

# General Concepts, Classification, Terminology, and Definitions

## 1.1 Introduction

A fertilizer is a material that furnishes one or more of the chemical elements necessary for the proper development and growth of plants. The most important fertilizers are fertilizer products (also called chemical or mineral fertilizers), manures, and plant residues. A fertilizer product is a material produced by industrial processes with the specific purpose of being used as a fertilizer. Fertilizers are essential in today's agricultural system to replace the elements extracted from the soil in the form of food and other agricultural products.

## 1.2 Plant Nutrients

Chemical elements that are essential for the proper development and growth of plants are typically referred to as plant nutrients. The list of plant nutrients recognized as being necessary for plant growth has increased over the years and now totals sixteen, as shown in Table 1.1.

### 1.2.1 Classification

Nine plant nutrients are required in relatively large amounts and are referred to as major elements or macronutrients. Of these, carbon, hydrogen, and oxygen are obtained from the carbon dioxide in the atmosphere and water and therefore are not dealt with as nutrients by the fertilizer industry. These three plant nutrients make up 90%-95% of the dry matter of all plants. The other major elements are subdivided into primary nutrients (nitrogen, phosphorus, and potassium) and secondary nutrients (calcium, magnesium, and sulfur). The remaining seven plant nutrients are required in much smaller amounts and are known as micronutrients or minor elements.

In addition to the 16 essential elements listed in Table 1.1, some other elements have been shown, in certain circumstances, to be helpful in increasing crop yields or in improving the value of crops for animal or human nutrition. Examples are sodium, silicon, cobalt, and vanadium.

### 1.2.2 Expression

Many countries express quantities or percentages of the primary nutrients in terms of elemental nitrogen (N), phosphorus pentoxide ( $P_2O_5$ ), and potassium oxide

Table 1.1. Classification of Elements Essential for Plant Growth

Major elements (macronutrients)	(Available from air or water)	Carbon Hydrogen Oxygen
Primary nutrients		Nitrogen Phosphorus Potassium
Secondary nutrients		Calcium Magnesium Sulfur
Minor elements (micronutrients)		Boron Chlorine Copper Iron Manganese Molybdenum Zinc

90-95% dry matter

Major (9)

Neither the elemental oxide form

( $K_2O$ ), Secondary nutrients and micronutrients usually are expressed on an elemental basis although calcium and magnesium sometimes are expressed in the oxide form. However, several countries express all plant nutrients on an elemental basis. Plants actually use neither the pure element nor the pure oxide form, so the difference is largely academic. Conversion factors for those plant nutrients that may be expressed in the elemental or oxide form, depending on the country, are shown in Table 1.2.

## 1.3 Fertilizer Grade

It is customary to refer to a given fertilizer product by a series of numbers separated by dashes. This set of numbers is called the "grade" of the fertilizer product. Each of the numbers indicates the amount of a nutrient that the manufacturer guarantees is contained in the fertilizer product. This number includes only the amount of nutrient found by prescribed analytical procedures, thereby excluding any nutrient present in a form that is deemed to be unavailable for plant nutrition. The content of each nutrient is always expressed as a percentage by

shows of age of fertilizer

Quantity or of age of primary nutrients

N elemental  
 P  $P_2O_5$   
 K  $K_2O$   
 Ca →  
 Mg →  
 → sacks in oxides for-

F.P.T.S. reflected by a series of numbers separated by dashes  
 This number is called

P<sub>205</sub> → P .44 .83  
 P 2.29 1.20

**Table 1.2. Conversion Factors of Plant Nutrients (From Oxide to Elemental and From Elemental to Oxide Form)**

P <sub>2</sub> O <sub>5</sub>	x	0.44	=	P
P	x	2.29	=	P <sub>2</sub> O <sub>5</sub>
K <sub>2</sub> O	x	0.83	=	K
K	x	1.20	=	K <sub>2</sub> O
CaO	x	0.71	=	Ca
Ca	x	1.40	=	CaO
MgO	x	0.60	=	Mg
Mg	x	1.66	=	MgO
SO <sub>3</sub>	x	0.40	=	S
S	x	2.50	=	SO <sub>3</sub>

kg of Nutrient / 100kg of fertilizer

weight, or in other words as kilograms of nutrient per 100 kg of the fertilizer product. These percentages are guaranteed minimum rather than actual content, which is usually slightly higher.

Usually, three numbers are used when giving the grade of a fertilizer product, and these three numbers always refer, in order, to the content of the primary nutrients: nitrogen, phosphorus, and potassium. If other nutrients are present, their content can also be indicated in the grade of the fertilizer product; each extra number is followed by the chemical symbol of the nutrient it represents. Many countries indicate the content of phosphorus and potassium not in the elemental form but in the oxide form, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O. When references are made to the phosphorus content of a fertilizer product, it is common to call it phosphate, which is the form in which it is mostly present within the fertilizer products, although all calculations and expressions of content are made using either the oxide form (P<sub>2</sub>O<sub>5</sub>) or the elemental form (P).

Some examples of fertilizer grades follow:

- A fertilizer product with a grade of 18-46-0 is guaranteed by the manufacturer to have the following content:
  - 18% N, or 18 kg of N in every 100 kg
  - 46% P<sub>2</sub>O<sub>5</sub>, or 46 kg of P<sub>2</sub>O<sub>5</sub> in every 100 kg
  - 0% K<sub>2</sub>O, or no K<sub>2</sub>O
- A fertilizer product with a grade of 12-6-22-2MgO is guaranteed by the manufacturer to contain:
  - 12% N, or 12 kg of N in every 100 kg
  - 6% P<sub>2</sub>O<sub>5</sub>, or 6 kg of P<sub>2</sub>O<sub>5</sub> in every 100 kg
  - 22% K<sub>2</sub>O, or 22 kg of K<sub>2</sub>O in every 100 kg
  - 2% MgO, or 2 kg of MgO in every 100 kg

12 - 6 - 22 - 2MgO

.44 .83 .60

Expressed on an elemental basis, the fertilizer grade of this product would be 12-2.6-18.3-1.2Mg (Table 1.2).

