

TECHNICAL NOTES

AGRONOMY TECHNICAL NOTE NO. 22

RE: From A to Z – Fertilizer Terms, Definitions and Materials

With the increasing growth in fertilizer technology and use and because of the key role proper fertilization plays in attaining high production and management, it is important to become familiar with terms used in the industry and in the field. It is also equally important to know materials from which various fertilizers are formulated. The attached information should be helpful to field personnel in their work with land owners, operators and groups.

If additional copies of this Technical Note are needed for individual reference and use in the field, request them from the Plant Science Section.

FERTILIZER TERMS, DEFINITIONS AND MATERIALS

1. Acidity and Basicity of Fertilizers – Some fertilizer materials leave an acid residue in the soil, thus tending to make the soil acid. Others leave basic residues, tending to make the soil more basic or alkaline. Still other materials leave residues which are neither acidic nor basic.

A. Fertilizer materials which tend to make the soil more acid include the following:

- 1) Fertilizer containing nitrogen in the form of ammonia or in a form subject to nitrification in the soil (unless sufficient base such as lime is present to neutralize this acidity).
- 2) Sulfate of ammonia leaves in the soil an acid residue amounting to the nitric acid equivalent of one-half of its nitrogen content plus the acidity of the equivalent sulfuric acid (sulfate) content.
- 3) All ammoniacal salts including sulfate of ammonia, urea, blood, cottonseed meal, fish, process tankages and even highly alkaline ammonium solutions.

B. Fertilizer materials which tend to make the soil more basic include:

- 1) Phosphate fertilizers in which more than one hydrogen is replaced by a base (excluding NH_4^+). Examples are decalcium phosphate and tricalcium phosphate.
- 2) Nitrogenous fertilizer materials in which the nitrogen is in the nitrate form and combined with bases such as sodium or calcium.

- 3) Cyanamid, nitrate of soda, nitrate of potash, calcium nitrate and bone meal.

C. Fertilizer materials whose residue has not effect on soil acidity or basicity include:

- 1) The common potash salts, such as muriate or sulfate of potash, manure salts, and kainite.
- 2) Phosphate fertilizer, in which one of the three hydrogens of phosphoric acid (H_3PO_4) is replaced by a base other than NH_4T . Examples are superphosphate and double superphosphate.

2. **Acid Forming** – A Term used to describe fertilizer materials which tend to cause the soil to become more acid. Several states require manufacturers to state whether fertilizer is acid or nonacid forming.

3. **Ammonia**

- A. Anhydrous ammonia (NH_3) is a gas containing about 82 per cent nitrogen. It changes to a liquid under pressure and is usually stored and transported in this form.

It is also used to make most of the solid forms of nitrogen fertilizer and also is used for direct application to the soil either as a gas or in the form of aqua ammonia.

- B. Aqua Ammonia (NH_4OH) is ammonium hydroxide formed by dissolving anhydrous ammonia in water. The commercial grades of this ammonia liquor usually contain from 12 to 25 per cent nitrogen.

It can be used for direct application to the soil or to manufacture solid fertilizer materials like ammonium phosphate, ammonium sulfate and ammoniated superphosphate.

4. **Ammoniation** – The process in which ammonia is used to treat superphosphate to form ammoniated superphosphate, or to treat a mixture of fertilizer ingredients in the manufacture of a complete fertilizer.

The ammonia used in this process can be anhydrous, aqua or a solution containing ammonia and other forms of nitrogen.

5. **Ammonium Hydroxide** (NH_4NO) – same as aqua ammonia.

6. **Ammonium Nitrate** (NH_4NO_3) – This is a solid chemical compound which contains about 33 per cent nitrogen. Approximately one-half of the nitrogen is in the ammonia form and one-half in the nitrate form. It is water soluble and is sometimes used in liquid fertilizer solutions. Because of its water solubility, it is one of the quickest acting nitrogen fertilizers.

Since ammonium nitrate is acid-forming material, it is sometimes mixed with dolomitic limestone to form a product containing 20.5 per cent nitrogen to cause a neutral effect on soil acidity.

7. **Ammonium Nitrate Limestone** – A fertilizer material where ammonium nitrate is mixed with a dolomitic limestone (see immediately above).

