Salts, Soils, and Turf

A misunderstood relationship

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Salt is not the evil turf killer that must-be-avoided-at-all-cost villain many turf managers have come to fear. It is in fact a necessary component of many fertilizers. That also doesn't mean that you should go out and sprinkle salt all over you turf like Morton's little girl in the rain coat. To better understand the function of salts in turfgrass management, you must first understand the basic process of nutrient absorption by turf. Turfgrass requires three nutrients in relatively large amounts from soil. They include: nitrogen, phosphorus, and potassium. Turfgrass also requires at least eleven other nutrients in relatively smaller amounts: calcium, magnesium, sulfur, boron, chlorine, copper, iron, manganese, molybdenum, zinc and nickel. Nutrients must be in a soluble form before turfgrass can use them. For instance nitrogen is readily available in the atmosphere, but is unavailable in this form to turf. Nitrogen must be in the form of ammoniacal or nitrate for turfgrass to utilize it. One of the factors controlling nutrient availability is soil pH levels. Many soil nutrients are hampered or restricted by high or low soil pH.

In order to have a healthier turf throughout the season, turfgrass managers must maintain a healthy reliable nutrient-rich soil. Turf managers are generally concerned with four soil salts: sodium, copper, chloride and boron.

To understand salts, one must understand what a salt is. Salts are the products, other than water, of the reaction of an acid with a base. That's quite a mouth-full, but it's actually very simple. The classical concept of acids and bases is the neutralization process of combining a hydrogen ion and a hydroxyl ion to form water. $H^+ + OH^- = H_2O$. When the fertilizer salt K_2SO_4 (potassium sulfate) is applied to the soil, the compound divides into K^+ and SO_4^-. The potassium ion can then be used by plant materials or it attaches to the clay colloids while the sulfate ion stays in the soil solution and moves with water to the roots, to be used by plants, or can be leached below the root zone or away from the plant materials. All fertilizer salts react the same way, whether they are potassium chloride (KCl), ammonium nitrate (NH_4NO_3), or ferrous oxide (FeO). The negative ions (anions), such as NO_3^-, SO_4^-, and Cl^-, ***all*** stay in the soil solution and don't attach to the soil colloids. The positive charged ions (cations), such as K^+, NH_4^+, Ca^{++}, etc. attach to the negative sites on the clay particles in the soil. All soils are negatively charged and only the positive cations can attach to it.

Of course, just as in life, too much of any one thing is not good. Moderation is the key. As salt levels in the soil increase, the soil will hold more tightly to water. As the soil increases its hold on water, plants will eventually fail to extract water and drought symptoms can occur. If the turf manager's water source has high amounts of salts, then

the management of the irrigation is a much more important task. We need large amounts of water to move excess amounts of salts through the soil.
This brings to light the chloride ion (Cl^-), which needs some discussion. Some turf managers feel that the chloride ion might add to a "salt" buildup in the soil. This is a false assumption. Since the chloride ion doesn't attach to the soil, just as the sulfate ion also reacts, it can leach from the soil. Sulfate of potash can add just as much "salt" to the soil as muriate of potash (potassium chloride) does. You need to apply more sulfate of potash (SOP) to add the same amount of "K" that you would get from a smaller amount of muriate of potash (MOP), because SOP is around a 50% K_2O, while MOP is around a 60% K_2O material.

About 95% of all potash used is from muriate of potash.[1] All potash fertilizer salts (KCl, KSO_4, and KNO_3) are soluble in water and are considered readily available. In general, it can be said that there is very little difference in their effects on crop production except in tobacco where sulfate of potash produces a superior burning quality leaf.[2]

Chlorides are readily leached from soils. Even though little is known about chlorine as a plant nutrient, it has been demonstrated that plants grown on soils that contained only 3 to 5 meq. Cl/100 g. showed severe chlorine deficiency.[2] The symptoms of chlorine deficiency are not easily identified. Plants so affected are said to wilt, to become chlorotic and necrotic in some area, and to exhibit leaf bronzing.[3] Potassium chloride has also shown fungicidal properties in turf, wheat, and other crops. The chloride in muriate of potash prevents black heart in celery for example.

Some turf managers are also concerned about the "salt index" of muriate of potash. The salt index is an index to compare the solubility of chemical compounds. Most nitrogen and potassium compounds have higher salt indexes while phosphorus compounds tend to have a lower salt index. Salt indexes are the measurement of burn potential, and are based on sodium nitrate (an index of 100). Below are some common indexes of some standard fertilizer products:

Ammonium sulfate	69.0
Potassium sulfate	46.1
Potassium chloride	116.3
Ammonium nitrate	104.7
Urea	75.4
Turf Supreme	65.6
6-20-20 xb	45.0
Calcium nitrate	52.5

All of the above fertilizers have a burn potential, but none of them will burn turf if they are applied at the right amount and irrigated in.
None of the above fertilizers add any harmful "salts" to the soil. All of the above fertilizers add good salts that the turf will use to facilitate proper growth. If you have

[1] Fundamentals of Soil Science, Fifth edition, Foth and Turk
[2] Soil Fertility and Fertilizers, Second edition, Tisdale and Nelson

heavy soils that don't drain well, you will want to watch your levels of those nutritive salts that can be toxic in high quantities. These are chlorine, copper, and boron.

Even though fertilizer salts can add the necessary nutrients to the soil, that doesn't mean that the elements will be available to the plant materials. Iron is a good example. Iron is taken up by plants as ferrous ions (Fe^{++}). Most of the soil iron is unavailable to plants. Deficiencies are common in high pH soils. Turfgrasses are especially susceptible to iron deficiency.[3] Iron deficiency can be caused by an imbalance of metallic ions, such as copper and manganese, excessive amounts of phosphorus, a combination of high pH, high lime, high soil moisture, and cool temperatures, and high levels of HCO_3^- (bicarbonate) in the rooting medium.[4] As you can see there are many factors that influence the availability of iron. In general, soil applications of ionizable ferrous salts, such as ferrous sulfate, have proven as ineffective as other forms because of their rather rapid oxidation to ferric iron. Fritted iron (sucrate) can be used on acid soils, but is not suitable for use on alkaline or calcareous soils (with calcium carbonate).[5] Iron oxide and ferrous sulfate will show some response on turf under alkaline conditions while iron sucrate generally won't be available. The best availability of iron on turf will be through foliar applied materials, whether ferrous sulfate or chelated iron. It's interesting that a side benefit to iron oxide is that it's been proven that iron oxide is second in importance behind microbial gum in soil aggregation (soil texture). Iron oxide is more important than organic carbon (organic matter), and clay.[5]

Turf managers wishing to control soil salt concentrations and salt types must test the soil. Soil tests can indicate the levels of soil pH, sodium, all of the necessary nutrients and the total salts in the soil. You should test for salts at the same time of the year to compare one test to another. The proper analysis of soils will allow turf managers to adjust the fertility levels and provide a reliable nutrient-rich soil for healthy turf.

There's a lot to understand about fertilizer salts, but the more you understand, the better you will be able to choose fertilizers for optimum turf performance.

[3] Western Fertilizer Handbook, Second edition, California Fertilizer Association
[4] Soil Fertility and Fertilizers, Second edition, Tisdale and Nelson
[5] Fundamentals of Soil Science, Fifth edition, Foth and Turk