WHAT IS NEW IN WHEAT FERTILITY

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The current thrusts in Kentucky on new fertilization practices on wheat involve an attempt to use ground-based remote sensing to apply variable rate nitrogen across fields and the use of a new polymer-coated urea product for nitrogen fertilization especially on more wet-natured soils.

Variable Rate Nitrogen Technology

The Greenseeker is a real-time, on-the-go sensor/applicator that senses the health of the wheat crop at the time nitrogen is applied and then simultaneously adds the precise amount of nitrogen that is determined to be needed by the machine. The sensing and application technology part of the machine has been very accurate and reliable. The weak part of the process has been the algorithm (formula) that is placed in the software of the machine to tell it how much nitrogen to add based on the remote sensed readings.

Research at Oklahoma State University and Virginia Polytechnic Institute and State University showed favorable results by increasing or maintaining wheat yields while reducing nitrogen application rates. Both places had different algorithms. Using these two algorithms and adding another that was quite dissimilar, the results in Kentucky were not as favorable. Using this technology with existing software is not feasible in Kentucky.

Basic research has begun to gain the information needed to develop an algorithm for Kentucky. Small plots using different nitrogen rates applied at different times on different soils was used in the process.

Results

The results are only for one year so it is preliminary. The Easter freeze also caused the severe damage to the plants and the results of this year may be atypical of that found most years.

Variable Rate Nitrogen (VRN)

The information gathered from the NDVI (normalized difference vegetative index) readings, and the nitrogen needed for optimum yields are shown in table 1. The relationships with yield (Figures 1 and 2) and the NDVI readings look quite good.

The different nitrogen rates explained 49% and 57% of the differences in plant health (NDVI) of the wheat grown on Zanesville and Pembroke soil, respectively, at Feekes 5. It explained 60% and 81% at Feekes 6 (data not shown). It appears that the technology will be more accurate at the later stage of growth and on the well-drained Pembroke soil. The fewer outside factors that affect growth (severe weather, drainage, diseases, etc.), the more accurate the readings will be when used for VRN. The height of the curve (difference between highest and lowest NDVI) is also greater at Feekes 6, which will result in a more accurate interpretation. This indicates that the technology may be better used at Feekes 6. The NDVI readings explained 71% to 92% of the variability in yield. This is quite high and gives us hope that it can be accurately used for VRN. The highest correlation was found on the Zanesville soil which was less affected by the freeze.

Table 1. Greenseeker/N Wheat Data and Algorithms
2006-2007

Feb. N	**NDVI**		**NDVI Difference**		**March N needed**	**NDVI Algorithm**	
Lb/ac	**F5***	**F6***	**F5***	**F6***	**Lb/ac**	**F5***	**F6***
PEMBROKE SOIL							
0	0.58	0.49	0.15	0.29	120	>0.13	>0.25
30	0.63	0.55	0.10	0.23	90	0.06–0.13	0.18–0.25
60	0.70	0.64	0.03	0.14	60	0.02-0.05	0.10-0.17
90	0.72	0.71	0.01	0.07	30	<0.02	0.04-0.09
120	0.73	0.75	0	0.03	0	0	<0.04
150	0.73	0.78	0	0	0		
ZANESVILLE SOIL							
0	0.34	0.42	0.16	0.27	120	>0.13	>0.20
30	0.40	0.56	0.10	0.13	60 (90)	0.07-0.13	0.10-0.20
60	0.45	0.62	0.05	0.07	60	0.02-0.06	0.05-0.09
90	0.45	0.65	0.05	0.04	30	<0.02	<0.05
120	0.51	0.72	0	0	0	0	0
150	0.50	0.69	0	0	0	0	0
***Feekes Growth Stages**							

Nitrogen Rates and Yield

It appears that 120 lbs/ac of N was the rate needed for maximum yields this year. This is higher than what is usually required. It is felt that this extra nitrogen was required this year to aid the wheat recovery from the Easter freeze by developing more secondary tillers and filling the heads. The yields were surprisingly good for the amount of damage sustained. The excellent weather conditions after freeze was probably the main factor in the surprising recovery.

Figure 1.

