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N-P-K fertilizers

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N-P-K FERTILIZERS

Types, Uses and Characteristics

August 1983

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THERE ARE MANY brands and analyses of Nitrogen (N), Phosphorus (P) and Potassium (K) fertilizers, but all can be grouped into three classes — liquids, solids and gaseous.

There is nothing magical about the different brands or types of fertilizer; for a particular analysis they often have the same chemical compounds and are used for the same basic purpose — to supplement those plant nutrients in the soil. Usually all that is needed to compare two fertilizers is the amount and the availability of plant nutrients in the material. This information is given on the label or bill of sale and is guaranteed.

FERTILIZER TYPES

Although it is generally agreed that fertilizers come in three physical forms (liquid, solid and gas), there are actually only two classes of fertilizers: liquid and solid. Anhydrous ammonia (NH_3) is a gas, but it is classified as a liquid because it is a liquid under pressure. The term, liquid fertilizer, therefore, applies to anhydrous ammonia, aqua ammonia, nitrogen solutions and liquid mixed fertilizers, including clear liquids, suspensions and slurry type mixtures of N, P and K, which require constant stirring to keep the solids suspended in the liquid.

Liquid fertilizer use in Michigan has increased steadily in the last 10 years. In 1970, 14% of the total fertilizer sales in Michigan consisted of liquids. In 1980, liquid fertilizers accounted for 23% of the market. Anhydrous ammonia and 28% N solution accounted for 76% of the total liquids sold.

Dry fertilizers (solids) still constitute the major part of the fertilizers sold in Michigan. About 62% of the total dry fertilizer is now sold as bulk material, and 38% is bagged. The bulk materials are generally less expensive and easier to handle, if large quantities are used.

Crop responses to liquid and dry fertilizers are similar, provided the same amounts of plant nutrients are applied and the same placement and water soluble phosphorus materials are compared. Reactions of these materials in soils are identical. When placed in the soil, dry fertilizers will absorb

water and undergo similar chemical reactions to liquid fertilizers.

Price per unit of plant nutrients, application costs, ease of handling and customer service are the prime factors to be considered when buying fertilizers.

CHARACTERISTICS AND USES

There are several properties of fertilizers and principles of fertilizer application which users should become familiar with. One important property of fertilizers is water solubility. Nearly all nitrogen fertilizers are completely water soluble. Because of their high water solubility, granule size and band placement is generally not important.

The two most common forms of nitrogen in fertilizers are ammonium (NH_4^+) and nitrate (NO_3^-). Under conditions of good plant growth NH_4^+ is rapidly converted to NO_3^- by bacteria. Both forms can be taken up and utilized by plants; however, crops such as tobacco, potatoes and tomatoes prefer nitrate as their source of N. Since nitrate is much more mobile than ammonium, ammonium forms of N are recommended for applications made prior to the time of greatest need in order to minimize the potential loss by leaching.

Most phosphate fertilizers are also highly water soluble. Phosphate water solubility is very important for early plant growth. Thus it is important for banded starter fertilizers to contain highly soluble forms of P. Soils normally contain very little water-soluble P (less than 2 ppm in soil solution) but concentrations as high as 100,000 ppm have been measured in the fertilizer band. During cool and wet conditions when the plant root system is small, band placement of P fertilizers becomes extremely important.

Broadcast applications usually affect less than 2% of the total soil volume. Consequently, water solubility is of little importance where P fertilizers are broadcast.

Phosphorus availability in the band is generally improved by the addition of N to the P starter and by increasing the granule size. Large granules contact less soil per unit of P than small granules.

Thus, initial P fixation is lower, and availability is improved.

Most potassium fertilizers are also highly water soluble. Like NH_4^+ , potassium (K^+) is held in the soil by clay and organic matter. Unlike NH_4^+ , however, K is not converted to a more mobile form. Potassium stays relatively close to the initial point of contact. Leaching of K is not generally a problem except on very sandy or gravelly soils, due to insufficient cation exchange sites and on organic soils where the cation exchange bonds are much weaker. Because K is not subject to the same fixation reactions as P, water solubility is not considered important. Potassium can be fixed in the crystal lattice of some clay minerals; however, high K-fixing soils in Michigan are not extensive.

