ESSENTIALS

POTASSIUM

NO. 3

Potassium (K) his involved in many essential functions in plants. Once taken up by the plant, K^+ does not become part of complex organic molecules. Instead it is a highly mobile free ion that is most known for its role in regulating water pressure in plant cells, affecting cell extension, gas exchange, and movement of leaves in response to light. Other roles include the activation of enzymes that help chemical reactions take place, assisting with protein synthesis, pH regulation within cells, and enhancing photosynthesis. Potassium also assists with the transport of chemical compounds around the plant. Plants that are supplied with adequate K are better equipped to withstand stress caused by pests and diseases compared to plants with a low supply of K.

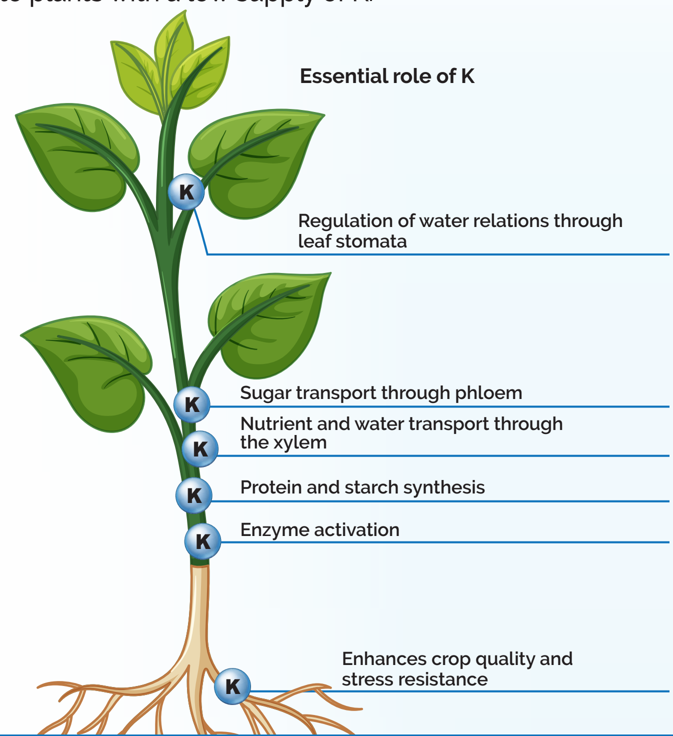

Figure 1. Some essential roles of potassium in plants.

POTASSIUM IN PLANTS

Plants contain relatively large amounts of K, similar to nitrogen (N), but the amount of K removed from the soil varies greatly among crops. Since plant tissues have relatively high K concentrations, the removal of crop residue can rapidly draw down soil K reserves. Soil K input-output balances are improved if crop residues are returned back into the field that produced them. **Table 1** shows the amount of K that it taken up by different crops as well as how much is removed from the soil when the crop is harvested.

Table 1. Potassium uptake and removal rates for selected crops.

Crop	Uptake in above ground biomass, kg K_2O per t	Removal in harvested product, kg K_2O per t
Maize	25	4.5 (18%)
Rice	24	3.6 (15%)
Wheat	27	5.6 (20%)
Sorghum	35	5.4 (15%)
Soybean	39	20 (51%)
Groundnuts	38	8.5 (22%)
Potato	12	6.5 (54%)

APNI data. To convert K_2O to K, multiply by 0.83. Numbers inside parentheses indicate the % of total K uptake removed in harvested product.

POTASSIUM IN SOIL

Soils are often high in total K, but most of it is unavailable for plant uptake. There are four major soil K pools; two of which the plant can access K from, and two that they cannot. The four pools of K are:

Structural K: Immobile and tightly bound. Potassium is gradually released as minerals (micas and feldspar) weather over time.

Interlayer K: Potassium can be trapped (fixed) between layers of clay minerals like illite, vermiculite, and smectitite and slowly released again when the conditions are favourable (previously called fixed K).

Surface-adsorbed K: Readily plant available K held on the surface of clay minerals and organic matter by its negative charge (previously called exchangeable K).

Solution K: Dissolved in soil solution and awaiting plant uptake. This smallest pool of K is continually replenished by the other three pools (especially exchangeable K).

