THE EFFECT OF DATE OF PLANTING ON THE YIELD OF POTATOES

By G. V. DYKE

Rothamsted Experimental Station, Harpenden, Herts

(With Three Text-figures)

In the years 1948–50 officers of the National Agricultural Advisory Service carried out a survey of potato crops in forty counties of England and Wales. A general account of the results of the first two years has been given by Boyd & Dyke (1950); Dyke & Avis (1953) have described the relation between the estimates of yield issued by the Ministry of Agriculture and those obtained during the survey by sampling methods.

Boyd & Lessells (1954) have discussed the effect of seed-rate on yield, using both survey data and the results of experiments. The present paper presents a similar consideration of the effect of date of planting, and of the room for improvement in growers' practice.

THE EFFECT ON YIELD OF DELAY IN PLANTING

Fig. 1 illustrates the effect of date of planting for all experiments known to the author and likely to be relevant to modern maincrop potatoes in England and Wales (for sources and reasons for the exclusion of certain experiments see Appendix). The graphs represent total yields of potatoes of all grades, these often being the only measurement available.

A general decrease in yield for planting after early April is evident; to give this a more precise description a single line has been obtained whose slope at any planting date represents the mean rate of decrease indicated by all the experiments which included dates both before and after the date considered (see Fig. 2). It should be noted that this curve is based entirely on comparisons between crops grown on the same site, all conditions being similar except the dates of planting. The elimination of site to site differences (e.g. higher mean yields at sites where the mean planting date was earlier) is essential; this is illustrated by the calculation of Gregory (1944) based on comparisons between sites, which seriously overestimated the adverse effect of delay in planting.

The curve is not well determined near the left-hand end, as few of the experiments included March plantings, but the indication is that there is little loss of yield due to delay in planting up till about 10 April. From that date onward there was a steady decline in yield, at the rate of about 0·3 ton per acre per week until mid-May and rather more rapid later. Although there is wide variation between the levels of yield of the individual experiments, eleven out of fifteen show losses for all delays after mid-April.

Fig. 2 presents also the estimates obtained from the survey of the effect on yield of date of planting.* The survey results agree with the experiments in showing a general decrease of yield with late planting of 0·4–0·6 ton per acre per week, though the curves are much less regular in form. The flattening of the curves for each year between 14 and 24 April may perhaps be ascribed to random variation (the standard error of the yield at each date of planting for a particular year is of the order of 0·4 ton per acre).

It seems clear, however, that the losses due to delay were greater in 1948 than in 1949 or 1950. This is borne out by the Rothamsted experiments, in which the rate of loss in 1948 was considerably higher than in 1949 or 1950. At Sprowston and Sutton Bonington, however, the differences were less marked† (yields in 1948 being exceptionally high at all dates of planting). The most marked difference between the curves of the individual experiments is the smaller loss from late planting in experiments with generally low levels of yield.

The results obtained at Craibstone (mainly on Golden Wonder) are illustrated in Fig. 3. The loss of yield of total tubers per week's delay in planting between 11 April and 21 May is about 0·5 ton per acre—slightly greater than in the English experiments.

* In each year the curve was obtained as follows: the mean sample yields of fields planted in successive intervals were adjusted by a procedure of Stevens (see Yates, 1949, §5·24) for the effects of other factors which may differ for differing planting dates. These adjusted ware yields were converted to total yields by the addition of the mean yields of seed and chats (0·3, 0·4 and 0·5 ton per acre in 1948, 1949 and 1950 respectively). The small numbers of fields which did not receive fertilizer containing N, P and K were excluded from the calculation.

† At both sites chitted seed was used, and this might be expected to show less benefit from early planting (see Fig. 3).

DATE OF PLANTING: GROWERS' PRACTICE

Table 1 shows the progress of planting on the sampled fields in 1948, 1949 and 1950. The right-hand column presents estimates of the loss of yield due to progressive delay, obtained from the mean curve of the experiments plotted in Fig. 2.

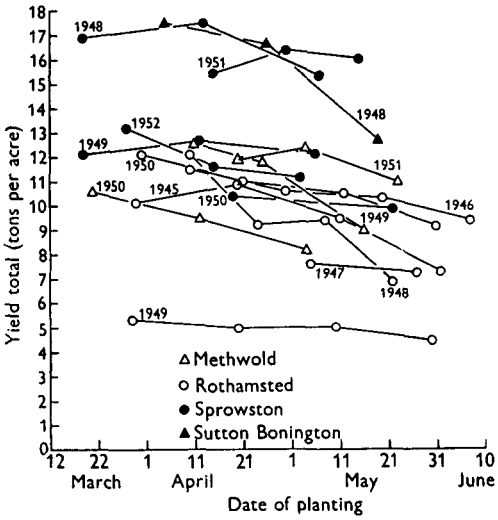

Fig. 1. Experiments on date of planting potatoes.