In this manual, the oxide form will be used unless otherwise specified.

The value of using fertilizer grades in identifying a fertilizer product cannot be overemphasized. This is a constant reminder to the consumer that he is purchasing plant nutrients, not a named fertilizer product. For example, the fertilizer product single superphosphate (SSP) is known worldwide by that name or acronym. However, the P<sub>2</sub>O<sub>5</sub> content in commercially available SSP products around the world ranges from 14% to 20%.

#### 1.4 Nutrient Availability

A commercial fertilizer is a material containing at least one of the plant nutrients in a form assimilable or "available" to plants in known amounts. Generally, a plant nutrient is taken up by plant roots or foliage in the form of a solution in water. Plant nutrients form many different chemical compounds having varying degrees of solubility in water. Thus, it would seem that water solubility should provide a simple conclusive measure of the availability to plants. Unfortunately, the situation is far too complex for water solubility alone to serve as a measure of availability. All materials are soluble in water to some extent, even the most "insoluble."

Many sparingly soluble materials have been found to be available to plants and, in some cases, even more effective than readily water-soluble materials. However, some materials are so insoluble as to be virtually worthless as fertilizers. Therefore, most countries specify some degree of solubility of the nutrient content in water or other reagents or alternatively require identification and approval of the source of the material.

For example, natural organic materials may be acceptable on the basis of total N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O content, provided the source of the material is identified and approved. Synthetic organic materials, if sparingly soluble, may require special methods of analysis, particularly if intended for controlled-release fertilizers. Likewise, special tests may be required for coated controlled-release fertilizers.

Because most common nitrogen and potassium fertilizers are readily water-soluble, water solubility usually is accepted as evidence of plant availability, and special methods are applied to less soluble materials only when there is some evidence to indicate that the low (or controlled) solubility may be advantageous.

In the case of phosphate fertilizers, there is a wide variety of both readily water-soluble materials and

benefit → He is buying the nutrient not a named fertilizer.

SSP → Acronym  
14-20%

Commercial fertilizer water soluble  
Sparingly sol also available even more effective than soluble.

Approval of source material

NOM  
S.O.M  
Controlled release fertilizer

N & K water soluble

6  
44  
24  
6  
2.64  
22  
83

2  
1.20

sparingly water-soluble materials, and several methods are in use for evaluating their agronomic availability. The most common methods other than water solubility are based on solubility of  $P_2O_5$  in neutral or alkaline ammonium citrate solutions or in solutions of citric or formic acid. In addition, the total  $P_2O_5$  may be acceptable for some materials. Examples of the solubility criteria used for quality control of phosphate fertilizers follow.

**Germany** - Phosphate is expressed as the sum of  $P_2O_5$  soluble in water and (alkaline) ammonium citrate. For superphosphate, at least 90% of the sum must be soluble in water. For compound fertilizers, at least 30% of the sum must be soluble in water.

**Belgium** - For TSP, 38%  $P_2O_5$  soluble in neutral ammonium citrate must be guaranteed; 93% of the indicated content must be water soluble.

Soft rock phosphate must contain not less than 25%  $P_2O_5$  soluble in mineral acids, of which not less than 55% must be soluble in 2% formic acid. It must be ground to a fineness so that at least 90% passes through a 63-micron sieve; 99% must pass through a 125-micron sieve.

For compound fertilizers, the  $P_2O_5$  content may be expressed as that which is soluble in neutral ammonium citrate, soluble in water, or soluble in water and neutral ammonium citrate. If the compound fertilizer contains Thomas (basic) slag as the only source of phosphate, the  $P_2O_5$  claimed is that which is soluble in 2% citric acid.

**United States** - The guaranteed  $P_2O_5$  content of all fertilizers is based on the "available phosphate" content, which is the  $P_2O_5$  content soluble in neutral ammonium citrate including that soluble in water. There is no provision for determining or stating the water-soluble  $P_2O_5$  content separately. The total  $P_2O_5$  may be stated but is not included in the guaranteed available phosphate content.

**European Union (EU)** - Directives specify the following permissible solvents as a basis for evaluating phosphate fertilizers:

1. Water for those materials "where applicable."
2. Formic acid (2%) for soft natural phosphates.
3. Citric acid (2%) for basic slag.
4. Petermann's solution at 65°C for precipitated dicalcium phosphate dihydrate.  $D \cdot C \cdot P \cdot 2 \cdot H_2 \cdot O$
5. Petermann's solution at ambient temperature for "disintegrated phosphates."
6. Joule's solution for all straight and compound fertilizers in which phosphate occurs in aluminocalcic form.

(4) Regulations have been made in many parts of the world.   
 labels & markets.   
 obj -> ensure uniformity   
 most economical product

(5) Regulation add to the cost -> surplus

## 7. Neutral ammonium citrate solution for all fertilizer.

Joule's and Petermann's solutions are alkaline ammonium citrates containing free ammonia. Solvent compositions, extraction methods, ratios of sample to solvent, and methods for analysis are specified for each solvent.

It is beyond the scope of this manual to describe in detail the analytical methods that are used for fertilizers. The development of suitable methods for analyzing fertilizers for availability has claimed the attention of agricultural chemists since the beginning of the industry. The methods are constantly being revised and improved as new knowledge and new tools become available to the chemist.

### 1.5 Fertilizer Regulations

Given the wide variety of natural and synthetic materials that are beneficial to the growth of plants, a virtually unlimited number of products could truthfully be labeled "fertilizer" and marketed as such. The main drawback to uncontrolled marketing of fertilizer materials is the problem of the relative effectiveness of the product, and this depends on its composition. Unless the farmer can be sure that each lot of fertilizer he buys will have the same effectiveness as the preceding lot, he cannot be sure that he is fertilizing his crops in a rational manner, regardless of his stock of personal experience or advice from experts.

