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Potassium in Irish Farming Present and Future

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POTASSIUM IN IRISH FARMING - PRESENT AND FUTURE

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The use of potassium fertilisers in Ireland was negligible before 1900, although nitrogen and phosphorus were well established by the end of the 19th century. During the first half of this century development was slow, but since 1945 there have been great increases in the use of all three major plant nutrients, and more K is now used than either N or P.

Table 1 : Use of Nitrogen, Phosphorus and Potassium in Ireland since 1953

('000 tons)

	N	P	K
1953/4	12.0	23.7	30.5
1954/5	14.7	23.6	31.5
1955/6	13.6	24.3	32.2
1956/7	15.9	23.9	39.5
1957/8	18.0	27.0	43.5

Table 1 (contd)

	N	P	K
1958/9	20.6	33.0	43.7
1959/60	21.7	36.0	48.0
1960/61	24.6	35.0	55.0
1961/62	29.0	40.0	66.0
1962/63	33.0	48.0	74.0
1963/64	34.2	50.6	75.6
1964/65	29.1	48.8	75.1
1965/66	31.4	43.2	69.0
1966/67	47.0	55.2	91.6
1967/68	53.0	63.6	103.5
1968/69	63.0	68.4	109.8
1969/70	70.7	72.6	115.7
1970/71	84.6	77.8	123.0

However the result of the situation which existed for the first half of this century, when there was relatively large use of N and P but little K, was that in 1954 over 90% of soil samples analysed had less than 38 ppm K (Morgan's extract), and 66% had less than 25 ppm. The improvement since this time is illustrated by the virtual disappearance of samples in the lowest category.

Table 2 : Percent of Advisers' soil samples analysed with 0 - 24 ppm of K

Year :	1954	'57	'58	'59	'61	'62	'65	'68	'70
% :	66	32	20	17	11	11	5	4	2

The situation, again reflected in analyses of soil samples, for 1970 was :

Table 3 : Analyses of advisers' soil samples 1970

ppm K	0-24	25-49	50-74	75-99	100-500
% of samples	2	14	27	21	36

The improvement in the analyses figures only shows that soil fertility is responding to the increased amount of K being used. We have to turn to the Fertiliser Use Survey 1967 for a guide to how K fertilisers are being used, and whether crops are under or over fertilised.

Table 4 : Rates of K used on tillage crops and grassland

Crop	lb. K applied per acre (actual)	Per cent Fertilised	Recommended rate lb/acre*
Wheat	56.1	97.5	30 - 50 (Wheat, Feeding barley, Malting barley, Oats)
Feeding barley	48.9	98.3	
Malting barley	41.5	99.1	
Oats	39.4	86.2	
Potatoes	103.1	93.2	100 - 200
Sugar beet	336.1	100.0	300
Feed roots	85.5	96.2	50 - 150
Hay	29.0	66.1	100
Silage	39.0	87.4	100
Pasture	25.9	35.1	30 - 80
Rough grazing	9.3	2.0	-

* Source : "Fertiliser Manual" An Foras Taluntais 1970.

Table 4 indicates that K use on tillage crops is mainly satisfactory. Parts of the oats, potato and feed roots crops are underfertilised but there are probably economic factors involved. The tillage crops which pay best are generally given enough fertiliser (including K) and often too much.

The satisfactory picture for cereals results from the cereal growers' tendency to use high K compounds such as 10:10:20. These crops tend to be underfertilised with nitrogen.

The most serious examples of under-use of K are on grassland. A high proportion of grazing, hay and silage gets no K at all, and where it is used the rates are inadequate. A hay or silage cut will remove up to 150 lb. of K per acre.

The rates recommended in the "Fertiliser Manual" allow for a soil contribution of about 50 lb/acre. Modern practice makes much greater demands on soil reserves than traditional systems and must result in reduced fertility and productivity where a field is cut for several consecutive seasons. Where more than one cut is taken per year this depletion will occur much more quickly.

There are a number of developments in grassland management whose implications for the use of potassium fertilisers should now be considered.

