ANHYDROUS AMMONIA APPLICATION – SPRING 2019

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It was a late harvest in the fall 2018, soils were wet, and when it was time that anhydrous ammonia could be applied soils became frozen. Those situations resulted in much less than normal anhydrous ammonia application last fall. Therefore, considerable anhydrous ammonia needs to be applied spring 2019. There is only so much capacity to switch from one nitrogen (N) fertilizer product to another. In Iowa, historically the two largest N fertilizers consumed are anhydrous ammonia (largest) and urea-ammonium nitrate (UAN) solution, with granulated urea a distant third. What should be considered if there becomes a tight window of time between ammonia application and corn planting?

Important considerations:

1) Application procedures are key to avoiding injury to corn seedlings. Deep injection (6-8 inches) and a good seal of the injection track are the best ways to avoid ammonia placed in or movement into the corn root zone.
    - Ammonia has greater opportunity to move from the initial injection site in coarse, dry, or cloddy soils.
    - Ammonia movement up the injection track can be greater if soils are wet and injection system smears the sidewalls.
    - If you can smell ammonia after an application pass, adjust equipment or wait for better conditions.
    - Wing sealers immediately above the outlet port on the injection system can help close the injection track, limit the size of the retention zone, and reduce vertical movement of ammonia.
2) Adjust planting plans to help reduce opportunity for crop injury. There is no magic number of days to wait to avoid injury; time will help, but won't prevent injury. However, other precautions can be taken:
    - Do not plant directly over ammonia injection tracks.
    - Using GPS technology to offset planter rows 4-6 inches or more from ammonia injection tracks to avoid root/seedling injury.
    - Ammonia applications on an angle from direction of crop planting is a way to reduce crop row-length exposure to ammonia bands.
    - Reduced application rate and narrower band spacing reduces the concentration of ammonia in each injection band.
    - If the injection zone is offset away from future corn rows, application can be done the same day as corn planting.
3) The chance for crop injury increases with higher application rates; due to greater ammonia concentration and a larger retention zone. If the injection point is 6 to 8 inches in depth, the outer edge of an ammonia retention zone (which would be low in ammonia concentration) could be 4 inches from the point of injection, and with seed planted at a 2-inch depth directly over an ammonia track, then the seed would be outside but close to the outer edge of the applied ammonia band. Shallower injection, greater movement upward from the injection

point, wider spacing (greater rate per injection point), and higher rates are situations that could lead to greater chance of root/seedling damage.

4) Anhydrous ammonia can be applied sidedress. It takes equipment (applicator and nurse tanks) that is set up to travel between corn rows. As long as the injection track does not cause soil to cover corn rows (not yet emerged or emerged plants), then sidedress application can begin right after planting and until corn is too tall to get application through the field. Considering sidedress application helps widen the window of ammonia application and will help lessen short-term product supply issues.

What happens when anhydrous ammonia is injected into soil?

Several physical and chemical reactions take place: dissolution in water, reaction with soil organic matter and clay, and attachment of resulting ammonium ions on the soil cation exchange complex. These reactions all tend to limit the movement of ammonia, with water having the greatest initial effect. The highest concentration of ammonia is at/near the point of injection, with a tapering of the concentration toward the outer edge of the retention zone. Usually the greatest ammonia concentration is within the first inch or two of the injection point, with the overall retention zone being up to 3-4 inches in radius in most soils. The specific size and shape of the ammonia retention zone vary greatly depending upon the rate of application, injection spacing, soil, and soil conditions at injection (soil texture, soil structure, organic matter, and moisture status).

Ammonia moves farther at injection in coarse-textured soils and soils low in moisture. Also, if the injection system causes sidewall smearing (when soils are wet), then ammonia may preferentially move back up the injection slot. Movement toward the soil surface can also occur for some time after application if the soil dries and the injection track “opens up” as the soil dries (also less soil moisture to retain free ammonia in solution with drying soils). A similar movement within the soil can occur if the soil breaks into clods at application and there are large air voids left in the soil. These conditions can result in greater ammonia concentration toward the soil surface, and greater potential for loss to the atmosphere at or after application.

When ammonia is injected into soil, the initial reaction at the point of release is violent. The ammonia reacts and binds with soil constituents such as organic matter and clays. It reacts with water to form ammonium (NH_4^+). These reactions help retain ammonia at the injection point. With the high affinity for water, soil moisture is important for limiting the movement of ammonia, but does not ultimately determine retention in soil. After conversion to ammonium, which is a positively charged ion, it is held on the soil exchange complex and does not move with water. Only after conversion to nitrate (NO_3^-), via the nitrification process, can it be lost from soil by leaching or denitrification.

Chemical and biological reaction of anhydrous ammonia in soil

1) $NH_3 + H_2O = NH_4^+ + OH^-$

This is the reaction of ammonia with water and causes an initial alkaline pH in the ammonia retention zone (pH can temporarily rise above 9 at the point of highest concentration). It is free ammonia (NH_3) and not ammonium that can be lost from soil at application and is damaging to microorganisms and plant roots/seedlings. As pH goes above 7.3, the equilibrium between ammonium and ammonia results in increased ammonia (the percentage as ammonia would be 1% at pH 7.3, 10% at pH 8.3, and 50% at pH 9.3).

2) $2NH_4^+ + 3O_2 \Rightarrow 2NO_2^- + 2H_2O + 4H^+$
3) $2NO_2^- + O_2 \Rightarrow 2\ NO_3^-$
These two reactions are the steps in the biological nitrification process that occurs with ammonium in soil, and ultimately results in a lowering of soil pH back to the original pH or lower. Nitrification occurs first at the outer edges of an ammonia retention band, and progresses inward as the initial effects of ammonia injection decrease and the soil conditions become more conducive to microbial activity.

Can anhydrous ammonia be applied to dry soils?
Yes. Dry soil can hold ammonia. Even air dried soil contains some moisture, although quite low. Ammonia dissolves readily in water, but it is held or retained in soil by clay and organic matter. The problem with dry soil and low moisture is that soil moisture is needed to temporarily hold ("go into solution") the ammonia so it can become attached to clay or organic matter as ammonium. If dry soils are cloddy and do not seal properly at application, the free ammonia can be lost at injection, or seep through the large pores between clods after application. Therefore, proper depth of injection and good soil coverage are a must for application into dry soils. Wing sealers immediately above the outlet port on the injection system can help close the injection track, limit the size of the retention zone, and reduce vertical movement of ammonia. Closing disks can reduce ammonia loss by covering up the injection track with soil that traps the ammonia as it moves to the soil surface. Reducing the application rate or narrowing the injection spacing reduces the concentration of ammonia in each injection band.

Final Thoughts:
Be mindful of what is happening at application, especially if soil conditions are not ideal. If the soil is breaking into clods or the injection track is smearing, there isn't good coverage of the injection track with loose soil, or ammonia is escaping from the soil (remember your nose tells you if ammonia is escaping; a white vapor is condensed water vapor, not ammonia which is colorless), then stop and either change the way the equipment is working or is set up, or wait until the soil has better structure or moisture.