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Fertilizer and Lime Materials

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Chemical fertilizers, when properly used, provide a satisfactory source of plant nutrients and can increase the yield and quality of crops when applied to nutrient-deficient soils. Other materials such as manure, sewage sludge, and industrial wastes may supplement the nutrient needs of most crops. In many situations, because of guaranteed analysis, accessibility, and transportation costs, chemical fertilizers provide the least expensive and accurate means of supplying plant nutrient requirements.

Soil acidity may be one of the factors that limit yield and growth responses to applied fertilizer. Lime is applied to reduce soil acidity.

Fertilizer grade

The grade of a fertilizer indicates the available nutrient content expressed in terms of percentages of nitrogen (N), phosphorus pentoxide (P_2O_5), and potash (K_2O), in that order. Nitrogen (N) is expressed on the elemental basis, and phosphate and potash are expressed as the oxides rather than elemental phosphorus (P) and potassium (K). A fertilizer grade of 10-20-5, contains:

10% N, 20% P_2O_5, and 5% K_2O

Fertilizers containing relatively large amounts of nutrients are "high analysis fertilizers." A fertilizer with a grade of 10-20-20 has a high analysis by comparison with a 4-8-8 grade. High analysis fertilizers often provide nutrients at lower relative cost due to lower costs per pound of plant nutrient for transportation, storage, and application. Fertilizers containing the three nutrients N, P, and K sometimes are referred to as "complete."

Other nutrients

Fertilizers often contain other nutrients such as sulfur (S) and magnesium (Mg), or micronutrients such as boron (B), zinc (Zn), or molybdenum (Mo). These nutrients are listed on the fertilizer label on an elemental basis similar to nitrogen and sometimes are included in the fertilizer grade. A 15-5-10-8S fertilizer contains an additional 8% S.

Some micronutrient elements such as B and Mo can be toxic to plants if applied in slightly excessive amounts. Apply only recommended amounts of these nutrients.

Application of fertilizers

Recommendations for the method of fertilizer application should be followed for these reasons:

1. Nutrients such as P, K, Mg, and Zn are immobile in the soil and should be "placed" or "banded" in the rooting zone or incorporated by tillage.
2. Fertilizers can cause plant damage if banded close to seed or roots at rates in excess of those suggested. Fertilizers containing B never should be banded but should be applied evenly to the fertilized area.
3. Losses of N into the atmosphere can occur when some N fertilizer materials are applied to the surface of the soil and are not incorporated.
4. N fertilizers applied in excess or before active plant growth can result in N contamination of groundwater.

Dilute solutions of fertilizers sometimes are applied as "foliar" sprays. This practice often is used to apply micronutrients. Large amounts of nutrients cannot economically be applied using foliar sprays. Foliar sprays often are used when a rapid response to a micronutrient deficiency is needed.

Rates of application of fertilizer materials

Most fertilizer applications suggested in OSU fertilizer guides are stated in terms of pounds per acre of N, P_2O_5, K_2O, or S, etc. To convert these recommendations to pounds per acre of an actual fertilizer material, use the following formula:

$$\frac{\text{Pounds of nutrient recommended}}{\text{Percentage of nutrient in fertilizer material}} \times 100$$

Example: To supply 80 lb of N using ammonium sulfate that has a grade of 21-0-0:

80/21 x 100 = 380 lb of ammonium sulfate should be applied.

Fertilizer guides dealing with lawns and gardens provide recommendations in lb/100 sq ft or lb/1,000 sq ft. Vegetable and fruit tree guides do not provide units for smaller acreage. To convert pounds per acre (lb/a) to lb/100 sq ft, divide by 400. A fertilizer application of

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400 lb/a would equal 1 lb/100 sq ft. Similarly, to convert lb/a to lb/1,000 sq ft, divide lb/a by 40. A fertilizer application rate of 400 lb/a would be 10 lb/1,000 sq ft.

Solid fertilizers

Solid fertilizer materials are available as pellets or granules. The solubility of solid fertilizer materials varies. Some, such as urea and ammonium nitrate, can be dissolved and applied in irrigation water.

Fluid fertilizers

This term applies to fertilizer solutions and suspensions. Suspensions are fluid mixtures containing dissolved and undissolved plant nutrient materials that may require agitation to ensure homogeneity. Solutions contain only dissolved materials. A common N solution in Oregon is urea-ammonium nitrate, 32-0-0, accounting for over 20% of the N applied. Suspensions usually have a higher P and K grade compared to solutions. The grade of liquid fertilizers is expressed similarly to solid fertilizers.