Another drawback to uncontrolled marketing of fertilizer is the lack of a rational basis for pricing. A tonne of low-analysis fertilizer is less valuable to the farmer than a tonne of higher analysis fertilizer; therefore, the farmer should have a simple method for determining the best buy from the existing market.

Because of the foregoing factors, regulations (some of them in the form of laws) have been established in many parts of the world to govern the labeling and marketing of commercial fertilizers at the retail level. These regulations are intended for local conditions and thus may vary from place to place; however, their primary purposes are to ensure uniformity and to provide a simple method whereby the farmer can select the most economical product available to him.

Regulations add to the cost of fertilizer. In order to guarantee a given nutrient percentage, the manufacturer must provide some surplus, and the amount of the surplus depends on the degree of technical control during manufacture. Enforcement of regulations adds further to the cost of fertilizers. These costs, inherent in controlling fertilizer composition at the retail level, are compensated by the inherent benefits. Without basic regulations, the fertilizer trade would become chaotic.

- 1) Relative effective - yield & growth
- 2) Lack of rational basis for pricing.

Tony Low Analysis fertilizer

Wish Analysis

with variety of natural & synthetic material packed and marketed as such. Drawback -> Relative effect not sure.

(90%)  
63/  
Micron  
Sieve  
99%  
from  
125  
Micron  
Sieve

As with other regulations, care should be taken to limit them to the essentials.

specification of invoice

to enhance... (Requisites) features

### 1.6 Fertilizer Specifications

Specifications are the requirements with which a fertilizer should conform, as agreed upon between buyer and seller. Fertilizer specifications meet differing requirements depending on the use or intent of the specification information.

Specifications are normally used in the contract between the buyer and seller of a fertilizer to ensure agreement on product characteristics or more often to define the product in sufficient detail to effect the satisfaction of both buyer and seller.

Normally a farmer (consumer) gets a specification on the fertilizer bag or, for a bulk delivery, on the invoice. This type of specification typically consists of the fertilizer grade, a guaranteed analysis, the net weight, and sometimes additional information about the product. This information is typically that which is required by government regulations, not necessarily by the customer.

More commonly, when one refers to specifications, it is to specifications that have legal implications for buyers and sellers of large quantities of materials. A well-written fertilizer specification should include the following elements in detail:

well written fertilizer

1. Nutrient contents and concentrations. ✓
2. Nutrient chemical composition. ✓
3. Moisture content. ✓
4. Particle size distribution. ✓
5. Physical condition. ✓
6. Solubility and/or availability. ✓
7. Conditioner. ✓
8. Special limitations pertaining to phytotoxic production byproducts or additives. ✓
9. Packaging details (if any). ✓
10. Methodology used in quantifying or qualifying items 1 through 9. ✓
11. Penalties or discounts for deviation from the stated values and conditions. ✓

Fertilizer specifications that include all of the above items may or may not meet the buyers' standards when bids are received. Usually when the buyer issues invitations to bid accompanied by the product's desired specifications, the seller tries to meet all items in order to

have a chance for his bid to be accepted. If the seller cannot meet all the terms and conditions of the specification, he would expect that his bid would be rejected by the buyer. However, there are instances where the seller will include exceptions with his bid. This is the seller's way of telling the buyer that he knows the product is not to the specification, but that he (the seller) is bidding a different (usually slightly different) material. Once the buyer accepts a bid with exceptions, the exceptions supplant the original specification and become part of a new contractual agreement between buyer and seller.

From a buyer's standpoint, one might consider that the more detailed a specification, the more certain the buyer becomes of the product quality. Usually, the more detailed a specification, the more difficult it is for the manufacturer to meet all the requirements, resulting in a more expensive material or severely limiting the number of sellers who are qualified to bid.

It is, therefore, to the purchaser's advantage to use standard products with the "normally accepted" specifications whenever possible. This approach allows more suppliers the opportunity to bid, resulting in a competitive market for the buyer.

Even when the material purchased meets all of the buyer's bid specifications, the material or product may not be well suited for its intended use. This is especially true of phosphate rock. Phosphate rock is quite variable in phosphate content from deposit to deposit and in quantities of impurities that drastically affect the rock's performance in production of nitrophosphates, phosphoric acid, superphosphates, and ammonium phosphates. Thus, the material purchased may not be what was initially wanted. Even though this material may meet all the stated specifications, it is possible for unspecified contaminants or impurities to affect the performance of the materials in subsequent processing or the crop response in finished fertilizers.

Ph  
R  
imp  
var  
dep

It is important then to state in the specifications not only what is wanted in the product but also what is not wanted in the product.

### 1.7 Terminology and Definitions

The following terminology and definitions commonly used in the fertilizer industry are limited to those whose meaning might not be obvious from usual dictionary definitions.

Fertilizer def. by J.P.T.

**Fertilizer** - In the simplest terminology, a material, the main function of which is to provide plant nutrients.

In Japan, fertilizer is defined as being any substance that is applied to the soil for the purpose of supplying

either the product meets the specific of like required nutrient content but it may contain heavy metals that can affect plant growth

Buyer must consider more detailed specifications that either this product is beneficial for his field

nutrients to plants or producing a chemical change in the soil that will contribute to the cultivation of plants or that is applied to the plant to supply plant nutrients.

In the Republic of the Philippines, the term fertilizer includes substances (either solid or liquid), nutrient elements (either organic or inorganic, single or in combination), and any materials applied directly to the soil for the purpose of promoting plant growth, increasing crop yields, or promoting their quality.

In Thailand, fertilizer means an organic or inorganic substance, whether of natural formation or produced through any method whatsoever, that is used as a nutrient element for plants or for causing a chemical change in the soil for the growth of plants.

In some countries, terms such as chemical fertilizer, mineral fertilizer, or inorganic fertilizer are used to distinguish the manufactured product from natural organic materials of plant or animal origin. The latter materials are called organic fertilizers.

