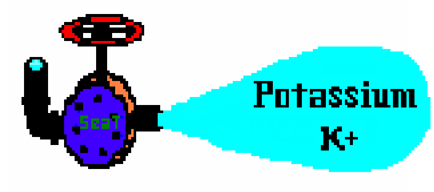
CCS POTASSIUM PIPELINE



POTASSIUM

Potassium is the seventh most abundant element in the earth's crust and is widely distributed around the world. Potassium salts comprise approximately 2.5% of the earth's crust. Potassium is a very reactive element and has a high affinity for other elements; therefore, it is never found in the elemental form. Pure potassium metal is very unstable and will violently react with water generating heat and sparks.

Potassium is found in igneous rocks (K-rich silicates and feldspars) and in sedimentary deposits formed by the evaporation of seawater. Most potassium is recovered from sedimentary deposits.

Potassium is essential for plant and animal growth and development. Together with nitrogen and phosphorus potassium is a macronutrient. Potassium is involved in many reactions and processes in living cells.

90 – 95% of potassium salts produced are used as fertilizer materials. The term Potash came from an old practice of burning wood in pots to obtain potassium salts. Potassium is expressed in fertilizer as K_2O on an equivalent basis. To convert K to K_2O multiply K by 1.2 or converting K_2O back to K requires division by 1.2.

Potassium salts were first mined in Germany in 1861 after Liebig's doctrine of mineral nutrition had demonstrated their value as fertilizer materials. Potassium requirements to sustain world food needs will continue to increase. Potassium can be a hard element to manage in soil. The potassium ion moves with water. In Florida soils and most other soils in the world potassium is the hardest element to manage.

Major sources of potassium salts and materials (ores) are: Sylvite (KCl) ~ 60 – 63 % K_2O, Langbenite ($K_2SO_4.2MgSO_4$) ~ 21 – 23% K_2O & Niter (KNO_3) ~ 44 – 46% K_2O. Many other ores containing potassium are found. These are only three examples of many.

North America has the world's largest deposits of high grade potassium ore. Canada's Elk Point Basin extends from northern Alberta southeast across Saskatchewan and Manitoba. This is the largest potassium source on earth and also is why North America holds the largest deposits. Potassium ores are found everywhere on Earth. The worlds total supply capacity of potassium is ~ 28 million tons.

North America supply capacity is ~ 10 million tons or about 36% of the worlds available supply capacity. This number is based on 1989 information. Refined ore and evaporated sea water provide potassium sources that give us: KCl, K_2SO_4 and KNO_3. Refined sources of potassium yield fertilizer materials with these K_2O levels: KCl ~ 61%, K_2SO_4 ~ 52%, SPM ~ 22% & KNO_3 ~ 44%. Potassium sulfate is produced by a controlled decomposition reaction of natural sulfate salts of potassium and reaction with KCl (1 & 2) , by reaction of the double sulfate salt Langbenite with KCl (3) and by the Mannheim process (4).

(1) $4(KCl + MgSO_4 + 3H_2O) + H_2O \rightarrow 2K_2SO_4 + MgSO_4 + 6H_2O + 2MgCL_2(Sol)$
(Kainite) → **(Schoenite)** **(Magnesium Chloride)**

(2) $K_2SO_4 + MgSO_4 + 6H_2O + 2KCl \rightarrow 2K_2SO_4 + MgCl_2\ (Sol)$
(Schoenite) **(Pot. Chl.)** → **(Pot. Sul.)**

