Potatoes

FARMERS' ATTITUDES TO FERTILISER USE ON POTATOES

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SUMMARY

1. This report considers the problems and attitudes of farmers using fertiliser on the potato crop. It is based on opinion surveys carried out in County Durham in 1961.
2. The object of the study was to determine in relation to the recommended optimum fertiliser rates for potatoes: (a) The quantities actually used by farmers; (b) The factors influencing their decisions on fertiliser use.
3. A comprehensive series of potato fertiliser experiments has recently been carried out by the National Agricultural Advisory Service and on the basis of these results, it is suggested that in the area of the survey, the optimum dressing where fertiliser is drilled, together with farmyard manure, is: 100 units N, 80 units P_2O_5, 150 units K_2O.
4. The average dressing used was near to the recommended optimum but the range of individual application for each of the three nutrients was about 300%. Even on adjacent farms, rates of application varied by as much as 50%.
5. Only 16% of the rates were within $\pm 10\%$ of the recommended optimum. 52% were more than 10% lower than the optimum for all three nutrients.
6. The most important reason given for not using more fertiliser was that the quality and hence the value of the resultant crop would suffer.
7. Farmers generally expected yield to increase if more fertiliser was used, and vice versa, but the shape of the estimated response curve differed considerably between individuals.
8. Many farmers felt that even in a normal growing year, potato yield might vary appreciably due to factors other than the quantity of fertiliser used.
9. The only factor taken into account by most farmers when deciding on the rate of fertiliser to use was whether farmyard manure had been applied.
10. 40% of the farmers would consider applying less fertiliser, if the price was increased by £10 per ton.
11. The majority of farmers showed a reasonable understanding of the meaning of the N.P.K. analysis of fertilisers but few chose between different compounds on the basis of value for money.
12. More economic use of fertilisers on potatoes would result if:
    (a) There was more experimental evidence of the effect of heavier fertiliser applications on tuber quality.
    (b) Farmers were prepared to carry out field trials on their own crops.
    (c) There was a wider use of soil analysis as part of an advisory programme to develop a better understanding of the basic principles of crop manuring.

FARMERS' ATTITUDES TO FERTILISER USE ON POTATOES

Introduction

The use of inorganic fertilisers has for many years been an accepted practice in British agriculture. Knowledge of fertiliser use has increased during the last 100 years until at the present time, optimum rates can be suggested for most crops with a reasonable degree of confidence. Nevertheless, surveys of fertiliser practice indicate that for some crops and in particular grass, the quantities actually applied are considerably below the recommended dressings. On the other hand, research workers in Scotland have shown that some farmers are using more fertiliser on the potato crop than can be economically justified.

It was in order to discover the attitudes of farmers to the use of fertiliser that this investigation was initiated. Attention has, in this instance, been confined to the potato crop, but it is intended that further studies related to other crops will be undertaken.

The Economic Significance of Fertilisers

Despite a reduction of over a million acres in the area of cereals and roots between 1952 and 1960, Table 1 shows that consumption of total plant food units had risen in the same period by nearly 50%.

Table 1. Consumption† of Inorganic Fertilisers United Kingdom

'000 tons of Plant Food					
Plant Food	*1952/5*	*1958/9*	*1959/60*	*1960/61**	*Difference 1952/5 to 1960/61*
					%
N	244·7	321·2	403·6	425·1	73
P_2O_5	350·6	383·2	454·6	435·3	24
K_2O	264·7	375·2	426·6	422·0	60
Total Plant Food Units ..	860·0	1,079·6	1,284·8	1,282·4	49

SOURCE: *Fertiliser Report and Statistics 1959, 1960 and 1961.*

* Preliminary. † Based on subsidy claims.

The biggest increase was in potash, in spite of the fact that at no time was it subsidised. To some extent, this was accounted for by the gradual easing of the import restrictions which were still in force in 1952 and the need to make good the accumulated deficiencies of the war years.

Economic conditions in the period were generally favourable to agriculture. Prices of most products increased (Table 2) and where they did not, as with cereals, any decrease was more than offset by the introduction of new crop varieties with a greater yield potential.

Table 2. Index Numbers of Prices of Main Products*

Product	1952	1955	1959
Wheat	100	108	95
Barley	100	82	86
Potatoes	100	125	172
Fat Cattle	100	123	131
Fat Sheep	100	117	116
Milk	100	103	99

SOURCE: *Agricultural Statistics, England and Wales.*

* Including subsidies.

In addition, whilst the cost of some factors such as land and labour rose, (Table 3) that of fertiliser fell mainly because of increased subsidy payments.

Table 3. Index Numbers of Certain Agricultural Costs

	1952	1955	1959
*Fertilisers**			
Sulphate of ammonia	100	89	73
Superphosphate (18%)	100	96	82
Muriate of potash (60%)	100	96	96
Feedingstuffs†			
Barley meal	100	96	85
Dec. Groundnut	100	137	124
Rent‡			
Dairy farms	100	114	120
Mixed farms	100	122	146
Labour§			
Minimum Agricultural Wage	100	118	145

* SOURCE: *Agricultural Statistics, England and Wales.* As at July of each year, net of subsidy.

† SOURCE: *Agricultural Statistics, England and Wales.*

‡ SOURCE: *Farm incomes in England and Wales*, Ministry of Agriculture.

§ SOURCE: *The State of British Agriculture 1959–1960.*

Consequently the relative cost of fertiliser in terms of the quantity of crop required to pay for it (Table 4) decreased, to a small extent in the case of wheat, and by 50% for potatoes.

Table 4. Relative Prices of Fertiliser and Crops*

	1952	1955	1959
	cwts.	*cwts.*	*cwts.*
Quantity of wheat needed to pay for 1 cwt. sulphate of ammonia	·5	·4	·37
Quantity of potatoes needed to pay for 1 cwt. compound fertiliser (7 : 7 : 10½)	1·25	1·0	·55†

SOURCE: *Agricultural Statistics, England and Wales.*

* Net of subsidy.

† Calculated from the cost of a 12 : 12 : 18 compound commonly used for potatoes.

This provided a strong incentive to potato growers to aim for the optimum level of fertiliser use, particularly as the available evidence at this time suggested that over-manuring would lead to little or no depression of yield.

For the individual farmer, the money spent on fertiliser does not often represent a very large proportion of the total annual expenditure. However, much of this total expenditure is fixed, at least in the short run and has to be met if the farmer is to stay in business. It can be argued that some of the fertiliser bill falls into the category of fixed cost; lime and slag must be applied to a part of the land each year as a matter of routine in order to maintain basic fertility. Expenditure on fertiliser is nevertheless one of the more important variable costs and so the farmer can use his discretion, whether to spend more or less on plant nutrients, depending on the circumstances in any one year.

The Theory of Fertiliser Use

In deciding on the quantity of fertiliser to use, the farmer is influenced by several factors and it was the purpose of this survey to assess their relative importance. It would however seem reasonable to expect that given adequate means of communication, the actions of every farmer would to some extent be guided by the available experimental evidence.

For many years, the standard source of information on the fertiliser requirement of crops was provided by Crowther & Yates' paper *Fertiliser policy in war time*[1] which summarised the results of a series of experiments carried out in the United Kingdom and some European countries between 1900 and 1939. The object in collating these results was to provide a logical basis on which the restricted supplies of fertiliser available in 1940 could be allocated. Changes in crop varieties, husbandry techniques, and levels of fertiliser use since these experiments were carried out seem to put severe limits on their application to present day conditions; but, until very recently, there was no serious attempt to summarise the results of post-war fertiliser experiments. Advisers and farmers, therefore, had no alternative but to rely on the earlier work.

The economic logic of decisions on fertiliser use is straightforward enough and is illustrated in Table 5 and Fig. 1.

*Table 5. The effect of using more Fertiliser on Potatoes**

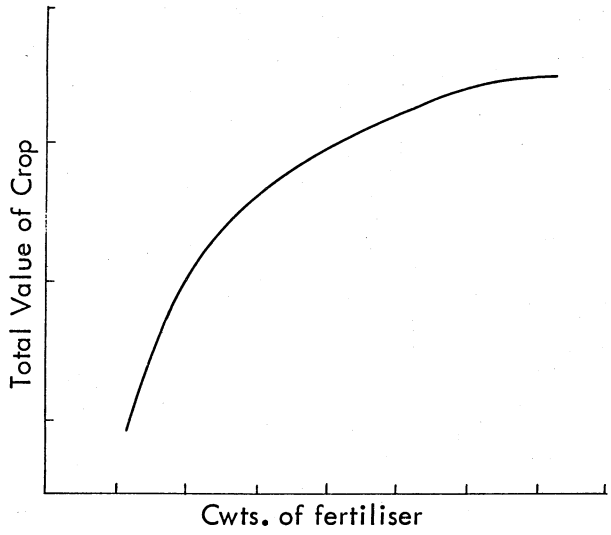
Fertiliser applied†		*Crop responses*‡		*Net return*
cwts.	*shs.*	*tons*	*shs.*	*shs.*
1·2	15·5	0·90	216	200·5
2	26	1·26	302	276
3	39	1·53	367	328
4	52	1·69	405	353
5	65	1·78	427	362
6	78	1·84	441	363
7	91	1·87	448	357

* Based on Table 6, Crowther & Yates op. cit.