Increased use of Nitrogen

The use of nitrogen to increase grass yields has been shown to increase K uptake and to deplete soil K. Under experimental cutting conditions, N responses have been greatly reduced where no K was applied and it has been suggested that the rate of K applied should be related to the N rate, e.g. 1 lb. of K per lb. of N, under continuous cutting.

Another factor to be considered is the effect of N on clover. In many cases, clover can be maintained in pastures receiving moderate quantities of N, provided that it is still able to get enough K. Because of the competition between grass and clover for K, pastures where clover is present need to be kept at a higher K status than those where it is absent.

Silage Making

A silage cut of about 10 tons/acre fresh weight, with 20% dry matter containing 2-3% K or higher, will remove 90-150 lb. of potassium per acre from the soil. There is no immediate return of K in urine, as with grazing, and areas cut for silage receive more nitrogen than pasture. (In the Fertiliser Use Survey 1967 the average N rate for silage was 35 lb/acre, and for pasture 12 lb/acre.) The increase in silage making will therefore tend to increase the K requirements for modern dairy farming.

Silage making is to a great extent replacing hay making. A hay cut also makes great demands on soil K, although generally hay receives less nitrogen. The practice of cutting hay with little or no applied K in the past, must have been one of the main causes of low K levels in grassland soils.

Two-Sward Systems

The use of separate swards for grazing and cutting will eliminate the return of K by grazing livestock on one part of the farm and concentrate it on another. Other factors will probably vary between the two areas. The grazed area may get less fertiliser nitrogen and rely to some extent on clover nitrogen fixation.

Two-Sward Systems (contd)

Different seeds mixtures may be used for the two swards. Obviously each sward will require a different K fertiliser regime. This system results in an increase in effective stocking rate on the grazed area, which is discussed under the next heading.

Increased stocking rates and closer grazing control

The increase in livestock units/acre and the more widespread use of paddocks and electric fencing to control grazing should improve the efficiency of the potassium cycle, and keep the K maintenance requirement for grazing to a fairly low level.

Cattle excrete up to 90% or more of the K ingested in herbage but, when voided on the sward, this is concentrated in small urine patches. For this return of K to be valuable a high proportion of the grazing area must be affected within a short period of time. Obviously this cannot happen at low stocking rates, and where cattle are allowed to range over relatively large areas. Increased stocking rates and controlled grazing improve the rate of ground cover by urine, and lead to more even distribution.

Application of slurry to grassland

Since livestock retain relatively little of the potassium they ingest, the return of slurry from winter-housed animals could replace much of the K removed by cutting for conservation. The figure quoted by J. Lee and S. Diamond ('Farm and Food Research' March/April 1972) is 60 lb. of K during a 120 day winter by one cow. Most of the potassium, however, is contained in the urine and unfortunately many systems for the recovery and storage of slurry allow much of the liquid excreta to escape into drains.

Collins (1) has estimated that with the complete collection of slurry, as in slatted floor systems, a 'closed' K system could operate at high stocking rates. If the return of slurry from feeding two silage cuts gives about 135 lb/acre of K, together with soil release of K this could be sufficient for optimum production.

Experimental Data - Grassland

Cutting trials on permanent grass were carried out at 27 sites, distributed over the major soil types, during the years 1967-1970. The effect of applied K on annual dry-matter yield and K-uptake is shown, for some of the soils, in Appendix 2.

Table 5 : The Effect of Applied K on Per Cent Yield

	Year	K Levels			
K applied lb/acre	1	0	110	220	330
	2	0	110	220	330
	3	0	70	140	280
	4	0	70	140	280
		Percent Yield			
Light textured Soils	1	87	98	100	100
	2	71	95	100	99
	3	57	87	100	100
	4	55	88	98	100
Heavy Textured Soils	1	93	98	96	100
	2	87	94	96	100
	3	81	93	100	99
	4	82	97	98	100

Table 5 summarises the effect of applied K on dry-matter yield. The soils have been divided into two groups according to the yield restriction in the zero-K plots in four years' cutting. Those which gave the greatest restriction in yield were the dry tillage (Associations 6,8,9,20,22, General Soil Map) whilst smaller restrictions were shown by the soils with heavier textures (13, 17, 24, 27).

