FERTILIZER PLACEMENT FOR HORTICULTURAL CROPS

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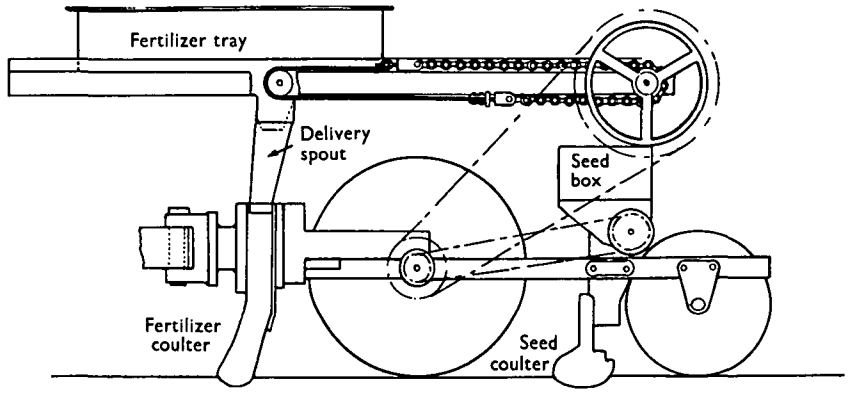
(With Plates 13 and 14 and One Text-figure)

Short-season arable crops with limited root-range grown on widely spaced rows have given consistently higher yields from fertilizer placed in a band at the side of the seed than from the same quantity of broadcast fertilizer (Cooke, 1949; Cooke & Widdowson, 1953). In contrast, sugar beet (which has a deep root system and long growing season) gave similar yields from broadcast and placed fertilizer, although placement gave the crops a more rapid start (Cooke, 1951). Many horticultural crops have short growing seasons and restricted root systems, and are likely to benefit from placement methods. Vegetables harvested early in the season often command high prices; even where broadcasting and placing give similar total yields, placed fertilizer may speed up growth so that crops are ready to harvest before those grown with broadcast fertilizer. For these reasons comparisons of placed and broadcast fertilizer for horticultural crops were made from 1952 to 1954; the results are described in this paper.

MACHINERY FOR THE EXPERIMENTS

A specially constructed three-row placement drill (described by Cooke, 1949) was used in previous experiments on row crops. This machine was used to place bands of fertilizer 3 in. below the soil surface in all the experiments on broad beans, and in a few other experiments listed below. The amounts of land available for the other experiments were restricted, and it was necessary to use small plots. The three-row drill was quite unsuitable, being too heavy and cumbersome for precise work on very small plots. The National Institute of Agricultural Engineering therefore designed and built a one-row drill for this work. It was suitable for working on small areas and was able to deliver a predetermined quantity of any kind of fertilizer.



Text-fig. 1. One-row drill fitted with 'end-delivery' fertilizer mechanism.

The one-row machine is illustrated in Text-fig. 1 and in Pl. 1. It was fitted with an 'end-delivery' fertilizer mechanism of the pattern described originally by Fairbank & Minges (1942), and which has been used extensively in recent American fertilizer placement work. A weighed quantity of fertilizer was spread evenly along the upper surface of a belt stretched over a roller. A tray resting on the belt prevented fertilizer escaping from the sides and edges. Tray and belt were moved horizontally by a drive taken from the large land roller. As the belt moved forward fertilizer was discharged from the end and delivered through a tube to the fertilizer coulter. The drive was so arranged that the load of

fertilizer on the belt was completely discharged after the machine had travelled a given distance. The combined seed and fertilizer unit consisted of a framework with the fertilizer coulter mounted at the front. A large land roller smoothed the seed-bed behind the fertilizer coulter and provided a drive for both seed and fertilizer mechanisms. A seed unit of conventional type was fitted behind the land roller, and a small grooved wheel consolidated the soil above the seed and maintained the depth of sowing. Both seed and fertilizer coulters were of a pattern developed by the National Institute of Agricultural Engineering; they had been successful when used on the three-row drill. The fertilizer coulter was adjustable both laterally and vertically, so that bands of fertilizer could be placed either in line with the seed or at 1 in. or 2 in. to the side, and at depths of 1 in. or 2 in. below the soil surface. These adjustments were made by hand without using tools. The belt and tray for fertilizer were mounted above the roller and seed unit. In the 1952 experiments the drill was drawn by a small 'walking' tractor mounted semi-rigidly to the unit and was steered by the handles fitted to the tractor. This arrangement was unsatisfactory. The wheel-base of the tractor was very narrow, the whole implement was laterally unstable and difficult to steer. In addition, the drill tended to 'crab' sideways, so that the correct positions of seed and fertilizer bands were not always maintained. The drill was modified in 1953 by fitting wheels mounted on a wide axle at the front of the unit; it was steered by handles fitted to the frame. The machine was then drawn by a horse, by hand, or by the power unit of a motor-scythe.