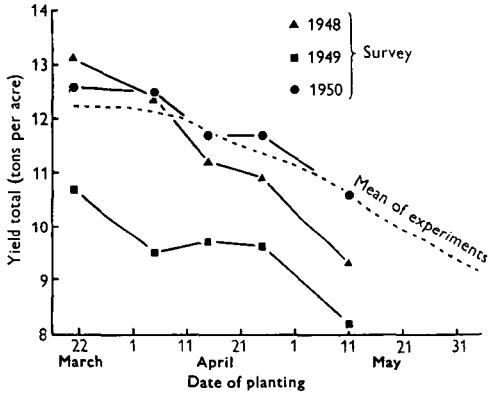

Fig. 2. Effect of date of planting on yield.

Practically the whole of the acreage was planted in each year between mid-March and mid-May; although the spring of 1948 was exceptionally favourable to early planting, growers in general seem to have taken little advantage of the opportunity. There were temporary shortages of fertilizer in spring 1948, and it may be that some growers delayed planting until fertilizer was delivered.

A loss of at least half a ton occurred on the fields planted after 19 April, which represented 40–50 % of the acreage; of this acreage about half, representing 20–25 % of the acreage, was planted after 29 April and lost at least 1 ton per acre. The total loss due to delay was equivalent to 0·6–0·8 ton per acre over the whole acreage. Since average yields for a given date of planting in the experiments were rather higher than in the survey, this estimate should probably be reduced slightly. We may conclude that the loss of yield in England and Wales due to delay in planting was approximately 5 %.

The progress of planting varied much more from place to place than from year to year (Table 2). Areas where planting was well ahead of the average are Devon and Cornwall and the Fens. These were the only areas in which appreciably over half the acreage was planted by 9 April. In the Fens growers do seem to have taken advantage of the favourable season of 1948 to plant the bulk of their acreage in good time. Growers in the north-west midlands (including the noted potato areas of Staffordshire and Cheshire) planted rather later than the average

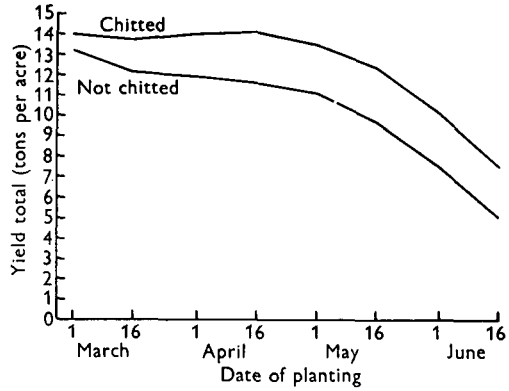

Fig. 3. Effects of date of planting and of chitted seed at Craibstone.

(only 20–30 % being planted by 9 April), as did also the growers on the higher land of the north. In Wales and the adjacent foothills of Shropshire planting was extremely late, less than 10 % being planted by 9 April and at least half left till May.

EFFECT ON PERCENTAGE OF WARE

Figures for the percentage of ware are available for most of the experiments shown in Fig. 2. They indicate little effect of date of planting; there is a tendency for the percentage of ware to decrease very slightly with later planting (the greatest decrease recorded was 6 % in 6 weeks).

The results obtained at Craibstone (mainly with the variety Golden Wonder) are shown in Table 3. The riddle sizes varied occasionally in the series, but were usually 1½ and 2 in. The general percentage of ware obtained is much lower than in the English

experiments (with more freely growing varieties). It decreases from 47 % for early March to 39 % for mid-May planting. The percentage of ware and seed (i.e. in most years tubers over 1½ in.) decreases only slightly in the same period.