8. **Ammonium Phosphate** – A solid fertilizer material which is manufactured by treating phosphoric acid with ammonia. Based on the amount of ammonia reacted with the phosphoric acid, different phosphates can be formed. Two of these phosphates which are commonly used for fertilizer are mono-ammonium phosphate, $\text{NH}_4\text{H}_2\text{PO}_4$ (11-48-O), and diammonium phosphate $(\text{NH}_4)_2\text{HPO}_4$ (21-53-O).

When wet process phosphoric acid is used, 16-48-O and 18-46-O can be manufactured.

9. **Ammonium Poly Phosphate** – A fertilizer material manufactured when ammonia and superphosphoric acid are reacted under moderate pressure. It can be used in either solid or liquid mixed fertilizer.

The superphosphoric acid part of this material prevents “salting out” of liquid fertilizers.

10. **Ammonium Sulfate** $(\text{NH}_4)_2\text{SO}_4$ – A solid fertilizer material which is manufactured by treating sulfuric acid with ammonia. The nitrogen in commercial grades ranges from 20.5 to 21.0 per cent. This fertilizer material also contains about 24 per cent sulfur.

11. **Ammoniated-Superphosphate** – Formed by treating ordinary and triple superphosphates with ammonia solutions. Ammoniated superphosphate is an important step in manufacturing mixed fertilizer.

12. **Analysis (Grade)** – The percentage composition of elements in a fertilizer that affects plant growth as found by chemical analysis. The official analysis is determined by state law.

People often use analysis and grade synonymously. However, the term grade actually applies to the three primary plant food elements only (nitrogen (N), available phosphate (P_2O_5) and potash (K_2O)).

Analysis usually includes secondary and minor or trace elements and in some instances elements that may be harmful in plant growth.

Some feel that the fertilizer industry may switch to reporting all elements in their elemental rather than oxide form. That is, phosphorous would be reported as P rather than P_2O_5 ; potassium as K rather than K_2O . Nitrogen is now reported in this way.

13. **Artificial Manure** A product resulting from the composting of waste straw, corn stalks, vines, leaves, etc., with phosphate, nitrogen-bearing material and liming material.

14. **Available** – Plant food in a form capable of being assimilated by growing plants.

- A. Available Phosphate – The P_2O_5 equivalent of a phosphate expressed as a percentage which is considered readily available to growing plants. Correct chemical names for P_2O_5 are phosphorous pentoxide, phosphoric anhydride or phosphoric oxide.

- B. Available Phosphoric Acid** – This is a term which has been erroneously used for available phosphate. Chemically, phosphoric acid is another compound (H_3PO_4) which has no direct relationship to P_2O_5 .
- 15. Basic Slag** - A by-product produced in the manufacture of steel. It contains phosphate, calcium, magnesium, manganese, sulfur and iron.
- 16. Blue Vitriol** (Copper Sulfate) ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) – This is probably the most common source of copper for trace element mixtures in fertilizers. It is also used as an insecticide and a fungicide.
- 17. Bone Meal** (raw) – A product resulting from the drying and grinding of animal bones that have not been previously steamed under pressure.
- 18. Bone Meal** (steamed) – A product resulting from grinding animal bones that previously have been steamed under pressure.
- 19. Borax** ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$) – A chemical compound, hydrated sodium tetraborate, containing about 11 per cent boron.
- 20. Boron** – This chemical element is important to plant growth. It is classified as one of the minor, or trace, plant food elements.
- 21. Brand Name** – A specific trade name applied by the manufacturer to his individual fertilizers.
- 22. Bulky Organic Materials** – Materials such as manures, alfalfa hay, alfalfa straw, bean straw, grain straw, which are used for both their organic content and content of plant nutrients.
- When these materials and other similar materials have low nitrogen content, chemical nitrogen should be added in amounts equal to about 1.0-1.2 per cent of the weight of the mulching material to offset nitrogen depression.
- 23. Calcite** (Ground Agricultural Limestone) – This is a name for ground limestone which contains calcium carbonate.
- 24. Calcium Carbonate** (CaCO_3) – The major component of calcitic limestone and a principal component of dolomitic limestone of which magnesium carbonate (MgCO_3) is the other. Oyster shells and marl contain mostly calcium carbonate.
- 25. Calcium Cyanamide** (CaCN_2) – A synthetic organic material which contains about 21 per cent nitrogen. Since it is highly alkaline in reaction, it is used for a defoliant and for control of weeds and certain soil-borne diseases as well as a fertilizer. Its common trade name is Cyanamid.
- 26. Calcium Oxide** (CaO) – The active ingredient in some liming materials. Liming materials are compared in terms of their calcium oxide equivalents.
- 27. Calcium Phosphate** – Has several different forms. The one found most often in nature is tri-calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$, in combination with calcium fluoride.