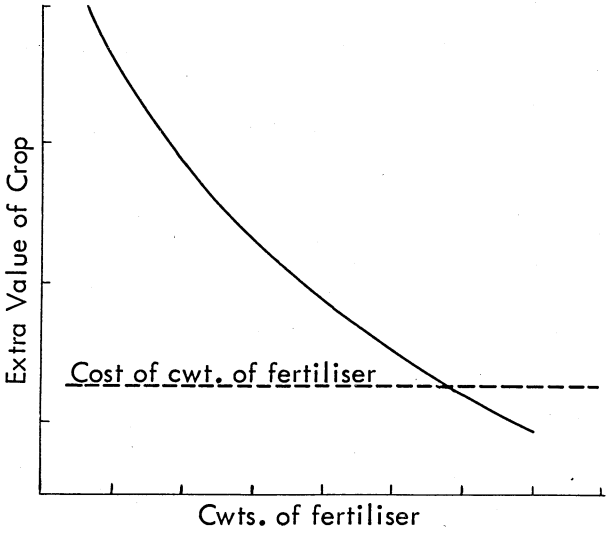
† Sulphate of ammonia at 13/- per cwt. including extra costs of spreading, etc.

‡ Crop price £12 per ton.

[1] Crowther, E. M. & Yates, F., *Fertiliser policy in war-time*. Emp. J. Exp. Agric. 9, 77.



a) Increasing Value of Crop



b) Value of Additional Crop

Fig. 1. The effect of using more Fertiliser on Potatoes

As more fertiliser is applied to the potato crop, total revenue increases but the rate of increase becomes less with successive quantities of fertiliser until a stage is reached where the value of the additional crop is insufficient to cover the cost of the extra fertiliser. The net return to the farmer remains fairly steady over a wide range around the optimum dressing; in this case 6 cwts. per acre. Therefore, although in order to save capital, there is an incentive to aim for the lower end of the range, heavier dressings of fertiliser need not result in any great decrease in profit.

Early in 1961, Boyd, in a paper to the Fertiliser Society[2], presented the results of an analysis which he had made of fertiliser experiments carried out between 1941 and 1959. These showed that in spite of the increasing use of fertiliser in post-war years, the average responses were substantially unchanged from Crowther & Yates' estimates. The earlier experiments had however, considerably underestimated the effect of interaction between nutrients in relation to both the magnitude of the response to a given level of a nutrient, and the rate at which the response falls off with increasing dressings. Boyd showed that at high levels of application, the exponential response curve was not valid and that instead of yields decreasing only slightly once the optimum fertiliser dressing had been exceeded, there was a definite fall off in the response to each nutrient which was more marked where the other major nutrients were present in only small quantities. The significance of these results is illustrated in Fig. 2. Whereas most potato crops were fertilised on the assumption that the penalty for exceeding the optimum dressing by even two or three cwt. was likely to be small, it is now believed that under some conditions, over-manuring may lead to a marked reduction in profits.

The precise form of the response curve has yet to be determined but the evidence is sufficiently strong to justify potato growers giving far more attention in the future to the question of manuring. The opinion survey carried out in July 1961 did in fact suggest that a few farmers were beginning to have second thoughts on the question but any assessment of the logic of either fertiliser practice in recent years or indeed, farmers' attitudes to the use of fertiliser has to be made in the light of the theories until recently current.

Optimum fertiliser rates for potatoes

In the past, there has been a dearth of information regarding the manurial requirements of individual soils, and the recommendation of optimum rates for potatoes has necessarily been based on experiments conducted on a range of soils under widely different growing conditions. Recently however the N.A.A.S. Soil Chemists have completed a series of experiments over a period of six years on a number of soil series in England and Wales. Three of these series covering twenty-nine sites were in the North of England, one of them in County Durham and although the detailed experimental results have not yet been published, the Regional Soil Chemist has suggested optimum fertiliser rates for potatoes grown on soils of this series. These are shown in Table 6.

The recommendations published by the manufacturers of fertiliser must often come to the farmer's notice when he is deciding on his requirements and are therefore likely to influence his decisions. The range in the recommendations of two manufacturers are also shown in Table 6. This illustrates the tendency for different manufacturers to recommend more uniform quantities rather than the same total nutrients.

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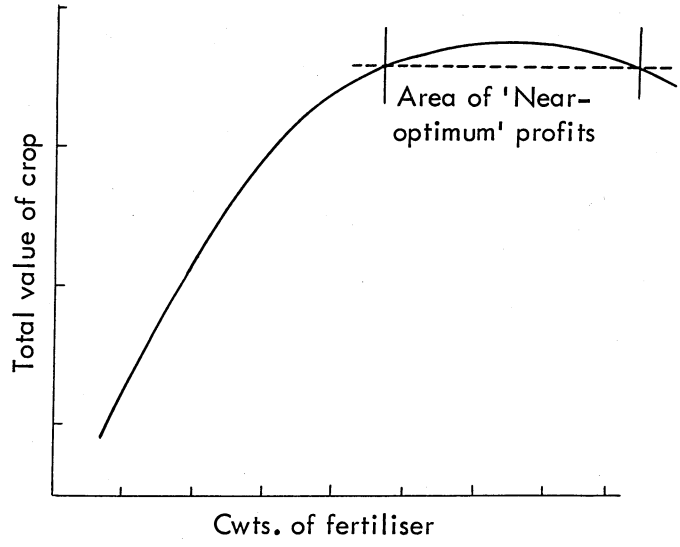
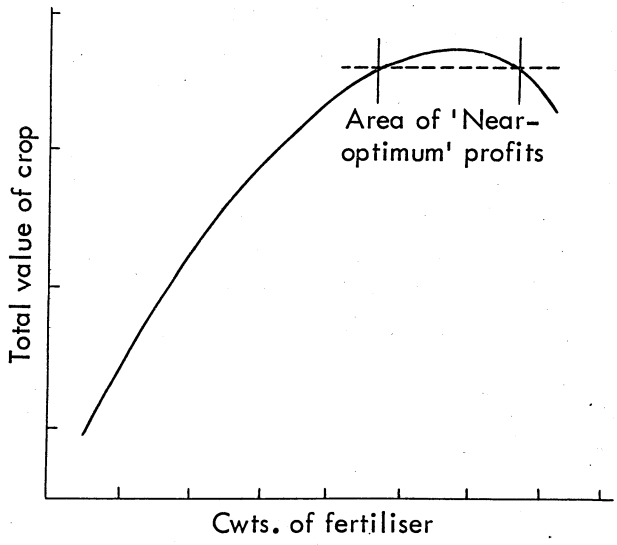
2 Boyd, D. A., *Current fertiliser practice in relation to manurial requirements.* Proc. Fert. Soc. No. 65.



a) Fertiliser Response - Crowther & Yates



b) Fertiliser Response - Boyd

Fig. 2. The Significance of Recent Theories on the effect of Over-manuring

Table 6. Recommended Rates of Fertiliser Application

Source of Recommendation	Quantity cwts.	Units of nutrient per acre			Notes
		N	*P*	*K*	
1. N.A.A.S. Soil Chemist*	—	100	80	150	Placement drilling and broadcast over ridges. With F.Y.M.
2. N.A.A.S. Soil Chemist*	—	120	120	180	Broadcast before ridging. With F.Y.M.
3. Manufacturer A† ..	8-12	96-144	96-144	144-216	Placement drilling and broadcast over ridges. With F.Y.M.
4. Manufacturer B† ..	8-12	72-108	72-108	120-180	Broadcast over ridges. With F.Y.M.

* For soils similar to those of the Croxdale series.

† For 'general use under average conditions'.

Previous surveys of fertiliser practice

Fertiliser practice surveys have been carried out in various parts of the country since 1942[3] [4] and in 1958 the Potato Marketing Board surveyed the growing of maincrop potatoes on nearly a thousand farms in England and Scotland[5] in the course of which, details were collected of the fertilisers applied to the crop.

All the surveys show that there is remarkably little variation in the manuring of potatoes from one part of the country to another (Table 7) and in both the surveys mentioned, the overall mean was 110 units N, 120 units P_2O_5, and 180 units of K_2O (1 unit = ·01 cwt.).

