Nutri-Facts

IPNI

Agronomic fact sheets on crop nutrients

Potassium

NO. 3

AUSTRALIA AND NEW ZEALAND GRAINS EDITION

Potassium (K) is an essential plant macronutrient taken up in large quantities, similar to that of nitrogen. In plants, K does not become part of complex organic molecules but moves as a free ion and performs many functions.

Potassium in Plants

K is highly mobile in plants and is involved in many essential functions. It serves to regulate water pressure in plant cells, affecting cell extension, gas exchange, and movement of leaves in response to light. K can activate enzymes, assist with protein synthesis, pH regulation, improved carbon dioxide fixation during photosynthesis. It also assists with transport around the plant.

Plants that are supplied with adequate K are also better equipped to withstand stress caused by pests, diseases, and some abiotic stresses compared with plants with a low supply of K.

Table 1. Potassium uptake and removal rates for crops.

Crop	Yield, t/ha	K uptake, kg/ha	K removal, kg/ha
Lucerne (Dry)	20	400	392
Corn (12% MC)	10	224	40
Corn Silage (67% MC)	60	183	183
Sorghum (10% MC)	7.5	221	57
Rice (12% MC)	8	171	25
Soybean (10% MC)	4	138	71
Switchgrass (Dry)	15	348	348
Wheat (11% MC)	4	90	20

For more crops, visit http://ipni.info/nutrientremoval

The amount of K removed from the soil varies greatly among crop species. **Table 1** shows the amount of K that it taken up by different crop species as well as how much is removed from the soil when the crop is harvested. It not only shows the difference in K uptake between crops with high demand such as lucerne and crops that require less K, such as wheat, it also shows that removing crops like lucerne hay or corn silage, leaves very little K to be recycled back into the soil compared to crops where only the grain is removed.

Potassium in Soils

Soils are often high in total K, but most of it is unavailable for plant uptake. There are four K pools in any given soil from which the plant can access K. The four pools of K are:

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

Fixed K: Slowly becomes available (or fixed) over a growing season. K is fixed between layers in clay minerals like illite, vermiculite and smectite and can be released if the conditions are favourable.

Exchangeable K: Readily plant available K held on the surface of clay minerals and organic matter by its negative charge.

Solution K: Dissolved in soil solution and awaiting plant uptake. This is the smallest pool and continually needs to be replenished by the other three pools.

As a cation with positive charge, K is relatively immobile in soil and does not move unless a root comes in direct contact, or it is mobilised into the soil solution. There are three methods by which K comes in contact with the root in order to be absorbed: root interception, mass flow and diffusion. Of these diffusion is the mode that moves the majority of the K in the soil solution. When the root takes up the K in solution that is in its vicinity it creates a diffusion gradient that draws other K particles towards the root.

Potassium Deficiency

Many agricultural soils in Australia contain sufficient K levels, but deficiencies have been reported in all states and are especially prevalent in areas that receive high rainfall in addition to sandy soils.

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This Nutri-Fact is one of a series of fact sheets written by scientific staff of the International Plant Nutrition Institute (IPNI) that is focused on essential plant nutrients and their use. This series is available as PDF files at www.ipni.net/nutrifacts.

Table 2. Commercial sources of potassium fertilizer.

Fertilizer name	Chemical formula	Typical nutrient concentration, %				
		N	P	K	Mg	S
Potassium chloride (Muriate of potash/Sylvite)	KCl			50		
Mono-potassium phosphate	KH_2PO_4		23	28		
Potassium nitrate	KNO_3	13		36		
Potassium thiosulfate (fluid)	$K_2S_2O_3$			21		17
Potassium sulfate (Sulfate of potash)	K_2SO_4			41		17
Potassium magnesium sulfate (Langbenite)	$K_2SO_4 \cdot 2(Mg\ SO_4)$			18	11	22

Because K is highly mobile within plant tissue deficiency symptoms are generally visible on the older leaves first. Deficiency symptoms include scorching or burning along the leaf margins, and generally poor growth resulting in smaller root systems, small leaves, weak stems (inducing lodging in mature plants) and small and shrivelled grain.

