Urea-based Fertilizers in Forage Production

Efficient forage production systems get the most value out of fertilization. This means taking steps to minimize nutrient losses. As fertilizer costs increase (**Figure 1**), it becomes even more important to make good decisions regarding fertilizer applications.

Traditional fertilizer applications such as 13-13-14, 17-17-17, or DAP are not always recommended to optimize forage production. Rarely do forage crops need the primary nutrients (N, P, and K) on a 1:1:1 basis.

The best way to determine economically viable fertilizer requirements of forage crops is through soil testing. Following science-based fertility recommendations is cost-effective and will have greater benefits in the long term. It will help you avoid under- or over-fertilization, which can reduce yields and profitability.

Because of increasing problems with storing and transporting ammonium nitrate, urea-based products such as urea (46-0-0), urea ammonium nitrate solutions (UAN) (28–32 percent), and urea ammonium sulfate (33-0-0-12S) are becoming more popular among forage producers.

It is important to understand how these urea-based products are broken down at the time of application. For urea to be used by forages, it has to be converted into ammonia (NH_3) and then react with water in the soil to form ammonium (NH_4^+). This conversion process, called hydrolysis, is encouraged by urease, an enzyme found in soil.

Ammonia that does not react with water in the soil surface will likely escape into the atmosphere through a process called volatilization. During the conversion of urea to ammonia, soil pH around the applied urea granules can increase to nearly 9.0. This pH increase contributes to volatile gaseous losses of ammonia.

Estimates of ammonia volatilization from urea or urea-containing fertilizers vary widely due to the many conditions that influence volatile loss. Typical losses between 10 and 40 percent may be expected. Several environmental condi-

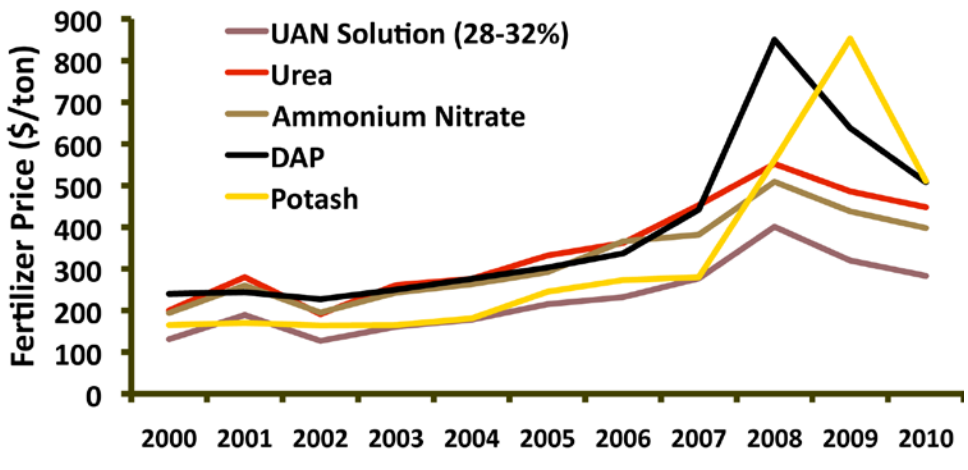

Figure 1. Average U.S. farm prices for selected fertilizers. Source: USDA, 2011.

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tions affect the rate of ammonia volatilization. These include the amount of surface residue, soil water content, temperature, and soil pH.

Soils that have high organic matter content also tend to have higher urease concentrations. High concentrations of soil organic matter and crop residues increase urea hydrolysis rates and volatilization. This is largely because the urease enzyme is produced by microorganisms that are more active in the presence of organic material. As a result, forage systems may have higher surface urea hydrolysis rates than bare soil and conventional tillage systems.

Ammonia volatilization reduces the economic efficiency of fertilization in forage production systems, especially in hay. Either yield will be reduced or costs will increase because additional applications of nitrogen fertilizer are needed.

The time between urea application and precipitation is critical. When applying urea, it is important that it is washed into the soil either by rainfall or irrigation (more than 0.1 inch) within 2 to 3 days. Up to 30 percent of the available nitrogen can be lost through atmospheric volatilization within 72 hours of application. A urease inhibitor could act as an insurance policy in case rainfall does not come quickly enough.

Urea-based products are more efficient on cold, dry soils. For this reason, urea may be a good fertilizer choice for cool-season forage production in late fall, late winter, or early spring (March to mid-May) when soil temperatures are still below 65 °F.

One of the most risky times to use urea-based products is in midsummer when air temperatures and humidity are very high. Urea volatilization increases when soil temperatures are above 65 °F (**Figure 3**) and humidity is above 60 percent. Higher NH_3 losses are expected when the relative humidity of the air is greater than the critical humidity of urea.

