The Importance of Potassium (K) in Agricultural Soils

The Fertilizer Association of Ireland in association with Teagasc
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10 Things to know about Potassium (K)

1. Potassium is a positively charged mobile cation
2. Potassium deficiency is often referred to as the "hidden hunger"
3. World potassium supplies are large, Canada largest supplier
4. Chloride in muriate of potash (MOP) is an essential plant element
5. Potassium can be applied all year round (365 days)
6. Sulphate of potash can be used as a potassium source on organic farms
7. Maximum grassland spring application is 90kg K/ha (Single App.)
8. Availability of K in manures is reduced to 90% on index 1 & 2 soils
9. Potassium increases cereal plant tolerance to powdery mildew infection
10. Potassium reduces plant brackling / lodging

Potash - another word for Potassium

The name comes from pot ash, which refers to plant ashes soaked in water in a pot, the primary means of manufacturing the product before industrialization.

Authors: Fertiliser Association of Ireland council members - Mark Plunkett, David Wall & Patrick Forrestal, Teagasc, Johnstown Castle Research Centre, Wexford & Tim Sheil, J. Bolger & Co, Wexford.

Table of Contents — Page No.

Section 1. Potassium in Soil and Plants

Section 2. Potassium Management and Agronomic Advice

Introduction

Potassium is an essential nutrient for plants, animals and humans. It is one of the major three plant nutrients - nitrogen (N), phosphorus (P) & potassium (K) and is required in large amounts (similar to N) during the growing season. It is a pivotal nutrient in plant structure development and plays a key role in the uptake and efficient use of N.

The primary functions of K in the plant are as follows:-

- Increase root growth and improved nutrient uptake
- Builds cellulose and reduces plant lodging / brackling
- Activator for over 60 plant enzymes for plant growth
- Translocation of plant starch and sugars
- Maintaining water balance in plant cells
- Maintains plant chlorophyll
- Increases plants tolerance to foliar diseases

Source:- The use of nutrients in Crop Plants (Fageria, N.K., 2009)

Section 1

Potassium in Soils & Plants

1.1 Mineral & Peat Soils

Potassium is a major element and is the eight most abundant mineral in the earth's crust. It occurs in many minerals and salts and due to its solubility it's relatively available. The total content of mineral soils usually ranges from 0.04 to 3% (see figure 1). The total K content of Irish soils measured by Fay et al, 2007 found higher total K levels due to the K extraction method used for K analysis which dissolved silicate minerals including the K-rich feldspars and micas.

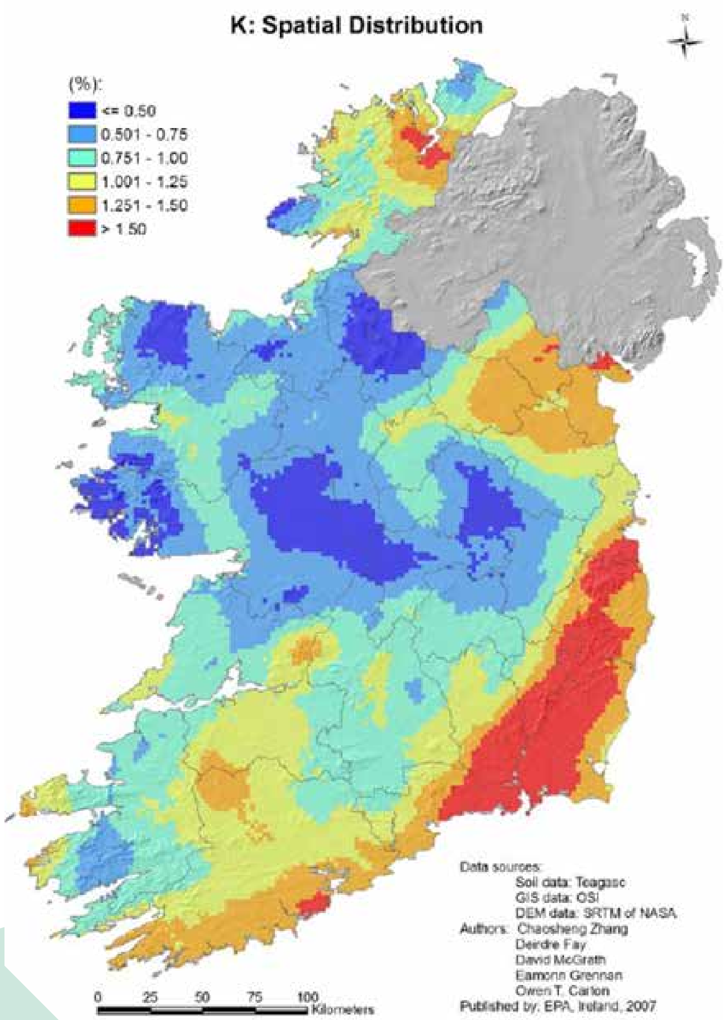

Figure 1:- Total soil K map of Ireland (Source: - Geochemical Atlas of Ireland).

Felspars and micas are the principle constituents of granites, schists, greywackes, sandstones and clay minerals (figure 2 shows a map of rock types for Ireland). Levels of total soil K above 1% in Donegal are attributed to the felspars in the local schists and granite. While similar levels in the north and south east are associated with fine feldspars in the greywackes, shales and granites and in southern Cork. In these soils it is probably due to the micas in the underlying shale's and siltstones. Levels of 0.5% are coincident with soils on limestone bedrock in the midlands to the north west (Fay, et al, 2007).

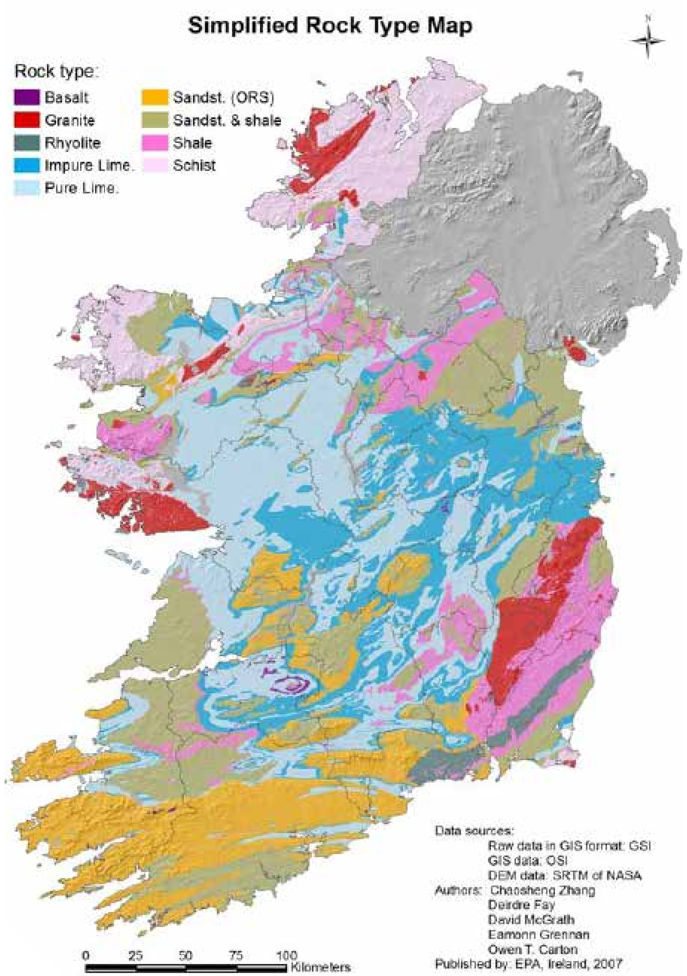

Figure 2:- Irish bed rock geology (Source: - Geochemical Atlas of Ireland).

