Bulletin 8:06

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SPECIAL ISSUE:

The WheatTech Watchglass

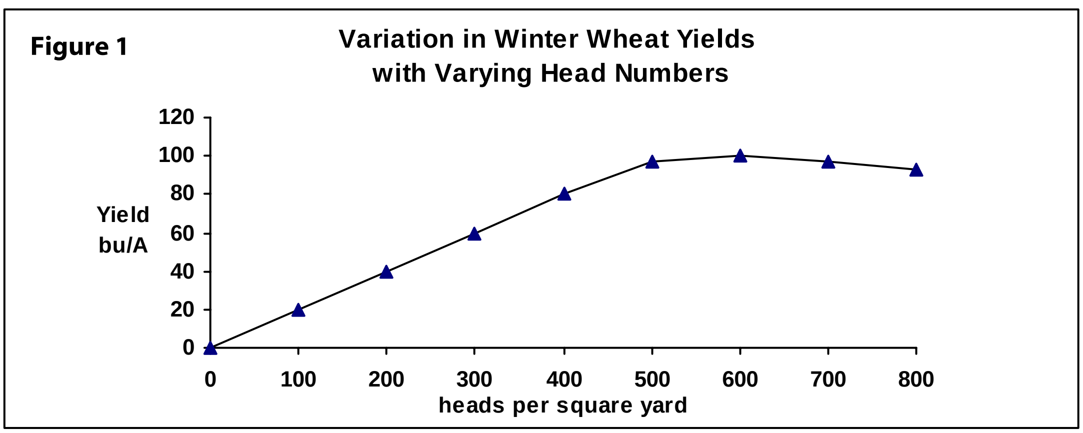
Wheat Management Tips from Chris Bowley - WheatTech Inc.

Spring Nitrogen Recommendations for Wheat

Optimum nitrogen (N) fertilization is essential for achieving maximum economic yields. Wheat has a very narrow range of ideal nitrogen rates for an individual field: 20 units above or below the optimum can result in 10-15 bu/acre yield reductions. Unfortunately, the optimum N rate for two adjacent fields could vary by 50 to 75 lb due to variations in organic matter, soil type and previous crop.

I. WHEAT YIELD COMPONENTS

Years of intensive wheat management research in Europe and the US have shown that nitrogen applied at specific growth stages affects both head numbers and yield dramatically. Maximum yields require an optimum head number (Figure 1) at harvest combined with optimum nitrogen rates applied at specific growth stages.



Optimum yields usually occur at a point close to 550-600 heads/yard². Below this range there is a direct relationship between yield and head numbers (a 50% reduction in head number will result in a 50% yield reduction). Head numbers above 600 do not result in dramatic yield loss unless severe lodging occurs; however, double-crop soybean yields and combine efficiency will both suffer. It is important to target a specific set of yield components to achieve 100 bu/acre yields. Table 1 depicts values that are ideal for wheat fields in Illinois, Indiana, and Ohio.

Table 1

plants/yard²	200
tillers (>3 leaves)/plant by Feb 1st	4
heads/plant	2.75
heads/yard²	550
spikelets/head	16
grains/head	32
seeds/lb	12500

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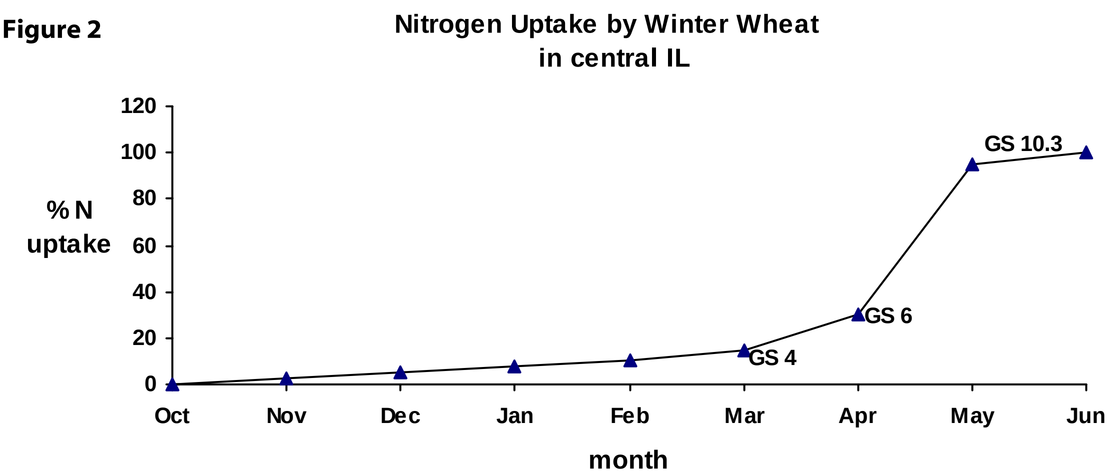
I. WHEAT YIELD COMPONENTS *(CONTINUED)*

