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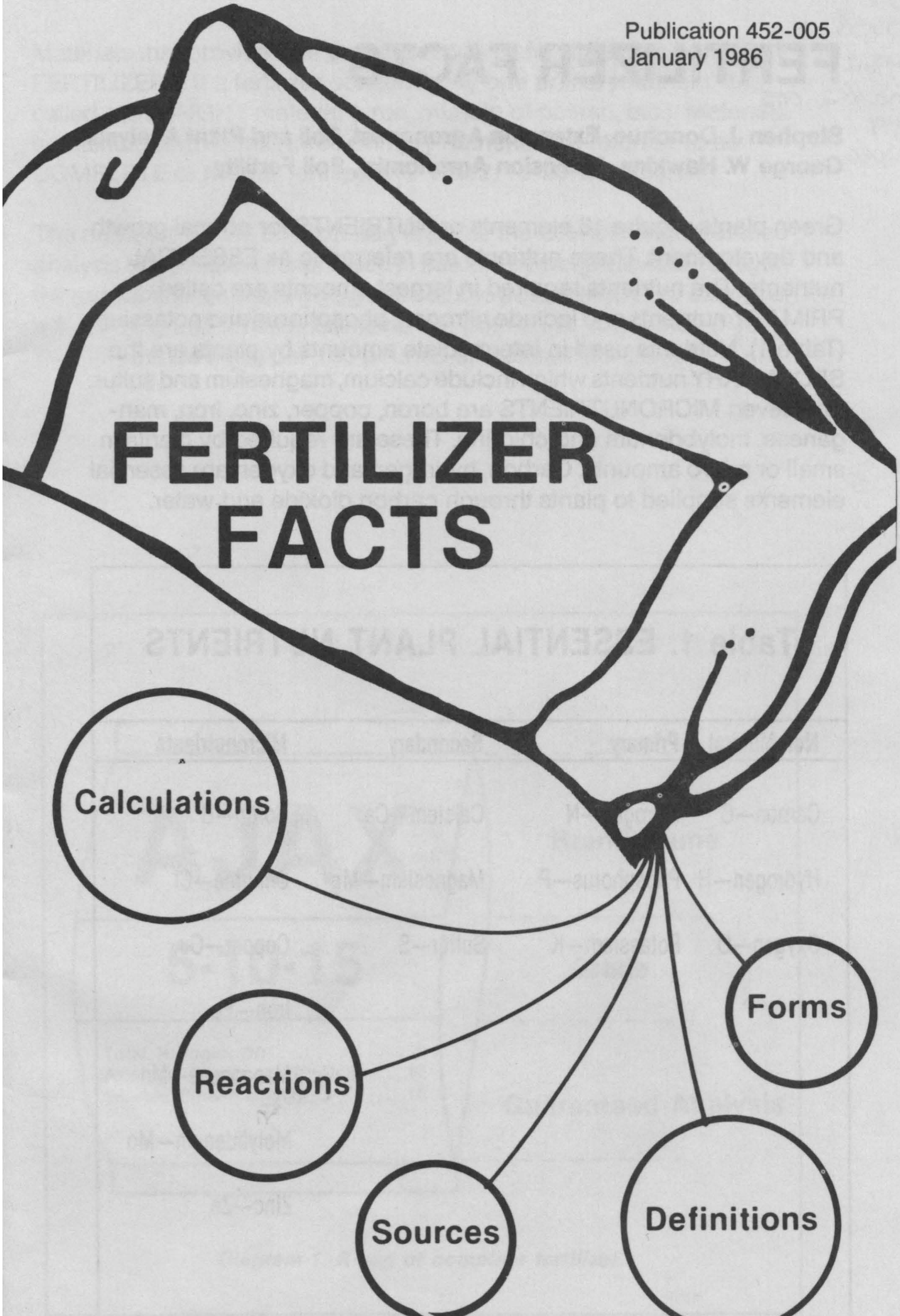
FERTILIZER FACTS



Virginia Cooperative Extension Service
Virginia Tech and Virginia State
Virginia's Land-grant Universities

FERTILIZER FACTS

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Green plants require 16 elements or NUTRIENTS for normal growth and development. These nutrients are referred to as ESSENTIAL nutrients. The nutrients required in largest amounts are called PRIMARY nutrients and include nitrogen, phosphorus and potassium (Table 1). Nutrients used in intermediate amounts by plants are the SECONDARY nutrients which include calcium, magnesium and sulfur. The seven MICRONUTRIENTS are boron, copper, zinc, iron, manganese, molybdenum and chlorine. These are required by plants in small or micro amounts. Carbon, hydrogen and oxygen are essential elements supplied to plants through carbon dioxide and water.