The soil's pH also has a strong effect on the amount of volatilization. Studies have shown that urea hydrolysis in high-pH soils (greater than 7.0) occurs within 2 days of application, while in acidic soils (low pH) the urea took twice as long to hydrolyze (**Figure 4**).

When field conditions are not optimal, applying an N stabilizer or a urease inhibitor directly to the urea-based fertilizer could help reduce nitrogen loss. An N stabilizer is an additive that may be applied to dry or liquid urea-based fertilizers to create an active shield or coat that prevents catalytic reactions caused by urease. It allows plant uptake of stable forms of nitrogen for a longer period of time.

A urease inhibitor specifically blocks activity of the urease enzyme and slows hydrolysis to ammonia. Urease inhibitors prevent the urease enzyme from breaking down the urea for up to 14 days and decrease volatilization by up to 90 percent. This increases the chance that the urea nitrogen will be absorbed into the soil after a rain event rather than volatilizing into the atmosphere.

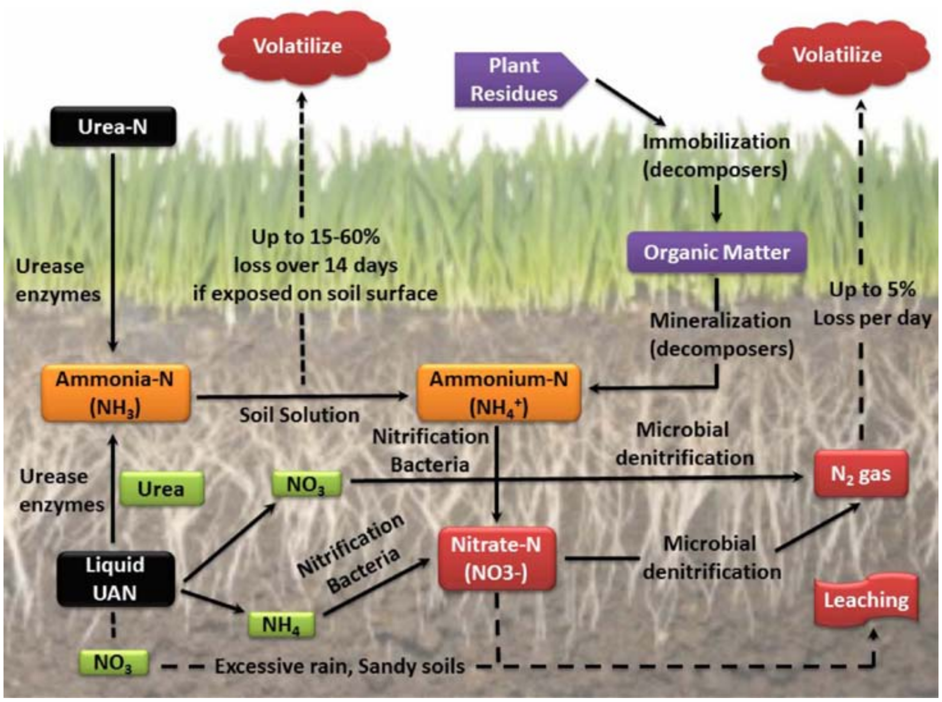

Figure 2. The nitrogen cycle as it relates to urea and UAN applications and their susceptibility to N loss mechanisms. Source: Adapted from Nielsen, 2006.

Table 1. Commercially available urea fertilizer enhancers.

Product Name	Company	Fertilizer Application Rates: Dry (Amount per ton of fertilizer)	Fertilizer Application Rates: Liquid (Amount per ton of fertilizer)	Approx. Avg. Retail Price ($/gallon)
Agrotain Ultra	Agrotain (NBPT urease inhibitor)	3.0 qt	1.5 qt	72.00
Environment Smart Nitrogen	Agrium	–	–	$0.18 to $0.20 lb per N unit
Nutrisphere-N	Special Fertilizer Products	2.0 qt	–	125.00
NZone	AgXplore	4.0 qt	2.0 qt 18-24 oz for liquid manure	50.00
Upgrade	Atlantic-Pacific Ag	3.0 qt	–	35.00

Disclaimer: The mention of these products is for educational purposes only. Reference to commercial products or trade names does not imply discrimination or endorsement by the Mississippi State University Extension Service. These products have not been tested on forage production systems in Mississippi by the Mississippi State University Forage Extension Program, and use of these products by producers is at their own risk. Rate and prices are based on companies' direct information and may vary by region or fertilizer dealer.

There is only one urease inhibitor on the market. **Table 1** provides more detailed information about the composition, rate of application, and average retail price of commercially available urea fertilizer enhancers.

N stabilizers may be more beneficial during the summer than early in the season. Early-season applications will reduce N availability and may prevent warm-season grasses from reaching maximum early growth after perennial grass species break dormancy. Pre-coated products such as ESN should be used in small ratios with uncoated urea early in the season to assure that plants will have the necessary available nitrogen.