**Chemical Fertilizer** - In Thailand, a fertilizer derived from inorganic substances or synthetic organic substances, including single fertilizer, mixed fertilizer, and compound fertilizer as well as organic fertilizer mixed with chemical fertilizer but excluding white lime, marl, plaster, or gypsum.

In Mauritius, chemical fertilizer means any substances containing one or more of the basic elements (nitrogen, phosphorus, potassium, calcium, magnesium, and silicon) used as a fertilizer.

**Inorganic (Mineral) Fertilizer** - A term used by the International Organization for Standardization (ISO) for fertilizer in which the declared nutrients are in the form of inorganic salts obtained by extraction and/or by physical and/or chemical industrial processes.

The Association of American Plant Food Control Officials (AAPFCO) defines "synthetic" as any substance generated from another material or materials by means of a chemical reaction.

**Organic Fertilizer** - Carbonaceous materials mainly of vegetable and/or animal origin added to the soil specifically for the nutrition of plants (ISO).

In Australia, organic fertilizers are defined as those manufactured from animal and vegetable byproducts. In Thailand, organic fertilizer means a fertilizer derived from organic material; it is produced through the process of drying, chopping, grinding, fermenting, sifting, or other methods but is not a chemical fertilizer. In Malaysia, organic fertilizers are fertilizers that are derived mainly from biological products (plant or animal) where most of the nutrient elements are present as organic compounds. In

Japan and the Philippines, the term "special fertilizer" is used to define organic-type fertilizer products.

AAPFCO, in the United States, uses the term "natural organic fertilizers" and gives the following definition:

Materials derived from either plant or animal products containing one or more elements (other than carbon, hydrogen, and oxygen) which are essential for plant growth. These materials may be subjected to biological degradation processes under normal conditions of aging, rainfall, sun-curing, air drying, composting, rotting, enzymatic, or anaerobic/aerobic bacterial action, or any combination of these. These materials shall not be mixed with synthetic materials or changed in any physical or chemical manner from their initial state except by manipulations such as drying, cooking, chopping, grinding, shredding, ashing, hydrolysis, or pelleting.

AAPFCO also defines organic fertilizer as a material containing carbon and one or more elements, other than hydrogen and oxygen, essential for plant growth.

The ISO and AAPFCO have defined several other terms relating to organic-type products. Some of the ISO terms are semi-organic fertilizer, organic nitrogenous fertilizer, synthetic organic nitrogenous fertilizer, manure, organic soil conditioner, and semi-organic soil conditioner. Some of the AAPFCO terms are compost, natural inorganic fertilizer, natural fertilizer, natural base fertilizer, organic base fertilizer, and animal manures.

**Soil Conditioner** - Material added to soils, the main function of which is to improve their physical and/or chemical properties and/or their biological activity (ISO).

In Malaysia, soil conditioner is defined as any substance that is added to the soil for the purpose of improving its physical or chemical character, enhancing soil productivity, or promoting the growth of crops - exclusive, however, of commercial fertilizers and farmyard manure. In Malaysia, "soil amendment" has the same definition as soil conditioner, except it includes the statement that a soil amendment supplies some nutrients.

AAPFCO defines soil amendment as any substance that is intended to improve the physical characteristics of the soil, except commercial fertilizers, agricultural liming materials, unmanipulated animal manures, unmanipulated vegetable manures, and pesticides.

**Liming Material** - An inorganic soil conditioner containing one or both of the elements calcium and magnesium, generally in the form of an oxide, hydroxide, or carbonate, principally intended to maintain or raise the pH of soil (ISO).

ISO

T → blendy, choppy

M → Biolos & Products

In Malaysia, a liming material is defined simply as a material used to neutralize soil acidity. AAPFCO in the United States defines "agricultural liming materials" as products whose calcium and magnesium compounds are capable of neutralizing soil acidity.

**Fertilizer Material** - A fertilizer that meets any of the following conditions (AAPFCO):

1. Contains important quantities of no more than one of the primary plant nutrients (nitrogen, phosphorus, or potassium).
2. Has 85% or more of its plant nutrient content present in the form of a single chemical compound.
3. Is derived from a plant or animal residue or byproduct or natural material deposit which has been processed in such a way that its content of plant nutrients has not been materially changed except by purification and concentration.

**Straight Fertilizer** - A qualification generally given to a nitrogenous, phosphatic, or potassic fertilizer having a declarable content of only one of the primary plant nutrients, i.e., nitrogen, phosphorus, or potassium (ISO).

In Malaysia, straight fertilizer is a generally loose term used in the fertilizer trade to signify a fertilizer that usually contains one nutrient element. In Australia, straight fertilizer is the term used to describe fertilizer containing only one of the elements nitrogen, phosphorus, or potassium. In Thailand, the term "single fertilizer" is equivalent to straight fertilizer.

**Compound Fertilizer** - A fertilizer that has a declarable content of at least two of the plant nutrients nitrogen, phosphorus, and potassium, obtained chemically or by blending, or both (ISO).

This term is defined and used around the world with several different meanings. Additionally, terms such as complex fertilizer, composite fertilizer, mixed fertilizer, mixture of fertilizers, fertilizer mixture, granulated mixture, physical mixture, and NPK fertilizer are also used in a similar vein and often have conflicting and/or overlapping definitions. A few examples follow:

1. **Compound Fertilizer (Malaysia)** - Any homogeneous product containing two or more of the following plant nutrient elements for fertilizing crops: nitrogen, phosphorus, potassium, and magnesium. It may also contain trace elements. The material is also known as composite fertilizer, complex fertilizer, and multinutrient fertilizer. The material shall be in the form of granules, pellets, prills, or crystals and shall be free-flowing.
2. **Compound Fertilizer (Thailand)** - A chemical fertilizer produced by chemical process and having at least two primary nutrient elements.

3. **Compounds (Australia)** - The term applied to fertilizer manufactured by a chemical reaction and containing two or more of the three main elements - nitrogen, phosphorus, and potassium.