We can use seed rates to achieve an adequate stand count in the fall (200-225 plants/yard²), and we can select a drilling date to achieve an ideal plant size prior to winter dormancy (3-4 main tillers). Unfortunately, weather and seedbed conditions can still result in lower than ideal tiller numbers. We must therefore use spring nitrogen applications as a tool to manipulate head numbers in fields with less than optimum tiller counts.

II. NITROGEN UPTAKE

Figure 2 illustrates the N uptake pattern for winter wheat. The wheat plant uses very little nitrogen from emergence to the break of winter dormancy in early spring. The period of maximum N uptake occurs during the stem elongation phase from Feekes GS 6 (jointing) to GS 10.3 (head emergence). Using the nitrogen uptake patterns of the wheat crop, we can target applications to coincide with the periods of maximum uptake and ensure efficient N usage.

Figure 2



III. NITROGEN TIMING

Spring nitrogen applications are timed to occur at two important wheat growth stages. These periods of growth are defined in Table 2. GS 3 nitrogen applications are used to manipulate the number of tillers surviving and to provide sufficient nitrogen for the early stages of head development. Two main factors affect tiller survival: nitrogen content and tiller size. We cannot affect tiller size after emergence, as this is temperature dependent, but we can affect available nitrogen in early spring.

Table 2

GROWTH STAGE	SIGNIFICANCE	ROLE OF NITROGEN
GS 3: end of tillering	start of tiller abortion & double ridge stage	increases tiller number
GS 5-6: pseudo stem erect-first node detectable	main vegetative growth & terminal spikelet stage	plant growth & increases head, spikelet, and grain numbers

III. NITROGEN TIMING *(CONTINUED)*

GS 5-6 signifies the onset of a period of maximum nitrogen uptake and includes a period of key embryonic growth called the terminal spikelet stage which occurs 5-7 days prior to the first node. During this growth phase, we are attempting to ensure optimum N availability to the 550 heads/yard^2 which should result in a large head size and a higher number of grains per head.

There are many benefits to using split applications: the main two reasons are to increase yields while at the same time minimizing late spring freeze damage. We have seen an average response of 3-5 bu/acre when split applications are used compared to a single February application. Other benefits include reduced lodging and reduced weed, insect, and disease pressures. Single applications in March have shown to be as effective as split applications, but timing is sometimes difficult in early March.

In 1999 and 2000 we harvested nitrogen plots from our Wabash, IN location (Table 3). The plots were conventionally tilled behind 40-60 bu beans and the soil type was a moderate to well drained, sandy loam.

Table 3

FEEKES 3	FEEKES 5-6	1999	2000	AVERAGE
LB N PER ACRE		YIELD (BU/ACRE)		
40	80	122.3	108.3	115.3
0	100	113.8	111.9	112.9
40	60	120.4	105.3	112.9
100	0	115.9	104.8	110.4
40	40	116.8	103.5	110.2
120	0	118.7	100.7	109.7

The numbers show the maximum response to nitrogen came from 100-120 lbs N rate. The best timing consisted of either a single application at GS 5-6 or from a split application. The worst timing was an early spring single application. The single March application did the best in 2000, while the split application was the best in 1999. This supports our nitrogen philosophy which is to apply a small amount of nitrogen in early spring followed by 60-70% at GS 5-6.

