W161-E

Turfgrass Maintenance Fertilizers

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As early as the mid-1800s, scientists recognized the benefits of developing fertilizer recommendations by first analyzing plants and studying the elements they contain. The German chemist Justice von Liebig (1803-1873) manufactured an original fertilizer based on his opinions regarding plant nutrition. He proposed that, assuming all other plant-nutrient elements are adequate, the growth of plants is limited by the one present in the smallest amount. Although results of much later research proved that plants require more of some essential elements and less of others, Liebig's 'law of the minimum' influenced fertilization practices for some time. Benjamin Franklin demonstrated the fertilizer value of gypsum (calcium sulfate) by selectively applying it to a pasture. By using gypsum, and the additional plant growth that followed, to outline the words 'this land has been plastered,' Franklin showed that plants can benefit from the timely application of certain materials called fertilizers.

Gypsum

The Fertilizer Analysis. Fertilizers applied to turfgrasses often contain the primary essential nutrients nitrogen (N), phosphorus (P) and potassium (K) and may contain essential secondary [calcium (Ca), magnesium (Mg) and sulfur (S)] and minor [boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn)] nutrients. The fertilizer label contains information regarding the nutrient content of the product. A fertilizer with a 20-5-15 analysis contains by weight 20 percent N, 5 percent phosphate (P_2O_5) and 15 percent potash (K_2O). A 50-lb. bag of 20-5-15 contains:

20-5-15

0.5 x 20 = 10 pounds of N
0.5 x 5 = 2½ pounds of P_2O_5
0.5 x 15 = 7½ pounds of K_2O

Since the fertilizer label reports by weight percent P_2O_5 and percent K_2O rather than percent elemental P and K, turfgrass managers often use the following conversion factors:

$$P_2O_5 \times 0.44 = P$$
$$K_2O \times 0.83 = K$$

In addition to 10 pounds of N, a 50-lb. bag of fertilizer with a 20-5-15 analysis contains:

0.5 x 5 x 0.44 = 0.5 x 2.2 = 1.1 pounds of P
0.5 x 15 x 0.83 = 6.2 pounds of K

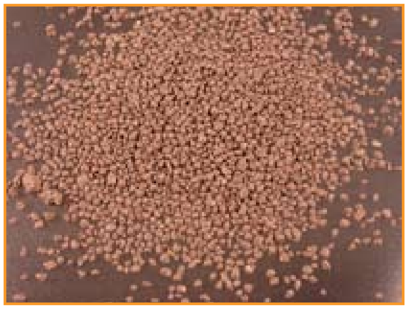
Nitrogen Sources. Some N sources are very soluble in water and are released to turfgrasses quickly. Others (controlled-release) are formulated to dissolve or release into the solution

Ammonium Sulfate

surrounding turfgrass roots very slowly. A N source may be inorganic (containing no carbon) or organic, synthetically produced or natural and coated or non-coated.

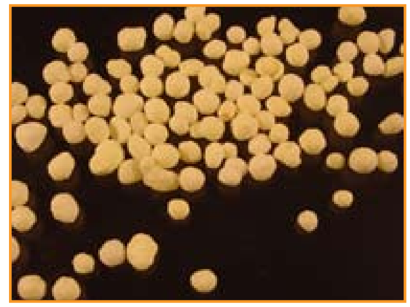
Ammonium nitrate, ammonium sulfate, calcium nitrate and potassium nitrate are examples of inorganic nitrogen sources. Each is very soluble in water and may absorb moisture from the air during storage. Aerial shoots of turfgrasses may be severely injured (e.g., foliar burn) if too much of an inorganic nitrogen source is applied.

Dried, activated sewage sludge and animal (e.g., manure and feather, leather and blood meal) and plant (e.g., corn gluten meal and proteins) by-products are examples of natural organic fertilizers. Nitrogen is released from these materials slowly, as a result of the activity of soil microorganisms. Natural organic fertilizers have a very low burn potential and do not usually release N when microorganisms in the soil are inactive due to cold temperatures or anaerobic conditions.



