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# FERTILISER NEEDS IN THE SEVENTIES

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(Paper presented at the fourth meeting of the Fertiliser Association of Ireland)

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In a previous lecture to the association, Murphy (1) presented the results of the Fertiliser Use Survey and listed the amounts and types of fertiliser which the farmer used in 1967 on each particular crop. Heavey (2) later compared the costs of fertilisers with other inputs into farming and with changes in agricultural production during 1960-68. I intend to discuss the nutrient requirements of crops and the supply of these nutrients from our soils and to estimate how much fertiliser we should use. A comparison of needs with practice as outlined by Murphy and Heavey may help us to decide what changes are necessary and how we may best accomplish these.

This is a convenient time to have such a discussion because changes have taken place in the fertility of our soils as a result of 20 years of fertiliser use since 1950. Over the past few months, the staff at Johnstown Castle have been reviewing these changes and we have this month published a 'Fertiliser Manual' (3) which we hope will be a useful guide to fertiliser practice. I will base the estimates for national fertiliser needs on the recommendations outlined in the Manual.

## Trends in fertiliser use

The progress in fertiliser use is well known (4) and is shown in Figure 1 to provide a perspective for other data I will use. This type of presentation shows that fertiliser consumption has increased with time and may give the illusion that this trend can be extrapolated into the future. However, a relationship with time can be purely fortuitous and an analysis of the variations may be of more help to us to predict the future than the overall upward trend. Such a study in depth would certainly be very valuable to those who must plan the future of the fertiliser industry.

There are, however, some obvious features that are worthy of comment here. The growth in the use of nitrogen has been most dramatic and the rate of increase has improved further since 1965. Some of the improvement is probably associated with the establishment of the nitrogen manufacturing plant at Arklow in that year. Potassium use has increased at roughly the same rate since 1955. This rate does not seem to have

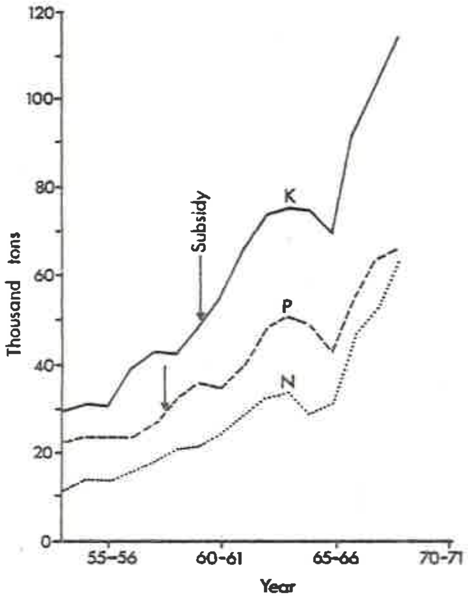

Fig.1: Fertiliser use in Ireland 1953-69



been affected by the payment of a subsidy from 1960 onwards. The use of phosphorus did increase after a phosphorus subsidy was introduced, but the rate of increase in this nutrient was slower than for the other two. If the subsidy was responsible for all the increase in phosphorus since 1957/58 over the 27,000 tons P then used, the extra phosphorus has cost the State £130 per ton P (current cost to farmers is £105 per ton P) so it seems that the rate of use of phosphorus has not been very sensitive to subsidy. An interesting detail of Fig. 1 is the temporary halt in potassium growth in the first year of the phosphorus subsidy 1958/59 and the decline in phosphorus use in the first year of the potassium subsidy 1960/61. This may be very relevant to progress in the seventies as there are no subsidies on fertilisers in the E. E. C.

