SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 28
Common Fertilizers Used in Corn Production

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Many South Dakota farmers spend $170/acre per year on fertilizers. Reducing these costs requires an understanding of the available products. Fertilizer can be solid, liquid, and gas, each with unique strengths and weaknesses. This chapter discusses the different commercially available fertilizers and provides examples on how to determine the cost of nutrients contained within the fertilizer.

Fertilizer Salt Index
The salting effect of the fertilizer is most important when developing recommendations for pop-up and starter fertilizers. A pop-up fertilizer calculator is available at http://www.ipni.net/article/IPNI-3268. A salt index is used to estimate the seed-germination risk, and generally, Na+ and K+ fertilizers have higher salt index values than P fertilizers.

Microbial Inhibitors
Nitrogen can be lost through three major mechanisms: leaching, volatilization, and denitrification. Different inhibitors are needed for each mechanism. Nitrification inhibitors can be used to reduce leaching and nitrification losses, whereas urea hydrolysis inhibitors can be used to reduce ammonia volatilization losses. Nitrification inhibitors slow the conversion of ammonium to nitrate. Nitrate, which is a negatively charged ion can be leached (move with percolating water) through negatively charged soil. Denitrification is the conversion of nitrate to N gas. In corn production, leaching and denitrification losses are highest when soil water content is high.

A commercially available nitrification inhibitor, Nitrapyrin, can be purchased as N-Serve® or InstinctTM, whereas Docyandiamide (DCD) can be purchased in SuperU®. Nitrification inhibitors generally are not recommended when the fertilizer is applied as a sidedressed application. Urea hydrolysis inhibitors slow the conversion of urea to ammonium, which in turn slow volatilization losses (Clay et al., 1990). Urea inhibitors include NBPT and Agrotain®.

Nitrogen Fertilizers
Slow-release N Fertilizer
Slow-release fertilizers release only a portion of the fertilizer immediately. Commercially available products include ureaform (38-0-0), which is a combination of urea with formaldehyde; sulfur-coated urea (36-0-0); isobutylidene diurea (IBDU); and polymer-coated urea (ESN®, Polyon®, and Nutricote®). The higher cost of these materials may warrant their use for high-value crops such as vegetables, fruits,

and ornamentals. Slow-release N fertilizers are used: 1) to improve fertilizer efficiencies where N losses (leaching or denitrification) are high, 2) to overcome the need for multiple application dates, or 3) in crops where delayed nutrient release is desirable. Additional information on slow- and controlled-release fertilizer is provided by Lui et al. (2014).

Ammonium Nitrate

This product may have limited availability, and it is the only commonly used solid fertilizer that contains N in the NO_3- form. The chemical formula for ammonium nitrate (AN) is NH_4NO_3. Ammonium nitrate is a hazardous material because it can become combustible if it comes in contact with petroleum, diesel fuel, herbicides, pesticides, elemental S, or powdered metals. Because ammonium nitrate absorbs water from the air, it should be stored carefully. Products such as urea ammonium nitrate (UAN) contain AN but are considered safe for widespread use.

Urea

Urea is a commonly purchased, dry, granular fertilizer with a grade of 46-0-0. Urea is an uncharged compound that can be moved into the soil with percolating water. After application, urea is hydrolyzed with water (i.e., undergoes a chemical breakdown due to a reaction with water) into ammonia (NH_3) and CO_2. The application of urea to soil can lower the pH and ammonia can be lost through volatilization if the urea is not incorporated into the soil. The application of urea with the seed (pop-up) can reduce germination. A calculator for determining pop-up fertilizer rates is available from the International Plant Nutrition Institute (www.ipni.net or http://www.ipni.net/article/IPNI-3268). Starter fertilizer is generally placed 2 inches to the side and 2 inches below the seed. By separating the fertilizer and seeds, the risk of salt injury is reduced. However, this risk is not eliminated. Traditionally, it has been recommended to keep the 2-inch by 2-inch application rate below 70 lbs of product/acre. Additional information on fertilizer placement is available in Jones and Jacobsen (2009). Urea can be blended with monoammonium phosphate (MAP) or diammonium phosphate (DAP), but it should not be blended with superphosphate or ammonium nitrate.