4. **Compound or Complex Fertilizer (India)** - A fertilizer containing two or more essential plant nutrients that have undergone chemical reaction during the production process.

5. **Complex Fertilizer (Malaysia)** - A term used in the fertilizer trade to denote a compound fertilizer, all the nutrient contents of which have undergone chemical interaction during the manufacturing process.

6. **Mixed Fertilizer (AAPFCO)** - A fertilizer containing any combination or mixture of fertilizer materials (see AAPFCO definition for fertilizer materials).

7. **Mixed Fertilizer (Australia)** - The term applied to a fertilizer that is a physical mixture of two or more of the straight fertilizers. Mixed fertilizer may be powdered or granulated.

8. **Mixed Fertilizer (Philippines)** - A fertilizer containing any combination or mixture of commercial fertilizers.

9. **Mixed Fertilizer (Thailand)** - A chemical fertilizer derived from a mixture of various kinds or types of chemical fertilizers to obtain required nutrient elements.

10. **Fertilizer Mixture (Malaysia)** - A product obtained by mixing different fertilizer stock materials and containing more than one of the major plant nutrients, namely, nitrogen, phosphorus, potassium, and magnesium. *intimately mixing*

11. **Granulated Mixture (India)** - A mixture of fertilizers containing any two or more essential plant nutrients made by intimately mixing two or more fertilizer materials with or without inert material, and granulating them together, without involving any chemical reaction. *physical*

12. **Physical Mixture (India)** - A mixture of fertilizers containing any two or more essential plant nutrients made by physically mixing fertilizers with or without inert material necessary to make a required grade, without involving any chemical reaction.

13. **NPK/NP/PK Fertilizers** - Terms similar to and often used in conjunction with mixtures and compounds. They signify that the fertilizer contains nitrogen (N), phosphorus (P), and/or potassium (K).

**Blended Fertilizer** - A fertilizer, obtained by dry mixing, that has a declarable content of at least two of

deklarable content of one primary nutrient

all of nutrients under chemical reaction in 2 or 3 straight fertilizers AAPFCO mix - AA combination

Note Trace elements

At least 2

the plant nutrients nitrogen, phosphorus, and potassium (ISO).

In the United States, bulk-blended fertilizer is generally defined as a compound fertilizer produced by mixing two or more fertilizers whose granules are similar in size. These fertilizers are also called blended fertilizers or bulk blends.

In Australia, bulk blends are considered to be mixtures of two or more compounds or compounds and straight fertilizers, preferably in a pelletized (granular) form.

**Granular Fertilizer** - Solid material that is formed into particles of a predetermined mean size (ISO).

In the United States, AAPFCO defines granular fertilizer as a product, 95% or more of which can be retained on a series of sieves within the range of U.S. No. 4 (4.75-mm opening) to and including U.S. No. 20 (850-µm opening) and whose largest particle can pass through a sieve having an opening not larger than four times that of the sieve which retains 95% or more of the product.

In the AAPFCO definition, granular fertilizer denotes a particular size range for products. The definition for "pelletized fertilizer" in the United States (AAPFCO) is similar to that of the ISO definition for granular fertilizer, although more specific. The AAPFCO defines a pelletized fertilizer as a product, uniform in size and usually of globular shape, containing one or more nutrients and produced by one of several methods including (a) solidification of a melt as it falls through a counter-current stream of air, (b) application of dried layers of slurry to recycling particles, (c) compaction, (d) extrusion, and (e) granulation.

In Australia, the comparable term is "granulated or pelleted fertilizers" and refers to fertilizers that have been treated in such a way that the granules are uniform in size.

In Malaysia, the comparable term is "granulated fertilizer" and is defined as a fertilizer that has been made into particles of approximately uniform size, with 90% of the material falling in the range of 1 mm to 4 mm diameter.

**Coated Fertilizer** - Granular fertilizer that is covered with a thin layer of a different material in order to improve the behavior and/or modify the characteristics of the fertilizer (ISO).

Other similar definitions or variations are as follows:

1. **Coated Fertilizer** - Granular fertilizer that has been coated with a thin layer of some substance to pre-

vent caking or dust formation, or to control dissolution rate.

2. **Conditioned Fertilizer** - Fertilizer treated with an additive to improve physical condition or prevent caking. The conditioning agent may be applied as a coating or incorporated in the product.

3. **Filler (AAPFCO)** - A substance added to fertilizer materials to provide bulk, prevent caking, or serve some purpose other than providing essential plant nutrients.

4. **Filler (ISO)** - Substance incorporated in a fertilizer solely to reduce the nutrient content and without any declarable fertilizer nutrients.

**Slow-Release Fertilizer** - A fertilizer whose nutrients are present as a chemical compound or whose physical state is such that the nutrient availability to plants is spread over time (ISO).

In Malaysia, a slow-release fertilizer is defined as a fertilizer whose rate of release is regulated by the use of coatings of such materials as sulfur and polymeric compounds.

The AAPFCO defines a slow- or controlled-release fertilizer as a fertilizer containing a plant nutrient in a form which delays its availability for plant uptake and use after application, or which extends its availability to the plant significantly longer than a reference "rapidly available nutrient fertilizer" such as ammonium nitrate or urea, ammonium phosphate, or potassium chloride. Such delay of initial availability or extended time of continued availability may be achieved by a variety of mechanisms. These include controlled water solubility of the material (due to semipermeable coatings, occlusion, or the inherent water insolubility of polymers, natural nitrogenous organics, protein materials, or other chemical forms), slow hydrolysis of water-soluble, low-molecular-weight compounds, or other unknown means.

Other related terms are:

1. **Coated Slow-Release Fertilizer (AAPFCO)** - A product containing sources of water-soluble nutrients, release of which in the soil is controlled by a coating applied to the fertilizer.

2. **Polymer-Coated Fertilizer (AAPFCO)** - A coated slow-release fertilizer consisting of fertilizer particles coated with a polymer (plastic) resin. It is a source of slowly available plant nutrients.

