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Anhydrous Ammonia—Its Use?

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The use of anhydrous ammonia is relatively new in North Dakota, especially in the western part of the state. This does not mean it is a new source of nitrogen. It has been a major source of nitrogen for crop production in the United States since the mid 1940's (1). It has been used in some parts of North Dakota since the late 1950's. Its growth in North Dakota has been very rapid in recent years. About 150,000 tons of nitrogen, applied as anhydrous ammonia, were used by North Dakota producers for the 1978 crop. This represents about 62% of the nitrogen used (5).

Supplemental information regarding how anhydrous ammonia fits into the soil nitrogen cycle can be found in Extension Bulletin No. 21 (3) available from County Extension Agents or from the Agricultural Communication Bulletin Room, Morrill Hall, NDSU, Fargo, ND 58105.

Information from soil tests that have been properly taken is the best guide to the profitable use of any fertilizer. Guidelines for obtaining representative soil samples for soil testing can be found in circulars such as S-F-336 (6) available from County Extension Agents.

What is anhydrous ammonia?

Anhydrous ammonia is one of the simplest forms of nitrogen fertilizer available to crop producers. It is a simple chemical compound made up of one part nitrogen and three parts hydrogen (NH_3). At normal temperatures, anhydrous ammonia is a gas. Anhydrous ammonia contains 82% nitrogen, making it one of the highest analysis and more economical fertilizers on the market today (1, 2).

Are there any advantages which encourage the use of anhydrous ammonia over the other nitrogen sources?

The biggest advantage is cost. In comparison to other nitrogen sources, anhydrous ammonia may cost up to 50% less per pound of nitrogen than other nitrogen materials (ammonium nitrate, urea, or nitrogen solutions). **Costs of conversion, application, etc., should also be considered when comparing costs of N materials as applied to the soil.**

What happens to anhydrous ammonia once it is injected into the soil; how long will it last?

As soon as anhydrous ammonia (NH_3) is injected into the soil it reacts with water or other sources of hydrogen associated with organic matter or clay in the soil to be converted into ammonium ions (NH_4^+). See Figure 1.

Ammonium ions (NH_4^+) are immobile and will not leach, since they are attracted to negative charges associated with the organic matter and clay in the soil. A small amount of nitrogen can be used by young plants as the ammonium ion, but the majority remains in the soil until soil temperatures rise above approximately 50°F. It then converts into nitrites and on to nitrates (mobile nitrogen) and is either used by plants, leached with downward movement of soil water, lost by denitrification (conversion of NO_3^- to nitrogen gas and oxygen), or remains in the soil solution (4).

How long nitrogen as the nitrate ion (NO_3^-) remains in the soil is dependent on crop demands, soil temperature, soil texture, and the amount of

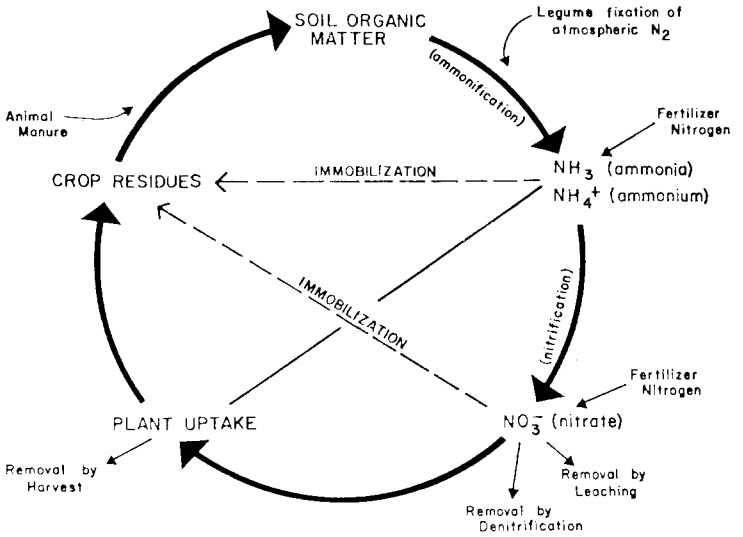

Figure 1. Simplified nitrogen cycle.

moisture received. Excess nitrogen will leach faster in sandy soil, slower in loam and clay soils and faster under high rainfall conditions. Not all the nitrate nitrogen will leach out at one time. It leaches down over a period of time.

When can anhydrous ammonia be applied?

Anhydrous ammonia can be applied in the fall, in the spring as preplant and as a sidedress, or as a postplant application. To avoid possible germination injury and stand reductions resulting from ammonia toxicity, delay planting for about a week to 10 days after NH_3 applications. However, in cases where NH_3 applications have been made at minimum depths of 5-6 inches and seeding depth carefully controlled to not exceed 1½ inches, farmers have been able to successfully seed right behind NH_3 application. Applying the ammonia diagonally with respect to row direction can also reduce injury.

