



BEST MANAGEMENT PRACTICES

Chapter 21:
Fertilizers Used in Soybean and Corn
Production



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Within the corn-followed-by-soybean rotation, N and P fertilizers are routinely applied. In many fields, enough N and P for both corn and soybeans are applied when corn is grown. The selection of the fertilizer source is dependent on producer preferences and available equipment, costs, fertilizer efficiency, and availability. Fertilizers are routinely applied to optimize soybean yields. The purpose of this chapter is to discuss the different types of commercial fertilizers that are available. Rules of thumb are provided in Table 21.1.

Table 21.1. Fertilizer Rules of Thumb.

1. Match the fertilizer source and application equipment to the problem.
2. In rotations that include soybeans, the P needed for both corn and soybean is often applied to corn.
3. Follow protocols that minimize losses.
4. Placing fertilizer with soybean seed should be used with caution.
5. A list of common fertilizers used in South Dakota are provided in Table 21.1.

Application techniques

Fertilizers are applied to corn and soybeans using many different approaches. For example, fertilizers can be applied as seed treatment, as a popup fertilizer, in a band near the row or as a broadcast application. Each approach has strengths and weaknesses (McCauley et al., 2009). When applying fertilizer as popup, it is important to remember that soybean seed is much more sensitive to salt injury than corn seed.

For seed treatments, a small amount of fertilizer is mixed and applied to the seed prior to seeding. For soybeans, iron (Fe) deficiency chlorosis (IDC) yield losses in calcareous soils (high pH) can be reduced by seed-treating with Fe chelated EDDHA (Chapter 26).

Starter fertilizer, or popup fertilizer, is placed with or near the seed at planting to speed up seedling emergence. Starter fertilizers may be most useful in cold wet soils, but caution must be used because applying too much starter can inhibit soybean seed germination (Hergert and Wortmann, 2006). When using starter fertilizer, check the metering equipment to make sure it's working. Maximum popup fertilizer rates for soybean are much lower ($\frac{1}{2}$) than corn. Starter fertilizers should not be confused with band

placement or applying nutrient to overcome nutrient deficiencies. Band placement can promote early growth and provide the nutrients needed to optimize growth. Broadcast applications generally are surface applied. Different fertilizers are better suited for different application techniques.

Sources

Liquid, solid, and gas fertilizer can be used to return nutrients to the field (Table 21.2). When selecting the fertilizer materials, prices, nutrient concentrations and amounts, potential losses, and special handling requirements should be considered. Each fertilizer type has individual requirements and may require slightly different calculations. For example, 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. In the U.S., the grade provides information relative to the percentage of N, P₂O₅, and K₂O (shorthand for nitrogen, phosphorus and potassium fertilizers) contained in the material (Table 21.2). Examples for converting P₂O₅ to P or K₂O to K and a discussion of fertilizers on soil pH are provided in McCauley et al. (2009).

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 three 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.

Table 21.2. Common fertilizers applied to soils in South Dakota.

Fertilizers	N %	P ₂ O ₅ %	K ₂ O %	Density lbs/gal	S %	Cl %
Solid						
Ammonium nitrate	33	0	0	--	--	--
Di-ammonium phosphate (DAP)	18-21	46-53	0	--	0-1.5	--
Mono-ammonium phosphate (MAP)	11-13	48-55	0	--	0-1.5	--
Potassium Chloride (KCl)	0	0	62	--	--	47
Potassium nitrate (KNO ₃)	13	0	44	--	--	--
Urea (NH ₄) ₂ CO	46	0	0	--	--	--
Nitrophosphates Many products are available	21	7	14	--	--	--
	28	14	0	--	--	--
	12	24	12	--	--	--
Triple superphosphate	0	46	0	--	--	--
Elemental S	0	0	0	--	90	--
Ammonium Sulfate (NH ₄) ₂ SO ₄	31	0	0	--	24	--
Gypsum CaSO ₄	0	0	0	--	18	--
Liquid						
Urea-ammonium-nitrate (UAN)	28-32	0	0	10.6-11.0	--	--
Ammonium polyphosphate	10	34	0	11.7	--	--
	11	37	0	11.9	--	--
Thiosulphates: ATS, (NH ₄) ₂ S ₂ O ₃	12	0	0	11.2	26	--
KTS. K ₂ S ₂ O ₃	0	25	0	12.2	17	--
Gas						
Anhydrous ammonia	82	0	0	--	--	--
Seed treatment						
Fe-EDDHA (dry)	--	--	--	--	6%Fe	--