Deficiency may be seen as better crop growth where there were windrows or header tracks the previous year. K from the residue of the previous crop is concentrated in rows, resulting in better crop growth in those areas. K taken from deeper in the soil profile as the crop grows and when the crop is cut and left to dry, K can be leached from the tissue and deposited on the soil surface. This process increases K in the soil surface and is a good "diagnostic" for low soil K.

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Figure 1. K deficiency in canola (left) and wheat (right).

If a K deficiency is suspected, soil testing is a useful tool to identify the need to apply additional K to the paddock. Because K can be transferred from the subsoil to the surface soil, a soil test that measures 10-30 cm as well as the top 10 cm may be useful, as a surface test may not reflect K concentrations at depth. The top 10 cm may indicate a concentrated supply of K in the soil, but at depth it may be deficient and additional management options may be required to avoid K deficiency.

Soil tests such as Colwell K and ammonium acetate extractions can accurately predict available and exchangeable K in low K fixing soils. Other tests, such as a nitric acid or sodium tetra-phenylborate extraction, are more accurate when it comes to soils with a higher content of multilayer clay minerals as these tests also measure the rate at which K will be released from the fixed pool. Testing for the amount of total or structural K is of little use due to its slow release rate.

Fertilizing Soils with Potassium

Potassium minerals are extracted from geologic sources located throughout the world. Impurities are removed from the ore and the remaining K is transformed into a variety of modern fertilizers.

Right Source: The most commonly used K fertilizer source is potassium chloride (KCl), also referred to as muriate of potash (**Table 2**). Chloride-free sources of K fertilizer are sometimes preferred for applications made to chloride-sensitive crops. Compound fertilizers containing chloride, sulfur and/or magnesium are appropriate when soil supplies of these other nutrients are limiting.

Right Rate: Recommended rates of K application are based on both soil testing and crop removal. "Maintenance rates" are those equal to the quantities of K removed and are used to maintain soil fertility. Cereal crops require less K than pastures or hay crops.

Right Time: In cropping systems, K fertilizer is usually applied at or before seeding. On soils that are sandy and/or have a low capacity to retain K, two or three applications of K fertilizer may be beneficial.

Right Place: Potassium sources vary widely in their effect on the soil solution (salt index). K fertilizer sources with a lower salt index may be used at higher rates when placed near or in direct contact with seed. Subsurface bands of K can provide benefits over broadcast applications when subsoil fertility is lower and where topsoils dry out during the growing season.

Crop Response to Potassium

The greatest crop response to K application in Australia have been seen in sandy soils. Maize is the most responsive crop followed by canola, pulses, wheat and then lupins least responsive. **Figure 2** gives some results for wheat responses to K rate, timing and placement.

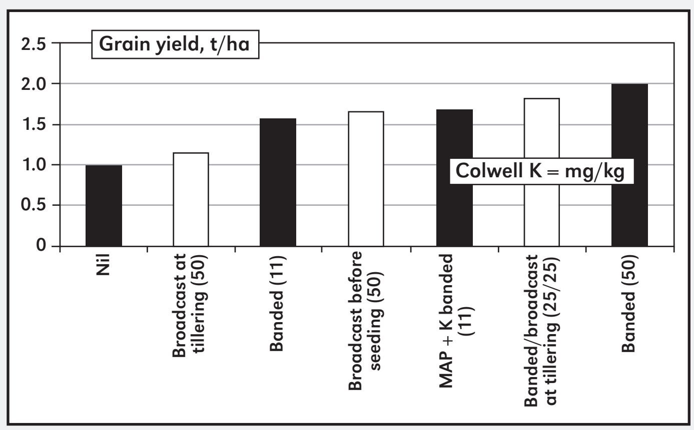

Figure 2. Response of wheat to K applied at different rates, timing and placement (Wilhelm and White, 2004).

References and Further Reading

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