Wheat: Spring Nitrogen Management

Phil Needham, Needham Ag Technologies, LLC. www.needhamag.com

Introduction

The recent increases in wheat and other commodity prices has farmers searching for every bushel, so nitrogen (N) is more important than ever for increasing yields and profits. N is the single most expensive, yet responsive nutrient that can be applied to a wheat crop. Many producers limit their yields by not applying enough of this element, not distributing it evenly, or applying too much N in the fall and generating too much growth. Total fall applications of N, especially in high rainfall areas are a poor management decision. Most European countries regulate when N can be applied to crops and many of them have banned fall nitrogen applications for environmental reasons. While producers would not take kindly to such regulations in the US, many could experience higher yields if they were forced to apply their N at growth stages based upon plant health and tiller density, in the spring.

Post Applied Nitrogen: Post applied spring applications offer numerous benefits, which include:

- **Higher nitrogen efficiencies.** Increased N efficiencies will result from spring applications because the opportunities for losses between application and utilization are reduced. N losses from fall applications can be 20-40%, perhaps more within higher rainfall areas or coarse soil textures. Many producers in North Central Kansas, who applied all of their nitrogen during the fall of 2006 had yellow wheat by April/ May because most of the N had leached away and yields were reduced. Producers who applied N during the spring (especially with a split application) had much better wheat yields. Fall applications may save you money on the N prices, but when N losses (at both application time and over the winter months) plus the interest on the money are all considered, they can turn into a more expensive proposition.

- **Better determination of yield potential.** Its impossible to determine what yield potential is available when N is applied in the summer or fall. Many producers in Western KS and North West Oklahoma suffered from extremely dry conditions last fall, some are still dry today and their winter wheat has not emerged. In these situations the N losses from soil applied applications will be very low, but applying 75-100lb/ac of N was a waste because the yield potential won't be high enough to justify such N rates.

- **Manipulation of tillers.** Most countries around the world utilize nitrogen as a tool to manage tillers and head populations at harvest. Applying all of the N in the fall can present big problems with regards to tiller management. If moisture is available, fall applications of N can create huge masses of tillers, especially when fields are planted early. Dense canopies like these are great for producers who want straw, but for producers who want grain, they will be disappointed. *(more on this subject later)*

Managing tiller populations early in the season helps create head densities for maximum yields. Target 500-650 heads per square yard across the central plains and use the higher end of this range in irrigated fields or higher rainfall areas.

- **Freeze Damage.** Producers who applied all or most of their N in the fall of 2006 suffered far greater freeze damage than producers who applied their N during the spring. High soil N reserves lead to luxury uptakes of the nutrient and rapid acceleration through early growth stages. Even in years without freeze injury, fall applications of N has also lead to increased insect, weed and disease levels.

- **Feed the wheat not the weeds.** 20-25lb/ac of fall N may be justified within later planted fields and no-till rotations. Placing this quantity of N within the row (assuming 7.5" row spacing) will help maintain plant health without feeding weeds. I have seen many examples where broadcast fall applications of N caused increased weed pressures. If left uncontrolled, weeds can rapidly reduce yields.

Soil and Tissue Testing. While many producers have good soil test records for most fields over time, others need to improve their system. There is not a better way of increasing yields and trimming production costs than by determining the nutritional status of each field (or regions within each field) and creating judicious application rates. Soil tests for no-till fields should ideally be pulled to the 4-5” depth, together with deep nitrate nitrogen tests down to 24 or 36”, depending on soil type and rooting depth. Tissue tests are also a good tool for determining plant health and their ability to pull nutrients from the soil. Such tests can also be beneficial for indicating potential fertility and soil structure problems such as pH and soil compaction, so use all the tools available to make the best decisions.

Forms of N. Nitrogen is nitrogen, however the significant differences include how evenly the nutrient can be distributed, when the various forms of N become available to the plant and how much of the nutrient is lost by processes which include leaching and volatilization. Urea and UAN are the primary sources of nitrogen for top-dressing wheat and each of these products will be discussed below:

Urea. Most years urea and UAN are around the same price per unit, but this year it appears that urea will be a few cents per unit cheaper. However, before growers start racing to their retailers to buy urea, they need to be aware of some potential concerns.

- **Availability**. Urea is slower converting to nitrate, this can be a problem for later planted fields or fields with poor plant health which need early N.

