*U N I V E R S I T Y OF MASSACHUSETTS:* ***www.Umass.edu/soiltest/***

# Fertilizer Materials and Soil Nutrient Amendment

Plant nutrients are available through root absorption of ions from soil solution. Molecules in solution also can be absorbed by roots in some cases. Thus, a fertilizer must first be dissolved to be used by plants. Fertilizers are categorized as organic[1] or inorganic. Inorganic fertilizers are generally composed of simple, mostly water-soluble nutrient salts in granular, slow release or liquid formulations. A fertilizer qualifies as naturally organic if derived from plant or animal materials or naturally occurring rocks and minerals containing one or more mineral elements that are essential for plant growth.

The relative content of the chemical elements nitrogen (N), phosphorus (P), and potassium (K) commonly used in fertilizers is labeled using NPK rating and any additional chemical element labeling follows after that. The N value is the percentage of elemental nitrogen by weight in the fertilizer. The values for P and K represent an expression of these elements as oxides in the form of $P_2O_5$ and $K_2O$. This usage derives from the traditional practices of reporting elements as oxides.

Materials may be used alone or blended with other fertilizers to form a multiple-nutrient fertilizer. Generally there is no measurable difference in crop response to multiple-nutrient or single- nutrient fertilizers, as long as they supply the same amount of soluble nutrients. The advantage of multiple-nutrient fertilizers over single-nutrient fertilizers is that only one fertilizer would be needed to supply several elements, rather than having to purchase several fertilizers. The following tables are a quick reference guides to various fertilizer materials that could be used to address soil nutrient deficiencies. The actual nutrient content may vary from this list depending on the manufacturer and other materials blended with the product. Most values are for the fertilizer- grade product and not the pure chemical. The chemical formulas given are the primary active compound.

Also included is the fertilizer liming and soil acidifying effect. Pure calcium carbonate ($CaCO_3$) is considered as the most commonly used liming material (lime) and is assigned a100% neutralizing effect index also known as *calcium carbonate equivalency* (CCE). The effectiveness of a liming material is based CCE scale where if greater than 100, the material is considered capable of neutralizing more acidity on a weight basis than pure $CaCO_3$.

At the end of these tables is an explanation with examples on how to calculate the amount of fertilizer to apply to meet agronomic nutrient requirements.

[1] Note: Organically Certified fertilizers are different from “naturally organic” http://www.omri.org/simple-opl-search/results/fertilizer

# TABLE 1. PRIMARY AND SECONDARY NUTRIENT SOURCES

**E** (Percentage)

## Nitrogen Sources

| Material | N | $P_2O_5$ | $K_2O$ | Ca | Mg | S | †CCE/100 lbs |
|---|---|---|---|---|---|---|---|
| Ammonium nitrate | 34 | 0 | 0 | 0 | 0 | 0 | -61 |
| Anhydrous ammonium | 82 | 0 | 0 | 0 | 0 | 0 | -148 |
| Ammonium nitrate sulfate | 30 | 0 | 0 | 0 | 0 | 5 | -71 |
| Calcium ammonium nitrate | 27 | 0 | 0 | 6 | 0 | 0 | 0 |
| Ammonium nitrate limestone | 20 | 0 | 0 | 6 | 4 | 0 | 0 |
| Ammonium sulfate | 21 | 0 | 0 | 0 | 0 | 24 | -110 |
| Aqua ammonium | 16-25 | 0 | 0 | 0 | 0 | 0 | -45 |
| Calcium nitrate/urea (Calurea) | 34 | 0 | 0 | 10 | 0 | 0 | -36 |
| Calcium nitrate | 15 | 0 | 0 | 21 | 0 | 0 | +20 |
| Crotonylidene diurea | 32 | 0 | 0 | 0 | 0 | 0 | none |
| Isobutylidene diurea | 31 | 0 | 0 | 0 | 0 | 0 | none |
| Nitrogen solutions (N-SOL or UAN solutions) (urea/ammonium nitrate): | | | | | | | |
| 32% UAN (35% urea + 45% A.N.) | 32 | 0 | 0 | 0 | 0 | 0 | -55 |
| 30% UAN (33% urea + 42% A.N.) | 30 | 0 | 0 | 0 | 0 | 0 | -52 |
| 28% UAN (30% urea + 40% A.N.) | 28 | 0 | 0 | 0 | 0 | 0 | -49 |
| 21% AN (60% A.N. + 40% water) | 21 | 0 | 0 | 0 | 0 | 0 | -37 |
| 19% AN (54% A.N. + 46% water) | 19 | 0 | 0 | 0 | 0 | 0 | -33 |
| Potassium nitrate | 13 | 0 | 44 | 0 | 0 | 0 | +26 |
| Sodium nitrate (nitrate of soda) | 16 | 0 | 0 | 0 | 0 | 0 | +29 |
| Urea (sulfur coated) | 36-38 | 0 | 0 | 0 | 0 | 0 | -118 |
| Urea | 45 | 0 | 0 | 0 | 0 | 0 | -81 |
| Ureaform | 38 | 0 | 0 | 0 | 0 | 0 | -68 |