Table 7. Average Manuring of Maincrop Potatoes in 1958

	Percentage of acreage receiving				Average dressing cwt. per acre		
	FYM	*N*	*P*	*K*	*N*	P_2O_5	K_2O
East Anglia—peat and silt..	41	98	100	100	1·19	1·35	1·94
other soils	38	98	98	98	1·24	1·34	1·94
East Midlands	61	98	98	98	1·16	1·19	1·97
Yorks and Lancs	88	98	98	98	1·05	1·07	1·85
West Midlands	55	95	95	91	0·98	1·00	1·69
Southern England	41	88	87	86	1·15	1·25	1·92
Northern England	88	97	97	97	1·09	1·03	1·56
Scotland—ware crops	63	98	98	98	0·90	1·00	1·37
seed crops	43	98	98	98	0·87	0·96	1·43
Great Britain	55	97	97	96	1·08	1·16	1·79

SOURCE: *Report on the Survey of Maincrop Potatoes 1958*, Potato Marketing Board.

[3] Yates, F., Boyd, D. A., & Mathison, Irena, *The manuring of farm crops: Results of a survey of fertiliser practice in England.* Emp. J. Exp. Agric. 1944, 12 163-76.

[4] Boyd, D. A., Church, B. M. & Hills, Mary D., *Fertiliser practice in England and Wales 1956-57.* Emp. J. Exp. Agric. 29, 35.

[5] Potato Marketing Board. *Report on the survey of maincrop potatoes 1958.*

Regardless of whether this average dressing approximates to the recommended level, it is apparent that farmers generally are not making any appreciable adjustment in their fertiliser applications for the known regional variations in soil fertility. Within regions the situation is even more confused; on 62 fields surveyed by the Potato Marketing Board in County Durham, the range in rates of application for each of the three nutrients was over 500% even though farmyard manure had been applied in all cases. Table 8 shows the distribution.

Table 8. Range in Rates of Application. County Durham 1958

	*Number of fields**				
	Units of nutrient per acre				
	0–50	*51–100*	*101–150*	*151–200*	*201+*
Nitrogen	26	19	15	2	0
Phosphate..	25	23	8	6	0
Potash	0	31	11	9	11

* All receiving farmyard manure in addition to the inorganic fertilisers.

SOURCE: Potato Marketing Board. Private communication.

The variation in the rates was almost entirely inter- rather than intra-farm; of the 20 farms in the sample, only 3 varied the quantity of fertiliser used on different fields.

THE STUDY OF FERTILISER USE IN COUNTY DURHAM

I Fertiliser Practice

Experiments may suggest where the limits to profitable production lie, but there are many reasons why the individual farmer does not farm as intensively as would at first sight appear to be possible. Lack of knowledge of new techniques, shortage of the necessary capital or a higher valuation of more leisure as opposed to extra effort are some factors which in different situations account for this apparently irrational behaviour.

Although in comparison with other management decisions, problems relating to the manuring of crops are usually less complicated, they are nevertheless typical of those facing the farmer and for this reason, it was considered an appropriate point at which to commence a study of decision making. Furthermore, the position of potatoes in the economy of most Durham farms is clearly defined and by concentrating attention on this crop, there was perhaps more likelihood of distinguishing the main factors concerned.

In order to minimise the importance of variations in climate, soil type and proximity to markets, the survey was restricted to an area of about 20 square miles near to Sedgefield and an approach was made to all farmers in this area who in previous years had grown more than five acres of potatoes. A questionnaire was developed (Appendix I) and pre-tested outside the area. Of the 26 eligible farmers, only two did not wish to co-operate in the survey, four others were ruled out for different reasons, giving 20 completed questionnaires. The average time required to complete the questionnaire was 58 minutes, with a range of 35 minutes to $2\frac{1}{2}$ hours.

Additional information was obtained by putting a small number of questions (Appendix II) to 35 farmers who visited the Ministry of Agriculture stand at the Durham County Agricultural Show. In view of the particular nature of this sample, the results are presented separately.

Soil Types in the area

The majority of the farms surveyed were in an area of gently undulating country which lies to the south of a ridge of Magnesium Limestone. The most important parent material was a Carboniferous Till but in the south there was a small area of Old Red Sandstone Till. The soils were generally described in the Soil Survey as sandy loams to loams, with two small pockets of clay loams but the farmers' descriptions varied considerably within the same soil series depending on previous treatment, drainage, etc. Nevertheless an experienced soil surveyor considered that there were no marked differences in inherent fertility.

Potato production in the two preceding seasons

1959 was an outstanding year. Although most farmers had a backlog of ploughing in the spring because of the previous wet autumn, they were soon able to catch up with the work and the record amount of sunshine coupled with sufficient moisture provided ideal growing and harvesting conditions, particularly for cereals. Seedbeds for potatoes were rather dry but nevertheless the crop made good growth during the season and lifted in excellent condition.

Table 9 shows the yield, price per ton and gross output per acre of potatoes obtained by a group of Durham farmers in both 1959 and 1960.

Table 9. Potato Yields and Prices 1959 and 1960 Crops*

		Yield tons/acre	*Price/ton £ . s.*	*Gross Output £/acre*
1959	Average	7·9	11.7	90
	Range	6–13	£9.8–£14.11	£61–£136
1960	Average	7·8	11.13	91
	Range	3–15	£10–£14.18	£30–£188

* For 20 Durham farms included in the Farm Management Survey Scheme.

Prices in the autumn of 1959 although considerably lower than the previous year, were regarded as reasonable by those growers who were able to dispose of their crop but there was a considerable surplus of potatoes and many were sold at a low price in the early spring before the Government stepped in to support the market.

1960 was an extremely difficult year for potato growing in Durham, as in most other parts of the country and this was undoubtedly responsible for the 13% reduction in the acreage planted on the surveyed farms in the following year. A good crop was grown but harvesting conditions were appalling. In October, three times the average amount of rain fell and some farmers had to abandon part of their acreage and most left at least a third of the crop in the ground. Prices were depressed from the start of the season and only improved in the late spring of 1961. Although Table 9 shows that yields and prices were very similar in both 1959 and 1960, most farmers would estimate that their harvesting costs were doubled in the latter year, to say nothing of the depressing effect of the job on the morale of all concerned.

*The farms and farmers included in the surveys**

Only farmers known to have grown more than five acres of potatoes in 1960 were approached, but two had planted less in 1961. The average area of maincrop

* Survey A = Opinion survey of 20 farmers in the Sedgefield area of County Durham.
Survey B = Questions answered by 35 farmers at the Durham County Agricultural show, August 1961.

potatoes grown per farm was 11 acres (Table 10) or approximately 5% of the total farm acreage of 235 acres. Tenants and owner-occupiers were nearly equally represented with four farmers both owning and renting land. Two thirds of the farmers had operated their present farms for over ten years and of the remainder, several had taken over from their fathers in recent years and could still call on them for advice regarding the fertility of the individual fields.

Five different varieties of potato were grown (Table 11) but over 60% of the total acreage was planted to Majestic, the most popular variety in the North-East. The crop most commonly followed cereals, in particular oats, with only 39 acres being planted after a one-year lay.

The 35 farmers questioned in Survey B grew an average of 13 acres of potatoes which was 6% of the total farm acreage of 212 acres (Table 12). Majestics were grown on 32 of the farms and the only other variety of any importance was Redskin, which was grown on twelve farms, generally together with Majestic.

Table 10. The Farms and the Farmers
Survey A

	Per farm		*Number of:*			*Number of farmers*	
	Total farm acres	*Potatoes acres*	*Tenants*	*Owner occupier*	*Both*	*Years on present farm*	
						Up to 10	*Over 10*
Average ..	235	11					
Range	56–686	3–30	7	9	4	7	13

Table 11. Varieties of Potato Grown and the Preceding Crop
Survey A

Variety grown	*Acres*	%	*Preceding crop*	*Acres*	%
Majestic	139	63			
Arran Peak	49	22	Oats	92	42
Redskin	15	7	Barley	55	25
Arran Consul	10	4	Wheat	35	16
Dr. Mackintosh ..	8	4	1 year ley	39	17
	221	100		221	100

Table 12. The Farms and the Varieties Grown
Survey B

	Per farm		*Varieties grown*
	Total farm acres	*Potatoes acres*	*Number of fields**
Average	212	13	Majestic only 11
Range	64–1,076	1–75	Majestic and others 20
			Redskin and others 12

* Or part fields.

Manuring of the 1961 crop

Considering the very wide cost: benefit ratio for the manuring of potatoes, particularly at the lower levels of use, it is not surprising to find that all farmers contacted in both surveys were using artificial fertilisers, but there was a very wide variation in the quantity and cost of fertiliser used and the methods of application.

The overall average for the 62 different rates (on 55 farms) was (Table 13):

96 units N, 92 units P_2O_5, 153 units K_2O.

This is less than the quantities reported in the two surveys of fertiliser practice mentioned earlier.

In spite of the range of soil types covered in Survey B, the average rate of application was virtually the same as in Survey A, with the exception of potash, where the equivalent of an extra $\frac{1}{4}$ cwt. of muriate of potash was used.