DATE OF PLANTING IN RELATION TO THE EFFECTS OF OTHER FACTORS

(*a*) *Manuring*

The Rothamsted experiments give some information on the relation between date of planting and the effects of dung and fertilizers. A test of dung was included in each year. The rate of application in 1945, 1947 and 1948 was 15 tons per acre (applied in the ridges) for the first planting, rates for later plantings being adjusted for the loss of weight during the subsequent storage; in 1946 all applications were at 15 tons per acre, the dung being drawn from adjacent parts of an undisturbed heap. In 1949 and 1950 dung was ploughed in in spring at the same time for all plantings, at 15 tons per acre. Tests of sulphate of ammonia (0·6 cwt. N per acre) were made in all years, of superphosphate (0·6 cwt. P_2O_5) in 1946 and 1948–50, and of muriate of potash (1·0 cwt. K_2O) in all years except 1945. In 1945 in addition, sprouted seed was compared with unsprouted (the latter being used in the other experiments). The variety was Majestic throughout.

The results are summarized in the Rothamsted Annual Report for 1950 (pp. 116–118), from which much of the following paragraphs and of Table 5 has been abstracted.

In Table 4 all the experimental data is combined (small adjustments being made to the values at the two April plantings to allow for the omission of these plantings in 1947). The responses to dung, nitrogen and phosphate all decreased by about 50 % between the first and last plantings, while the response to potash fell by about four-fifths. Too much reliance should not be placed on individual comparisons between dates, as some were affected by block differences in some years, but we may perhaps note that the effects of dung, nitrogen and potash

Table 1. *Progress of potato planting* (*all sampled counties*)

	Percentage of acreage			Loss of yield (tons per acre)
	1948	1949	1950	
By 20 March	7	4	4	—
21–30 March	12	8	8	—
31 March–9 April	18	14	18	0·1
10–19 April	23	23	25	0·5
20–29 April	21	25	20	0·9
30 April–9 May	10	16	13	1·3
10–19 May	6	7	8	1·9
After 19 May	3	3	4	2·5
Mean date of planting	15 April	19 April	18 April	
Mean loss (tons per acre)	0·64	0·77	0·74	
Mean gross yield of sampled fields (tons per acre)	9·8	8·9	10·4	

Table 2. *Planting of potatoes* (*England and Wales, sampled counties*)

	Percentage of acreage planted by					
	1948		1949		1950	
Regions	9 April	29 April	9 April	29 April	9 April	29 April
Northern uplands	23	76	13	65	10	63
North-east	38	85	24	76	29	78
North-west midlands	26	78	20	81	17	59
Wales and the Marches	6	49	5	31	8	45
Fens	84	99	54	94	56	96
Rest of East Anglia	57	92	33	82	43	90
Cotswold	(5)	(76)	—	—	—	—
Chalk	33	85	28	79	27	66
Home Counties (excluding Chalk)	32	85				
West of England	45	97	(19)	(92)	(31)	(88)
South coast	(35)	(81)	—	—	—	—
Devon and Cornwall	67	95	—	—	(85)	(100)
All	37	81	26	74	30	75

Note. Figures in parentheses are based on samples of less than fifty fields.

all fell sharply when planting was delayed from early to late April, and again in the interval from mid-May to late May. Between 23 April and 12 May, however, the changes were smaller, whilst by contrast, phosphate suffered its main loss of effect in this interval.

Table 5 shows the mean yield with and without nitrogen, with and without phosphate, and for the four combinations of dung and potash for the four experiments which included all these factors. Interactions (except that of dung and potash) were small and varied irregularly with planting date; they have been ignored in the following summary. The losses per week in the last column were calculated on the assumption of steady rates of decrease.

The effect of potash in the absence of dung decreased rapidly, but even at the last date of planting yielded 1 ton. When dung was applied, however, the addition of potash produced a response of 1·6 tons at the first date, but none whatever at later dates. The effects of nitrogen and phosphate in the same series of experiments fell off proportionately much more slowly than those of potash, and still gave appreciable responses at the last planting.

The combined effect of dung, nitrogen, phosphate and potash used together fell from 8·1 tons per acre at the first planting date to 5·2 at the second and thereafter more slowly, the value for planting in late May being 3·8 tons. Although the dressings used in these experiments were all profitable at all plantings (except for potash in the presence of dung at the last three dates), there is no doubt that the optimum rates of application decrease markedly with delay in planting. In this connexion it may be noted that in areas where planting is very late (e.g. the surveyed counties of Wales and West Shropshire) less fertilizer is used; there is probably little advantage to be gained from increased use of fertilizer unless planting dates are advanced.