Table 1. ESSENTIAL PLANT NUTRIENTS

Non-Mineral	Primary	Secondary	Micronutrients
Carbon—C	Nitrogen—N	Calcium—Ca	Boron—B
Hydrogen—H	Phosphorus—P	Magnesium—Mg	Chlorine—Cl
Oxygen—O	Potassium—K	Sulfur—S	Copper—Cu
			Iron—Fe
			Manganese—Mn
			Molybdenum—Mo
			Zinc—Zn

Materials that provide one or more nutrients for plant use are called FERTILIZERS. If a fertilizer contains only one primary nutrient, it is called a STRAIGHT material (urea, muriate of potash, etc.). Materials containing each of the three primary nutrients are referred to as COMPLETE or MIXED fertilizers (6-12-12, 10-20-20, etc.).

The numbers on the fertilizer bag indicate the GRADE or guaranteed analysis of the material expressed in percent by weight as total nitrogen (N), available phosphate (P_2O_5) and soluble potash (K_2O). For example, a 5-10-15 grade fertilizer contains five pounds N, 10 pounds (P_2O_5) and 15 pounds (K_2O) per 100 pounds of material (Diagram 1).

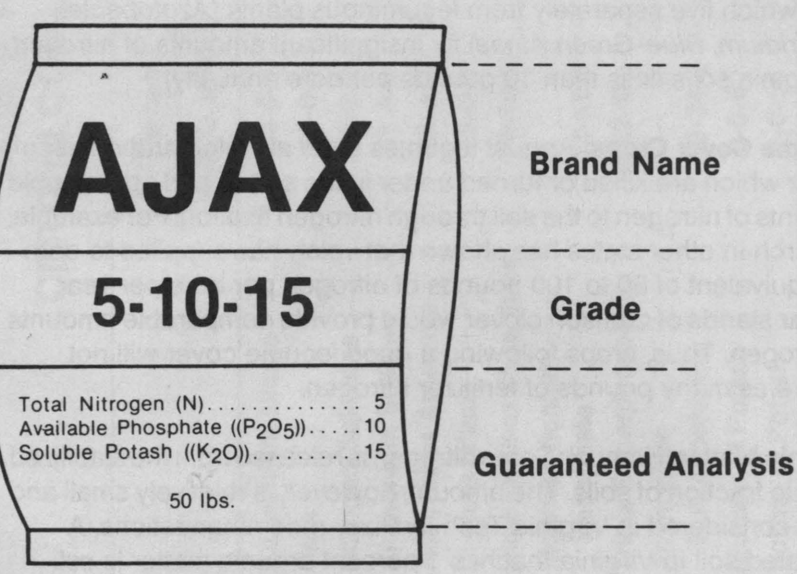


Diagram 1. A bag of complete fertilizer.

Fertilizer phosphate and potash can be converted to elemental phosphorus and potassium as follows:

$P = (P_2O_5) \times 0.44$	**or**	**$(P_2O_5) = P \times 2.29$**
$K = (K_2O) \times 0.83$	**or**	**$(K_2O) = K \times 1.2$**

NITROGEN SOURCES

Commercial Fertilizers: Nitrogen sources most commonly used in Virginia are 30% solutions, ammonium nitrate and urea. Significant amounts of nitrogen are also supplied through mixed materials such as 18-46-0 and 10-10-10.

Nitrogen Fixation: Legumes such as alfalfa and soybeans have the capacity to produce their own supply of nitrogen. Bacteria (*RHIZOBIA*) living in nodules on the roots of legumes are able to remove nitrogen from the atmosphere and convert it into usable forms. Micro-organisms which live separately from leguminous plants (*Azotobacter, Clostridium, Blue-Green Algae*) fix insignificant amounts of nitrogen in Virginia soils (less than 10 pounds per acre annually).

