4 POTASSIUM

4.1 Role in citrus production.

Potassium (K) is involved in activation of many enzyme reactions in the biology of the plant. More than 60 enzymatic reactions require potassium for optimal functioning.

One distinct roll of potassium is in the transport of products of photosynthesis from the leaves to the roots. In contrast to Ca, K is completely mobile within the plant. Potassium is present in plant tissue in fairly large concentrations and a deficiency will lead to malfunctioning of many physiological and biochemical processes. Potassium is strongly absorbed by the roots and is easily transported to the meristem tissue. Relocation of K from old to young tissue occurs commonly. That is why it is quite difficult to identify a responds to a foliar spray. Soon after absorption the K is removed to other tissue. Potassium is also involved in the synthesis processes of protein, cytokinin and hence the growth rate of plants.

Translocation of potassium is best when the nitrogen status of the plants is optimal. Translocation also occurs in the phloem vessels and potassium can move up and down in the plant.

Absorption of potassium is being reduced by high concentration of H^+, (low pH in the soil), calcium (Ca), magnesium (Mg), sodium (Na) and ammonium (NH_4).

Potassium plays an important roll in the activities of the stomata. Plants that are well supplied with potassium require less water for the same mass of synthesised organic material compared to plant lacking potassium. The transpiration rate is reduced and the opening of the stomata better regulated when potassium is in sufficient supply.

Potassium cannot be substituted by other mono-valent cations in these functions. When potassium is in short supply the stomata will take much longer to close but also to re-open once it in responds to climatic factors.

Potassium improves the assimilation of CO_2 (photosynthesis) and the relocation of the formed products.

The potassium requirement for maximum number of citrus fruit is reached at fairly low levels. However whenever fruit size become an issue, much higher levels of potassium are required. A leaf concentration of 0,75% K is optimal for number of fruit but a K status of 1,00 to 1,50%, depending on the cultivar is required for optimal fruit size.

Potassium deficiency

Plants suffering from a short supply of potassium do not show visual symptoms. The first symptom is a decrease in growth rate followed by chlorotic (yellow) and eventually necrotic (dead) tissue. Symptoms develop firstly on the old but not the oldest leaves. Plant resistance against diseases, drought and cold decrease when the supply of K is deficient. This alone is another good reason to apply potassium nitrate to young trees during February to May, prior to an expected frosty winter.

Sometimes the leaves of K deficient trees show a bronze colour with a leathery touch.

In practise, a K deficiency is first of all expressed in a decrease in fruit size followed by a decrease in number of fruit. Fruit tend to change colour earlier with little change in the juice and acid content.

The cation exchange capacity (CEC) of the roots has a distinct influence on absorption of K and is also related to growth rate. The CEC of the roots of rough lemon rootstock is ±40 and that of trifoliate only 16 me/kg. Rough lemon rootstocks absorb K much stronger than trifoliates.

Potassium is the element that has a major impact on the manufacturing of sugars and starch. A lack of K will harm these processes.

Nematodes reduce the absorption of K more than that any other element. It is even possible that K can leach out of damaged cells. Usually young citrus trees utilises the potassium in the soil very efficiently but in replant soils not treated to control nematode, the potassium status of the trees were low. reduction in K status and an increase in the concentration of chloride in the leaves.

Normally the potassium status of citrus trees decline with age. When the concentration in the leaves is allowed to decline below 0,50% K, it is almost impossible to correct the level. Therefore, it is very important to prevent the K status from declining to an irreversible level.

Excessive potassium

Potassium is utilised very efficient by young trees and an excess of K is usually only a problem with young trees during the first or second year of bearing. As the trees aged, the K status will decrease and less symptoms of excess K is present. Therefore it is important to be cautious with the application of potassium on young trees, especially grapefruit and navels.

Excessive absorption of potassium results in large fruit with coarse and thick skins, except in lemons where the skins will tend to be smoother. Fruit size will, like with other cultivars, increase when the K status of lemons increased.

Potassium and magnesium react antagonisticaly during absorption and even as a responce to foliar sprays. It is important to watch the magnesium status when focussing on increasing the K status to improve fruit size.

Foliar applications of potassium usually result in a decrease in the concentration of magnesium in the leaves. An excessive concentration of potassium will result in large fruit with less juice, delayed colour break, less TSS and an elevated acid content.

4.2 Sources of potassium

The most freely available sources of potassium in Southern Africa are potassium chloride (50% K) and potassium sulphate (40-43% K). Both are also used in preparing mixes.

Potassium chloride is the cheapest source but cannot be used on chloride sensitive crops and crops that require chloride free conditions. In some circles citrus is regarded "Symptoms" of nematode infestation are a as sensitive to chlorides but no proof is available that citrus is harmed by moderate applications of potassium chloride.

Potassium sulphate can be used as a source of both K and sulphur (S) and on soils where the application of chloride is unwanted.

Potassium nitrate is also freely available but is mostly used in foliar sprays and hydroponic mixes. The combination of K and NO_3 enhances the absorption of K by the roots and this formulation is an excellent source of both K and N in hydroponics and fertigation with drippers. Due to the cost, potassium nitrate is seldom applied by conventional systems to the soil.

Potashmagnesium is a double salt of K and Mg and can be used when both K and Mg need to be applied. It contains 22% potassium and 6% magnesium.

4.3 Fertilisation with potassium

The reaction to soil applications of potassium is faster/easier on sandy than clayey (20-25% clay) soils. The volume of the root hairs has a direct relationship with the mass of K absorbed by the roots.

Applications to the soil

One method to evaluate an application of K to the soil is to calculate the potassium saturation. K-saturation is the %K in terms of the total cations namely K+Ca+Mg+Na. The %K should ideally be 5 to 7,5. In soils containing more than 20% clay, levels of >10%K may suppress growth (Citrus Industry Vol. 3, p 141).

