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Understanding Ammonia Volatilization from Fertilizers

Authored by: Wade Thomason, Mark Alley, and Timothy Woodward, School of Plant and Environmental Sciences, Virginia Tech,

Introduction

Loss of nitrogen (N) as ammonia gas (NH_3) is known as volatilization. While volatilization directly from soil can occur ,such loss is generally relatively small compared to the amount that can be lost from fertilizers. Volatilization losses can be significant with granular urea and urea-ammonium nitrate (UAN) sources, but the amount of loss varies greatly depending on placement of the fertilizer, soil pH, soil texture, and climatic conditions after application.

A number of factors influence the occurrence and/or rate of ammonia volatilization.

Fertilizer Placement – Placing fertilizers below the soil surface into the mineral soil essentially eliminates the potential for volatilization losses. In continuous no-till this means using a coulter to cut residue and place the fertilizer below the residue either as a starter band at planting, or for example, as a band injected beside the row for corn.

Soil pH - Ammonia volatilization increases with increasing soil pH. The ammonium ion (NH_4^+) is positively charged and thus binds with negatively charged soil clay particles. Ammonia (NH_3) has no such charge and so cannot bind to soil. At soil pH less than 7, the ammonium ion is favored because of the hydrogen (H^+) in soil solution, and so less volatilization occurs. At soil pH levels greater than 7, ammonia (NH_3) is favored and more volatilization occurs.

Temperature - Ammonia volatilization risk increases with increasing temperature as the rate of all chemical reactions increases with increasing temperature. Volatilization risk is much greater when air temperatures are 80° than 50°. Volatilization is much more likely in summer than winter.

Wind – Ammonia loss increases with windy conditions. If possible, avoid application of urea or ammonium containing fertilizers on very windy days or with high winds (and no rain) in the short-term forecast.

Cation Exchange Capacity (CEC) – As previously mentioned, NH_4^+ binds to soil. The number of potential binding sites is determined by the CEC, so a higher CEC (higher clay content) results in a higher potential capacity to retain NH_4^+.

Buffering capacity (resistance to pH change) – When NH_4^+ -forming fertilizers are applied to soil, pH in the soil in the immediate vicinity of the fertilizer source is increased. At this very local scale, pH can increase above 7.0, favoring NH_4^+ losses. Soils with greater buffering capacity, higher CEC, resist this pH change which results in less NH_3 loss. So volatilization losses for similar climatic and pH conditions will be expected to be greater on low CEC (sandy) soils as compared to higher CEC (clay) soils.

Soil moisture/humidity– The conversion from urea and NH_4^+ and NH_3 is controlled by chemical and microbial reactions. If soil is dry and humidity is low these processes are inhibited. Evaporation of water from the soil surface encourages volatilization. Ammonia losses are often greatest when urea or ammonium containing fertilizers are applied to wet soil that dries slowly over several days. Heavy dew creates a very similar situation that favors volatilization.

Rainfall/Irrigation following fertilization– Approximately ¼ to ½ inch of rain is necessary to dissolve N fertilizer and move it into the soil to a depth where volatilization is no longer a concern. If rain falls within about two days of N application, volatilization losses will likely be minimal. Rainfall amounts less than ¼ inch will likely encourage volatilization as this is not enough moisture to move the fertilizer into the soil.

Ground cover/vegetation/residue. – Application of urea or ammonium containing fertilizers to residue can greatly increase volatilization losses. Residue traps moisture and so maintains wet and humid conditions near the soil surface. When liquid sources are used, the dried solution must be washed off the residue which may further increase the volume of rain needed to prevent or stop volatilization.

Management considerations

All N in urea fertilizer is subject to volatilization losses, and the portion of N in fertilizers containing urea as a component, such as liquid Urea Ammonium Nitrate (UAN) can be lost through this mechanism as well.

There are a number of ways to decrease volatilization compared to surface applied urea fertilizers including fertilizer additives that inhibit volatilization and subsurface injection to place the fertilizer directly into the soil. Tillage to incorporate the fertilizer is not an option in continuous no-till. These techniques are effective but generally there is greater cost involved. Cost of fertilizer and the amount of potential N loss ultimately determine the best management approach. To that end, the following examples illustrate the type of decision-making steps necessary to choose what approach to take.

Example 1. Corn is to be sidedressed with 100 lb N/acre with UAN solution dribbled on the surface in a band. UAN solution contains 50% of the N as urea, so in this example only 50 lb N can be potentially lost as NH_3. Dribbling liquid N results in less potential loss than broadcast applications so that under severe conditions where high volatilization rates are expected, 25% of that 50 lb of N might be lost as NH_3. So total N loss under these conditions could be expected to be 12-13 lb N/acre. If fertilizer cost is $0.50/lb of N then this relates to a loss of $6-7/acre and this is the figure that should be used to decide appropriate management. Remember that this is a “high loss” scenario and that if rainfall greater than ¼ inch occurs within 3 days of N application losses would probably not be this high.

Example 2. Corn is to be sidedressed with 100 lb N/acre as urea broadcast on the surface. All N in urea is subject to volatilization so that all 100 lb N can be potentially lost as NH_3. Under severe conditions where high volatilization rates are expected, 35% of that 100 lb of N might be lost as NH_3. So total N loss under these conditions could be expected to be up to 35 lb N/acre. If fertilizer cost is $0.50/lb of N then this relates to a loss of $17-18/acre and this is the figure that should be used to decide appropriate management. Again, this is a “high loss” scenario and that if rainfall of greater than ¼ inch occurs within a week of N application losses would be much less.

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