Legume Cover Crops: Annual legumes such as vetch and crimson colver which are killed or turned under in the spring add appreciable amounts of nitrogen to the soil through nitrogen fixation. For example, research in other states has shown that vetch has supplied to corn the equivalent of 80 to 100 pounds of nitrogen per acre per year. Similar stands of crimson clover would provide comparable amounts of nitrogen. Thus, crops following a good legume cover will not require as many pounds of fertilizer nitrogen.

Organic Matter (Humus): Some nitrogen is released from the stabilized organic fraction of soils. The amount, however, is relatively small and is not considered in Virginia Tech fertilizer recommendations. A cultivated soil in Virginia that has 1 percent organic matter is estimated to release about 10 pounds of nitrogen per acre annually.

Table 2. PROPERTIES OF CERTAIN COMMERCIAL FERTILIZERS

	Percent $N-(P_2O_5)-(K_2O)$	Major Components	Form	Percent Water Solubility
Ammonium Nitrate	34-0-0	NH_4NO_3	dry	100
Urea	46-0-0	$(NH_2)_2CO$	dry	100
Nitrogen Solutions	30-0-0	$(NH_2)_2 CO + NH_4NO_3$	liquid	100
Ammonium Sulfate	21-0-0	NH_4SO_4	dry	100
Anhydrous Ammonia	82-0-0	NH_3	gas	100
Sodium Nitrate	16-0-0	$NaNO_3$	dry	100
Diammonium Phosphate	18-46-0	$(NH_4)_2HPO_4$	dry	95-100
Monoammonium Phosphate	11-48-0	$NH_4H_2PO_4$	dry	95-100
Triple Superphosphate	0-(42-50)-0	$Ca(H_2PO_4)_2$	dry	90-100
Ammonium Polyphosphate	10-34-0	$(NH_4)_3HP_2O_7 + NH_4H_2PO_4$	liquid	100
Muriate of Potash	0-0-60	KCL	dry	100
Sulfate of Potash	0-0-50	K_2SO_4	dry	100

Table 3. SOME COMMON SOURCES OF SECONDARY AND MICRONUTRIENTS

Nutrient Materials	Percent Nutrient	Pounds of Material for 1 lb. Nutrient
Boron		
Fertilizer Borate 40	13.3	7.5
Solubor	20.5	4.9
Calcium		
Calcitic Limestone	35	2.8
Calcium Sulfate (Gypsum)	22.5	4.4
Copper		
Copper Sulfate	25	4.0
Copper Chelates	13	7.7
Iron		
Iron Sulfate	19	5.3
Iron Chelates	5-14	7-20
Magnesium		
Dolomitic Limestone	9	11.1
Magnesium Sulfate (Epsom Salts)	9	11.1
Potassium-Magnesium Sulfate	11	9.1
Manganese		
Manganese Sulfate	27	3.7
Manganese Chelates	12	8.3
Molybdenum		
Ammonium molybdate	54	1.9
Sodium molybdate	39	2.6
Sulfur		
Gypsum	17	5.9
Potassium-Magnesium Sulfate	22	4.5
Elemental Sulfur	30-99	1-3
Zinc		
Zinc Sulfate	36	2.8
Zinc Chelates	10-14	7-10

PHOSPHORUS SOURCES

Diammonium phosphate (DAP) and triple superphosphate (TSP) are the main sources of fertilizer phosphorus used in the state. DAP is the basic ingredient in dry bulk blends while TSP is available in bags, bulk or blends. The remaining phosphorus used is supplied largely through mixed grades.

Ground rock phosphate is a low analysis, extremely slow reacting phosphorus source used in organic gardening.

POTASSIUM SOURCES

The state's primary sources of potassium are potassium chloride (MURIATE) and potassium nitrate. The nitrate form is recommended and used mainly as a potassium source for tobacco and certain horticultural crops.

