COOPERATIVE EXTENSION SERVICE

UNIVERSITY OF ALASKA FAIRBANKS

fraction. If applied in elemental form, sulfur must be converted in the soil to sulfate, the form of sulfur that can be used by plants. For this reason, sulfur fertilizers should be scrutinized for their relative plant availability. Another manufactured sulfur fertilizer is ammonium sulfate. Sulfur in ammonium sulfate is readily available to plants; therefore, where immediate sulfur response is required, a sulfate source should be selected. In a soil sulfur building program or where long term sulfur availability is required (perennial crops), a combination of elemental sulfur and sulfate is desirable. Care should be used when applying elemental sulfur as this material lowers soil pH during the converting process.

Calcium, and magnesium if required, is normally applied in liming materials discussed in the next section. Gypsum (calcium sulfate) and calcium nitrate are sources of calcium that do not signif-cantly raise the pH of the surrounding soil.

The micronutrients required by plants include zinc, manganese, copper, iron, boron, nickel and molybdenum. The term micronutrient accurately describes these nutrient elements because they are required in very small amounts for plant growth, although they are just as important as macronutrients. For this reason, micronutrients are often applied with seeds or in foliar sprays. Table 2 lists various inorganic micronutrient sources and their solubility in water.

Metallic micronutrients (manganese, copper, iron and zinc) are also commercially available in chelated forms. Chelates are designed to hold the micronutrient atoms in solution for increased plant availability. These forms are important agriculturally since micronutrients are often plant unavailable because of soil physical and chemical limitations or are relatively water insoluble pH. Oyster shells are pure calcium carbonate which, when finely ground, increase soil pH.

Oxides, liming materials commonly known as burned lime, quicklime and unslaked lime, are made by baking or roasting crushed calcitic or dolomitic lime in an oven or furnace, which drives off carbon dioxide and leaves a pure oxide. These oxides are the most efficient liming materials on a pound-for-pound basis and react

Lime application rates are typically much higher than fertilizer application rates. Soils should be limed to a pH of 6.0 to 6.5 for the best crop production. Observing proper lime application rates will limit the chance of overliming, which, in addition to being expensive, can drastically

Table 1. Primary and secondary fertilizer nutrient source composition.

Fertilizer Material	Chemical Formula	Nutrient Composition (%)					
		Primary			Secondary		
		N	P_2O_5*	K_2O	S	Ca	Mg
Ammonium nitrate	NH_4NO_3	34	—	—			

Table 2. Micronutrient sources and water solubility.

Fertilizer Material	Chemical Formula	Element %	Water Solubility g/100g H_2O	Temperature °F
Boron				
Granular borax	$Na_2B_4O_7 \cdot 10H_2O$	11.3	2.5	33
Sodium tetraborate, anhydrous	$Na_2B_4O_7$	21.5	1.3	32
Solubor	$Na_2B_8O_{13} \cdot 4H_2O$	20.5	22	86
Ammonium pentaborate	$NH_4B_5O_8 \cdot 4H_2O$	19.9	7	64
Copper				
Copper sulfate	$CuSO_4 \cdot 5H_2O$	25.0	24	32
Cuprous oxide	Cu_2O	88.8	*	
Cupric oxide	CuO	79.8	*	
Cuprous chloride	Cu_2Cl_2	64.2	1.5	77
Cupric chloride	$CuCl_2$	47.2	71	32
Iron				
Ferrous sulfate	$FeSO_4 \cdot 7H_2O$	20.1	33	32
Ferric sulfate	$Fe_2(SO_4)_3 \cdot 9H_2O$	19.9	440	68
Iron oxalate	$Fe_2(C_2O_4)_3$	30.0	very soluble	
Ferrous ammonium sulfate	$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$	14.2	18	32
Ferric chloride	$FeCl_3$	34.4	74	32
Manganese				
Manganous sulfate	$MnSO_4 \cdot 4H_2O$	24.6	105	32
Manganous carbonate	$MnCO_3$	47.8	0.0065	77
Manganese oxide	Mn_3O_4	72.0	*	
Manganous chloride	$MnCl_2$	43.7	63	32
Manganous oxide	MnO	77.4		
Molybdenum				
Sodium molybdate	$Na_2MoO_4 \cdot H_2O$	39.7	56	32
Ammonium molybdate	$(NH_4)Mo_7O_{24} \cdot 4H_2O$	54.3	44	77
Molybdic oxide	MoO_3	66.0	0.11	64
Zinc				
Zinc sulfate	$ZnSO_4 \cdot H_2O$	36.4	89	212
Zinc oxide	ZnO	80.3	*	
Zinc carbonate	$ZnCO_3$	52.1	0.001	60
Zinc chloride	$ZnCl_2$	48.0	432	77
Zinc oxysulfate	$ZnO \cdot ZnSO_4$	453		

Table 3. Calcium Carbonate Equivalence (CCE) values of various liming materials.

Liming Material	Chemical Composition	CCE
Calcitic limestone	$CaCO_3$	98–100
Dolomitic limestone	$CaMg(CO_3)_2$	100–109
Hydroxides	$Ca(OH)_2$ or $Mg(OH)_2$	120–136
Oxides	CaO or MgO	150–179
Marl	$CaCO_3$•X*	60–90
Slags	$CaSiO_3$•X*	50–90
Sludges	$CaCO_3$•X*	30–80
Wood ashes		