(3) $K_2SO_4 + 2MgSO_4 + 4KCl \rightarrow 3K_2SO_4 + 2MgCL_2(Sol)$

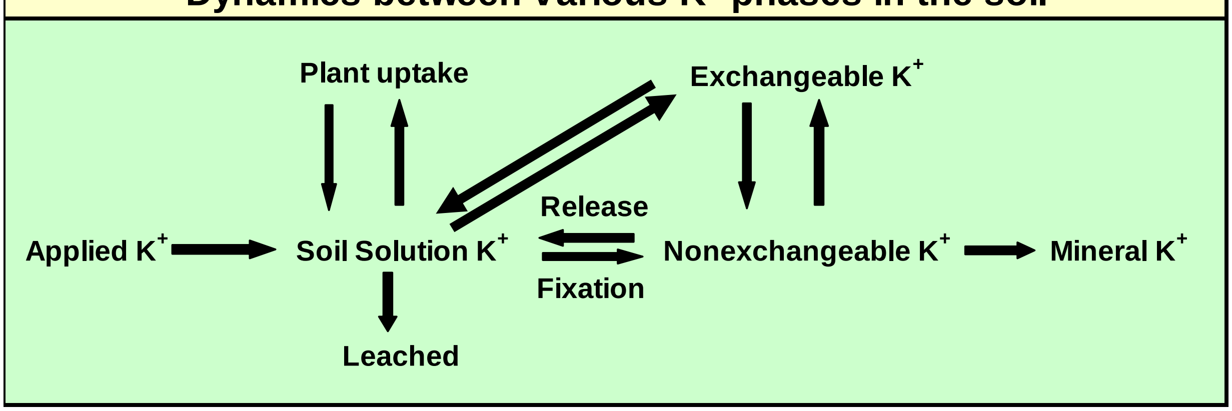
(4) $2KCL + H_2SO_4 \rightarrow K_2SO_4 + 2HCl$
(Sulfuric Acid) **(Hydrochloric acid)**

A small amount of potassium nitrate is found in and supplied from natural deposits of Caliche ($NaNO_3$) in Chile. Potassium nitrate is also produced by the reaction of KCL with HNO_3 . Potassium nitrate analysis is (13-0-44). It is used primarily in specialty crops; tobacco, turf, vegetables and fruits.

Potassium phosphates are produced in a limited amount by the reaction of $H_3PO_4 + KCL \rightarrow KH_2PO_4 + HCl$ or $H_3PO_4 + KOH \rightarrow KH_2PO_4 + H_2O$. Potassium phosphates have low salt index and are used for specialty application purposes like foliar nutrition. Some disease fighting benefits have also been found.

The amount of potassium found in a soil is a reflection of the parent materials of the soil, degree of weathering and amount of K fertilizer added minus losses due to crop removal, erosion or leaching. Potassium is a very dynamic element involved in many processes. At any given time in a low CEC sandy loam soil only 5 – 10% of the potassium may be available for plant use. As the CEC climbs this number declines quickly. This schematic representation summarizes the dynamics between various K phases in the soil.

Dynamics between various K^+ phases in the soil



All crops have a requirement for balanced fertility. Growth, development, fruiting and fruit quality are all dependent upon this balance. 17 different nutrients are required for growth and development and potassium is a key element. Potassium is an essential nutrient and along with nitrogen and phosphorus is a macronutrient. It not only improves yields but directly affects crop quality. Balanced potassium fertility results in a higher crop quality that may bring more return to the farmer.

Some aspects of crop quality that affect marketability:

- **Attractiveness:**
  Uniform size – consistency
  Big size – meet packaging and consumer needs
  Good color – uniform color
- **Organoleptic:**
  Enhanced flavor
  Enhanced aroma
- **Nutritional value:**
  % protein, % oil, vitamin C, etc.
- **Intact state:**
  Free of blemishes or unusual markings (mechanical injuries)
  Free of any sign of disease
- **Long shelf life:**
- **Adequate processing quality to meet industry needs**

Potassium is recognized as the quality element in crop production. In Citrus, potassium increases fruit size, reduces fruit creasing and cracking, improves fruit color, increases vitamin C and soluble solids content and peel thickness. Potassium enhances storage and shipping quality of bananas, tomatoes, potatoes, onions, peppers, squash and also extends shelf life.

An important role of potassium that gives rise to many quality attributes is its role in promoting synthesis of photosynthates and subsequent transport to fruit, grain, storage organs, tubers or vegetative component (leaves, buds and blooms). Potassium enhances photosynthate conversion into starch, protein, vitamins, oil and seeds.