SCOPE OF THE EXPERIMENTS

For most of the experiments the areas of land available were limited, and a simple set of treatments was chosen to compare broadcast and placed fertilizer. The two methods tested were:

Fertilizer broadcast and harrowed (or raked) into the seed-bed.

Fertilizer placed in one band 2 in. to the side of the seed.

(Cooke (1949) showed that bands of fertilizer should be placed at least 2 in. to the side of the seed to avoid damage to germination. The depth of the band is less important; in these experiments the bands were placed 2 in. below the soil surface for crops sown with the one-row drill and 3 in. below the surface where the three-row drill was used.)

Each method of application was tested at two rates of dressing: 2·5 and 5·0 cwt./acre. The four fertilizer treatments and unfertilized plots were arranged either in 5 × 5 Latin squares or in randomized blocks. Details of the experimental designs which were used are given below:

1952. All experiments at Luddington used 5 × 5 Latin square designs. At Rothamsted randomized blocks each of five plots were laid down; there were four blocks in experiments on broad beans and beetroot, and three blocks in the other experiments.

1953. The experiments at Luddington used 5 × 5 Latin squares. All other experiments consisted of four randomized blocks each of six plots, there being two unfertilized plots in each block.

1954. The experiments on broad beans at Rothamsted and on cabbage at Barton Hill consisted of four randomized blocks each of six plots, there being two unfertilized plots in each block. All the other experiments used 5 × 5 Latin squares.

The fertilizers used in all the experiments were granulated mixtures. National Compound Fertilizer no. 7 (13 % P_2O_5, 13 % K_2O) was used in all the 1952 experiments on beans and in the 1953 experiment on broad beans at Luddington. In all other experiments carried out in 1952 and 1953 National Compound Fertilizer no. 1A (8 % N, 6 % P_2O_5, 10·5 % K_2O) was used; in the 1954 experiments National Compound Fertilizer no. 1 (7 % N, 7 % P_2O_5, 10·5 % K_2O) was used.

METHODS OF LAYING DOWN THE EXPERIMENTS

The sizes of the individual plots varied from year to year at the different centres according to the amount of land that was available. The plots were commonly 0·00379 acre at Rothamsted and 0·00690 acre at Luddington. The cabbage experiments at Barton Hill used plots of 0·0152 acre.

After the site had been marked out, fertilizer was broadcast by hand on appropriate plots and the dressings were raked or harrowed into the seed-bed. The 1953 and 1954 cabbage experiments at Barton Hill, all experiments at Luddington in 1952, and the 1952 beetroot experiment at Rothamsted were sown with the three-row drill. For all other crops, except broad beans, the single-row 'end-delivery' drill was used. Both drills were used to sow seed and apply dressings of placed fertilizer beside the seed on appropriate plots. Beans were not sown regularly by the seed mechanism; therefore bands of fertilizer were drilled on appropriate plots and seed was 'dibbled-in' by hand on the marks left by the seed coulters.

After sowing, normal market garden cultivations were carried out. At harvest the crops were picked or cut when ready for market; in some experiments several harvests were necessary. Except where otherwise stated, only the total yields of saleable produce from all harvests are given here.

The crops grown in the experiments were summer cabbage, cabbage lettuce, round beetroot, maincrop onions, broad beans, french beans and runner

beans. Commercial varieties suited to the soil and locality were used. In addition, parallel experiments were carried out in 1953 and 1954 on maize (varieties: Goudster and C.I.V.2) imported from Holland; for convenience the results of the maize experiments are described here. Both years were wetter and colder than normal and the maize grew very slowly. By mid-October the cobs had reached the stage at which sweet corn is sold for market. They were harvested and the total weights of grain (at 'milk' stage) plus cobs and husks were recorded.