Consequently the importance of banding K is only important where soil tests for K are extremely low.

The following is a discussion of several of the more commonly used N-P-K fertilizers. Table 1 contains the chemical analysis of these and other fertilizer materials.

NITROGEN FERTILIZERS

Anhydrous ammonia (82% N) is a liquid under high pressure and must be injected into a moist soil at least 6 inches because it becomes a gas once it is released from the tank. In soil, ammonia will react with water to form the ammonium (NH_4^+) ion, which is held on clay and organic matter. Anhydrous ammonia is generally the cheapest

Table 1 — Primary and Secondary Nutrient Composition of Some Selected Fertilizer Materials¹

Fertilizer Materials	Percent water solubility	Nutrient composition					
		N	P ₂ O ₅	K ₂ O	Ca	Mg	S
Nitrogen		----- % -----					
	N						
Ammonia, anhydrous	100	82	—	—	—	—	—
Ammonia, aqua	100	16-25	—	—	—	—	—
Ammonium nitrate	100	33.5	—	—	—	—	—
Ammonium nitrate - limestone	100	20.5	—	—	7.3	4.4	—
Ammonium sulfate	100	21	—	—	—	—	23.7
Ammonium sulfate - nitrate	100	26	—	—	—	—	15.1
Calcium cyanamide	100	21	—	—	38.5	—	—
Calcium nitrate	100	15	—	—	19.4	1.5	—
Nitrogen solutions	100	21-49	—	—	—	—	—
Sodium nitrate	100	16	—	—	—	—	—
Sulfur-coated urea	Variable	35	—	—	—	—	21
Urea	100	46	—	—	—	—	—
Ureaform	Variable	38	—	—	—	—	—
Phosphate		----- % -----					
	P						
Ammoniated super-phosphate	35	3-6	18-20	—	17.2	—	12
Ammoniated phosphate nitrate	100	27	15	—	—	—	—
Ammonium phosphate sulfate	90+	13-16	20-39	—	—	—	15.4
Ammonium polyphosphate	100	10-15	34-62	—	—	—	—
Bone meal	—	2-4.5	22-28	—	20-25	—	—
Diammonium phosphate	95+	16-21	48-53	—	—	—	—
Monoammonium phosphate	90+	11	48	—	1.1	—	2.2
Nitric phosphates	40	14-22	10-22	—	8-10	—	1-3.6
Phosphoric acid	100	—	52-60	—	—	—	—
Rock phosphate	<1	—	3-8	—	—	—	—
Superphosphate, normal	85	—	18-20	—	20.4	—	11.9
Superphosphate, concentrated	87	—	42-50	—	13.6	—	1.4
Superphosphoric acid	100	—	69-76	—	—	—	—
Potash		----- % -----					
	K						
Nitrate of soda-potash	100	15	—	14	—	—	—
Potassium chloride (muriate)	100	—	—	60-62	—	—	—
Potassium magnesium sulfate	100	—	—	22	—	11.2	22.7
Potassium nitrate	100	13	—	44	—	—	—
Potassium sulfate	100	—	—	50	—	1.2	17.6

¹From *Fertilizer Handbook*, The Fertilizer Institute.

source of nitrogen; however, the method of application is less convenient and requires more power for application than most other liquid or dry materials.

Nitrogen solutions (28 to 32% N). The most popular nitrogen solution is 28% N. It is a mixture of urea and ammonium nitrate in water. It has no ammonia vapor pressure and is generally sprayed or dribbled on the soil surface. The loss of nitrogen from surface application of 28% N solution is generally not considered to be of great concern in Michigan. Under certain conditions, however, nitrogen loss due to ammonia volatilization may be serious. If the conversion of urea in the liquid fertilizer to ammonia takes place on the surface, some ammonia can be lost by volatilization. The remainder of the ammonia may react with water on the surface to produce an alkaline condition, which also promotes volatile ammonia loss.