Potassium has a crucial role in the energy status of plants, translocation and storage of assimilates and maintenance of tissue water status. Potassium predominantly exists as a free or absorptive bound cation and can be displaced very easily at the cell level and translocated within the whole plant. The high mobility of potassium contributes to the major functional characteristics of potassium as the main cation involved in the neutralization of charges and the most important inorganic osmotic active substance. Potassium helps to maintain cell cytoplasm, cell wall and external cell electric potential.

Potassium is involved with many processes involved in plant physiology and chemistry. Some of these are:

- **Activates more than 60 enzymes**
- **Aids in photosynthesis activities**
- **Helps maintain high energy status at the cell and plant level**
- **Maintains cell turgor (pressure related to solute and water movement)**
- **Regulates opening of leaf stomata**
- **Promotes water uptake via osmotic changes**
- **Regulates nutrient translocation in plants**
- **Favors carbohydrate transport, storage and utilization**
- **Enhances N uptake, protein synthesis as well as other elements**
- **Promotes starch synthesis in leaves and other chlorophyll containing cells**

Potassium helps to maintain the balance of electric charge in chloroplasts, thereby, assisting in the phsophorylation of ADP to ATP (high energy molecule) and reduction of NADP to NADPH (another energy molecule). Potassium assists in the transfer of radiation energy (photon generated electric potential) into primary chemical energy in the form of ATP (photophosphorylation) and NADPH (Fe^{+3} cyanide reduction in the chloroplasts). This energy transfer is a fundamental process in plants and adequate potassium supply insures high levels of energy in the form of ATP and NADPH.

A high energy status of a crop with adequate potassium promotes synthesis of secondary metabolites like vitamin C. Potassium affects photosynthesis at many levels and processes.

- **Synthesis of ATP needed for photosynthesis reactions where CO_2 is added to a five carbon sugar ribulose making glucose (Calvin-Benson Cycle).**
- **Activation of enzymes involved in photosynthesis**
- **CO_2 uptake via leaf stomata (gas exchange)**
- **Balance of electric charges across membranes that is needed for photophosphorylation in chloroplasts**
- **Potassium is a counter ion (anti-port) to H^+ flux across the thylakoid membranes where phsophorylation of ADP to ATP is driven by an ATP-ase enzyme powered by H^+ flux (movement across the membrane). Potassium counters (keeps the charge balanced) this movement, thereby, preventing an electric imbalance.**

Without adequate potassium, CO_2 uptake would be greatly reduced, thereby reducing the potential for sugar production from the ATP and NADPH powered Calvin-Benson Cycle. This cycle and components supporting, promoting and regulating it supply sugar energy for all life forms and life processes. Potassium is a key cation in this cycle. The rate of photosynthesis is measured as the rate of CO_2 assimilation. This basic concept is one of the most important providing energy supporting life on earth.

Potassium is involved in activation of more than 60 enzymes including; synthetases, oxidoreductases, dehydrogenases, transferases and kinases. These enzymes are necessary for essential plant processes involving energy utilization, starch synthesis, nitrogen metabolism and respiration. Optimum potassium supplies result in higher concentrations of starch in plants. This directly affects crop yield and quality. The high energy status of an adequately potassium supplied plant is high total carbohydrate content, better water movement and utilization, better cold stress, disease resistance, stress recovery, fruit set, fruit fill, leaf and root growth and total solute movement within the plant.

Better water movement leads to better transport of assimilates and nutrients. Potassium promotes phloem transport of photosynthates (sucrose and amino acids) to physiological sinks (fruits, roots, tubers, seeds, leaves and grains). Potassium is involved in phloem loading with sucrose and increasing transport rate of phloem sap solutes and eventual phloem unloading at the sink site. With adequate potassium the osmotic potential and subsequent volume flow rate are higher than in potassium deficient plants.

Potassium is also involved in the mobilization of storage materials. Potassium is involved as a counter ion for nitrate transport in the xylem. After nitrate reduction in the shoot, charge balance has to be maintained by corresponding net increase in organic acid anions. Malate (organic anion) can be retranslocated with potassium as the accompanying cation through the phloem to the roots.