Table 13. Average Quantity of Nutrients Applied

	N	*P*	*K*
	Units of nutrients per acre		
Survey A (25 different rates)*	95	89	146
Survey B (37 different rates)	98	95	159
Overall average	96	92	153

* Some farmers varied the rate of application between fields. Of the 62 rates, 52 were in addition to farmyard manure.

An analysis of the rates applied in the two groups (Table 14) reveals a range of about 300% for each, but in Survey A, where because of the more uniform conditions, a pronounced modal rate might have been expected, there was a fairly even scatter throughout the range.

Table 14. Range in Rates of Application

Units of nutrient per acre	*Number of different rates*					
	Survey A (25 rates)			*Survey B (37 rates)*		
	N	*P*	*K*	*N*	*P*	*K*
Below 50	1	3	0	3	3	0
51–75	9	5	1	3	4	3
76–100	6	9	0	22	21	0
101–125	6	6	8	4	6	4
126–150	3	2	6	3	2	11
151–175	—	—	3	1	—	2
176–200	—	—	5	1	1	13
Over 200	—	—	2	—	—	4

On pairs of adjacent farms, rates in some cases were virtually identical and in others, differed by as much as 50% (Table 15).

Table 15. Rates of Application on Pairs of Adjacent Farms

	N	*P*	*K*
	Units of nutrients per acre		
Farms 3	125	125	189
Farms 14	114	114	171
Farms 5	72	72	120
Farms 8	120	120	180
Farms 7*	70	80	160
Farms 10*	126	126	210

* No farmyard manure used.

Comparisons of the fertiliser dressings actually used in Survey A with the optimum rates suggested by the N.A.A.S. Regional Soil Chemist (page 11) shows, in Table 16, a tendency for farmers to apply too little rather than too much fertiliser. Of the 25 different rates used, only four were within the range of 10% above or below the optimum and thirteen, or more than half, were 10% lower than the optimum for all three nutrients. This might suggest that the decision to apply less fertiliser was influenced by consideration of factors other than the nutrient status of the soil.

Table 16. Comparison of Fertiliser Dressings with Suggested Optimum Rates

	Number of rates
More than 10% above optimum rate for:	
1 nutrient	1
2 nutrients	0
3 nutrients	3
More than 10% below optimum rate for:	
1 nutrient	2
2 nutrients	2
3 nutrients	13
Within 10% above or 10% below optimum rate	4
	25

The use of farmyard manure

Traditionally, farmyard manure has been applied to the land for potatoes, contributing both fertiliser nutrients for the crop and humus to improve soil structure. In recent years, some farmers have decided that both objectives could be achieved more cheaply by using additional artificial fertiliser and ploughing in leys. Nevertheless, fifty two of the rates recorded were applied in conjunction with farmyard manure and of the remaining ten, several were the result of adverse weather in the spring rather than a definite policy decision. Estimates of the quantities of farmyard manure used were obtained in Survey A and they ranged from 12–20 tons per acre but in view of the difficulty of assessing accurately either quantity or composition, it is proposed to assume that where manure was used, it supplied the equivalent of 20 units N, 20 units P_2O_5 and 30 units K_2O per acre.

This is less than the quantities suggested by some authorities[6] but a conservative estimate seems more appropriate in this particular year (1960/61) because of the unfavourable conditions both during the winter and at planting time. Thus the total nutrients available to the crop where manure was applied were:

114 units N, 110 units P_2O_5, 180 units K_2O (52 rates); and where manure was not applied:

109 units N, 107 units P_2O_5, 172 units K_2O (10 rates).

Methods of fertiliser application used

In recent years, experiments have shown[7] [8] that under certain conditions the placing of fertilisers in bands results in a bigger crop of potatoes than if the same quantity is broadcast on the land before ridging. Consequently if all farmers were aware of, and were intending to use optimum dressings, it might be expected that there would be a significant variation in the rates with smaller quantities applied where placement drills were used. Table 17, however shows that in Survey A, farmers using placement drills also applied more fertiliser and in Survey B, the rate of application was approximately the same for both methods.

Table 17. Fertiliser used with Different Methods of Application

Method of application	*Survey A**			*Survey B**		
	N	*P*	*K*	*N*	*P*	*K*
	Units of nutrient per acre					
Broadcast before ridging ..	86	77	129	99	83	146
Broadcast after ridging ..	—	—	—	81	85	139
Placed in bands	104	99	153	97	92	148

* All rates in addition to farmyard manure.

Farmers broadcasting fertiliser over the ridges before planting, a method considered to be as effective as placement drilling, used slightly smaller quantities.

A nitrogenous top dressing was applied in five of the 62 cases recorded, the quantity varying from 15 to 42 units of nitrogen.

Type and quantity of fertiliser used

With the exception of the top-dressing, no 'straight' fertilisers were applied and of the thirteen different compounds (Table 18), two were used in over 60% of the cases. The ratio of nutrients was mainly between 1 : 1 : $1\frac{1}{2}$ to 1 : 1 : 2 but on one farm a low phosphate fertiliser ($2\frac{1}{3}$: 1 : $3\frac{1}{3}$) was used.

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[6] Boyd, D. A., *The effect of farmyard manure on fertiliser response.* J. Agric. Sci. 52, 384.

[7] Cooke, G. W., Jackson, M. V. & Widdowson, F. V., *Placement of fertilisers for potatoes planted by machines.* J. Agric. Sci. 44, 327.

[8] McConaghy, S. & McAllister, J. S. V., *Fertiliser placement for the potato crop.* The Research and Experimental Record of the Ministry of Agriculture, Northern Ireland. Vol. VIII, Part I 1959.

Table 18. Compound Fertilisers Used

Analysis			Number of times used
N	*P*	*K*	
%	%	%	
6	6	10	1
7	7	10½	1
7	8	16	2
7	8½	12	5
8	9	20	1
9	7	21	1
9	9	15	7
10	10	15	2
10	10	18	16
12	8	18	1
12	12	18	23
14	6	20	1
17	11	22	1
			62

The dressing most commonly applied (Table 19) was between nine and eleven cwts. per acre.

Table 19. Range in Weight of Fertiliser Applied

	Number of different rates				
	Cwts. of fertiliser per acre				
	5-7	*7-9*	*9-11*	*11-13*	*13-15*
Survey A	6	7	8*	2	2
Survey B	4	11	20†	1	1

* Including 5 of 10 cwts. per acre.
† „ 18 „ „ „ „ „

However, Table 20 shows that because of the variation in the analysis of the compounds, the range in the quantities of nutrients supplied by this modal dressing was nearly as wide as in the survey as a whole.

*Table 20. Range in the Quantities of Nutrients Supplied by the Modal Dressing**

	N	*P*	*K*
	Units of nutrient per acre		
Survey A	70–120	80–120	120–180
Survey B	70–170	70–120	120–220

* 10 cwts. per acre of compound fertiliser.

The cost of the fertiliser used

Expenditure on fertiliser was about £1 per acre less in Survey A than Survey B (Table 21) but the overall mode lay in the range £8–10 per acre. Although only an approximate price comparison can be made between compounds of different composition, there was some indication that certain farmers were getting better value for money.

Table 21. Range in Cost of Fertiliser Used

	Number of different rates				
	Fertiliser cost per acre				
	£ *4–6*	£ *6–8*	£ *8–10*	£ *10–12*	£ *+12*
Survey A	2	9	8	4	2
Survey B	3	7	16	8	3

Summary of fertiliser practice in the two surveys

1. The average dressing was 96 units N, 92 units P_2O_5 and 153 units of K_2O.
2. For each nutrient, the range of application between farms was in the region of 300%.
3. On some adjacent farms, the rates varied by as much as 50%.
4. In Survey A, over 50% of the dressings used were more than 10% lower than the suggested optimum rates for all three nutrients.
5. Where no farmyard manure was used, more fertiliser was applied, and the additional quantity was sufficient to make good the deficiency if a conservative estimate is placed on the nutrient value of farmyard manure.
6. The dressing most frequently used was 10 cwts. per acre but because of the variation in composition, there was a wide range in the quantity of nutrients which this supplied.
7. Expenditure on fertiliser was most frequently between £8–10 per acre.

II Farmers' Attitudes and Opinions

Rational decisions on fertiliser use require not only a knowledge of the recommended optimum rates, but also an ability to interpret this information according to the circumstances of the individual farm. Several questions have to be answered before the final decision can be taken. 'Is the optimum dressing likely to produce too many big potatoes or adversely affect the keeping quality?' 'If capital is in short supply, would it be better to use some of the money to buy more livestock, which would give a smaller but safer return?' 'If potatoes don't use the fertiliser, will it be there for the corn crop next year?' It may not be necessary to review the position every year but unless the manuring policy is looked at critically from time to time, it can soon become a matter of convenient habit.

The farmers in Survey A were asked why they did not use more or less fertiliser than the quantity actually applied and their answers are classified in Table 22.