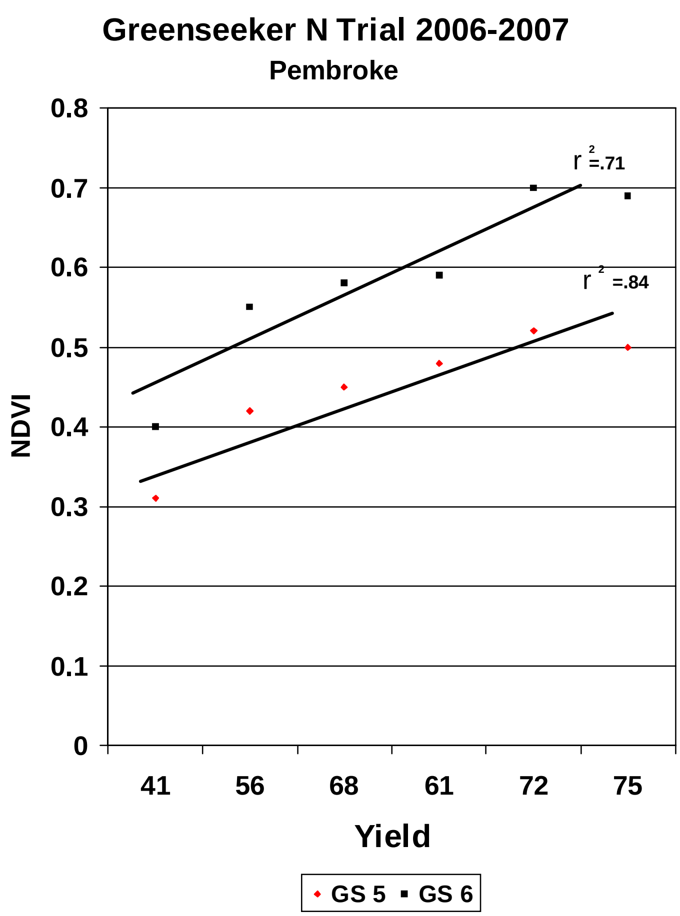
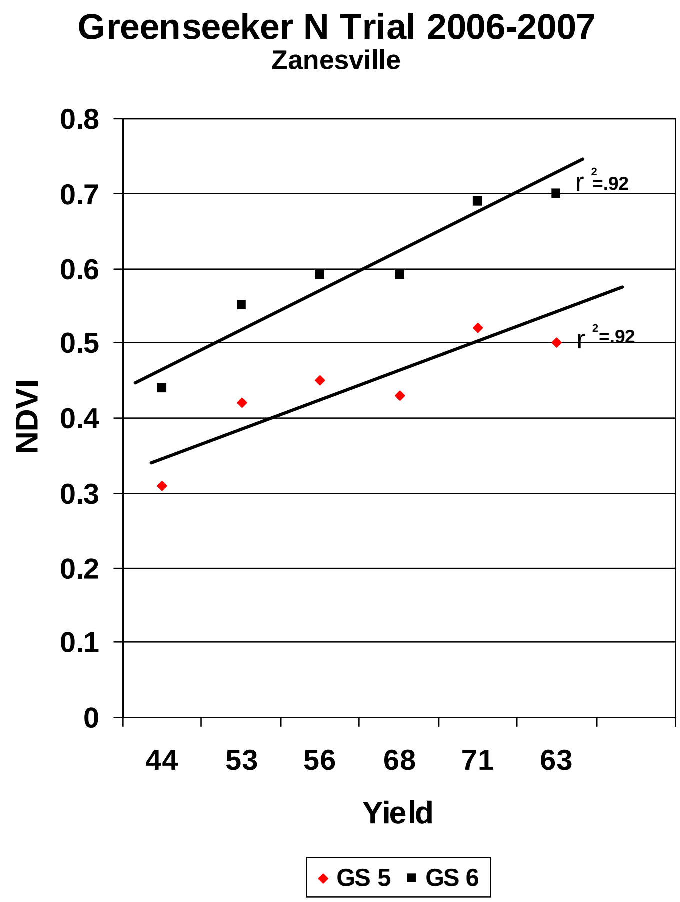


Figure 2.