Mineral Soils

Mineral soils have developed from continuous weathering (freezing, thawing, rainfall & biology) of parent materials. The most important soil fractions that determine the supply of K are the finer soil components that are less than 2mm (silt and clay). Organic matter is also an important in the supply of K as it has similar characteristics to clay in that it is negatively charged with a large surface area.

Mineral soils contain large amounts of K depending on soil mineralogy but only between 1 to 5% are available for plants.

Potassium in high organic matter (Peaty) Soils

Organic matter rich soils, and peat soils (organic matter concentration >20%) have much lower capacity to retain K as they do not contain clay minerals (due to lower mineral matter levels) (Wall & Plunkett, 2016). The soil K index for peat soils is different compared to mineral soils see section table 1, which should be considered before developing a K fertilizer strategy for these soils.

Peat soil > 40cm deep

Peat over mineral soil

1.2 Soils and soil potassium availability

Potassium exits in the soil in a number of different states / pools. The supply of soil K is outlined in figure 3 below which shows the different soil K pools, there size, movements and availability for plant uptake. Potassium ions move from one pool to the next whenever there are removals or additions of K which change the balance within the K pools. The ability of the soil to supply K very much depends on the transformations between the various liable K forms and the balances with the soil solution. The main pools of K are outlined below:-

"Available K pool" tends to be the smallest K pool in the soil and contains water soluble K for plant uptake.

"Readily available K" pool replenishes the available K pool many times during the growing season as K is released from the surfaces of the clay particles.

Available K and readily available K combined are what the soil test measure which is an indication of the soils ability to supply K to the crop.

"Less readily available K" is interchangeable with the readily available K pool.

"Very slowly available K" pool is made available over time through weathering (clay) and organic matter decomposition processes and this pool of K tends to be very stable.

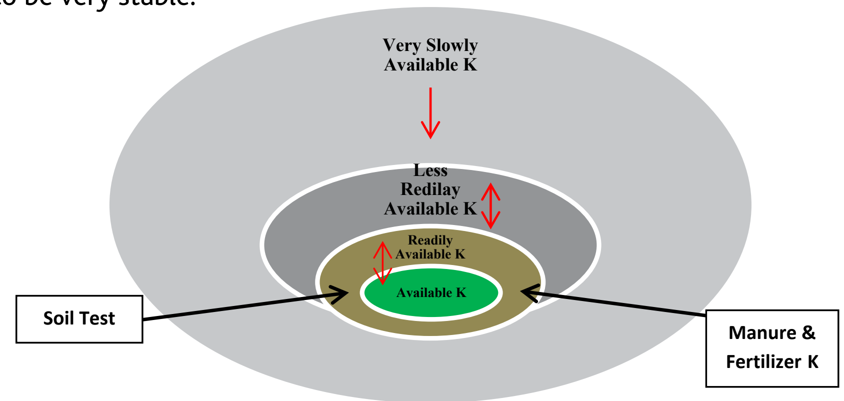

Figure 3:- A simplified diagram is showing different soil K pools, availability and movement between pools.

The available K in the solution is reported to be very low at 0.1 to 0.2% compared to the readily available pool which contains 1 to 5% because of the strong K adsorption by 2:1 silicate minerals (Fageria, 2009). The less readily available pool is estimated to contain 1 to 10% and the very slowly available pool contains 85 to 95% of mineral K.

Clay type & Soil K Supply

The clay fraction along with soil organic matter has a major role in the supply of available K. Within the clay fraction most of the K occurs in a crystal lattice structure (1:1 or 2:1 type minerals) of silicate minerals (see figure 4), especially feldspars and micas. These silicate minerals weather and slowly release K. These secondary clay minerals, especially 1:1 type clay minerals (kalonite) supply K more easily than 2:1 type clay minerals (montmorillinate, vermiculite and illite) (Fageria, 2009). This is due to the positions of the K ions on the clay mineral, for example K ions will be absorbed on the surfaces, edges and inter layers as shown in figure 4 below. Soils will generally contain a range of these clay minerals. For example, soils dominated by illite or vermiculite will have good soil K reserves compared to soils dominated by kaolinite this due to the clay mineral structure and K

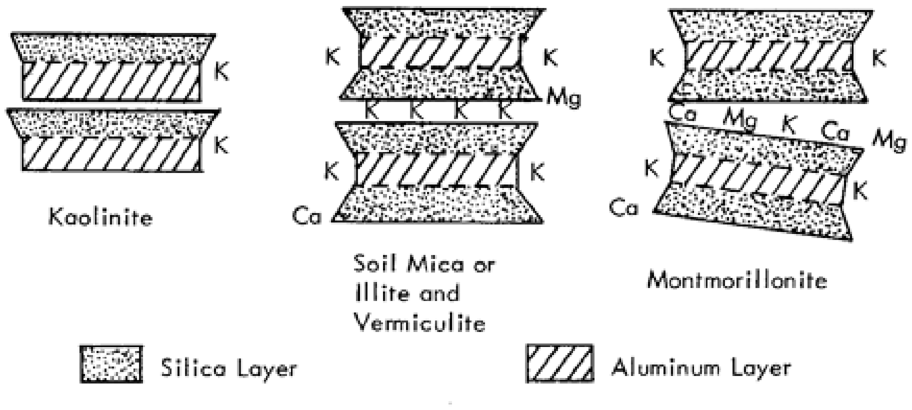

Figure 4:- The structure of 4 types of clay minerals (Murdock, L., et al, Agr 11)

K Fixing Soils

Potassium fixation occurs when the exchangeable or water soluble K cations are converted into a form that cannot be readily extracted by plants. For example soils dominated by illite or vermiculite type clay can fix K in their crystal lattices. This is because the positions on the clay lattice are the same size and shape of the K ion. When K ions are adsorbed / entrapped between these layers of the clay particle a contraction of the mineral takes place resulting in the K ions been fixed. The lowly charged montmorillonite minerals can hold a large amount of exchangeable K but only fix a small percentage of it.

There are a number of counties where K fixing soils occur notably the Mylerstown soil series (See below).

Soil profile of the Mylerstown soil series (K-Fixing).
This was previously known as the Athy soil series.

1.3 Soil potassium mobilisation and movement in soils

Potassium is a relatively mobile nutrient in the soil compared to P (figure 5) and is held in the soil on the clay particle complex. Potassium moves by diffusion where the K ions move randomly in soil solution from a relatively high concentration to a lower concentration. During periods of rapid plant K uptake the zone around the root becomes depleted and therefore applied K moves into this zone of low K concentration. This results in a net movement of K towards the root zone but it is reported that there maybe a concentration gradient that extends into the soil to between 0.1 to 15mm from the root surface, depending on then ion and the rates of diffusion and uptake (Barber, 1984). Where crops experience a K deficiency during the growing season, a timely application of fertilizer K can rectify the problem due to its mobility provided there is sufficient soil moisture to move the K into soil solution.