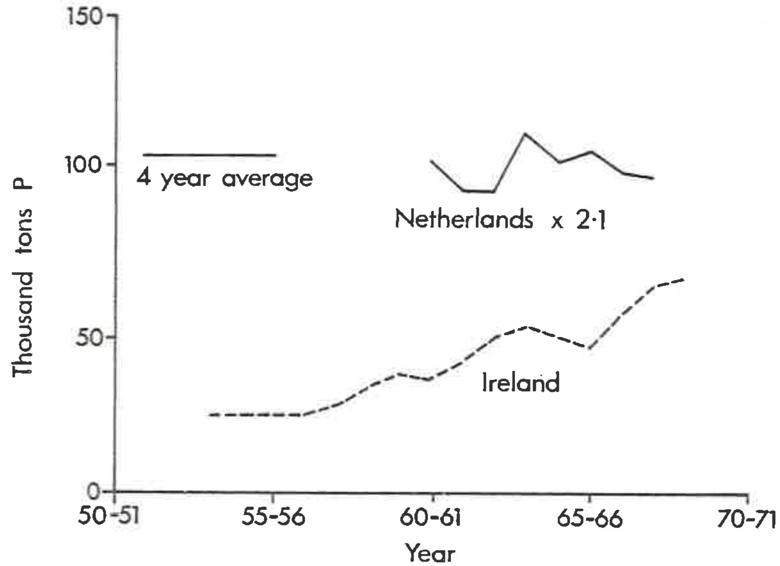

Fig. 2: Phosphorus use in Ireland and the Netherlands

The most striking feature in Fig. 1 is the decline in fertiliser use in 1965/66. Agricultural output was depressed in that year. Tillage acreage dropped and the wheat harvest was late and difficult. Cattle prices were poor and exports were down. Recent statistics from Britain suggest that immigration from Ireland was much higher than average in 1966. A general setback in the agricultural economy and poor weather would seem to have been the main cause of the reduction in fertiliser use.

As examples of different fertiliser/time relationships we can examine Figures 2 and 3. These show the changes in phosphorus and potassium use in The Netherlands as a contrast to those in Ireland (5). I have multiplied The Netherlands data by 2.1 to allow for the difference in area of agricultural

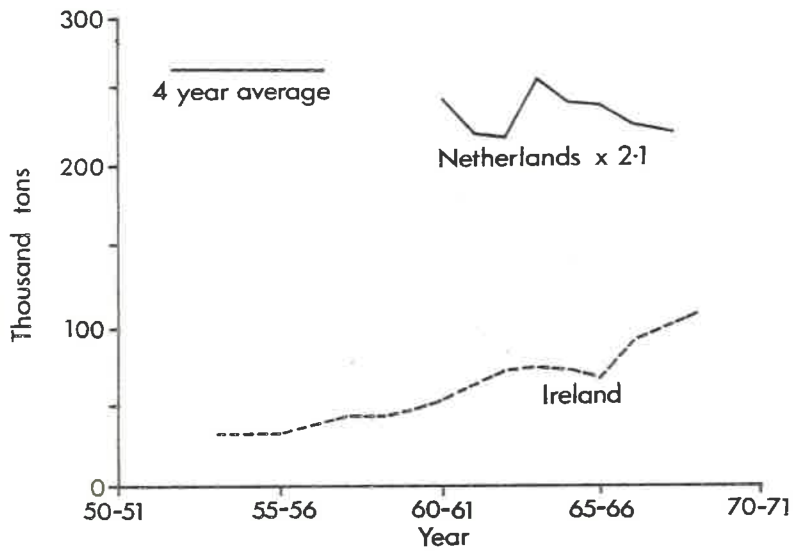


Fig. 3: Potassium use in Ireland and the Netherlands



land. Phosphorus use in The Netherlands has remained static for some 15 years and we have changed our relative position from 23% to 66% of their rates of P per acre. The use of potassium has declined in The Netherlands over the 15 years and, although we have increased our relative position, we still only use 45% of The Netherlands rates of K per acre. We are already, however, using more phosphorus and potassium per acre than the United Kingdom and have moved away from the backward situation described by Walsh, Ryan and Kilroy in 1957, in their paper to the Society for Statistical and Social Inquiry (6).

## Changes in soil fertility

The higher rates of fertiliser use have already been reflected in increased fertility in our soils. Some of the changes are illustrated in Tables 1, 2 and 3.

Table 1 : Changes in soil phosphorus values 1954-70

| | % of soil samples in each category | | | |
|---|---|---|---|---|
| Soil phosphorus (ppm) | 0-0.5 | 0.6-1.0 | 1.1-3.0 | 3.1 or higher |
| 1954 | 77 | (—— 23 ——) | | |
| 1965 | 0 | 18 | 49 | 33 |
| 1970 | 0 | 18 | 45 | 37 |

Table 2 : Changes in soil potassium values 1954-70

| | % of soil samples in each category | | | |
|---|---|---|---|---|
| Soil potassium (ppm) | 0-24 | 25-49 | 50-99 | 100 or higher |
| 1954 | 66 | (—— 34 ——) | | |
| 1965 | 6 | 24 | 43 | 27 |
| 1970 | 2 | 13 | 48 | 36 |