- **Distribution Accuracy.** Unless an air-truck or air-system is available to apply the product evenly, then consider liquid UAN. Most spinner truck applications result in streaked fields. Even after many hours of pattern testing these units, subtle differences in product density, topography or wind speeds can turn a simple process into streaked fields. As expensive as nitrogen is, it pays to deliver the nutrient evenly.

- **Application Window.** Unless a row-crop air spreader is available, I strongly discourage the use of urea applications after Feekes growth stage 5. Some producers apply urea at this stage (or later) but if large Terra Gators are used, excessive crop damage from the tires frequently result.

Later planted fields of wheat with less than 300 tillers per square yard at green-up will require an early boost to help generate more spring tillers and help push yield potential up. Such fields will benefit from UAN applications rather than urea, because the first day the plant begin growth in the spring, they will seek N. Around this time the temperatures will also be suitable for urea to begin its conversion to nitrate from ammonium and this delay in availability of 10-14 days can result in a lower tiller populations and lower yields.

UAN. UAN or liquid nitrogen as it is sometimes called, is available in the forms of 28%, 30% or 32%. All of these begin as the same product, the only difference is the amount of water that’s added at the terminal to make 30% or 28%. 32% improves logistics on account of its higher concentration, but it will salt out at around 32^{o}F, so if you plan to apply UAN during cold conditions, be sure and purchase 28%. As with urea, there are some concerns with UAN.

- **Supply.** Supply of UAN is tight for the 2008 spring season, so on-farm storage is recommended to have the product on hand when you need it.

- **Sprayer and Semi-Trailers**. To be able to apply large quantities of nitrogen to lots of acres in a timely fashion, large self propelled sprayers and semi trailers to haul it with are both encouraged.

- **Pumps.** As fundamental as it sounds, many producers try to pump UAN into 500-1000 gallon sprayer tanks with 5 hp 2” pumps. The density of the material is too high to achieve good performance out of such pumps, so buying larger 10hp 3 or 4” pumps can double or triple capacity and reduce fill times.

Choosing Which Nitrogen Form To Apply

The differences in price between urea and liquid nitrogen frequently sways the producer towards one form of N or the other for obvious reasons. If the product selected can be distributed uniformly and accurately across the wheat fields, then go with the cheapest product. However, I encourage producers to consider the condition of the application equipment and its previous history, because there have been many examples where dry and liquid applications have reduced yields as a result of poor distribution characteristics.


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Applying Dry Urea Uniformly

Many farmers and dealers spend time pattern testing dry spinner trucks, but it frequently appears that differences in topography, variations in product density, side winds or the addition of other fertilizer products to the urea can all have an impact on product distribution. If you are planning on spending around $500 per ton on urea (price at time of writing this handout), then you need to be sure that the product is applied accurately and uniformly across the working width of the application equipment.


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Image 1 (above, right) illustrates a field streaked with dry urea, fortunately few fields are striped this badly. However when flying over OK and KS during the spring, its surprising how many fields have poor N distribution problems which I suggest have reduced yields.


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Image 2 (above, right) illustrates the preferred method of delivering dry urea evenly across the working width of the equipment. Providing that air-trucks are maintained, calibrated and a competent operator is utilized, (preferably aided with GPS guidance) the distribution standard is usually very good.


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Image 3 (right) illustrates one potential concern with the large flotation trucks illustrated in Image 2. This is the crop damage associated with applying urea either too late in the spring or trying to apply the second application of a split applied N program with an air truck.

Ideally once the wheat passes Feekes growth stage 5 but definitely after the wheat passes Feekes growth stage 6 (jointing), the use of floater tire equipped spreaders should be discontinued and substituted with either row-crop liquid application equipment fitted with stream bars or row crop dry application equipment as illustrated in Image 4.

Applying Liquid N Uniformly

Applying liquid N with flat fan (Image 5) or flood nozzles should be avoided as discussed on page 7. While growers commonly state that the wheat soon greens back up after being burnt, the reduction in yield frequently shows up at harvest.

With $7-10 wheat prices the additional yield captured from splitting the applications of N and herbicide will easily pay for the extra pass. Many producers don't have sufficient sprayer capacity to apply their inputs timely as it is, so extra sprayer capacity may also need to be considered.

Wider tires are also strongly encouraged, especially on fields which are more difficult to get across in the early spring. Many of the larger sprayers come with row-crop tires and they cut like a hot knife into butter if its wet. If you are in this category, then flotation tires or duals should be considered.