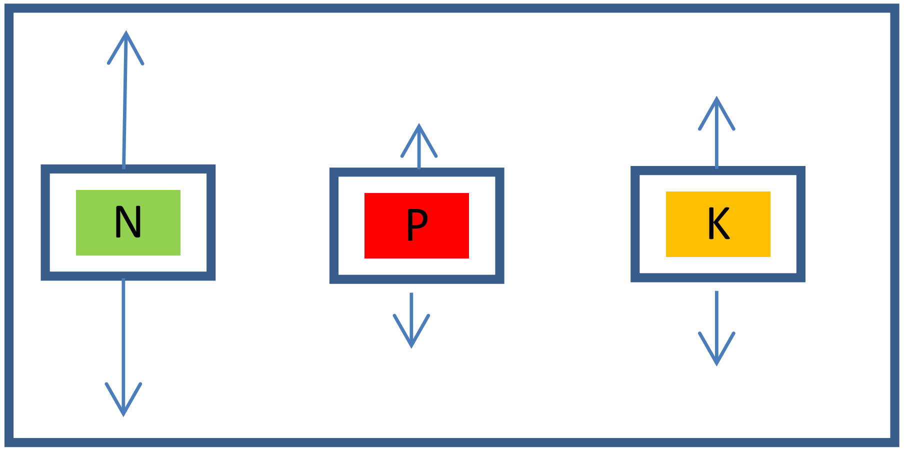

Figure 5. Relative movement of N, P & K in soil (Soil Fertility Manual, 2006).

1.4 Soil test potassium

The soil test is a very reliable measure of plant available soil K during the growing season. In Ireland the Morgan's soil K extraction method has been shown to be well correlated to plant growth. The soil K index system is shown in table 1 for mineral and peat soils. For peat soils soil test K levels are higher as peat soils do not contain any clay minerals so they do not store and their K supply can be low. The Morgan's K therefore relates more to the total K content for peat soils resulting in higher soil test K as shown in table 1.

Table:- 1 Soil K index, response to fertilisers (Teagasc, 2016)

Soil Index	Response to Fertilisers	Soil test K (mg/l)	
		Mineral	Peat
1	Definite	0–50	0–100
2	Likely	51–101	101–75
3	Unlikely/Tenuous	101–150	176–250
4	None	>151	>250

The optimum soil K index on mineral soils is Index 3. This is deemed to be the desired soil index to maximise production for agricultural field crops.

Figure 6:- The impact of soil K index on spring barley establishment and crop development. Plot on the left is K index 1 and plot on the right is K index 2 (Oak Park, 2015).

1.5 Potassium function in plants & crop K deficiencies

Potassium is extremely mobile in plants and plays a key role in plant functions such as the opening and closing of plant stomata in the leaves, the uptake of water by root cells, plant osmotic potential and turgor of the guard cells and transport of photosynthate from the leaves.

Disease control

Potassium increases a plants tolerance / resistance to diseases in cereals such as powdery mildew. This was observed in many trials conducted in both winter and spring barley at Teagasc see figure 7.

Figure 7:- Powdery mildew on winter barley receiving a zero application of K (Arklow, 2016).

Potassium reduces brackling & lodging

As reported previously K is a plant building lock and is very important in plant cell wall development. Cereal trials demonstrated the important role of K in helping to prevent both lodging and brackling in cereal crops. Figure 8 shows a crop of winter barley with brackling and its impact on straw quality.

Figure 8:- Potassium plays a key role in reducing plant lodging and brackling in cereal crops.

Plant Analysis & Potassium

Plant analysis is a useful tool to identify plant K sufficiency / deficiency during the growing season. As plants develop the uptake of K increases and plant K concentrations will decline due to K dilution. Once cereal plants reach maturity at harvest time there tends to be approximately 50:50 split of K between grain and straw. While for beans there tends to be a 60:40 split between seed and shoot K concentrations. Table 2 below shows typical K concentrations in plants.

Table 2:- Plant K Concentration (g/kg Dry Matter)			
Element	Deficient	Low	Sufficient
K	<20	20-30	30-60
			Source – Teagasc Green Book, 2016

Where crops are harvested green such as grass silage / whole crop cereals significantly higher levels of K are removed at harvest time compared a crop of hay which tends to be cut later and more mature at harvest time similar to ripe cereal crops resulting in lower K off takes.

Potassium deficiency

Potassium deficiency is often called the "hidden hunger" as crop K requirements are often large and visual symptoms to a K deficiency are can be quite difficult to identify during the growing season. Potassium deficiency will be most likely when K concentrations in soils are suboptimal for grass or crop production.

If K supply to the plant is sub optimum this will have knock on effects on plant health and function and ultimately growth. While potassium plays such a key role at a cellular level, visual symptoms and visual diagnosis of a K deficiency is difficult. In general – K deficiency can be evident in older leaves as K is mobilised to the stems with the result of the necrosis of the leaf tips (dying).

Potassium plays an important role in water movement in the plant and as such has been shown to play a key role in times of heat, drought and cold stress. Playing an important role in water movement throughout the plant means a lack of K can be important in time of drought and heat stress. Potassium supply has also been shown to increase plant growth in times of drought or heat stress.

The main visual effects of a K-deficiency in grassland is associated with a change in the botanical composition of grasslands – changing from productive species, such as ryegrass, to unproductive or unpalatable species such as bent-grass or cocksfoot. None the less there are some apparent deficiency symptoms that can be observed in the field such as poor / pale grass growth see figure 9.

Figure 9:- Potassium deficiency in grassland. The dung / urine patched showing good grass growth and other parts of the field demonstrating poor grass growth which is pale and little growth showing a K deficiency. (Source:- www.dairynz.co.nz/ via Chris Dawson, Ag Consultant, UK).

Cereals

Cereal crops have a high K requirement as a lot of biomass is produced in a short space of time. As in grassland K will often show similar deficiency symptoms in cereals / maize as K is mobilised from the margin of older leaves to the growing parts of the plant (see figure 10 below).

K Deficiency in Cereals

K Deficiency in Maize

Figure 10. K deficiency symptoms in cereals and maize leaves.

In cereals, low K status can affect stem strength and rigidity. This can lead to an increased risk of lodging / brackling in cereals which can have a knock on effect on crop yield and quality.

Potassium deficiency can be more pronounced in crops with a high K requirement such as potatoes. General symptoms include bronzing of leaves and necrosis of leaf margins and tips. Potatoes growing in low K status soils can be stunted and bushy, with small leaves, and premature senescence before tubers are fully formed. Low K status can also cause quality issues and affect the marketability of the potatoes.

Figure 11:- Early signs of K deficiency in spring barley on a K index 1 after intensively cut grass silage.

Figure 12:- Potassium deficiency symptoms "Bleaching on the older leaves" or "paper like" symptoms in spring barley.

