

## UNDERSTANDING TURF MANAGEMENT

The tenth in a series by  
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# SOIL POTASSIUM

Most soils contain relatively large amounts of the essential element for plant growth - potassium ( $K^+$ ); often as much as two percent of the weight of the mineral portion. At the same time the concentration of potassium in the soil solution from which the grass draws its needs may be only 50 to 100 ppm. This relationship illustrates the reason why the total chemical analysis of a soil has little correlation with its ability to supply grass with a nutrient and why soil testing procedures were developed which were more closely related to plant growth.

A healthy grass leaf will contain 2.5 to 3.5 % potassium. The potassium in the leaf is not associated with the structure of any specific compound such as protein or carbohydrate in the leaf. It appears, however, as a free ion in the cell sap and functions as an aid in maintaining the ionic and pH balance within the cell as well as with some enzyme functions. In fact when a leaf dies most of the potassium contained in the leaf will be leached out by the rain and returned to the soil.

The major portion of the potassium in the soil is found as a element in the structure of clay minerals and sand grains originating from the minerals known as mica and feldspars in igneous rock. An example of the partitioning of the potassium in a fertile soil is outlined in Table 1.

Over a long period of time, measured in years, if not centuries, the potassium containing minerals, feldspars and mica break down. The potassium released on this breakdown may become part of the structure of secondary minerals known as clay minerals or become exchangeable ions in the soil solution. The potassium which is part of the clay structure is considered slowly available to the soil solution and can slowly recharge the potassium in the soil solution over a period of weeks or months. The rate at which the restructuring or breakdown of clay minerals releases potassium is known as the potassium supplying power and can vary significantly between soils. Finally, the readily available potassium for immediate plant uptake is made up of potassium in the soil solution and the exchangeable potassium. These various steps are illustrated in Figure 1.

In the above discussion we have mentioned exchangeable potassium which is potassium associated with the exchange complex of the soil. Cation exchange is a phenomena of compounds or minerals which have a sphere of negative electrical influence surrounding them, resulting in the ability to attract ions which have a positive charge. Ions such as potassium, calcium and magnesium, which carry a positive charge are attracted by the negative charge the same as the north pole of a magnet attracts the

south pole (thus the general term cation because the positive charged ions are attracted to a cathode).

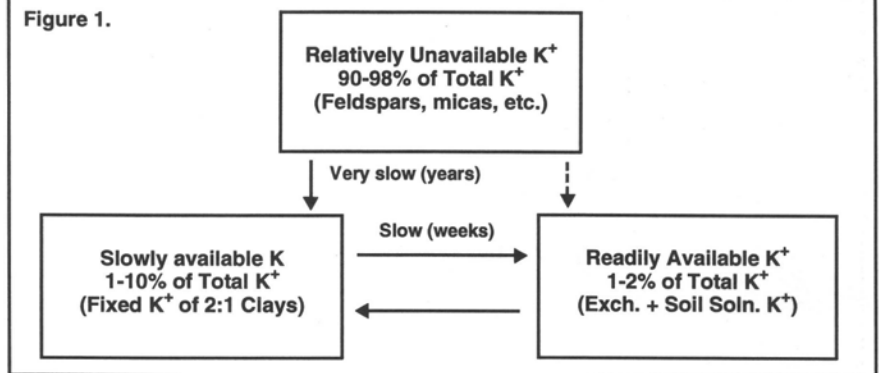
Cation exchange is also a property of large organic matter molecules, particularly when in the stable form known as humus, because they also have a sphere of negativity about them. Since clay minerals and humus have a negative sphere of influence and hence have the ability to attract the cations in the soil solution to their surface, the cations are held from leaching in the percolating ground water.

