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Importance of Potash for Potatoes

Potash (potassium, K) has a major effect on yield and quality of potatoes as well as the general health and vigour of the crop. It is involved in regulating the amount of water in the plant; in the absence of sufficient potassium crops do not use water efficiently. Also adequate K levels in the plant help it to withstand water stress during periods of drought. Potassium plays a vital role in maintaining the turgidity (rigidity) of plant cells. Because of its importance in turgor maintenance, potassium is essential to obtain maximum leaf extension and stem elongation. This helps to achieve rapid ground cover so maximising interception of sunlight and thus the rate of growth in the critical early periods of the growing season which is of particular importance for spring sown crops such as potatoes.

Another need to ensure an adequate supply of K is because it plays a vital role in the movement of sugars, produced in the leaf by photosynthesis, to the tubers where the sugars are converted to starch. Potassium also contributes to various aspects of tuber quality that may be vital for a marketable sample. The balance between nitrogen (N) and K supply is of particular importance for this crop.

It is well established that crops deficient in potash are less able to handle stress caused by drought, waterlogging, frost, heat, wind, etc. However, it appears that there is no advantage to be gained from applying larger amounts of K than those justified for yield and replacement requirements, unless aiming to build up soil reserves. Whilst yield variation will occur according to the growing conditions in different years, smaller yields in "poor" years can be minimised by ensuring an adequate potash supply.

Potash shortage leads to:

- Low yield
- Poorer marketable quality
- Thinner cell walls and less lignification
- Weaker stems
- Reduced resistance to disease
- Lower starch content of the tubers
- Increased susceptibility to bruising and mechanical damage
- Greater susceptibility to the adverse effects of drought
- Reduced response to nitrogen

Potatoes take up more potash than many other arable crops. In the six weeks after plant emergence, the crop will take in at least two thirds of the total K uptake (Figure 1). During peak vegetative growth, potatoes may require 10 kg K_2O/ha per day from the soil. Maincrop potatoes contain the maximum quantity of potash in late July – early August, in both tubers and haulm, and this may be more than 500 kg K_2O/ha for high yielding crops.

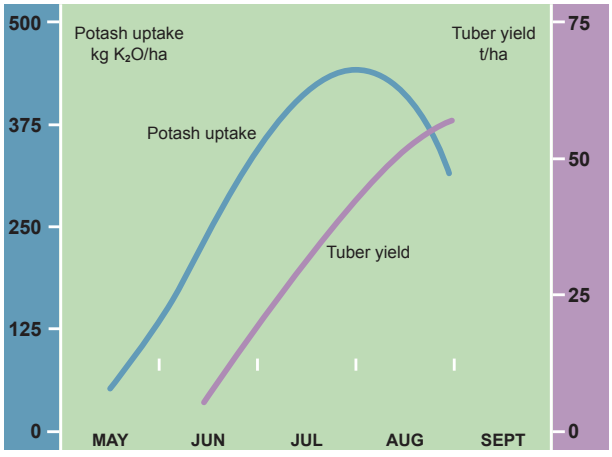

Figure 1. Potash uptake by potatoes

Potatoes need an available reserve of potash in the soil that can satisfy both the peak daily rate of demand during early vegetative growth and the total uptake in late summer. Where soil reserves are insufficient to meet either of these two requirements, the soil supply needs to be supplemented by adding K in fertiliser and/or manure, if available. However, these additions may not be as efficient

in providing K as are the reserves in the soil. Long term experiments at Rothamsted and Woburn have shown that yields from impoverished low index soils cannot match yields on fertile soils even if large amounts of K fertiliser are applied (table 1). Also, it can take several years to improve a soil with a low K status once soil K reserves have been run down.

Table 1. The need to maintain soil K Index: fresh K cannot fully compensate for low soil K reserves

Soil K Index *Soil K mg/kg*	**1** *113*	**2-** *166*
K_2O applied	**Potato tuber yield, t/ha**	
0 kg/ha	**28.8**	**43.1**
250kg/ha	**39.6**	**44.0**

Potash yield and deciding the need for potash

There are three reasons why potash should be applied for potatoes :

- to ensure no loss of yield due to shortage of K and to reduce unit costs of production, "Response requirement"
- to maintain soil K fertility and yields of future crops, "Replacement requirement"
- to achieve specific "Quality requirements"

It is important to identify the relevance and interaction of these different reasons.

"Response requirement"

A large number of experiments from many countries have confirmed that potash supply has a major influence on yield. Therefore, in the short term a grower needs to know how much potash to apply for the best economic return. However, the increase in yield to an application of K fertiliser will depend on the supply of K from the soil, i.e. the K Index of the soil on which the crop will be grown. For the UK, current recommendations in The AHDB Fertiliser Manual are based on the average amount of K required to achieve optimum yield for crops grown on soils at different soil K Indices. As in all experimental data, there was considerable variation for different sites and years. In general, however, the response to added K is usually large at low levels of soil K and the requirement for added K tends to decrease as soil K level increases.