Table 3 : Changes in lime status of soil samples 1954-64

| | % of soil samples in each category | | |
|---|---|---|---|
| Soil pH | 4.1-5.5 | 5.6-6.0 | 6.1-8.0 |
| 1954 | 21 | 37 | 42 |
| **1964** | 27 | 34 | 39 |

These tables show the percentages of soil samples analysed at Johnstown Castle which were classified as high or low for phosphorus, potassium and lime. The data are more detailed for 1965 and 1970 than for 1954 as the later surveys were analysed by computer. A trend towards higher fertility is obvious and is continuing for phosphorus and potassium. Differences do occur between areas and cropping systems and one of the more important effects - removal of potassium by hay or silage - is shown in Table 4.

Table 4 : Difference in soil potassium following pasture or hay

| | % of soil samples in each category | | |
|---|---|---|---|
| Soil potassium (ppm) | 0-49 | 50-74 | 75 or higher |
| Pasture | 14 | 28 | 58 |
| Hay | 21 | 35 | 44 |

The changes in soil fertility were not uniformly distributed over the whole country. The six counties with the highest proportion of samples in the low category for phosphorus in 1968 were Kilkenny, Wexford, Waterford, Carlow, Clare and Longford and the corresponding six for potassium were Meath, Dublin, Kildare, Laois, Offaly and Kilkenny. In the 1967 Fertiliser



Use Survey, it was reported that Clare and Longford used less than average fertiliser on pasture, but the other counties quoted above used more than average. The grouping of the low-phosphorus soils in the south-east and the low-potassium soils in the midlands suggests that soil properties in these areas are responsible for the low fertility values. Current research projects at Johnstown Castle are designed to identify and measure the soil properties which control the absorption and storage of these nutrients in an available or unavailable form. Such information will increase in importance as fertiliser residues continue to increase.

The overall trend in lime status was towards a fall in pH between 1954 and 1964 but some tillage areas have increased in average pH while pH values in grassland have decreased.

Changes in crop responses to fertiliser

The increase in soil analysis values was accompanied by a reduction in response to phosphorus in cereals (Table 5). It is worth comment that in 1952-53, 59 sites out of a total of 109 gave an average response of 7.8 cwt of grain in a series of experiments on oats. Responses to potassium were never as high as those to phosphorus, but were found to be less than 1 cwt of grain in a number of experiments carried out during 1961-69 (9, 10).

The pattern for responses in grassland shown in Tables 5 and 6 is not as clear as that for cereals since the experiments carried out used different techniques, and grassland covers a much wider range of soils than cereals. It seems, however, that the average response to phosphorus in grassland under

Table 5 : Yield response to phosphorus in cereals

| Year | Crop | No. of sites | Soil test (ppm) | Max. yield (cwt/ac) | Response (cwt/ac) |
|---|---|---|---|---|---|
| 1948 (7)* | Wheat | 1 | | 35 | 13.5 |
| 1952-53 (8) | Oats | 59 | 0-0.5 | 27.3 | 7.8 |
| | | 32 | 0.6-1.5 | 27.6 | 6.3 |
| | | 18 | 1.6 and higher | 28.4 | 3.4 |
| 1956 (8) | Barley | 14 | | 33 | 9.0 |
| 1961-62 (9) | Barley | 13 | | 29 | 0.9 |
| 1968 (10) | Barley | 8 | | 40 | 1.6 |

*See list of references

Table 6 : Yield responses to phosphorus in grassland

| Year | % response | Trial |
|---|---|---|
| 1958 | 13 | 24 sites grazing, cages (11) |
| 1967* | 15 | 27 sites cutting 2nd of 5 cuts 1st year (12) |
| 1968* | 25 | 27 sites cutting 2nd year (13) |

*1967 and 1968 Soil Productivity Experiment

Table 7 : Yield responses to potassium in grassland

| Year | % response | Trial |
|---|---|---|
| 1944-1957 | 11 | 217 sites hay (14) |
| 1958 | 5 | 21 sites grazing, cages (11) |
| 1967* | 7 | 27 sites, cutting 2nd of 5 cuts 1st year (12) |
| 1968* | 21 | 27 sites, cutting average 5 cuts 2nd year (13) |
| 1969* | 35 | 27 sites, cutting average 5 cuts 3rd year (13) |