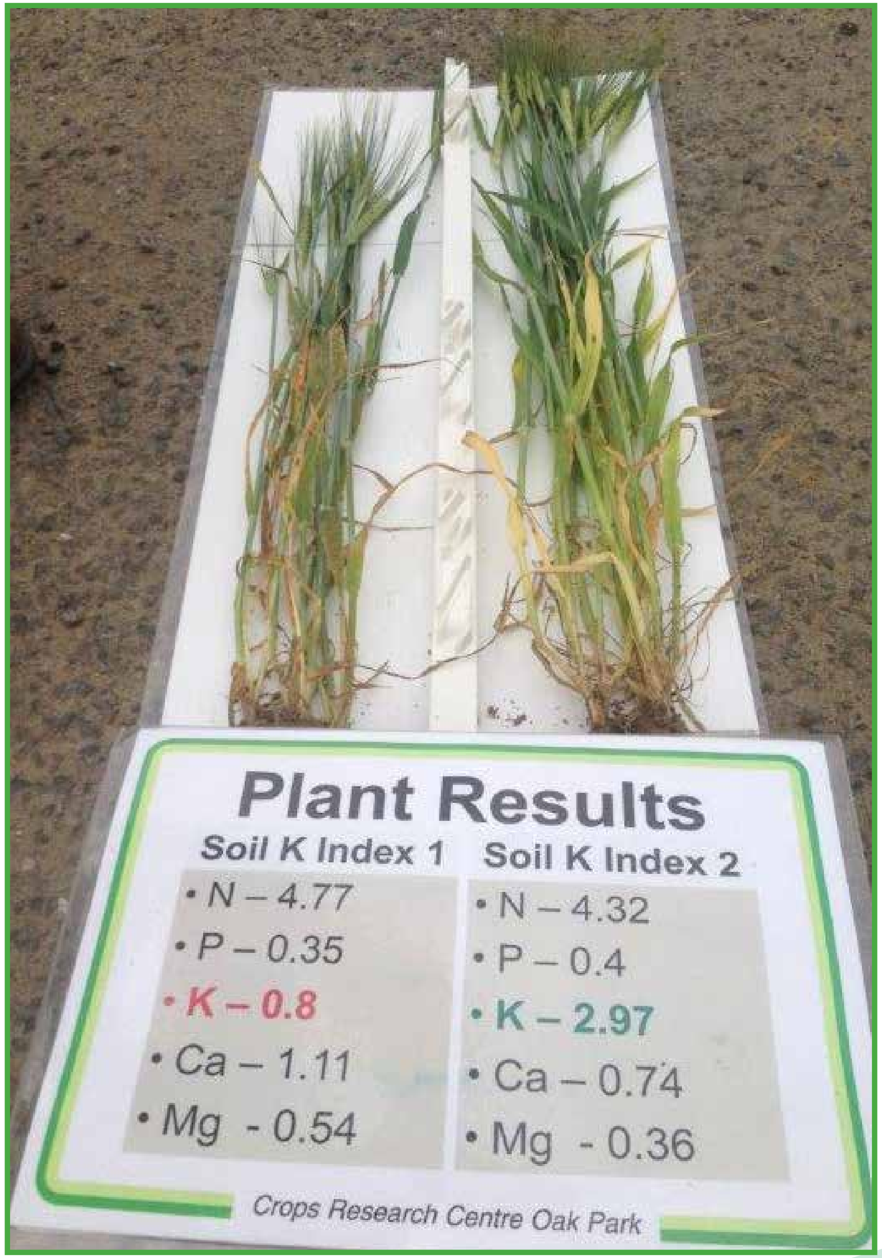

Figure 13:- Potassium deficiency in spring barley. Plants on the left showing powdery mildew infection on the leaves and stunted plant growth compared to the plant on the right.

1.6 Potassium and impacts on yield in grass and cereals

Low soil K levels will reduce crop yields and profitability. Intensive cropping such as grass / maize silage or cereals on grown K deficient soils will result in lower crop yields. Where adequate levels K are not applied annually based on soil test results as either organic or fertilizer K, soil K levels will drop rapidly depending on soil type and K removals. Crop yield, quality and nitrogen use efficiency will decrease rapidly depending on soil type.

Ideally, where ploughing is not required, minimum cultivation during seedbed preparations for grass sward reseeding is preferred as it will help retain soil P & K Fertility in the top 10cm of the soil corresponding with the main grass rooting zone.

Figure 14:- Harvesting 1st cut grass silage at Johnstown Castle research centre.

Grassland

A study of grass silage response to K fertilizer application was conducted from 2005 to 2009 at Teagasc, Johnstown Castle. Swards with ryegrass mixed with wild grasses had higher grass yield response to K fertilizer than the ryegrass only sward (figure 15). The mixed grass swards were responsive to K applications up to approximately 180 kg K/ha while ryegrass swards were responsive to K fertilizer rates up to 240 kg K/ha. Three sward types with varying perennial ryegrass levels were evaluated.

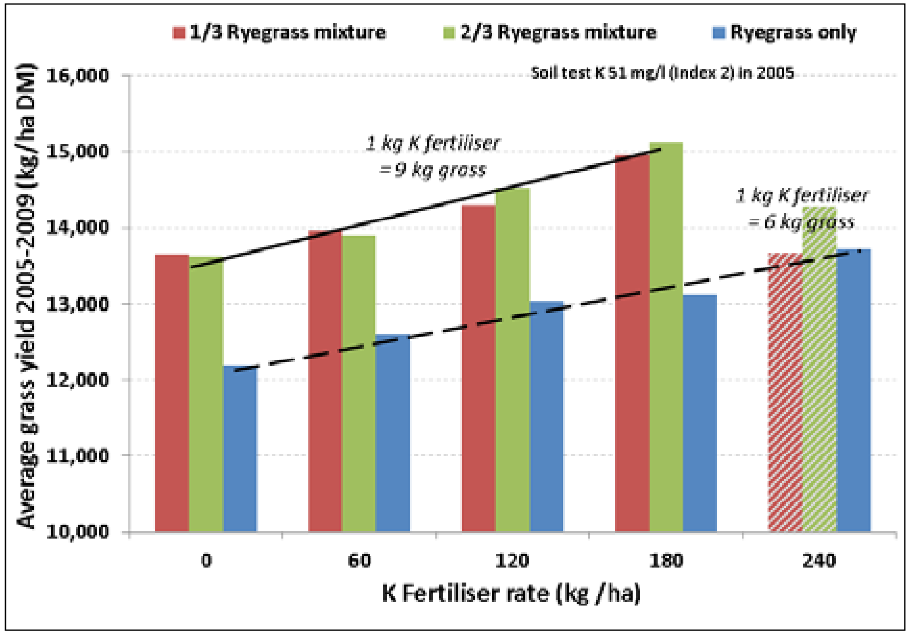

Figure 15:- Relationship between average grass yield (kg/ha) and potassium (K) fertilizer rate (kg/ha) for a 4 cut silage experiment at Johnstown Castle between 2005 and 2009.

Potassium and Nitrogen Use Efficiency

To maximise the efficient use and return from applied nitrogen it is important to maintain sufficient soil K levels and apply K regularly based on recent soil analysis to optimise grass production. Figure 16 shows the effect on grass yield for 2 different rates of N (200 v 400kg N/ha) and 5 rates of K (zero to 240kg K/ha) per year for a continuous cut grass silage sward at Johnstown Castle (2005 to 2009).

This clearly shows that higher rates of N required higher rates of K to ensure applied N is used efficiently in producing higher grass yields.