Where no potassium was applied on the dry soils, yield was restricted to 87% of the maximum in the first year and had fallen to 55% in the fourth year. On the heavier texture soils, the corresponding figures are 93% falling to 82%. In view of this difference, it is interesting to note that the quantities of applied K required for maximum yield by the two groups are very similar.

The difference between the two groups when no K is applied is apparently due to the greater quantity of K supplied by the heavier textured soils (Table 5).

Table 6 : Uptake of K where no K was applied (lb/acre)

	Light Textures	Heavy Textures
1967	194	222
1968	96	165
1969	67	132
1970	50	97

The 'Fertiliser Manual' suggests that the soil can be relied on to replenish about 50 lb/acre of the K removed in a silage cut. These figures indicate that even the 'dry' soils should be able to provide this, if there is no more than one cut per year.

Deapite the fact that the soils varied greatly, physically and chemically, and were subjected to a regime highly demanding of potassium (3-5 cuts per year + 200 lb/acre of N) it appears that their fertiliser K requirement for maximum yield is roughly constant at about 140-200 lb/acre. In practice, and in particular where there is a risk of hyponmagnesaemia, a smaller rate could be used on the wetter soils, with only a slight yield restriction. The wetter soils should also need less K with less demanding systems, such as grazing only and lower nitrogen rates.

Experimental Data - Tillage Crops

At 19 of the grassland experimental sites mentioned above two tillage rotations were carried on over the same period. The rotations and potassium treatments were as follows:

Table 7 : Potassium Rates (lb/K/acre)

Year	Crop	K Levels			
		0	1	2	3
1967	Wheat	0	30	60	90
1968	Barley	0	30	60	90
1969	Swedes	0	60	120	180
1970	Potatoes	0	80	160	240
1967	Swedes	0	84	168	252
1968	Potatoes	0	84	168	252
1969	Wheat	0	20	40	60
1970	Barley	0	20	40	60

Table 8 gives the effect of K treatments on crop yields. Each figure is the average of all sites, except that data from some badly lodged cereal sites were ommited.

Table 8 : Crop Yields (cwt of grain or tons of roots per acre)

Year	Crop	K Levels			
		0	1	2	3
1967	Wheat	33.3	34.1	34.0	32.8
1968	Barley	39.9	40.0	38.1	38.1
1969	Swedes	19.6	21.2	21.5	22.1
1970	Potatoes	7.6	13.3	14.6	15.1
1967	Swedes	17.8	19.8	20.1	20.0
1968	Potatoes	10.7	18.1	20.9	22.7
1969	Wheat	39.4	42.5	43.7	43.1
1970	Barley	31.0	32.5	32.7	31.6

These figures show that generally there is little response to potassium in cereals, whilst potatoes are still very responsive. The crops were grown in rotation (as shown) on the same plots. Consequently the Zero-K plots would have become progressively more depleted during the experiment. In view of this the small K responses in Barley 1970 are surprising. It is also noteworthy that 60 lb K/acre depressed the yield of the cereals slightly when compared with 30 lb K/acre ('67/'68) or 40 lb/K/acre ('69/'70).

Table 9 gives the per cent responses of each crop on particular tillage soils (numbered according to the General Soil Map of Ireland).

$$\text{Per cent response to K} = \frac{\text{Maximum Yield} - \text{Zero-K Yield}}{\text{Maximum Yield}} \times 100$$

Table 9 : Per cent response to K on different soils

	Swedes 1967	Potatoes 1968	Swedes 1969	Potatoes 1970
6	14.7	49.4	16.8	47.4
8	11.3	48.4	16.7	53.4
20	22.3	71.5	18.8	63.0
22	31.9	38.5	14.0	54.0
24 Limerick	12.1	46.9	9.1	36.2
24 Meath	17.9	55.3	11.8	55.6
	Wheat 1967	Barley 1968	Wheat 1969	Barley 1970
6	2.5	1.4	11.2	1.8
8	4.9	3.0	8.7	8.9
20	5.7	3.4	20.5	42.9
22	4.3	2.2	18.7	5.7
24 Limerick	6.8	L	5.3	3.8
24 Meath	8.9	L	22.5	4.9

(L = Lodged)

Although soil 24 was a better source of K for grassland than the dry tillage soils, the figures above show that this soil still gives good responses to K on tillage crops (potatoes in particular). The Meath sites gave better responses than those in Co. Limerick.

