EFFECTS OF POLYMER COATED UREA ON WHEAT

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BACKGROUND:

University of Kentucky wheat fertilizer recommendations call for fertilizer N to be applied in one or two applications between early greenup (Feekes 3) and first node formation (Feekes 6). Wheat growers with wetter soils know and understand these recommendations, but also must deal with the reality that soil conditions often do not allow fertilizer N application at optimal times. Applications of N fertilizer earlier than Feekes 3 can cause excessive early season growth and increase the risk of frost injury. There is also the potential for serious losses by leaching and denitrification of these early applications, resulting in reduced N availability and ultimately a reduction in yield. Late applications (beyond Feekes 6) can cause early-season nitrogen stress and reduced tillering which can also be detrimental to grain yield. A new fertilizer product used in the turf industry for several years is becoming available at prices that are competitive in the agricultural market, and might reduce the risks associated with early N applications. This product, polymer coated urea (PCU), is urea coated in a plastic membrane. Release of the urea is controlled by diffusion through the membrane, and the rate is dependant on soil temperature (higher temperature faster release). A study was initiated in the fall of 2002 to determine the effectiveness of fall and early spring applied PCU as a nitrogen source for wheat. In 2003, additional sites were added to examine N rates at each of the application times.

RESEARCH APPROACH:

The study was initiated in the fall of 2002 on imperfectly drained soils located near Lexington and Princeton, KY and was continued at the Lexington site in 2003. The objective was to compare application timing of PCU (product name is ESN manufactured by Agrium Inc.) and urea for wheat production. Because only small differences in N availability were expected, a less than optimal rate of nitrogen was used (60 lb N/a) for all treatments. Plots received top-dressed PCU or urea applied in the fall after planting, January (dormant application), February (Feekes 3), or March (Feekes 5). A blend of 1/3 urea and 2/3 PCU was applied at Feekes 3 and was compared to a split application of urea 1/3 Feekes 3 and 2/3 Feekes 5 for a total of 14 treatments plus a control with no N added. In 2003, an additional treatment (30 lbs N/a at F3 and 60 lbs N/a F6) was added to determine the yield potential of the site. In 2002, Pioneer varieties 25W60 on October 23 and 25R47 on October 11 were planted at the Lexington and Princeton sites, respectively. In 2003 Pioneer 25R25 was grown. All three varieties have a high yield potential and are commonly grown in Kentucky. Data collected included dry matter and N uptake (2003 only) at Feekes 10.5 (flowering) and grain yield, moisture, test weight and grain N content at maturity. Nitrogen removal was calculated by multiplying pounds of grain by N%. Nitrogen use efficiency (NUE) was calculated by subtracting N removal in the check plot from N removal in the treatment and then dividing by applied N (60 lbs/a). Higher NUE means that more of the applied N was taken up by the crop.

In 2003, two additional sites on poorly drained soils were established to examine the yield effects of both nitrogen rate and application timing for PCU and urea. The sites were located near Princeton and Murray, KY and were classified as a Zanesville silt loam and Grenada silt loam, respectively. Rates of 0, 40, 80, and 120 lbs N/a were applied at planting, in January, and at Feekes 3. At this time, only yield data was available for the 2003-04 crop year.

RESULTS AND DISCUSSION:

2002-03 Growing Season

The measured plant responses to fertilizer source and application timing are given in Table 1 and Table 2. At the Lexington site (Table 1), there was a high amount of variability in the dry matter and N uptake measurements taken at flowering, so the least significant difference (LSD) is high for both parameters. Generally, N uptake at this stage was higher for PCU than urea when comparing pre-plant application treatments. Although usually not significant, post-plant applications of nitrogen generally produced higher dry matter and N uptake than pre-plant application. Considering that only 60 lbs N/a was applied to the plots, grain yield for this study was very high. Yield of the pre-plant PCU was significantly higher than pre-plant urea or ammonium nitrate indicating that the polymer coating did prevent at least some N losses. Urea applied in February produced lower yields than urea applied in either January or March indicating 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 indicating that the PCU was not subject to as much loss. Nitrogen removal in the grain for the split application of urea was statistically higher than the treatment that received a mix of urea and PCU applied in February. This observation is probably related to N loss mechanisms discussed with the other February applications.

