Why UAN Solution?

Adaptability and Flexibility!

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Summary: *The popularity of urea-ammonium nitrate solution (UAN) in the U.S. has increased steadily and substantially over the past 50 years. While direct-applied anhydrous ammonia dominated the overall U.S. nitrogen (N) marketplace through the 1980s, UAN and anhydrous ammonia have each had about the same market share (nutrient basis) in the U.S. over the past decade (Figure 1). While UAN consumption is not as high in other places across the globe as in North America, the global popularity of UAN continues to increase, especially in Europe and the former Soviet Union.*

Uan is a non-pressure N solution primarily manufactured by combining urea liquor, ammonium nitrate liquor and water in large production plants. In addition, a small amount of ammonia (to neutralize acidic pH) or other corrosion inhibitor is added to reduce the corrosivity of the product. As manufactured, UAN can be safely and easily stored, handled, and applied with mild steel equipment and storage.

UAN is based on the principle that mixtures of urea and ammonium nitrate are more soluble, and provide for a higher N analysis than either urea or ammonium nitrate by themselves. These types of solutions are termed 'eutectic solutions' and the specific ratio of salts at which maximum solubility exists is termed the 'eutectic point'. This principle is presented in Figure 2 for urea and ammonium nitrate solutions. Note that if only urea or only ammonium nitrate were used to make N solutions, the resulting product would only contain about 19 percent N with a salt-out temperature of 32°F.

However, if the N solution is comprised of about 35 percent urea,

Figure 1. U.S. N Product Marketshare 1960-2010

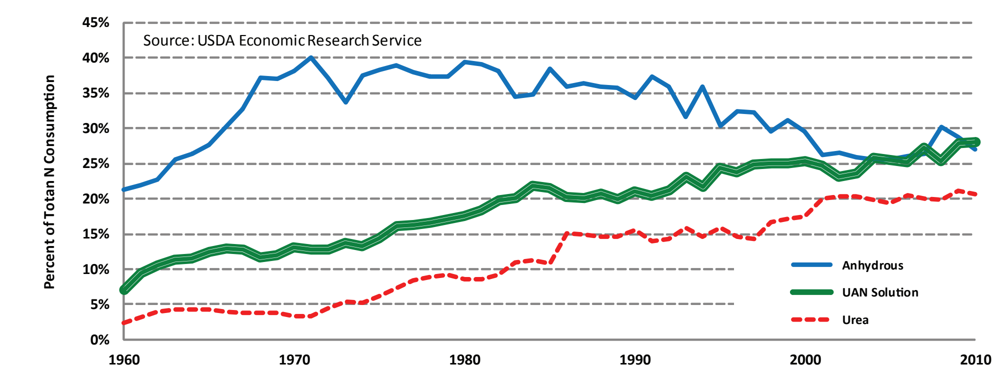

Figure 2. Urea-Ammonium Nitrate-Water Eutectic Solution.

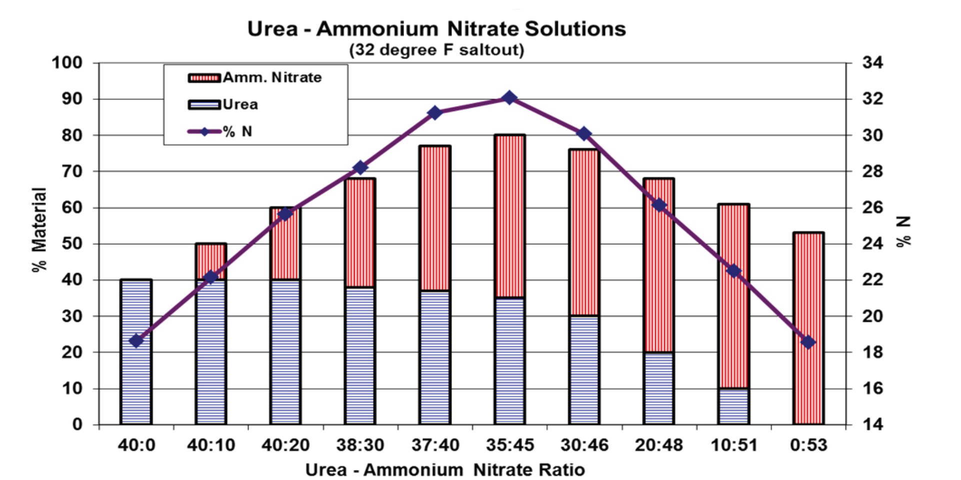

Table 1. Typical Composition and Characteristics of UAN Solutions

		28% N	30% N	32% N
Composition		Typical Weight Percentage Of UAN Solutions		
	Urea	39.4	42.2	45
	Ammonium Nitrate	30.6	32.8	35
	Water	30.0	25	20
Characteristics		Typical Characteristics of UAN Solutions		
	pH	7.0-7.5	7.0-7.5	7.0-7.5
	Density (60° F)	10.67 lbs/gal	10.87 lbs/gal	11.06 lbs/gal
	Salt-out Temperature	~0° F	~16° F	~32° F

