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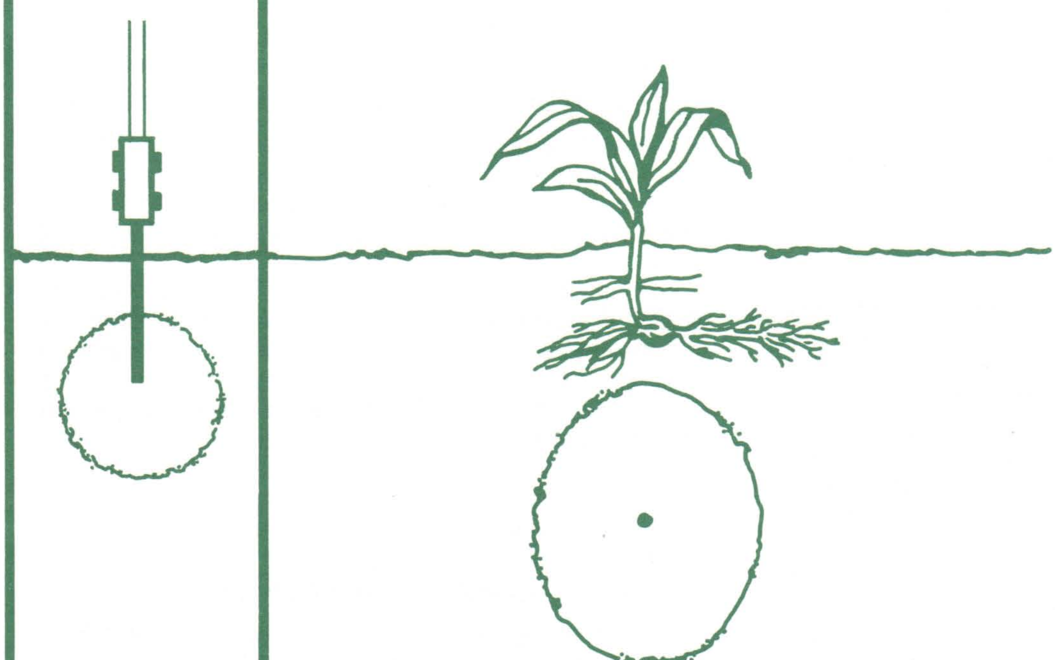
NH_3

Using Anhydrous Ammonia in Minnesota



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USING ANHYDROUS AMMONIA IN MINNESOTA

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What It Is

Pure ammonia (NH_3) is made up of 82.24 percent nitrogen (N) and 17.76 percent hydrogen. It has been formed by the combination of N_2 gas from the air (a form not available to crops) and hydrogen. The simple compound is called anhydrous ammonia (NH_3): anhydrous meaning "without water." It is gas but must be stored, transported, and handled under pressure in special containers. When under pressure it is a liquid, looking and flowing like water. Its weight varies with temperature but is approximately 5 pounds per gallon.

If liquid NH_3 is released on the soil surface it expands rather rapidly into a gas and will evaporate. When evaporating, it is actually colorless although it first appears as a white vapor because of heat intake from the air. It has a sharp, pungent odor which serves as its own warning signal to the user in detecting losses during application.

Reaction In The Soil

Soil application of NH_3 takes advantage of the rapid expansion of liquid ammonia into the gaseous form and its tremendous affinity for water. When the liquid is released in the soil, it quickly spreads out to a diameter of about 6 inches depending on the rate applied, soil moisture, and soil texture. It dissolves immediately in soil moisture and then is no longer a gas. The compound formed is ammonium hydroxide (NH_4OH) which breaks into two parts: the ammonium ion (NH_4^+) with a plus charge and the hydroxyl ion (OH^-), the negative ion. The (NH_4^+) will cling to either the negatively charged clay particles or the soil organic matter. In this form it moves very little.

At the immediate point of injection where the NH_3 becomes NH_4OH, the soil pH is temporarily high since the latter compound is strongly alkaline. When bacteria act on the NH_4^+ to convert it to nitrate, H^+ ions are released. Thus NH_3, over the entire growing season causes a slight reduction in soil pH. Soil organisms are discussed in a later section.

Applying Effectively

DEPTHS OF APPLICATION

Experiments using dyes as indicators to determine the extent of NH_3 spread, show that a 6-inch depth is necessary on most soils to avoid loss to the air during application. Deeper applications may be needed to hold NH_3 in dry sandy soils. Speed of travel while injecting can affect depth. The faster the travel speed the greater the tendency for the knives to lift, resulting in shallower application than intended. Figure 1 shows the preferred position of the NH_3 zone in relation to the corn plant.

INJECTION UNDER WET OR DRY SOIL CONDITIONS

Losses of NH_3 vapor often occur when applications are made to soils which are too wet. The knife area may stay open or partially open allowing the NH_3 gas to escape. There will be little, if any, loss if soils are dry enough for tillage.