Nitrogen use efficiency followed similar trends as yield. Nitrogen use efficiency was higher in the fall PCU compared to the other fall treatments. 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. 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.

Results for the Princeton site are given in Table 2. Dry matter and N uptake at flowering were highly variable and were not statistically different. 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. Overall yields of the pre-plant treatments were not much 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.

2003-04 Growing Season

There was a significant source by timing interaction for the yield results at Lexington (Fig. 1). An interaction simply means that the highest yielding plot at some application timings was PCU and at other timings was urea. Yield of the fall applied plots was approximately 10 bushels higher than no N treatment, but much lower than the plots fertilized later. Both products performed similarly when applied in the fall, and seemed equally susceptible to N losses during the winter months. For the January applications, the yield of the PCU treatment was 15 bu/a higher than the urea treatment. In fact, January applied PCU produced a statistically equivalent yield to the split application treatment (considered the best management practice). The slow release nature of the PCU most likely prevented N loss at this application timing. For applications later than F3, urea outperformed PCU probably due incomplete (or delayed) release from the coated material. The results at this site suggest that the optimal application timing for PCU is earlier than urea, and PCU applications after Feekes 3 should be avoided.

Results for the Calloway County and Princeton locations were very similar to the Lexington location (Figs. 2 and 3, respectively). At the 80 lbs N/a rate, early applications of PCU (at planting for Calloway and January for Princeton) produced higher yields than urea applied at the same time. It is interesting to note that fall applications dramatically increased yield compared to the no nitrogen check. There was no statistical difference in yield between the two products at the 120 lbs N/a rate at either location (data not shown). The lack of yield difference at the high rate indicates that 120 lbs N/a exceeded the N requirement for maximum yield. Therefore N losses at this application rate were inconsequential to grain yield.

CONCLUSIONS:

Less than well drained soils are a particular challenge for wheat producers in Kentucky because N applications are often delayed as a result of wet soils. Research results for the past two years indicate using PCU reduces some of the risk associated with earlier than recommended N applications, and wheat yield for early PCU applications can be very similar to optimally timed urea. Nitrogen loss was reduced and nitrogen use efficiency was improved by using PCU instead of uncoated urea. At this point, it is still unclear if using PCU either in the fall or in January increases the chances of late spring frost injury. For wheat producers on well drained soils, there is no reason to believe PCU would be better than timely applications of uncoated urea. It is also important to note that there was no advantage to using PCU after spring green-up. In fact, a yield reduction was observed for PCU application at jointing. Additional studies will be conducted.

TABLE 1. DRY MATTER AND N UPTAKE AT FEEKES 10.5 (FLOWERING), YIELD, MOISTURE, TEST WEIGHT, GRAIN N AND TOTAL N REMOVAL OF WHEAT (VARIETY 25W60) AS AFFECTED BY FERTILIZER APPLICATION TIMING, SOURCE AND INCORPORATION (LEXINGTON, 2003).