The most responsive soil was soil 20 which was the only soil to give a significant response in barley in 1970.

These are coarse-textured limestone gravels found in the Midlands, Co. Carlow and Co. Kildare, and described in detail in "The Soils of Co. Carlow" Soil Survey Bulletin 17, as the Athy complex.

Information on another important tillage crop, sugar beet, is currently being obtained from a separate series of experiments, being carried out in co-operation with C.S.E.T. Particularly good responses to K were obtained in 1971, but since only one year's results are available they must be interpreted with caution. Potassium increased both root yield and sugar content. The resulting effect on sugar yield is summarised in Table 10.

Table 10 : Effect of K on sugar yield (Cwt/acre) according to soil type

lb/K/acre	Soil 7	Soil 8	Soil 9	Soil 20	Soil 21	Soil 23
0	62.9	71.1	62.0	65.1	64.0	58.2
200	65.2	70.8	67.0	70.9	67.0	64.7
400	63.7	75.2	69.8	76.1	71.7	68.2

(N rate 80 lb/acre; P rate 80 lb/acre; Na not used).

The soils chosen for this study were predominant in areas where beet growing is concentrated and high yields are obtained.

It is apparent, therefore, that although K applications on cereals now appear to be mainly necessary as an 'insurance' and to maintain fertility, root crops (particularly potatoes and sugar beet) continue to give good yield responses.

Residual Value of Potassium

Ten of the tillage sites referred to earlier were examined in 1971, to evaluate the residual value of the K treatments applied during the previous four years. The results are summarised in the following table.

Table 11 : Effect of residual and freshly applied K on yield of potatoes - tons/acre

K applied 1967/1970 (lb/acre)	(average of 10 sites) K applied in 1971 (lb/acre) 0	75	150	300
0	6.1	9.0	10.1	11.8
208	8.4	9.8	10.7	11.7
416	10.4	11.2	11.7	12.1
624	11.3	11.9	11.8	12.7

These figures demonstrate the value of high fertility in obtaining maximum yield. They also suggest that a response to freshly-applied K can also be obtained even at high levels of fertility. It is notable that although

witholding K for 5 years restricted yield to about 48% of the maximum,residual K from the first four years could provide up to 89% of maximum in the fifth year. In general, both residual and freshly-applied K were required for maximum yield.

Conclusions

The authors believe that the use of potassium fertilisers in Ireland must continue to increase in the immediate future for the following reasons :

1. Grass, which is by far the most important and most extensive crop, is generally inadequately fertilised with K at present.
2. Grassland productivity will need to be increased if we are to take full advantage of our membership of E.E.C.
3. Silage making is likely to continue increasing in popularity for some time, since there is still considerable room for expansion in this area.

There are also a number of developments which can be expected to slow down this increase eventually. Of these, the setting up of more efficient systems for collecting dung and urine during overwintering of cattle seems to be particularly important.

Increases in stocking rates will tend to keep the K requirements of grazed areas down to relatively low 'maintenance' levels.

Despite increases in fertility, root crops still give good responses to K and 'maintenance' dressings are still recommended for cereal crops. No change is foreseen here at present. However, in response to economic pressures and bearing in mind the absence of fertiliser subsidies in E.E.C., there may have to be some re-thinking on the subjects of 'maintenance' levels, residual values and rationalising K applications to make better use of soil K reserves while avoiding depletion. With regard to the rationalisation of K-use on grassland, this paper has already indicated that soil properties other than K status can affect the requirements of different soils. In considering what has been said about "heavy" and "light" soils, it must be remembered that the former generally will support a lower stocking rate and require a longer overwintering period. These are obstacles to the efficient cycling of potassium under grazing on these soils which may tend to offset the advantages which they have as suppliers of K.

A great deal of future research is now needed so that the factors which influence potassium requirements can be quantified. For instance, we have suggested that there are differences between soils which are of practical importance. It is essential that studies of the K requirements of grassland should take into account potassium cycling under different soils, management systems and stocking rates. Such studies will have to be extended to marginal land if this continues to grow in importance under economic pressures.