Most of the experiments were carried out on the farms of Rothamsted Experimental Station and Luddington Experimental Horticulture Station. The soils at Rothamsted were clay-loams derived from Clay-with-Flints; the sites used for the 1953 and 1954 experiments were limed. At Luddington a light loam was used (Pershore series, gravelly phase). The 1954 experiment on cabbage at Pershore was carried out on medium loam of the Pershore series. Cabbages were grown in both years at Barton Hill, Beds., on calcareous loam overlying chalk.

SUBSIDIARY EXPERIMENTS ON ESTABLISHED CROPS

It is common market garden practice to apply mid-season top-dressings of nitrogen fertilizers to crops like cabbages and Brussels sprouts. Top-dressings may be used inefficiently if rainfall is insufficient to wash them into the soil. Broadcast fertilizer is usually spread over the whole soil surface and part of the dressing may be too far away from the plants to be reached by the roots. For these reasons a few simple field experiments were carried out in 1953 and 1954 to compare broadcast dressings of nitrogen fertilizers with dressings placed below the soil surface and near to the base of each plant.

The experiments were laid down on suitable areas of autumn-planted cabbages and of Brussels sprouts which had already received a basal dressing of complete fertilizer at planting. Placed fertilizer was injected to a depth of 3 in. below the soil surface and about 6 in. to the side of the stem of each plant; the dressings were applied by a simple hand dispenser. These dressings were compared with the same amounts of fertilizer broadcast by hand over the whole surface of each plot.

'Nitro-Chalk' (containing 15·5 % N) was applied at all centres except the 1953 experiment on Brussels sprouts at Bidford-on-Avon where 'potash-nitrate' (15 % N, 15 % K_2O) was used.

In most experiments placed and broadcast fertilizer was tested at two rates of dressing (the rates varied somewhat from centre to centre but averaged 3 and 6 cwt./acre). In the 1953 spring-cabbage experiments broadcast fertilizer was applied at three rates and placed fertilizer at the low rate only. The four fertilized plots and one plot which received no top-dressing were arranged in 5 × 5 Latin squares. The size of individual plots was chosen so that each contained about twenty plants. (In the cabbage experiments each plot was about 0·001 acre, the plots used for Brussels sprouts were about 0·005 acre.) The experimental top-dressings were applied in March for autumn-planted cabbage and in August for Brussels sprouts.

RESULTS OF THE EXPERIMENTS

Main series of experiments on drilled crops

Unmanured yields and the increases given at each rate of dressing by broadcast and placed fertilizer are set out fully in Appendix Table 1. These data are summarized in Table 1 by averaging all experiments on each crop.

Placing fertilizer gave higher average yields than broadcasting in the experiments on cabbage, lettuce, onions, maize, broad beans, french beans and runner beans. The low rate of placed fertilizer gave higher yields than the high rate of broadcast fertilizer on average of all experiments on each crop. In experiments on broad beans the average response to broadcast fertilizer was very small.

There were sufficient experiments on lettuce, cabbage, broad beans and runner beans to provide fairly reliable averages. For these crops the response curves were drawn for both broadcast and placed fertilizer; they were regularly shaped. A smooth curve was drawn for placement which was taken as the standard method. The amounts of placed fertilizer required to give yields equal to those given by broadcast fertilizer were read off. The values found were expressed as percentages of the amounts of broadcast fertilizer actually applied. These data provided the following percentage efficiencies of broadcasting taking placing as the standard (= 100):

	At low rate	At high rate
Lettuce	44	31
Cabbage	52	49
Runner beans	20	18
Broad beans	12	3

For lettuce and cabbage broadcast fertilizer was not more than half as efficient as placed fertilizer; for runner and broad beans broadcasting was of little use. There were insufficient experiments on beetroot, onions, maize and french beans to justify this treatment.

The experiments are summarized further in Table 2 by stating for each crop the gains from broadcast fertilizer and comparisons between broadcasting and placement after averaging rates of dressing. The numbers of positive and negative effects on

yield are also set out in Table 2, together with the numbers of significant effects ($P = 0{\cdot}05$ or greater).