Losses can also occur when soils are extremely dry. Then there is no water available to react with NH_3 and this is true especially if the soil is cloddy. Delays in application are suggested during periods of extended drouth. Figure 2 illustrates conditions which lead to loss of NH_3 at the time of application.

Effect on Soils

AVOID SEED GERMINATION PROBLEMS

Early planting of corn combined with preplant NH_3 additions sometimes results in germination damage. This problem has been observed most frequently on coarse-textured soils, but problems have also been encountered on fine-textured soils. If applications are too shallow and corn is planted close to or on top of the band, the toxic effects of NH_3 could damage seed and new roots. This will be more of a problem when soils are dry.

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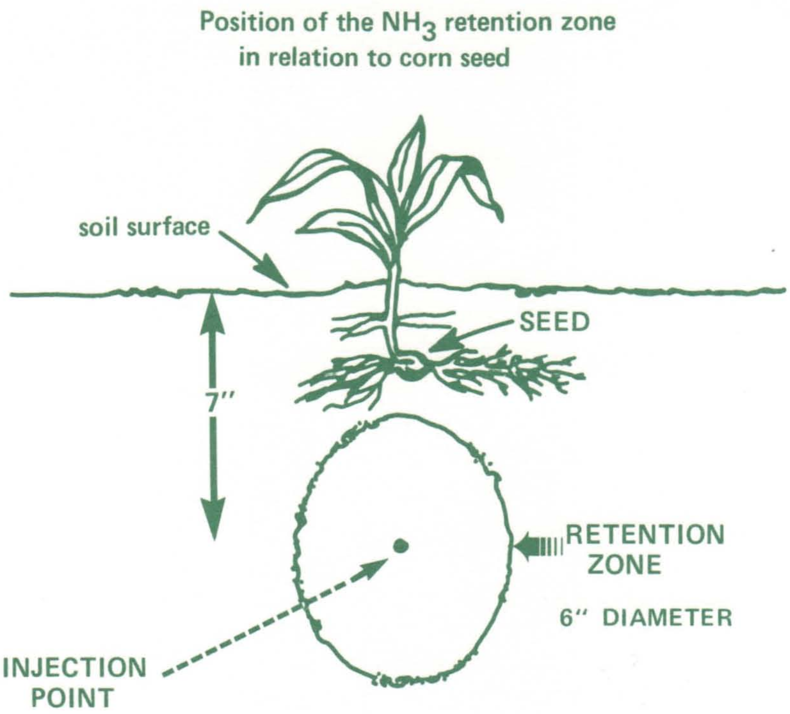

Figure 1. Position of ammonia retention zone in relation to corn

Research on preplant NH_3 and damage to corn was conducted by University of Illinois agronomists Colliver and Welch. They studied germination damage caused by NH_3 applied at different rates, depths, and times before planting. They used 30-inch knife spacings and planted corn 2 inches deep in the band directly above the injected NH_3.

Some treatment combinations caused injury where germination was either delayed or stopped and root development was retarded. They used 0, 100, 200, 400, and 600 pounds N per acre as NH_3 and applied it at depths of 4, 7, or 10 inches. They also applied the NH_3 at 2 weeks, and 1 week before planting as well as on the same day as planting. The following table shows the results.

