Improved N Use Efficiency for Wheat in Southwest Indiana[1]

Charles L. Harms[2]

About one-third of the wheat acreage in Indiana is grown in southwest Indiana. During most years this area of Indiana receives excessive precipitation during the late winter and spring growth period for wheat. This presents problems with losses of available soil nitrogen (N) through leaching and/or denitrification and low uptake of N by the crop even on fields which have been well-fertilized. These experiments were conducted in 1986 and 1987 to evaluate fall, mid-winter and late-winter topdressing of ammonium-forming fertilizers which contained dicyandiamide (DCD) as a nitrification inhibitor. If available soil N can be kept in the ammonium form for uptake by the wheat rather than converting to the nitrate form where it has the potential for loss by leaching or denitrification, the Nuse efficiency of wheat may increase and less N will potentially move through the soil into the groundwater.

Methods

Caldwell soft red winter wheat was planted on Alford silt loam soil in Posey County and Bloomfield loamy sand soil at the Southwest-Purdue Agricultural Center (SWPAC) in Knox County in 1985 and at SWPAC in 1986. Soils in Posey County, 1985 and SWPAC, 1986 were fertilized with N rates of 75, 100, and 125 lb/a before planting in the fall and all three site-years were topdressed with 75, 100, and 125 lb N/a in January and March. The four fertilizers sources included urea. urea-5% DCD, urea-7.5% DCD, and urea-10% DCD where the percentages of DCD represent the percent of the N that was present in the fertilizer as DCD. Soil ammonium and nitrate concentrations were determined on a bi-weekly basis from the plots receiving 100 lb N/a during the spring months to a two foot depth. Grain yields were determined for all fertilizer rates and materials.

Results and Discussion

Rainfall patterns varied somewhat between years in southwestern Indiana; however, both years were considered to have dry late winter and spring climatic conditions. Rainfall for fall, 1985 was characterized by conditions whereas fall 1986 was dry (Table 1). These rainfall patterns affected the wheat yield responses to the N fertilizer and the dicyandiamide (DCD) nitrification inhibitor.

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[2] Assistant Professor' Dep. of Agron., Purdue Univ., West Lafayette, IN 47907.

For the preplant applications of urea and urea-DCD fertilizers, yields were increased by the urea-DCD combinations which contained either 7.5 or 10% of the N as DCD cogranulated with the urea in Posey County in 1985-86. In 1986-87 at SWPAC, there were no differences in yields among the fertilizer sources (Table 2). The rainfall patterns infuenced the yield responses to the nitrification inhibitor. The November, 1985 rainfall exceeded 8 inches and resulted in losses of a available N as nitrate in the soil which have a yield response to urea containing DCD. Nitrate -N concentrations declined from preplant levels of 16 ppm on October 22 to 7 ppm by Dec. 18 sampling date (Table 6) indicating the loss of available N from the soil during fall, 1985. In fall 1986, rainfall totals at SWPAC were moderate and N losses from the soil were probably not great. The control plots yielded 54 bu/ac (Table 3) because the soil contained an average of 10 ppm NO_3-N in the top 2 feet prior to planting and most of this remained in the root zone through the winter.

Table 1. Growing season precipitation for soft red winter wheat for Posey County in 1985–86 and for Southwest Purdue Agricultural Center (SWPAC) in 1985–86 and 1986–87.

Month	Rainfall		
	Posey Co, 1986	SWPAC, 1986	SWPAC, 1987
	inches		
November	8.3	11.2	2.2
December	1.7	2.0	2.6
January	1.2	0.5	0.9
February	5.8	3.8	1.8
March	2.9	3.2	2.5
April	2.2	1.1	2.6
May	3.3	7.9	4.7
Total	25.4	29.7	17.3

Table 2. Grain yields of Caldwell soft red winter wheat as affected by preplant applications of urea and urea–dicyandiamide (DCD) fertilizers averaged across three N rates.

Preplant N Fertilizer Source	Grain Yield	
	Posey County, 1986	SWPAC, 1987
	bu/ac	
Urea	41.5	63.2
Urea with 5% DCD	43.3	63.0
Urea with 7.5% DCD	46.9	60.1
Urea with 10% DCD	46.0	60.9
$LSD_{.05}$	4.0	NS

When comparing the preplant applications with January and March topdress applications (Table 3). no differences were obtained in yields at Posey County in 1986, but the preplant and March applications resulted in higher yields than the January topdressing at SWPAC in 1987. At SWPAC in 1986, the January topdressing resulted in higher yields than the March topdressing. The 1986 March topdressing was done in late March. Only 1.1 inches of rain occurred in April and the N did not move into the root zone for uptake until wheat was growing rapidly. In 1987 the January topdressing resulted in increased lodging as compared to March application and as a result yields were slightly lower than the March application. Grain yields were increased through the 125 lb N/ac application rate at both locations in 1986 and were increased through the 75 lb N/ac rate in 1987. When averaged across the three N rates and times of application, yields were equal among the urea and urea-DCD combinations for the three sites. The relatively dry spring conditions for both years negated any yield response to inclusion of a nitrification inhibitor with urea for the January and March topdressings.