Nitrogen Fertilization for Wheat Grown on Wet Soils

Kentucky wheat production has declined from 530,000 acres in 1996 to 320,000 acres currently. During this time, the state average yield has increased at a rate of approximately 1.5 bushels per acre per year reaching a record high of 71 bu/a this year (USDA NASS, 2006). With the projection of higher wheat prices, many Kentucky wheat growers are considering increasing their wheat acreage by placing marginal soil back into wheat production.

The Purchase Region (extreme Western Kentucky) and the Ohio, Green, and Pond River bottoms are the areas currently not in wheat production, mainly due to wet soil conditions in the early spring. In the Purchase Region, fragipans dominate the landscape, while in the river bottoms poor internal drainage is the greater issue. As

Kentucky growers bring these soils back into production, the main agronomic challenge is timely nitrogen application. In the more productive areas (well-drained soils) of the state, spring nitrogen application is generally split with about 30% applied at Feekes 3 and 70% applied at Feekes 5 with a total application of 110-120 lbs/a (Lime and Nutrient Recommendations for Kentucky, 2006-07). Naturally, one would assume that split applications would also be required for maximum production on a less than well-drained soil. Unfortunately, more often than not, even a timely single application is difficult or impossible in these wet regions.

This study was designed to examine N fertilizer options for wheat grown on wet soils; specifically, using polymer coated urea (PCU) (ESN manufactured by Agrium Inc.) to protect N applied earlier than recommended.

Results and Discussion

In the first year of the study (Table 1), temperature and precipitation from planting to jointing was slightly colder and slightly drier for both locations, indicating that overall nitrogen loss potential was slightly less than normal.

There was a high amount of variability in dry matter and N uptake measurements taken at flowering. Generally, N uptake at this stage was higher for PCU than urea when comparing pre-plant application treatments (data not shown). Considering that only 60 lbs N/a was applied to the plots, grain yield for this study was very high. At the Lexington location, yield of the pre-plant PCU treatment was significantly higher than pre-plant urea or ammonium nitrate, indicating that the polymer coating did help decrease some N losses (Table 1). Urea applied in February produced lower yields than urea applied in either January or March, therefore we inferred that some of the February urea was lost via denitrification, leaching, or ammonia volatilization. Regardless of the loss mechanism, February PCU yields were not statistically different than January or March yields, therefore PCU was not subject to as much N loss. At this site, Nitrogen use efficiency (NUE) followed similar trends as yield. Nitrogen use efficiency was higher in the fall PCU treatment when compared to the other fall treatments. As anticipated, very low NUE was observed for the fall urea and ammonium nitrate treatments with an average of only 25% of the applied N in the grain at harvest; while the fall applied PCU had more than 50% of the applied N in the grain at harvest. A maximum NUE of 88% was measured at the Lexington site when urea was applied prior to spring green-up.

Grain yield results for the Princeton site are also given in Table 1. Like the Lexington location, we were surprised by the high yields with only 60 lbs N/a. The yields of all treatments were statistically higher than the no N check. Generally, yields of the pre-plant treatments were not statistically different than the post-plant treatments, indicating that conditions at Princeton during this growing season were not as conducive to N loss mechanisms. Of the pre-plant applications, grain yield of the incorporated ammonium nitrate was higher than the non-incorporated PCU treatment. The overall highest yielding treatment was the split product (1/3 urea – 2/3 PCU) application, and it was significantly higher than all of the other post-plant applications, except for urea applied in March. At this site, the yield of the urea/PCU mix was over 8 bu/a higher than the traditional split application of urea. In addition to the yield increase, the producer (using the blended product) would have also saved the charge for the second nitrogen application – making this treatment even more economical. Nitrogen use efficiency at this site varied from 34% to 82%. The average NUE for the pre-plant treatments was 37% while the post-plant treatments averaged 56%. The maximum NUE was measured when a mix of 1/3 urea and 2/3 PCU was applied in February.

Subsequent Years

The study was expanded after the first year to include urea timing by rate effects and a source comparison for early N application treatments. The results of the urea timing by rate portion of the study (averaged over the four site-years) are given in Figure 3. There was not a significant timing by rate interaction. For these somewhat poorly drained soils, a single N application at Feekes 3 consistently produced the highest yield and highest economic return compared to the other application times. Applications made after Feekes 6 dramatically reduced yield. The N rate required to obtain maximum yield could not be established for most of the application times, because yield increased in a near linear fashion up to the highest N rate (120 lbs/a). For the treatments where N application was delayed until Feekes 8, there was no yield benefit to adding greater than 80 lbs N/a, and if N applications were delayed until Feekes 9, yield was maximized with only 40 lbs of N/a.