Table 22. Farmers' Reasons For Not Using More Fertiliser

	Adverse effect on quality	*Habit*	*No greater crop*	*High cost*	*Other*
	% of farmers				
Survey A	80	15	—	5	—
Survey B	49	11	34	—	6

Of the twenty farmers, sixteen gave as their prime reason for not using more fertiliser, the possibility of adversely affecting either the quality or the size of the sample, one restricted the application for financial reasons and the remaining three saw no good reason for changing their normal practice.

In view of the importance of Majestic potatoes in the area, it is not surprising that farmers were so keenly aware of the risk of producing a high proportion of large split tubers if they increased the quantity of fertiliser above a certain level. Whilst it was possible at one time to dispose of the 'big, ugly' Majestic potato in the ware sample, the imposition of a maximum riddle size for the 1960 harvest meant that some growers were unable to sell as much as 20% of their total crop. Little experimental evidence appears to be available on this question, and opinions vary among workers and farmers as to the relative importance of heavier fertiliser dressings and changing weather conditions in causing splitting. Not all sixteen farmers had experienced a reduction in quality with heavier fertiliser dressings but the possibility was undoubtedly acting as a powerful deterrent. Altogether four farmers mentioned that they could not afford to use more fertiliser but when questioned further some of their replies were not entirely consistent, due possibly to bias introduced by the intervening questions.

The farmers in Survey B, when asked if they thought that it would pay to use more fertiliser (Question 8) put less emphasis on the possible effect on tuber quality and more than a third of them considered that the crop would not be increased (Table 22). Two said that more fertiliser would cause the succeeding corn crop to lodge.

It was apparent from some remarks, that although the profit potential of potatoes was appreciated, the value of the part played by the crop in restoring soil fertility and preventing a build-up of annual weeds was also regarded as important. This may be a justifiable attitude on the few farms with heavy land, but unless the crop is profitable, there are probably cheaper ways of achieving the same objective.

Other farmers considered that variations in soil and weather conditions were likely to have more influence on yield than small changes in the quantity of fertiliser used. Later questioning was designed to elucidate this point.

The reason given for not using less fertiliser was, without exception, that farmers 'wanted to grow a good crop' and only in one or two cases was any inconsistency in this attitude shown later in the survey.

Farmers' quantitive estimates of response to fertiliser

Whilst farmers may all use fertilisers 'to grow better crops', their estimates of the benefits to be obtained are likely to vary considerably. To quantify these estimates, one must determine what each farmer considers to be his normal fertiliser use and yield expectation.

Four farmers had diverged in 1961 from their usual fertiliser practice; three used more because it had not been possible to apply the normal dressing of farmyard manure, and one reduced the rate as a larger acreage was planted.

In arriving at the yield of potatoes expected from the usual fertiliser dressing in a year with average growing and harvesting conditions, farmers were inclined to work out an average of the last few years rather than to identify the modal yield over a longer period of years. The latter might have been a better basis for a manuring policy. It was not easy however, to make this distinction clear in the interview, but the impression was gained that most farmers did in fact discount to a certain extent the low yield resulting from the very wet harvesting conditions in 1960.

Having established normal yield expectations, farmers were then asked what variation they would expect if more or less than the usual amount of fertiliser was applied. The general reaction to this question was as follows: 'I've had no personal experience of using different dressings. More fertiliser would certainly give a bigger crop, but the quality would suffer. Less fertiliser would reduce the yield and the size of tuber.' Two farmers had recent experience of the effect of differential rates of fertiliser use (as a result of the partial blocking of drill spouts) and were quite prepared to make estimates on this basis. Otherwise, there was an understandable reluctance to forecast the likely variation. Though all were prepared to discuss their expectations in general terms, only twelve made quantitive estimates which allowed response curves to be constructed. The nature of these estimates is shown in Table 23a.

More of the estimates suggested returns that were diminishing or constant rather than increasing and the average expected response (Table 23b) decreased by 21% over a range of four cwts. of fertiliser.

Table 23. Farmers' Estimates of Yield Variation With More or Less Fertiliser

(a) Nature of the estimates

	Number of farmers
Yield increases bigger than decreases*	3
,, ,, equal to ,, †	4
,, ,, smaller than ,, ‡	5
Incomplete estimate	7
No estimate	1

* Increasing returns
† Constant returns
‡ Diminishing returns

(b) Magnitude of the estimates

	Variation in crop yield	
	2 cwts. less fertiliser	*2 cwts. more fertiliser*
Average ..	(−) 1 ton 8 cwts.	(+) 1 ton 2 cwts.
Range	1½ cwts.–2 tons	5 cwts.–3 tons

In all, eleven farmers made specific mention of an upper limit beyond which they thought that yield would not increase. These included the three who predicted increasing returns. Typical estimated response curves are shown in Fig. 3. Curves 2 and 19 illustrate the extreme in anticipated response. Farmer No. 2, who had noticed the effect of partially blocked fertiliser spouts in the previous year, predicted that a 'tremendous crop' could be grown if more fertiliser was used, but that the quality of the potatoes would suffer. He was confident therefore that he was applying the optimum dressing for his conditions. Farmer No. 19 was using a similar

quantity of fertiliser but unlike No. 2, attached great importance to the contribution of farmyard manure, and the thoroughness of the pre-planting cultivations. Consequently, he felt that variations in the quantity of fertiliser, within the range discussed, would have little influence on the crop yields, although earlier he had said that his present dressing was necessary 'to get a good crop'. Apparent inconsistencies of this nature were frequently encountered.

Curves 1 and 4 both approach the more normally accepted shape though the former shows increasing returns at the higher rates of application. Both these farmers set a limit on the increase to be expected, but neither of them expressed any concern about the possibility of depressing yield with larger fertiliser dressings.

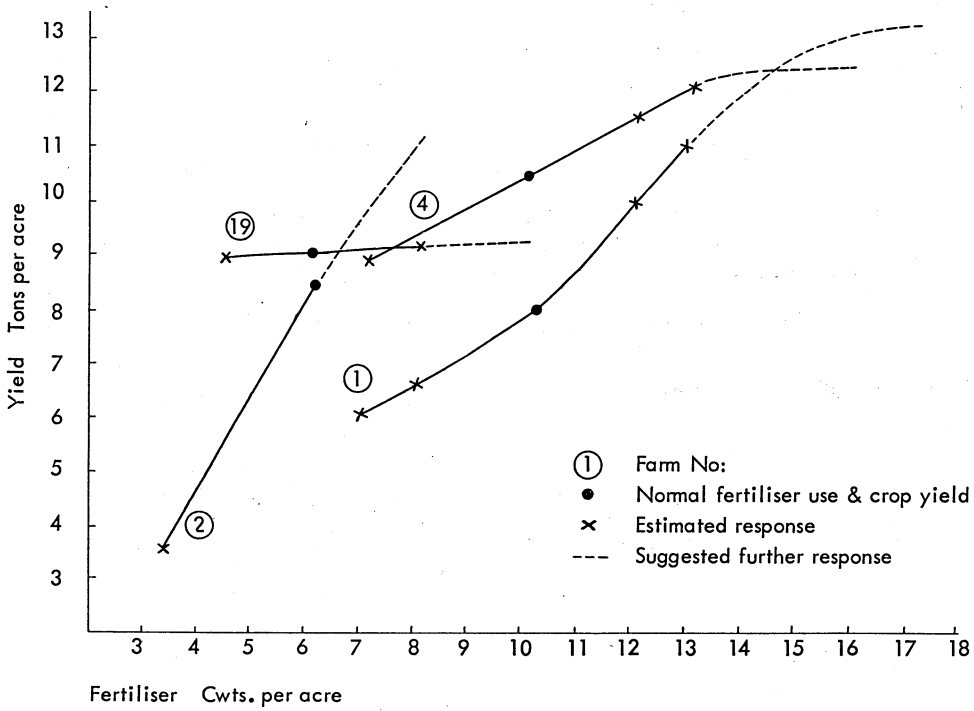

Fig. 3. Typical Estimated Response Curves

It was obvious at this stage of the interview that although most of the farmers were aware of the general benefits to be obtained from using fertilisers, their assessment of the appropriate dressing was largely subjective and that they gave little consideration to the possible effect on costs or returns of varying the rate of application.

The significance of seasonal variation in potato yields

Over the last ten years, the average yield of potatoes has varied by as much as 26% for England and Wales as a whole and 18% for County Durham. A large part of this variation can be attributed to differences in the amount and distribution of rainfall and sunshine from one year to another. It is probably true that the introduction of new varieties has far less influenced the yield potential of potatoes than of

cereals. Most farmers considered that potatoes needed adequate moisture at planting time and early in the growing season until they were ridged but that subsequently, sunshine was the most important yield factor. All farmers considered 1960 an exceptional year and the possibility of a recurrence of such climatic conditions did not appear to influence their decisions on the use of fertiliser. Nevertheless, there was a general appreciation that a certain amount of variation about the average yield was to be expected. Of the twenty farmers, only one would have expressed any surprise if, in an apparently average growing year, the variation was ± 1 ton, and 14 or 70% were prepared to accept that a range in yield from 6·8 tons to 10·8 tons per acre was likely.

