

SOILS AND FERTILIZERS
MODULE 8
POTASSIUM FERTILIZER – MANUFACTURE, MATERIALS, AND USES

1. Potassium fertilizer production and consumption
 - a. The top five potash-producing countries in 1996 were: Canada, Russia, Germany, United States, and Israel.
 - b. Top five potash-consuming states in 1997 were: Illinois (727,088 tons), Iowa (479,811 tons), Indiana (398,026 tons), Minnesota (315,893 tons), and Wisconsin (303,275 tons).
 - c. Florida consumed 228,495 tons of potash in 1997 (ranked 9th among states).

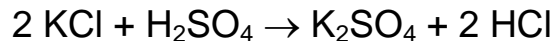
2. Functions of potassium (K) in plants
 - a. Water relations - Role of K^+ in osmotic regulation within plants; K provides much of the osmotic "pull" that draws water into plant roots; K-deficient plants are less able to withstand water stress; the opening of stomata in leaves occurs with an increase in turgor pressure of the guard cells surrounding the opening; this is brought about by an influx of K^+
 - b. Co-factor for some enzymes - K is required to activate many plant enzymes; mechanism involves the attachment of K ions to the surface of the enzyme molecule, changing the molecule's shape or exposing the active site.
 - c. Promotion of flowering, fruiting, fruit size, and maturity.
 - d. General plant K concentration: usually >1% K in the plant is adequate.

3. Sources of potassium for fertilizer production
 - a. Potassium is abbreviated with the letter K from the Latin word Kalium.
 - b. The preparation of potassium carbonate, or **potash**, by leaching and concentrating wood ashes was the subject of the first U.S. patent, issued in 1790 and signed by George Washington; the process used about 5 acres of timber to produce 1 ton of potash; the term potash was derived from the manufacture of this product by the leaching of hardwood ashes in large iron pots.
 - c. Commercial-scale production of K fertilizers began in Germany around 1861; salt deposits from old inland seas were mined for the production of common table salt, but mined material also contained KCl; the KCl needed to be upgraded (**beneficiated**) before it could be used as fertilizer. Beneficiation processes were developed by German chemists.
 - d. Potassium deposits were discovered in the U.S. in the California Mojave Desert in 1916, and later at Carlsbad, New Mexico and in Utah; the world's largest deposits are in southeastern Saskatchewan, Canada, discovered in the 1960s.
 - e. Principle sources for world potash production today originate in Canada, Russia, USA, Germany, Israel, Jordan, France, Spain, and South Africa.
 - f. Potassium chloride is known as **sylvite**; other important K minerals include **langbeinite** (potassium-magnesium sulfate mixture), **sylvinite** (a mixture of KCl and NaCl), and **kainite** (a mixture of KCl and $MgSO_4$).

4. Mining systems
 - a. Mined salts can be several hundred to several thousand feet beneath the surface.
 - b. Ore is either mined as a solid and brought to the surface to be processed, or dissolved underground and brought to the surface as a solution to be evaporated.

5. Production of potassium fertilizer materials

- a. Potassium chloride (KCl)
 - i. The direct product of the mining/purification process; KCl is 60 to 63% K₂O.
 - ii. KCl varies in color from pink or red to white, depending on the mining and recovery processes used; there is no agronomic difference between these.
 - iii. Marketed in five particle sizes: 1) special standard, 2) white soluble, 3) standard, 4) coarse, and 5) granular.
- b. Potassium sulfate (K₂SO₄)
 - i. Produced by the reaction of KCl with sulfuric acid:

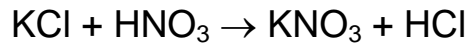


- ii. Can also be produced from langbeinite:



- iii. Agricultural grade K₂SO₄ contains 50 to 53% K₂O, 18% S, and a maximum of 2.5% chloride.
- iv. K₂SO₄ **is produced mainly to satisfy the trade requirement for a potash source containing a low percentage of chloride**, e.g. for tobacco, and potatoes grown for chips.
- v. Potassium sulfate can also be formed by the decomposition of the kainite mineral to form **schoenite** (K₂SO₄ • MgSO₄ • 6H₂O); the K₂SO₄ component of this product is extracted by chemical manipulation.
- c. Potassium-magnesium sulfate (K₂SO₄ • MgSO₄) (Sul-Po-Mag or K-Mag)
 - i. Produced by mixing langbeinite with sodium and potassium chlorides.
 - ii. Contains about 22% K₂O, 11% Mg, 22% S, and a maximum of 2.5% Cl; good for use on crops that require both magnesium and sulfur as well as K.
- d. Langbeinite
 - i. Agricultural langbeinite has minimum K of 18.3%, minimum Mg of 10.8%, and maximum chloride of 2.5%.
 - ii. Langbeinite ore that does not contain enough recoverable KCl undergoes a process which removes the NaCl in the ore; the resulting product can be used for agricultural purposes.
 - iii. Langbeinite ores which contain substantial KCl are first used as raw material for KCl production.