Table 2. Corn Yield and N Recovery Increased By Split Applications of UAN
G. Randall, Univ. of Minnesota

Fall Ammonia	Spring Preplant	At Planting	Sidedress	Yield	N Recovery
Lbs N/A				Bu/A	%
0	0	0	0	118	---
100 + N-Serve	0	0	0	167	63
80 + N-Serve	0	0	0	169	60
0	100 NH_3	0	0	164	60
0	100 UAN b'cast	0	0	163	59
0	0	40 UAN dribble	60 UAN coulter	175	73
0	0	40 UAN b'cast	60 UAN coulter	177	73

45 percent nitrate, and 20 percent water (eutectic point), the resulting solution contains 32 percent N with a salt-out temperature of 32°F (Figure 2). At this ratio, about 50 percent of the N in UAN is present as urea-N and 50 percent as ammonium nitrate-N. As a result UAN provides about 25 percent of total N as nitrate-N, 25 percent as ammonium-N, and 50 percent as ammonium forming Urea-N. The principle of eutectic solutions is the backbone of the N solution industry (and interestingly enough, the backbone of the fluid phosphate industry as well).

Salt-out temperature is the temperature at which the concentration of salts in solution exceeds the solubility of those salts at a specific temperature and those salts begin to crystallize ('come out' of solution). Table 1 provides typical compositions and characteristics of the most common grades of UAN solution found in the market. Both the salt-out temperature and the density of UAN increase as the nutrient content increases. Notice that UAN contains a remarkably small amount of water with 28 percent UAN containing 30 percent water (wt/wt), but 32 percent UAN contains only 20 percent water--or about one quart of water per gallon of 32 percent UAN! These numbers may vary slightly from one manufacturer to another, but will be relatively close.

Popularity increases

There are many reasons the popularity of UAN has continued its steady increase over the years. While advantages of dry fertilizers and ammonia generally center on the purchase price of needed N, there are many other aspects of overall crop production management that influence the final applied fertilizer cost and overall profitability.

Safety issues. While direct-applied ammonia dominated the U.S. fertilizer N marketplace through the 1970s and into the 1980s, its popularity has gradually declined in the decades since. Part of this loss of direct-applied ammonia market share is due to safety and liability issues that result in the need for strict safety precautions when handling and using this product. Dry fertilizer N sources tend to absorb moisture during storage, which may result in some caking problems. At the same time, whenever dry fertilizer is handled, some loss of product quality occurs as "fines" develop, which may lead to dust problems and bridging in application equipment. Handling, storage, and application of UAN, in comparison, are much safer and simpler than other N sources. UAN has a long shelf life, does not absorb moisture or suffer loss of product quality in storage, and does not require high pressure tanks and plumbing for storage and application. Also, there are many more equipment options for non-pressure UAN application than other N sources.

Logistics. Tendering UAN is easy and convenient. It is much easier and more logistically efficient to pump UAN as compared to shoveling or using an auger or belt conveyor.

Easily blended with many secondary and micronutrients, UAN can be mixed with many other fluid fertilizer products to fill a 'prescription' of nutrient needs for efficient crop production. And unlike blending of several dry fertilizer products with urea, fluid blends of UAN with other fertilizer products are homogeneous, each drop has the same analysis and does not segregate. Dry blends of urea with other dry fertilizer products may be uniformly mixed at the local blend plant, but they begin to 'unmix' and segregate as they are transported, handled, and applied.

Pesticides of many types can be included in a simultaneous application to fields, including pesticides in a single application. The practice of combining UAN with certain pesticides (especially herbicides) in a simultaneous application eliminates a trip across the field, which greatly reduces application costs. Additionally, depending on specific field and weather conditions, these combined applications potentially increase yield potential by providing for more timely fertilizer and/or pesticide applications, as well as other time-critical management practices affecting the crop.