It is concluded that potassium will continue to be an important factor in agricultural production, and will deserve a good deal of attention from the farmer, the adviser and research scientist.

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Appendix I - Soil Description

Soil Association*	Series	Parent Material
6	Borris	Granitic glacial drift.
6	Screen	Morainic sand.
8	Clonroche	Ordovician or Silurian Shale glacial drift.
9	Not yet named	Old red sandstone glacial drift.
13	Abbeyfeale	Upper Carboniferous Shale glacial till.
17	Not yet named	Carboniferous/Ordovician Sandstone/Shale glacial till. (Wet Drumlin).
20	Athy Complex	Carboniferous limestone morainic gravel.
22	Not yet named	Carboniferous limestone glacial drift.
23	Not yet named	Carboniferous limestone rock and glacial drift.
24	Elton	Carboniferous limestone glacial till.
27	Macamore	Dense calcareous glacial mud of marine origin.

* See General Soil Map of Ireland.

Appendix II

Effect of K* on Grass D.M. Yield and K Uptake

Soil	Year	Yield lb/acre D.M. K_0	K_1	K_2	K_3	Uptake lb/acre K K_0	K_1	K_2	K_3
6 Borris	1	8120	9420	9500	9280	247	365	442	479
	2	6910	10290	10960	11180	73	205	322	380
	3	6240	9750	10770	11210	70	126	250	352
	4	4400	7520	9380	9080	35	95	230	329
8	1	8320	8950	9530	9510	223	317	422	465
	2	7320	9580	10020	9940	91	212	308	391
	3	6070	10080	12050	11970	65	164	255	396
	4	5270	8680	10190	10550	60	116	215	343
20	1	7910	8960	9230	9410	196	302	368	398
	2	6810	9280	9920	10010	104	204	294	352
	3	5100	7930	8990	9460	67	123	201	338
	4	5850	7500	8350	9220	65	116	207	302
22	1	6760	8240	8340	8750	131	246	354	410
	2	6220	8640	9130	9350	95	172	267	321
	3	5080	8230	9760	9390	52	143	249	322
	4	4050	7930	8580	8770	33	108	214	328
13	1	7260	8080	7720	8230	224	283	315	348
	2	9310	10450	10520	10230	189	280	378	401
	3	8390	9390	10840	10270	155	212	310	343
	4	7090	7380	8120	8370	118	168	259	322

contd ...

* See Table 5 for potassium treatment levels.

Appendix II

Soil	Year	Yield lb/acre D.M. K_0	K_1	K_2	K_3	Uptake lb/acre K K_0	K_1	K_2	K_3
17	1	6690	6110	6260	6290	163	197	215	230
	2	6810	6800	7130	8000	108	193	233	278
	3	7640	9350	10030	9320	143	274	289	358
	4	6600	8655	7770	7740	66	171	245	260
24 Limerick	1	7710	8320	8120	8270	232	325	397	421
	2	8470	9840	10390	10750	122	222	343	395
	3	8430	9890	10400	10160	102	172	277	372
	4	7970	9480	9620	9710	92	161	262	405
24 Meath	1	9560	9940	9850	10130	336	433	499	549
	2	9490	9880	10590	11290	226	314	366	464
	3	8720	10050	10780	11540	150	822	283	384
	4	8550	9710	10620	11240	87	137	250	315
6 Screen	1	7148	8133	8461	7387	122	229	321	338
	2	5458	7607	8468	7327	64	153	245	288
	3	5260	8786	9402	8777	49	107	186	297
	4	4640	7502	7256	6187	39	116	172	235
9	1	7731	7921	7702	8164	242	311	344	386
	2	9100	10406	10534	10762	146	235	334	401
	3	8346	10536	12164	12578	98	170	285	411
	4	5925	8925	9888	10870	66	141	234	353
27	1	7727	8652	8372	8925	156	269	323	359
	2	8284	8971	8430	8664	182	252	255	267
	3	7573	8382	8402	8469	109	149	185	261
	4	7778	9899	9374	9335	123	191	232	304