In 2003-2005 we had our plots following beans in central IL (Table 4), the data does not show a dramatic benefit for split applications but does show a 1.8 bu advantage. The data also shows how much N was needed for maximum yields and again shows that a minimum of 110 lb N was needed for maximum yields. This was particularly interesting when you consider the fact that this plot location had above average drainage for the region, which means most other fields in the region would need even higher rates to achieve the same results.

Table 4

Treatment LB N Per Acre	Yield Bu Per Acre	Test Weight (LB)
40-90	95.8	58.5
40-70	93.7	58.3
110-0	91.9	58.5
40-50	87.6	58.7

IV. ASSESSING LATE WINTER / EARLY SPRING CROP CONDITION

Key decisions concerning the rate of nitrogen to be applied at a specific growth stage are controlled by expected residual nitrogen as well as by stand counts and tiller numbers present in early spring. Therefore, it is important to visit each field to take stands counts. It is also important to take notes on tiller numbers, tiller size, overall growth, and crop color. Field visits should be 2-3 weeks prior to the wheat crop breaking dormancy in early spring.

In drilled fields, use a yard stick to take 7-10 random counts. At each location count the number of plants on either side of the yard stick avoiding double drilled areas. Also take note of the number of tillers with 3-4 fully unfolded leaves, crop color, and row spacing. Make sure that plants are counted and not tillers; this is especially difficult when the wheat has multiple tillers.

To calculate plants/yard^2, average the number of plants per yard of row and multiply by 6, 5.14, 4.8, or 4.5 for 6, 7, 7.5, and 8 inch rows respectively. Multiply this by the average number of tillers with more than 3-4 leaves to attain the total number of tillers per yard^2. An ideal stand count in February is 225 plants/yard^2 for early planted wheat and 250-275 plants/yard^2 for later planting dates. Our goal is to achieve 650-750 tillers with more than 3 leaves just prior to breaking dormancy. This should give us our desired head number at harvest time. If you have stand problems as a general rule I would want to have the following minimum viable plants to keep the crop :

3 leaf plants	125-150 plants/yard^2
1 large + 2 small tillers	100-125 plants/yard^2
3 large + 3 small tillers	75-100 plants/yard^2

As soon as you can determine that the majority of plants will survive and that the number of plants is acceptable, then nitrogen should be applied to encourage tiller development.

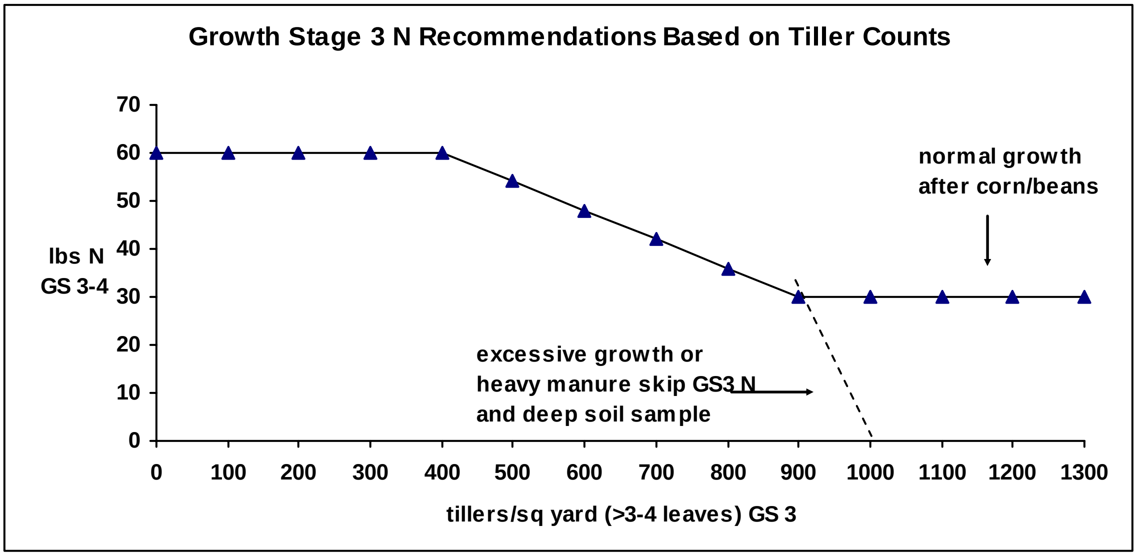
V. GROWTH STAGE 3 NITROGEN RECOMMENDATIONS

The objective of early spring applications is to manipulate the tiller number to achieve 550-600 heads/yard^2 at harvest time. This will require different nitrogen rates according to the number of tillers present in the field (Figure 3).