The results for the treatments comparing the source affects for 2004 and 2005 are given in Figures 3 and 4, respectively. As one might expect, PCU increased yield when compared to urea for the early application times, but only in years when N loss potential was high (e.g., Calloway 2004). In years when N loss potential was low (due to dryer than normal winters), yield for the urea treatments was generally higher than the PCU (Lexington 2005). Yields were generally lower for PCU if it was applied at Feekes 3 or later, which was likely due to incomplete release. The exception to this occurred in 2006 at the Princeton location (Figure 5). Polymer-coated urea was superior to urea at nearly every application time. Early in the growing season, denitrification was likely the predominate N loss mechanism, however volatilization was probably responsible for N loss in the March 15 and April 1 application times.

Conclusions

When wheat is grown on less than well-drained soils in Kentucky, N application timing is critically important. If a farmer is using uncoated urea and a single application time, then it is best to apply the N at Feekes 3 (early green-up). On average (for site years), applications made before or after Feekes 3 resulted in yield reductions of 5 bu/a or more. Significant yield losses were obtained when N applications were delayed to Feekes 7 or later, however, significant yield increases above the check were obtained even when N was applied as late as Feekes 9.

When nitrogen loss potential was high, PCU out-yielded uncoated urea. However, in years with excessive winter precipitation and above normal precipitation, wheat yields for treatments receiving PCU were not significantly higher than the check. This likely indicates that the PCU released too quickly, causing N loss. Later applications (Feekes 6) of PCU resulted in lower wheat yield likely due to incomplete N release. Nevertheless, in 2006 when weather conditions favored volatilization loss at the last two application times, the yield from PCU treatments were higher than uncoated urea. This suggests that PCU might also reduce volatilization losses. However, more research is needed to verify this observation.

Table 1. Grain yield and N use efficiency of wheat as affected by fertilizer application timing, source, and incorporation for the Lexington and Princeton sites (2003).

--------- Treatment ---------		Lexington		Princeton	
		Yield	N Use Efficiency	Yield	N Use Efficiency
Fertilizer*	Growth Stage	bu/a	%	bu/a	%
Check		42.5		68.3	
PCU	Pre-plant	80.9	65	88.8	43
NH_4NO_3	Pre-plant	63.2	33	94.3	52
Urea	Pre-plant	61.1	23	89.7	44
PCU	Feekes 2	78.3	64	85.3	36
Urea	Feekes 2	80.1	88	89.7	41
PCU	Feekes 3	73.4	53	87.1	42
Urea	Feekes 3	64.8	35	89.7	40
PCU	Feekes 5	79.2	77	92.9	62
Urea	Feekes 5	80.0	74	95.8	55
PCU/Urea	67/33% Feekes 3	76.8	57	101.3	82
Urea	33% Feekes 3 67% Feekes 5	82.0	80	92.5	54
		8.6	19	6.3	14

* All treatments except the check received a total of 60 lbs N/a.
** Dry matter and N uptake at Feekes 10.5.