Ammonium Sulfate

Ammonium sulfate has a lower risk of volatilization than urea and is a good product in high pH soil. Ammonium sulfate will lower the soil pH faster than urea and it can be used to provide S in sulfur-deficient soils. The primary disadvantage is that it requires more lime to neutralize the acidity produced during nitrification than other N fertilizers. Its cost per unit of N is generally higher than urea. The main benefit of AMS is using it to supply the crop's sulfur requirements while receiving a nitrogen credit.

N Solutions

These are liquid fertilizers with grades that range from 28-0-0 to 32-0-0. These solutions are mixtures of urea and ammonium nitrate. Because the risk of precipitation decreases with increasing temperature, UAN solutions are made more dilute in regions with cold winter temperatures. These solutions do not have a vapor pressure and can be sprayed or dribbled onto the soil surface. The UAN solution, 28-0-0, is nonflammable, nontoxic, and therefore is relatively safe and easy to handle, ship, and store. However, these fertilizes can be corrosive to some metals. UAN is well-suited for in-season N application, and the density is used to convert gallons to pounds. A rule of thumb for UAN (28-0-0) is that one gallon of fertilizer contains 3 lbs of N. Example: (10.8 lbs/gal*.28=3.024 lbs N/gal).

When applied to the soil, volatilization losses are highest when applied to warm, high pH soils. When applied to soils with high residue, some of the N will likely be immobilized by the residue. To reduce this risk, broadcast applications are not recommended in high-residue soils. Immobilization can be reduced in high-residue soils by surface or subsurface banding

Gas N Fertilizers

In the manufacturing of N fertilizers, atmospheric N is combined with H+ to form anhydrous ammonia (NH_3). NH_3 is a colorless gas with a grade of 82-0-0. Anhydrous ammonia (NH_3) is typically the most inexpensive, commercially available N fertilizer. To assure stability in the soil, injection is required for this N source. When applied to soil, it is rapidly converted to NH_4^{+1}. In addition to its use as a fertilizer, it is a key ingredient in the illegal production of methamphetamine. When using this material, always follow safety protocols.

Phosphorus Fertilizers

The production of most commercial phosphate fertilizers begins with the conversion of rock phosphates to phosphoric acid. Ammonia is then added to superphosphoric acid to create the liquid, 10-34-0. Liquid ammonium phosphate (10-34-0), can be mixed with a finely ground potash (0-0-62), water, and UAN solution (28-0-0) to form many different grades of fertilizer.

The addition of ammonia with phosphoric acid produces a slurry that is solidified to produce monoammonium phosphate (11-52-0 or 10-50-0) or diammonium phosphate (18-46-0). It is important to consider that P fertilizers are produced from rock phosphate, which is mined. These resources, like oil, are limited. Table 28.3 presents guidance for the use the P fertilizers. The United States is one of the leading producers of apatite (calcium phosphate minerals).

Plant-available P consists of water and citrate-soluble P. Water-soluble P is the P solubilized in water, while citrate-soluble P is the amount of nonwater-solubilized P that is solubilized when placed in citrate. Fertilizer can also contain polyphosphate and orthophosphate forms. Polyphosphate (P_2O_5) is produced by heating orthophosphate (H_3PO_4) to remove the water. This process converts 40% to 60% of the ortho-P to poly-P.