Nitrogen solutions are classed as pressure or nonpressure. Pressure solutions have appreciable vapor pressure due to ammonia. Such solutions must be injected into the soil to prevent loss of ammonia.

Blended fertilizers

Blending fertilizer materials may be necessary to obtain a desirable grade or ratio of nutrients. Not all materials can be blended. For instance, urea and ammonium nitrate, when blended, give a moist, mushy mixture. Fertilizer materials may be of different sizes, creating segregation and the potential for uneven distribution of the materials. Segregation is most likely to occur during transportation. Segregation can be reduced by using fertilizer material of similar particle size in blended fertilizers. This is especially important for micronutrients or nutrients included in small amounts compared to the major amount of fertilizer being blended. Segregation can be avoided by adding micronutrients as a coating to the particles of bulk fertilizer material.

Blended fertilizers are available in solid and liquid forms. Chemicals that control weeds, insects, and other pests sometimes are blended and applied with fertilizer materials. Before preparing such blends, determine the compatibility of the ingredients.

Slow-release fertilizers

Some fertilizers, such as urea formaldehyde, magnesium ammonium phosphate, and coated fertilizers, release nutrients slowly to supply plant food over a relatively long time period. Uses for these materials include potting mixtures and turf management. Slow-release fertilizers can reduce plant toxicity hazards due to a slower release of nutrients into the soil solution. These materials usually are comparatively expensive. Slow-release N fertilizers offer the potential for reduced N leaching if the N fertilizer release can be matched to crop demand. Other materials that release nutrients at relatively slow rates include organic fertilizers such as blood meal, tankage, sewage sludge, manure, and seafood waste.

Fertilizer salt effect (salt index)

Fertilizer applications increase the concentration of salt in the soil and when incorrectly applied can create toxic salt concentrations. Fertilizer materials differ in their ability to create salt problems in the soil. The salt index is a measure of the tendency of a fertilizer to create a salty condition in the soil.

The salt index of a fertilizer is based on a comparison with sodium nitrate and is used to compare solubility of fertilizers. Fertilizers with high salt index have a high potential to damage young plants compared to fertilizers with a lower salt index. The salt index for selected fertilizers is listed in Table 1. Salt toxicity is likely to be more serious in soils with low moisture content, in sandy soils, or where fertilizer is banded close to seed or plants.

Acidity from fertilizers

Some N fertilizer materials acidify soil. The continuous use of acidifying fertilizers over a period of years can appreciably lower soil pH. The acidifying effect of fertilizers can be neutralized through the application of lime. Fertilizer materials vary in their ability to create soil acidity, and some have no acidifying effect (see Table 1). Some fertilizers, such as urea, initially raise the pH of the soil, but the longer term effect is an increase in soil acidity.

Table 1.—Acidifying potential and salt index for selected fertilizers.

Fertilizer material	Grade	Acidity*	Salt index
Anhydrous ammonia	82-0-0	140	47.1
Sodium nitrate	16-0-0	—	100
Ammonium nitrate	34-0-0	62	105
Ammonium sulfate	21-0-0	110	69
Urea	46-0-0	71	75
Monoammonium phosphate	11-48-0	58	27
Ammonium-phosphate-sulfate	16-20-0	88	
Triple super phosphate	0-45-0	0	10
Potassium chloride	0-0-60	0	116
Potassium sulfate	0-0-50	0	46

*The acidity value indicates the pounds of 100-score lime needed to neutralize the acidity produced by fertilizer application of 100 lb/a.

Soil amendments and lime quality

Materials used to alter the pH or physical properties of soil are referred to as amendments. Examples of soil amendments are: lime used to reduce soil acidity; elemental sulfur and aluminum sulfate used to increase soil acidity; and gypsum and elemental sulfur used to improve the physical condition of alkali soil. Liming materials are used to raise soil pH and supply calcium or magnesium. The quality of liming material is related to its degree of fineness or particle size, the chemical composition or calcium carbonate equivalent, and the moisture content.

Calcium carbonate equivalent

The calcium carbonate equivalent *(cce)* is an expression of the acid neutralizing value of a liming material compared to pure calcium carbonate. Pure calcium carbonate is given a rating of 100. The *cce* of common materials is listed in Table 2.