Thus ruling out extreme weather conditions, farmers considered that chance variations in the vigour of seed, timing of operations and seasonal distribution of both rainfall and sunshine would materially influence the final yield of the crop and possibly mask the effect of the fertiliser dressing applied. Questions were asked to discover whether farmers felt that they were likely to get more benefit from the use of fertilisers in favourable rather than unfavourable years but with one or two exceptions they could not express an opinion on what is certainly an involved question, particularly when price fluctuation is taken into account. The general impression obtained in discussion was that in a favourable year, a good crop would be grown anyway: extra fertiliser might produce a bigger yield but the proportion of large, cracked potatoes would inevitably be much higher. In an unfavourable year, little benefit would be obtained from fertiliser and money spent on more than the normal amount would be wasted. Consequently, plans were always made in the expectation of an 'average' year in the knowledge that although some profit might possibly be lost in favourable years, this would be offset to some extent by the saving each year in the cost of fertiliser. Such an argument is incontestable in the absence of experimental evidence on the effect of fertiliser both on potato yields in favourable and unfavourable years and on the quality of the different varieties.

In Table 24, certain assumptions have been made in order to illustrate the way in which additional fertiliser might result in increased output, and hence profit, over a five-year period. In an unfavourable year, the return on the additional expenditure on fertiliser might be as little as £2 per acre but provided that the extra crop grown in the normal and favourable years was of good quality, the average annual increase in output over the period might be £15 per acre, which represents a return on the extra capital of 750% and probably an addition to the gross margin per acre for the crop of between 25%–33%.

Table 24. Estimates of the Effect of Using More Fertiliser Over a Five Year Period

Assumptions

1. Using 10 cwts. per acre compound fertiliser, the yield of potatoes might be:

Normal year*	8 tons per acre
Unfavourable year*	6 ,, ,, ,,
Favourable year*	10 ,, ,, ,,

2. Using an extra 2 cwts. of fertiliser (12 cwts. per acre in all) the yield of potatoes might be:

Normal year	$9\frac{1}{4}$ tons per acre
Unfavourable year	$6\frac{1}{4}$,, ,, ,,
Favourable year	12 ,, ,, ,,

* *i.e.* Years in which the growing conditions are either normal, unfavourable or favourable.

3. Potato prices might be:

Normal year	.. £13 per ton
Unfavourable year	.. £15 „ „
Favourable year	.. £11 „ „

4. In a five year period, the distribution of seasons might be 1 unfavourable, 3 normal and 1 favourable.
5. On the basis of these assumptions, the effect of using extra fertiliser over a five-year period would be:

	Output per acre			
	Using 10 cwts. per acre of fertiliser		*Using 12 cwts. per acre of fertiliser*	
1 Unfavourable year		£90		£92†
3 Normal years	3 × £104	£312	3 × £118	£354†
1 Favourable year		£110		£130†
		£512		£576†
Average per year		£102		£115†

† Net of the cost of the extra fertiliser (£2/acre).

Returns of this magnitude are not easily obtained in other ways and it suggests that potato growers who limit their use of fertiliser either because of the possibility of waste in an unfavourable year or because of the possible effect on the quality of the sample would be well advised to seek the answers to these problems from the research worker, or by carrying out simple trials each year on their own farms.

The significance of fluctuations in potato prices

Although the average price for potatoes did not vary greatly between 1959/60 and 1960/61 (see p. 13) some growers experienced a reduction in price of as much as £5 per ton, or 33%. Nevertheless when the survey was carried out in July 1961, it was quite obvious that fluctuations in price, even of this magnitude, had no influence on farmers' fertiliser policy (Table 25).

Table 25. Price Expectations and Reactions to Price Change

Number of farmers who:									
Anticipated certain prices for 1961 crop		*Would be surprised if price was:*				*Would alter fertiliser dressing if potato prices were:*			
Price/ton	*No.*	*Up*		*Down*		*Up*		*Down*	
		£2	£4	£2	£4	£2	£4	£2	£4
£9	1								
£10	3								
£11	6								
£12	7	2	15	18	20	0	0	0	0
£13+	3								

Number in sample = 20.

In view of the wide cost: benefit ratio for the manuring of potatoes, it would have been difficult for any farmer using the optimum amount of fertiliser to have made the very slight reduction in quantity necessitated by the price change and for

others, the possibility of moving nearer to the optimum position by using more fertiliser was ruled out by the likely adverse affect on quality.

Some farmers mentioned that if prices deteriorated, they would consider reducing the acreage planted in the following year, indeed several of them had contracted their acreage after the unfavourable 1960 crop. This decision was on the assumption that although there was now very little profit in growing potatoes there was always the chance that prices would improve in the following year. In any case, it would be difficult to find a substitute cleaning crop in the rotation. Possibly a few more acres of swedes could be grown, so reducing the risk should prices again be unfavourable.

Generally, price expectations for the 1961 crop were influenced by the level at which the Potato Marketing Board had acted to support the market in previous years. The announcement by the Board that the area of potatoes planted was about 100,000 acres less than in the previous year, a fact which would obviously influence growers' attitudes, was made a few days after the survey was completed. As is shown in Table 25, 65% of the farmers anticipated a price in the region of £11–£12 ton but this was a conservative estimate, as further questioning showed that only two growers in the sample would have been surprised if in fact, prices were £2 per ton more than they had anticipated. 75% however, did not expect prices to be as much as £4 per ton higher.

Factors influencing decision on the quantity of fertiliser to apply

It is conceivable that the process of deciding on the appropriate fertiliser rate might be more or less continuous, with observations made during the growing of one crop affecting the dressing used on the next. But the predominant impression gained during this survey was that most farmers, having once decided on the rate to use, influenced by manufacturers' recommendations, technical advisers or the farming press, are seldom inclined to vary it.

The 1961 crop was planted in difficult conditions after a very wet winter. Seven farmers were unable to apply farmyard manure to some or all of the potato acreage but only three of them increased the quantity of artificial fertiliser used, by 3-5 cwts. per acre. One other grower applied less than normal because after he had ordered the fertiliser, his acreage quota was increased from 7 to $8\frac{1}{2}$ acres.

In reply to an open-ended question, only four farmers said that they reconsidered the fertiliser rate each year and they were the three who had been unable to apply farmyard manure and one who considered that part of a field needed a heavier dressing as it was 'in poor condition'. Further probing however, suggested that eleven others were prepared, if necessary, to vary the rate, although they did not do so in 1961. As Table 26 shows, 10 or half the farmers took account of the contri-

Table 26. Factors Taken into Account when Deciding on the Rate of Fertiliser Use

Factor	*Number of farmers*
1. Absence of farmyard manure ..	10
2. Position of potatoes in the rotation ..	1
3. Soil analysis	2
4. General fertility status*	2
	15
Same rate used each year	5
	20

* *i.e.* An assessment of soil fertility made without the aid of a soil analysis.

bution of farmyard manure to total nutrients (two others said that dung was of no importance other than as a source of humus) and using Boyd's estimates[6], they were certainly right to do so. The absence of farmyard manure cannot be easily overlooked whereas small differences in other factors such as soil analysis or the previous cropping may appear of little significance in relation to the normal seasonal variation in yield.

Later in the interview, a specific question was asked to determine whether variation in the price of fertiliser would in any way influence the quantity used. Whilst eleven farmers said that they would make no change even if the price varied by as much as ±£10 per ton, others mentioned the possibility of adjusting the rate to some extent (Table 27).

Table 27. Reaction to Changes in the Price of Fertiliser

	Number of farmers who would alter fertiliser dressing if prices were:			
	Up		*Down*	
	£5	*£10*	*£5*	*£10*
Make no change	17	12	14	16
Decrease	3	8	—	—
Increase	—	—	6	4

Most farmers appreciated that a small increase in the price of fertiliser was of no significance, but 40% said they would consider reducing the rate if compounds cost £30 per ton, i.e. the present price without subsidy.

Using the same assumptions as in Table 24, the effect of reducing the fertiliser dressing from 12 cwts. to 10 cwts. per acre would be as follows:

Table 28. The Effect of Using Less Fertiliser as its Price Increases

Per Acre					
Fertiliser			*Potatoes*		*Margin*
Price/ton	*cwts.*	£	*tons*	£	£
£20	12	12	9¼	120	108
£30	12	18	9¼	120	102
£30	10	15	8	104	89
				Reduction in margin	£13

NOTE: This calculation is based on the same yield and price assumptions as Table 25.

Even at the unsubsidised price of £30 per ton, the cost of 1 cwt. of fertiliser is covered by as little as 2½ cwts. of potatoes at £12 per ton and any farmer at present using about the optimum quantity of fertiliser (see p. 11) would be unwise to attempt to offset even a 50% price increase by a reduction in the quantity used.