Nitrogen applications should first be targeted towards fields with thin stands, low tiller numbers, and those appearing deficient (light green-yellow), leaving the fields with good color, adequate stands and tiller numbers until last. Nitrogen should be applied to fields as close to spring green-up as possible. Wheat will not take up nitrogen until it breaks dormancy; therefore, applying nitrogen onto ground frozen 3-4 inches deep will not help the crop and can result in severe loss. Wait until the ground has thawed and apply the nitrogen to dry ground or when the ground is frozen in the early morning for 3-4 hours.

V. GROWTH STAGE 3 NITROGEN RECOMMENDATIONS *(CONTINUED)*

Figure 3



It is important to note that Figure 3 assumes the previous crop was either corn (150 bu +) or beans (40-50 bu) and that the wheat crop received 15-20 lb N preplant. If this is not the case, the nitrogen rate may need to be adjusted up or down to compensate.

Nitrogen should be applied to all fields at GS 3 unless tiller numbers are very high (>1000 tillers/yard^2) or the field is known to have a large amount of residual N due to tobacco, hog manure or a very poor corn crop.

VI. AREA CROP CONDITION

Area crop condition will affect the decisions with regard to early nitrogen applications. Once again it was an interesting fall with very dry conditions for 4-6 weeks during the planting season. Since we finally did get rain in mid November we have had above normal temperatures for most of the fall and winter. As a result of this the majority of the wheat crop that had sufficient moisture to emerge has tillered well and has above average growth (Fig. 4). Only fields that emerged late due to dry weather or were planted 3-4 weeks after the fly date have low tiller numbers and reduced growth (Fig. 5).

Fig. 4 Late emerged wheat with 1 main and 1-2 very small tillers

Fig. 5 Early emerged wheat with 4-5 large and 4-6 small-medium tillers

VI. AREA CROP CONDITION *(CONTINUED)*

In fact if the warm winter conditions persist much longer, we will be setting ourselves up for big problems in March/April due to late spring freezes. For this reason we have been in no rush to start applying spring nitrogen except on the very small wheat.

In reality most of the wheat in Kentucky, Illinois, Indiana, and Ohio has above average growth and will need little early N. 35-45 LB N applied early will be adequate in most regions. There will be a few regions in northern IN/MI and southern OH where extremely dry conditions persisted late into the fall. In these cases 50-55 lb N would be a better rate. (Remember this assumes 10-15 lb fall N rates and no residual N.)

VII. GROWTH STAGE 5-6 RECOMMENDATIONS

The objective with the second split application is to ensure that sufficient nitrogen is present during this 4-5 week period of maximum uptake. At this stage, the embryonic wheat head is at the terminal spikelet stage, and the stem is beginning to lengthen. If the wheat crop is allowed to become deficient at this stage, head numbers, spikelet numbers and grains per head can be lowered substantially. Ideally, we need to make this application just prior to jointing, a little earlier if using urea to allow time for nitrate conversion. GS 5 occurs when the plant is fully erect and the length of the leaf sheath of the last fully unfolded leaf is two inches, measured from ground level to the base of the leaf. GS 6 occurs when a cut into the stem exposes a solid green node (Figure 6) in the stem with 0.5-0.75 inches of hollow stem between the node and the base of the plant.