*1967, 1968 and 1969 Soil Productivity Experiment



grazing is approximately 15% and the average response to potassium is approximately 7% (of fertilised yield). These estimates are surprisingly low when it is realised that only 35% of pasture received any fertiliser in 1967. Although the average response is relatively small the fertility levels can be depleted quickly under a system of continuous cutting, as can be seen in Tables 5 and 6. The Soil Productivity Experiment (12, 13) began in 1967 and included in its design four rates of application of phosphorus and potassium fertiliser on grass which was cut five times each year. The data for the first cut in 1967 are not quoted because yields from the wet soils in April were very low so the second cut may be taken as the start of the experiment. The responses were 15% to phosphorus and 7% to potassium. In 1968 on the same plots, however, over all five cuts the responses were 25% to phosphorus and 21% to potassium. Responses in 1969 were still higher. This shows how quickly a soil will deteriorate from sufficient fertility to deficiency if fertilisers are not applied.

The rate of decline in yield on the plots receiving no fertiliser differed markedly between soils, e.g., in 1969 after 3-years' cutting the control plots on the Borris series (15) gave only 42% of the yield on the K-fertilised plots but on the Macamore soil (16) the control plots produced 86% of potential. This again illustrates the need for information on the absorption and storage of nutrients by our soils.

When crop responses to fertiliser were universally high, recommendations for the amount of fertiliser were based on the optimum economic rates. Now, however, when some crops, notably cereals and pasture which have been fertilised for some years, show no response to phosphorus or potassium, we must place more emphasis on the maintenance of soil fertility. Two phases of fertiliser use are therefore separated in the Fertiliser Manual.

1. Fertiliser for crop response
2. Fertiliser for maintenance.

In the first phase the rates of fertiliser recommended are calculated to ensure maximum crop response and to build up fertility. In the second phase the rates are calculated to replace nutrients removed in the crop. Soil analyses can be used to distinguish between the two phases.

Our recent experiments indicate that root crops are still giving worthwhile responses to phosphorus and potassium (10). It is obvious from our work that root crops need much higher levels of available P and K in the soil than either cereals or grasses, so standard rates of fertiliser for these should be based on the optimum economic response until 1975-80 at the earliest.

National fertiliser requirements

I have combined the recommended fertiliser rates quoted in the Manual with the expected crop acreages, to calculate the national fertiliser requirement. The rates chosen are listed in Table 8. For grazing, two rates (lb N, P and K per acre) of application are quoted, 50-15-30 for intensive grazing at 90 to 100 livestock units (L. U.) per 100 acres and 0-10-10 for extensive grazing at 50 L. U. per 100 acres. These are both maintenance rates for P and K. It is unlikely that a farmer would need to apply the rates which are recommended at the



Table 8 : Recommended rates (lb/acre)

| | N | P | K |
|---|---|---|---|
| Intensive grazing (100 L. U. /100 acres) | 50 | 15 | 30 |
| Extensive grazing (50 L. U. /100 acres) | 0 | 10 | 10 |
| Silage | 80 | 20 | 100 |
| Cereals | 40 | 20 | 40 |
| Potatoes | 100 | 100 | 200 |
| Swedes | 50 | 100 | 150 |
| Sugar beet | 80 | 100 | 300 |

response phase, i. e., 40 lb P/acre and 80 lb K/acre for more than 5 years before maintenance dressings would be adequate. Maintenance levels are, therefore, more appropriate for a long-term forecast of total annual needs. The maintenance dressings are intended to cover losses of phosphorus and potassium in animal products, by leaching and by transfer of dung and urine to collecting yards etc. The rates quoted for silage are those recommended and discussed in the Fertiliser Manual. For cereals, I have quoted 40-20-40 lb N, P and K per acre. This is really an average between 50-15-30 and 25-25-50, which I have combined to simplify the calculation. The rates quoted for the roots are those listed for the response phase in the Manual.

In Tables 9a and 9b selected rates are combined with the appropriate acreages to calculate the national fertiliser needs. Eight million acres are listed in Table 9a as suitable for intensive grazing although some of this area would need drainage and 2 m. acres are listed as suitable for extensive grazing only.