Although cheaper fertiliser would enable a grower short of capital to move nearer to the optimum level of use, the possibility of depressing yield or adversely affecting quality would normally be important factors to consider before using more. Several farmers did comment that if fertilisers cost less, they would certainly

[6] Boyd, D. A., *The effect of farmyard manure on fertiliser response.* J. Agric. Sci. 52, 384.

use more on cereals and grass, where they could be confident of obtaining a worthwhile return.

Generally there was a keen appreciation of the part played by fertilisers in the growing of potatoes. In answer to Question 20(b), only four farmers said that they put any restriction on the amount of money which they were prepared to spend on fertilisers for this particular crop. One farmer had only been on the farm for a short while and was obviously having to ration capital fairly severely, whereas the other three were established farmers who for one reason or another were not successful in business.

The time at which farmers ordered fertilisers gave a further indication of their attitude to crop manuring. Whereas orders were mostly placed around the turn of the year, and by February at the latest, the three farmers mentioned above delayed ordering until March, presumably to gain the maximum time for payment. Only in one case was fertiliser being stored on the farm over winter but seven orders were placed in the late autumn for spring delivery.

Reducing the cost of crop manuring

Economy in the use of fertiliser can be obtained by buying 'straight' fertilisers in bulk and mixing them on the farm. For potatoes, it is possible to save between £2–£3 per ton compared with the purchase of compounds but the home-mixing of fertilisers presents many problems and none of the farmers in the survey felt that the saving was worthwhile. Also, most manufacturers offer a range of compounds to suit the requirements of different crops and different soils, though many farmers preferred to use potato fertiliser for other crops and grass (Table 29) supplementing it in some cases with straight nitrogen as a top-dressing. This had the advantage of simplicity in ordering, and handling by farm staff. Undoubtedly on some occasions, there is a waste of nutrients (in part, offset by the discount for buying in large lots) and on others, a degree of under-fertilising. If we recognise however that the manuring of crops is by no means an exact science, the intelligent use of a small number of fertilisers will in most conditions, achieve satisfactory results, providing that the major differences between soils and crops are taken into account.

Table 29. The Use of Potato Fertiliser on Other Crops

Number of farmers using potato fertiliser for:			
All crops	*Roots and corn**	*Roots*	*Potatoes only*
9	4	3	4

* With additional nitrogen in many cases.

Farmers understanding of the principles of fertiliser use

Whilst the majority of farmers appreciate the need to use fertilisers, particularly on high value crops, it is less certain whether they have the necessary understanding of fertiliser action to enable them to derive the maximum economic benefit from their use. Profitable manuring requires both an appreciation of the principles of crop nutrition and the ability to compare the cost of obtaining plant nutrients from different sources. The fact that farmers operating under very similar conditions are using widely different amounts of fertiliser, indicates the scope for economy that still remains.

The science of fertiliser use has developed rapidly in the last twenty years. Except to the farmer who has had the benefit of a technical training in agriculture

however, the language of the agricultural chemist is relatively meaningless and needs interpretation in order to be understood.

The farmers in the survey were asked (Question 17b) to select from a card the fertiliser which they would recommend a fellow farmer, growing potatoes for the first time, to use. The choice given to them was as follows:

	Nitrogen *N* %	*Phosphate* *P* %	*Potash* *K* %
Compound A	5	10	5
Compound B	12	12	18
Compound C	15	8	8

It was unfortunate that Compound B was actually used by seven farmers, who not unnaturally all selected it. However, answers to this and other questions (Table 30) showed that fifteen farmers were aware of the general significance of fertiliser analysis in relation to crop requirements. They were mostly influenced by the high potash content of Compound B, but one farmer also mentioned that he would not use Compound C because of the high nitrogen content.

Table 30. Farmers' Understanding of the Meaning of Fertiliser Analysis

Number of farmers who:	
1. Understood meaning of N.P.K. analysis ..	15
2. Were doubtful of meaning of N.P.K. analysis ..	2
3. Did not understand meaning of N.P.K. analysis	3
	20

The proportion of the three nutrients in different compounds usually varies and in order to compare their value, it is necessary to base the calculation on the unit price of nitrogen, phosphate and potash in 'straight' fertilisers, but the farmers in the survey were asked to select between two compounds in which the nutrients were in the same proportion but at different concentrations, viz.:

	Nitrogen *N*	*Phosphate* *P*	*Potash* *K*	*Price/ton*
Compound D	8	8	12	£16
Compound E	12	12	18	£20

Although fourteen farmers chose Compound E (Table 31), only three did so because it represented better value for money. Six mentioned again that because of its high potash content, it was more suitable, which suggests that the meaning of analysis was not wholly understood.

Table 31. Farmers' Choice of Fertiliser Giving the Best Value for Money*

Number of farmers who:	
1. Chose Compound E	
(a) By comparing value of fertiliser	3
(b) For other reasons	
(i) On basis of analysis	6
(ii) More concentrated and hence less bulky	3
(iii) Merchant's recommendation	2
2. Were unable to make a choice	6
	20

* See above for details of choice offered.

Three considered that it was the greater concentration of Compound E that made it a better buy, and two, having chosen it on the basis of suitability for the crop, commented that in any case they always relied on their merchant to give them value for money. In later discussion they were surprised to learn that the difference in price between manufacturers for comparable fertilisers may sometimes be measured in £'s rather than in shillings, particularly if any of the nutrients are in the organic form.

CONCLUSIONS

Inevitably the production of potatoes will become much more competitive in the next ten or fifteen years. For many growers, the scope for cost reduction lies in the more rational use of fertilisers. No other farm crop shows such a marked response to fertiliser and unless this potential is exploited to the full, the prospect of meeting competition will be considerably reduced.

There are however certain factors which make farmers reluctant to increase their dressings. The possibility of adversely affecting quality is one that cannot be easily overlooked, particularly as in normal years, the market is likely to discriminate in no uncertain manner against the large misshapen potato.

Of equal significance is the suggestion resulting from the recent analysis of experiments that fertiliser applied in excess of the optimum quantity may significantly reduce yield.

These problems can only be satisfactorily resolved by large-scale experimentation covering a range of soil types and seasons. The series of experiments recently completed by the N.A.A.S. will presumably provide a clearer picture of the shape of the response curve beyond the optimum but unless careful consideration has also been given to the effect of heavier dressings on quality, few farmers will feel justified in altering their present fertiliser practice.

It is unfortunate that research work can seldom provide the answers to farmers' problems as quickly as some of them would wish and although field trials have obvious limitations, there is undoubtedly scope for more farmers to observe the effect of different fertiliser treatments on their own crops. The subdivision of a field into two or even three parts presents some problems, but with modern equipment for drilling fertiliser and handling potatoes, they should not be insuperable.

Whilst the majority of farmers appreciate the need to use fertiliser, those with limited technical knowledge tend to be guided by the recommendations of fertiliser manufacturers and distributors which, of necessity are general in nature. They sometimes restrict their use for wholly irrational reasons and seldom make any allowance for variations in soil fertility and other conditions. It might be considered that of the different skills required by the farmer, livestock feeding and crop manuring have much in common, but whereas the composition of a ration can be altered from time to time on the basis of visual assessment or weighing the stock, the progress of crops and, in particular potatoes is not easily measured and, after a certain stage, cannot be influenced by the use of more fertiliser. This makes it vital that the needs of the crop should be fully satisfied at the time of planting. Therefore even though soil analysis is still subject to some margin of error, its wider use might ensure a better understanding of the principles of crop manuring and as a result, a more general movement towards the optimum level of fertiliser use.

APPENDIX I SURVEY A

No.....

QUESTIONNAIRE

The use of fertiliser on the potato crop

Date of interview...../...../61. Time started.....

1. How large is the farm?
   .....acres
2. How many acres of crops are there this year?
   .....acres
3. Are you
   (a) a tenant?
   (b) an owner-occupier? Tenant.....acres
   (c) both? Owner-occupier.....acres
4. How many years have you farmed this farm on your own account?
   .....years
5. How many acres of potatoes have you this year?
   1961.....acres
   1960.....acres
   1959.....acres
6. Referring now to this year's (1961) crop of potatoes, how many separate fields are there?
   .....
7. *Field 1.*
   (a) Soil type.....
   (b) *Preceding crop* *Fertiliser applied*
   1960.....
   1959.....
   1958.....
   (c) Seed potatoes used:
   Variety(ies)..... Quality .....
   ....
   ....
   (d) Quantity of F.Y.M. applied (Convert to tons):
   .....loads/acre .....tons/acre
   (e) Quantity of fertiliser applied:

Quantity	*Type*	*Analysis*	*Cost (net)*
cwts./acre	(i.e. make)	N. P. K.	shs. per cwt.

   (f) Method of application:
   Broadcast before ridging/Broadcast over ridges/Drilled in bands/ .....