The average gains from placement were not great in experiments on beetroot and runner beans; for french beans broadcast fertilizer depressed average yields slightly, while placed fertilizer had no effect. Sideband placement gave much heavier crops of cabbage, lettuce, onions, maize and broad beans than broadcasting. For runner beans broadcasting was better than placing in three experiments, while placement was better in two experiments. For all other crops broadcasting was better than placing most of the crops grow more vigorously in the early stages than broadcast fertilizer; this advantage from placement was generally reflected in higher yields and, often, in earlier maturity. Pls. 2 and 3 show that both maize and onions having placed fertilizer grew more rapidly than crops with broadcast fertilizer. Where crops were harvested on more than one occasion placed fertilizer generally gave higher yields than broadcast fertilizer at the first harvest and the benefits from placement were less marked at later harvests. Several harvests were made in most of the experiments on lettuce, french

Table 1. *Yields of vegetables without fertilizer and with broadcast and placed fertilizer, averaging all experiments on each crop*, 1952–4

(Yields in cwt./acre.)

	No. of experiments	Without fertilizer	With fertilizer broadcast at		With fertilizer placed at	
			Low rate	High rate	Low rate	High rate
Cabbage	4	97·4	133·8	154·8	155·9	180·0
Lettuce	6	124·3	139·8	144·5	154·9	175·5
Beetroot	3	58·5	62·2	64·7	67·2	68·7
Onions	2	208·6	237·0	227·6	259·5	261·2
Maize	2	103·4	102·0	118·8	124·2	125·1
Broad beans	5	64·4	67·0	65·8	74·4	76·2
French beans	3	72·5	66·5	68·3	70·5	74·8
Runner beans	5	97·2	102·4	105·3	110·1	111·7

Table 2. *Unmanured yields and increases from broadcasting, and from placing over broadcasting, together with the numbers of significant and non-significant positive and negative effects*

(Averages of all experiments in 1952–4.)

	No. of experiments	Yield without fertilizer (cwt./acre)	Increase in yield (cwt./acre)		Placing *over* broadcasting			
			From broadcasting	From placing *over* broadcasting	No. of effects		No. of significant effects	
					Positive	Negative	Positive	Negative
Cabbage	4	97·4	46·9	23·6	3	1	1	0
Lettuce	6	124·3	18·0	23·0	5	1	2	0
Beetroot	3	58·5	5·0	4·4	2	1	0	0
Onions	2	208·6	23·8	28·0	2	0	1	0
Maize	2	103·4	7·0	14·2	2	0	1	0
Broad beans	5	64·4	2·0	11·7	4	1	3	0
French beans	3	72·5	−5·1	5·2	2	1	1	0
Runner beans	5	97·2	6·6	7·1	2	3	1	0

in not more than one experiment. Placing was significantly better than broadcasting in at least one experiment on each crop except beetroot; there were no significant decreases in yield from placed as compared with broadcast fertilizer. There were thirty experiments altogether; in twenty-two experiments placing gave higher yields than broadcasting, and in ten experiments the difference in favour of placement was significant.

Since early vegetables often command a higher price than later crops it is important to determine whether placing fertilizer gives earlier produce than broadcasting. The experiments were 'scored' visually for vigour of growth. Placed fertilizer made beans, runner beans and cabbage; on each occasion only the produce ready for market was gathered. Table 3 gives the yields at the first and second harvests and the total yields for all harvests, after averaging all appropriate experiments on each crop and taking means of yields given by the two rates of application. To demonstrate the changes in effectiveness of methods of applying fertilizer, these data have also been converted into relative yields, taking yields given by broadcasting as the standard (= 100).

For lettuce and runner beans the advantages of placement were at a maximum at the earlier harvests; for cabbage the whole of the gains from placing as compared with broadcasting were achieved at the

first cutting. The effects of fertilizer on french beans were small and irregular, the unmanured plots produced the highest yields at the first picking.