The most favorable conditions for nitrogen loss from surface-applied urea (solid or liquid) are alkaline soils, warm temperatures, intermediate relative humidity (50 to 90%) and sandy soils with low organic matter content and low cation exchange capacities.

One half inch of rain will normally move the urea into the soil before it is converted to ammonia, thus reducing nitrogen losses. Nitrogen solutions should not be applied in the fall, because one-fourth of the nitrogen is in nitrate form and is subject to loss by leaching or denitrification.

Surface applications of a nitrogen solution to large amounts of plant residue in no-till situations have been shown to be less effective than where incorporated or knifed-in. Nitrogen is believed to be tied up in the residues and unavailable to the crop until the residues decompose.

Aqua ammonia (21% N) is a liquid under low pressure and must be incorporated to prevent the loss of free ammonia to the atmosphere. It is possible to lose all of the free ammonia if it is not incorporated. Aqua ammonia has one advantage over anhydrous ammonia: placement need not be as deep and high-pressure applicators are not required.

Urea (46% N) is the most widely used dry nitrogen fertilizer. Once applied to the soil, urea is converted to ammonia which reacts with water to form ammonium within two to three days (faster under warm conditions). Some volatilization of ammonia can occur when urea is surface applied. Volatile ammonia loss from early spring top-dressing of urea on wheat or pasture is seldom a problem. Topdressing of urea on pastures during summer months, however, should be avoided because of greater ammonia losses.

Ammonium nitrate (33% N) is decreasing in popularity because of storage problems associated with fire and explosion hazards. It is an excellent

material for many purposes; however, one-half of the nitrogen is in nitrate form, which makes it susceptible to potential leaching and denitrification losses. Calcium ammonium nitrate is a mixture of ammonium nitrate and crushed limestone. Neither of these materials should be used for fall application.

Ammonium sulfate (21% N), although not used extensively because of lower analysis and higher cost, is excellent for fall application and top-dressing of wheat and pastures. Availability has increased in recent years primarily because it is a byproduct of some industries which use ammonia to remove sulfur from smoke stacks. All of the nitrogen is in the ammonium form. It is a good material for alkaline soils and can be used where sulfur deficiency is suspected. If applied to alkaline or calcium soils, it should also be incorporated to eliminate potential ammonia volatilization losses. It has the disadvantage of being the most acidifying form of nitrogen fertilizer.

Calcium nitrate (16% N) contains all of its nitrogen in the nitrate form, which is highly susceptible to leaching and denitrification losses. It is used most extensively in the fruit and vegetable industry where a readily available source of nitrate nitrogen is desirable. It should not be applied in the fall.

PHOSPHATE FERTILIZERS

Rock phosphate (3 to 8% available P_2O_5) has virtually disappeared from the market because of its very low water solubility and high transportation costs. Rock phosphate may, however, supply sufficient P for good crop growth where soils are moderately acid and where decomposing organic matter is abundant. Large applications of 1,000 to 2,000 pounds per acre, however, may be necessary for good plant growth if soil test levels for P are low. On fields with high soil tests for P, broadcast rock phosphate to replace crop removal may be acceptable, but rock phosphate is not acceptable for a starter fertilizer because of its low water solubility. Today, rock phosphate is generally processed before it is used as a fertilizer.

Normal superphosphate (20% P_2O_5), also referred to as ordinary superphosphate, is no longer used in large quantities. Because of its lower analysis and higher transportation costs, it has been replaced by concentrated superphosphate (46% P_2O_5) and the ammonium phosphates. One of the advantages of normal superphosphate was its significant sulfur content. As consumption of this material has slowly decreased, concerns over the need for sulfur have come primarily from the fertilizer industry. Sulfur from the atmosphere now appears to be keeping pace with that used in crop removal.

Concentrated superphosphate (46% P_2O_5), also known as triple superphosphate, is being used in Michigan in direct application as well as in

granulated processes and in bulk blending with other materials. Consumption has decreased in recent years due to the competitiveness of diammonium phosphate (18-46-0) and monoammonium phosphate (11-48-0). The latter materials have better storage properties and are more desirable for bulk blending, particularly where nitrogen is required in the final product.