A study conducted at the University of Georgia on 'Russell' bermudagrass indicated that Agrotain reduced ammonia volatilization by more than 63 percent and produced 11 percent more forage yield when compared to urea applied in the same way. There also was a 19 percent increase in recovery of applied nitrogen.

A study conducted in 2010 at Mississippi State University showed no advantage of Nutrisphere-N-coated urea products in annual ryegrass production. This is an indication that fertilizer enhancers will not give a yield advantage in the spring; they should be used mainly in the summer and early fall when temperature and humidity are high, and higher volatilization loss potential exists.

When trying some of the available products, do so cautiously. Use them on a small area and leave untreated check strips (uncoated urea application vs. urea with enhancers) for comparison of results. Do not judge results solely on plant appearance, but also on forage yield and quality.

Fertilizer enhancers are intended to treat urea-based fertilizers (granular or liquid). They are not for use on the soil to retard the volatilization or loss of nitrogen in pasture or hay field situations where fertilizer will be broadcast. It is important to evaluate your hay production systems before deciding if fertilizer enhancers will fit into your management system. It is difficult to cut forage production costs without compromising yield, but investing in fertilizers in a more efficient way could help reduce fertilizer expenses.

Application of high N rates or the entire amount at the beginning of the season does not provide any economic advantage and could lead to unnecessary environmental risks such as leaching, volatilization, or nitrate toxicity. One approach to reducing nitrogen loss is splitting nitrogen applications throughout the growing season. Splitting nitrogen among two to four applications during the season could help increase yields by 5–10 percent and N use efficiency by 20–30 percent.

Another good approach is to apply nitrogen, phosphorus, and potassium to hay fields where soil pH is in the optimum range and there is an indication of an economic yield response. Always follow the four Rs of nutrient stewardship: use the **right product**, use the **right rate**, use it in the **right place**, and apply it at the **right time**.

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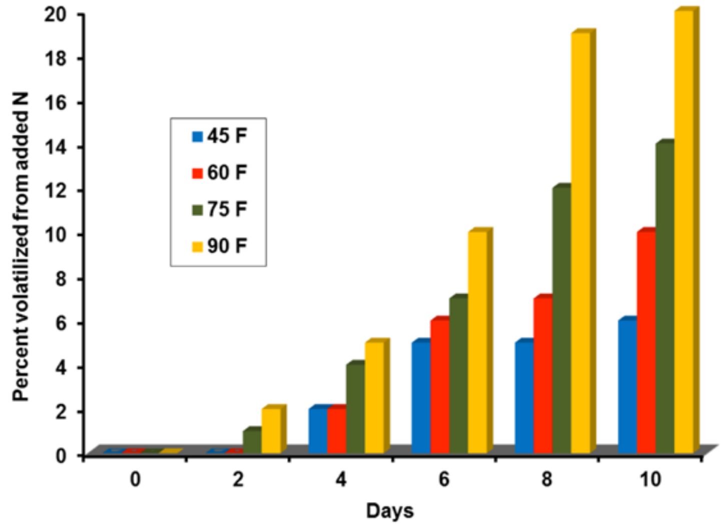

Figure 3. Percent of surface-applied urea volatilized over time as ammonia at different temperatures. Urea was applied at a rate of 100 lb N/acre on a silt loam soil. Source: Overdahl et al., 1991.

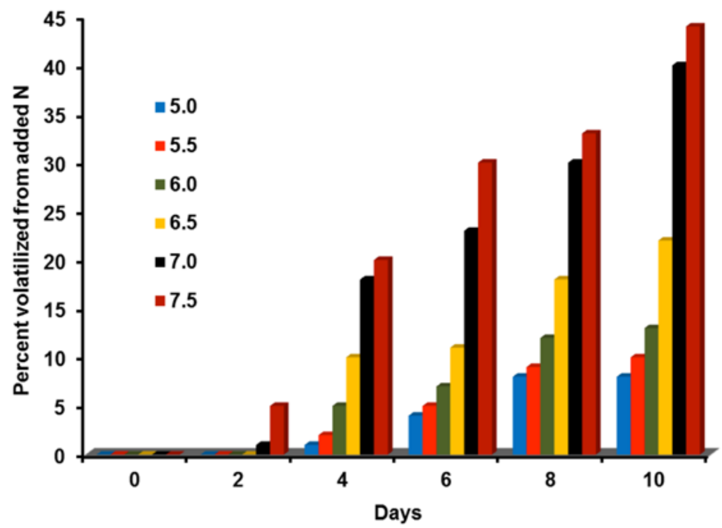

Figure 4. Percent of surface-applied urea volatilized over time as ammonia at various soil pH levels. Urea was applied at a rate of 100 lb N/acre on a silt loam soil. Source: Overdahl et al., 1991.

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