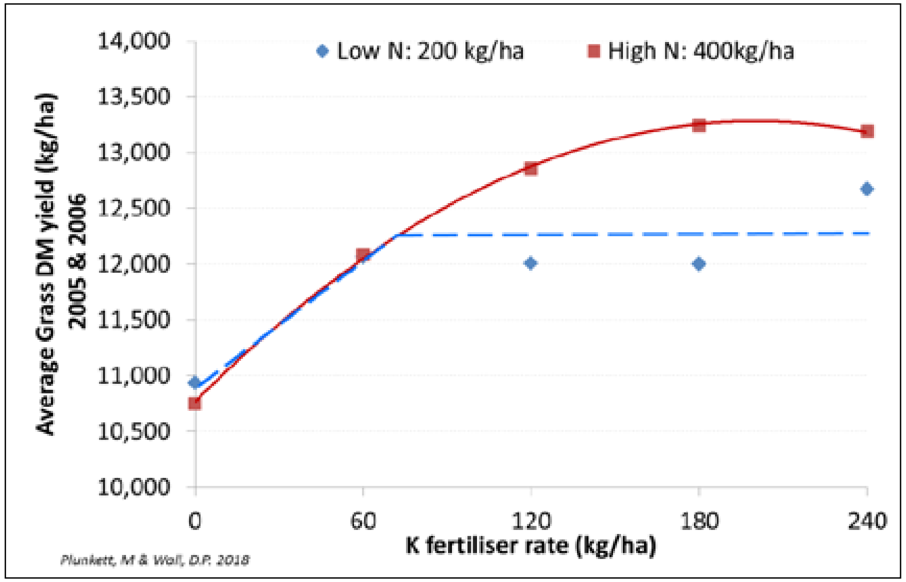

Figure 16:-The effect of 2 rates of N (high & Low) and 5 different rates of K.

Cereals

Cereal crops have a large demand for K due to high grain yields and the removal of straw at harvest time. The following graphs (figures 18 to 22) show the yield responses to K for spring and winter barley at different soil K indexes and various rates of K fertilizer.

Figure 17:- Plants taken from spring barley K trial in 2018 (Rathdrum, Co. Wicklow). Showing the effect of fertilizer K rates from 0 to 200kg/ha on plant development on the 11th June.

Soil K Index

Figure 18 shows the impact of soil K index (1 & 2) on grain yield in spring barley and grain yield response at three rates of K fertilizer (0, 50 & 100kg/ha) . Soils at K index 2 yielded 2.3t/ha extra grain compared to soil K index 1. An application 50kg K/ha of fertilizer K increased the yield on the index 1 by 1.2t/ha and no further yield response to higher rate (100kg/ha) of K applied on this index 1 site. This indicates the importance of soil index when maximising grain yield potential which cannot be replaced by fertilizer K.

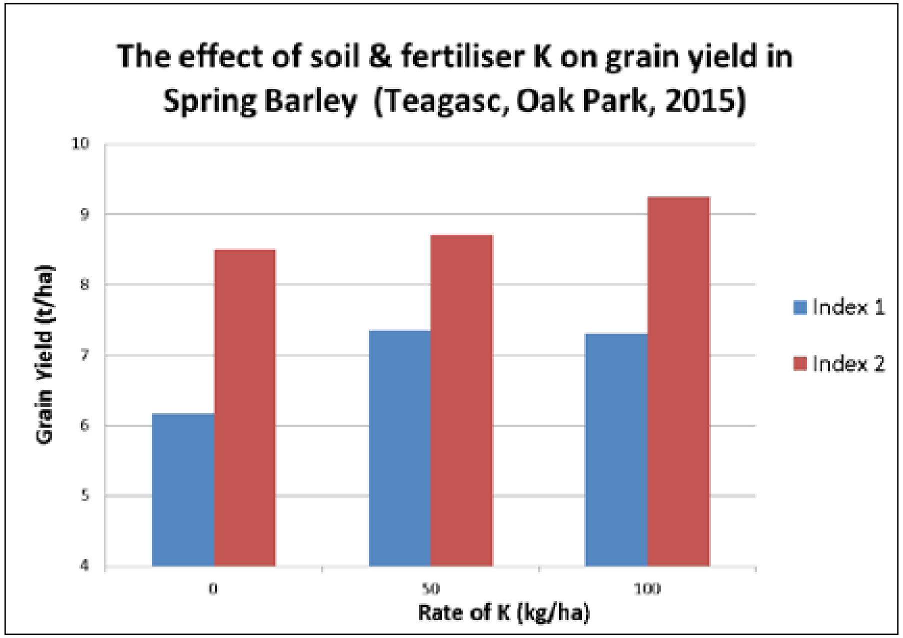

Figure 18:- Spring barley grain yield response (t/ha) to fertilizer K application rates (kg/ha) on a soil K index 1 & 2 on a very light soil at Teagasc, Oak Park.

Yield response on a very low index 1 soil

Where soil K has been depleted from the intensive cropping such as the cutting of continuous grass silage and inadequate K applications. Crops such as cereals will be very responsive to K applications as shown in figure 19 below. This shows the yield response on a medium soil type from 0 to 200kg K/ha. On this site soil K levels were very low at 26mg/l K. This had a large impact on grain yield, where zero plots yield 2.4t/ha compared to the fertilised plots yielding 8.6t/ha.

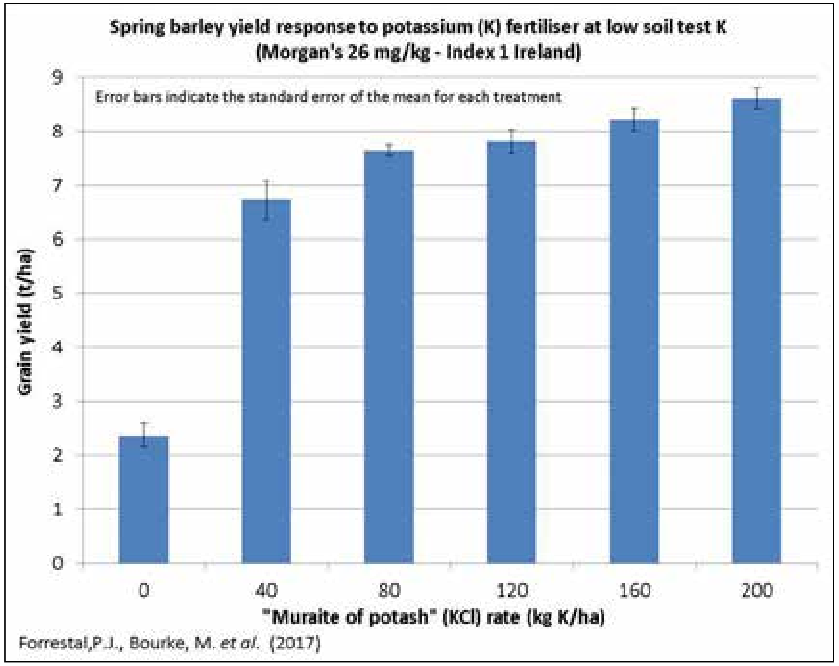

Figure 19:- Spring barley grain yield response (t/ha) to fertilizer K application rates (kg/ha) on a soil K index 1 Arklow, Co. Wicklow.

Figure 20:- The impact of a very low (Index 1) soil K on spring barley development. Crop at GS 30 / 31, plant on left is zero K treatment (showing visual and stunted plant effects) compared to plant on the right which received 160kg K/ha. (Arklow, Co. Wicklow 2017)

Muriate of Potash (MOP) v Sulphate of Potash (SOP)

Muriate of potash is the most widely used source of K fertilizer in Ireland, with SOP usually used for high value crops such as vegetables due to the benefit of sulphur and absence of KCL in SOP. There has been much discussion on the merits of SOP vs. MOP for cereal crops and the additional cost of SOP is justified. In 2016 both MOP and SOP were applied to the 2-row and 6-row winter barley varieties. The MOP produced significantly higher grain yield (0.4t/ha) compared to SOP for the 6-row barley, but there was no significant difference for the 2-row barley (see figure 22). On sites known to respond to S applications, SOP, which supplies 18% S, may achieve high yields than MOP. Research has shown that MOP treated barley crops are more effective at protecting against powdery mildew and may explain why the MOP tended to produce higher yields (significantly higher in the 6 row barley) compared to the SOP treated plots.