When applying potassium chloride or sulphate by hand or mechanically, the fertilisers should be spread out evenly below the canopy where the water is applied.

The total application can be spilt into one or more applications depending on the clay content of the soil. Not more than 250g potassium chloride should be applied to soils containing less than 10% clay. Even if it is spread over 6 to 8m^2 around the tree. The increase in the concentration of soluble salts due to potassium chloride or sulphate will damage the roots, could scorch the leaves and cause leaf drop. The maximum for soils containing 15 to 20% clay is 500g per tree per application. Soils containing more than 25% clay can handle up to 750g potassium chloride per application.

Potassium chloride or sulphate cannot be banded. Temporary salinity created by the concentrated application will damage the roots, leaves and even shoots.

Fertigation by microjets
Both potassium chloride and sulphate can successfully be applied through the microjets. Even on soils with properties that limit the absorption of K, fertigation can be effective. However, the requirements are low concentrations of K applied over the entire length of the irrigation cycle during the day. During the day when the trees utilises the water enriched with K, the K is absorbed before it is subjected to all the negative forces in the soil. This approach was applied in the Sundays River valley with a positive responds (Table 15).

Table 15. The improvement of the potassium status of the trees over 6 seasons when 1600 g potassium chloride per tree was applied in dosages of 100g per tree during irrigation periods of 5 hours.

Year	% K
1996	0,56
1997	0,74
1998	0,91
1999	1,24
2000	1,29
2001	1,44

This is a low-dosage-high-frequency application. However, the concentration should not be less than 100mg K per litre water.

Fertigation with drippers.
Potassium salts are potentially more saline than calcium salts. This limits the application of potassium chloride and sulphate to fairly low concentrations. Solutions of potassium salts have higher EC's than calcium salts at comparative concentrations (Table 16).

Table 16. Comparative EC's of 0,10% solutions of some fertilisers.

Salt	EC mSm^{-1}	pH
Potassium nitrate	105	5,25
Potassium sulphate	140	5,35
Potassium chloride	185	5,50
Calcium chloride	150	5,55
Calcium nitrate	120	5,25

Due to the mobility of potassium in the plant, continuous applications are not required. This can therefore be utilised to control the EC of the nutrient solution. For instance if more calcium is required in spring, the concentration of Ca can be increased during this critical period without increasing the EC, by lowering the concentration of K in the solution. To ensure that the trees will not lack K during this period, K can be stored in the trees for use when the concentration is lowered.

4.4 Foliar sprays
Reactions to foliar sprays with potassium are much faster than to applications to the soil. With soil applications the time required to notice an increase in the K status can be

months or years while it shows within seconds after a foliar spray. Being so mobile K will be removed from the site of absorption (leaf) after a few hours resulting in a concentration not much higher than before the foliar spray. The rate of relocation depends on the initial potassium concentration in the leaves. With trees having a K status of <0,70%, the increase in the leaf status could be disguised by the relocation of K, but the results on the crop is still significant (Table 17). To obtain a permanent increase in the concentration of K in the leaves the status must be lifted to between 1,00 to 1,25%K when relocation is limited.

Table 17. The apparent lack in responds of the concentration of K in the leaves following a foliar spray, compared to the response in crop performance.

Treatment	Fruit diameter in mm	%> 62 mm ø	%K in leaves
0	64	29,7	0,36
2x4%KNO_3	68	7,30	0,36
3x4%KNO_3	69	6,70	0,40

According to SRCC Tech Dept 1977.

Foliar applications of 9 to 10% KNO_3 acidified with phosphoric acid to pH 4,5 to 6,0 (in the retail known as Bonus-NPK) on fruit with a diameter of 18 tot 22mm did however increase the concentration of K in the leaves and skin and increased fruit size by 28% (Achilea, 1999).

The concentration of the potassium in the spray solution is less important than the mass actually applied to the trees. It appears that the volume of water applied per ha can be reduced but then the concentration must be increased to apply an equal mass of the nutrient. This can only be done if the higher concentration is safe and the contact period is not reduced. Up to 10% potassium nitrate has been applied without detrimental effects. An increase in concentration or a decrease in volume requires better climatic conditions to allow for absorption.

Potassium nitrate should not be applied within 3 weeks following an application of Corasil-E^R. This could aggravate drying out in certain mandarins.

The efficiency of foliar sprays with potassium nitrate can be improved by adding urea or fulvates to the mix. (Table 18, Coetzee unpublished data). Adding urea will also increase the nitrogen content of the mix which will not always be acceptable.

Table 18. Increase in the potassium status of the leaves following foliar sprays with potassium nitrate, with or without fulvates and urea.

Treatment	%K in leaves	% Efficiency*
0	0,93	-
4% Potassium nitrate	1,87	30
4%+0,1% Fulvates	2,23	40
4%+0,5% urea	1,99	33

* 152g K was applied per tree and 1,87-0.93x4750÷100g was detected in the leaves. A mature tree carries 4750g dried leaf material (Embelton in Citrus Industry Vol 2).

The limiting factor with foliar applications of potassium nitrate is the nitrogen component. The nitrates restrict the applications to periods 6-8 weeks prior to blossom and after fruit drop. It is therefore so important that the formulations of potassium that contains no available nitrogen should be tested independently. These formulations have the potential to be applied during cell division when extra K could have a major impact on fruit size. These formulations are chelates of K and some of the available once are K-Charge, Only K, K-metalosates etc. However, EDTA-chelated K contains a lot of N.

An application of about 50g K per mature tree is required. Also note that a concentration of 5000mg K per litre is required to be successful, when potassium nitrate is the carrier. This means 500g K per 100 litre water.