Chelated Fe

Research conducted across the U.S. North Central region suggests that iron deficiency chlorosis (IDC) yield losses in calcareous soils can be reduced by seed treating with Fe chelated EDDHA (Chapter 26). In some situations, yields can be increased even if tolerant cultivars are seeded. The fertilizer rate depends on the degree of iron deficiency, but most data suggest that the rate should be between 1 to 4 lbs product per acre (Ferguson et al., 2006).

Fe-EDDHA is a dry product that can be mixed with water prior to seed treatment (Ferguson et al., 2006). Products are being marketed as soygreen (<http://www.westcentralinc.com/Product/Soygreen.aspx>) and ironworks (<http://www.fertilizerandchemicals.com/ironworks.html>). Both products are relatively inexpensive and contain approximately 6% iron that is chelated with Fe-EDDHA.

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, mono-ammonium phosphate (11-52-0) or di-ammonium 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 21.3 presents guidance for the use of P fertilizers. The United States is one of the leading producers of apatite (calcium phosphate minerals).

[http://www.ipni.net/publication/nss.nsf/0/82604AED72555BAD852579AF00736BC3/\\$FILE/NSS-02%20Polyphosphate.pdf](http://www.ipni.net/publication/nss.nsf/0/82604AED72555BAD852579AF00736BC3/$FILE/NSS-02%20Polyphosphate.pdf)

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 non-water solubilized P that is solubilized when placed in citrate. Fertilizer can also contain polyphosphate and orthophosphate forms. Polyphosphate is produced by heating orthophosphate to remove the water. This process converts 40 to 60% of the ortho-P to poly-P.

Mono-ammonium phosphate (MAP)

MAP fertilizer grades range from 11-13 for N and 48-55 for P_2O_5 . MAP $[(NH_4)H_2PO_4]$, if pure, would have a fertilizer grade of 12.2-61.7-0. MAP contains less ammonia than DAP, making it a preferred pop-up fertilizer. <http://www.ipni.net/specifics>

Depending on the manufacturing process, MAP may contain some S.

<https://www.certifiedcropadviser.org/files/certifications/certified/education/self-study/exam-pdfs/40.pdf>

Di-ammonium phosphate (DAP)

The fertilizer grade of DAP can range from 18-21 for N% and 46-53% for P_2O_5 . DAP $[(NH_4)_2HPO_4]$, if pure, would have a grade of 21.2% N and 53.8% P_2O_5 . Information about DAP is available at <http://www.ipni.net/specifics>. Depending on the manufacturing process DAP may contain some S.

<https://www.certifiedcropadviser.org/files/certifications/certified/education/self-study/exam-pdfs/40.pdf>

Polyphosphates

Polyphosphates contain both orthophosphate and polyphosphate. Two common ammonium polyphosphate fertilizers have N- P_2O_5 - K_2O composition of 10-34-0 or 11-37-0. These liquid fertilizers do not require special handling and storage; however, equipment should be made of resistant materials.

http://www.fluidfertilizer.com/newsletters/fertilizer_newsletter2.html

To minimize problems, storage over the summer should be minimized. 10-34-0 is not compatible with Aqua or Anhydrous Ammonia. http://www.liquidproducts.net/SpecSheets/10-34-0_spec_shet.pdf

10-34-0 can be sprayed on to the soil surface and incorporated into the soil. The salting out temperature, separation of liquid and solid components, for 10-34-0 and 11-37-0 are 0° and 32°, respectively.
http://www.fluidfertilizer.com/newsletters/fertilizer_newsletter2.html

Nitrophosphates

This material is produced by reacting phosphate rock with nitric acid. The products are phosphoric acid and calcium nitrate. Information about this project is available at <http://www.ipni.net/specifics>. Depending on your needs, a range of products is available. This product absorbs moisture and should be stored accordingly.

