**SOIL 4234 Laboratory #9**

**Fertilizer Calculations (20 points)**

**Due Wednesday, October 24th at the beginning of lab**

Student

Lab

TA

**Objectives**

1. Become familiar with different forms of fertilizer sources and their nutrient analysis.
2. Gain a basic understanding of commonly used fertilizer application equipment.
3. Understand how to calibrate liquid and dry fertilizer application equipment.

**Fertilizer Materials and Sources**

Table 1. Major fertilizer sources of nitrogen, phosphorus and potassium sold in Oklahoma.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Nutrient Composition | | | | | | |
| Source | N | P2O5 | K2O | CaO | MgO | S | Cl |
|  | - - - - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - - - - | | | | | | |
| Nitrogen |  |  |  |  |  |  |  |
| Ammonium sulfate | 21 | - | - | - | - | 24 | - |
| Anhydrous ammonia | 82 | - | - | - | - | - | - |
| Ammonium nitrate | 33-34 | - | - | - | - | - | - |
| Calcium nitrate | 15 | - | - | 34 | - | - | - |
| Urea | 45-46 | - | - | - | - | - | - |
| Urea-ammonium nitrate (solution) | 28-32 | - | - | - | - | - | - |
|  |  |  |  |  |  |  |  |
| Phosphorus |  |  |  |  |  |  |  |
| Monoammonium phosphate (MAP) | 11 | 48-55 | - | 2 | 0.5 | 1-3 | - |
| Diammonium phosphate (DAP) | 18-21 | 46-54 | - | - | - | - | - |
| Ammonium poly-phosphate (solution) (APP) | 10-11 | 34-37 | - | - | - | - | - |
| Urea-phosphate | 17 | 43-44 | - | - | - | - | - |
| Ordinary super-phosphate\* | - | 16-23 | - | 18-21 | - | 11-12 | - |
| Conc. (triple) super-phosphate (TSP) | - | 44-53 | - | 12-14 | - | 0-1 | - |
| Rock phosphate\* | - | 25-40 | - | 33-36 | - | - | - |
|  |  |  |  |  |  |  |  |
| Potassium |  |  |  |  |  |  |  |
| Potassium chloride | - | - | 60-62 | - | - | - | 47 |
| Potassium sulfate | - | - | 50-52 | - | - | 17 | - |
|  |  |  |  |  |  |  |  |

\* - no longer important sources in Oklahoma

Nitrogen Fertilizers

**Anhydrous Ammonia, NH3, 82% N.** Nitrogen was one of the first nutrients to be produced in a liquid form (liquid under pressure). Nitrogen is taken from the air and reacted with a hydrogen source in the presence of a catalyst to produce anhydrous ammonia. Virtually all nitrogen manufacturing facilities use natural gas as a source of hydrogen. Approximately 33,000 cubic feet of natural gas are required to produce a ton of ammonia.

Under pressure, anhydrous ammonia becomes a liquid that returns to a gas when released from the storage container. To prevent excessive loss of N, it must be injected into the soil and sealed until ammonium (NH4+) is formed. Anhydrous ammonia is a hazardous material and care must be taken in handling to avoid exposing human, animal or plant life to direct contact with liquid or gaseous forms. In nitrogen producing plants, anhydrous ammonia is the basic material used to produce other kinds of nitrogen fertilizers.

Urea ammonium-nitrate, 28-32% N. A common liquid N fertilizer is made from soluble urea and ammonium nitrate mixed in equal parts with water to form non-pressure N solution containing 28 to 32 percent nitrogen. Ammonium nitrate or urea solution, alone, can only be handled satisfactorily in the field, in approximately 20% N concentrations.

Like any salt solution, nitrogen solutions will salt out. Salting out is simply the precipitation of the dissolved salts when the temperature drops to a certain degree. The salting out is determined by the amount and kind of salts in solution. As a general guide, 28% non-pressure solution salts out at about 0°F and 32% salt out at about 32°F, although this can vary between the materials produced by different manufacturers.

Corrosion inhibitors and a pH near 7.0 in nitrogen solutions reduce corrosion of carbon (mild) steel. The following materials are satisfactory for storing and handling nitrogen solutions: aluminum, stainless steel, rubber, neoprene, polyethylene, vinyl resins, glass and carbon steel. Materials that will be destroyed rapidly include copper, brass, bronze, zinc, galvanized metal, and concrete.