---------- Treatment ----------				Dry Wt**	N Uptake**	Yield	Moisture	Test Wt	Grain N	N Removal	N Use Efficiency
Fertilizer*	Growth Stage	Date	Incorporation	--- lbs/a ---		bu/a	%	lbs/bu	%	lbs/ac	%
Check						42.5	14.6	55.9	1.63	41.5	
PCU	Pre-plant	10/22/02	Yes	5328	39.9	70.9	14.0	56.0	1.56	66.8	42
PCU	Pre-plant	10/22/02	No	5200	43.1	80.9	14.1	55.9	1.65	80.6	65
NH_4NO_3	Pre-plant	10/22/02	Yes	3238	25.4	51.2	14.5	56.2	1.56	48.0	11
NH_4NO_3	Pre-plant	10/22/02	No	4076	33.4	63.2	14.1	55.1	1.61	61.1	33
Urea	Pre-plant	10/22/02	Yes	4046	36.9	58.9	14.2	55.6	1.59	56.0	34
Urea	Pre-plant	10/22/02	No	3943	29.8	61.1	13.8	55.3	1.50	55.1	23
PCU	Feekes 2	01/09/03	No	5729	50.0	78.3	14.0	56.4	1.70	80.0	64
Urea	Feekes 2	01/09/03	No	5677	69.2	80.1	13.5	52.9	1.97	94.6	88
PCU	Feekes 3	02/25/03	No	4448	44.4	73.4	14.0	56.2	1.67	73.4	53
Urea	Feekes 3	02/25/03	No	3172	25.0	64.8	13.9	56.0	1.60	62.2	35
PCU	Feekes 5	03/20/03	No	4953	54.9	79.2	14.1	55.8	1.85	88.0	77
Urea	Feekes 5	03/20/03	No	5032	50.1	80.0	13.2	54.8	1.78	85.8	74
PCU/Urea	67/33% Feekes 3	02/25/03	No	4805	41.6	76.8	14.2	55.6	1.64	75.4	57
Urea	33% Feekes 3 67% Feekes 5	02/25/03 03/20/03	No	4925	50.2	82.0	13.5	55.1	1.82	89.7	80
			$LSD_{(0.10)}$	1443	16.3	8.6	NS	0.7	0.12	11.5	19

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

TABLE 2. DRY MATTER AND N UPTAKE AT FEEKES 10.5 (FLOWERING), YIELD, GRAIN N, TOTAL N REMOVAL AND N USE EFFICIENCY OF WHEAT (VARIETY 25R47) AS AFFECTED BY FERTILIZER APPLICATION TIMING, SOURCE AND INCORPORATION (PRINCETON, 2003).

---------- Treatment ----------				Dry Wt**	N Uptake**	Yield	Test Weight	Grain N	N Removal	N Use Efficiency
Fertilizer*	Growth Stage	Date	Incorporation	--- lbs/a ---		bu/a	lbs/bu	%	lbs/ac	%
Check						68.3	59.0	1.45	59.3	
PCU	Pre-plant	10/18/02	Yes	9911	90.4	89.2	58.9	1.48	79.7	34
PCU	Pre-plant	10/18/02	No	7444	65.9	88.8	58.9	1.60	85.3	43
NH_4NO_3	Pre-plant	10/18/02	Yes	9133	94.3	95.9	58.5	1.59	91.4	53
NH_4NO_3	Pre-plant	10/18/02	No	9137	85.6	94.3	59.0	1.59	90.3	52
Urea	Pre-plant	10/18/02	Yes	8186	78.9	91.4	58.0	1.61	88.2	48
Urea	Pre-plant	10/18/02	No	7436	74.6	89.7	58.0	1.59	85.8	44
PCU	Feekes 2	01/14/03	No	8145	70.8	85.3	58.5	1.61	81.1	36
Urea	Feekes 2	01/14/03	No	9862	93.2	89.7	58.9	1.59	84.2	41
PCU	Feekes 3	02/24/03	No	8470	82.7	87.1	59.3	1.59	84.4	42
Urea	Feekes 3	02/24/03	No	7441	62.7	89.7	58.4	1.58	83.4	40
PCU	Feekes 5	03/24/03	No	7819	78.2	92.9	58.8	1.56	96.8	62
Urea	Feekes 5	03/24/03	No	8470	81.6	95.8	58.9	1.61	92.3	55
PCU/Urea	67/33% Feekes 3	02/24/03	No	8169	92.8	101.3	58.7	1.78	108.5	82
Urea	33% Feekes 3 67% Feekes 5	02/24/03 03/24/03	No	8169	77.7	92.5	58.7	1.65	91.7	54
			$LSD_{(0.10)}$	NS	NS	6.3	1.2	0.07	8.4	14

* All treatments except the check received a total of 60 lbs N/a.