(g) Seed planted by Hand/Machine
(h) Date of planting.....
(i) Yield Ware ..... tons/acre
Seed..... „ „
Chats ..... „ „
(j) How sold? From Field Wholesale/Retail
„ clamp „ / „
„ store „ / „
(For other fields, use duplicate sheet for Question 7)

8. You will appreciate that I'm interested to find out what factors farmers consider when they're deciding how much fertiliser to use, so don't think I'm being critical if I now ask you why you did not use either more or less.
(a) Why did you not use more?

(b) Why did you not use less?

9. Am I right to say that the dressing that you used this year is your usual one?
Yes/No

10. Taking the fields on which you normally grow potatoes, in a year that's *average* for *both* growth and harvesting, how many tons of ware potatoes would you expect having applied your *usual* fertiliser dressing?
....:.....tons/acre

11. In answering the last question
(a) Did you work out your average yield over several years?
or (b) Were you thinking of the yield you were likely to get most often (modal)?
or (c) Were you thinking of the lowest yield that you would expect to obtain but would hope to exceed in many years?
(d) What would the yield be if you were thinking of the most usual (modal) conditions?
.....tons/acre

12. (a) On how many occasions during the last 5 years have you been unable to harvest the whole of the crop? What were the reasons?
(b) If any, how much did you lose?.....tons/acre

13. Would it surprise you if in a year with apparently average conditions for growth the yield was:

	Yes	*No*
*1 ton + or −	.....	
2 „ + „ −	.....	
3 „ + „ −	.....	
More	.....	

*(i.e. than expectation in Q. 10)

14. You said earlier that . . . . (Repeat replies to Question 8). Assuming that you did in fact put on more/less fertiliser, what extra/reduced yield would you expect?

More	*Less*
1 cwt.....tons/acre	1 cwt.....tons/acre
2 „ ..... „ / „	2 „ ..... „ / „
3 „ ..... „ / „	3 „ ..... „ / „
4 „ ..... „ / „	4 „ ..... „ / „

15. (a) When do you usually order your fertiliser for the potato crop?
(b) When did you order them for this year?
(c) Is it a standing order?
(d) *If Yes* does this mean then that you order the same amount of fertiliser each year?
(e) *Both No and Yes* Might you place a further order? In what circumstances?
(f) Do you ever order *more* than you plan to use? If so, why?
(g) Or use *less* than you planned? Why?
(h) Then you do/do not deliberately reconsider each year whether you should change your fertiliser dressing on potatoes?
(If *Yes* i.e. he does reconsider, ask 16. If *No* ask 17.)

16. What factors do you take into account?
e.g. Previous cropping and manuring (Incl. F.Y.M.)
Soil analysis
Likely price for potatoes
Effect on quality of potatoes
Price of fertiliser

17. (a) Does your merchant suggest any changes in fertiliser use to you?
(i) Type (ii) Quantity
(b) There are a tremendous number of compounds on the market these days. If you were advising a friend on the best fertiliser to buy for potatoes which of these would you recommend? (Show card) Why?
(c) If your merchant offerred you these two fertilisers at the prices shown, which would you choose? (Show card) Why?

18. Do you ever cut your dressing on potatoes because it would cost too much to do what you would like?
(If *Yes*—see 19. If *No*—see 20.)

19. (If Yes to 18).
(a) Do you in fact say that you can't afford more than so much for fertiliser on all your crops and then work out how you can best spread this amount over them?
or (b) Do you work out what you would like to put on each crop and then cut down the total if you cannot afford it?
(c) If you have to cut down your dressings in either way, how do you decide where to cut down?

20. (If *No* to 18):
    (a) What is your fertiliser bill for
        (i) Potatoes £
        (ii) All crops and grass £
    (b) How much larger would your total fertiliser bill need to be before you considered limiting your dressings?

21. In the last few years we have seen prices for potatoes as high as £20 per ton and as low as £8 per ton.
    (a) What was your average price per ton last year?
        £...../ton (1960 crop)
        With what average yield/acre (Potatoes sold)
        .....tons/acre
    (b) Ditto, 1959 crop (if possible)
        £...../ton
        .....tons/acre
    (c) When you planted this year's crop, what price per ton and what yield per acre were you expecting?
        £...../ton
        .....tons/acre
    (d) Would it surprise you if the price of potatoes was in fact:
        Up £2 £4 £6 per ton (Mention total price each time)
        Down £2 £4 £6 „ „
        What makes you think this?
    (e) If *Yes* to (d) (i.e. he would be surprised if prices varied). If you had reason to expect the price of potatoes to be:
        Up (i) £2/ton (ii) £4/ton
        Down (iii) £2/ton (iv) £4/ton
        how would this have affected your fertiliser application?
    (f) If the price of fertiliser varied by:
        Up (i) £5/ton (ii) £10/ton
        Down (iii) £5/ton (iv) £10/ton
        how would this affect your fertiliser application?

22. From what you have said, it appears that you estimate the possible gain from using another..... cwts. per acre of fertiliser (i.e.....cwts. altogether) to be.....tons per acre of ware potatoes. In other words you might pay out another £..... and get back at least £....., assuming average conditions.
    Again you will appreciate that I'm not being critical in any way when I ask you why, in fact, you have not put on this additional application?

23. What do you consider to be:
    (a) a favourable
    (b) an unfavourable year for growing potatoes?

24. (a) If in fact you did put on the extra.....cwts. per acre of fertiliser, what do you think that you would stand to lose if weather conditions were *unfavourable?*
    (b) How much do you think that you might stand to gain from this extra.....cwts. per acre of fertiliser if the weather was *favourable.*
    (c) In five years, how many favourable and unfavourable years do you expect, as far as yield is concerned?

25. Do you always make your plans in the expectation of an 'average' year?

26. Do you think that you get more financial benefit from fertilisers in a 'poor' growing year or in a 'good' growing year?

27. (a) 'Poor' year
    Would you say then, that the possibility of poor growing weather does *not* deter you from using more fertiliser?
    (b) 'Good' year
    Would you say then, that the possibility of poor growing weather *does* deter you from using more fertiliser?

28. Are you affected by (any other) considerations of possible weather conditions as effecting harvest or growth? In what way?

29. (a) How do you consider the possibility of potato quality to be affected by fertiliser use?
    (b) How do you take account of this?

30. (a) Some people say that although they believe it would pay to make larger fertiliser applications, they have a better use for the extra money. Is this so in your case?
    (b) *If so*, what better use would you have for the money?

31. (a) Do you find that Income Tax deters you from trying to earn a higher income?
    (b) *If Yes*, does it affect the quantity of fertiliser you use?

Time finished.....

APPENDIX II SURVEY B

No.....

QUESTIONNAIRE

Potato fertiliser survey

Do you grow potatoes? If so, would you care to answer a few questions on fertiliser use?

1. How big is your farm.....acres

2. Approx. where is it? .....
   (nearest village or town) .....

3. How many acres of *maincrop* potatoes this year? ..... acres

4. Variety(ies) .....

5. F.Y.M. Yes/No

6. Fertiliser used:

Quantity	*Type*	*Analysis*	*Cost (net)*
cwts./acre	(i.e. make)	N. P. K.	shs. per cwt.

7. Method of application:
   (a) Broadcast before ridging
   (b) Broadcast over ridges
   (c) Drilled in bands
   (d) .....

8. Do you think that it would pay you to use any more? Yes/no. Why?

9. What is your average yield of potatoes over the last few years?
   Ware .....tons or 1960.....tons/acre
   Seed .....tons 1959.....tons/acre
   1958.....tons/acre

10. What do you think would be the yield if instead of using.....cwts./acre of fertiliser, you applied 2 cwts./acre less,
    i.e.....cwts./acre
    .....tons/acre

APPENDIX III

TABLES AND DIAGRAMS

DIAGRAMS

Some Recent Reports Published by The Department of Agricultural Economics

Report	139.M	Herd Maintenance on North of England Small Dairy Farms A Study of practices and farmers' opinions	Price 2/6
„	140.M	Productivity and Efficiency of Labour Use on Small North of England Dairy Farms	Price 5/–
„	143.M	The Effect of Herd Maintenance Policies on the Economy of Small Dairy Farms	Price 5/–
„	144.G	Attitudes to Incentive Schemes and their Importance in Agriculture	Price 2/6
„	145.G	Beef Production Case Studies	Price 2/–
„	146.FM	Hill Sheep Farming in the North of England, 1957-59	Price 5/–
„	147.G	Commercial Egg Production Financial Results of Farm Flocks for 1959-60	Price 5/–
„	148.FM	Profitability of Farming in the North of England, 1959-60 Results for Selected Groups of Farms	Price 5/–
„	149.G	Single Suckled Calf Production in Northumberland, 1959-60	Price 3/–
„	150.G	Incentive Payments and Improved Man and Machine Performance	Price 5/–
„	151.G	Production and Marketing of Single Suckled Calves in Northumberland, 1960	Price 7/6
„	152.M	Economics of Milk Production in Northern England, 1960-61	Price 5/–
„	153.FM	Profitability of Farming in the North of England, 1960-61	Price 5/–

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