These data show clearly that for certain crops placed fertilizer may give heavier yields of earlier produce. For the other crops grown in these experiments the benefits of placement were reflected in higher yields, and there was little difference in the stage of maturity on plots having different treatments. Maize does not ripen well in this country in a bad summer. It had been hoped that placing fertilizer would cause earlier ripening, but although the maize grew much more rapidly in the early stages on plots having placed fertilizer, it did not ripen earlier, and in both years the crop on all plots had to be harvested in October when the grain was still soft.

Table 3. *Average yields and relative yields of cabbage, lettuce, french beans and runner beans at the first and second harvests and the totals of all harvests*

	Yield (cwt./acre)			Relative yields		
	First harvest	Second harvest	Total of all harvests	First harvest	Second harvest	Total of all harvests
	Cabbage (4 experiments)					
Without fertilizer	31·8	58·4	97·4	45	92	67
With broadcast fertilizer	71·4	63·8	144·4	100	100	100
With placed fertilizer	98·0	61·8	168·0	137	97	116
	Lettuce (5 experiments)					
Without fertilizer	12·6	30·0	144·2	33	85	89
With broadcast fertilizer	37·9	35·2	161·8	100	100	100
With placed fertilizer	54·5	47·3	182·1	144	134	113
	French beans (3 experiments)					
Without fertilizer	11·1	13·8	72·5	116	112	108
With broadcast fertilizer	9·6	12·3	67·4	100	100	100
With placed fertilizer	9·0	13·1	72·7	94	106	108
	Runner beans (5 experiments)					
Without fertilizer	3·8	10·4	97·2	88	93	94
With broadcast fertilizer	4·3	11·2	103·8	100	100	100
With placed fertilizer	5·9	12·1	110·9	137	108	107

Subsidiary experiments on established crops

There were four experiments on autumn-planted cabbage and five on Brussels sprouts. The results are summarized in Table 4 by stating for each experiment unmanured yields, increases from broadcast fertilizer and the gains from placing as compared with broadcasting. (Comparisons of placing and broadcasting were made after averaging the yields given by the two rates of dressing in the experiments on Brussels sprouts and in the 1954 cabbage experiments.)

There were significant increases in yields of cabbage from broadcast fertilizer at Ridgmont and Ickwell in 1954; at both centres placing gave less cabbage than broadcasting, the difference being significant at Ridgmont. There were no significant increases in yield from broadcast fertilizer in any of the Brussels sprouts experiments, and the differences between yields given by placing and broadcasting were small and not significant.

DISCUSSION

Some of the experiments in 1952 were imprecise, having standard errors per plot which exceeded 20 % of the general mean yields. This was due to limitations imposed by the very small amounts of land available for the work. Larger sites were available in the two later years and only one experiment (on cabbage at Pershore) had a standard error greater than 20 % of the mean yield; at this centre the plant was uneven due to weed competition and attacks by pests.

In 1952 there was a long dry spell from mid-June until early August and yields of some of the crops were reduced; 1953 was wetter and there was sufficient rain throughout the season for satisfactory growth at both Rothamsted and Luddington. In 1954 rainfall at Rothamsted was much above average in May, June, July and August; cold, wet and sunless weather persisted throughout the season and crops grew slowly.

On average of all experiments on each crop and of yields given by the two rates of dressing, placing fertilizer was clearly superior to broadcasting for all crops except french beans (they are excluded from general conclusions stated below). Broadcasting was not more than half as efficient as placing for any crop, the average yields given by the low rate of placed fertilizer being greater than those given by the high rate of broadcast fertilizer.

The main series of experiments on drilled crops

has established that placing a given quantity of complete fertilizer near to the seed produced higher yields of many vegetables than broadcasting the same dressing. For most crops placement methods allow economies to be made in fertilizer dressings; for broad beans and runner beans placing phosphate-potash fertilizers increased yields under conditions where broadcasting had little effect. The experiments have also demonstrated that placement causes earlier maturity of some crops. These advantages are profitable when high-value crops are grown and will justify the purchase of special placement drills.

This work has been carried out on ordinary arable land, generally carrying a rotation which included occasional vegetable crops. No experiments have been carried out on intensively manured and cultivated horticultural holdings. Where soils have received heavy dressings of organic and inorganic manures for many years it is unlikely that fertilizers will give sizeable responses, and it is also unlikely that placement methods will have any special merit. Placement for market garden crops may be most valuable when they are taken as part of an ordinary arable rotation, or where intensive horticulture is introduced on ordinary soils and before nutrient reserves are built up by heavy dressings of organic and inorganic manures.