Table 3. Grain yields of Caldwell soft red winter wheat as affected by time of N application, rate of N application, and percentage of dicyandiamide (DCD) in the N fertilizer.

	Grain Yield		
	Posey County, 1986	SWPAC, 1986	SWPAC, 1987
	bu/ac		
Time of Application			
Fall, Preplant	43.7	--	61.8
January Topdress	44.2	53.6	57.4
March Topdress	45.0	45.9	61.5
	NS	**	*
Rate of N Application			
lb/a			
0	--	25.6	54.0
75	42.9	49.0	64.6
100	42.0	47.9	59.9
125	48.0	52.5	56.2
	**	**	**
DCD Concentration			
%			
0	44.0	50.2	61.9
5	--	50.1	61.6
7.5	--	49.8	58.8
10	44.6	49.0	58.8
	NS	NS	NS
LSD.05 Time	--	--	2.7
N Rate	2.6	2.3	2.7

** Significant at the 1% level.
* Significant at the 5% level.
NS Not significantly different.

Soil ammonium concentrations in the top six inches, where most of the conversion of ammonium to nitrate occurs, indicated that DCD was effectively inhibiting nitrification. For the preplant application of urea cogranulated with DCD, ammonium concentrations remained higher throughout the fall and early winter at Posey County (Table 4) and SWPAC (Table 5). The data from SWPAC in 1986 indicated that DCD concentrations of 7.5 and 10% of the N present in the fertilizer were required to retard nitrification in the fall until soil temperatures cooled to less than 50°F. For the January topdressing nitrification apparently was inhibited until April 1 at SWPAC, and from the March topdressing nitrification was inhibited until April 29 (Table 4). While maintaining N in the ammonium form for a longer time in the soil during and 1987, it indicates that during wet springs N availability in the root zone can be maintained by topdressed applications of N fertilizer which contain a non-volatile nitrification inhibitor.

Soil nitrate concentrations were decreased at SWPAC (Table 7) by topdressing the urea-DCD fertilizer in comparison to urea, but not in Posey County (Table 6). The residual nitrates from the preceding corn crop as indicated by soil sampling to a 2 ft. depth on October 22 may have over ridden any differences in soil nitrate concentrations between the urea and urea-DCD applications at this location. At SWPAC nitrate concentrations in the soil for the urea-DCD remained lower through April 1 for the January topdressing and lower through April 15 for the March topdressing. Crop removal of N from the soil equalized both the ammonium and nitrate concentrations in the soil for April 29 and May 12 sampling dates.

Table 4. Soil ammonium concentrations in the topsoil (0–6 inches) as affected by urea and urea–dicyandiamide applications in wheat for 1985–86.

Location	N Fertilizer Source	Date of Application	Ammonium– N				
			12–18–85	4–1–86	4–15–86	4–29–86	5–13–86
			ppm				
Posey Co.	Urea	October	5	3	--	2	5
	Urea–10% DCD	October	14	6	--	4	4
	Urea	January	--	3	--	3	3
Posey Co.	Urea–10% DCD	January	--	8	--	4	3
	Urea	March	--	3	--	6	2
Posey Co.	Urea–10% DCD	March	--	16	--	10	9
SWPAC	Control	--	--	2	6	3	2
	Urea	January	--	7	8	3	4
SWPAC	Urea–10% DCD	January	--	5	8	4	2
	Urea	March	--	10	11	4	3
SWPAC	Urea–10% DCD	March	--	11	16	21	3

At SWPAC wheat N uptake decreased soil nitrate concentrations to very low levels by May 12. Nitrate concentration in soil were decreased to values found in the control (Table 7) indicating that wheat can efficiently utilize most of the applied N if excessive N rates are not applied. This decreases the possibility of nitrate movement into the ground water after the wheat is harvested and prevents the occurrence of ground water contamination with nitrates.

Table 5. Soil ammonium concentrations for the control and 100 lb N/a application rate in the topsoil at SWPAC in fall, 1986.

N Fertilizer Source	Date of Application	Ammonium – N		
		10–27–86	11–11–86	11–26–86
		– – – – – – ppm – – – – – –		
Control	October	2	2	5
Urea		12	4	6
Urea–5% DCD		30	24	9
Urea–7.5% DCD		26	29	23
Urea–10% DCD		28	24	21

Table 6. Soil nitrate–N concentrations as affected by urea and urea–10% DCD applications on Alford silt loam soil in Posey County, Indiana.