3. **Controlled-Release Fertilizers** - Fertilizers in which one or more of the nutrients have limited solubility in the soil solution, so that they become available to the growing plant over a controlled period.

The ideal in such a fertilizer would be the release of nutrients at a rate exactly equal to the needs of the plant. The limited solubility may be an inherent characteristic of the fertilizer, or it may be imparted to a soluble fertilizer by coating the particles.

4. **Nitrogen Stabilizer (AAPFCO)** – A substance added to a fertilizer to extend the time that the nitrogen component of the fertilizer remains in the soil in the ammoniacal form.

5. **Nitrification Inhibitor (Australia)** – Complex chemical substance that has the effect of killing or temporarily reducing the activity of the soil bacterium Nitrosomonas, which is responsible for the conversion of ammonium-nitrogen in the process of nitrification. The effect is similar to that of slow-release fertilizers. Nitrification inhibitors are added to nitrogen products before application.

6. **Urease Inhibitor (Australia)** – Complex chemical substance that has the effect of temporarily preventing the activity of the soil enzyme urease.

**Liquid Fertilizer** – A term used for fertilizers in suspension or solution and for liquefied ammonia (ISO).

In Malaysia, this term includes anhydrous ammonia, ammoniating solutions, liquid mixed fertilizer solutions, suspensions, and slurries. The principal materials used in making liquid fertilizer are ammonia, ammonium nitrate, urea, phosphoric acid, and potassium chloride.

In the United States, the term liquid or fluid fertilizer is a general term usually including fertilizers wholly or partially in solution that can be handled as a liquid. This includes clear liquids, liquids containing solids in suspension, and usually anhydrous ammonia; however, anhydrous ammonia sometimes is referred to as a gaseous fertilizer even though it is applied as a liquid. AAPFCO defines liquid fertilizer as a fluid in which the plant nutrients are in true solution.

Other related terms are:

1. **Solution Fertilizers (ISO)** – Liquid fertilizer free of solid particles.
2. **Suspension Fertilizer (ISO)** – A two-phase fertilizer in which solid particles are maintained in suspension in the aqueous phase.
3. **Suspension Fertilizer (AAPFCO)** – A fluid containing dissolved and undissolved plant nutrients. The suspension of the undissolved plant nutrients may be inherent with the materials or produced with the aid of a suspending agent of nonfertilizer properties. Mechanical agitation may be necessary in some cases to facilitate uniform suspension of undissolved plant nutrients.

4. **Suspension Fertilizer** – A liquid (fluid) fertilizer containing solids held in suspension, for example, by the addition of a small amount of clay. The solids may be water-soluble in a saturated solution, or they may be insoluble, or both.

5. **Slurry Fertilizer (AAPFCO)** – A fluid mixture that contains dissolved and undissolved plant nutrient materials and requires continuous mechanical agitation to assure homogeneity.

**Specialty Fertilizer** – A fertilizer recommended or used principally for golf courses, lawns, home gardens, house plants, or for any purpose other than growing farm crops. The AAPFCO defines specialty fertilizer as a fertilizer distributed for nonfarm use.

**Powder** – A solid substance in the form of very fine particles (ISO).

Powder is also referred to as "nongranular fertilizer" and is sometimes defined as a fertilizer containing fine particles, usually with some upper limit such as 3 mm but no lower limit.

Very few fertilizer materials are sold now in the powder form. This was the standard form of fertilizer materials many years ago, before granulation processes were developed. Powders present problems in handling and application because of their tendency to cake (becoming cemented in large blocks), their usual inability to flow freely, and their dustiness during application. Powders are not amenable to machine broadcasting because the fine particles cannot be spread evenly by the machine. Some fertilizer materials of low solubility are made into very fine powders to enhance their availability to the crops by increasing their surface area. Amendments such as agricultural limestone are applied as finely divided powders to speed reaction with the soil.

**Run-of-Pile (ROP)** – Products that are taken from the production piles without undergoing careful control of the particle size. This form of material consists of particles of many different sizes, from very fine powders to coarse, pebble-like particles. Usually the coarse particles are very friable and can be crushed under finger pressure. Typical examples of fertilizers sold as run-of-pile materials are some forms of single superphosphate and monoammonium phosphate.

**Granulation** – A general term for processes such as agglomeration, accretion, or crushing used to make a granular fertilizer (ISO).

Granulation has a number of advantages, particularly in reducing the quantity of dust in a fertilizer, improving uniformity of flow when it is being applied, and minimizing segregation when these fertilizers are blended.



**Prill** - A granule obtained by solidification of droplets of fertilizer or by crystallization under special conditions (ISO).

Prills are smooth, spherical particles. In the fertilizer industry, by far the most common method of producing prills is by the solidification of molten drops of the fertilizer product. The molten fertilizer is sprayed from a height inside a closed tower while a stream of air is moved upward inside the tower. As the drops fall, they cool and solidify. Prills are usually smaller than particles produced by other processes. This process is mostly used in producing urea, ammonium nitrate, and some NPK grades.

**Granules** - Relatively spherical particles produced by enlarging small particles through successive deposition of a liquid or slurry material, which solidifies on the surface through crystallization and/or drying. Different processes are used depending on the material being granulated. The surface of granules is not as smooth as that of prills, although some granulation processes will produce surfaces that are much smoother than others. These particles are usually stronger (have greater resistance against crushing) than prills. Granular diammonium phosphate (DAP) is a typical example of slurry granulation.

**Crystals** - Particles that have flat sides and sharp edges and corners, resembling the particle shape of sugar and table salt. These particles are made by letting the fertilizer crystallize from a strong solution by removal of water through heat and, in some cases, vacuum. The final processing steps for some crystalline materials sometimes include tumbling to break off some of the edges and corners, which tends to give a more spherical particle. Some forms of ammonium sulfate and muriate of potash are produced by crystallization. The large crystals are often separated from the smaller particles by screening. The large crystals are often called granules.