Multiple functions of potassium in metabolic processes lead to:

- **Increase in root growth and a key cation in diffusion**
- **Maintaining osmotic potential and solute-water movement charge balance**
- **Improvement in drought resistance by allowing plants to utilize water efficiently**
- **Reduce water loss and wilting by helping to maintain turgor pressure**
- **Enhance winter hardiness by helping to load sugars**
- **Improve resistance to pest and disease**
- **Build cellulose and reduces stalk lodging**
- **Increases nodulation of legumes**

Specific effects of potassium on crop quality:

- **Increase protein content of plants**
- **Increase starch content in grains, tubers and fruits**
- **Increase vitamin C and solid solubles content**
- **Improve fruit color and flavor**
- **Improve size of fruit and tubers**
- **Increase peel thickness**
- **Reduce physiological disorders (creasing and cracking in citrus, blotchy ripening complex in tomatoes, etc.)**
- **Reduces incidence and helps recovery of pest and diseases**
- **Enhances shipping and storage quality**
- **Extends shelf life**

TOMATO POTASSIUM INFORMATION

Potassium is absorbed by tomatoes at higher amounts than any other nutrient. Total K uptake is two to three times higher that nitrogen uptake. Depending upon yield, variety, planting density, type beds, etc., potassium requirements for tomato production can top 500 pounds per acre for a crop. Tomato plants deficient in potassium grow slow and are stunted. Yield reduction can be directly related to potassium shortage. Adequate potassium during a tomato growth cycle promotes yield, size, marketability and overall quality of fruit.

Tomatoes typically have an N:K requirement of 1:3 during the first 40 – 50 days then the shift is to 1:2 and just after the first harvest the ratio may shift to 1:1. Maintaining adequate potassium levels in fertility programs can only be done if tissue and petiole testing are initiated early and deficiencies or excess nutrient levels are adjusted immediately when detected.

Potassium can be foliar applied to tomato plants to help keep tissue potassium levels at sufficient percentage and to help increase petiole sap potassium levels. Optimum yields and fruit quality can be achieved by monitoring total nutrient status and correcting deficiencies as soon as they are observed. Weekly tissue analysis coupled with petiole sap readings are necessary for top production.

Some suitable potassium sources for tomato plants are:

- **Potassium Nitrate**
- **MKP – Mono Potassium Phosphate**
- **Potassium Sulfate**
- **Sul-Po-Mag**
- **Potassium Carbonate**
- **Potassium Hydroxide neutralized blends with low salt index (< 50).**

CITRUS POTASSIUM INFORMATION

Potassium is essential for quality citrus production. Potassium is removed by citrus fruit more than any other nutrient. Large amounts of potassium are reflected by high potassium content of citrus juice.

Potassium nutrition influences:

- **Fruit size**
- **Peel thickness**
- **Fruit color**
- **Acid content**
- **Sugar content**
- **Citric and ascorbic acid content (Vitamin C)**
- **Acid/Sugar ratio**
- **Soluble solids content**
- **Enhancing fruit storage and reducing transport damage**

Application of potassium decreases fruit granulation. This condition leads to harder and dry juice sacs. Foliar spraying with potassium reduces granulation in citrus. At high N:K ratios these below disorders may be observed:

- **Creasing: Narrow sunken furrows on the rind surface; the fruit is not desirable for processing as the peel disintegrates easily.**
- **Plugging: Removal of the peel in the stem end area of the fruit, increased incidence of post harvest decay**
- **Splitting: Vertical split at the styler or blossom end and opening longitudinally towards the stem end.**
- **Reduced fruit size**
- **Lower sugar content**

Potassium is needed in relatively large quantities by all plants. Deficiencies as well as imbalance with other nutrients can lead to lower yields, reduced crop quality and poor plant growth and development. Balanced fertility begins with a good soil test and fertility program that includes all nutrients. Irrigation water quality and quantity should also be monitored and measured, tissue testing and petiole sap analysis will help identify and quantify nutrient problems that if not corrected may lead to crop failure, reduced yield or reduced crop quality.

For more information on this subject please email: creechcrop@aol.com

Creech Crop Services, LLC - 11417 Lake Minneola Shores Dr. – Clermont, Fl 34715

Buford Creech, CCA - 941-737-2719