Table 3. *Effect of date of planting on percentage of* (*a*) *ware*, (*b*) *ware and seed* (*Craibstone*)

Date of planting ...	16 March	1 April	16 April	1 May	16 May	1 June	16 June
Percentage ware	43	42	42	41	38	32	27
Percentage ware and seed	93	92	92	92	90	87	81

Table 4. *Date of planting potatoes, Rothamsted*, 1945–50. *Mean yields and effects* (*total tubers, tons per acre*)

Mean date ...	3 April	23 April	12 May	31 May	Mean
Mean yield ...	10·04	9·15	8·66	7·32	8·79
Effects:					
Dung	3·59	2·97	2·40	1·68	2·66
N	1·80	1·02	1·08	0·72	1·16
P	0·80	0·78	0·44	0·42	0·61
K	2·07	0·61	0·86	0·38	0·98

Notes. (1) Values for 3 and 23 April have been adjusted for the missing values of 1947.
(2) The figures for 1945 are taken from plots planted with unchitted seed only.

Table 5. *Mean yields of potatoes, Rothamsted* 1946, 1948–50 (*total tubers, tons per acre*)

	Mean date of planting				
Manuring	4 April	24 April	12 May	30 May	Loss per week
No nitrogen	9·5	8·6	8·3	7·0	0·29
Nitrogen	11·1	9·3	9·4	8·0	0·34
No phosphate	9·9	8·6	8·6	7·3	0·29
Phosphate	10·7	9·4	9·1	7·7	0·34
No dung, no potash	7·1	6·5	6·3	6·0	0·13
Dung, no potash	11·2	10·6	10·3	8·5	0·31
Potash, no dung	10·1	8·6	9·0	7·0	0·33
Dung and potash	12·8	10·2	9·8	8·4	0·50
Mean	10·31	8·97	8·85	7·50	0·32

Another aspect of the interaction of date of planting with manuring is important; the loss due to late planting is much smaller for a poorly-manured crop than for a well-manured one. For example (Table 5), crops grown with neither dung nor potash decreased by only 1·1 tons with delay from early April to late May, whereas those to which both dung and potash were applied decreased by 4·4 tons. Now crops grown without fertilizer form a negligible proportion of the maincrop acreage in England and Wales (survey results quoted by Church, 1952). Therefore in considering the late planting of commercial crops we shall underestimate the loss of yield if we use the mean effects shown by factorial

experiments in which each manure was applied to only half the plots (as at Rothamsted in 1946, and 1948–50). If we assume that the plots receiving potash (half with dung in addition, half without) roughly correspond to commercial practice we arrive at a loss per week of 0·41 tons per acre, compared with 0·32, the mean for all combinations of manures.

The Methwold experiments included as a factor a comparison of two rates of application of fertilizer* (there were no plots without fertilizer). There was no consistent response to the higher rate, and no conclusion can be drawn regarding the effect of date of planting on the response to fertilizers on fen soils.

Experiments at Boghall (Mukhtar Singh, 1952) in 1946 and 1947 confirmed the Rothamsted finding that fertilizer effects decrease sadly when planting is delayed. In 1946 the loss of yield between plantings on 10 April and 20 May was 3·2 tons per acre for plots receiving 10 cwt. per acre of compound fertilizer, but no loss was found on a subsidiary series without fertilizers. In 1947 nitrogen and potash were included factorially, but all plantings were rather late. The effect of the higher level of nitrogen (5 cwt. per acre of sulphate of ammonia) decreased from 4·1 tons per acre (planted 7 May) to 3·1 tons (4 June), while the effect of 2 cwt. of muriate of potash per acre showed little change (1·2 and 1·0 tons per acre for the first and last plantings). This last result is at variance with the Rothamsted experiments, where the potash response was more seriously affected by late planting than the nitrogen response. It should be noted, however, that the conditions of the two sets of trials were very different.

(*b*) *Varieties*

The English experiments mostly contained only one variety—Majestic. The five trials at Sprowston, however, included Majestic and Arran Banner

Table 6. *Comparison of varieties at Sprowston, 1948–52 (total tubers, tons per acre)*

Approximate planting date	22 March	12 April	7 May
Majestic	14·1	13·7	13·2
Arran Banner	13·3	13·3	12·8
Difference	0·8	0·4	0·4

(Norfolk Agricultural Station, 1953), and the 1950 trial at Methwold included Majestic and Record.

The Sprowston results varied widely from year to year, but on the whole Majestic lost more with late planting than Arran Banner (Table 6). The results obtained at Methwold in 1950 showed that the Record stock yielded about 2 tons higher than the Majestic, and the loss due to delayed planting of Record was roughly double that for Majestic (0·5 ton per acre per week against 0·3).