**Compacted Particles** - Particles that have totally irregular shapes. They resemble the shapes of crushed rocks. These particles are made by crushing down to size from thick and wide continuous sheets made by pressing solid particles of the component materials between cylindrical rolls under high pressure. Some muriate of potash products are typical compacted materials.

**Recycle** - In a fertilizer process, a portion of the finished or partially finished product that is returned to an early stage of the process for an additional pass through the subsequent processing steps in fertilizer granulation processes, it is common practice to return under-size product and crushed oversize product as recycle to the granulator. Such recycling not only reclaims these off-size materials but also serves the important functions of reducing moisture content and lowering temperature

in the granulator. The latter functions are of such importance that frequently it is beneficial to also crush and recycle some product-size material.

**Formula** - A term used in some countries to express, by numbers, in the order N-P-K (nitrogen-phosphorus-potassium), the respective content of these nutrients in a compound fertilizer.

The AAPFCO defines "fertilizer formula" as the quantity and grade of the crude stock material used in making a fertilizer mixture. Malaysia uses the same definition. Another common definition is a list of the kind, nutrient content, and amount of stock materials required to produce a given weight of mixed fertilizer of a given nutrient content.

**Bulk** - Qualification given to a fertilizer or soil conditioner not packed in a container (ISO).

The AAPFCO defines a "bulk fertilizer" as a fertilizer delivered to a purchaser either in solid or liquid state in a nonpackage form to which a label cannot be attached. Malaysia uses the same definition.

**Guarantee (of Composition)** - Quantitative and/or qualitative characteristics with which a market product must comply for contractual or legal requirements (ISO).

Other similar or related terms are:

1. **Declarable Content (ISO)** - That content of an element (or an oxide) which, according to national legislation, may be given on a label or document associated with a fertilizer or soil conditioner.

2. **Guaranteed Analysis (Japan)** - The minimum amount of each of the main components, expressed as percentages, which are guaranteed by the producer, importer, or dealer to be contained in any fertilizer he produces, imports, or sells.

3. **Guaranteed Analysis (Philippines)** - A statement guaranteeing the contents in terms of the minimum percentage of plant food claimed on the manufacturer's label.

4. **Guaranteed Analysis (AAPFCO)** - The minimum percentage of plant nutrients claimed in the following order and form:

A. Total nitrogen (N) \_\_\_\_\_ %

Available phosphate ( $P_2O_5$ ) \_\_\_\_\_ %

Soluble potash ( $K_2O$ ) \_\_\_\_\_ %

B. For unacidulated mineral phosphatic material and basic slag, bone, tankage, and other organic phosphatic materials, the total phosphate and/or degree of fineness may also be guaranteed.

C. Guarantees for plant nutrients other than nitrogen, phosphorus, and potassium may be permitted or required by regulation. The guarantees for such other nutrients shall be expressed in the form of the element. The source (oxides, salts, chelates, etc.) of such other nutrients may be required to be stated on the application for registration and may be included on the label. Other beneficial substances or compounds, determinable by laboratory methods, also may be guaranteed with permission from the regulatory authority and with the advice of the Director of the Agricultural Experiment Station. When any plant nutrients or other substances or compounds are guaranteed, they shall be subject to inspection and analysis in accord with the methods and regulations prescribed by the regulatory authority.

**Fertilizer Unit** - The unit mass of a fertilizer nutrient (in the form of the element or an oxide), generally 1 kg (ISO).

In the United States, fertilizer unit is defined as 10 kg of plant nutrients or 1% of a 1,000-kg tonne of fertilizer.

**Plant Food Ratio** - The ratio of the numbers of fertilizer units in a given mass of fertilizer expressed in the order N-P-K (ISO). In other words, it is the ratio of two or more nutrient percentages to another. A 5-10-15 grade has a 1-2-3 ratio; 10-20-20 a 1-2-2 ratio; 0-10-20 a 0-1-2 ratio.

**Label** - Piece of paper or plastic, or a printed area of a package or container, marked with the necessary information to identify the product and make known its essential characteristics (ISO).

The AAPFCO defines label as the display of all written, printed, or graphic matter, upon the immediate container, or a statement accompanying a fertilizer.

The Philippines defines label as a display or written, printed, or graphic matter designed in any manner or by any means upon the immediate container of commercial fertilizer.

**Brand** - Term, design, or trademark used in connection with one or several grades of fertilizer (AAPFCO). The Philippines uses the same definition.

**Custom Mixture** - A fertilizer formulated according to specifications that are furnished by/for a consumer prior to mixing, usually based on the results of soil tests.

**Chloride-Free Fertilizers** - Fertilizers containing less than some specified amount of chlorine. Because the usual source of chlorine in fertilizer is potassium chloride, the term usually means a fertilizer containing potassium from some other source such as potassium sulfate or potassium nitrate. Low-chlorine fertilizers may be

preferred for agronomic reasons or, in the case of some compound fertilizers containing ammonium nitrate, to avoid hazardous thermal instability. The maximum chloride content of chloride-free fertilizers may be in the range of 1.0%-2.5% depending on the type of fertilizer and country regulations.

**Standard Chemical Fertilizer** - A chemical fertilizer for which the Minister has announced the formula and minimum or maximum quantity of nutrient element or poisonous substance and other necessary characteristics for each kind of soil chemical fertilizer (Thailand).

**Sampling Unit** - A defined quantity of material having a boundary which may be physical - for example, a container - or hypothetical - for example, a particular time or time interval in the case of a flow of material (ISO).

A similar term, "lot," is defined by the AAPFCO as any identifiable quantity of fertilizer that can be sampled officially.

**Investigational Allowance** - An allowance for variations inherent in the taking, preparation, and analysis of an official sample of fertilizer (AAPFCO).

In the Philippines, a similar term, "tolerance," means the variation from the guaranteed analysis authorized by laws or rules and regulations.