It is often difficult and costly to obtain enough of both the bulky and the concentrated organic manures which have been used extensively by most successful vegetable growers. The high cost of traditional market garden manuring is justified by growers on the grounds that the crops grow rapidly and uniformly and mature quickly as well as being of high quality. Fertilizer placement practices may be valuable where supplies of traditional manures cannot be obtained. Correct placement will allow smaller fertilizer dressings to be used and it may also provide earlier crops of uniform quality. Side-band placement avoids the injury to germination which may occur when heavy dressings of broadcast fertilizers are used on light soils.

The subsidiary experiments were designed to test mid-season dressings of nitrogen fertilizers localized quite near to the plants, against top-dressings spread in the ordinary way over the surface of the soil. Gains from the top-dressings, however applied, were small in most experiments, and in no experiment have placed dressings given significantly higher yields than broadcast dressings. On the soils where these experiments were carried out, it is difficult to justify the practice of mid-season top-dressings for Brussels sprouts which have received an adequate amount of nitrogen at planting-time. Autumn-planted cabbage are likely to need dressings of nitrogen in spring on most soils since nitrogen applied in autumn may be lost by leaching during winter, and since it is desirable to start the plants growing in spring before nitrification has provided sufficient nitrate. The experiments show that where top-dressings are justified there is no need to introduce special machines to apply bands or pockets of fertilizer close to the plants in established crops.

Table 4. *Unmanured yields of cabbage and Brussels sprouts, increases from broadcast top-dressings and comparisons of placing with broadcasting*

(Total yields in cwt./acre.)

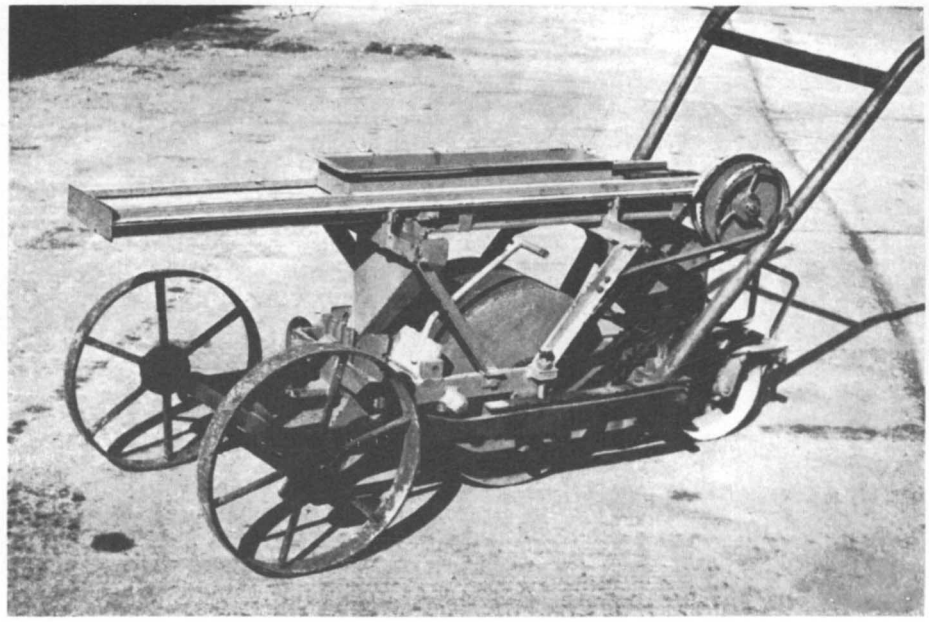
	Yield without top-dressing	Increase in yield from: Broadcast fertilizer	S.E.	Placing *over* broadcasting	S.E.
		Autumn-planted cabbage			
1953 Luddington	303	4	±14·9	2	±14·9
1953 Bidford-on-Avon	471	18	±38·0	47	±38·0
1954 Ridgmont	106	15*	± 6·5	−14*	± 5·3
1954 Ickwell	201	42**	± 9·9	−13	± 8·1
		Brussels sprouts			
1953 Luddington I	69	11	± 6·4	− 2	± 5·2
1953 Luddington II	69	1	± 4·7	2	± 3·8
1953 Bidford-on-Avon	72	9	± 7·9	5	± 6·4
1954 Biggleswade	79	4	± 4·8	1	± 3·9
1954 Ickwell	86	4	—	− 1	—

(Significant effects marked ** for P < 0·01,* for P = 0·05 to 0·01.)