- e. Potassium nitrate
 - i. Produced by the reaction of KCl and nitric acid:



- ii. KNO_3 contains 44% K_2O and 13% N.
- f. Other products
 - i. Waste products from tobacco processing (stems and ribs of leaves) are ground and sold for use as fertilizers; these contain 4 to 8% potassium and 2 to 4% nitrogen.
 - ii. Seawater contains vast amounts of K (one cubic mile contains the equivalent of 1.6 million tons of K); extraction of K from this source is not yet economically feasible.
 - iii. Most of the world uses KCl as a source of K fertilizer; In Florida, certain crops such as potatoes, tomatoes, and other vegetables have shown a sensitivity to applications of KCl (i.e. sensitivity to chloride), thus KNO_3 and K_2SO_4 are popular sources of K in these situations.

6. Sources of K in the soil

- a. K-bearing minerals (These occur in midwestern soils, which can be high in native K; Florida has little native K because of weathering).
 - i. Mica
 - ii. Feldspars
 - iii. Clay micas (illite)
 - iv. Minerals may be 5,000 to 25,000 ppm total K; can be as high as 1.5% in a given soil.
- b. Exchangeable K
 - i. K is held on the cation exchange complex of the soil (clay and organic matter).
 - ii. Can range from 60 to 200 ppm K in the soil.
 - iii. K^+ can be replaced by H^+ , Ca^{2+} , Mg^{2+} , Al^+ , etc. at the exchange site (acid weathering will remove K from the soil).
- c. Non-exchangeable K
 - i. Exists within the lattice crystal structure of clay minerals (K is **fixed** within the mineral and is not available to plants).
 - ii. Can range from 50 to 700 ppm K in the soil.
- d. Soil solution K
 - i. Can range from 1 to 10 ppm K in the soil (contrast to soil solution P, which ranges from 0.03 to 0.5 ppm).
 - ii. Potassium in the soil moves to the plant root by:
 - (1) Diffusion - Movement in response to a concentration gradient, i.e. away from fertilizer bands (movement only 1 to 4 mm)
 - (2) Mass flow - Movement of dissolved K^+ ions with the flow of soil water; amount taken up in this manner depends on the amount of water used by plants.

- (3) Direct contact - Interception of soil K by a growing root (roots only encounter about 10% of required K via direct contact).
- iii. Direct contact does not provide sufficient K for plant growth, thus must have increased K in solution through mass flow and diffusion.
- iv. In Florida, soil K exists mainly in the exchangeable form and the soil solution form from fertilizers; Florida has no mineral K or non-exchangeable K.
- v. Potassium leaches in Florida soils rather quickly because of the lack of clay and organic matter; soil analysis for K may not provide useful results due to the mobility of K in the soil (i.e. what is present this month may not be present next month).

7. Plant availability of soil K

- a. K status in soil
 - i. Exchangeable K^+ and **soil solution K^+** comprise the "**immediately-available**" K in the soil; plant roots excrete H^+ ions and exchange them for K^+ ions in the uptake process.
 - ii. Non-exchangeable K comprises "slowly-available" K in the soil.
 - iii. Mineral K comprises "very slowly-available" K in the soil.
- b. K fertilization of south Florida crops
 - i. Because low organic matter sandy flatwoods soils are low in CEC, K will leach almost as fast as nitrogen. For acceptable production of most crops, a potassium (K_2O) rate in the same range as the nitrogen rate is required.
For example:
Tomato or pepper - 180 lbs/acre N, 180 lbs/acre K_2O
Watermelon - 120 lbs/acre N, 120 lbs/acre K_2O
Golf course fairway - 2 lbs/1000 sq. ft. N, 2 lbs/1000 sq. ft. K_2O
 - ii. Citrus groves also usually require N and K_2O applications in a 1:1 ratio. (Example: 200 lbs/acre N, 200 lbs/acre K_2O). K is usually applied with N in a mixed fertilizer. If dry fertilizer N is applied 3 or 4 times per year, the K fertilizer is also applied on the same schedule.