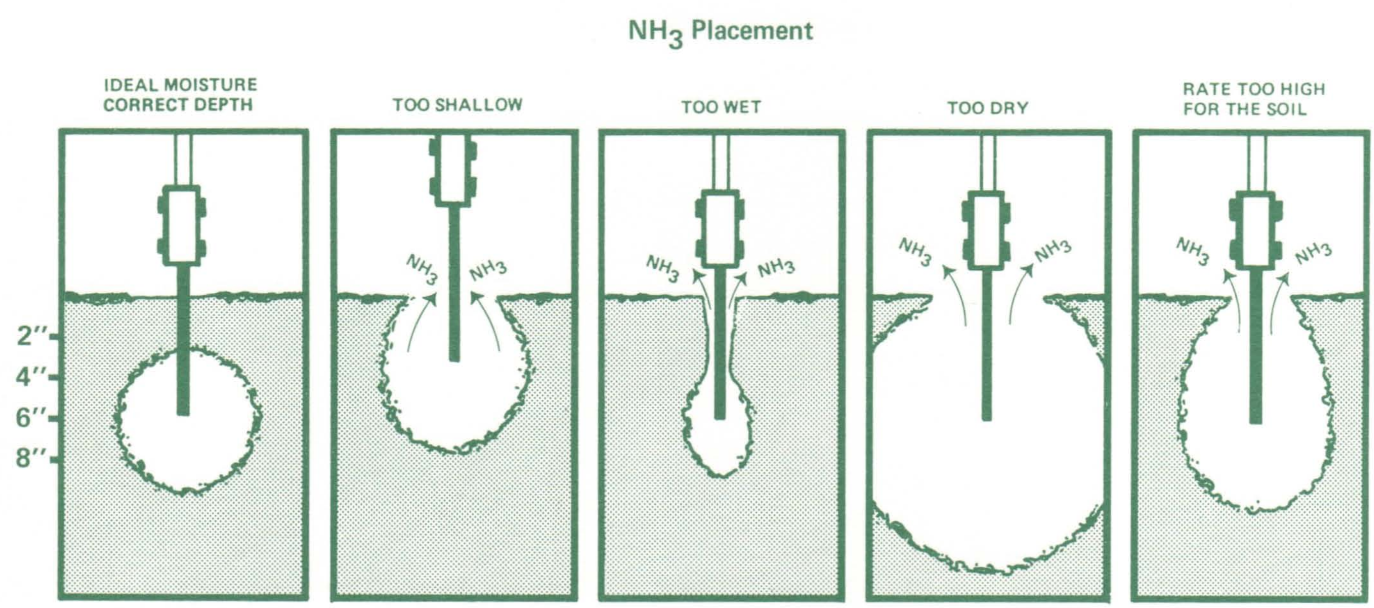

Figure 2. Conditions which lead to loss of ammonia at the time of application.

The Effect of Injection of Anhydrous Ammonia on Corn Germination

N rates	time before planting	NH_3 Injection Depth 4" early*	4" later*	7" early*	7" later*
lb./acre		— — — — % germinated — — — — —			
100	same day	86	100	100	100
200	same day	39	65	90	100
100	1 week	100	100	100	100
200	1 week	96	100	100	100

*Early means less than a week after emergence. Later varied between 12 and 19 days after first emergence of nondamaged corn.

There was no damage to germination when NH_3 at all rates was applied 2 weeks before planting. Germination was 100 percent when the NH_3 was applied at 10 inches at all rates for all times of application.

If 1 week was allowed before planting with NH_3 application 4 inches deep, there was only a 4 percent loss in stands at the 200 pounds per acre rate of N. There were no germination reductions at the 7-inch application depth, if there was a week between application and planting. Rainfall during this time could be a factor.

The Illinois researchers reported that seedling roots would not grow in an area where concentration of NH_3 was high. The plant roots, however, showed a remarkable ability to grow around the NH_3 band and establish a good root system if the NH_3 was not too close to the seed. Where corn was damaged the leaves were purple at the 4-to 5-leaf growth stage. Based on plant analysis, this corn was diagnosed as being phosphorus deficient. Apparently, this was due to damaged roots, but as root development improved, the purple color disappeared.

The damage would be less than shown here if the knife band did not coincide with the corn row. Traveling diagonally from the anticipated direction of the row will help reduce the potential for damage.

KNIFE SPACINGS

The ideal spacing needed for the application of NH_3 will vary with time of application, crop, and equipment used for application. It's important to point out that the potential for loss and damage to crops following application is reduced as the amount of NH_3 coming from each release point decreases. For any rate of N application, the amount of NH_3 released from each opening decreases as the spacing between release points narrows.

When the NH_3 is applied before planting, spacing will be dictated by the equipment used. Spacing should be 12- to 15-inches when NH_3 is applied to small grains before planting. For row crops, spacing, of course, will be dictated by row width when NH_3 is applied after planting.

THE EFFECT OF NH_3 ON SOIL ORGANISMS

As with seed germination or root development, soil micro-organisms can also be affected in the immediate area of NH_3 injection. The extreme affinity of NH_3 for water destroys living organisms, and the ammonium hydroxide formed when NH_3 and water have combined can also be caustic. The reduced bacteria population is temporary because only the soil near the immediate injection point (1 inch or less) is seriously affected. The bacteria population soon begins to rebuild from the unaffected adjacent area.

University of Florida research reported by Eno and Blue shows that immediately after application, NH_3 is very highly concentrated at the injection point. They found 1 day after application that the numbers of bacteria, fungi, and nematodes had decresed compared with an adjacent untreated area. On the 10th day following injection, the fungi and nematode count was still markedly reduced, but the bacterial population recovered and increased 6 to 25 *times when compared with the nearby untreated soil.*

It is this decrease in bacterial count at the injection point that has prompted some to think that NH_3 makes a soil sterile. The basic work by Eno and Blue shows that this is not true. The use of fertilizer nitrogen as an energy source for bacteria and its enhancement of bacterial populations has been known for a long time.

Eno and Blue reported that the drop in fungi and nematode count did not show a rapid recovery. This might explain why nitrification inhibitors have been identified as an aid in the control of stalk rot of corn. The inhibitor keeps the injected NH_3 in the ammonium form longer.