Table 2.—Calcium carbonate equivalents.

Common name	Chemical name	Chemical formula	cce
Ground limestone	Calcium carbonate	$CaCO_3$	100
Dolomitic limestone	Calcium magnesium carbonate	$CaMg(CO_3)_2$	109
Hydrated lime	Calcium hydroxide	$Ca(OH)_2$	135
Burned lime	Calcium	CaO	179

Fineness factor

The fineness factor (ff) is related to the particle size of a liming material. The particle size affects the rate at which a liming material goes into solution in the soil. Lime does not neutralize acidity or release its nutrients until it has dissolved, so fine particles will react rapidly if sufficiently mixed with the soil.

One T/a lime with all particles passing a #10 screen will react with the soil in 1 year or less if thoroughly mixed with the soil. Increased lime rates, larger particle size, and incomplete mixing increase time for reaction of lime with the soil.

Lime particles that are less than 7⁄100 (7 hundredths) of an inch in diameter (particles of this size will pass through a #10 sieve) are considered to be soluble enough to be effective. Liming material particles that do not pass a #10 sieve are considered to be relatively noneffective. The degree of solubility increases as the particle size decreases from #10 to #40 sieve, with lime particles that pass a #40 sieve being given the maximum solubility rating. Solubility ratings for particle sizes shown in Table 3 are given in Table 4. A fineness factor value based on particle size is calculated in Table 4.

Table 3.—Example analysis of a liming material.

Sieve analysis	
Passing #10	98%
Passing #20	92%
Passing #40	78%

Table 4.—Calculation of fineness factor.

Particle size group	Percent in particle size group (A)	Solubility rating (B)	Fineness value (A)x(B)
No. 40 sieve or smaller (% passing #40 sieve)	78	1.00	78
#20–40 sieve (% passing #20 minus % passing #40 sieve)	14	0.60	8.4
#10–20 sieve (% passing #10 minus % passing #20 sieve)	6	0.30	1.8
#10 sieve or larger (100% minus % passing #10 sieve)	2	0	0
		TOTAL	88.2

The values for “percent in particle size group” are obtained from Table 3. The percent passing a #40 sieve is 78. The percent passing a #20 sieve and caught on a #40 sieve is 92 – 78 = 14. A similar subtraction is made for the last two categories, 98 – 92 = 6 and 100 – 98 = 2.

$$\text{Fineness factor } (ff) = \frac{\text{Total fineness value}}{100} = \frac{88.2}{100} = 0.88$$

Moisture factor

As water does not reduce acidity, the acid neutralizing value of a liming material decreases on a weight basis as the moisture content increases.

$$\text{Moisture factor } (mf) = \frac{100 - \%\text{ water in lime}}{100}$$

A liming material containing 15% water would have a moisture factor of:

$$mf = \frac{100 - 15}{100} = 0.85$$

Lime score

The lime score of a liming material is a numerical expression of the quality of the lime using *ff*, *cce*, and *mf*. A sample calculation of a lime score using a *cce* of 92 and the preceding values for *ff* and *mf*, follows:

Calcium carbonate equivalent *(cce)* = 92
Fineness factor *(ff)* = 0.88
Moisture factor *(mf)* = 0.85

$$\text{Lime score} = cce \times ff \times mf = 92 \times 0.88 \times 0.85 = 69$$

Amount of liming material to apply

Liming recommendations are based on 100-score liming material. Liming equivalent is the amount of liming material needed to equal 1 ton of 100-score dry lime. In general, this amount will be greater than 1.0 for limestone and by-product materials and less than 1.0 for burned and hydrated lime. The lime equivalent is calculated as:

$$\frac{\text{Recommended liming rate}}{\text{Lime score } (ls)} \times 100$$

If a liming material has a lime score of 69 and the recommended liming rate is 3 T/a, then:

$$\text{The lime equivalent} = \frac{3\text{ T/a}}{69} \times 100 = 4.35\text{ T/a}$$

Liming recommendations are based on soil test results and vary with the soil and crop to be grown.

A 1 T/a application of 100-score ground limestone supplies about 2 milliequivalents of calcium/100 grams of soil to the surface 6" of a mineral soil.