Image 6 (right) illustrates the leaf damage associated with spraying liquid nitrogen. I have frequently seen damage much worse than this when a herbicide is tank-mixed with the nitrogen. While this field is greening back up, the field is set backwards at a critical stage of grain initiation.

Some growers prefer to purchase the 3 hole nozzles illustrated in Images 7 and 8. While these nozzles do represent a small cost savings over the stream bars illustrated in Image 9, the 3 hole nozzles frequently produce streaks in the field. Unless the operator can maintain a consistent height above the crop, the triangular pattern produced by the 3 hole nozzles can cause skips or double applied areas. Image 7, for example shows the boom lowering over a ridge within a field and strips between the nozzles do not receive N. Within image 8, the boom is slightly higher and two streams come together at the surface of the crop to receive a 2X application rate of nitrogen. Small details like this can have a big impact on final field uniformity and yields, so select the stream bars for the highest standards of accuracy and uniformity.

Stream bars are available for 20" and 15" spacing and have 4 outlets per bar. This configuration is not height sensitive, so if its windy you can run the boom lower to the ground. If you have terraces, you can raise up the boom without compromising product uniformity. Stream bars also reduce the amount of N tied up on surface residue, especially when compared to a flat fan spray nozzle.


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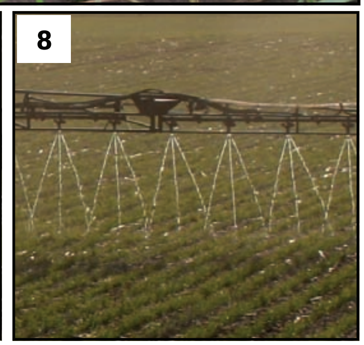
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Single vs. Split Spring Applications of N.

Post applied split N systems should be encouraged, but only if logistical requirements are met (If a grower does not have the labor or equipment capacity to split apply N, then they should be encouraged to concentrate on a single application). Split applied N systems are particularly beneficial to growers in low rainfall areas, because fertilizing for high yields during a dry growing season can reduce yields and significantly increases input costs. By utilizing a post applied split application program, producers can apply their 2nd N application based upon crop health and soil moisture.

When comparing a properly timed split spring application with the total N rate being consistent with a single N application, research indicates the following:

1) Yields are increased an average of about 3-5 bu/ac with the split application.
2) Splitting N increases N use efficiency (compared to an early single application on a dense stand) by reducing the number of additional tillers. The majority of the N will be applied at around Feekes 5-6 to fuel the reproductive stage.
3) Splitting N reduces lodging potential, especially in higher yielding or irrigated fields.
4) Splitting N eliminates or significantly reduces the injury which results from spring freeze damage.
5) Splitting N spreads the workload and aids in risk management.
6) Splitting N offers producers a chance to correct any problems created during the first application, such as skips or streaks induced with 3 way caps.

Timings of Single and Split Applications of N

To be able to interpret the chart below, it is essential to be able to quantify the number of tillers per square yard. This can be accomplished as follows.

- Determine the average number of plants per foot (or preferably yard) of row, then calculate the number of plants per square yard by multiplying it by the number of rows within a yard (6" row spacing = 6, 8" row spacing = 4.5 etc). Next pull up a representative number of plants (10+) and determine the average number of tillers per plant. (Tillers should only be counted if they have at least 2 unfolded leaves). Once this is established, the numbers can be entered into the chart below and a N rate and timing recommendation can be determined.

Tiller Number (per sq yd)	Rates of Actual N and N Timing
Split Application	
<300	Apply 60lb N at green-up, followed by the balance at GS 5-6
450 - 500	Apply 45lb N at green-up, followed by the balance at GS 5-6
>700	Apply 30lb N at green-up, followed by the balance at GS 5-6
Single Application	
<300	Apply all N at green-up
450-500	Use split application discussed above
700>	Apply all N at GS 5-6

- *Growth stages discussed in the chart above are all Feekes Large Growth Stages (GS 6 = Jointing).*
- *The Balance of N (discussed above) can be obtained from the chart later in this handout.*

Determination Of The Total Spring N Rate.

Producers should start the process of N calculations by selecting an appropriate yield goal. This is not an easy process because no two years are the same, so field experience, average production histories and a sound understanding of the soil and the moisture conditions should be used within the equation.