Activated Sewage Sludge

The rate of N release varies among the synthetic organic nitrogen sources. Urea, one of the most concentrated and widely used, quickly available, synthetic organic N sources, releases N rapidly and has a moderate burn potential. Slow-release, synthetic, organic N sources are formed by coating granular urea (e.g., with molten sulfur, a polymer or a combination of the two) or reacting it with other chemicals. Ureaformaldehyde (UF) or methylene ureas are formed by a process known as polymerization. Chains of nitrogen-containing molecules are produced as urea is reacted with formaldehyde. Chain length increases as the polymerization reaction proceeds. Generally, the longer the chain, the slower the rate of N release and the lower the burn potential. Triazone, formed by reacting urea, formaldehyde and additional ammonia, is a clear liquid. Isobutylidine diurea (IBDU), formed by the reaction of isobutyraldehyde and urea, contains 31 percent N. Nitrogen release from IBDU is not dependent on the activity of soil microorganisms. Increasing temperatures accelerate the rate of N release from IBDU and other slowly soluble nitrogen sources.



Polymer-coated, Sulphur-coated Urea

Some common sources of nitrogen in turfgrass fertilizers.

Source	Formula	~ Content (%)			Salt Index per Unit[a]	Acidifying Effect[b]	Cold-water Solubility[c] (lbs. / gal.)	Comments
		N	P_2O_5	K_2O				
Ammonium nitrate	NH4NH3	33	0	0	3.2 H	62	14.5	Contains both ammonium ions that are adsorbed by soil colloids, and nitrate ions that may be mobile in soils
Ammonium sulfate	(NH4)2SO4	21	0	0	3.3 H	110	5.7	Contains 24 percent sulfur and has the greatest acidifying effect of materials listed

Source	Formula	~ Content (%)			Salt Index per Unit[a]	Acidifying Effect[b]	Cold-water Solubility[c] (lbs. / gal.)	Comments
		N	P_2O_5	K_2O				
Calcium nitrate	Ca(NO3)2	15	0	0	---	---	---	Calcium-containing (19 percent) source of nitrogen; absorbs moisture very rapidly
IBDU (isobutylidene diurea)	[CO(NH2)2]2C4H8	31	0	0	0.2 L	---	SS	Two urea molecules are linked by a carbon group, resulting in a source of nitrogen dependent on hydrolysis for release
Milorganite	organic - N complex	6	4	0	0.7 L	---	SS	Nitrogen in this activated sewage sludge is released by microbial activity
Polymer (plastic)-coated urea	CO(NH2)2 + polymer	38	0	0	---	---	SR	Nitrogen release is dependent on hydrolysis
Potassium nitrate	KNO3	13	0	44	5.3 H	(-23)	1.0	May slightly increase soil pH as it rapidly releases nitrogen
SCU (sulfur-coated urea)	CO(NH2)2 + sulfur	32	0	0	0.7 L	---	SR	Permeable sulfur (molten) coating allows water to slowly move through the barrier, dissolving the enclosed urea; nitrogen release is dependent on microbial activity and hydrolysis
Urea	CO(NH2)2	45	0	0	1.7M	71	6.2	This highly water-soluble nitrogen source contains the highest nitrogen concentration of any granular fertilizer
UF (urea formaldehyde or methylene ureas)	[CO(NH2)CH2]nCO(NH2)2	38	0	0	0.3L	---	SS	Nitrogen is released from these various-size, 'chain-like' polymers of urea as a result of soil microorganism activity

[a] Expressed as the relative salinity of mineral salts per unit of nutrient compared to sodium nitrate (6.3). High = 2.6 or greater; moderate = 1.0 to 2.5; and low = less than 1.0.

[b] Units of $CaCO_3$ required to neutralize 100 units of fertilizer (by weight)

[c] SS = slowly soluble; SR = slow release

Some common sources of calcium, magnesium and sulfur for turfgrasses.