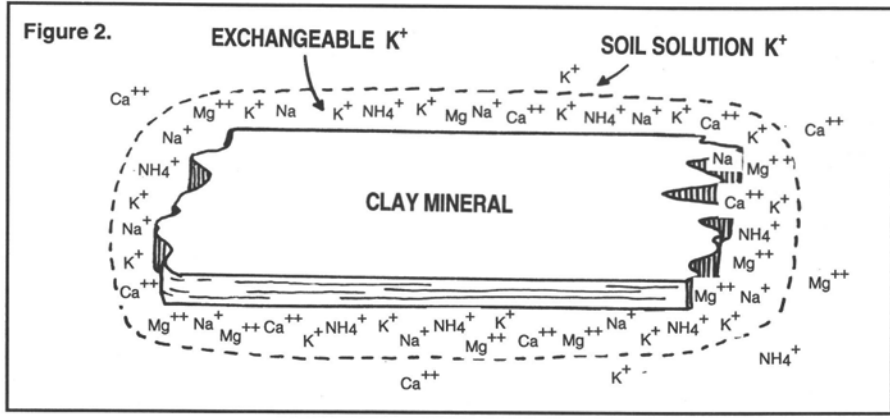
Figure 2 illustrates the concept of cation exchange. Visualize a clay particle or large, complex organic molecule floating in water (i.e., the soil solution). The clay mineral or organic molecule is negatively charged, the intensity of the charge diminishing with increasing distance away from its surface. In the water surrounding the particle are a swarm of dissolved ions of calcium ( $Ca^{++}$ ), magnesium ( $Mg^{++}$ ), potassium ( $K^+$ ), sodium ( $Na^+$ ) and many other cations such as iron, manganese, zinc, and copper which plants require for their growth. When a potassium ion is close to the surface, the negative influence is strongest; as the potassium drifts away from the surface the effect decreases and at some distance from the surface the potassium may finally be considered as free floating or part of the potassium available for plant uptake. As the com-

**Table 1:** The partitioning of potassium ( $K^+$ ) in a fertile soil into categories of availability for plant growth.

Form of Potassium	Kg K+/ ha.15 cm
Total $K^+$	26,000
Relatively Unavailable $K^+$	23,400
Slowly Available $K^+$	2,080
Readily Available $K^+$	520
Exchangeable $K^+$	468
Soil Solution $K^+$	52

**Figure 1.**





position of the cations in the soil solution changes so does the composition of the ions close to the negative charge.

An illustration of the principle of cation exchange can be found in the operation of a water softener (Figure 3). The resin in the softener tank is negatively charged. When the resin is conditioned and ready for action the negative charges of the resin are neutralized (covered) with positively charged sodium ions. As the hard water from the city main flows over the resin the calcium and magnesium (ions which create the 'hardness' of water) replace the sodium on the resin because there are many orders of magnitude more calcium and magnesium ions around the resin than sodium. The sodium, therefore, migrates into the water leaving the calcium and magnesium on the resin. The water leaving the tank to the household tap is 'soft' and no longer flocculates the soap.

When the majority of the sodium on the resin has been displaced by calcium and magnesium the water from the softener begins to feel 'hard' again and the resin must be recharged. This is done by back washing the resin with a saturated solution of sodium from the brine tank in which you have placed salt - sodium chloride. And so the cycle is repeated.

The ability of clay and humus to exchange cations has great importance in plant growth. The exchange system acts as a reservoir which prevents cations from leaving the rooting zone in the percolating ground water. It allows the reservoir of elements required for plant growth, such as potassium, to be built up by a regular fertilization program, or, it allows the pH of the soil to be modified through liming.

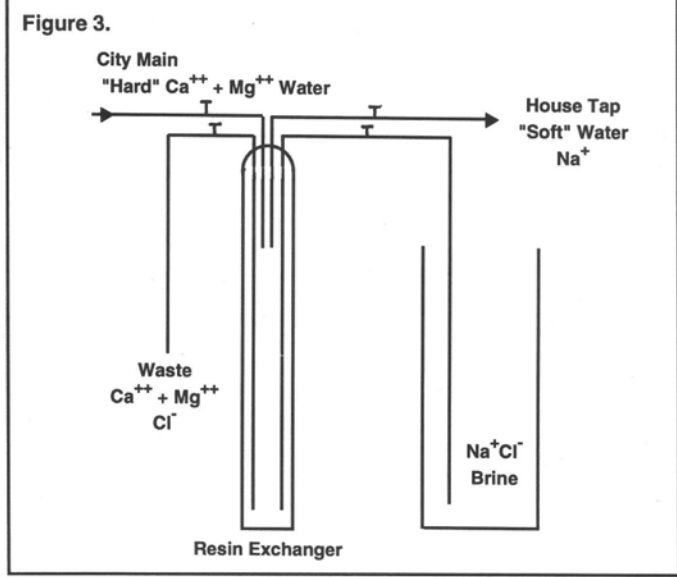
Let us use liming as an example. As we mentioned in a previous article, acid soils have a high concentration of hydrogen, aluminum and manganese in the soil solution. Since

these elements are all cations they will be the major ions in the negative sphere of influence. If limestone is added to the soil, the soil solution becomes saturated with calcium ions. When their number become sufficiently large they begin to displace the hydrogen, aluminum and manganese from the clay and humus. As the ion swarm around the clay and humus becomes increasingly saturated with calcium the hydrogen and aluminum are forced away from the negatively charged surface and are washed out in the percolating water. The soil thus becomes increasingly alkaline and the pH rises. As the pH rises the solubility of aluminum and manganese decreases, resulting in an even more favourable environment for grass root growth.