In the manufacture of superphosphate, tri-calcium phosphate is changed into mono-calcium phosphate, $\text{CaH}_2(\text{PO}_4)_2$, and di-calcium phosphate, $\text{Ca}_2(\text{HPO}_4)_2$, which are more soluble and more available to growing plants.

28. **Calcium Metaphosphate** – A fertilizer material which contains 60-65 per cent P_2O_5 . Most of the phosphate material in this mixture is citrate soluble.

29. **Calcium Sulfate or Gypsum** ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) – A calcium which is used in the fertilizer industry to obtain calcium and sulfur.

Even though Gypsum has calcium content, it has no effect on soil acidity and can not be used as a liming material. It is widely used in reclaiming alkali soils. It is sometimes also called Land Plaster.

30. **Castor Pomace** – Ground residue of the castor bean remaining after the extraction of oil.

31. **Concentrated Superphosphate** – refer to superphosphate.

32. **Copper Sulfate** – refer to Blue Vitriol.

33. **Curing** – A conditioning process that takes place when fertilizer materials are mixed and stored.

34. **Cyanamid** – Refer to Calcium Cyanamid.

35. **Di-Ammonium Phosphate** – refer to Ammonium Phosphate.

36. **Dolomite** – A liming material made by grinding dolomitic limestone which contains both magnesium carbonate (MgCO_3) and calcium carbonate (CaCO_3). It is good for liming soils when there is a magnesium as well as a calcium need.

37. **Elements** – Simple forms of matter which cannot be decomposed by ordinary means.

38. **Fertilizer** – Any material or mixture used to supply essential plant food elements.

39. **Formula** – An explanation or statement of how different ingredients are combined to make a fertilizer. It gives the quantities and grades of materials used in manufacture.

40. **Guano** – The excrement of bats and birds used for fertilizer. A commonly known guano comes from islands off the coasts of Peru and derived from sea fowl.

Bat guano due to conditions under which it is taken from caves varies widely. Recent deposits run 8-13 per cent N, 4-5 per P_2O_5 and 2 per cent K_2O .

41. **Gypsum** ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) – refer to Calcium Sulfate.

42. **Humus** – The well decomposed, more or less stable part of the organic matter of the soil.

43. **Hydrated Lime** ($\text{Ca}(\text{OH})_2$) – Is Calcium Hydroxide. It is produced by treating burned lime (CaO) with water or steam.

44. **Hydrogen Ion Concentration** (pH test) – The pH test is probably the most commonly known and widely used test for measuring soil reaction. Potential hydrogen (pH) is a scale from 1 to 14 used to denote the relative intensity of acidity or alkalinity.

A neutral solution, or soil, has a pH of 7.0. As values decrease below 7.0, progressively more intense acid conditions exist. Those values above 7.0 similarly indicate more intense alkaline conditions.

Except for water, no other single factor has more influence over the availability of plant food to growing crops.

45. **Hygroscopic** – This is a term used to describe material which tends to absorb moisture from the atmosphere. Since many materials used fertilizer are hygroscopic, they may require special treatment to prevent caking.

46. **Inorganic Nitrogen** – This form of nitrogen was first available in the form of Chilean nitrogen of soda. Commercial production of the natural source of nitrate nitrogen for commercial export first began in 1820. The nitrate nitrogen is mined and extracted from mineral deposits in the desert of northern Chile.

47. **Land Plaster** – Refer to Calcium Sulfate or Gypsum.

48. **Lime** – (CaO) – Lime is calcium oxide. However, in agricultural terminology, this term has been used to designate almost any liming material.

49. **Liming Materials** – Materials whose calcium and magnesium content is capable of neutralizing soil acidity. Common sources of liming materials are calcitic limestone, dolomitic limestone, marl and oyster shells.

Commonly used materials are ground calcitic and dolomitic limestones. These are referred to as ground agricultural limestone.

50. **Liquid Fertilizers** – Plant food elements or combinations of elements which are prepared for application in liquid form. Liquid anhydrous ammonia, aqua ammonia, ammonia solutions, nitrogen solutions and liquid mixed fertilizers are the principle forms of liquid fertilizer.