Diammonium phosphate (18-46-0) is a dry material being used extensively for bulk blending and for direct application where soils do not need potassium or where potassium is broadcast. It has the advantage of being completely water soluble, having a high analysis and often a price advantage. Diammonium phosphate has an acid effect upon the soil similar to anhydrous ammonia. Because of the high ammonia content, this material can cause germination injury if used in direct contact with the seed.

Monoammonium phosphate (11-48-0) is a dry material being used for bulk blending or direct applications. Some research has shown monoammonium phosphate to be more effective than diammonium phosphate, particularly on calcareous soils. This may be due to the initial high pH of diammonium phosphate as it dissolves in the soil as compared with the acid reaction of monoammonium phosphate.

Both diammonium and monoammonium phosphate ultimately produce an acid effect in the soil; however, it is thought that the initial high pH reaction of diammonium phosphate may revert more of the phosphorus to insoluble reaction products. For most soils with pH less than 7.5, the agronomic effects of diammonium and monoammonium phosphates are equal.

Polyphosphates differ slightly from the more common orthophosphates fertilizers. Nearly all of the liquid fertilizers containing phosphorus are of the polyphosphate type. Polyphosphates are composed of a series of orthophosphate molecules connected by the process of dehydration (removal of water). Commercial ammonium polyphosphates are usually a mixture of ortho- and polyphosphates. Solutions of ammonium polyphosphate most commonly made are 10-34-0 and 11-37-0. The most common dry polyphosphate is 13-52-0.

In the soil, polyphosphates convert to orthophosphate by hydrolysis (adding on water). The time required for hydrolysis to occur varies with soil conditions. In some cases, 50% of the polyphosphate hydrolyzes to orthophosphate within 2 weeks. Under cool, dry conditions, hydrolysis may take longer.

Some claims have been made that polyphosphates will make certain unavailable micronutrients in the soil more available for plant uptake. Due to the rather rapid conversion of polyphosphates to orthophosphates in the soil, it is not likely that such complexes would be available for any significant length of time. Research at Kansas State University has shown that micronutrient uptake is not enhanced by polyphosphate materials. The efficiency of polyphosphates is considered to be equal to, but not better than, the orthophosphates with more than 80 percent water solubility.

POTASSIUM FERTILIZERS

Potassium chloride (60 to 62% K₂O), also referred to as muriate of potash, is the major source of K used in Michigan. Nearly half is used for direct application, and the remainder is used in granulating processes or bulk blending of mixed fertilizers. It is available in four particle sizes. The fine-size material is used primarily for liquid suspensions. Standard, coarse and granular sizes are used for granulating processes, bulk blending and direct application.

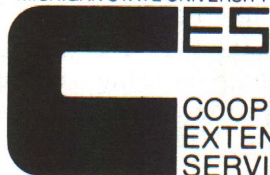
Potassium sulfate (50% K₂O), also referred to as sulfate of potash, is used to a limited extent on crops such as tobacco, potatoes and a few vegetable crops where chloride from potassium chloride is undesirable. Potassium sulfate in some research studies has improved specific gravity of potato tubers. Potassium sulfate may also be a source of sulfur when sulfur is required.

Potassium magnesium sulfate (22% K₂O) also known as sulfate of potash magnesia, is used for both direct application and in bulk blending, particularly where magnesium is needed. It may also be used as a source of sulfur.

Potassium hydroxide also known as caustic potash is used to a limited extent in the production of liquid mixed fertilizers. The present cost of producing potassium hydroxide has limited its use in the fertilizer industry even though it is a very desirable product due to high solubility and low salt index.

Potassium nitrate (44% K₂O) also known as nitrate of potash or saltpeter is being used in Michigan primarily on high value crops such as tomatoes, potatoes, leafy vegetables and a few fruit crops. It has a low salt index and provides nitrate nitrogen which may be desirable for these specialty crops. Production costs have limited general use for most agronomic field crops.

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