A similar process takes place when potassium fertilizer is applied. When the potassium fertilizer is dissolved in the soil water the potassium ions displace calcium and magnesium ions from the clay, building up the level of readily available potassium, hence the fertility, of the soil.

The ability of a soil to retain all cations by the exchange system is called the cation exchange capacity; commonly termed the C.E.C. of a soil. The C.E.C. of a soil depends on the amount of organic matter, the amount of clay and the type of clay found in the soil. The silt and sand fractions do not have a negative charge so they have no effect on the C.E.C.

Soil chemists measure the C.E.C. in the soil in units known as milliequivalents per 100 grams. To compare some



**Table 2:** A comparison of the ability of humus and types of clay minerals to retain potassium by cation exchange.

	(grams potassium/kg material)
Humus	78
Montmorillonite clay mineral	39
Illite clay mineral	15.60
Kaolinite clay mineral	3.12
Sandy loam low in organic matter	0.76
Sandy loam high in organic matter	3.90
Clay loam having kaolinitic clay mineral	1.56
Clay loam having illite clay minerals	21.45

soil conditions let us assume the only cation in the soil is potassium. With this assumption the weight of potassium which could be retained under some soil conditions is recorded in Table 2.

These values demonstrate the very important role the decomposition product of organic material, humus, plays in the ability of a soil to retain cations. In a sandy loam soil the increase in organic matter percentage from 1.5% to 6% could result in an increase 5-fold in the C.E.C. Similarly the type of clay mineral which makes up the clay fraction has a large influence. Clays found in the tropics tend to be the kaolinitic types with a low C.E.C. On the other hand clays found in the temperate regions such as Canada have illite to montmorillonite type clays and thus are more fertile due to a higher C.E.C.

There is little which the turf manager can do to alter the amount or type of clay in his soil. He can, however, increase the humus content by returning clippings, top dressing with composted organic materials and using management practices which favour a dense, deep root system. Don't look for immediate results - the process is slow.

Sports fields constructed on an all sand rooting medium will have a very low C.E.C. as evident from the above discussion. The lack of any C.E.C. in sand is one of the reasons many designers will advocate the inclusion of a small amount (3 -10%) of natural top soil in the mix. The important factor, however, is the management procedures which will favour the long term build up of organic matter in the sand.

Furthermore, attention to the potassium nutrition of turf growing on a sand system is critical. More frequent appli-

cations will be required. A soil testing system, which, in fact, measures the exchangeable potassium plus potassium in soil solution, in a sand system will be giving a reading on the potassium primarily in the soil solution, potassium which may be quickly lost by excessive rain or irrigation. There will be little reserve in the cation exchange system.

Controlled release forms of potassium fertilizer are becoming available which have a type of coating to delay the release of the potassium. The turf manager must decide the economics of frequent light applications of soluble forms of potassium versus the cost of the coated materials. There is little research available to guide him regarding the application timing of slow release potassium.

An additional factor to consider in potassium nutrition of turf is the problem of luxury consumption. When a grass plant is exposed to an abnormally high level of potassium in the soil solution it will continue to absorb potassium to concentration levels in the leaf tissue which are in excess of what is required for normal growth. While not directly harmful, luxury consumption is wasteful if the clippings are removed from the site. Of more concern is the suppression effect the high levels of potassium has on the uptake of other cations such as calcium and magnesium. Where turf is produced on normal mineral soils with an average C.E.C. luxury consumption and depression of calcium and magnesium uptake is not a concern. Where the rooting medium is sand, however, it becomes an additional positive factor when debating the use of controlled release potassium.

All potassium fertilizers, with the exception of controlled release forms, are

water soluble. As a result they can cause foliar burn when applied at high rate or where there has been an over application due to equipment failure or operator error. It is recommended that not more than 1.0 kg K<sup>+</sup>/100 m<sup>2</sup> be applied in any application.

Estimating the rate of application of potassium is best done on the basis of a soil test for turf grown on normal soils. On sand rooting system a rule of thumb which calls for 3/4 to one kilogram of potassium for each kilogram of nitrogen may be used.

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