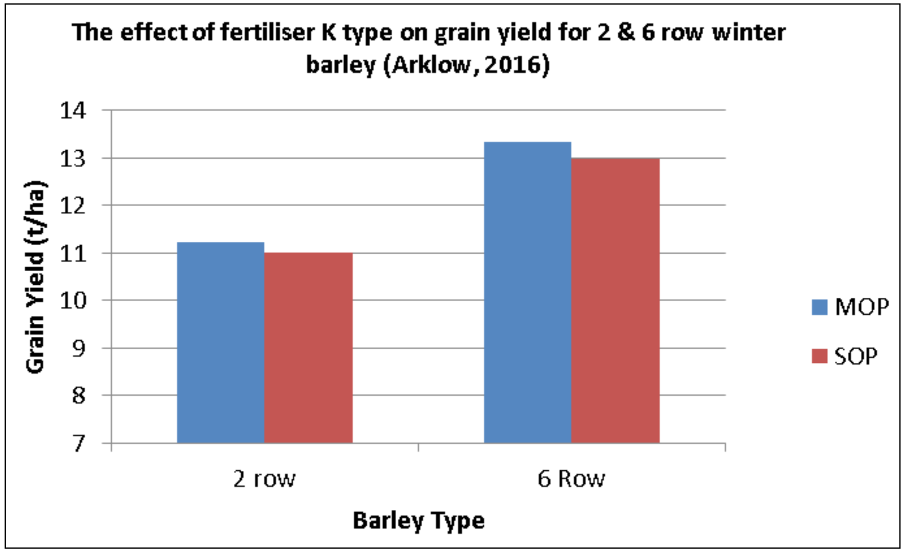

Figure 22:- Grain yield response (t/ha) to different types of fertiliser K (MOP v SOP) for 2 & 6 row winter barley varieties at Arklow, Co. Wicklow in 2016.

Section 2

Potassium Management and Agronomic Advice

2.1 Nutrient Advice - Grassland & Cereal Crops

The aim is to maintain soil K levels at Index 3 for optimum production. For grassland fertilizer K advice is based on soil analysis and whether the sward is been grazed or cut for silage. Crops such as cereals grain yields are taken into account plus the most recent soil analysis to determine crop K advice.

Potassium Advice for Grassland

The K requirements for grazing are relatively low as the majority of K is recycled by the grazing animals in dung and urine. For grass silage there can be large K off takes depending on grass silage yields and the number of grass cuts annually. Typical K off takes for grazing at 2 LU/ha and silage (5t/ha DM) are shown in figure 23 below.

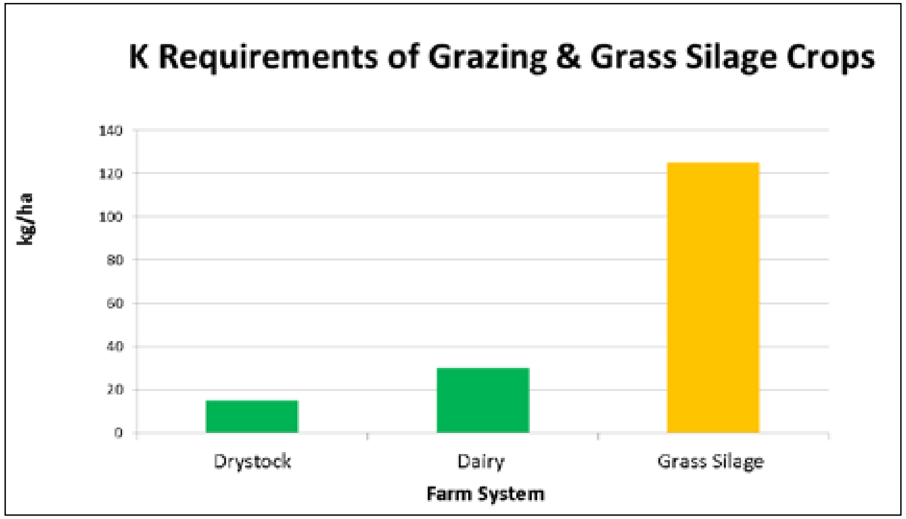

Figure 23:- Potassium requirements (off takes) for dairy, drystock grazing and grass silage (1st Cut).

Maintenance (Index 3)

Nutrient advice at index 3 is to replace K removed in meat and milk. The K fertilizer K maintenance requirements are shown in table 3.

Table 3. Grazing maintenance rates of available soil K to replace offtakes (kg/ha)		
Grassland Stocking Rate (kg/ha) Org N	Farming System	
	Dairy	Drystock
≤100	20	5
130	25	10
170	30	15
210	35	20
≥210	40	25

Soil K Build-Up (Index 1 & 2)

To build soil K levels to the optimum index 3 additional levels of K needed to be applied for a number of years. Soil K build-up rates are shown in table 4. It is recommended to apply build up rates of K in the autumn to reduce the risk of grass tetany in bovines. Whereas in K fixing soils (e.g. Mylerstown Series) K should be little and often throughout the year.

Table 4. Available K rates (kg/ha) for Build-Up on mineral soils	
Soil K Index	K Rates (kg/ha)
1	60
2	30
3	0
4	0

Luxury amounts of K can be taken up by the grass when more than 90kg/ha of K is applied. This can reduce K fertilizer efficiency and may upset the K:Mg:Na balance in the herbage. When more than 90kg/ha is advised use split applications with the second application later in the year. Table 5 shows the K advice (build-up & maintenance) for dairy and drystock grazing stocked at 2 LU/ha.

Table 5. Potassium advice (kg/ha) for a Dairy or Drystock farm stocked at 2.0LU/ha		
Soil K Index	Dairy	Drystock
1	90	75
2	60	45
3	30	15
4	0	0

Potassium for Silage and Hay

Potassium requirements for silage and hay are large due to high K off-takes in harvested grass. Each 1 tonne of grass dry matter removes 25kg K/tonne. Table 6 shows the K fertilizer advice for 1st and 2nd cut grass silage based on a grass yield of 5 and 3t/ha, respectively. It is important to remember that there is a K fertilizer requirement is for each cut. The K fertilizer requirement can be reduced by substituting some or all of the K fertilizer with organic manures.

Table 6. Potassium advice for 1st and 2nd cut grass silage (kg/ha)[1]		
Soil Index	1st Cut / hay(5t DM/ha)	2nd Cut(3t DM/ha)[2]
1	185[3]	75
2	155[3]	75
3	125[3]	75
4	0	0[4]

[1] Increase K by 25kg/ha for each extra t/ha of dry matter

[2] Where K build-up has already been applied for the previous grass silage crop (i.e.1st cut) apply K based on crop off takes.

[3] Apply no more than 90kg/ha K at closing for silage and apply the remainder at least 3 months in advance or after silage harvest.

[4] In the year of sampling omit K and revert to Index 3 advice until new soil test.

Potassium for Pasture Establishment

Potassium is important when establishing new grass swards and grass and clover swards. Table 7 shows the K fertilizer requirements when reseeding. Note K requirement at soil K index 4.

Table 7. Potassium advice for grass establishment (kg/ha)		
Soil Index	Grass Only	Grass / Legume
1	110	120
2	75	90
3	50	60
4	30	40

Cereal Crop K Advice

Cereal nutrient advice for K is based on maintaining the soil test at the agronomic optimum level of index 3. Potassium advice is determined by soil analysis and the expected grain yield for the crop. Where soil test results are below index 3 additional K will be required for a number of years to build soil K levels (see table 9). Fertilizer K advice takes crop yield into account since 2008.