Table 9a : Total nutrients needed - intensive grazing

| | Acres (million) | N | P | K |
|---|---|---|---|---|
| | | (1000 tons) | | |
| Grazing intensive | 8.0 | 178 | 54 | 107 |
| extensive | 2.0 | 0 | 9 | 9 |
| Silage | 5.0 | 178 | 45 | 223 |
| Cereals | 0.9 | 16 | 8 | 16 |
| Potatoes | 0.1 | 4 | 4 | 9 |
| Swedes | 0.1 | 2 | 4 | 7 |
| Sugar beet | 0.06 | 2 | 3 | 8 |
| Total | | 380 | 127 | 379 |
| Grassland | | 356 | 108 | 339 |
| Tillage | | 24 | 19 | 40 |

Table 9b : Total nutrients needed - extensive grazing

| | Acres (million) | N | P | K |
|---|---|---|---|---|
| | | (1000 tons) | | |
| Grazing extensive | 10 | 0 | 45 | 45 |
| Silage | 2.5 | 89 | 23 | 112 |
| (or low yield hay | 4 | 0 | 23 | 112) |
| Tillage | | 24 | 19 | 40 |
| Total | | 24-113 | 87 | 197 |
| Now used | | 63 | 67 | 109 |

This is a simplification based on work by Lee and Diamond (17). The poorer land corresponds to the Abbeyfeale soil in Clare and Kerry and the Drumlins in Leitrim (18). Five million acres have been allocated to silage to provide winter keep for nine



million animals. This is based on harvesting 4,500 lb dry matter per acre or 2,500 lb DM per L. U. If there is a 20% wastage in the pit and the winter is 130 days long, only 16 lb DM per day per L. U. will be available to provide a maintenance diet. Some of the cereals would also go into the animals' diet. I have presumed that the tillage area will remain at today's acreage. If some cereal acreage is transferred to grass the fertiliser needs will be higher. As grass is the cheapest feed for livestock this seems the most likely change in a very intensive animal system.

Grassland completely dominates the fertiliser needs calculated in Table 9a. The total tillage requirements amount to only 6% for nitrogen, 15% for phosphorus and 11% for potassium so that variation in the rates recommended for tillage will not alter the total significantly. Unfortunately, these estimates are not directly relevant to our present situation and, if the stocking rates quoted are to be realised, a massive investment in livestock, drainage, machinery etc. will be necessary. We can, however, learn important lessons from the patterns shown in Table 9a by comparing it with Table 9b where similar calculations are based on current national stocking rates. Here the pattern is radically different. Grassland is still more important than tillage but the fertiliser requirements are only a fraction of those for the higher stocking rates. The low fertiliser rates recommended for grazing at low stocking rates are based on the fact that current grass production is sufficient to carry these stocking rates and soil P and K levels in pastures are rising with average applications of 8 lb P and 9 lb K per acre. Ten pounds of each nutrient are adequate to replace losses in leaching and animal products, but might be in error if there was significant transfer in dung and urine from the fields.

The acreage allotted to silage (2.5 million) should be sufficient to carry 5 million L. U. for 110 days winter as these will graze later in the year. There is an alternative system for the provision of winter feed. This is to accept a lower yield (approximately 3,000 lb DM/acre) over 4 million acres. This would mean more cutting but would save on nitrogen. In 1967, farmers produced 2 million acres of hay and approximately 0.25 million acres of silage which probably provided 14 lb DM per L. U. per day for the winter. This is lower than a maintenance diet so the balance was probably made up by foggage, meals, lower stock numbers over the winter or loss in weight. It would appear, therefore, that there is a direct and immediate need for winter feed. This is significant for fertiliser use because the fertiliser needs of silage, particularly N and K, account for a high proportion of the total, even at the low stocking rates in Table 9b.

Farmers are already making up the deficit as can be seen by the rate of increase in silage shown in Figure 4. Already nearly 0.5 million acres are devoted to silage and this is added to rather than substituting for the area already under hay. So it seems that farmers are using both methods of producing more winter feed - increasing both yield and acreage.

