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Chapter · January 2010

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CHAPTER TEN

Fertilizers Used In Wheat Production

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In South Dakota, fertilizers are routinely applied to optimize yields. The purpose of this chapter is to discuss the different types of commercial fertilizers that are commercially available.

Fertilizer Rules of Thumb

1. Match the fertilizer source and application equipment to the problem;
2. 1 gallon of 28-0-0 provides approximately 3 lbs of N;
3. Follow protocols that minimize losses; and
4. MAP is often preferred over DAP as a pop-up (placement with the seed) fertilizer.

Sources

Liquid, solid, and gas fertilizer can be used to return nutrients to the field (Table 10.1) [http://www.tfi.org/factsandstats/fertilizer.cfm]. When selecting the fertilizer, each of these elements should be considered: materials, prices, nutrient concentrations and amounts, potential losses, and special handling requirements. Each type of fertilizer has individual requirements and may require slightly different calculations. For example, to liquid and dry fertilizers can be applied to the soil surface while gas fertilizers need to be injected into the soil.

All fertilizers are characterized by their grade. The grade provides information relative to the percentage of N, P_2O_5, and K_2O (shorthand for nitrogen, phosphorus and potassium fertilizers) contained in the material (Table 10.1). Liquid fertilizers are also characterized by their density, or concentration (lbs/gal). Different fertilizers are better suited for different applications. For example, liquid urea ammonia nitrate (UAN) is well suited for in-season N application, while anhydrous ammonia is well suited for cultivated land. A rule of thumb for UAN (28-0-0) is that one gallon of fertilizer contains 3 lbs of N. When working with liquid fertilizers the density is used to convert gallons to lbs or lbs to gallons.

All fertilizers should be applied following protocols that minimize losses. For example, N can be lost through a variety of mechanisms including volatilization, leaching, and denitrification. Volatilization is the gaseous loss of ammonia to the atmosphere which occurs when ammonia-based fertilizers, such as urea, are left on the soil surface. Volatilization losses can be reduced by using a urease inhibitor such as NBPT.

Nitrate leaching is the loss of the negatively charged nitrate ion with percolating water. Nitrate losses can be reduced by splitting the N application or by using a nitrification inhibitor. Nitrate loss is most likely to occur in well drained soils following rainfall. Nitrification inhibitors reduce losses by slowing the rate that the positively charged ammonia (NH_4^+) is converted to the negatively charged nitrate (NO_3^-) ion. Two extensively tested nitrification inhibitors are DCD and nitrapyrin (N-serve®).

Nitrogen fertilizers

The source of N in most fertilizers is the air. In the manufacturing of N fertilizers, atmospheric N is combined with H from natural gas to form anhydrous ammonia (NH_3), which has a grade of 82-0-0. Producing anhydrous ammonia requires a large amount of energy. For example, the amount of energy required to produce 5 lbs of ammonia fertilizer is approximately equivalent to the energy contained in a gallon of gasoline. Anhydrous ammonia can be used to produce a variety of N products. All ammonia based products will slowly reduce soil pH.

Urea

Urea is commonly purchased as a solid fertilizer with a grade 46-0-0. To minimize volatilization losses, urea must be incorporated into the soil. Urea is a neutral compound that can be moved into the soil with percolating water. After application, urea is hydrolyzed into ammonia and CO_2. This ammonia can be volatilized if the urea is not incorporated. The application of urea with the seed will reduce germination; however, it can be side placed in a band 2 inches to the side and 2 inches below the seed. Additional information on fertilizer placement is available in Jones and Jacobsen (2009). Urea can be blended with MAP or DAP. It should not be blended with superphosphate because it reacts with the superphosphate molecule.

Since urea does not adsorb as much water from the air as ammonium nitrate, it has fewer problems with sticking and caking. Urea should not be mixed with ammonium nitrate because, when mixed together, they absorb atmospheric water and can form a slurry. http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%20%231%20Urea.pdf

Ammonium nitrate

It is the only commonly used solid fertilizer that contains N in the NO_3- form. The chemical formula for ammonium nitrate is NH_4NO_3. Ammonium nitrate is considered to be a hazardous material because of its combustible and explosive properties. If ammonium nitrate comes in contact with oxidizable carbonaceous materials, such as oily substances (petroleum, diesel fuel, herbicides, pesticides, elemental S or powdered metals), they are capable making ammonium nitrate more combustible. If highly contaminated with any of these materials, it can become explosive.

Table 10.1. Common fertilizers applied to soils in South Dakota.