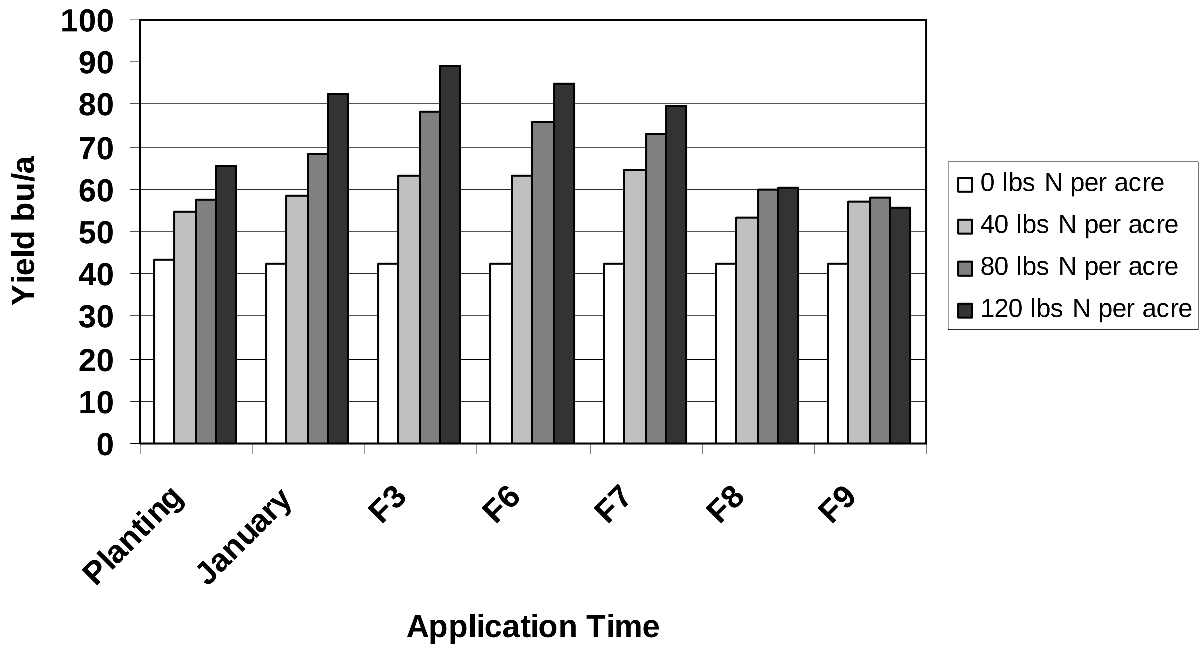


Figure 3. Average wheat yield response to urea application time when planted on less than well-drained soils (4 site years).

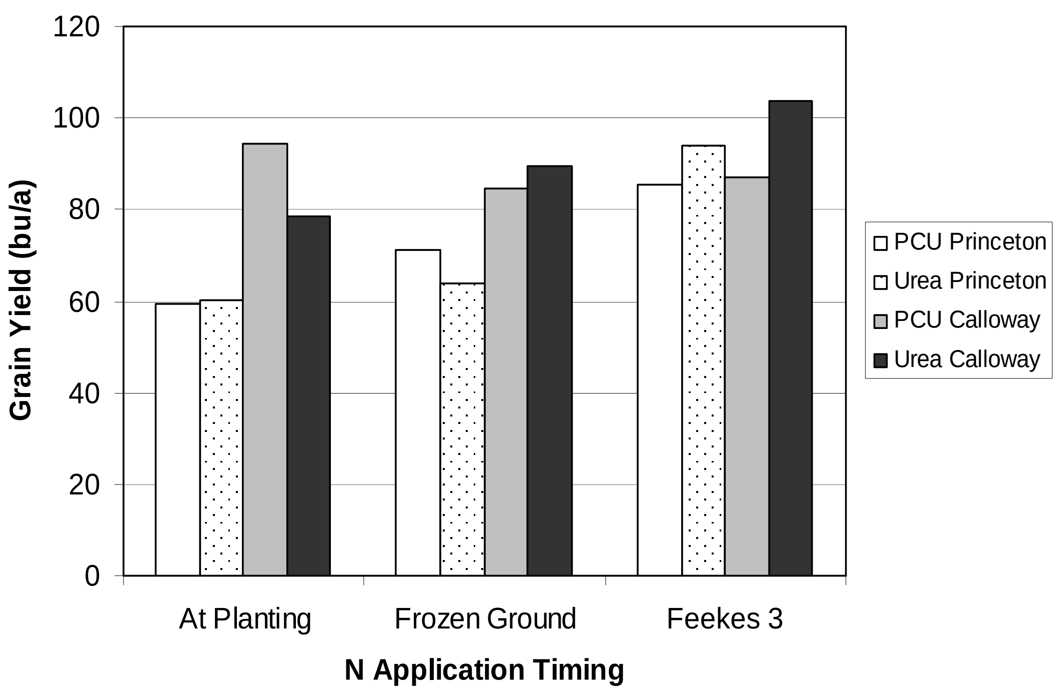


Figure 4. Wheat response to PCU and urea applications (80 lbs/a) in 2004 (somewhat-poorly drained).