If nitrate nitrogen leaching is a concern when fall-applying anhydrous, do not apply until surface soil temperature reaches 50 degrees F. or lower. Fall and springtime leaching losses are considered to be insignificant in North Dakota because of limited rainfall and the frozen conditions overwinter. Plant and soil scientists at NDSU and in surrounding areas suggest applications can be made any time in the fall, regardless of soil temperature, on most medium and fine textured soils.

Is anhydrous ammonia toxic? Does it kill microorganisms and earthworms?

As mentioned previously, there can be a germination and/or stand reduction in the fertilizer application zone. Generally, everything near the center of this zone will be affected, microorganisms, crop and weed seeds, and earthworms. Three characteristics of anhydrous ammonia cause damage to living organisms:

a. At the point of release from the injector knife, the temperature will be about -28 degrees F. (boiling point of anhydrous ammonia), freezing everything coming in contact with it.
b. The soil pH (hydrogen ion concentration) is quite high (9.5-10) for a short period in the injection zone resulting in a toxic condition.
c. The affinity of NH_3 for water withdraws water from living cells, killing them.

Soil microorganism population reductions in the injection zone are temporary. They respond to and use the applied nitrogen, usually resulting in an increase in microorganism populations (7).

Does anhydrous ammonia cause the soil to crust or get hard?

To date there is little, if any, research to support this idea. There may be occurrences of soil crusting or hardening if anhydrous ammonia, or for that matter any other nitrogen source, is used in a continuous cropping situation where all the plant materials produced are removed; corn silage production as an example. If no residue is returned to the soil there may be a breakdown in the nitrogen cycle as some microorganisms need fresh organic matter to live on. If they are starved, the cycle will eventually be broken. In other words, it is residue mismanagement that can eventually cause soil structure problems, poor tilth and hardening or crusting of the soil.

Is soil moisture content a factor when applying anhydrous ammonia?

Soil moisture content is an important consideration in providing proper soil physical conditions to insure rapid and complete sealing of the injection channel. In soils which are too wet, the shank opening or injection channel tends to stay open and the ammonia gas comes right to the surface and is lost. Losses will be minimal in dry soils if the soil has good tilth. However, if the soil is too dry and cloddy, the ammonia gas can escape to the atmosphere and be lost. Direct losses of anhydrous ammonia is minimized druing application if soils are in the intermediate moisture range. If the soil is too wet, freezing of injection points may be a problem.

Should soil temperature be a consideration in determining time of application of anhydrous ammonia?

Cold soils can retain ammonia very well. This is important to remember in considering fall applications. If nitrate nitrogen leaching or denitrification is a concern, delay fall applications until the surface soil temperatures are about 50 degrees F. or below, or consider the use of a nitrogen stabilizer.

Spring applications can be made any time field conditions allow. Too-wet soils can cause sealing problems and ammonia gas losses behind the injector shanks. Also, planting of crops should be delayed 7-10 days after spring applications to prevent toxicity damage resulting in poor germination and stand reductions.

What depth of application is best when injecting anhydrous ammonia?

Application depths should be 5 to 6 inches on most soils, preferably 6 inches. The 6-inch depth is particularly important on sandy or coarse textured soils. Losses can occur if injection points are too shallow.

What injection spacing is best to obtain uniform application of anhydrous ammonia?

Injection spacing will be somewhat dependent on the time of year the application is made. For preplant spring application on small grains, 9 to 12-inch spacings are desirable to prevent nitrogen streaking. If a tillage operation is done 10 days or so following application and before planting, 15 to 18-inch spacings could be used successfully. This secondary tillage would redistribute the nitrogen.

In a fall application where some secondary tillage s performed in the fall or before seeding in spring, 18 or 20-inch spacings would be adequate.

Is speed a factor to consider when applying anhydrous ammonia?

The faster the equipment travels, the greater tendency injector knives or shanks have to bounce and lift out of the soil. As a result the depth may be more shallow than desired, resulting in ammonia losses. The rate of chemical applied will also be affected. Most application equipment is precalibrated for a particular speed. Consult your dealer for recommended application speed.

What are the equipment needs for applying anhydrous ammonia?

Anhydrous ammonia can be injected into the soil with any type of equipment that is run beneath the soil surface (1). A moldboard plow, chisel plow, field cultivator, Noble blade, or even a disk can be modified for application when carrying out normal crop production practices. Also, regular commercial applicators are available.

How does soil texture affect the application of anhydrous ammonia?

Soil texture primarily affects ammonia retention. In medium and fine textured soils, anhydrous ammonia adheres readily to the clay and organic matter. In sandy or coarse textured soils, organic matter becomes very important for retaining anhydrous ammonia as clay content is minimal. Late fall (after soil temperature is about 50 degrees F.) or spring applications are recommended on sandy soils.