** Dry matter and N uptake at Feekes 10.5.

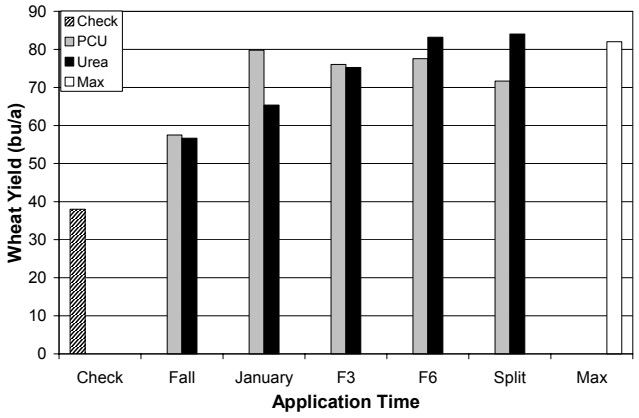

FIGURE 1. THE EFFECT OF N APPLIED AS POLYMER COATED UREA (PCU) AND UREA ON 2003-04 WHEAT GRAIN YIELD IN LEXINGTON.

THE CHECK RECEIVED NO N FERTILIZER, THE SPLIT UREA APPLICATION RECEIVED 20 LBS N/A AT F3 AND 40 LBS N/A AT F6.

THE SPLIT PCU APPLICATION RECEIVED 20 LBS N/A (AS UREA) AND 40 LBS N/A AS PCU BOTH AT F3, THE MAX TREATMENT RECEIVED 30

LBS N/A AT F3 AND 60 LBS N/A AT F6, AND ALL OTHER TREATMENTS RECEIVED 60 LBS N/A AT THE TIME INDICATED.

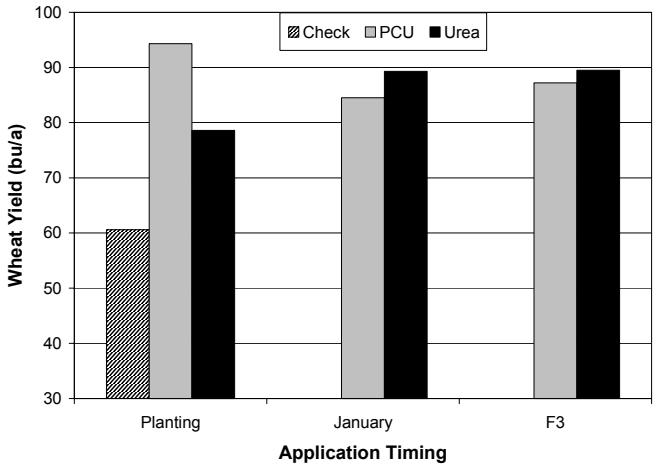

FIGURE 2. WHEAT YIELD RESPONSE TO 80 LBS N/A APPLIED AS PCU OR UREA AT DIFFERENT APPLICATION TIMES AT THE CALLOWAY COUNTY SITE, 2003-04. THE CHECK RECEIVED NO FERTILIZER.

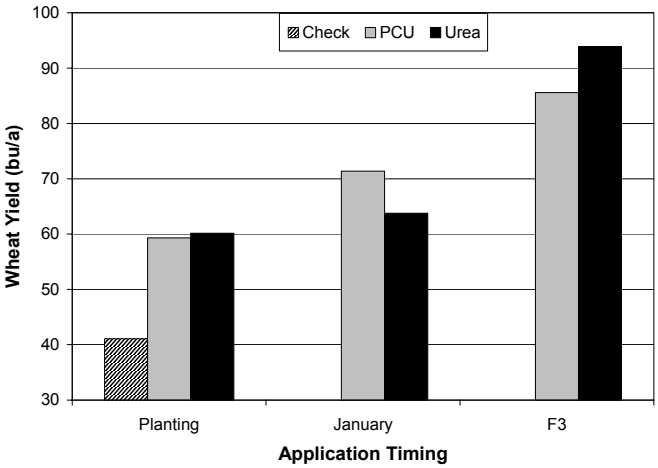

FIGURE 3. WHEAT YIELD RESPONSE TO 80 LBS N/A APPLIED AS PCU OR UREA AT DIFFERENT APPLICATION TIMES AT THE PRINCETON SITE, 2003-04. THE CHECK RECEIVED NO FERTILIZER.