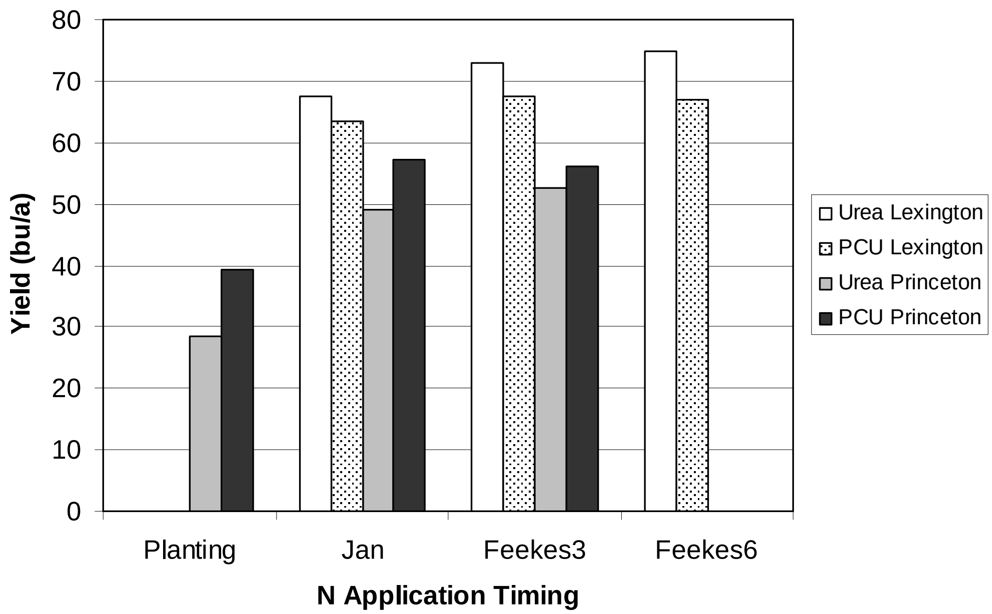


Figure 5. Wheat response to PCU and urea applications (80 lbs/a) in 2005 (somewhat-poorly drained).

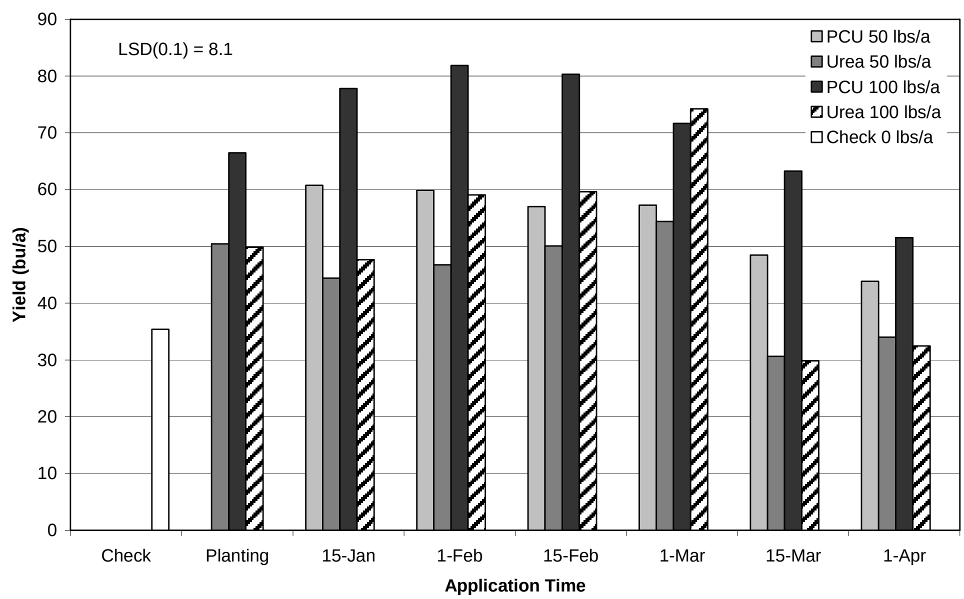


Figure 6. Wheat yield response to urea and PCU application rate and timing (Princeton, 2006).