The most common mixed liquid fertilizers are prepared by reacting anhydrous ammonia with phosphoric acid in water solution and adding a potash salt. Nitrogen solutions are water solutions of ammonia, ammonium nitrate and sometimes urea which are used in ammoniating superphosphate – the manufacture of complete fertilizers and as a source of nitrogen for application directly to the soil. Such solutions vary in their nitrogen content and in composition.

51. **Magnesia** – This is a term used to refer to magnesium oxide (MgO).

52. **Magnesium Carbonate** – (MgCO₃) – One of the two principle components of dolomitic limestone. Calcium carbonate, CaCO₃, is the other major component of dolomitic limestone.

53. **Magnesium Oxide** (MgO) – An ingredient of certain liming materials which are used to apply both magnesium and calcium to the soil.

54. **Magnesium Sulfate** (MgSO₄) – A soluble salt used to supply magnesium. Epsom salts is a common form.

55. **Manganese Sulfate** (MnSO₄) – A chemical compound often used as a source of manganese for growing plants.

56. **Manure Salts** – Potash salts which contain a high percentage of chloride and from 20 to 30 per cent of potash (K_2O).
57. **Mono-Ammonium Phosphate** – Refer to Ammonium Phosphate.
58. **Multiple Carriers** – Fertilizer materials which contain more than one plant food nutrient.
59. **Muriate of Potash** (KCL) – The principle source of potassium for fertilizer. It is potassium chloride and contains 95-99 per cent KCL, with a K_2O equivalent of 60% to 62%.
60. **Natural Organic Nitrogen** – A source of nitrogen which was supplied from natural organic materials in the early days of the fertilizer industry. It was supplied from oil seed meals, castor pomace, fish products, dried blood, animal tankage, guano, sewage products and dried manures.

Due to the high unit cost, low nitrogen content, limitation of readily available supplies, and rapid growth of the synthetic nitrogen industry, these materials have largely been diverted to use in animal feeds.

61. **Nitrate of Soda** (Sodium Nitrate) ($NaNO_3$) – A fertilizer material containing about 16 per cent nitrogen. It is produced synthetically in the United States but the principle source of this salt has been from natural deposits in Chile.
62. **Nitric Phosphate** – A superphosphate material which is prepared with nitric acid rather than sulfuric acid. It usually has a grade of 14-14-0 but can be produced with a considerably higher analysis when prepared with a mixture of nitric and phosphoric acids.
63. **Nitrification** – A process which takes place in the soil as soil micro-organisms convert ammonia forms of nitrogen to nitrite ions and nitrite ions into nitrate ions.
64. **Nitrogen Solutions** – They are classified as pressure and non-pressure types.
- A. The pressure group consists mainly of water solutions of ammonia-ammonium nitrate, ammonia-urea, ammonia-ammonium nitrate-urea, and ammonia-ammonium sulfate-urea.
- 1) These pressure solutions are used mostly to ammoniate superphosphate and mixtures which contain superphosphate.
 - 2) In diluted low pressure forms, some of these water solutions are used for direct application to the soil.
 - 3) The percentage of nitrogen in ammoniac, nitric and organic form varies between manufacturers and specific uses which will be made of the solutions. The total nitrogen content will range from 21 per cent up to 58.5 per cent.

B. Non-pressure types are water solutions of nitrogen compounds which are used almost exclusively for direct application include the following:

ammonium nitrate	20% N	
calcium-ammonium nitrate	17% N	
ammonium bisulfite	8.5% N	17% S
ammonium polysulfide	20.6% N	40-45% S
ammonium thiosulfate	11% N	26% S
urea	23% N	
urea-ammonium nitrate	32% N	
sodium nitrate-ammonium nitrate	20% N	

- 1) The bisulfite, polysulfide and thiosulfate ammonia solutions are mixed with aqua ammonia in varying proportions to supply sulfur in a ratio formulated to meet particular soil requirements.
- 2) In addition to this non-pressure group, liquid anhydrous ammonia and aqua ammonia are used both in ammoniation processes and for direct field application.
- 3) Five of the above nitrogen solutions also supply calcium, sodium, or sulfur when needed for special crop or soil conditions.

65. **Non-Acid Forming** – Fertilizer materials which are not capable of increasing the residual acidity of the soil.