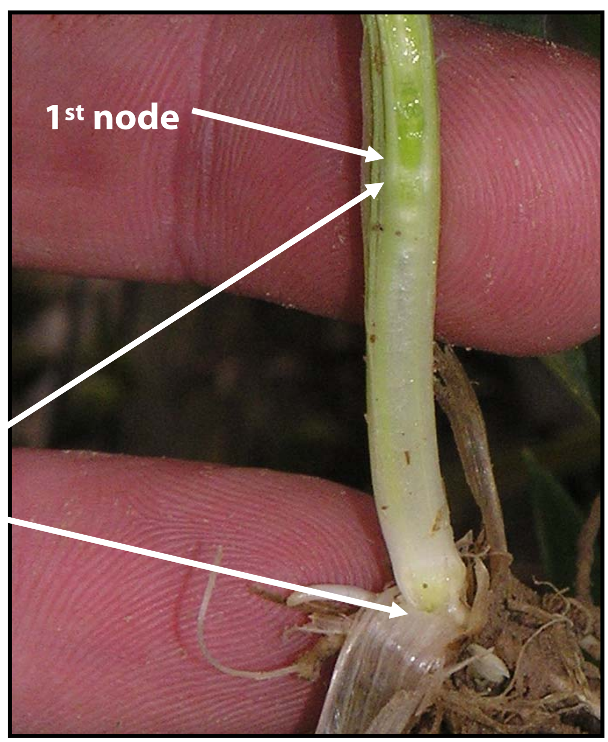


Fig. 6 Wheat plant @ GS 6 - 3/4 inch separation between base and 1st node

VII. GROWTH STAGE 5-6 RECOMMENDATIONS *(CONTINUED)*

For this application, we normally reverse our order to target the most advanced wheat crops and fields with the lowest N rates applied at GS 3. Scout the crop to determine the most advanced fields and those exhibiting N deficiency. The key to maximum wheat yields is to determine how much total spring nitrogen is needed for a particular field. Too much nitrogen can cause lodging; whereas, too little nitrogen does not produce maximum yields. There are four methods currently being used to determine total N rates, Previous experience, tissue testing at GS 5, deep soil sampling and the use of a chlorophyll meter. Unfortunately soil sampling is very unreliable and the other two methods are both time consuming and require some expertise to implement.

In practice, we use a combination of all of the above methods. We use practical experience combined with many years of research to make most of our decisions; this is the only practical method currently available. If we expect significant carryover due to hog manure or a poor corn crop, we will deep soil sample. In order to check our assumptions, we tissue test and take chlorophyll readings at GS 5. The problem with all nitrogen tests is that nitrogen levels are not static; nitrogen is entering and leaving the soil profile continuously.

Test plot data from KY, IL, and IN over the last 10 years has shown that, in years with average to good corn and bean crops, wheat requires an optimum spring N rate of 100-120 lbs. Both Indiana and IL data showed the highest yield from 120 lb N but only slightly higher than 100 lb N. The big break was from 80-100 lb N in IL which was 6.1bu. The optimum N rate is affected most by the soil type, specifically differences due to organic matter and soil drainage. This will vary from season to season based on plant growth and soil moisture conditions. The rate to be applied at GS 5-6 will be the total N rate minus the amount applied at GS 3.

In northern areas, soybeans are the predominant previous crop which wheat follows. Our experience has shown that bean yields will not change the overall N recommendation very much. If drainage is a problem or if the wheat was no-tilled, don't count on much if any benefit (0-10 lbs) from higher bean yields. The nitrogen benefit may be higher (10-15 lbs) in well drained or cultivated fields.

We would normally select a total spring N rate of 100 lbs (assuming previous crop was either 40 bu beans or 150 bu corn and that the corn received 175 lbs N preplant) and adjust the rate up or down according to specific variables (Table 5).

Table 5

RESIDUAL N FACTOR	RESULTING ACTION
organic matter (O.M.)	decrease spring N 10 lbs per 1% O.M. above 1.5%
200+ bu corn	increase spring N 10 lbs
less than 100 bu corn	tissue test/ chlorophyll meter GS 5
poor drainage	increase spring N 10-15 lbs
excellent standability	increase spring N 10 lbs
poor standability	decrease spring N 10-15 lbs

VII. GROWTH STAGE 5-6 RECOMMENDATIONS *(CONTINUED)*

Total nitrogen rates that we will use for this season will most likely range from 80-90 lbs N on the well drained, higher organic matter fields to 115-125 lbs N on the lower organic matter, poorer drained fields. It is also important to adjust N rates by variety. There can be as much as a 25-35 lb N difference in how much N can be applied to very good vs very poor standing varieties.