Once a reasonable field yield goal has been determined, multiply this yield goal (in bu/ac) by 2.5. For example, 100 bu/ac wheat (for a round number) needs 250 lb/ac of total N.

Nitrogen Credits

The 250 lb/ac N figure shocks producers, but this does not mean that 250 lb/ac should be applied. There are a number of credits that should be calculated to offset the crop N demands. Each of these are discussed below and these will each be added up to achieve a total N credit for that field.

- **Soil Testing.**

Determine the total soil nitrate N levels for the 0-30" zone. Example, if the 0-6" nitrate level is 20 lb./ac and the 6-30" level is 40 lb./ac, then the total level is 60 lb./ac. This amount of N will be credited towards the total crop demand.

- **Organic Matter & Mineralization.**

Nitrogen in the soil organic matter becomes available to plants via the mineralization process. About 15 lb/ac N is available to the crop for every 1% of organic matter in the soil. Be aware that factors including soil moisture, soil types and soil temperature can make a big impact on relative availability and the actual release period, making this number difficult to pinpoint. A trained and experienced agronomist will be able to look at the plant health, number of tillers and overall plant color and offer a good N recommendation. Example, 3% organic matter = 45 lb./ac of mineralized N.

- **Pre-Applied N Credits.**

Credit the crop with any pre-applied N applications. For example, if 100 lb./ac of 18-46-0 was applied with the seed at planting, there will be 18 lb./ac of N available to the wheat. If poultry or hog manure has been applied in the past 3-5 years, be sure to soil test and include these values. Alfalfa or pasture, commonly catches producers off guard by releasing high levels of N, even 5 years or more after the crop has been rotated from those crops, so be sure to include these values.

Mineralization is the process by which N is released from organic matter. This process is accelerated with warm, moist soils and especially by tillage. The image above illustrates a field which was no-tilled into wheat stubble, apart from one pass around the field with a disc (for fire-break reasons). The single pass around the field with the disc appeared greener all season long.

- **No-Tillage.**

If wheat is planted into conventional soils, the rate of mineralized N will be higher and released earlier in the season. If a field has been no-tilled for a short amount of time (for example less than 3 consecutive years) there will be a significant proportion of N tied up in previous crop residue (especially wheat or corn residue) and its biological process. Therefore, fields with a short no-till history will require more N than longer term (10 years +) no-till fields. It is our opinion that N rates should be increased, especially in early no-till wheat after wheat rotations by around 20-25 lb. N/ac.

Determination Of Total Spring N Rate (continued)

The example provided to the right provides a simple example. BUT BEWARE! Many of the factors included within it can change significantly. For example, following a heavy rain on a coarse textured soil, some of the N within the 0-30" zone could be lost. Another good example would include a cool spring, within which mineralization would be significantly reduced compared to what the chart suggests.

This chart is provided as a guide, and providing that a watchful eye is maintained over your fields to establish the overall heath of your wheat, then adjustments can be made on a field basis. This is the beauty of post applied N, you can deliver what the crop needs! For example, if a field is dark green despite the soil sample showing very little N, you might reduce your N rates more than the chart recommends. On the other hand, if the field is yellow and the chart only recommends 50lb/ac of N, you need to consider raising the N rate based upon the health of the field.

Example - 100 bu/ac Conventional Wheat

Nitrogen Demand

(100 bu/ac wheat x 2.5 lb. N/bu = 250 lb. N/ac)

Nitrogen Credits

Soil nitrate levels 0-6" 20 lb./ac
Soil nitrate levels 6"-30" 40 lb./ac
(60 total)

Soil Organic Matter = 3.0% (3.0 x 15 = 45 total)

DAP application at seeding = 100# (18 total)