How can a person tell if losses are serious when applying anhydrous ammonia?

The best guideline is your nose. If your nose starts to run and you can smell ammonia, losses are getting to the point where they are significant. It is best to have someone walk behind the applicator while in operation to check for losses. If this is not possible, stop the equipment, jump down and walk around behind the applicator. The smell will linger for a short time if ammonia losses are occurring.

Is anhydrous ammonia a safe material to use?

Anhydrous ammonia can be used safely as a fertilizer, provided it is handled with the proper care, equipment, and precaution. Know the product and its characteristics. Anhydrous ammonia is under pressure, so equipment should be in tip-top shape and inspected regularly. Anhydrous ammonia has a tremendous affinity for water. If it comes in contact with any part of the body it causes very serious dehydration burns. Blindness is a danger if it gets in the eyes. Have plenty of clean water available to wash down the affected area for at least 15 minutes. Consult a physician as soon as possible and inform him that anhydrous ammonia was involved. **Wear protective equipment, particularly rubber gloves and goggles, whenever handling or transferring anhydrous ammonia.**

Can anhydrous ammonia be used on existing stands of small grains, grass (pastures), or alfalfa?

If nitrogen, as anhydrous ammonia, is applied to existing stands it is best to use the true anhydrous applicator knife to keep mechanical damage to a minimum. A few plants will be injured or destroyed, but tillering will compensate for any losses. When making applications on grass pastures, attention should be given to insure a good seal on the slot created.

Vigorous, healthy alfalfa stands should require no addition of nitrogen fertilizer. Alfalfa is a leguminous plant and, if properly inoculated when planted, should take care of its own nitrogen needs by means of nitrogen fixing nodules.

Can row crops be sidedressed with anhydrous ammonia?

If additional nitrogen is needed after the crop is planted, sidedressing with anhydrous ammonia can be done. However, keep the knife near the center between rows to minimize root damage.

Are there any new developments with regard to the use of anhydrous ammonia?

Two recent developments are N-Serve[1] and Cold-flo[2]. N-Serve is a chemical which slows down the conversion of ammonium-nitrogen into nitrate-nitrogen, the leachable form of nitrogen. This is, in essence, the same situation created by soil temperature of about 50 degrees F. or below. N-Serve has possibilities under special conditions to delay the conversion of nitrogen into the leachable form on soils in which leaching or denitrification losses of nitrate are significant. (Results to date with N-Serve in North Dakota have been erratic.)

Cold-flo makes use of the refrigeration characteristic of anhydrous ammonia, allowing it to be applied primarily as a liquid instead of a gas. With the addition of an expansion chamber on the application equipment, the refrigeration action of anhydrous ammonia transforms approximately 85% of the ammonia into a cold liquid. The remaining 15% is a very low pressure gas. The cold-flo ammonia is released under the soil as a non-pressure liquid or as a very low pressure vapor. This allows for less chance of anhydrous ammonia escaping (8).

Is there any benefit to injecting anhydrous ammonia into livestock feed?

This is one application of the cold-flo system. Anhydrous ammonia can be sprayed into silage (via chopper or as it is going into the silo) or hay crops (via the baler). It is a non-protein nitrogen supplement which, after it is converted into usable protein, raises the protein content of the forage. Other nitrogen forms can also be used as additives to livestock feeds (8).

Is anhydrous ammonia as effective as dry or liquid nitrogen in giving crop response?

Research conducted in several states indicates that anhydrous ammonia, when properly applied, is as effective in giving crop response as other nitrogen sources. The following examples of actual data in Tables 1 and 2 support this.

TABLE 1. RESPONSE OF DURUM WHEAT TO NITROGEN SOURCES. (Unpublished data from 1975-78 at the North Central Experiment Station, Minot, ND)

Nitrogen Source (50 lbs N/Acre)	Yield (Average 1975-78)		
	Fall Applied (Bu/Acre)	Spring Applied (Bu/Acre)	Average of Fall & Spring Applied
None	28.2	26.6	27.4
Urea	32.5	29.4	31.0
Anhydrous Ammonia (82-0-0)	33.7	30.8	32.2
Ammonium Nitrate (34-0-0)	32.7	31.5	32.1
Average	31.8	29.6	

[1] N-Serve is a trademark of the Dow Chemical Company.

[2] Cold-flo is a patented product of United States Steel Agri-Chemicals.

TABLE 2. WINTER WHEAT YIELDS AS INFLUENCED BY NITROGEN MATERIALS (9).

Nitrogen Material	Average Yield (1969-76) Bu/Acre
None	33
Ammonium Nitrate (34-0-0)	39
Urea (46-0-0)	39
Nitrogen Solution (28-0-0)	38
Anhydrous Ammonia (82-0-0)	41

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