CHARACTERISTICS OF WATER SOLUBLE NITROGEN FERTILIZERS

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Nitrogen is the keystone of a lawn fertilization program, and both soluble and slowly soluble sources are available to the turfgrass industry. Soluble nitrogen fertilizers are less expensive than the slowly soluble sources but, in general, have a higher burn potential and are more likely to be lost through leaching and volatilization. These risks can be minimized, however, if the contributing factors are understood.

Fertilizer burn

Fertilizers contain salts that are similar to table salt (sodium chloride) except that fertilizer salts contain the elements essential for plant growth. When salts dissolve in water, they dissociate into positively and negatively charged ions, **and it is in this form that nutrients are absorbed by plant roots.** Soluble fertilizers are in the salt form when applied to turfgrass, which accounts for their immediate availability for absorption. Slowly soluble fertilizers may contain some soluble salts, but most of the nutrient salts are released over a period of time as the slowly soluble fertilizer is hydrolyzed or decomposed in the soil. Thus, a major difference between soluble and slowly soluble fertilizer is the release rate of the nutrient salts.

Salts dissolved in soil solution increase the osmotic pressure that governs the flow of water across a root cell membrane. Water always moves through a cell membrane from the side that has the lowest osmotic pressure to the side that has the highest pressure. Since root cells actively absorb nutrient salts, the osmotic pressure of the cell sap is normally higher than that of the surrounding soil solution — and water is absorbed into the root tissue. This process, in fact, is how plants absorb water. However, if excess fertilizer salts in the soil solution increase the osmotic pressure above that of the cell sap, water is drawn out of the roots, and the resultant injury is termed "fertilizer burn." Symptoms of fertilizer burn resemble those of drought injury since, in both cases, the immediate problem is lack of water in the plant.

The relative tendency of a fertilizer to release salts and increase the osmotic pressure of the soil solution is measured by the salt index. The higher the salt index value, the greater the tendency of a fertilizer to increase the osmotic pressure and the greater the burn potential. The salt indexes of common soluble nitrogen fertilizers are listed in Table 1, which also compares the adjusted salt indexes, based upon the total nutrient content.

Environmental factors such as temperature, humidity, and soil moisture also affect the burn potential of a fertilizer. As the air temperature increases and as the humidity decreases, the water requirement of plants increases. Because of the increased water requirements for plants, the level of soluble salts in soil solution that is "safe" during

Table 1. Solubility and Salt Indexes of Soluble Nitrogen Fertilizers

Fertilizer	Formula	Primary analysis (percent) N	P_2O_5	K_2O	Total plant food[a]	Salt index[b]	Adjusted salt index[c]	Solubility[d]
ammonia	NH_3	82.0	—	—	82.0	47.1	57.4	90
urea	H_2NCONH_2	46.0	—	—	46.0	75.4	163.9	67
ammonium nitrate	NH_4NO_3	33.5	—	—	33.5	104.7	312.5	118
ammonium sulfate	$(NH_4)_2SO_4$	21.0	—	—	21.0	69.0	328.6	71
sodium nitrate	$NaNO_3$	16.0	—	—	16.0	100.0	625.0	73
calcium nitrate	$Ca(NO_3)_2$	15.0	—	—	15.0	65.0	433.3	134
potassium nitrate	KNO_3	13.0	—	46.0	59.0	73.6	124.7	13
monoammonium phosphate	$NH_4H_2PO_4$	11.0	48.0	—	59.0	29.9	50.7	43
diammonium phosphate	$(NH_4)_2HPO_4$	18.0	46.0	—	64.0	34.2	53.4	25
ammonium polyphosphate (liquid form)	NH_4PO_3	10.0	34.0	—	44.0	29.9[e]	67.9	—

[a]Percent N + percent P_2O_5 + percent K_2O (primary analysis).
[b]Rader, L. F., Jr., et al. 1943. *Soil Science* 55(3):201-18.
[c]Salt index per unit of plant food = (2) x 100/(1).
[d]Parts in 100 parts pure water at 32° F.
[e]TVA.

cool, humid weather may cause burn injury during periods of warm weather or low humidity or both.

Soil moisture is a major factor in determining the fertilizer's potential to burn. If the soil is relatively dry, a fertilizer will have a greater effect on increasing the osmotic pressure of the soil solution. Conversely, if the soil is saturated, the fertilizer salts will disperse and the osmotic pressure will not increase greatly. In addition, the evapotranspiration of water will help cool the plant and raise the humidity near the soil surface, effectively reducing the plant's water requirement.

Leaching

Nutrient leaching is the removal of soluble fertilizers from the root zone by the downward percolation of water. Most of the soluble fertilizer nitrogen will be present in one or more of three forms: ammonium (NH_4+), nitrates ($NO_3—$), and urea ($CO(NH_2)_2$).

Ammonium is water soluble, but the strong attraction between the positively charged ammonium ion and the negative sites on clay minerals and soil organic matter prevents leaching. Ammonium, however, is rapidly oxidized to nitrates when the soil temperature is above 50°F.

Nitrate is a negatively charged ion and, as such, is readily leached because it does not bind to soil particles. Leaching of nitrate from the rooting zone is a much greater problem in coarse-textured soils. Research has shown that nitrate may be leached about 1 inch of rainfall for each inch of rainfall in clay loam soils to 2.5 inches for each inch of rainfall in sandy loam soils.

Urea fertilizer is readily soluble when it is first applied to the soil, but when it changes to ammonium it is held by clay and humus is a form that is readily available to plants. Under favorable temperature and moisture conditions, urea hydrolyzes to ammonium carbonate and then to nitrate within less than a week.

Volatilization

Volatilization involves the conversion of nitrogen to ammonia gas, which is lost to the atmosphere. This process is favored by alkaline soils, dry soils, soils with a low exchange capacity, and warm temperatures. When conditions favor volatilization, 25 percent or more of the applied nitrogen may be lost to the atmosphere.

When ammonic fertilizers and urea are placed in the soil, the ammonia gas that they release is held by the soil particles. However, when urea or ammonic fertilizers are placed on top of the soil, the released ammonia does not have the clay or moisture to hold it from being partly volatilized.

All of the characteristics of nitrogen fertilizers should be considered when a turf fertilization program is planned. If the materials are applied properly for the existing soil and environmental conditions, soluble nitrogen fertilizer can be just as effective as slowly soluble sources in providing the turfgrass plant with the nitrogen it requires. **WTT**