Monoammonium Phosphate (MAP)

MAP fertilizer grades range from 11% to 13% N and 48% to 55% for P_2O_5. If pure, MAP [$(NH_4)H_2PO_4$] would have a fertilizer grade of 12.2-61.7-0. MAP contains less ammonia than DAP, making it a preferred pop-up fertilizer. Depending on the manufacturing process, it may contain some sulfur. MAP is water-soluble and when added to soil, NH_4+ and H_2PO_4- ions are formed. The acidity of this product reduces the risk of ammonia volatilization. Map is a good fertilizer to use as a pop-up. It should not be mixed with calcium (Ca) and magnesium (Mg) fertilizer when applied with irrigation water. Clumping and caking can be reduced by using chemical conditioners. Purified products may be used as a feed additive, and it may be found in dry chemical fire extinguishers.

Diammonium Phosphate (DAP)

The fertilizer grade of DAP can range from 18% to 21% N and 46% to 53% P_2O_5. If pure, DAP [$(NH_4)_2HPO_4$] would have a grade of 21.2% N and 53.8% P_2O_5. Depending on the manufacturing process, it may also contain some sulfur. DAP is water-soluble and when added to soil, the NH_4+ and H_2PO_4- ions are formed. The area surrounding the dissolving fertilizer granule is slightly alkaline. The impact of DAP on seed germination is greater in basic than acid soils. Ammonia volatilization risk with this product is minimal.

Nitrophosphates

This material is produced by reacting phosphate rock with nitric acid. The products are phosphoric acid and calcium nitrate. Depending on the requirement, a range of products is available. These products attract moisture, so they should be stored carefully to prevent caking.

Polyphosphates

Polyphosphates contain orthophosphate and polyphosphate. Two common ammonium polyphosphate fertilizers have an N-P_2O_5-K_2O composition of 10-34-0 or 11-37-0. This is a liquid fertilizer that does not require special handling and storage. However, it can be corrosive, so storage and handling equipment should be made of resistant materials. With time, polyphosphate splits apart. A general guideline is to minimize storage time and avoid storage over summer. Aqua or Anhydrous Ammonia is not compatible with 10-34-0. Polyphosphates (10-34-0) can be sprayed on to the soil surface and incorporated into the soil. The salting-out temperatures, where precipitation can occur, for 10-34-0 and 11-37-0 are 0°F and 32°F, respectively. Rules of thumb for P fertilizers include that:

1. MAP and DAP are soluble in water.
2. Manure can add a significant amount of P to the soil. Generally, P from organic sources is slightly less available when compared with dry or liquid fertilizers. In the year following manure applications, 60% to 80% of the P is typically available to the plant.
3. Orthophosphate or polyphosphate fertilizers are produced by removing the water from phosphoric acid.
   a. The resulting products contain approximately 40% to 60% orthophosphate with the remaining portion in the polyphosphate form.
   b. Examples of fertilizers containing orthophosphates (H_3PO_4) are MAP and DAP.
   c. Polyphosphates have the chemical formula $H_4P_2O_{10}$, and fertilizer grade of approximately 10-34-0.
   d. The P in orthophosphates and polyphosphates is generally considered plant available.

Potassium Fertilizers

Potassium Chloride

Potassium chloride (60% to 62% K_2O) is often referred to as potash. The color of potash can vary from pink or red to white. White potash is often higher in K analysis. One of the advantages of potash is that it often provides chlorine, which may provide disease resistance. Potassium chloride is approximately 47% chloride. Other fertilizers providing Cl^{-1} are ammonium chloride (NH_4Cl), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), and sodium chloride (NaCl).

This material should be stored in a dry location. Heat or cold will have little effect on this fertilizer, and KCl can be blended with a variety of N and P fertilizers to make grades such as 10-30-10, 8-24-24, or 13-13-13. KCl is readily soluble in water and can be applied as a liquid fertilizer.

Potassium Sulfate

Potassium sulfate (K_2SO_4) can be used to apply both K and S. The K_2O content of this fertilizer ranges from 48% to 53%, while the S ranges from 17% to 18%. This fertilizer can be applied when additional Cl- is undesirable. The salting effect per unit K of K_2SO_4 is less than KCl. K_2SO_4 can be used in sulfur-deficient soils. More information is available from the International Plant Nutrition Institute, www.ipni.net.