**Solubility of a Fertilizer Nutrient** - The quantity of a given nutrient that will be extracted by a specific medium under specified conditions, expressed as a percentage by mass of the fertilizer (ISO).

The AAPFCO defines available phosphate as the sum of the water-soluble and the citrate-soluble phosphate. Malaysia defines phosphate available as the sum of the water-soluble and the citrate-soluble phosphoric acid (as  $P_2O_5$ ).

The term "available," as applied to each of the three primary fertilizer constituents, nitrogen, phosphorus, and potassium, has somewhat different meanings. For each nutrient, all the content that is soluble in water is available. In addition, however, some of the content that is not soluble in water is available to plants.

It is preferable to use the terms "active" and "inactive" as applied to insoluble nitrogen, unless the results of actual field or growing tests can be used. Animal and vegetable materials may decompose in damp, warm soils, and part or all of the nitrogen thus becomes available to growing plants. Some of the nitrogen may, however, remain unavailable. In order to anticipate the relative value of the nitrogen contained in organic (animal and vegetable) materials, empirical laboratory methods have been developed which give results in reasonable agreement with field tests.

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Available phosphate in ammonium phosphates, superphosphates, or mixed fertilizers is the water-soluble plus the ammonium citrate-soluble phosphate. For basic slag, fused phosphates, and phosphate rocks, the available phosphate is determined as the part soluble in a 2% citric acid solution.

Available potash is considered to be that which is soluble in water, aqueous ammonium oxalate, or aqueous ammonium citrate.

"Available plant nutrient" is intended to mean that which is in a form capable of being assimilated by growing plants or of being converted into such a form in the soil during the growing season.

**Moisture** - Free water held by solids as distinguished from water of crystallization and water of constitution which are in chemical combination and no longer have the properties of water.

**Heavy Metals** - Metallic elements that are located in the transitional series of the periodic chart of elements. These metals are not required in plant nutrition and usually are found in relatively small amounts in nature. Toxicity to plants could result with high concentrations of some heavy metals in soil, and problems in animal and human health may result if heavy metal concentrations in the diet are above certain critical levels. Examples are cadmium (Cd), chromium (Cr), lead (Pb), nickel (Ni), and vanadium (V). Levels of heavy metals may be a problem in some phosphate rock deposits, sewage sludge, animal manures, and some industrial byproducts used as a source of fertilizer.

**Fines** - Fertilizer particles that are smaller than the size of particles intended to be manufactured for sale.

**Deficiency** - The amount of nutrient found by analysis to be less than that guaranteed, which may result from a lack of nutrient ingredients or from lack of uniformity (AAPFCO).

In the Philippines, deficiency is defined as the amount found by analysis to be less than that guaranteed.

**Deteriorated Chemical Fertilizer** - A chemical fertilizer which has expired or, as a result of any factor, has deteriorated in quality so that the quantity of nutrient element is reduced or its condition changed (Thailand).

**Misbranding** - A fertilizer shall be deemed to be misbranded:

- soluble + AgA.C
- If its labeling is false or misleading in any particular.
  - If it is distributed under the name of another fertilizer product.
  - If it is not labeled as required by regulation.
  - If it purports to be or is represented as a fertilizer, or is represented as containing a plant nutrient or fertilizer unless such plant nutrient or fertilizer conforms to the definition of identity, if any, prescribed by regulation (AAPFCO).

**Adulteration** - A fertilizer shall be deemed to be adulterated:

- If it contains any deleterious or harmful ingredient in sufficient amount to render it injurious to beneficial plant life when applied in accordance with directions for use on the label, or if the label does not contain adequate warning statements or directions for use that may be necessary to protect plant life.
- If its composition falls below or differs from that which it is purported to possess by its labeling.
- If it contains unwanted crop seed or weed seed.

**Application** - General term for all processes of administering fertilizer and soil conditioners to a crop or soil or both (ISO).

This term embraces broadcasting, spreading/spraying, or dusting, as well as more specific placement methods including injection into the soil and the drilling of seed and fertilizer combined. It may be broadened to cover nutrient film techniques and the addition of fertilizers to irrigation water (fertigation).

**Dose Rate; Dose** - The mass or volume of a fertilizer or soil conditioner or nutrient applied to unit area of cultivated land or unit mass of growth medium (ISO).

**Plant Food** - Marketing term used to express plant nutrients in a fertilizer.

**Fertilizer Distribution** - General term for transportation, intermediate storage, and marketing of fertilizer, including all operations after the fertilizer leaves the factory and before it reaches the farm.

**Abbreviations** - Many of the more common fertilizers are often identified or referred to by abbreviations. The following list indicates those abbreviations most commonly encountered:

Abbreviation	Name of Product	Typical Grade
AN	Ammonium nitrate	33%-34% N
APS	Ammonium phosphate sulfate	16-20-0
APP	Ammonium polyphosphate solution	10-34-0
AS	Ammonium sulfate	21% N
CAN	Calcium ammonium nitrate	21%-26% N
CN	Calcium nitrate	15% N
DAP	Diammonium phosphate	18-46-0
KCl	Potassium chloride	60%-62% K <sub>2</sub> O
MAP	Monoammonium phosphate	10-50-0 to 11-55-0
MOP	Muriate of potash (fertilizer-grade potassium chloride)	60%-62% K <sub>2</sub> O
SOP	Sulfate of potash (fertilizer-grade potassium sulfate)	50% K <sub>2</sub> O
Sul-Po-Mag®	Sulfate of potash-magnesia	22% K <sub>2</sub> O; 18% S; 10%-18% MgO
SSP	Single superphosphate	16%-22% P <sub>2</sub> O <sub>5</sub>
TSP	Triple superphosphate	44%-48% P <sub>2</sub> O <sub>5</sub>
-	Urea	45%-46% N
UAN	Urea-ammonium nitrate solution	23%-32% N

Note: Sul-Po-Mag® is a registered trade name of IMC Global USA.

### 1.8 Fertilizer-Related Information Sources