66. **Normal Superphosphate** – Refer to superphosphate.

67. **N-P-K** – An expression used to describe fertilizer materials or compounds which may have a content of calcium, sulfur, magnesium, sodium and other elements in combined form in addition to their supply of nitrogen, phosphorous and potassium.

68. **Organic** – Materials containing carbon (other than as carbonates as an essential ingredient. This term usually refers to material derived from plant or animal sources.

69. **Organic Concentrates** – Material such as tankage, blood, fish, and seed meals which are used more in mixed fertilizers than they are for direct application.

70. **Organic Fertilizers** – A material containing carbon. Urea and calcium cyanamide which are manufactured synthetically are organic fertilizers. However, fertilizer materials which are designated as “organic” usually are derived from plant or animal residues.

“Organics” still are used to a small extent in special fertilizers and as conditioning agents in mixed chemical fertilizer for general use.

71. **Peat** – Partly decayed organic matter of natural occurrence.

72. **pH (Potential Hydrogen)** – Refer to Hydrogen Ion Concentration.

73. **Phosphate Rock** – A natural rock containing one or more calcium phosphate minerals of such purity as to allow its use in the manufacture of commercial products.
74. **Phosphoric Acid** (H_3PO_4) – An inorganic acid used in the manufacture of triple superphosphates and ammonium phosphates. It is also sometimes used for direct application to the soil.
75. **Phosphoric Anhydride** – Refer to available phosphate.
76. **Phosphoric Oxide** – Refer to available phosphate.
77. **Phosphorus Pentoxide** – Refer to available phosphate.
78. **Plant Food** – Also referred to as plant nutrients, plant food elements or essential plant food elements. At least 16 elements have been recognized as essential for healthy growth of plants. Carbon, hydrogen and oxygen are mainly supplied by air and water. The remaining essential plant food elements are normally obtained by the plant from the soil.
79. **Potash** – A term used to signify the potassium oxide (K_2O) equivalent of materials containing potassium. Potash in fertilizers are supplied by the three following compounds:
- A. Potassium chloride (KCl) – Refer to muriate of potash.
 - B. Potassium Nitrate (KNO_3) – A solid fertilizer material which contains about 14 per cent nitrogen (N) and 44-46 per cent potassium oxide (K_2O). Although it is a good source of both nitrogen and potassium, its main use is in the manufacture of soluble fertilizers because natural deposits are limited.
 - C. Potassium Sulfate (K_2SO_4) – This is also called sulfate of potash. It is a solid fertilizer material with a potassium oxide (K_2O) equivalent ranging from 48-52 per cent. This material is especially useful on crops that are sensitive to the high amounts of chlorine contained in muriate of potash.
80. **Potassium Metaphosphate** – The grade of this material is 0-55-35. This is a new material which shows considerable promise because of its high analysis. It is only slightly soluble in water but becomes available through hydrolysis.
81. **Potassium-Magnesium Sulfate** ($K_2SO_4 \cdot 2MgSO_4$) – This is also called sulfate of potash-magnesia. This material is water soluble and is readily available for plant use. It is a very good source of potash when there is a need for water soluble magnesium in the fertilizer mixture. It is also called Langbeinite. It occurs in salt deposits primarily in New Mexico and in several European countries.

Commercial potassium-magnesium sulfate usually has a K_2O equivalent of 21-26 per cent, contains 11-53 per cent magnesium and approximately 15-23 per cent sulfur. It usually does not contain more than 2.5 per cent chlorine.

82. **Potassium Nitrate** (KNO_3) – Refer to Potash.
83. **Potassium Sulfate** – (K_2SO_4) – Refer to Potash.