With no manure applied the total residual N is (60 + 45 + 18)
= 123 lb./ac

Total Nitrogen Requirements

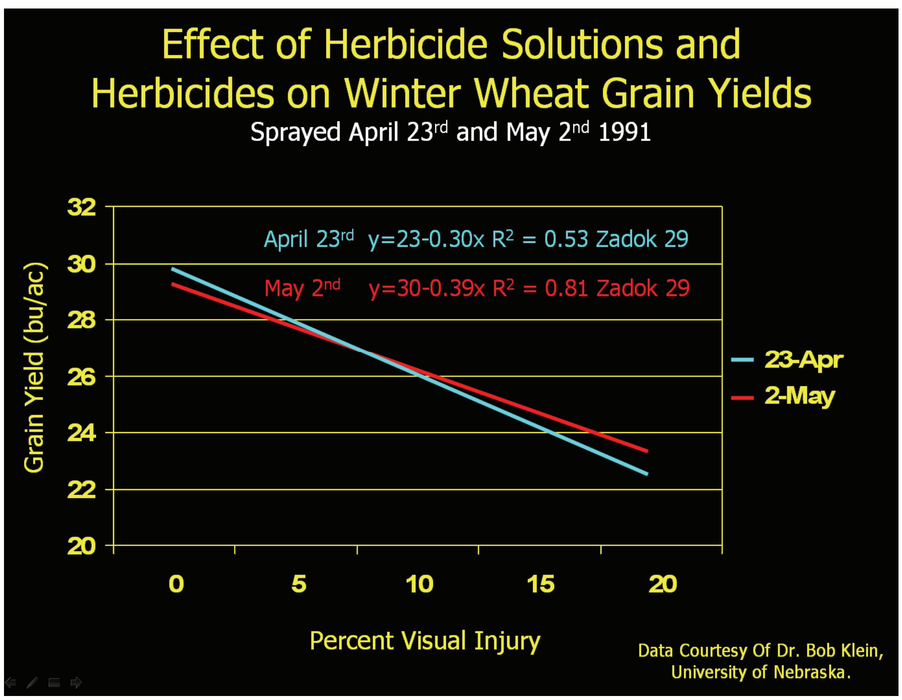
250 lb./ac (demand) - 123 lb./ac (credits) = a total spring N fertilizer requirement of 127 lb./ac

Tank Mixing Herbicides With UAN?

Tank mixing liquid nitrogen and herbicides should be discouraged, as significant plant injury and yield losses can result.

Yield reductions in the order of at least 5-10% frequently occur because of the increased leaf scorch and the accumulated plant stresses during critical grain initiation stages. Most weeds can be controlled in the fall, which enable straight liquid N applications with stream bars in the spring.

The data (right) comes from the University of Nebraska and illustrates yield loss to leaf injury relationships associated with liquid nitrogen plus herbicide tank mixes.



Crop Sensing And Variable Rate Application.

In 1998, Phil Needham conducted research with the first commercially available optical crop sensing system in the USA called the European Hydro N Sensor. 22 replicated trials were conducted on wheat and corn and these trials resulted in slightly over 2 bu/ac average wheat yield responses and also lower N application rates, making wheat production more profitable.

The concept is simple, by using reference strips to calibrate the unit, the system optically sensed the health of the crop and delivered a variable rate prescription at 10 mph. Nitrogen rates commonly varied from 5 up to 25 gallons per acre when an average rate of 17 gallons (for example) would have been utilized by standard farm practices.

Today more systems are available on the market. The optical sensing technologies have improved and as the systems have become adopted on a larger scale, the prices have fallen. The system most common on the US market is the GreenSeeker. A system which uses 5-7 sensors to control individual boom sections, delivering variable rate prescriptions based on plant health.

The research below illustrates three years of research conducted by OSU. It compares farmers standard nitrogen application practices to the GreenSeeker system and provides yield and financial return per acre. Notice the 2002 — 2004 commodity prices and N prices wiith in the summary, when these are doubled (or tripled) the return per acre will be even higher.

OSU: Three Year Wheat Trial Summary

Study	Acres Under Study	Number of Studies	Nitrogen Per Acre	Yield Per Acre	Return/Acre in Study Year
2004					
Farmer Practice	700	16	97	46.1	$128.00
GreenSeeker	700	16	64	48.5	$141.00
Difference			**-33**	**2.4**	**$13.00**
2003					
Farmer Practice	100	8	92	48.1	$134.00
GreenSeeker	100	8	55	50.6	$147.00
Difference			**-37**	**2.5**	**$13.00**
2002					
Farmer Practice	100	10	92	34.6	$86.00
GreenSeeker	100	10	79	39.6	$104.00
Difference			**-13**	**5**	**$18.00**
Prices	**2002**	**2003**	**2004**		
Wheat	$3.00	$3.15	$3.20		
Pre-Plant N	$0.15	$0.19	$0.19		
Top Dress N	$0.25	$0.25	$0.31		