	N %	P_2O_5 %	K_2O %	Density lbs/gal	S %	Cl %
Solid fertilizers						
Ammonium nitrate	33	0	0			
Di-ammonium phosphate (DAP)	18-21	46-53	0		1-1.5	
Mono-amonium phosphate (MAP)	11-13	48-55	0		1-1.5	
Potassium chloride (KCl)	0	0	62			47
Potassium nitrate (KNO_3)	13	0	44			
Urea $(NH4)_2CO$	46	0	0			
Liquid fertilizers						
Urea-ammonium-nitrate (UAN)	28-32	0	0	0.6-11.0		
Ammonium polyphosphate	10	34	0	11.7		
Gas fertilizers						
Anhydrous ammonia	82	0	0			

Anhydrous ammonia

Anhydrous ammonia (NH_3) is one of most inexpensive, commercially available N fertilizers. Injection is required for this N source. This product is a flammable and toxic alkaline gas that is stored as a liquefied gas. The fertilizer grade is 82-0-0 and its price is linked to the price of natural gas. In addition to its use as a fertilizer, it is a key ingredient in the illegal production of methamphetamine.
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%20%2310%20Ammonia.pdf

N solutions

These are liquid fertilizers with grades that range from 28-0-0 to 32-0-0. They are mixtures of urea and ammonium nitrate. Because the solubility of UAN increases with 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 on the soil surface. 28-0-0 is nonflammable, nontoxic, and therefore is relatively safe and easy to handle, ship, and store. These fertilizes can be corrosive to some metals.

When applied to the soil, volatilization losses can also occur. Volatilization losses will be the most when applied to warm high pH soils. When applied to soils with high residue, some of the N will likely be immobilized in the residue; this can result in yield losses. To reduce these losses, broadcast applications are not recommended in high residue soils. Surface banding, using stream bars, can be used to reduce losses.
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%207%20Urea%20Ammonium%20Nitrate.pdf

Slow release fertilizer

Slow release fertilizers are one approach for overcoming the need for multiple application dates. In a slow release fertilizer only a portion of the fertilizer is immediately available. Commercially available products include ureaform (38-0-0) that is a combination of urea with formaldehyde, sulfur coated urea (36-0-0), and isobutylidene diurea (IBDU).

Phosphorus fertilizers

The production of most commercial phosphate fertilizers begins with the conversion of rock phosphates to phosphoric acid. The phosphoric acid is heated, driving off the water, to produce superphosphoric acid. Ammonia is then added to superphosphoric acid to create the liquid, 10-34-0, which can be mixed with a finely ground potash (0-0-62), water, and urea-ammonium nitrate solution (28-0-0) to form many different grades. When ammonia is added to the phosphoric acid that has not been heated, monoammonium phosphate (11-52-0) or diammonium phosphate (18-46-0) is produced, depending upon the ratio of the mixture.
It is important to consider that P fertilizers are produced from rock phosphate, which is mined. These resources, like oil, are limited. Table 10.2 presents guidance for the use the P fertilizers. The United States is one of the leading producers of apatite (calcium phosphate minerals).
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%20%232%20Polyphosphate.pdf

Mono-ammonium phosphate (MAP)

MAP fertilizer grades range from 11-13 for N and 48-55 for P_2O_5. In addition, MAP can contain 1 to 1.5% S. The chemical form for MAP is $(NH_4)H_2PO_4$ and, if pure, it would have a fertilizer grade of 12.2-61.7-0 . MAP contains less ammonia than DAP, making it a preferred product to band with seeds.
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%20%239%20Monoammonium%20Phosphate.pdf

Di-ammonium phosphate (DAP)

The fertilizer grade of DAP can range from 18-21 for N% and 46-53% for P_2O_5. The chemical formula for DAP is $(NH_4)_2HPO_4$ and, if pure, would have a grade of 21.2% N and 53.8% P_2O_5. DAP can contain 1 to 1.5% S.

10-34-0

This is a liquid fertilizer that does not require special handling and storage. This fertilizer is corrosive to some metals; therefore equipment that comes in contact with it must be made of resistant materials. To be kept in a liquid state, it must be stored at a temperature above -18° C. 10-34-0 is nonflammable, nontoxic, and therefore is relatively safe and easy to handle. 10-34-0 can be sprayed on to the soil surface and incorporated into the soil.

Table 10.2. Rule of thumb for P fertilizers.

