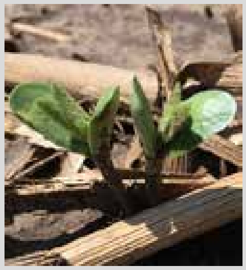
CROP FOCUS

Potassium Behavior in Soil

- Potassium is an essential plant nutrient that plays a role in a wide range of physiological processes, from regulation of the stomata to enzyme activation.
- Potassium is held in the soil by the cation exchange capacity. Soils with finer particles, such as clay, and organic matter are able to hold more positively charged ions than soils with larger particles, such as sand.



States of Potassium

Potassium in Soil Solution (1-2%)

- Potassium dissolved in soil water, available for plant uptake.
- Exists in equilibrium with the exchangeable, fixed, and mineral states; replenished by the exchangeable supply as potassium is removed through plant uptake.

Exchangeable Potassium (1-2%)

- Potassium held on exchange sites of soil clay and organic matter; available for plant uptake.
- Readily released into soil solution when the concentration of potassium dissolved in soil water decreases.

Fixed (Non-Exchangeable) Potassium (1-9%)

- Potassium trapped inside clay materials; not immediately available to plants.
- Moves to more available forms when the soil solution is depleted of potassium.

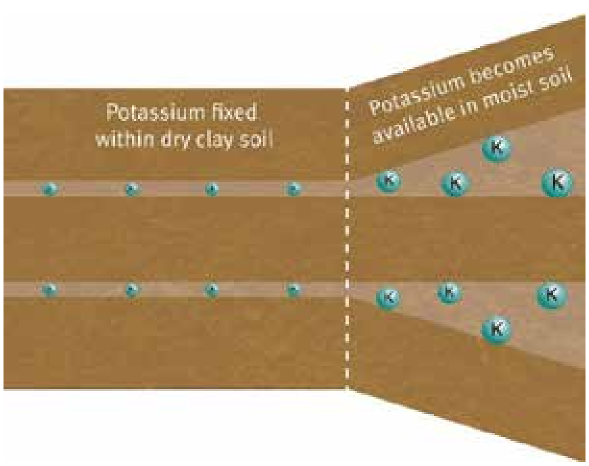


Figure 1. Fixed potassium inside clay becomes available as water is added to soil.

Mineral Potassium (90-98%)

- Potassium contained in feldspar and mica sand and rocks; not available for plant uptake.
- Not measured in soil tests.
- Potassium can be held in this state for many years before it is released through weathering of minerals.

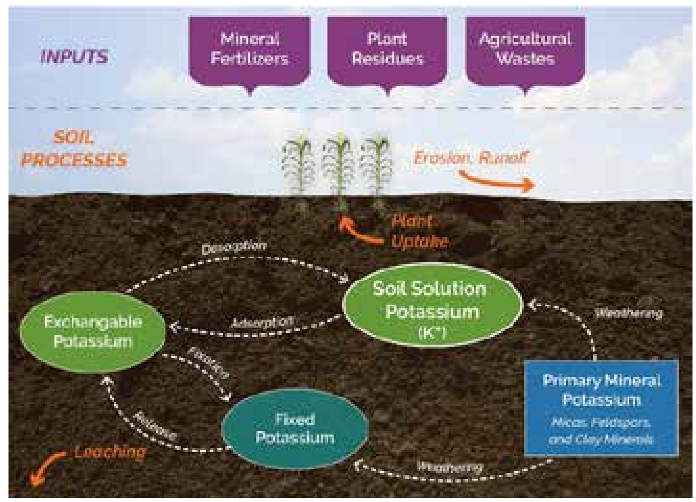


Figure 2. Soil potassium cycle.

Potassium Reactions in the Soil

Adsorption – Binding of potassium to negatively charged sites on soil particles through weak electrostatic attraction.

Desorption – Release of exchangeable potassium from soil particles.