SOIL HARDNESS

Soil hardness has been reported as a problem in some areas. It has been suggested that NH_3 treatments are responsible. The idea might be related to the same thinking that soils are becoming sterile.

Hardness measurements were taken in a 10-year study involving NH_3 and 28 percent liquid N reported from the University of Nebraska by Olsen et al. Using instruments to record penetration and shear stress, both a measure of the degree of compaction, they sampled plots for the two nitrogen forms that had been used for 10 years. They also measured hardness in the tractor wheel track and in areas where there was no traffic. Contrary to expectations, results of both measurements showed slightly less compaction from use of both of the N forms compared with untreated check plots. The wheel track area showed an increase in compaction when compared with the non-tracked area. Wheel tracks in these plots were in the same place each year. The conclusion was that soil hardness is possibly related to machinery traffic from tillage operations. Where hardness appears to be increasing in farmer's fields it was suggested that traffic is an important contributing factor especially if fields are worked when too wet. Any form of nitrogen promotes growth, and when the increased quantities of residue are returned to the soil regularly, a soil will loosen up not become harder, after several years.

Kansas State University researchers Stone, Ellis, and Whitney also conducted a 10-year-study comparing the effects of 28 percent liquid, NH_3, urea, and ammonium nitrate on the physical properties of soils. Their conclusion was the same as the Nebraska work. They found no measurable influence on soil structure or compactibility among the N sources or when the N sources were compared with the no-N check.

APPLICATION TIMES AND TEXTURE RELATIONSHIPS

Anhydrous ammonia is adaptable to fall, spring, or sidedress applications, but is not recommended for use in irrigation systems. Fall application on sandy soils, of course, is never recommended and the use of a nitrification inhibitor is strongly encouraged when NH_3 is applied to a sandy soil before planting. Any application shallower than 6 inches should be made a week or 10 days before planting.

For most of Minnesota, it is difficult to recommend the best time for NH_3 application. Factors such as crop, probability of rainfall, soil moisture content, and drainage must be considered when a grower decides on the time of application for fertilizer N.

Methods of Application

EQUIPMENT

Besides the regular commercial application equipment for NH_3, several types of tillage implements can be used. Application of NH_3 with tillage equipment can save an expensive trip over the field. The chisel or moldboard plow, disk, field cultivator, and applications by the corn cultivator have been used successfully. Proper depth of applications and a good soil seal during injection are the chief concerns in avoiding losses.

APPLICATION ON ESTABLISHED STANDS

Ammonia can be applied for emerged small grains or pastures but knives need to be quite close together. When using NH_3 on established small grains stands, there will be a slight stand reduction but tillering will usually overcome this if additions are made early. On pasture sod, attention must be given to proper seal where the knife cuts the turf. Power requirements are also high in grass pastures. This method of application is not highly recommended.

Inhibitor Use With Ammonia

Nitrification inhibitors can be used with any N form to delay the conversion of NH_4^+ to NO_3^-. Injecting the inhibitor into the NH_3 tank is convenient and the intimate contact that takes place is desirable for best results. Inhibitors are used to reduce leaching losses on irrigated coarse-textured soils or to reduce denitrification losses on fine-textured soils. For corn production on irrigated sands, it is desirable to add an inhibitor to the NH_3 if the fertilizer N is applied at or before the 8-leaf stage. Denitrification is the loss of N to the air in warm, wet soils after nitrate has been formed.

Ammonia Use With Other Fertilizer

Besides being the base material for making urea, ammonium nitrate, and 28 percent UAN, NH_3 is used in manufacture of mixed goods such as ammonium phosphates and complete NPK combined materials. The ammonium phosphates are also used in the blended NPK mixes. The relatively new method with dual application ("NH_3 plus 10-34-0") has been successfully demonstrated in research and on some farms. Dual application is probably best suited for situations where small grains are grown on soils that have a low soil test for P in combination with low soil moisture throughout the growing season.

Safety

If the prescribed precautions for handling are followed, anhydrous ammonia is a safe product. For best safety, however, the characteristics of NH_3 and the equipment must be understood. Pressurized material requires preventive maintenance of equipment. Constant attention to conditions of valves and transfer hoses is necessary. Ammonia's strong attraction to water causes it to react with skin moisture and the eyes. It can cause serious dehydration burns. Eyes are especially sensitive and blindness could result if direct NH_3 contact is made unless immediately washed with water. Water must be kept available for an immediate washdown of any part of the body that comes in contact with NH_3.

Ammonia is classified by the Interstate Commerce Commission as a nonflammable compressed gas, hence explosions are not of great concern. It is not a poison and has no cumulative toxic effects.

Protective equipment is essential when NH_3 is used. Rubber gloves, goggles or face shield must be worn when transferring NH_3 to application tanks. It must not be inhaled since it will damage lung tissue and the upper respiratory tract.

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