- MAP and DAP have very high water solubilities.
- Manure can add a significant amount of P to the soil. Generally P from organic sources is slightly less available when compared to dry or liquid fertilizers. In the year following manure applications, 60 to 80% of the P will be available to the plant.
- Ortho or polyphosphate fertilizers are produced by removing the water from phosphoric acid.
    - The resulting products will contain approximately 40 to 60% orthophosphate with the remaining portion in the polyphosphate form.
    - Examples of fertilizers containing orthophosphates (H_3PO_4) are MAP and DAP.
    - Polyphosphates have the chemical formula $H_4P_2O_{10}$. A fertilizer that contains polyphosphates is 10-34-0.
    - Ortho and polyphosphates are generally considered equally 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 analysis. One of the advantages of potash is that it often provides chlorine. This material should be stored in a dry location. Heat or cold will have little effect on this fertilizer. KCl can be blended safely with both N and P fertilizer to make grade 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.
http://www.ipni.net/ipniweb/portal.nsf/0/8D207ECED27B691385257713004B611D

Potassium sulfate

Potassium sulfate 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.
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%205%20Potassium%20Sulfate.pdf

Micronutrients applied to wheat

In addition to N, P, and K, many South Dakota fields also require chlorine and sulfur. Dry fertilizer sources, which include sulfur, include ammonium sulfate (21-0-0-24), elemental S (0-0-0-90S). gypsum (calcium sulfate, 0-0-24), superphosphate (0-20-0, 11-12% S), potassium sulfate (0-0-50-18S), and di-ammonium phosphate (DAP, 18-46-0, 1-1.5S) and mono-ammonium phosphate (MAP, 11-48-0, 1-1.5S).
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%20%2313%20Sulfur.pdf

Two common S containing liquid fertilizers are ammonium polysulfide and ammonium thiosulfate. Ammonium polysulfide is a dark red solution that contains about 20% N and 40% S. It has a density of 9.4 lbs/gal and can be mixed with anhydrous ammonia or 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→NH_4) may be slowed, which in turn can reduce N losses.
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%20%2308%20Thiosulfate.pdf

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 both macro- and micronutrients.
http://www.ipni.net/ipniweb/portal.nsf/0/8d207eced27b691385257713004b611d/$FILE/NSS%234 Compound Fertilizer.pdf

Potassium chloride (KCl).

This fertilizer is often called muriate of potash or just potash. The fertilizer provides both K and Cl. Both of these nutrients are needed for wheat health. Potassium chloride is approximately 47% chloride. In wheat, Cl^{-1} can help suppress leaf rust. Other fertilizers providing Cl^{-1} are ammonium chloride (NH_4Cl), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), and sodium chloride (NaCl). Potash can be either pink to white. White potash generally has a higher analysis than pink potash.

Compound fertilizers

A compound fertilizer contains multiple nutrients in each granule. These fertilizers differ from blends, where the fertilizers are mixed together. Compound fertilizers are often more expensive than blended fertilizer.

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.

Manure

Manure can be used to meet many of the wheat plants nutrient requirements. Mass balance calculations show that manure returns much of the nutrients removed in the harvested grain. Different livestock handling systems are more efficient than others at efficiently returning these nutrients to the soil. Average amounts of N and P_2O_5 contained in different manures are shown in Table 10.3.

Table 10.3. Amounts of N and P_2O_5 by livestock type (based on Lorimor and Powers, 2004).

	Nitrogen					
Type of livestock	Liquid manure N organic	Liquid manure N inorganic	Solid manure N organic	Solid manure N inorganic	P_2O_5 Liquid	P_2O_5 Solid
	lb N/1000 gal		lbs N/ton		lbs/1000 gal	lbs/ton
Swine						
Farrowing-finish	12	16	8	8	24	7
Nursery	11	14	8	5	19	8
Farrow-feeder	10	11	5	5	18	7
Dairy						
Cow	25	6	8	2	15	3
Heifer	26	6	2	14	3	
Calf	22	5	8	2	14	3
Herd	25	6	7	2	15	4
Beef						
Beef cow	13	7	4	3	16	4
Feeder calves	19	8	6	3	18	4
Finishing cattle	21	8	7	4	18	7
Poultry						
Broilers	50	13	24	12	40	53
Layers	20	37	22	12	52	51
Tom turkeys	37	16	32	8	40	50
Hen turkeys	40	20	32	8	38	50
Ducks	17	5	13	4	15	21

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Acknowledgements

Support for research activities was provided by South Dakota Corn Utilization Council, South Dakota Soybean Research and Promotion Council, South Dakota Wheat Commission, NASA, South Dakota 2010 Initiative, and North Central SARE program.

Clay, D.E., and C.G. Carlson. 2011. "Fertilizers used in wheat production." *In* Clay, D.E., C.G. Carlson, and K. Dalsted (eds). iGrow Wheat: Best Management Practices for Wheat Production in South Dakota. South Dakota State University, South Dakota Cooperative Extension Service, Brookings, SD.