Nitrogen solutions that do not contain free ammonia can be applied to the soil surface without loss of N, although incorporation is recommended where ammonia volatilization loss from urea may be a problem. Ammonia free N solutions can also be applied in sprinkler irrigation systems with good success. Non-pressure N solutions are probably the most versatile of all N materials for application to a broad range of crops with a wide variety of application equipment.

**Ammonium Nitrate, NH4NO3, 33.5-34% N.** Ammonium nitrate is made by reacting anhydrous ammonia and nitric acid. Half of the total nitrogen in the material is in the nitrate form and half is in the ammoniacal form. Most ammonium nitrate is prilled and coated.

**Urea, (NH2)2CO, 45-46% N.** Urea is formed by reacting ammonia and carbon dioxide. All of the nitrogen in urea is in the ammoniacal form. Urea is produced in both prilled and granular forms. It is classed as an organic compound since it contains carbon.

**Ammonium Sulfate, (NH4)2SO4, 20.5-21% N.** Ammonium sulfate is formed by reacting ammonia with sulfuric acid. All of the material’s nitrogen is in the ammoniacal form. Ammonium sulfate is an effective source of sulfur since it contains 24 percent S. It is produced in both crystalline and granular forms.

Phosphorus Fertilizers

**Diammonium Phosphate, DAP, (NH4)2HPO4, 18% N, 46% P2O5.** This popular N-P material is produced by reacting ammonia and phosphoric acid. All of the nitrogen is in the ammoniacal form and the P is highly water-soluble. It is produced in the granular form.

**Monoammonium Phosphate, MAP, NH4H2PO4, 11-12% N, 48-60% P2O5.** This material is produced by reacting ammonia and phosphoric acid. All of the N is in the ammoniacal form and the P is highly water-soluble. Most MAP is produced in the granular form.

**Phosphoric Acid and Superphosphoric Acid, 54-85% P2O5.** Phosphate rock deposits are the basic source of all phosphate materials. The principal world reserves are located in North Africa, North America and the former Soviet Union. The primary intermediate step in the production of phosphorus fertilizers is phosphoric acid. In some areas, phosphoric acid is applied to the soil as a form of fertilizer; however, the handling problems associated with this acid has limited its use.

In fluid fertilizer production two types of acid are commonly used; ortho phosphoric (phosphoric acid) containing about 54% phosphorus (P2O5) and superphosphoric (polyphosphoric acid) containing up to 85% phosphorus (P2O5). Being more concentrated, it is possible to produce a higher analysis P fertilizer from superphosphoric acid.

When ortho phosphoric acid is reacted with ammonia, the acid can be neutralized to a pH of about 6.5 to produce a nitrogen phosphorous solution of 8-24-0. This was the basic phosphorous material used in mixed liquid fertilizers for several years. The development of superphosphoric production procedures make it possible to produce the higher analysis nitrogen phosphorous solutions (10-34-0), currently used as the basic phosphorous source in liquid and suspension grades of liquid fertilizer.

**Ammonium Polyphosphate Solutions, APP, 10% N, 34% P2O5.**  The ability to produce 10-34-0 ammonium polyphosphate solution played an important role in the rapid growth of liquid N-P-K fertilizers during the 1960’s. Improved storage and application equipment and other technical advances have enabled this growth to continue.

Ammonium polyphosphate solutions can contain up to 70 percent of the total P2O5 as a poly-P form. The remaining P2O5 is as an orthophosphate. All phosphate fertilizers contain some orthophosphate with many being 100% in the ortho form. In fluids, it is generally accepted that high poly content, above 55 percent, improves storage quality and the opportunity to carry low cost sources of micronutrient metals in liquid grades.

**Ordinary Superphosphate, 20% P2O5.** Ordinary superphosphate is made by treating finely ground phosphate rock with sulfuric acid. The P2O5 content of this source ranges between 18 and 22 percent. This source has between 11 and 12 percent sulfur as calcium sulfate and is sold as granular form. This low analysis material is no longer readily available in Oklahoma.

**Concentrated Superphosphate, 46% P2O5.** This source is produced by treating ground rock phosphate with phosphoric acid. The product will vary from 42-46 percent P2O5 with the most common analysis 46% P2O5.

Potassium Fertilizers

Potassium (K) is found throughout the world in both soluble and insoluble forms. The soluble forms are the principal form used in fertilizers. Potassium chloride is by far the most important source of fertilizer K.