The difference between fertiliser requirements at high and low stocking rates is very large (Tables 9a and 9b). Fertiliser needs over the next few years will, therefore, be



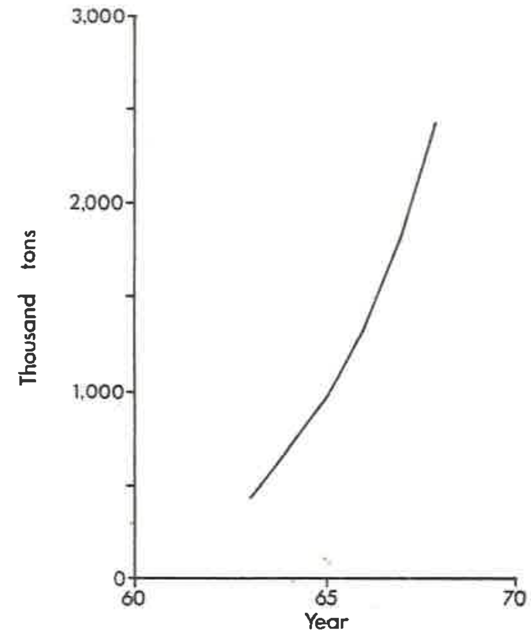


Fig. 4: Increase in the use of silage

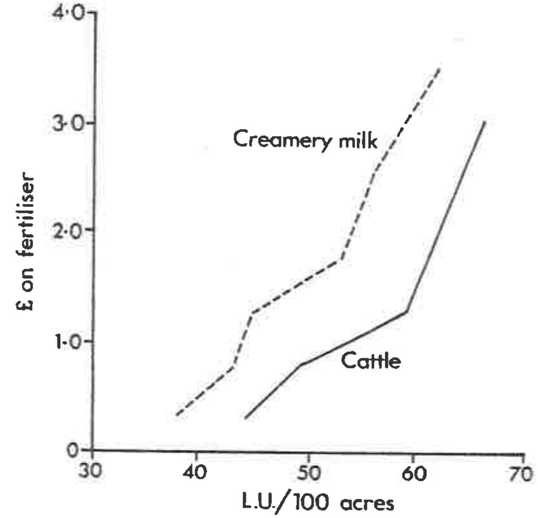


Fig. 5: Effect of stocking rate on fertiliser use

controlled by the number of livestock we carry. If our stock numbers increase we will need more fertiliser but at our present stocking rates our fertiliser application is probably adequate for pastures even though only 35% are fertilised each year. The relationship between stocking rate and fertiliser use is true in current farm practice as well as in projections for the future. This is illustrated in Figure 5 which is based on data presented previously to the Fertiliser Association by Heavey (2) and shows the relationship of money spent on fertiliser to stocking rate for cows and cattle. The general slope of the curves in this diagram suggests that farmers would spend approximately £8 on fertiliser at a stocking rate of 1.00 L.U./acre and this agrees with our recommendation. It is also obvious from these data that a farmer's spending on fertiliser is influenced strongly by the value of his product. At 0.5 L.U. per acre his spending on fertiliser for cattle was £0.8 but this was £1.6 for cows at the same stocking rate although presumably the same amount of grass is needed by both. A similar pattern is obvious in tillage. Thus sugar beet is over-fertilised, but feed roots in general are under-fertilised.

No allowance has been made in the calculations of Tables 9a and 9b for the return of nutrients via farmyard manure. If all the dung and urine which were produced from silage were returned to the harvest area then theoretically little replacement P or K would be needed. In the 1967 Fertiliser Use Survey, however, Murphy and Heavey (1) found that only 1.5% of pasture and 8% of hay or silage areas received F.Y.M., so its effect on the total fertility must be very small. As well as this, its quality is variable and the cost of spreading is high



so its place in modern farming is doubtful. In the future, however, with further intensification it may prove a pollution problem and more of it may be returned to the land. If it is spread uniformly on the silage areas it will greatly affect total fertiliser needs. As slurry handling is likely to improve this is very much an open question.

The changes which I have outlined may lead to many other possibilities in the 1970's. High speed machines may broadcast fertilisers for cereals instead of drilling them with the seed; less soluble forms of phosphorus fertiliser may be suitable for maintenance of fertility; liquid fertilisers may become more important; new forms of nitrogen may be introduced; it may be necessary to include sulphur and magnesium in fertilisers. My main concern today, however, was to estimate the need for major nutrients for our present farming systems and to discuss the factors which are likely to influence the supply of these nutrients over the next 5 years.

To summarise, we have seen that fertiliser use is :

a) very sensitive to the value of the crop or animal, and

b) adequate for grazing at current stocking rates.

Fertiliser use in the seventies

1. Will depend on national stocking rate.
2. In the immediate future will be related to the amount of silage made.
3. Will depend on the use of slurry on grass.
4. Will increase more quickly for N and K than for P.

## ACKNOWLEDGMENT

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