Potassium Fertilizers

Potassium chloride

Potassium chloride (60 to 62% K₂O) 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 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 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.
<http://www.ipni.net/specifics>

Table 21.3. Rules 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 (H₃PO₄) are MAP and DAP.
 - ▷ Polyphosphates have the chemical formula H₄P₂O₁₀. A fertilizer that contains polyphosphates is 10-34-0.
 - ▷ Ortho and polyphosphates are generally considered equally available.

Potassium sulfate

Potassium sulfate can be used to apply both K and S. The K₂O 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 K₂SO₄ is less than KCl. <http://www.ipni.net/specifics>

Nitrogen Fertilizers

N fertilizers generally are not recommended for soybeans. The source of N in most fertilizers is the air. In the manufacturing of N fertilizers, atmospheric N₂ is combined with H from natural gas to form anhydrous ammonia (NH₃), 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 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 CO₂. Ammonia can be volatilized if the urea is not incorporated. The application of urea with the seed will reduce germination; however, it can be placed in a band two inches to the side and two 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/specifics>

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 contaminated with any of these materials, it can become explosive. Because ammonium nitrate absorbs water from the air, it should be stored carefully.

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. When using this material always follow safety protocols. <http://www.ipni.net/specifics>

N solutions

These are liquid fertilizers with grades ranging 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 fertilizers can be corrosive to some metals.

When applied to the soil, volatilization losses can occur. Volatilization losses are the highest when applied to warm high pH soils. When applied to high residue soils, N will likely be immobilized in the residue. To reduce immobilization losses, broadcast applications are not recommended in high residue soils.

<http://www.ipni.net/specifics>

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).

Micronutrients

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 ammonium thiosulfate 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/specifics>

Chloride

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 micro-nutrients.

<http://www.ipni.net/specifics>

Potassium chloride (KCl)

This fertilizer is often called muriate of potash or just potash. The fertilizer provides both K and Cl. Potassium chloride is approximately 47% chloride. Other fertilizers providing Cl⁻¹ are ammonium chloride (NH₄Cl), calcium chloride (CaCl₂), magnesium chloride (MgCl₂), and sodium chloride (NaCl). Potash can be either pink to white. White potash generally has a higher analysis than pink potash.

Sulfur Fertilizers

Sulfur-based fertilizers are used to mitigate sodic soils as well provide S to sulfur deficient crops.

Ammonium sulfate (21-0-0-24S) is a product that provides both N and S to the plant. This material will not help mitigate sodic soils. **Elemental S** (0-0-0-90S) is made available to plants when it is transformed to sulfate ions by soil bacteria. When added to soil, this product will decrease soil pH and help mitigate sodic soils. The transformation to sulfate ions may take a year or more. **Calcium sulfate** (gypsum) (0-0-0-24S) is a neutral salt that is used in sodic soil mitigation. **Ammonium polysulfide [20-0-0-(40-50S)]** can be directly applied to soil, applied with irrigation water or metered into irrigation water, or mixed with ammonia solutions. Ammonia polysulfide is not completely compatible with all liquid fertilizers. **Ammonium thiosulfate** can be applied in irrigation water and it is compatible with aqua ammonia, nitrogen solutions containing ammonium nitrate, urea solutions, and most nitrogen, nitrogen-phosphate, or complete fertilizer solutions. Do not mix ammonia thiosulfate with anhydrous ammonia or acid solutions such as phosphoric acid.

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 fertilizers.

Blended Fertilizers

Many custom blends of N-P₂O₅-K₂O 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

Mass balance calculations show that manure returns much of the nutrients removed in the harvested grain. Different livestock handling systems are more effective than others at efficiently returning these nutrients to the soil. Average amounts of N and P₂O₅ contained in different manures are shown in Table 21.4.

Table 21.4. Amounts of N and P₂O₅ by livestock type. (Based on Lorimor and Powers, 2004)

Type of Livestock		Nitrogen				P ₂ O ₅	
		Liquid Manure		Solid Manure		Liquid	Solid
		N organic	N inorganic	N organic	N inorganic		
		lb N/1000 gal	lb N/1000 gal	lbs N/ton	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	8	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 Soybean Research and Promotion Council USDA-AFRI, NASA, South Dakota 2010 Initiative, and North Central SARE program.

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