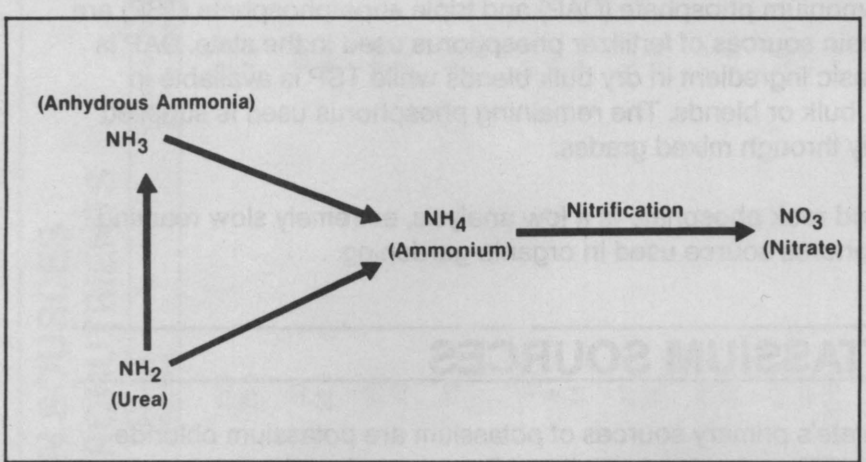
SECONDARY AND MICRONUTRIENTS

Since secondary and micronutrients are required by plants in relatively small amounts, most soils in Virginia contain sufficient levels naturally and do not require the addition of fertilizer sources for corp production. Thus, the need to apply secondary and micronutrients is limited to certain soils and cropping conditions. Use soil tests and plant tissue analyses to determine need. Also, refer to Table 3 for information about commonly available sources.

FERTILIZER REACTIONS IN SOILS

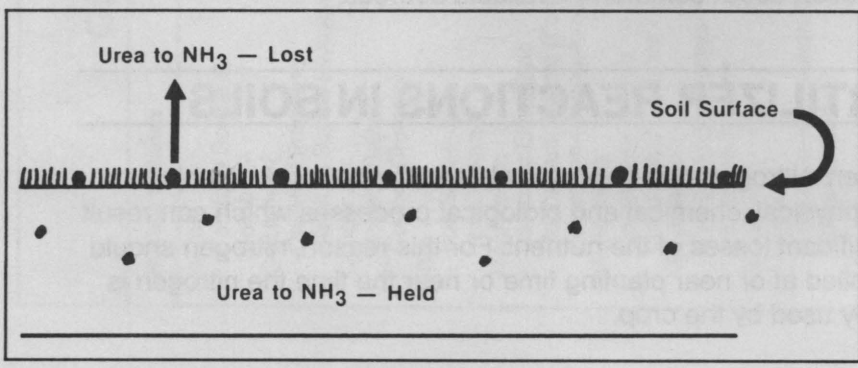
Nitrogen: Nitrogen can be very mobile in the soil and is subject to many physical, chemical and biological processes which can result in significant losses of the nutrient. For this reason, nitrogen should be applied at or near planting time or near the time the nitrogen is actually used by the crop.

Regardless of the form applied, transformation processes drive soil nitrogen towards the nitrate (NO_3) form. The general reaction is as follows:



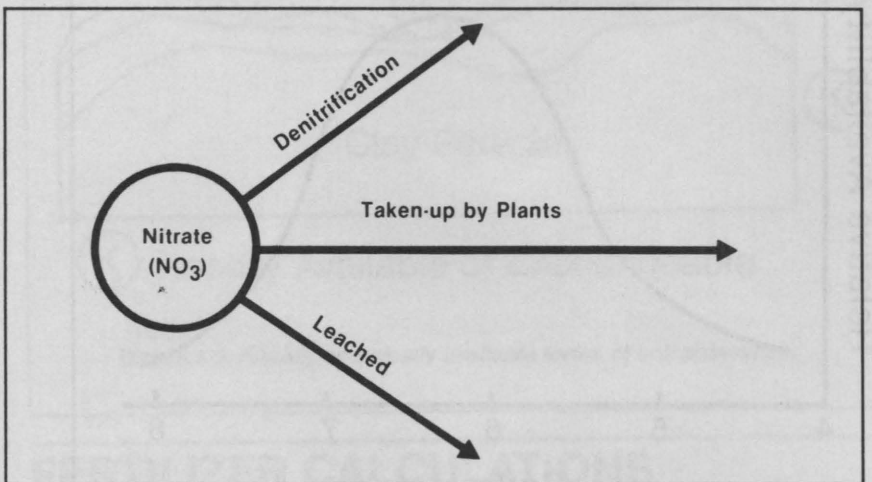
Urea and anhydrous ammonia are converted to the ammonium form. The process requires from a few hours to a few days with warm conditions but may require several days under cool temperatures. The ammonium form of nitrogen is held by the soil, used in limited amounts by plants or converted to nitrates through NITRIFICATION.