Uniformity/accuracy. It is much easier to calibrate equipment to uniformly apply UAN via fluid applicators as compared to other types of fertilizer materials. Additionally, it is also much easier to accurately regulate the desired rates of crop nutrients with fluid application equipment as compared to other dry and ammonia equipment. As a result, it is much easier, accurate, and cheaper to variably apply UAN across fields in modern precision agriculture systems as compared to other sources of fertilizer N.

Adaptability. The ease of adaptability of UAN to a very wide range of crop production systems (no-till, reduced-till, perennial forages, etc.), crop nutrient placements (subsurface band, surface applied, surface bands, etc.), methods of fertilizer application (broadcast and incorporated, included in starter fertilizer, fertigation, etc.), and time of N application relative to crop growth (preplant, at planting, post-plant, etc.) have had a large effect on the increased adoption of UAN in modern crop production systems. While other N fertilizer products can be fit into some of these cropping situations, UAN is the only common N source that can be easily and affordably fit to all of these situations. Visit with researchers who study various crop nutrient application methods and you will most likely find that UAN is the product of choice due to the ease and cost of adapting equipment to various placements and timings.

Agronomics

Agronomic advantages of UAN relative to other N products are not due to the forms of N present in the product since it is no more than a combination of urea, ammonium nitrate, and water. However, there are many benefits associated with the fact that UAN is a non-pressure, fluid N source. It is the adaptability of UAN to a wide variety of cropping systems, a large array of efficient application equipment, and an accompanying multitude of nutrient placements and timings that sets UAN apart.

'4R' concept. With continued increased emphasis on crop profitability and environmental stewardship, a relatively new term has come to the forefront in this regard—'4R' Nutrient Stewardship'. The 4R Nutrient Stewardship concept, initially developed by the International Plant Nutrition Institute, is increasingly being adopted by agriculture as a way of promoting and communicating fertility related best management practices (BMP's) to the public, agribusiness, and farmers. While the promotion of fertility BMP's is certainly not new, the 4R Nutrient Stewardship concept provides a clear, concise, and simple approach to increasing the adoption of BMP's in agriculture--applying the appropriate rate of crop nutrients, in an efficient manner, at the right time, using crop nutrient products that are right for a specific situation. When 4R Nutrient Stewardship is mentioned, UAN should immediately come to mind.

Relative to the '4R' concept, there are many methods/times of N application that come to mind:

- preplant subsurface/band
- surface band
- surface dribble
- starter application
- sidedress
- topdress
- pivot fertigation
- drip irrigation fertigation
- weed and feed application
- split applications
- variable N rate application
- spoon feeding
- broadcast unincorporated
- broadcast incorporated

There has been much research conducted over the years on a variety of crops relative to various application methods and timings. While a few examples are detailed in the following discussion, it is beyond the scope of this brief review to discuss all of the relevant application methods and timings that have been studied. The Fluid Journal has published articles on many of these application methods/timings and can easily be searched in the Fluid Journal archives: (http://www.fluidjournal.org/subscribe_archives.php)

NUE. It has been known for a very long time that nitrogen use efficiency (NUE) can often be improved by subsurface banding of fertilizer N. Placement of N bands below the soil surface helps manage the immobilization of fertilizer N in decomposing crop residues and eliminates the potential for urea N volatilization losses. Additionally, placement of N bands below the soil surface provides for better 'positional availability' in the event that adequate rainfall does not occur to move surface-applied fertilizer N into the root zone. A few common N application methods that place fertilizer N below the soil surface include knifed applications, simultaneous application with tillage

Table 3. Effect of UAN Application Method on Bermudagrass Production
Habey et al., Texas A&M - 3 year average

	Bermudagrass		Apparent
UAN Method	Yield	Forage N	NUE
	Lbs/A	%	%
Surface Broadcast	13,927	1.55	51.7
Surface Band	15,007	1.6	61.9
Subsurface Band	14,110	1.62	55.8

Table 4. Application Method Effects on Bromegrass
Lamond and Whitney, Kansas State University

5 site year average

	Bromegrass Forage Yield					
N Treatment	1987	1988	1989	1990	1991	5 yr average
	Pounds per Acre					
N Check	3034	1905	2530	2630	2950	2610
UAN Broadcast - 60 Lbs N/A	6085	3296	2930	6540	5050	4780
UAN Surface Band - 60 Lbs N/A	6258	4341	3330	7680	5510	5424
UAN Broadcast - 120 Lbs N/A	7083	4795	3060	8740	6320	6000
UAN Surface Band - 120 Lbs/A	7199	4736	3440	8780	5930	6017
Significant Level	0.1	0.05	0.05	0.05	NS	---

equipment, coulters, and even spoke wheels. All of these are easily adapted to UAN. As the number of crop acres under complete no-till management continues to increase, the benefits of subsurface placement of fertilizer N continue to increase as well.