VIII. STABILIZED NITROGEN

Several companies have promoted nitrogen stabilizers as a way to avoid timing problems by preventing losses to the environment and keeping nitrogen in the rooting zone season long. Our experience has shown that stabilized compared to non stabilized N in a single application yields a 3.5-4 bu increase. However, compared to a well timed split application, we have seen no yield benefits, and, in severe freeze damage years, we have seen a 15-20 bu/acre decrease in yield. The yield loss is due to the availability of the nitrogen allowing the plant to grow unchecked, which is conducive to increased freeze damage. If a single N application is necessary, a stabilizer may be justified, but on average, the split application will be much more consistent.

IX. SINGLE N APPLICATIONS

If for some reason you decide to make a single application of nitrogen, it is still important to time this application correctly (Table 6). Single application N rates should be 10-15 lbs/A less than a total split application; otherwise, all other guidelines for N rates would be the same. A single application at GS 3 would be a situation where a stabilizer may be beneficial.

Table 6

TILLER > 3 LEAVES / SQ YARD	SINGLE N APPLICATION TIMING
450	GS 2-3
650	GS 4-5
800	GS 5-6
1000+	GS 5-6 after some of the smaller tillers have aborted.

Single applications could be very effective if the tiller numbers are low or if the crop has been damaged due to heaving. If this is the case, then you need to ensure that your stand is adequate. If it is adequate, try to apply a single application as soon as you can to the crop after it starts to really grow in the spring. This could range from the mid-end of February in southern IN/IL to early to mid March in northern regions. If wheat is well-tillered, later applications will produce much better and consistent yields. Based on this, I would expect most single applications for 2006 to be applied at GS 5. In most cases rates between 85-105 lbs/acre are more appropriate for single applications.

X. SANDY SOIL TYPES

Extremely sandy soil types with low cation exchange capacities are difficult to manage. The trick is to maintain sufficient nutrients in the rooting zone throughout the key uptake periods. Split applications are essential; in many cases three applications (GS 3, GS 5-6 and GS 7-8) are necessary to ensure nutrient availability. Nitrogen stabilizers can also play a part in this program by reducing leaching losses from the GS 3 application.

Sandy soils are the first fields to exhibit major N deficiency symptoms especially if no late fall nitrogen was applied. These fields will be some of the first that need to be fertilized.

XI. SULFUR, MICRONUTRIENTS, AND TISSUE TESTING

There has been a lot of debate about sulfur and micronutrient responses across the US. In many areas and soil types, additional sulfur and micronutrient applications are not necessary. However, there are certain soil types, particularly low organic matter sands and high organic matter, high pH soil types where deficiencies can cause severe problems. The best way to check for potential problems is to perform a tissue test at GS 5-6, just prior to the period of maximum N uptake.

Typical tissue test levels should be:

P (%)	K (%)	S (%)	Mg (%)	Ca (%)	Fe (ppm)	Mn (ppm)	B (ppm)	Cu (ppm)	Zn (ppm)	Mo (ppm)
0.30	2.25	0.26	0.15	0.40	50	30	6	6	20	0.6

Sulfur and boron are both highly leachable and often not present at high levels in the top 4-6 inches. Sandy soil types will typically be low in both of these elements. In 1997, 1998, and 2000 we conducted sulfur studies at two locations to try to improve our understanding of the amount of sulfur needed (Table 7). In 2000 we added an additional location on a very sandy soil type. The objective of the studies was to identify if additional sulfur applications are necessary. In 1997 both locations received preplant sulfur; 10 lbs/acre in Kentucky and 20 lbs/acre in Missouri which is what we would generally recommend. The 1998 and 2000 plots received no preplant sulfur. We pulled soil tests which suggested we had adequate sulfur in the soil profile once we got below the top six inches. Soil samples pulled from the top 3-6 inches nearly always indicate deficient sulfur levels.