In addition to being converted to ammonium (NH_4), urea can be converted to ammonia (NH_3). If the conversion occurs below the soil surface, little or no ammonia is lost. However, if the conversion occurs on the soil surface, the ammonia gas is lost to the atmosphere (VOLATILIZATION).



Although ammonia losses are usually less than 10 percent, they can be significantly greater when urea is topdressed on warm moist soils followed by three or more days of good drying conditions. The presence of significant amounts of plant residue on the surface can intensify the loss. Thus, if dry or liquid urea is broadcast on the surface during warm weather, it should be applied prior to rain if possible. Urea is water soluble and can be incorporated with enough rainfall to wet the top two to three inches of soil. INCORPORATING or injecting urea unto the soil usually eliminates volatilization.

Nitrate nitrogen can be taken-up by plants, leached or denitrified. Significant amounts can also be held in subsoils with clayey textures. DENITRIFICATION takes place under flooded or water-logged soil conditions and converts nitrates back to the elemental form of nitrogen (N_2) which is a gas and is lost to the atmosphere.



Losses through denitrification are estimated to be 15-30 percent of the total applied nitrogen from an area flooded for three to five days. Fields flooded for longer periods likely lose even greater amounts. Denitrification losses from well drained soils may occur during short periods of low oxygen concentrations caused by high microbial activity.

Leaching losses of nitrates occur mainly in sandy soils but can be significant in medium textured soils when excessive rainfall is received.

Phosphorus: Phosphorus is very immobile in the soil and moves primarily as soil particles are moved. It is lost from the soil through plant removal and soil erosion.

The reaction of phosphorus in the soil is closely related to soil pH. Its maximum availability occurs under slightly acid soil conditions (pH 6.1-6.8). At lower or higher pH levels, phosphorus becomes chemically fixed and less available as insoluble iron, aluminum or calcium phosphate (Diagram 2). Soil testing high to very high in phosphorus will contain lower, but not necessarily deficient amounts of phosphorus, at very low or very high pH levels.

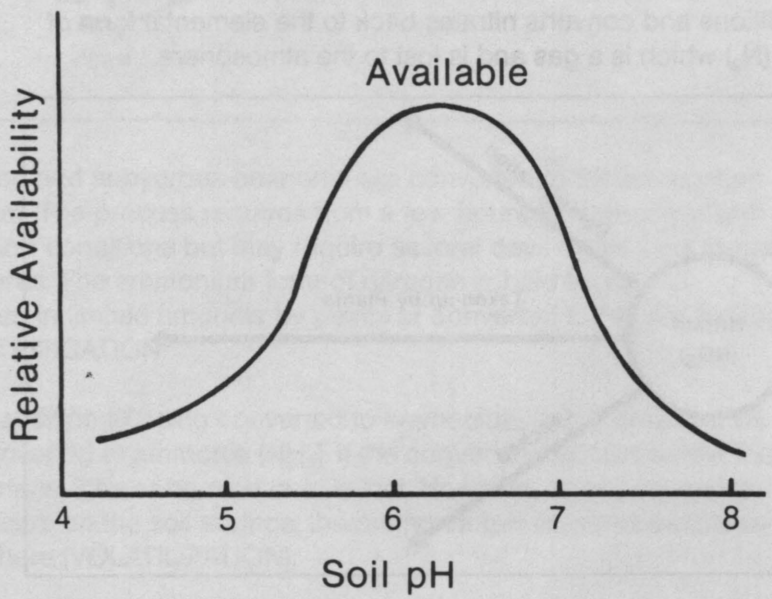


Diagram 2. Soil Phosphorus Availability

Potassium: Potassium mainly reacts with soil particles. It is readily held by clay and organic matter at exchange sites. Some potassium may become held in less available forms between soil particles (Diagram 3). Although some leaching of potassium may occur in sandy soils, it is primarily lost through crop removal and soil erosion.

Because of its relatively low mobility, phosphorus can be applied in the fall to properly limed soils that are not subject to severe erosion or flooding. Except for deep, sandy Coastal Plain soils, potassium may also be applied in the fall if the soil is properly limed and not subject to serious erosion or flooding.