Date of Fertili–zation	Soil depth	10–22 Pre–plant	12–18–85		4–1–86		4–29–86		5–12–86	
			Urea	Urea DCD	Urea	Urea DCD	Urea	Urea DCD	Urea	Urea DCD
	in.		– – – – – – – – – – – – ppm – – – – – – – – – – – –							
Oct. 85	0–6	15	4	5	15	14	13	10	12	6
	6–12	18	10	6	14	10	9	9	8	4
	12–18	19	8	8	14	9	8	7	6	3
	18–24	14	7	8	12	10	7	7	8	2
Jan. 86	0–6				13	19	23	14	7	7
	6–12				10	17	18	19	8	6
	12–18				12	12	8	7	4	3
	18–24				11	14	7	10	6	2
Mar. 86	0–6				16	14	17	6	7	7
	6–12				11	10	9	9	6	5
	12–18				9	11	9	6	6	5
	18–24				9	12	11	9	6	6

Table 7. Soil nitrate–N concentrations as affected by urea and urea–10% DCD fertilization on Bloomfield loamy sand soil at SWPAC.

Date of fertilization	Soil depth	Nitrate–N, Date of Sampling: 4–1–86 Con	4–1–86 Urea	4–1–86 Urea DCD	4–15–86 Con	4–15–86 Urea	4–15–86 Urea DCD	4–29–86 Con	4–29–86 Urea	4–29–86 Urea DCD	5–12–86 Con	5–12–86 Urea	5–12–86 Urea DCD
	in.	ppm											
Jan. 86	0–6	6	24	14	7	11	9	4	9	8	2	2	0
	6–12	8	11	9	6	4	5	7	9	6	3	2	1
	12–18	6	20	8	8	9	5	5	7	4	2	1	2
	18–24	4	11	5	5	8	6	5	6	6	1	2	0
Mar. 86	0–6		13	6		16	8		7	7		0	0
	6–12		8	6		5	6		8	5		2	1
	12–18		6	4		7	6		6	5		1	2
	18–24		4	4		7	5		5	4		2	1

Con – Control, No N fertilizer.
Urea – 100 lb N/a urea.
Urea DCD – 100 lb N/a urea–10% DCD.

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PROCEEDINGS

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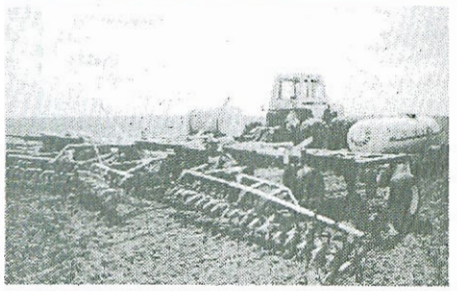

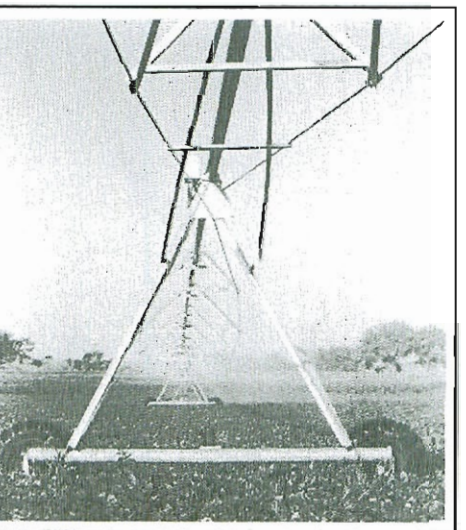
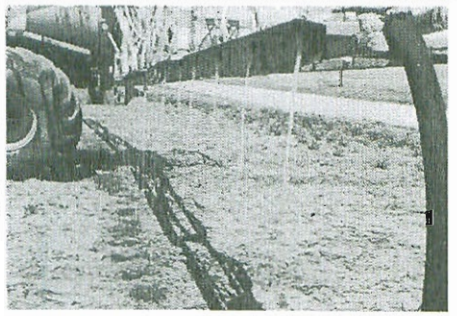
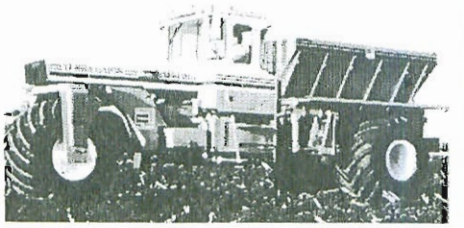
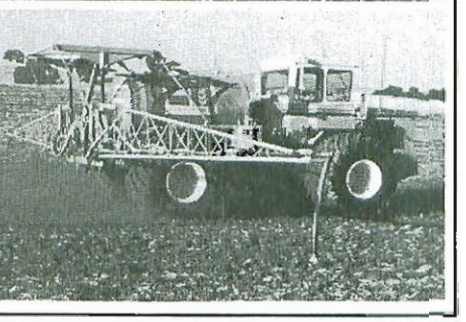

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