Micronutrients

Sulfur

A range of different S products are available. The most concentrated fertilizer is elemental sulfur. To make it available to the plant, it must be oxidized:

$$S + 1.5O_2 + H_2O \rightarrow 2H^+ + SO_4 + \text{energy}$$

Elemental S is often used in sodic (high Na) soil remediation. Other solid S sources are gypsum ($CaSO_4$), ammonium sulfate (21-0-0-24), and potassium sulfate (0-0-50-18). Two liquid S fertilizer products are ammonium polysulfide and ammonium thiosulfate. Ammonium polysulfide is a dark-red solution that contains about 20% N and 40% S. Ammonium polysulfide has a density of 9.4 lbs/gal and can be mixed with ammonia solutions. Ammonium thiosulfate (12-0-0-26S) has a density of 11.1 lbs/gal and is compatible with aqua ammonia and UAN. This fertilizer should not be placed in contact with a seed or mixed with anhydrous ammonia or phosphoric acid. When this fertilizer is mixed with UAN, the rate that the urea is hydrolyzed (urea-N$\rightarrow$ NH_4) may be slowed, which in turn can reduce N losses.

Chlorine

Chlorine can be applied with potassium chloride (0-0-60), which is 47% chloride, ammonium chloride (NH_4Cl), calcium chloride ($CaCl_2$), and magnesium chloride ($MgCl_2$). In many situations, compound fertilizers are applied to soils. These fertilizers can provide macronutrients and micronutrients.

Blended Fertilizers

Many custom blends of N-P_2O_5-K_2O are available. Common dry blends are 20-10-10, 10-20-20, 8-32-16, and 6-24-24. With dry-blended fertilizers, segregation can occur when these materials are transferred from a bin to a truck or a truck to a bin.

Compound Fertilizers

A compound fertilizer is typically a solid product that contains multiple nutrients within each granule. These fertilizers differ from blends, where the fertilizers were mixed together. Compound fertilizers are often more expensive than blended fertilizers.

Manure

Manure is an excellent source of nutrients in agricultural systems. Different livestock handling systems are more efficient than others at returning nutrients to the soil. Average amounts of N and P_2O_5 contained in different manures are shown in Table 28.3. Manure can be used to provide the plant nutrient requirements in organic agriculture. Manure has the added benefit of adding organic matter to soil, which should improve soil heath and water-holding capacity. Manure should be incorporated into the soil to minimize nutrient losses.

Determining the Lowest Cost Fertilizer Mixture

There are many different fertilizer formulations commercially available. The question is, which is least expensive?

Example 1. Urea (46-0-0)cost \$450/ton, what is the price per pound of N.

$$\frac{\$450}{2000\ lbs} \times \frac{1\ pound}{0.46\ lbs\ N} = \$0.489/_{lb\ N}$$

Example 2. Ammonium sulfate (21-0-0-24) costs \$375/ton.

Solution a. Assume the S does not have a value.

$$\frac{\$375}{2000} \times \frac{1\ pound}{0.21\ lbs\ N} = \$0.89/_{lb\ N}$$

Solution b. Assume each lb S has a value of \$0.25.

Calculate the value of the S

$$2000\ \text{lbs fertilizer} \times \frac{0.21\ lb\ S}{1\ pound} \times \frac{\$0.25}{1\ lb\ S} = 105$$

Subtract value of S from the cost of the fertilizer and calculate cost of N

\$375-105=\$270/ton

$$\frac{\$270}{2000\ lbs} \times \frac{lb\ pound}{0.21\ lbs\ N} = \$0.64/_{lb\ N}$$

Additional examples of calculations for determining the lowest-cost material are available in Clay et al. (2011).

References and Additional Information

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