Whilst there is no precise critical value for the soil K level, and due to the potato crops poor root system, maintaining soils towards the upper end of index 2 would be seen as an appropriate target to aim for on most soils. These levels are unlikely to be achieved on true sands and loamy sands because they have little ability to retain exchangeable K and for these soils it is essential to apply adequate K as fertiliser and/or manure each year.

"Replacement requirement"

If the response requirement is less than the amount of potash removed by the crop (about 6kg K_2O/tonne, 300kg K_2O/ha for a 50 tonne crop) it would run soil reserves down and would not be sustainable in the long term. As soil K reserves are reduced, the response to added potash fertiliser would rise and the optimum "response" dressing would become larger. This may be a theoretical ideal economic optimum approach but assumes far more precision in adding K fertiliser than is possible in practice and ignores the fact that potash held in historically accumulated reserves is more efficiently taken up and used by the plant than fresh fertiliser K.

"Quality requirement"

Potash supply also contributes to quality characteristics that may affect marketability of potatoes such as dry matter, specific gravity, sample size and tuber number, starch content, fry colour, fat absorption, internal blackening, susceptibility to mechanical bruising, cooking quality and flavour. Many other factors also affect these characteristics (often to a greater degree than potash) and additional potash supply will not improve the characteristic where it is being controlled by an excess or limitation of another factor.

If adequate potash is available to the crop for full yield, additional nutrient is unlikely to provide cost effective additional quality benefits.

Phosphate for Potatoes

Like with all crops, phosphate is important for shoot and, particularly, root development, providing energy to the plant. At tuber initiation, an adequate supply of phosphate ensures optimal tuber numbers. With the nutrient being relatively immobile in soil, and potatoes having a relatively shallow root system, ensuring adequate supply by maintaining good soil P levels is important.

Phosphate deficiencies may not always be easy to identify as plants tend to be smaller, more stunted, than normal, with poor root growth and stunted top growth, however these symptoms are only really identifiable when directly compared against healthy plants. They are likely to be behind in their development and yield and quality are likely to be reduced as a result.

Sulphur for Potatoes

Sulphur is required by plants for both yield and quality and this is no different for potatoes. Sulphur is specifically important for assisting with nutrient uptake and chlorophyl production, reducing stress and increasing pest resistance and carbohydrate and vitamin synthesis.

Sulphur deficiencies have increased over the years as the amount of atmospheric sulphur deposition has reduced through the improvement in air quality, but this spring could see an even greater deficiency risk due to the high level of over winter rainfall, increasing the leaching potential of mobile nutrients such as sulphur.

There are concerns about the formation of the carcinogen acrylamide in cooked starchy foods, which is associated with insufficient available sulphur for the growing crop. Potato crisp producers are potentially affected and usually make a specific requirement that their crops are adequately fertilised with sulphur. Acrylamide formation during cooking results from increased levels of free asparagine, an amino acid which can accumulate to very high levels where sulphur supply is deficient.

Calcium for potatoes

Calcium is a somewhat overlooked nutrient for arable crops, except perhaps for its role in soil structure and through its link with the liming properties of limestone. Potatoes are the one crop where the importance of calcium is better understood, through its impact on tuber quality. Calcium plays a role in the maintenance of healthy cell walls thereby reducing the incidence of the internal brown spots within tubers known as internal rust spot. The maintenance of healthy cell walls also helps to improve skin finish and protect against physical tuber damage at harvest and during storage. Another important role of calcium, again linked to cell wall strength, is the protection against pest and specifically disease as thinner, weaker cell walls are more likely to lead to attack from disease.

There are reports of beneficial effects from the application of a non-liming source of calcium to potatoes.

Magnesium for potatoes

Magnesium is a key nutrient for all crops due to its role in photosynthesis, being part of the chlorophyll molecule. It is also involved in the production and use of carbohydrates, helping transport them from the leaves down to the tubers.

Deficiency symptoms are likely to develop in the older leaves nearer the base of the plant as the nutrient is mobile in plants and is therefore able to move to areas of new growth when uptake is limited. A deficiency of magnesium can reduce crop productivity long before visual symptoms can be seen. An inadequate supply will result in reduced root growth as well as lowering the chlorophyll concentration of the plant, reducing the photosynthetic rate.

Potassium : Magnesium imbalance

There is some evidence that potash availability and uptake can be reduced on soils where magnesium levels are excessive, even though the level of soil K may not be deficient. This situation is most frequently associated with long term use of magnesian limestone to correct pH. Firstly, it would be sensible to switch to a magnesium free source of lime, but it has also been suggested that where the soil concentration of Mg is significantly more than that of soil K, potash applications may need to be increased above the normal recommended rate to achieve adequate potash nutrition of the crop.