K Off-takes

Table 8 below shows the amount (kg) of K removed per tonne of grain yield. For example a 10t/ha crop winter wheat removes 98kgK/ha (Grain & straw). Where straw is chopped and incorporated after harvest crop K off takes are reduced from 98kg K/ha to 47kg K/ha. There is approximately a 50:50 split of K between grain and straw in cereal crops. Where high yielding crops are harvested each year it is important to adjust the K advice to take account for higher K removals. This will help maintain soil K levels at the optimum soil K index 3.

Table 8:- K offtakes in cereal crops (kg/ha) per ton of grain yield

Crop	Straw Removed	Straw Chopped
W.Wheat/ Barley	9.8	4.7
Sp.Wheat/ Barley	11.4	4.7
Oats	14.4	4.7

K Build-Up

Table 9 blow shows additional K required at soil index 1 and 2 to build soil K levels to the optimum soil Index 3. Building soil K will take a number of years depending on the soil type and the clay mineralogy. On sandy or organic soils, don't build soil K levels. Apply adequate K levels for yield on an annual basis e.g. index 3 advice as per table 10.

Table 9. Available K rates (kg/ha) for Build-Up on mineral soils

Soil K Index	K Rates (kg/ha)
1	30
2	15
3	0
4	0

Table 10 below shows the K advice for a range of cereal crops where straw is removed at harvest time.

Table 10:- K advice for cereal crops where straw is removed (kg/ha)1

Soil Index	Winter Wheat[2]	Winter Barley[2] / Spring Wheat[3]	Spring barley[2]	Winter Oats[4]	Spring Oats[4]
1	140	130	115	160	140
2	115	115	100	145	125
3	110	100	85	130	110
4	0	0	0	0	0

[1]Assumed crop yields

Winter wheat – 11t/ha Spring wheat – 8.5t/ha

Winter barley – 10t/ha Spring barley – 7.5t/ha

Winter oats – 9.0t/ha Spring oats – 7.5t/ha

[2]For winter wheat and winter barley crops increase / decrease K rate by 9.8 kg/ha per tonne increase / decrease in grain yield.

[3]For spring wheat and spring barley crops increase / decrease K rate by 11.4 kg/ha per tonne increase / decrease in grain yield.

[4]For spring oats and winter oats crops increase / decrease K rate by 14.4 kg/ha per tonne increase / decrease in grain yield.

2.2 Fertilizer selection & programmes

Grassland P & K fertilizers should be selected based on either grazing or grass silage requirements. In a grazing situation the majority of P and K is recycle back to the soil in the form of dung and urine. Phosphorus (P) and potassium (K) that leave the farm in the form of either milk or meat needs to be returned in a fertilizer blend with a P : K ratio of 1 : 2 to replenish soil nutrient reserves. However, in a grass silage situation there are significant removals of both P and K as there is total crop removal at harvest time. P and K removed in cut grass needs to be return in a fertiliser blend with a P : K ratio of 1 : 6 / 7 to replenish soil nutrient reserves.

Grazing

Tables 11 & 12 show recommended rates of both P and K for dairy and drystock farms and suitable fertilizer products and rates to match P and K requirements as recommended for grazing ground. Where additional P and K is applied for soil fertility build-up the P : K ratios will change due to additional P and K required over index 3 rates. Additional nutrient (build-up) can be applied early / late in the growing season. Plan to apply P early (March / April) and K late (August / September).

Table 11. Recommended rates (kg/ha) of P & K for Dairy farms stocked at 2 LU/ha & suggested fertilisers

Soil Index	P[1]	K[2]	P:K Ratio	Typical P-K Products
1	34	90	1:2.6	566 kg/ha 18-6-12
2	24	60	1:2.5	400 kg/ha 18-6-12
3	14	30	1:2.1	230 kg/ha 18-6-12
4	0	0	---	---

[1] Adjust P rates for concentrate P fed on farm each year
[2] Additional K is required at Index 1 & 2 as 65 to 130kg/ha of 50% K (MOP) once every 3 years (for soil K build-up)

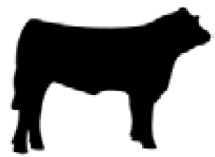

Table 12. Recommended rates (kg/ha) of P & K for Drystock farms stocked at 2 LU/ha & suggested fertilisers

Soil Index	P[1]	K[2]	P:K Ratio	Typical P-K Products
1	30	75	1:2.5	300 kg/ha 10-10-20
2	20	45	1:2.25	200 kg/ha 10-10-20
3	10	15	1:1.5	400 kg/ha 27-2.5-5
4	0	0	---	---

[1] Adjust P rates for concentrate P fed on farm each year
[2] Additional K is required at Index 1 & 2 as 30 to 90kg/ha of 50% K (MOP) once every 3 years (for soil K build-up)

Grass Silage

The grass silage crop removes significant amounts of both P and K as shown in table 13 and 14 below. Firstly, recycle cattle slurry on the silage fields in order to return both P and K removed at harvest time in the grass silage crop. Table 13 shows fertilizer advice (P & K) and suggested fertilizer products where 33m^3/ha cattle (3,000 gals/ac) is recycled on the silage fields. The 2nd application of fertilizers after the 1st cut is removed is required to replenish / build soil fertility reserves.


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Table 13. 1st Cut Grass silage P & K requirements (5t/ha DM) & suggested fertilizers programmes

Soil Index	P[3]	K[4]	P : K ratio	33m^3/ha Cattle Slurry		
				P - K Supplied (kg/ha)		Balance Application (after 1st Cut)[5]
1	40	185	1:4.6	13	1062	265 kg/ha 0-10-20
2	30	155	1:5.2	13	1062	170 kg/ha 0-10-20
3	20	125	1:6.3	26	116	90 kg/ha 50% K every 5 years
4[5]	0	0	---	---		

[1] Don't exceed 90kg K/ha in single application.
Index 1, 2 & 3 soils apply P & K balance after 1st cut as shown above.
[2] Additional K is required at Index 1 & 2 as 90 to 160kg/ha of 50% K (MOP) once every 3 years (for soil K build-up)
[3] P availability in slurry reduced to 50% availability on index 1 & 2.
[4] K in slurry reduced to 90% availability on index 1 & 2. 5Rounded to the nearest 5kg/ha. [5]Omit fertiliser K on Index 4 soils for 1 year and revert to K advice for index 3 until next soil test.

Table 14 below shows suggested recommended fertilizer products in the absence of cattle slurry. A crop of grass silage removes approximately 4kg P and 25kg K /tonne of grass DM. The 1st fertilizer applications are shown in table 14 will supply a proportion of the crops P and K requirements during the growing season which is driven by the rate of K and not to exceed 90kg K/ha in a single application. The remaining crop requirements are applied after the 1st cut is removed to balance / build soil fertility levels as shown in table 14.