POTASSIUM DEFICIENCY SYMPTOMS

Potassium deficiency slows the growth rate of plants, but the symptoms of deficiency are specific to different crops. A shortage of K often first appears as a deep dark green colour. The edges of the older mature leaves may turn yellow or die, or spots may appear on the mature leaves. A lack of K sometimes results in smaller leaves, short internodes, and stunted plants. Stalks become weak, leading to greater breaking and lodging. A K deficiency leads to delayed pollination and maturity, with small and shriveled grain. Plants with

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Potassium deficiency in (left to right) sorghum, mango, peanut, oil palm, banana.

inadequate K have a lower resistance to many diseases and stress. Additionally, K-deficient crops generally have lower quality and poor water use efficiency.

FERTILIZING SOILS WITH POTASSIUM

There are many excellent options for K fertilizer when it is required. Potassium chloride (KCl) is the most widely used K fertilizer, but many other sources are available (**Table 2**). The K in all commercial fertilizers is water soluble and rapidly becomes available for plant uptake after it dissolves. Since the K in all fertilizers is identical, the selection of a particular fertilizer source is largely based on the other plant nutrients that are in the fertilizer (such as sulfate, phosphate, nitrate, etc.).

The application of K fertilizer is ideally based on soil testing or from an estimate of K removed in the harvested crops. Soil testing can identify if K is limiting and recommend the amount of supplemental fertilizer that will be needed by the next crop (if any). A "maintenance" approach to K application is to merely replace the K removed during harvest in order to avoid soil nutrient depletion.

Since K losses are not large in most soils, K applications can be applied prior to planting or at the time of planting. On very sandy soils with low cation exchange capacity, K fertilizer application may be best split into two or three separate doses.

Table 2. Commercial sources of potassium fertilizer.

Fertilizer name	Formula	Typical nutrient concentration, %				
		N	P_2O_5	K_2O	Mg	S
Potassium chloride	KCl			60		
Mono-potassium phosphate	KH_2PO_4		52	34		
Potassium nitrate	KNO_3	13		44		
Potassium thiosulfate (fluid)	$K_2S_2O_3$			25		17
Potassium sulfate (Sulfate of potash)	K_2SO_4			50		17
Potassium magnesium sulfate (Langbeinite)	$K_2SO_4 \cdot 2(MgSO_4)$			22	11	22

CROP RESPONSE TO POTASSIUM

When soils do not supply adequate K, fertilization has a high chance of providing profitable crop responses. Recent soil mapping efforts in Africa identified wide-spread areas of soil with inadequate K for many crops.

In western Kenya, a maize study conducted over three years (six cropping seasons) found a progressive increase in the yield gap between nutrient omission treatments and the NPK treatment (**Figure 1**). In this trial, one treatment received a blend of NPK while for the other treatments a single nutrient was omitted from the blend.

The treatment receiving NPK sustained maize yields around 5.5 t/ha over the six harvests. However, when K was omitted from the fertilizer (NP treatment), grain yields gradually dropped to below 4 t/ha as the soil K reserve was slowly exhausted.

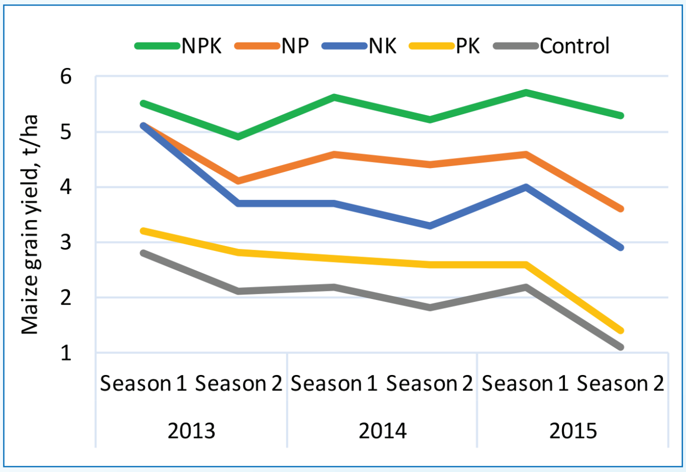

Figure 1. Maize grain yield for nutrient omission trials conducted on 23 farms in Sidindi, western Kenya show the importance of including K for balanced nutrition. Njoroge, S. et al. 2017. doi:10.1016/j.fcr.2017.09.026