*

(cwt. per acre)	Sulphate of ammonia	Super-phosphate	Muriate of potash
Medium rate	1	7	2
High rate	1½	10½	3

The Craibstone results provide some information on the relation of Golden Wonder and other varieties occasionally included in the trials (Great Scott 3 years, Arran Banner 3 years, and Di Vernon 4 years; in two of the last group Majestic also was included and in one, Kerr's Pink; of these varieties Great Scott is a second early, Di Vernon a first early).

There is an indication that the optimum date of planting for Golden Wonder is earlier than for the other varieties except Arran Banner; this is most marked for Di Vernon, which yielded over 2 tons per acre better when planted on 16 April than on 16 March, whilst Golden Wonder in the same trials yielded 1½ tons per acre more at the earlier date. The comparison between Arran Banner and Golden Wonder shows the two varieties to vary in much the same way with date of planting; the Arran Banner yields are generally higher by about 7 tons per acre and decrease rather more rapidly with late planting after mid-May.

These results seem to indicate that under Craibstone conditions planting of 'early' varieties before mid-April is of no advantage in terms of ware potatoes, whereas the slower developing Golden Wonder will generally benefit (though slightly) from March planting. (N. Scot. Coll. Agric. 1931, 1936 and 1937.)

(*c*) *Chitting*

Only one of the English experiments on date of planting included a comparison between chitted and normal sets at each date of planting (Rothamsted, 1945).

Table 7 is quoted from the Rothamsted Report for 1950 (p. 118).

There was no appreciable improvement in yield due to chitting for the two earlier plantings, but when planted on 11 May or 1 June unsprouted sets yielded more than a ton less than the sprouted. The comparison of chitted and 'ordinary' seed at the two late dates is, however, somewhat artificial, as even the 'ordinary' seed must have sprouted to some extent by May.

The Craibstone series included chitting as a factor every year. The results plotted in Fig. 3 show two very smooth curves which are well determined except at the earliest date of planting (which was included in only four of the twenty experiments).

The graph indicates a mean effect of chitting of 2·3 tons per acre (total tubers). The effect increases steadily from 1·7 tons per acre for plantings on 16 March (ignoring the ill-determined value for 1 March) to about 2·5 tons per acre for plantings on 16 April and later. The general form of the curves

shows that (under Craibstone conditions) for chitted seed there is a period of at least a month from mid-March to mid-April in which variations in date of planting have little average effect. There are, however, considerable differences between years, most years showing some gain for planting before mid-April but a few showing losses of a ton or more, with one case (1942) of a loss of over 6 tons.

For unsprouted seed, on the other hand, there was a general slight gain from planting at mid-March or early April with serious losses in a smaller proportion of years (the worst, in 1942, being a loss of 4·5 tons per acre).

The single Rothamsted experiment is at variance with the Craibstone series in showing practically no benefit from the sprouting of sets if planting is early. In the absence of further experiments it is uncertain whether this important difference is due to the difference of situation or variety, or a chance effect of the 1945 season. Before a general recommendation is widely made to farmers it is desirable to have much more information relevant to conditions in England and Wales. It may be that a satisfactory increase in yield could be obtained from commercial fields by encouraging earlier planting (at little expense), without asking growers to provide expensive chitting houses for their seed potatoes.

Table 7. *Mean yields of potatoes, Rothamsted,* 1945 (*total tubers, tons per acre*)

	30 March	20 April	11 May	1 June	Mean
Ordinary seed	10·02	10·85	8·96	6·63	9·12
Chitted seed	10·27	10·90	10·11	7·99	9·82
Effect of chitting	0·25	0·05	1·15	1·36	0·70

SUMMARY

Evidence obtained in the Agricultural Improvement Council Survey of Maincrop Potatoes 1948–50 and in experiments shows that yields in England and Wales are decreased by delay in planting after about 11 April at the rate of about 0·4 tons per acre per week. The effect is rather greater in years with fine springs, and on high-yielding fields.

In Rothamsted experiments the responses to dung and fertilizers were all greatly reduced when planting was delayed; between early April and late May the effects of dung, nitrogen and phosphate were halved, while that of potash was reduced by about 80%. The evidence on the responses of different varieties to early planting in English experiments is contradictory, except for an indication that higher yielding varieties respond better. Data from Craibstone suggest that, if bulk yield is the only criterion, 'early' varieties which make rapid growth early in the season have a later optimum planting date than maincrop varieties.