Source	Formula	Neutralizing value %	~ Calcium %	~ Magnesium %	~ Sulfur %
Ammonium sulfate	$(NH_4)_2SO_4$	0	0	0	24
Calcium carbonate	$CaCO_3$	100	32	0	0
Calcium hydroxide	$Ca(OH)_2$	136	46	1	0
Calcium metaphosphate	$Ca(PO_3)_2$	0	19	0	0
Calcium nitrate	$Ca(NO_3)_2$	0	19	2	0
Calcium oxide	CaO	179	52	0	0
Dolomitic limestone	$CaMg(CO_3)_2$	109	22	11	0
Ferrous ammonium sulfate	$(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$	0	0	0	16
Ferrous sulfate	$FeSO_4 \cdot 7H_2O$	0	0	0	18
Gypsum	$CaSO_4 \cdot 2H_20$	0	22	0	19
Magnesium carbonate (Magnesite)	$MgCO_3$	119	0	28	0
Magnesium hydroxide	$Mg(OH)_2$	172	0	40	0
Magnesium oxide	MgO	250	0	55	0
Magnesium sulfate (Epsom salt)	$MgSO_4$	0	0	10	14
Potassium magnesium sulfate	$K_2SO_4 \cdot 2MgSO_4$	0	0	11	22
Potassium sulfate	K_2SO_4	0	0	0	17
Sulfur, elemental	S	0	0	0	99
Superphosphate	$CaH_4(PO_4)_2$	0	21	0	12

Some common sources of micronutrients applied to turfgrasses.

Micronutrient	Source	Formula	Content
Boron	Borax	$Na_2B_4O_7 \cdot 10H_2O$	11% boron
	Boric acid	H_3BO_3	17% boron
	Solubor	$Na_2B_4O_7 \cdot 5H_2O + Na_2B_{10}O_{16} \cdot 10H_2O$	20% boron
Chlorine	Potassium chloride	KCl	47% chlorine
Copper	Copper chelate[a]	CuEDTA	6 to 13% copper
	Copper oxide	CuO	75% copper
	Copper sulfate, pentahydrate	$CuSO_4 \cdot 5H_2O$	25% copper
Iron	Ferric oxide	Fe_2O_3	69% iron
	Ferric sulfate	$Fe(SO_4)_3 \cdot 4H_2O$	23% iron
	Ferrous ammonium sulfate	$(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$	14% iron
	Ferrous oxide	FeO	77% iron
	Iron ammonium polyphosphate	$Fe(NH_4)HP_2O_7$	22% iron
	Iron (ferrous) sulfate	$FeSO_4 \cdot 7H_2O$	20% iron
	Iron chelate[a]	NaFeEDTA	5 to 14% iron
Manganese	Manganese carbonate	$MnCO_3$	31% manganese
	Manganese chelate[a]	MnEDTA	12% manganese
	Manganese chloride	$MnCl_2$	17% manganese
	Manganese methoxyphenylpropane	MnMPP	10 to 12% manganese
	Manganese oxide	MnO_2	63% manganese

Micronutrient	Source	Formula	Content
	Manganese sulfate	$MnSO_4 \cdot 3H_2O$	26 to 28% manganese
	Manganous oxide	MnO	41 to 68% manganese
Molybdenum	Ammonium molybdate	$(NH_4)_2MoO_4$	49% molybdenum
	Sodium molybdate	$Na_2MoO_4 \cdot 2H_2O$	39% molybdenum
Zinc	Basic zinc sulfate	$ZnSO_4 \cdot 4Zn(OH)_2$	55% zinc
	Zinc carbonate	$ZnCO_3$	52% zinc
	Zinc chelate[a]	$Na_2ZnEDTA$	14% zinc
	Zinc oxide	ZnO	78% zinc
	Zinc phosphate	$Zn_3(PO_4)_2$	51% zinc
	Zinc sulfate monohydrate	$ZnSO_4 \cdot H_2O$	35% zinc
	Zinc sulfate heptahydrate	$ZnSO_4 \cdot 7H_2O$	23% zinc

[a] Micronutrients can be combined with organic compounds to produce more stable or 'chelated' carriers. Chelated micronutrient carriers have a longer residual response in soils and are less prone to loss by leaching. Chelating agents include: EDTA (ethylenediamine tetraacetate), DTPA (diethylenetriamine pentacetate) and EDDHA [ethylenediamine di-(*o*-hydroxyphenylacetate)].

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