Fixation – Incorporation of potassium between layers of clay in the soil; making it temporarily unavailable for plant uptake; occurs when soil potassium is high and when soil is dry, causing clay layers to collapse.

Release - Dissolution of potassium that occurs when soil minerals dissolve.

Weathering - Disintegration of rock and minerals by precipitation, organisms, and/or temperature.

Cation Exchange Capacity (CEC)

Potassium is held in soil by charges known as CEC.

Charges in the Soil

- CEC is the quantity of the negatively charged particles in the soil, measured in milliequivalence per 100 grams (meq/100g).
- The higher the number, the more attraction there is between the negatively and positively charged particles.

Nutrient Mobility in Soil Solution

- Forces of attraction between nutrient ions, soil, and water molecules determine their behavior and mobility in soil.
- Cations such as K^+ bond to negatively charged soil particles, thus are not as abundant in soil water and are not highly mobile.
- Anions such as NO_3^- do not as readily bond to soil, therefore are more abundant and more mobile in soil water.
- Phosphorus is an exception, as it exists as an anion but has low water solubility, making it relatively immobile in the soil.

Table 1. Essential nutrients for plant growth, forms available for plant uptake, and relative mobility in soil water.

Nutrient	Plant-Available Form(s)	Soil Mobility
Nitrogen	NO_3^- NH_4^+	Mobile Immobile
Phosphorus	HPO_4^{2-}, $H_2PO_4^-$	Immobile
Potassium	K^+	Somewhat mobile
Sulfur	SO_4^-	Mobile
Calcium	Ca^{2+}	Somewhat mobile
Magnesium	Mg^{2+}	Immobile
Boron	H_3BO_3, BO_3^-	Very Mobile
Chlorine	Cl^-	Mobile
Copper	Cu^{2+}	Immobile
Iron	Fe^{2+}, Fe^{3+}	Immobile
Manganese	Mn^{2+}	Mobile
Molybdenum	MoO_4^-	Somewhat Mobile
Zinc	Zn^{2+}	Immobile

Factors Affecting Potassium Availability

Cation Competition

- Cations that are attracted to the soil by CEC include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+) and aluminum (Al^{3+}).
- Of these elements, Mg^{2+} is most likely to bind to the exchange sites; a high concentration of competing cations when potassium concentrations are low can reduce the adsorption of potassium.
- Cations that are available in CEC are contingent on environmental factors including parent material, soil pH, climate, and soil inputs.

Soil Moisture

- More potassium is available when the soil is moist. Potassium can move more freely in the soil solution between the plants and the soil surfaces. Exchangeable potassium can replenish the solution with greater ease.

Temperature

- As temperature decreases, it is harder for plants to take up potassium.

Weathering

- Excess fertilizer can become fixed in soil. Available forms of potassium become fixed as the clay dries out.
- Old soils that are very weathered lose their mineral form of potassium and can no longer supply the soil solution with this nutrient.

Luxury Consumption

- Plants will take up excess potassium if the soil allows, even if the plant does not need it.
- This does not harm the plant, but it can be an economic concern if too much fertilizer is being applied.

Potassium Loss from the Soil

- Potassium very seldom leaches from the soil. It is most abundant in its mineral form, and available forms are most often taken up by plants promptly.
- Erosion rarely affects potassium loss from the soil.
- Potassium in the grain is removed from the field during harvest.
  - 200 bu/acre corn grain removes about 50 lbs K_2O/acre.
  - 60 bu/acre soybean grain removes about 80 lbs K_2O/acre.
  - 45 bu/acre wheat removes about 15 lbs K_2O/acre.
- Corn silage and stover removal also removes K from the system. Rain prior to stover removal allows K from the plant sap to reenter the soil.
- When potassium fertilizer or manure is applied in large amounts to soil with low cation exchange capacity, such as sandy soils, the potassium is not able to bond in the soil and can be leached.

Author: Samantha Reicks

August 2017