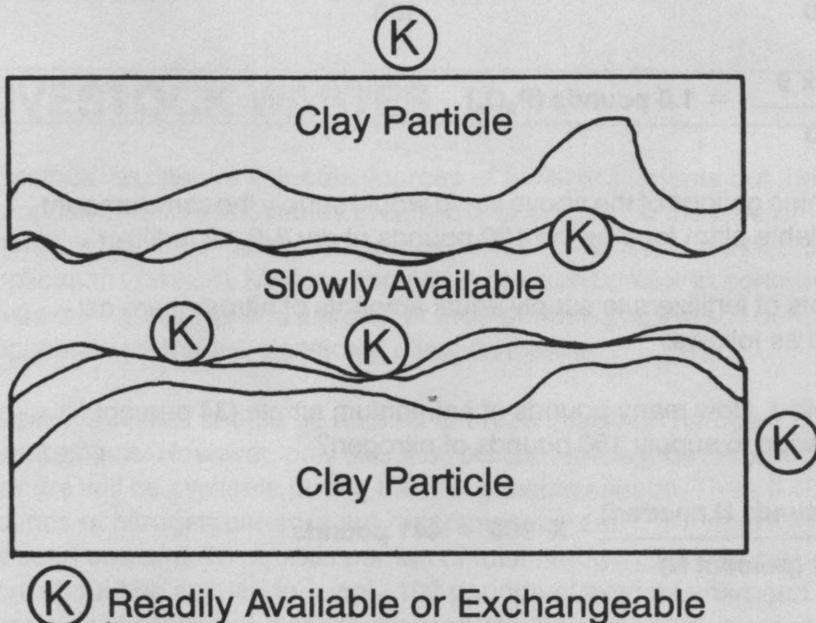


Diagram 3. Readily and slowly available forms of soil potassium.

FERTILIZER CALCULATIONS

To determine the N, (P_2O_5) and (K_2O) content of a DRY fertilizer, multiply the weight of the material by the percent of each fertilizer nutrient and divide by 100. For example, 100 pounds of a 3-9-18 grade would contain:

$$\frac{100 \times 3}{100} = 3 \text{ pounds N} \qquad \frac{100 \times 18}{100} = 18 \text{ pounds } (K_2O)$$

$$\frac{100 \times 9}{100} = 9 \text{ pounds } (P_2O_5)$$

To calculate the N, (P_2O_5) and (K_2O) content of a LIQUID fertilizer, it is necessary to know both the grade and weight per gallon. One gallon of liquid 3-9-18 weighing 11.1 pounds would contain:

$$\frac{11.1 \times 3}{100} = 0.33 \text{ pounds N} \qquad \frac{11.1 \times 18}{100} = 2.0 \text{ pounds } (K_2O)$$

$$\frac{11.1 \times 9}{100} = 1.0 \text{ pounds } (P_2O_5)$$

Thus, nine gallons of the above liquid would supply the same amount of available plant food as the 100 pounds of dry 3-9-18 fertilizer.

Amounts of fertilizers to supply equal amounts of nitrogen are calculated as follows:

Example 1. How many pounds of ammonium nitrate (34 percent N) are needed to supply 150 pounds of nitrogen?

$$\frac{150 \text{ (pounds N needed)}}{34 \text{ (percent N)}} \times 100 = 441 \text{ pounds}$$

Example 2. How many gallons of liquid nitrogen (30 percent N and weighing 10.8 pounds per gallon) are needed to supply 150 pounds nitrogen?

$$\frac{150 \text{ (pounds N needed)}}{30 \text{ (percent N)}} \times 100 = 500 \text{ pounds of liquid nitrogen}$$

then,

$$\frac{500 \text{ pounds}}{10.8 \text{ pounds per gallon}} = 46 \text{ gallons}$$

SOLIDS OR LIQUIDS?

Research and demonstrations have shown both solid and liquid fertilizers perform equally well when equivalent amounts are properly applied. Although there are advantages and disadvantages to each in storing and handling, it makes little difference to plants which form is used. Nutrient availability of water soluble dry materials and liquids are similar. Therefore, fertilizers should be selected based on economics, market availability and other factors — not whether they are solids or liquids.