Chemical composition of liming materials

Liming materials vary in chemical composition. The chemical makeup of lime affects its neutralizing value and nutrient content. Ground limestone, for instance, consists of calcium carbonate and is a source of calcium. Dolomitic limestone consists of calcium and magnesium carbonates.

Kinds of liming materials

Several different kinds of liming materials are available in Oregon. They include:

Ground limestone

Consists of calcium carbonate and varying amounts of impurities. This material sometimes contains small amounts of magnesium carbonate. Pure calcium carbonate (calcite) contains 40% Ca.

Dolomitic limestone

Limestone containing from 10 to 49% dolomite, and from 50 to 90% calcite. The magnesium carbonate ($MgCO_3$) content of dolomitic limestone may range from approximately 4.4 to 22.6%. Dolomitic lime commonly is recommended as a liming material for acid soils that are deficient in magnesium.

Dolomite

A mineral containing approximately equal amounts calcium carbonate and magnesium carbonate.

Hydrated lime

Sometimes referred to as slaked, spray, or builder lime. Consists of calcium hydroxide with varying amounts of impurities. It is a white powder that reacts quickly when mixed with moist soil. Often mixed with copper sulfate to make Bordeaux fungicide sprays.

By-product liming materials

Effective liming materials are produced as by-products of industrial processes such as the manufacture of cement, wood pulp, sugar, and calcium carbide. These by-products contain varying amounts of calcium and magnesium compounds and other materials. Some of the names used for these by-product materials are: sugar lime, Cotrell lime or dust, lime sludge, carbide lime, and pulp mill lime.

Soil testing for lime requirement

The SMP lime requirement test is used to estimate the amount of lime required to raise the pH of the surface 6" of soil. The SMP test is performed by mixing a soil sample with a buffer solution and determining the resulting pH of the mixture. The “SMP buffer” value is used to estimate lime requirement. The choice of the pH column in Table 5 depends on the crop to be grown and possibly other factors. These lime rates are adjusted for western Oregon conditions based on the research of Peterson. The practical upper limit for a single application of lime is 4 to 5 T/a.

Some soils may have a fairly high SMP buffer value (>6.2) and a low pH (<5.3). This condition can be caused by the application of fertilizer. In this case, the low pH value is temporary and the pH of the soil will increase as the fertilizer completes its reaction with the soil. It often is encountered after dry periods and is found when soil samples are obtained in late summer.

Sandy soils to which fertilizers have not been recently applied sometimes record low pH and high SMP buffer values. In such cases, a light application of lime (1 to 2 T/a) should suffice to neutralize soil acidity.

Lime requirements for organic soils, very sandy soils, or orchards in the Hood River Valley should be obtained from your county agent of the OSU Extension Service.

Table 5.—SMP lime requirement table.

SMP Buffer	**T/a of 100-score lime needed to raise pH of surface 6" of soil to the following pH's**			
	5.3	**5.6**	**6.0**	**6.4**
6.7	-	-	-	-
6.6	-	-	-	1.1
6.5	-	-	1.0	1.7
6.4	-	-	1.1	2.2
6.3	-	-	1.5	2.7
6.2	-	1.0	2.0	3.2
6.1	-	1.4	2.4	3.7
6.0	1.0	1.7	2.9	4.2
5.9	1.4	2.1	3.3	4.7
5.8	1.7	2.5	3.7	5.3
5.7	2.0	2.8	4.2	5.8
5.6	2.3	3.2	4.6	6.3
5.5	2.6	3.6	5.1	6.8
5.4	2.9	3.9	5.5	7.3
5.3	3.2	4.3	6.0	7.8
5.2	3.6	4.7	6.4	8.3
5.1	3.9	5.0	6.9	8.9
5.0	4.2	5.4	7.3	9.4
4.9	4.5	5.8	7.7	9.9
4.8	4.8	6.2	8.2	10.4

Example: If the "SMP buffer" value is 5.9, then the estimated lime requirement to raise the pH to 6.0 would be 3.3 tons of 100-score lime/a.

For more information

You can obtain additional copies of this publication, *Fertilizer and Lime Materials*, FG 52, from your county office of the OSU Extension Service or from the Extension and Experiment Station Communications Web site at eesc.ads.orst.edu

Other publications

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John Hart, Extension soil scientist, Oregon State University, prepared this revision; it was reviewed by OSU county extension agents and by personnel of the Oregon Agricultural Experiment Station, the Oregon State Department of Agriculture, and the fertilizer industry.

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