Managing N loss. Subsurface N placement of all required N is not always the most efficient practice in terms of agronomics and/or logistics. Leaching and denitrification are two soil N loss pathways that affect NUE. Leaching is the movement of nitrate-N through the soil profile and out of the crop rooting zone. Leaching is most common on coarse-textured, sandy soils. Denitrification is the conversion of nitrate-N to plant unavailable forms of N by soil microbes in saturated (low oxygen) soils. Both leaching and denitrification are associated with very wet conditions and UAN can be an integral part of a plan to manage these losses.

Split applications that provide a portion of required N at or before planting, and another portion later in the season to the time of crop demand and uptake, can increase NUE and crop yields. Table 2 provides an example of the types of results that are possible when splitting the N application as compared to a single preplant application. Multiple N applications via irrigation systems are another way of improving NUE by minimizing leaching and/or denitrification losses. UAN is the common N source for split and/or multiple N applications since UAN may be easily and affordably adapted to these systems.

Surface banding (also termed dribble applications) consists of directing coarse streams of UAN to the soil surface. It is a valuable tool for improving NUE in small grains, reduced- and no-till systems, and forage crops. Surface banding provides fertilizer N performance results approaching subsurface banding, but without the need of soil disturbance associated with subsurface applications. Benefits include reduced potential for immobilization of N in crop residues, reduced potential for urea-N volatilization losses, easy fit with split and/or multiple N applications, and reduced potential for foliage burn. Tables 3 and 4 present examples of surface banding advantages over broadcast N application from a brome grass study in Kansas and a Bermuda grass study in Texas. These same types of results have been demonstrated for field crops in no-till and reduced-till cropping systems. Surface banding of UAN is often overlooked as an improved N management practice in many areas.

Table 5. Effect of Including Additional UAN with NPK Starter on No-Till Corn
B. Gordon, KSU, 2011

NPK Starter	Surface Band and 2 X 2 Placements *Corn Yield, Bu/A*
No Starter	159
5+15+5	187
15+5+5	192
30+15+5	211
45+15+5	210

Along this same line are research findings demonstrating that surface banding (dribbling) liquid NPKS starter fertilizers on the soil surface beside the row at planting is about as efficient as traditional 2 x 2 starter applications. The advantage is that these surface band liquid systems can easily and affordably be retrofitted to existing planters, while 2 x 2 starter equipment cannot. Additionally, research has clearly demonstrated that taking some of the total N to be applied and placing it in the starter program is very beneficial. Adding the UAN to the NPKS starter to make a high N starter material provides consistent yield responses as compared to the NPKS starter by itself--especially with high residue levels associated with reduced- and no-till systems. Table 5 provides research results that are typical for including a surface banded high N starter fertilizer in the row crop fertility program.

An easy choice

Over the years there have been many discussions about what N source is the best. Of course, it does depend on the specific field situation being addressed, but in general, what N source tends to be favored? If agriculture was limited to only a single N product to serve the entire marketplace, what should it be? Many would argue that direct-applied anhydrous ammonia should be that single product because it typically has the lowest purchase price per pound of N and it must be placed below the soil surface, which reduces the potential for certain N loss pathways. Others might favor urea, because unlike ammonia it can be easily and safely stored, handled and applied plus the fact that it is the most common N source globally.

But specialized equipment is required for ammonia application and that equipment is somewhat costly and not easily adapted to many desired fertility program options. Also, the fact that ammonia is limited to direct application below the soil surface is a huge limitation relative to other N sources. And while urea is the dominant global N fertilizer, that is a reflection of limited infrastructure and equipment for other N sources that are not yet readily available in many regions of the world. Urea is also subject to potential volatilization loss under certain conditions and equipment for subsurface application is not as affordable or common for many producers.

As a result, if we could have only one N source in the marketplace, it is an easy choice: UAN solution. Why? Adaptability and flexibility. In addition to issues related to safety, storage, handling, and equipment requirements, the main reason UAN is much more a universal N source than other N sources in the marketplace can be summed up in one phrase: unsurpassed adaptability and flexibility!

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