## Phosphorus Sources

| Material | N | $P_2O_5$ | $K_2O$ | Ca | Mg | S | CCE/100 lbs |
|---|---|---|---|---|---|---|---|
| Ammoniated superphosphate | 12-17 | 22-35 | 0 | 0 | 0 | 0 | -7 |
| Ammonium polyphosphate | 10 | 34 | 0 | 0 | 0 | 0 | |
| Diammonium phosphate (DAP) | 18 | 46 | 0 | 0 | 0 | 0 | -70 |
| Ammonium phosphate nitrate | 30 | 10 | 0 | 0 | 0 | 0 | -54 |
| Monoammonium phosphate (MAP) | 11 | 48 | 0 | 1 | 0 | 0 | -65 |
| Ammonium phosphate sulfate | 16 | 20 | 0 | 0 | 0 | 15 | -80 |
| Basic Slag | 0 | 0-6 | 0 | 3-29 | 0 | 0 | +70 |
| Bone meal | 0-2 | 10-20 | 0 | 19-25 | 0 | 0 | +20 |
| Concentrated superphosphate | 0 | 46 | 0 | 14 | 0 | 2 | 0 |
| Nitric phosphate | 12-17 | 22-35 | 0 | 0 | 0 | 0 | -20 |
| Phosphate rock | 0 | 2-35 | 0 | 0 | 0 | 0 | +10 |
| Normal superphosphate | 0 | 20 | 0 | 21 | 0 | 11 | 0 |
| Phosphoric acid | 0 | 2-35 | 0 | 0 | 0 | 0 | |
| Conc. Wet-process acid | 0 | 40-54 | 0 | 0 | 0 | 0 | -90 |
| Wet-process acid | 0 | 30 | 0 | 0 | 0 | 0 | -63 |
| Superphosphoric acid | 0 | 76 | 0 | 0 | 0 | 0 | -110 |
| Urea-ammonium phosphate | 25 | 35 | 0 | 0 | 0 | 0 | |
| Urea phosphate | 17 | 44 | 0 | 0 | 0 | 0 | -82 |

## Potassium Sources

| Material | N | $P_2O_5$ | $K_2O$ | Ca | Mg | S | CCE/100 lbs |
|---|---|---|---|---|---|---|---|
| Greensand | 0 | 1 | 6 | 0 | 0 | 0 | |
| Potassium Carbonate | | | | | | | |
| Solid | 0 | 0 | 48 | 0 | 0 | 0 | +70 |
| Liquid | 0 | 0 | 34 | 0 | 0 | 0 | +50 |
| Potassium chloride | 0 | 0 | 60 | 0 | 0 | 0 | 0 |
| Potassium magnesium sulfate | 0 | 0 | 21 | 0 | 11 | 23 | 0 |
| Potassium metaphosphate | 0 | 059 | 39 | 0 | 0 | | |
| Potassium nitrate | 13 | 0 | 44 | 0 | 11 | 23 | +26 |
| Potassium sulfate | 0 | 0 | 52 | 0 | 0 | 16 | 0 |

## Calcium Sources

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Calcium chloride | 0 | 0 | 0 | 36 | 0 | 0 | 0 |
| Calcitic limestone (ground) | 0 | 0 | 0 | 36 | 0 | 0 | +98 |
| Burned Lime | 0 | 0 | 0 | 70 | 0 | 0 | +178 |
| Dolomitic limestone (ground) | 0 | 0 | 0 | 24-30 | 6-12 | 0 | +100 |
| Gypsum | 0 | 0 | 0 | 22 | 0 | 18 | 0 |
| Selma chalk | 0 | 0 | 0 | 32 | 0 | 0 | +80 |
| Hydrated lime | | 0 | 0 | 0 | 50 | 0 | 0 +134 |

