.8	13.7	12.9
7.0	—	13.4	13.6	13.6	13.7	13.7
Mean of rates	12.6	13.3	13.3	13.7	13.7	13.3
Plant number in thousands/acre						
3.5	—	28.1	29.0	28.2	28.5	28.0
7.0	—	28.0	27.6	29.1	28.8	28.1
Mean of rates	28.1	28.0	28.3	28.6	28.7	28.0

of the experiments fertilizer placed beside the seed gave better early growth than broadcast fertilizer. Differences in growth of tops due to different methods of applying fertilizer became smaller in July and August and had vanished at harvest time. Pl. 19 shows two adjoining rows of beet at the Kidderminster centre on 11 July (fig. 1) and on 29 August 1949 (fig. 2). The left-hand row received 7 cwt. of fertilizer placed beside the seed and for the right-hand row the same dressing was broadcast and harrowed into the seed-bed. In July there was much better growth from placed fertilizer but the difference in the size of tops had vanished by the end of August. At harvest placed fertilizer gave 35.0 cwt. of sugar and 11.0 tons of tops per acre while broadcast fertilizer gave 33.2 cwt. of sugar and 11.8 tons of tops per acre.

DISCUSSION

Although the sites for the 1949 experiments were chosen by selecting soils likely to respond to phos-

phate was generally below average, no damage to germination in the experiments was caused by fertilizer placed to the side of the seed. Damage to germination occurred in experiments in 1947 and 1948 when the centre of the fertilizer band was directly below or below and 1 in. to the side of the seed. The centre of the band was 2 in. to the side of the seed in the 1949 experiments and this lateral separation of seed and fertilizer is quite safe for sugar beet.

The results of the experiments in all 3 years are summarized in Table 2. Average yields without any fertilizer in 1947 and 1948 and without phosphate-potash fertilizer in 1949 were high; broadcast fertilizer gave marked increases in yield only in 1948. Dressings of fertilizer broadcast at an early stage in the preparation of the seed-bed were in general slightly inferior to late applications on the seed-bed at drilling. There were no significant differences in the yields of sugar given by early and late broadcasting; late broadcasting gave significantly more tops than early dressings at one centre in both 1948 and 1949. The differences in the effects of placing



Fig. 1. 11 July 1949.



Fig. 2. 29 August 1949.

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and broadcasting fertilizer on the yields of sugar and of tops have been small and irregular in all years. Placed fertilizer gave significantly higher yields of sugar than broadcast fertilizer in three of the thirty-one experiments, and a significantly lower yield in one experiment. Of thirty experiments where the tops were weighed placing fertilizer has given significantly higher yields in three experiments and significantly lower yields in two experiments.

Table 2. *Comparisons of the effects of broadcasting and placing fertilizer in experiments on sugar beet in 1947, 1948 and 1949*

	1947	1948*	1949
No. of experiments ...	8	13	10
Fertilizer:			
% N	9.0	9.0	0.0
% P ₂ O ₅	7.5	7.5	16.0
% K ₂ O	4.5	4.5	13.4
Amount (cwt./acre)	6.8	7.5	5.2
Mean unmanured yields:			
Sugar (cwt./acre)	44.3	39.6	37.0
Tops (tons/acre)	7.7	9.9	12.6
Mean increases in yield from broadcast fertilizer:			
Sugar (cwt./acre)	2.0	4.8	1.1
Tops (tons/acre)	1.1	2.8	0.9
No. of significant increases in yield from broadcast fertilizer:			
Sugar	1	8	3
Tops	2	11	4
Early minus late broadcasting:			
Sugar (cwt./acre)	—	-0.8	0.0
Tops (tons/acre)	—	-0.1	-0.4
No. of significant effects on yields of tops from early over late broadcasting:			
Positive	—	0	0
Negative	—	1	1
Mean increase in yield from placing over broadcasting:			
Sugar (cwt./acre)	-1.0	0.4	0.0
Tops (tons/acre)	0.5	0.1	-0.2
No. of significant effects from placing over broadcasting:			
Yields of sugar:			
Positive	1	2	0
Negative	1	0	0
Yields of tops:			
Positive	2	1	0
Negative	0	1	1

* The tops were weighed in twelve experiments.

Combinations of placing half of the fertilizer and broadcasting the remainder were tested in 1949 to secure the early rapid growth normally caused by placed fertilizer together with any advantage which broadcast fertilizer might have late in the season. These split applications were not markedly superior to either broadcasting or placing the whole of the dressing. On the average of all the experiments half the fertilizer placed and half broadcast on the seed-

bed produced slightly higher yields of sugar than any other method of application; this method produced the highest yields of sugar in four of the ten experiments. Half the dressing placed and half broadcast early produced the highest yields at two centres; early broadcasting of the whole dressing gave the highest yields at two centres. Late broadcasting and placing of the whole dressing each gave the highest yield at one centre.

Two arguments are frequently advanced in favour of placing fertilizer near to the seed. A high concentration of nutrients gives the young plant a good start; fertilizer placed below seed level remains in moist soil during dry periods when broadcast fertilizer confined to the dry surface soil is useless to the crop. The high local concentration of nutrients given by placing fertilizer near to the seed is favourable to young sugar-beet plants since the crops have grown more vigorously each year during early summer with placed fertilizer. Although early rapid growth is usually desired by farmers, it is not essential for maximum yields. Presumably the mature plants have ample time to develop sufficient roots to take up broadcast nutrients. Both 1947 and 1949 were dry years which would have demonstrated any superiority of fertilizer placed below the seed when nutrients in the surface soil were immobilized during drought.

In districts where sugar beet is normally grown in England there is no case for placing the full dressing of fertilizer beside the seed except that labour is saved. If the crop is expanded into other areas having soils acutely deficient in phosphate, placing the fertilizer may be more efficient than broadcasting by promoting rapid root development and by reducing the extent of fixation of phosphate to useless forms. Where attacks by soil pests are common, the rapid early growth caused by placed fertilizer may be of value in establishing a satisfactory plant.

SUMMARY

Ten experiments on sugar beet in 1949 tested a phosphate-potash fertilizer applied in different ways. There was no damage to germination or plant establishment by fertilizer placed in bands 2 in. to the side and 2 in. below the level of the seed.

There were no significant differences between the yields of sugar given by placed and broadcast fertilizer. Similar yields were given by broadcast applications applied early and worked deeply into the seed-bed and by dressings on the seed-bed which were worked in shallowly. Split dressings where half the fertilizer was broadcast and half was drilled beside the seed were not markedly superior to placing or broadcasting all the fertilizer. In most of the experiments placing gave more vigorous growth than broadcasting the fertilizer during late spring

and early summer; at harvest this superiority had vanished.

The results of these experiments confirm those carried out in 1947 and 1948. There is no advantage from placing the full dressing of fertilizer beside the seed in districts where the crop is normally grown, except that labour is saved in applying the fertilizer.

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