- 84. Primary Elements (or Nutrients)** – They are nitrogen, phosphorous and potassium. They are called primary or major plant food nutrients or elements because they are needed for healthy plant growth in large amounts. They are also the common constituents of commercial fertilizer. State laws require that they be guaranteed in commercial fertilizer as N, P₂O₅ and K₂O.
- 85. Ratio** – The numerical ratio among the concentrations of the primary plant foods in a fertilizer. For example a 10-20-10 would be a 1-2-1 ratio, and a 13-39-0 would be a 1-3-0 ratio.
- 86. Salt Index** – This index is used to compare solubilities of chemical compounds. Most nitrogen and potash compounds have a high index, and phosphate compounds have a low index. The chemical compounds with high salt indexes may cause plants to wilt or die if they are applied too close to the seed or foliage.
- 87. Secondary Elements** – A term used in referring to calcium, sulfur and magnesium. These are also essential plant food elements. They may be present in some soils in adequate amounts and lacking in other soils.
- 88. Sodium** – A chemical element found in soils and is contained in some fertilizer materials. Sodium is not considered an essential plant food element; it seems to substitute for calcium under some conditions when soils are low in potash.
- 89. Sodium Nitrate** (NaNO₃) – Refer to Nitrate of Soda.
- 90. Soil Correctives for Alkali Soils** – Correction of alkali soils is for the most part dependent upon the addition of amendments such as gypsum, sulfur, sulfuric acid and ferric sulfate. Materials like these either contain calcium or cause the calcium in the soil to become available for correcting alkali conditions.
- 91. Soil Reaction** – Refer to Hydrogen Ion Concentration.
- 92. Soluble Potash** – That portion of potash in fertilizers that is soluble in an aqueous ammonical solution of 0.8 per cent ammonium oxalate.
- 93. Sulfate of Ammonia** (NH₄)₂SO₄) – Refer to Ammonium Sulfate.
- 94. Sulfate of Potash-Magnesia** (K₂SO₄•2MgSO₄) – Refer to Potassium-Magnesium Sulfate.
- 95. Superphosphate** – The source of most phosphorous used in fertilizer. There are two principal kinds of superphosphate-normal or ordinary and concentrated.
- A. Normal Superphosphate – Contains about 18-20 per cent P₂O₅. It is manufactured by mixing sulfuric acid and finely ground phosphate rock which results in a material containing primarily monocalcium phosphate and gypsum. In addition, dicalcium phosphate, a small amount of tricalcium phosphate and phosphoric acid may also be present.
 - B. Concentrated Superphosphates – Also called double, treble and triple superphosphates. Their available P₂O₅ equivalent ranges from 30-50 per cent. They are manufactured by reacting phosphoric acid or a mixture of phosphoric

and sulfuric acids with rock phosphate. If only phosphoric and sulfuric acids with rock phosphate. If only phosphoric acid is used, the material contains no gypsum.

96. Super Phosphoric Acid – Has a P_2O_5 equivalent of 76 or 77 per cent. It can be used to increase the concentration of liquid fertilizer. It can also be used as an agent to help hold impurities in suspension.

97. Synthetic Materials – Fertilizer materials which are manufactured by synthesis or artificial means. An example would be synthetic ammonia (NH_3) which is made by combining nitrogen from the air with hydrogen under pressure. When NH_3 is compressed and cooled in liquid form, it is called liquid anhydrous ammonia.

98. Trace, or minor, Elements (Micronutrients) - These elements are boron, copper, zinc, molybdenum, manganese, iron and chlorine. Although these minor elements are required by plants in only small amounts, crop yields will be affected adversely when soils are deficient in one or more of them.

There is some evidence that in addition to the above, cobalt, sodium, fluorine, lithium, vanadium and iodine may also be essential in plant growth.

99. Transplanting Solution – An aqueous solution of fertilizers at the time of setting out of plants.

100. Triple Superphosphate – Refer to Superphosphate.

101. Unit – A “unit of plant food” has been adopted as an official chemical term by the Association of American Fertilizer Control Officials. The definition they agreed upon is as follow: “A unit of plant food is twenty (20) pounds or one per cent (1%) of a ton”.

102. In the field you will often have the expression, “I used ‘X’ units of nitrogen (or other plant food) per acre on my lettuce—“. This is not technically correct usage of the term “units”. “Units” is related only to the per cent of plant food in a ton of fertilizer material.

103. Urea – ($CO(NH_2)_2$) – The most concentrated solid nitrogen carrier which is commercially available. It is 45% nitrogen (N). This solid synthetic material is manufactured by reacting carbon dioxide with ammonia in the liquid phase under high temperature and pressures.

104. When in the soil, its nitrogen changes to the ammonia form and finally to the nitrate form.

105. Zinc Sulfate – ($ZnSO_4$) – This is a solid fertilizer material which is often used as a source of zinc for plants.

REFERENCES

“Our Land and Its Care” - National Plant Food Institute

“Western Fertilizer Handbook” – The Pacific Northwest Plant Food Association and the California Fertilizer Association

“La Motte Soil Handbook” – Reprinted March, 1971