SUMMARY

In field experiments on vegetable crops dressings of appropriate fertilizers were placed 2 in. to the side of the seed and 2–3 in. below the soil surface, and compared with the same amounts of fertilizer broadcast and worked into the surface soil. The work was carried out on ordinary arable land carrying rotations which included vegetables.

Placing fertilizer gave higher yields of cabbage, lettuce, beetroot, onions, broad beans, runner beans and maize, than broadcasting. Fertilizer, however



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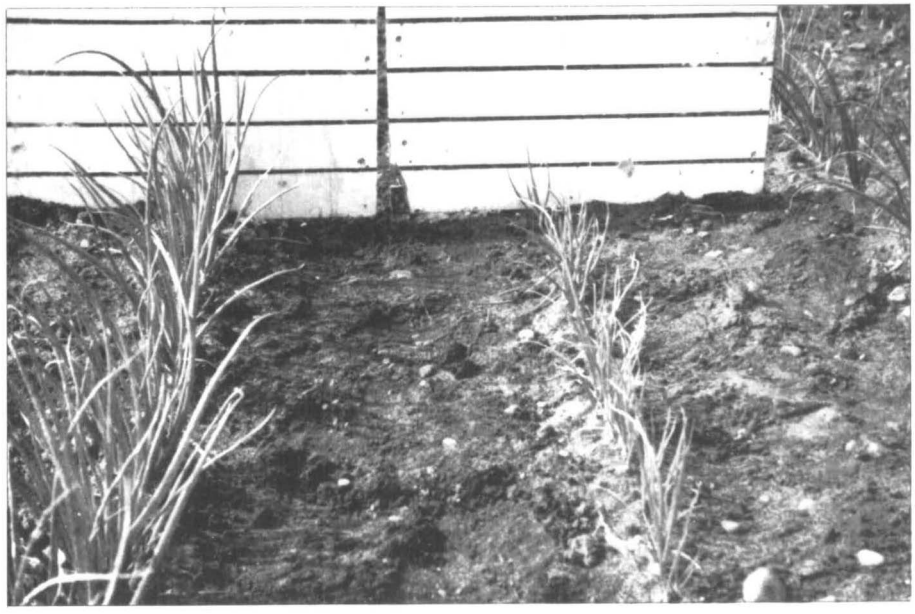

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applied, had no regular effect on the yield of french beans.

Both placed and broadcast fertilizer were tested at two rates of dressing. On average of all experiments on each crop, placing fertilizer at the low rate gave higher yields than broadcasting at the high rate. Broadcast fertilizer had little effect on yields of runner beans and broad beans, while placed dressings gave marked increases.

In two-thirds of all individual experiments placing gave higher yields than broadcasting, and in one-third of the experiments placement was significantly better than broadcasting. There were no instances of significantly higher yields from broadcasting as compared with placing.

Placing fertilizer made most of the crops grow more rapidly in the early stages than broadcasting, this improvement being often reflected in earlier maturity. For cabbage, lettuce and runner beans the relative gains from placing, as compared with broadcasting fertilizer, were much higher at the first than at the second harvest.

By drilling fertilizer beside the seed of vegetable crops grown on ordinary soils, it is possible to economize in the dressings needed. In addition, some crops having placed fertilizer may be ready for market earlier. These advantages may be very profitable where high-value crops are grown and will justify the purchase of special placement drills.

A small series of field experiments on established Brussels sprouts and autumn-planted cabbages compared mid-season top-dressings of nitrogen fertilizer broadcast by hand over the whole soil surface, with dressings placed at one point beneath the surface and near to the plants. The dressings used had practically no effect on yields of Brussels sprouts. Top-dressings broadcast in spring increased yields appreciably in two experiments on cabbage, and at both centres placing gave lower yields than broadcasting.