The effect of chitting seed at Craibstone is to increase yields by 1·7 tons per acre for March plantings, and by 2·5 tons per acre for plantings in mid-April and later. There is negligible loss of yield from sprouted seed at Craibstone for plantings delayed up to mid-April, but for unsprouted seed there is evidence of a gain from plantings a month earlier. Sprouted seed planted even as late as 1 May yielded as well as unsprouted planted two months earlier.

About half the maincrop potato acreage of England and Wales in each of the years 1948–50 was planted so late as to suffer appreciable loss of yield. At least one-fifth seems likely to have lost 1 ton per acre or more from delay. The potential increase in national production if all fields were planted by 11 April is equivalent to about 0·5 ton per acre, or 5% of the total production.

APPENDIX

Experiments on date of planting potatoes

I. *Experiments used in compiling Figs.* 1 *and* 2.

(*a*) Methwold, three experiments, 1949, 1950, 1951 (unpublished). Results used by permission of the Fenland Experiments Committee, N.A.A.S. Eastern Province.

(*b*) Rothamsted, six experiments, annually 1945–50 (Rothamsted, 1939–47, 1948, 1949, 1950).

(*c*) Sprowston, five experiments, annually 1948–52 (1948 experiment: Harvey, 1949; 1951 experiment: Norfolk Agricultural Station, 1952; remainder unpublished, communicated by R. W. Shepherd and P. J. Jones).

(*d*) Sutton Bonington, one experiment, 1948 (Ivins & McDermott, 1949).

II. *Earlier experiments in England, not discussed in the paper*

(*a*) Cockle Park, six experiments, annually 1905/6–11 (Northumberland County Agricultural Experiment Station, 1906–11).

(*b*) Bedfordshire, one experiment, 1891 (Malden, 1891).

These experiments were omitted from Figs. 1 and 2, and the discussion, since they were carried out with varieties which are no longer in large-scale cultivation and under conditions different from those of present-day potato-growing. At Cockle Park autumn planting was tried with some degree of success.

III. *Experiments in Scotland discussed in the paper*

(*a*) Boghall, two experiments, 1946, 1947 (Mukhtar Singh, 1952).

(*b*) Craibstone, twenty experiments, 1927–47 (except 1941) (1927–38, N. Scot. Coll. Agric., Craibstone, Aberdeen; 1939–40, 1942–7, unpublished, communicated by R. Bain).

REFERENCES

Boyd, D. A. & Dyke, G. V. (1950). *N.A.A.S. Quart. Rev.* no. 10, pp. 47–57.

Boyd, D. A. & Lessells, W. J. (1954). *J. Agric. Sci.* **44**, 465–76.

Church, B. M. (1952). *Emp. J. Exp. Agric.* **20**, 257–70.

Dyke, G. V. & Avis, P. R. D. (1953). *J. Agric. Sci.* **43**, 450–5.

Gregory, P. H. (1944). *Agriculture*, **49–50**, 557–9.

Harvey, P. N. (1949). *Agriculture*, **55**, 543–4.

Ivins, J. D. & McDermott, N. (1949). *Agriculture*, **55**, 452–3.

Malden, G. (1891). *J. R. Agric. Soc.* 3rd series, **2**, 864–9.

Mukhtar Singh (1952). *Emp. J. Exp. Agric.* **20**, 301–15.

Norfolk Agricultural Station (1952). *Farm Guide.*

Norfolk Agricultural Station (1953). *44th Annual Rep.* 1951–2.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1928). *Scot. J. Agric.* **11**, 82.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1929). *Scot. J. Agric.* **12**, 69–70.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1930). *Scot. J. Agric.* **13**, 79–80.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1931). *Scot. J. Agric.* **14**, 82–3.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1932). *Scot. J. Agric.* **15**, 79–80.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1933). *Scot. J. Agric.* **16**, 87–9.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1934). *Scot. J. Agric.* **17**, 85–7.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1935). *Scot. J. Agric.* **18**, 64–6.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1936). *Scot. J. Agric.* **19**, 64–5.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1937). *Scot. J. Agric.* **20**, 57–60.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1938). *Scot. J. Agric.* **21**, 169–71.

N. Scot. Coll. Agric., Craibstone, Aberdeen (1939). *Scot. J. Agric.* **22**, 177–9.

Northumberland County Agricultural Experiment Station (1906–11 *seriatim*). *Guide to Experiments.*

Rothamsted. *Results of the Field Experiments* (1939–47, **2** and 1948, 1949, 1950).

Yates, F. (1949). *Sampling Methods for Censuses and Surveys* (2nd ed. 1953). London: Griffin.

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