CATION EXCHANGE CAPACITY (CEC)

The soil is made up of a diverse number of components. The smallest fraction of these are known as colloids, which are less than 1 micron in diameter. Being so small they have a large surface area and are very reactive. They are responsible for holding most of the nutrients in the soil.

All elements have a positive or negative charge. The soil colloid has a negative charge. Like magnets, opposites attract and ions with the same charge, repel.

Therefore, the soil colloid attracts ("fixes") positively charged nutrients (cations) and repels negatively charged ions (anions).

The strength of the bond depends upon the number of positive charges the ion has.

Anions are free to move in the soil solution, being readily available to the plant and readily leached. At times (such as the case with Phosphorus) the anion will form compounds with cations and become insoluble and temporarily unavailable to the plant or for leaching.

So whilst Phosphorus is an anion, it will usually combine with Iron or Aluminium and act like a cation.

The more fine colloids in the soil (such as clay) then the greater the ability of the soil to bind cations.

Table 1. Common cations and anions present in the soil.

Cations		Anions	
Chemical Symbol & Charge	Name		
K^+	Potassium	NO_3^-	Nitrate
NH_4^+	Ammonium	Cl^-	Chlorine
Na^+	Sodium	SO_4^{--}	Sulphate
Cu^{++}	Copper	HPO_4^{--}	Phosphate
Zn^{++}	Zinc	BO_3^{---}	Boron
Mn^{++}	Manganese	MoO_4^{--}	Molybdenum
Ca^{++}	Calcium		
Mg^{++}	Magnesium		
Fe^{++}	Iron		

- **Cation Exchange Capacity (CEC).** The **total number** of exchangeable cations that a soil can hold at any one time.
  The strength of a cation's positive charge varies, allowing a cation to be replaced by a stronger cation on the surface of a negatively charged soil particle. The likelihood of cations leaching through the soil profile decreases progressively with increasing CEC.
- **Factors Affecting CEC**. The amount and types of clays and organic matter present. The more clay and organic matter available, the greater the ability of a soil to adsorb cations. A soil is likely to have a low CEC if it has been highly weathered and has a low organic matter content. If the soil has been protected from erosion most of its life and has high levels of organic matter, then its CEC should be high.
- Sandy soils, having a low CEC, adsorb smaller quantities of cations and this has important implications when deciding on a fertilisation program. For instance, if nitrate-based fertilisers (such as urea) or products containing sulphate sulphur are applied at a

time of heavy rain and there is very little organic matter covering the soil, then dramatic losses of nitrogen or sulphur may occur via leaching. Split or delayed applications of fertiliser may be more appropriate as it is more effective in avoiding leaching or run-off loss. Lowering the nutrient losses due to leaching, by separating the application of fertiliser, is applicable in a wide array of soil types and climatic conditions.

Cation Imbalance: Cation saturation is a concept that is being used to develop fertiliser regimes. The concept is based around the assumption that a specific nutrient ratio, or 'balance', is required for correct nutrient uptake to ensure maximum yields. Evidence suggests that a healthy, high-yielding crop or pasture cannot be grown in a soil without this specific nutrient ratio.
So long as each nutrient is present in adequate amounts, a high yield can still be obtained.

Cations and Lime: Cation Exchange Capacity has an effect on the liming requirement of a soil. The higher a soil's CEC, the harder it becomes to change pH. The total amounts of clay and organic matter present in a soil, as well as the actual type of clay, govern how strongly soils are buffered. In other words, how much it takes to produce a shift in pH. Rising clay and organic matter content leads to a higher buffering capacity. Soils such as these need more lime to raise the pH than soils with a low buffering capacity, namely sandy soils.

Lime, Gypsum and Potassium: Most soils contain 10kg/ha or less of potassium in solution. This can barely supply an actively growing crop for more than a few days. However, as the crop removes potassium that is in solution, some of the exchangeable-K moves into solution. It is replaced on the soil colloid by another cation. This movement continues until a new equilibrium is established.

Therefore, via the cation exchange process, potassium is constantly available for plant growth, so long as the soil contains enough available-K at the start of the growing season.

However, when the plant is growing rapidly, for instance in warm, moist spring conditions, the potassium removed from the soil solution may not be replaced at a fast enough rate with potassium from the exchangeable pool. If this occurs, the crop or pasture may show signs of a potassium deficiency.

The absorption of potassium by plant roots is influenced by the activity of other cations, principally calcium and magnesium. As the concentration of calcium and magnesium ions increases, the absorption of potassium decreases. Some potassium can be exchanged from the soil colloid to the plant root when the two come into direct contact with each other.

The addition of lime or gypsum will increase the supply of calcium, which may reduce the availability of Potassium. (see article on Potash)