## Magnesium Sources

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dolomotic limestone (ground) | 0 | 0 | 0 | 24-30 | 6-12 | 0 | +100 |
| Magnesium oxide | 0 | 0 | 0 | 0 | 45 | 0 | +250 |
| Magnesium ammonium phosphate | 8 | 40 | 0 | 0 | 15 | 0 | |
| Magnesium sulfate (Kieserite) | 0 | 0 | 0 | 0 | 17 | 23 | 0 |
| Magnesium sulfate (Epsom salt) | 0 | 0 | 0 | 0 | 10 | 13 | 0 |
| Potassium Magnesium sulfate | 0 | 0 | 21 | 0 | 11 | 23 | 0 |

## Sulfur Sources

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ammonium thiosulfate | 12 | 0 | 0 | 0 | 0 | 26 | |
| Ammonium sulfate | 21 | 0 | 0 | 0 | 0 | 24 | -110 |
| Elemental sulfur | | | | | | | |
| Wettable S | 0 | 0 | 0 | 0 | 0 | 95 | -312 |
| Flowable S | 0 | 0 | 0 | 0 | 0 | 60 | -218 |
| Flowers of S | 0 | 0 | 0 | 0 | 0 | 95 | -312 |
| Potassium sulfate | 0 | 0 | 52 | 0 | 0 | 16 | 0 |
| Potassium Magnesium sulfate | 0 | 0 | 21 | 0 | 11 | 23 | 0 |
| Gypsum | 0 | 0 | 0 | 22 | 0 | 18 | 0 |
| Magnesium sulfate (Epsom) | 0 | 0 | 0 | 0 | 10 | 13 | 0 |
| Sulfuric acid | 0 | 0 | 0 | 0 | 0 | 20-26 | -70 |

† CCE = Approximate calcium carbonate equivalence; Negative value indicates net acidifying effect on soil; positive value indicates net basic reaction in soil (AOAC).

Symbol k ey: N = Nitrogen; $P_2O_5$ = Phosphate; $K_2O$ = Potash; Ca = Calcium; Mg = Magnesium; S = Sulfur; $CaCO_3$ = Calcitic Limestone

## TABLE 2. MICRONUTRIENTS SOURCES

| Materials | Nutrient Content |
|---|---|
| **Copper (CU)** | |
| Chelated Cu | |
| Cu EDTA | 13% Cu |
| Cu HEDTA | 9% Cu |
| Cupric ammonium phosphate | 30% Cu |
| Cupric oxide | 60-80% Cu |
| Copper sulfate | 35% Cu |
| **Boron (B)** | |
| Fertilizer borate | |
| Borate granular | 14% B |
| Borate 48 (i.e., 48 % $B_2$03) | 15% B |
| Borax | 11% B |
| Boric acid | 17% B |
| Sodium borosilicate | 6% B |
| Calcium borate | 10% B |
| Solubor | 20% B |
| Magnesium borate (boracite) | 21% B |
| **Iron (Fe)** | |
| Basic slag | 10-13% Fe |
| Ferric sulfate | 20% Fe |
| Ferrous ammonium phosphate | 29% Fe |
| Ferrous ammonium sulfate | 14% Fe |
| Ferrous carbonate | 42% Fe |
| Ferrous sulfate | 20% Fe |
| Ferrous oxalate | 30% Fe |
| Magnesium borate (boracite) | 21% B |
| **Zinc (Zn)** | |
| Chelated Zn | 9-14% Zn |
| Zinc sulfate | 22-36% Zn |
| Zinc ammonium phosphate | 34% Zn |
| Zinc oxide | 78-80% |
| Zinc sulfide | 61% Zn |
| Zinc polyflavonoid | 7-10% |
| **Manganese (Mn)** | |
| Manganese oxide | 68-70% Mn |
| Basic slag | 1-3% Mn |
| Manganese carbonate | 31% Mn |
| Manganese sulfate | 24% Mn |
| Manganese chloride | 17% Mn |
| Manganese ammonium phosphate | 28% Mn |
| **Molybddenum (Mo)** | |
| Sodium Molybdate | 38-46% Mo |
| Impurities in Superphosphate | trace |
| Molybdenum frits | 30% Mo |