LIVESTOCK WASTES

Livestock wastes are valuable sources of fertilizer nutrients but their composition and value varies greatly depending upon the type of animal, length and method of storage, water content and method of application (Table 4). Manure should be covered or kept in confined areas during storage and injected or incorporated into the soil during application to prevent significant nitrogen losses.

Livestock wastes should be applied to crops based on nitrogen requirements. However, only about 50 percent of the total nitrogen in manure will be available during the first growing season. Thus, if 100 pounds of nitrogen per acre are recommended and the manure to be used contains 10 pounds per ton of total nitrogen, 20 tons per acre should be applied to supply 100 pounds of available nitrogen. If annual applications of manure are made to the same field, greater than 50 percent availability can be expected in subsequent years. Most of the (P_2O_5) and (K_2O) will be available for plant use soon after application.

If significant quantities of animal wastes are used as fertilizer, a chemical analysis of the material should be obtained from a commercial laboratory. The local Extension office can provide names and addresses of laboratories available.

NON-TRADITIONAL PRODUCTS

Numerous products on the market have little or no fertilizer value. These products are sold as soil activators or conditioners, nutrient release agents, soil inoculants, foliar sprays, soil wetting agents and other types of soil amendments. Claims about such materials are

Table 4. COMPOSITION OF WASTE MATERIALS*

Material	Percent Solids	Pounds Per Ton N	Pounds Per Ton (P_2O_5)	Pounds Per Ton (K_2O)	Pounds Per 1000 Gallons N	Pounds Per 1000 Gallons (P_2O_5)	Pounds Per 1000 Gallons (K_2O)
Dairy							
Fresh	16	12	5	12	---	---	---
Covered Stack	18	10	4	10	---	---	---
Lagoon	1	---	---	---	4	4	5
Tank	12	---	---	---	46	18	40
Pit	8	---	---	---	24	18	29
Beef	20	14	9	11	---	---	---
Swine							
Fresh	25	10	7	13	---	---	---
Lagoon	1	---	---	---	6	5	7
Broiler	75	34	37	30	---	---	---
Sewage Sludge	4	---	---	---	14	17	2
Composted Sewage	70	20	60	4	---	---	---

**The values in this table are averages. Actual values may vary significantly.*

many and often subject to misinterpretation. Also, several years of testing various non-traditional soil products by land grant universities has shown no benefit as a result of their use. Therefore, buyers should CHECK the label for a guaranteed analysis and determine whether or not the material has proven beneficial in unbiased university research before considering a product supported only by undocumented claims.

DEFINITIONS

Acre Furrow Slice: A one-acre layer of dry mineral soil six inches thick, weighing approximately two million pounds.

Buffering Capacity: The capacity of a soil to resist a change in pH. Increases with clay and organic matter.

Cation Exchange Capacity (C.E.C): A property that indicates the amount of nutrients or elements that a soil can hold in exchangeable form. Increases with clay and organic matter content.

Quick Release Fertilizer: Fertilizer that is water soluble and readily used by plants. Materials in Table 2 are examples.

Ratio: Refers to the relative amounts of nitrogen, phosphate and potash in fertilizers. A 5-10-5 grade has a 1-2-3 ratio.

Slow Release Fertilizer: A low water-soluble fertilizer that requires from a few days to several weeks to dissolve in the soil. Commonly applied to lawns and turfs.

Sulfur Coated Urea (SCU): A slow release source of nitrogen that is produced by coating urea granules with elemental sulfur. The thickness of the sulfur layer determines the rate of nitrogen release.

Unit: Is 20 pounds of either N, (P_2O_5) or (K_2O). One hundred pounds of 0-20-20 would contain one unit each of (P_2O_5) and (K_2O).

CONVERSION FACTORS

Parts per million (ppm) x 2 = pounds per acre

Pounds per acre ÷ 2 = parts per million

Percent X 10,000 = parts per million

Parts per million ÷ 10,000 = percent

$P = P_2O_5$ X 0.44

$P_2O_5 = P$ X 2.29

$K = K_2O$ X 0.83

$(K_2O) = K$ X 1.2

Pounds NH_4NO_3 X 0.74 = Pounds Urea

Pounds Urea X 1.35 = Pounds NH_4NO_3

Pounds KCL X 1.2 = K_2SO_4

Pounds K_2SO_4 X 0.83 = Pounds KCL

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