This work was carried out under the auspices of the Agricultural Research Council's Conference on Fertilisers. The authors' thanks are due to the Agricultural Research Council and to members of the staffs of the National Institute of Agricultural Engineering, the National Agricultural Advisory Service and the Rothamsted Experimental Station for much assistance in carrying out the work.

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EXPLANATION OF PLATES

PLATE 13

One-row drill fitted with end-delivery fertilizer mechanism and modified for the 1953 experiments.

PLATE 14*a*

Placed fertilizer promoted rapid growth of maize. Both plots received the same amount of complete fertilizer. Left: broadcast; right: placed beside seed.

PLATE 14*b*

Placed fertilizer promoted rapid growth of onions. Both rows received the same amount of complete fertilizer. Left: placed beside seed; right: broadcast.

(*Received* 30 *July* 1955)

Appendix Table 1. *Unmanured yields of horticultural crops and the increases from broadcast and placed fertilizer*

(Yields of saleable produce in cwt./acre.)

			Increase in yield from fertilizer				
			Broadcast at		Placed at		
		Yield without fertilizer	Low rate	High rate	Low rate	High rate	Standard error of increase
			Cabbage				
1953	Luddington	157·2	33·4*	52·6**	39·6**	58·8**	11·58
	Barton Hill	34·6	16·0	40·2*	85·4**	111·2**	10·28
1954	Pershore	118·0	43·0	65·1*	35·2	60·4*	24·50
	Barton Hill	79·9	53·4	71·8*	73·7*	100·2**	25·97
			Lettuce				
1952	Luddington	288·3	−11·0	− 1·6	2·5	51·4	30·10
	Rothamsted	13·0	14·1	4·2	62·5*	91·7**	21·11
1953	Luddington	95·4	12·8*	26·0**	40·2**	39·0**	4·56
	Rothamsted	98·4	7·8	−10·8	0·4	−14·8	8·38
1954	Rothamsted (I)	140·6	16·1*	12·5	8·7	36·2**	5·94
	Rothamsted (II)	110·1	53·2**	91·0**	69·4**	103·7**	15·22
			Broad beans				
1952	Luddington	53·3	11·2	− 2·9	− 3·8	− 0·3	11·60
	Rothamsted	22·8	1·7	3·8*	6·7**	9·0**	1·71
1953	Luddington	50·6	4·1	− 3·3	6·2	7·1	6·60
	Rothamsted	67·7	− 5·5	6·7	20·5**	28·4**	5·98
1954	Rothamsted	127·7	1·6	2·6	20·4**	42·9**	6·21
			Runner beans				
1952	Luddington	115·5	− 6·6	− 9·3	0·5	−23·4	12·01
	Rothamsted	59·7	11·0	12·8	10·2	8·3	10·00
1953	Luddington	141·1	16·3*	16·3*	13·8*	10·1	5·95
	Rothamsted	109·7	− 1·3	4·5	12·6	17·3	9·21
1954	Rothamsted	60·1	6·5	15·9	27·4**	60·1**	7·76
			French beans				
1952	Luddington	65·3	− 3·5	− 5·1	− 9·5	− 9·7	5·41
	Rothamsted	50·1	−11·7	−10·7	4·8	9·7	6·90
1953	Luddington	102·2	− 2·9	3·1	− 1·3	6·7	5·67
			Onions				
1952	Luddington	178·7	38·2	8·5	60·3	62·7	42·00
1954	Rothamsted	238·5	18·7	29·6**	41·5**	42·6**	8·73
			Maize				
1953	Rothamsted	119·3	− 3·9	15·5	25·9*	16·8	10·27
1954	Rothamsted	87·6	1·1	15·1	15·6	26·5**	7·50
			Beetroot				
1952	Luddington	68·4	7·5	2·8	12·2	− 4·8	10·31
	Rothamsted	79·8	−16·2	−15·8	−14·8	0·8	22·60
1953	Luddington	27·2	20·0**	31·8**	28·8**	34·6**	4·00

(Significant effects marked ** for $P < 0{\cdot}01$,* for $P = 0{\cdot}05$ to $0{\cdot}01$.)