## TABLE 3. ORGANIC[2] FERTILIZER MATERIALS

**(Approximate Percent Values)**

| Material | N | $P_2O_5$ | $K_2O$ | Ca | Mg | S | Micro-nutrients |
|---|---|---|---|---|---|---|---|
| **Manure:** (dried) | | | | | | | |
| Horse | 0.4 | 0.2 | 0.3 | * | * | * | * |
| Cattle | 1.5 | 1.5 | 1.2 | 1.1 | 0.3 | * | * |
| Poultry | | | | | | | |
| Broiler litter | 3.0 | 3.0 | 2.0 | 1.8 | 0.4 | 0.3 | * |
| Hen-caged layers | 1.5 | 1.3 | 0.5 | 6 | 0.4 | 0.3 | * |
| Hen-litter | 1.8 | 2.8 | 1.4 | * | * | * | * |
| Swine | 0.6 | 0.4 | 0.1 | * | * | * | * |
| Sheep | 0.6 | 0.3 | 0.2 | * | * | * | * |
| **Blood** (dried) | 12-15 | 3.0 | 1.0 | * | * | * | * |
| **Bone meal** (steamed) | 0-2 | 10-20 | 0 | 19-25 | 0 | 0 | * |
| **Blood meal** | 15 | 1.0 | 1.0 | * | * | * | * |
| **Compost** (garden) § | 1 | 1 | 1 | | | | |
| **Cottonseed hull ash** | 0 | 27 | * | * | * | * | * |
| **Cottonseed meal** | 6-7 | 2.5 | 1.5 | * | * | * | * |
| **Cotton motes** (composted gin wastes) | 2 | 0.5 | 3 | 4 | 0.7 | 0.6 | * |
| **Fish scrap** | | | | | | | |
| (acidulated) | 7-10 | 1-2 | 0 | * | * | 2 | * |
| (dried fish meal) | 9 | 3 | 6 | * | * | * | * |
| **Hay:** | | | | | | | |
| Legume | 3.0 | 1.0 | 2.4 | 1.2 | 0.2 | 0.3 | * |
| **Peat/Muck** | 2.3 | 0.5 | 0.7 | * | * | * | * |
| **Sawdust** | 0.2 | 0 | 0.2 | * | * | * | * |
| **Seaweed** (dried) | 0.7 | 0.8 | 5.0 | * | * | * | * |
| **Sewage sludge** (dried, municipal) | 5 | 6 | 0.5 | 3 | 1 | 1 | * |
| **Tankage** | 7 | 10 | 7 | * | * | * | * |
| **[3]Wood ashes** | 0 | 2 | 6 | 20 | 1 | * | * |

Symbols: N = Nitrogen; $P_2O_5$ = Phosphorus; $K_2O$ = Potassium; Ca = Calcium; Mg = Magnesium; S = Sulfur

*Unknown amounts

§Depends on raw materials and amendments composition

[2] Note: Organically Certified fertilizers are different from "naturally organic" http://www.omri.org/simple-opl-search/results/fertilizer

[3] Contains > 70% $CaCO_3$ equivalent

# *Appendix*

## *Appendix 1. Fertilizer Rates Calculations*

Before using any fertilizers, it is important to understand how to read a fertilizer label. All fertilizers are labeled with %N - % $P_2O_5$ - %$K_2O$ by weight.

**Example:** 80 pounds of Potassium nitrate (13-0-44) would contain 10.4 pounds of N (80 X 0.13), 0 pounds of $P_2O_5$ (80 X 0), and 35.2 pounds of $K_2O$ (80 X 0.44).

## *Appendix 2. Amount of solid fertilizer to apply for a specific amount of nutrient*

The basic formula for calculating how much fertilizer to apply to a given area for a specific amount of nutrient is:

$$\text{Pounds of Fertilizer} = \frac{\text{(Pounds of nutrient needed)}}{\text{(\% nutrient in the fertilizer)}}$$

**Examples:**

1. How much Potassium nitrate (13-0-44) is needed to apply 80 pounds of potassium (K)?
   **It would take 182 pounds (80 ÷ 0.44) of Potassium nitrate to apply 80 pounds of $K_2O$.**

2. What if Potassium chloride (0-0-60) was used instead?
   **It would take 133 pounds (80 ÷ 0.60) of Potassium chloride to apply 80 pounds of $K_2O$.**

## *Appendix 3. Amount of liquid fertilizer to apply for a specific amount of nutrient*

The basic calculation formula for liquid fertilizers is similar to solids, but the density of the liquid fertilizer must be known before calculating the amount of fertilizer to apply.

**Example:**

How much N, $P_2O_5$, and $K_2O$ is in a 5 gallon jug of a 9-18-6 liquid fertilizer weighing 11.1 pounds per gallon?

Steps: 1. How much fertilizer is present in the 5 gallons?

*There would be 55.5 pounds of fertilizer (11.1 lb/gal X 5 gal).*

2. What is the amount of each of N, $P_2O_5$, and $K_2O$ in the jug?

*There would be:*

- *5 pounds of N (55.5 X 0.09),*
- *10 pounds of $P_2O_5$ (55.5 X 0.18),*
- *and 3.3 pounds of $K_2O$ (55.5 X 0.06).*

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