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Table 14. 1st Cut Grass Silage, P & K Requirements (5t/ha DM) & suggested fertilizer programmes

Soil Index	P	K	P : K ratio	Fertiliser Options	
				1st Application[3]	Balance Application (after 1st Cut)[3]
1[1,2]	40	185	1:4.6	310kg/ha 0-7-30	250 kg/ha 0-7-30
2[1,2]	30	155	1:5.2	310kg/ha 0-7-30	185 kg/ha 0-7-30
3	20	125	1:6.3	310kg/ha 0-7-30	125 kg/ha 0-7-30
4[3]	0	0	---	---	---

[1] Don't exceed 90kg K/ha in single application. Index 1, 2 & 3 soils apply P & K balance after 1st cut as shown above.
[2] Additional K is required at Index 1 & 2 as 40 to 100kg/ha of 50% K (MOP) once every 3 years (for soil K build-up). [3]Omit fertiliser K on Index 4 soils for 1 year and revert to K advice for index 3 until next soil test. [5]Rounded to the nearest 5kg/ha

Potassium Fertilizer Advice for Cereals

Soil testing will provide the basis for decision making around K fertilizer requirements for cereal crops and target crop yield potential. As cereals have a high K requirement due to high K off-takes at harvest time. Potassium advice should be adjusted where straw is chopped at harvest time. The K offtake will be higher for crops that are not fully mature at harvest (e.g. ensiling or whole crop cereals).

Timing of K fertilizer application while generally not as important as P the majority of the K should be applied before the crop reaches stem extension (GS 30). For winter cereals a split application between autumn (30) and spring (70) of K may be useful where the K soil index is low (1 or 2) and the crop requirement is large.

Winter Wheat

When selecting a suitable fertilizer compound for winter crops it will depend on a number of factors such as soil test results, crop type and yield potential. Table 15 below shows the P and K requirements for a crop of winter wheat or barley yielding 10t/ha and recommended P & K rates based on grain yield and suggested fertilizer products.

Table 15. P & K Advice for 10t/ha[1] Winter Wheat or Barley & suggest fertilizer programmes

Soil Index	P kg/ha	K kg/ha	P : K ratio	kg/ha[2]
1	58	130	1:2.2	555kg 10-10-20[2]
2	48	115	1:2.4	555 kg 12-8-20
3	38	100	1:2.6	525 kg 10-7-20
4	0	0		---

[1] Adjust P by 3.8kg/t, K by 10kg/t for lower or higher grain yields
[2] Additional K is required at Index 1 & 2 as 40 to 190kg/ha of 50% K (MOP) once every 5 years (for soil K build-up)

Spring Barley

When selecting a suitable compound fertilizer for spring barley it is important to select a fertilizer that will supply all the P and K in a single application at sowing time in close proximity to the seed. Choose the correct compound to supply the correct amount of P and K depending on the soil test result. Examples of appropriate fertilizer blends / programmes based on P : K ratios and soil P and K indexes are shown in Table 16.

Table 16. P & K Advice for 7.5t/ha1 Spring Barley or Wheat & Suggest Fertilizer Programmes

Soil Index	P kg/ha	K kg/ha	P : K ratio	kg/ha[2]
1	49	115	1:2.2	480kg 10-10-20[2]
2	39	100	1:2.4	480 kg 12-8-20
3	29	85	1:2.6	480 kg 13-6-20
4	0	0	---	---

[1] Adjust P by 3.8kg/t, K by 11.4kg/t for lower or higher grain yields
[2] Additional K is required at Index 1 & 2 at 40 & 190 kg/ha as 50% K (MOP) once every 5 years (for soil K build-up)

Potassium requirements (kg/ha) for other crops

Table 17:- Recommended rates (kg/ha) of K for a range of other crops

Crop Type	Soil K Index			
	1	2	3	4
Potatoes (main crop)	305	245	185	120
Fodder / Sugar Beet	320	240	160	80
Swedes	250	200	170	125
Oilseed Rape (5t/ha)	105	90	75	0
Beans / Peas	90	60	40	0
Maize	250	225	190	120
Kale	220	210	170	0
Forage Rape	100	75	50	0

[1]Note for some crops soils at K index 4 there is a crop requirement for potassium.

2.3. Timing of Potassium Applications

Grassland

The fertilizer K application strategy should be carefully planned especially where high levels of K are required. For example in springtime K applications should not exceed 90 kg K/ha in a single application on silage fields. Where higher rates are required it is advised to split the application and apply the balance to the silage aftermath or in late autumn. For grazing ground apply maintenance rates of K in the spring and apply the balance in August / September.

On fast growing swards which have received high levels of nitrogenous and potassic fertilizers grass tetany (grass staggers) can become more prevalent. High soil K levels can induce grass tetany as it antagonises magnesium uptake by the grass crop. In areas where the disease is known to be problematic it's advisable to feed cal mag three weeks before and after susceptible periods.

Tillage Crops

For cereal crops the timing of application will depend on crop type for example winter or spring cropping. For winter cereals on very low to low K index soils it is recommended to apply a portion of the crops K requirements and incorporate at sowing time for exmple ~30% of recommended rate. The remaining crop K requirements can be top dressed in early spring to coinside with N, P, K & S applications. On Index 3 soils K can be applied at time during the growing season ideally with the 1st application of fertilizers in spring time.

For spring crops it is recommended to apply all crop K requirements at sowing time and incorporate into the seedbed.

On index 4 soils it is recommended to omit K applications for 1 year and revert back to K index 3 requirements until the next soil sample.

Other crops

For other crops such as root crops / peas / beans it is recommended to apply crop K requirements at sowing time and work into the seedbed before or during crop establishment.

2.4 Sources of Potassium
(Source; Teagasc Green Book)

Organic fertiliser potassium

Animal manures are a valuable source of K but there nutrient content can vary considerably. Such factors as animal type, diet, bedding type and dilution with water will have a large impact on the actual K content of the manure. For example in cattle slurry the K content can range from 0.5% to 7.7% which is a fifteen-fold variation in K content. Table 18 below shows the typical nutrient K values for a range of animal manures.

It is recommended to test manures to determine their actual nutrient values. This will help ensure that the crop is supplied with the desired rate of K and manure application rates can be adjusted depending on manure dry matter content. The majority (90%) of the K in manures is in the organic form and is available for plant uptake at time of application. The availability of K in manures applied to K index 1 or 2 soils is deemed to be 90% available. On low K index soils organic fertilisers can supply the entire crops K requirements.

Table 18. Average available K values in Organic Fertilizers

Manure Type	Dry Matter %	K (kg/m³ or ton)	P (units/1,000gals or ton)
Cattle Slurry	6.3	3.5	32 / 1,000gals
Pig Slurry	3.2	2.2	20 / 1,000 gals
Farm yard manure	20	6.0	12 unit / ton
Broiler Manure	60	18	36 units / ton
Layer Manure	55	12	24 units / ton
Mushroom Compost	35	7.7	15 units / ton

Commonly used potassium fertilizers in Ireland

Potassium Chloride (KCl) also known as Muriate of Potash (MOP)

Muriate of potash (MOP) is the most commonly used K fertilizer in agriculture. It contains 50% potassium (K). It is available in many colours and sizes as traces of iron oxide give some particles a reddish colour. Dissolving MOP will increase the soluble salt concentration and as a result it is often banded to the side of seed to avoid damage to germinating seeds. MOP is widely used in Ireland for the production of blended fertilizers and is commonly applied as a straight K source to improve soil K levels.

Potassium Sulphate also known as Sulphate of Potash (SOP)

Sulphate of potash (SOP) contains 42% potassium (K) and 18% sulphur (S). SOP can be used when both K and S are required. It contains very low levels of chloride and is used for chloride sensitive crops. SOP is more expensive than MOP.

Polyhalite

Polyhalite marketed as polysulphate contains 11.5% potassium, 19% sulphur, 3.5% magnesium & 7% calcium.

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