Table 7

PRODUCT	RATE (LBS/A)	GROWTH STAGE	KY YIELD (BU/A)			MO YIELD (BU/A)		
			1997	1998	2000	1997	1998	2000
non treated			103.6	81.1	100.3	66.3	88.3	89.0
ammonium sulfate	20	5-6	98.9	79.6	100.2	75.4	93.2	89.3
ammonium thio sulfate	20	5-6	103.4	80.4	103.2	71.5	85.8	88.1

XI. SULFUR, MICRONUTRIENTS, AND TISSUE TESTING *(CONTINUED)*

The data did not show a large response at either heavy soil location, but the trend in Missouri was towards increasing yields with higher sulfur rates. The Kentucky plots exhibited no response in any of the 3 seasons. The reason for the difference between the two locations is unclear, but is very likely due to the higher sand content in 1997 and a less well drained soil type in 1998. Plot data over the 3 seasons suggests adding high levels of sulfur in Kentucky or Missouri on heavy soil types is not necessary; however, we still see some response especially on sandy soil types or on poorly drained soils. To evaluate the response on sand we added a location at Bertrand, MO 2002 (Table 8).

Table 8

PRODUCT	RATE (LBS/A)	TIMING	YIELD BU/AC
ammonium sulfate	10 + 10	Fall + GS 5	99.6
ammonium sulfate	10	GS 5	98.9
ammonium thiosulfate	10	GS 5	96.6
ammonium sulfate	10	Fall	91.0
non treated			70.2

The data shows that soil type made a dramatic difference with all treatments giving a minimum of 21 bu response. The biggest response was to timing rather than product or rate. Fall applications obviously performed worse due to the leaching losses. Our current recommendation is to apply 5-7 lbs sulfur in the spring in conjunction with one of the split nitrogen applications on the heavy soil types. On sandy soil types apply 20-25 lbs sulfur in the spring 2-3 splits.

XII. FERTILIZER TYPES

It does not make much difference which nitrogen product is used as long as it is applied uniformly at the correct rate in a timely manner. There are some differences in the speed of availability; if the crop is deficient, liquid (UAN) or ammonium nitrate would be preferred. With this exception, the main determining factors for nitrogen type should be price and accuracy of application.

Dry product can be applied using a spinner or air truck, but both should be carefully calibrated with urea or ammonium nitrate to determine accuracy and effective spread width. Dusty material and windy conditions make accurate applications with spinner trucks almost impossible; under these conditions, air spreaders would be preferred.

Liquid products can be applied accurately with a variety of sprayer equipment, but calibration is still necessary to ensure uniform distribution along the boom. The biggest problem with UAN solutions is crop damage. Table 9 shows yield and leaf burn data from several years of research comparing flood nozzles to band applications of UAN. Over the last 4 years yield increases of 5-13 bu/acre were achieved consistently when stream bars were compared to flood nozzle applications. Yield reductions were the highest with a combination of UAN solution, Harmony Extra and surfactant. It only takes one bu/acre to justify an additional application; therefore, we strongly recommend applying liquid N in bands of 5-7” and then applying any herbicides separately.

XII. FERTILIZER TYPES *(CONTINUED)*

Table 9

NOZZLE TYPE	28% GAL/A	LEAF BURN (%) 4 year average 1996-1999	YIELD (BU/A) 4 year average 1996-1999
Chafer streambar	20	4.0	101.4
TeeJet 7 way cap	20	9.3	96.5
flood nozzle plus Harmony Extra 0.5 oz plus surfactant	20	67.3	88.5

Stream bars are designed for 15" or 20" nozzle spacing and produce four bands 3.5"-5" apart allowing a very large droplet size with little or no leaf retention thus reducing leaf burn. The data shows the reduction in leaf burn from an average of 67% with a flood nozzle + Harmony Extra + surfactant to 4.0% with a stream bar.

Early nitrogen applications can be done using flotation equipment, but once the plant has reached GS 6 flotation rigs should be avoided. It works well in many situations to apply dry fertilizer using floater trucks and to make the second application with liquid UAN with a narrow tired sprayer with 60-80 ft booms to minimize crop damage. There are also advantages during dry years to making band applications, as the stream is able to get the nitrogen down into the ground and improve uptake. As with any application, it is essential to apply nitrogen at the correct rate and at the proper time for maximum efficiency. Tramlines are especially beneficial as they limit damage due to traffic and compaction to specific areas while providing a guideline for even application.