**Potassium Chloride (Muriate of Potash), KCl, 60% K2O.** This is the K salt of hydrochloric (muriatic) acid. Most potash deposits are in this form. It is the most popular potash material used in fertilizers. Muriate of potash is a crystalline material. It is available in various particle sizes which are chosen to coincide with other materials for bulk blending. Some muriate of potash contains iron coatings, giving it a reddish color. Most muriate of potash is white or translucent. Color or particle size does not affect potassium availability for plant growth since it is a water soluble compound. In addition, potassium chloride is the major source of potash for liquid fertilizers. The fine soluble 0-0-62 grade is used for both liquid and suspension. About 10% K2O is the maximum that can be dissolved in a liquid but up to 30%K2O can be carried in a suspension.

**Potassium Sulfate, K2SO4, 50% K2O.** Like muriate of potash, potassium sulfate occurs naturally in limited deposits. It is extensively used in tobacco fertilizers where there is concern regarding chlorine build-up. It contains 17 percent sulfur and is widely used in areas where both potassium and sulfur are needed. Potassium sulfate has a lower solubility than KCl and is primarily used in suspensions to produce chloride free potassium and sulfur.

Methods of Application

Comprehensive evaluation of fertilizer placement research reveals that no single question has been asked so many times for so many different crops and production systems as the question of whether to "band or broadcast". Interestingly, it remains an important question today and may well be in the future. The most common method of applying fertilizers in modern times has been to broadcast, either with or without incorporation. However, the method used depends on various factors including the fertilizer to be applied, tillage, equipment available and crop grown.

Banding

Banding immobile nutrients such as P has become a common method for soils with high fixation capacities. In general, banding is the placement of fertilizer nutrients in a concentrated zone near the seed. Initial reasons for banding were:

1. to reduce the surface area of the fertilizer in direct contact with the soil, and thus minimize fertilizer-soil reactions that reduce chemical availability;
2. to apply the nutrient where there is the greatest chance for root contact.

Banding will likely have little beneficial effect for mobile nutrients such as N and S. Banding P and K has been beneficial where starter effects were desired in cool, wet climates. Recent work has shown banding P with the seed at planting on highly acid soils can reduce aluminum toxicity.

Soluble fertilizers placed in a band may cause germination and/or seedling injury if rates are too high. In general, ***the salt index (applied N + K2O) should not exceed 30 lb/ac for wheat and 7 lb/ac for corn.*** In extremely arid regions and/or where rapid drying takes place, salt rates less than these can adversely affect wheat and corn seed germination. Although banding P with the seed has become popular for Oklahoma wheat farmers with acid soil, it remains as a temporary alternative to liming.

Unlike broadcasting, there are several variations of band applications including with the seed, below the seed, beside the seed, dribble surface bands, spoke tooth bands, spot placement, point injection, and dual band applications. Accurate characterization of band applications must also consider spacing, form (liquid or solid), and depth of placement. Roots respond to increased P availability, increasing in growth within the band where the P is placed. If a soil were deficient in P, all roots would not explore the entire soil profile in search of this limiting element. Instead, some roots penetrate the band or localized area where P has been applied, and proliferate in that zone.

Broadcast

Broadcast applications of granular fertilizers are most often applied prior to planting. For many grain producers, this method of application can be more economical and requires less time, which can be important when one operator must cover a large acreage. However, poor distribution patterns from bulk dry spreaders can result in uneven stands and lower grain yields. Ultimately, it is up to the farmer to check commercial fertilizer applicators. Using sample pans (8 to 10 pans, 2 ft wide) spread across the application width; one can quickly assess the distribution pattern of the fertilizer applicator. If the weighed amounts in the pans differ by more than 10-15%, the application equipment should be adjusted accordingly. Applicators which can cover a broad width (30-60 feet with each pass), need close monitoring to avoid uneven distribution of the applied fertilizer.

Broadcast applications of phosphorus have proven to be satisfactory in minimum tillage crop production since this method of placement effectively reduces the surface area of the soil in contact with the fertilizer. The advantages of this method in reduced tillage crop production, at least under humid region cropping conditions is also a function of placing the fertilizer near the zone (surface horizon 0-2 in) where increased moisture and root mass are present. In this regard, broadcast applications of P in minimum tillage systems have been viewed as surface horizontal bands. Alternatively, localized band applications of P in conventional tillage have commonly increased uptake efficiencies and grain yields when compared to broadcast methods as a result of effectively reducing soil-fertilizer P fixation.

**Data sheet will be provided in class**