ANNUAL REPORT

1988 GROWING SEASON

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I. Project orientation

Experiments were conducted with three objectives. The first objective was to measure the nitrification rates of various fertilizers under field conditions as influenced by fertilizer composition and particle size. The second objective was to determine the influence of nitrogen rate, nitrogen source, and KCl fertilization on the disease incidence of wheat. A third set of laboratory methods were established to compare methods of soil analysis for chloride.

II. Nitrification experiments

A micro-plot bag technique was used, as was last year, to measure the nitrification rate of various fertilizers under field conditions. There were two experimental designs conducted at four field locations. The first experimental design consisted of a factorial combination of three sizes of urea granules (0.01, 0.10, and 1.0 g per pellet) and five rates of DCD addition to the fertilizer (0, 1, 2, 5, and 10% of the N as DCD). The fertilizer materials were prepared by Mr. George Jones of TVA.

Ten pellets of the 0.01 g size, and one pellet of the 0.10 or 1.0 g pellet size were added per bag in the first experimental design. Each bag contained 600 g (moist weight) of topsoil, previously sieved to pass a 0.5 cm sieve. The bags were made of nylon netting. The soil was packed gently so that the final bulk density of the soil within the bags was about 1.2. The small fertilizer pellets were mixed with all of the soil, and the larger pellets were placed in the middle of the bag. The bags were buried so that the top of the bag was about 1-2 inches below the soil surface.

The second experimental design consisted of various liquid fertilizer mixtures. The treatments consisted of a factorial combination of DCD (0 and 2% of N), ATS (0 and 10% v/v), and KCl (0 and 20% wt/vol). The liquids were mixed so as to contain the equivalent nitrogen content of 40 g of urea/100 mL. A 0.25 mL droplet of liquid fertilizer was placed in the center of the soil in the bag. Thus the liquid treatments were comparable to the 0.10 g pellet size in the first experimental design.

Nitrapyrin plus 0.01g urea pellets was included for comparison with the other treatments. The ratio of nitrapyrin to urea was calculated based on a field rate of 0.56 kg/ha and a nitrogen rate of 150 kg N/ha. The urea + DCD mixture was placed in a deep freeze and kept frozen during measurement, transport, and installation in the field. Every attempt was made to prevent volatilization of the nitrapyrin during fertilizer preparation.

After 4 or 8 weeks of field incubation, the bags were removed, air dried, and analyzed for residual ammonium (or urea + ammonium where appropriate). The data is calculated in terms of the apparent recovery of applied N as ammonium (or urea + ammonium). Minor amounts of urea were measured, especially with the largest fertilizer pellet sizes with the first sampling date.

The influence of pellet size and DCD on nitrification of urea for the 4-week sampling is found in Table 1. The summer of 1988 was extremely dry between application time and sampling 1, so nitrification was less than normal. There was considerable variability in the degree of nitrification between sites. The Leonard site was a sandy site, so that an early rain apparently was more effective in stimulating nitrification than at the nearby Davenport site.

The most striking feature of Table 1 is the great effect of granule size on nitrification. Considering the averages of all four sites and the 0.01 g granule size, it took 5% of the N as DCD to equal 0.01 g granules plus nitrapyrin. However, at the 0.1 g granule size, it only took 1% of N as DCD to surpass the nitrapyrin treatment. All of the 1.0 g granules were greatly superior to 0.01 g granules plus nitrapyrin.

Nitrification was essentially complete after 8 weeks with the unmodified 0.01 g urea pellets (Table 2). Again there was considerable variation between sites with respect to degree of nitrification. Urea applied at the Davenport site had nitrified considerably since the first sampling.

The general conclusions were similar to those obtained with the first sampling. Granule size had a great influence on the degree of nitrification. Again, with the 0.01 g granule size, the addition of 5% of the N as DCD was needed to equal the degree of nitrification control obtained with nitrapyrin. One percent of the N as DCD in conjunction with 0.1 g granules was superior to the nitrapyrin treatment, and all 1.0 g granule treatments were considerably superior to the 0.01 g treatment with nitrapyrin.

If future studies confirm these observations, it seems that large granules with low levels of DCD could give slow-nitrifying characteristics greatly superior to those obtained with conventional materials plus nitrapyrin. Large granules are not the only possible application of this technology. Large droplet "dribble" technology or "spoke-wheel" applications would theoretically give nitrification patterns similar to those obtained with larger fertilizer granules.

The effect of liquid fertilizer composition on nitrification rate after 4 weeks is shown in Table 3. The effect of KCl was insignificant at all sites. The addition of KCl can inhibit nitrification on acid soils, but has been totally ineffective in our soils in ND. Averaged across sites and KCl rate there was 25, 35, 46, and 45% of N recovered as ammonium for urea alone, urea + ATS, urea + DCD, and urea + ATS + DCD, respectively. The addition of ATS in the absence of DCD tended to inhibit nitrifcation at all sites but Davenport.

There did not seem to be any additional benefit to adding ATS to fertilizer mixtures already containing DCD. Agrico is now marketing its "Super-N" line of products which contain both DCD and ATS.

The results after 8 weeks were similar to those obtained after 4 weeks (Table 4). There was no consistent effect of KCl. ATS, in the absence of DCD, slowed nitrification at all sites but Davenport. Averaging across sites and KCl, there was 4, 9, 11, and 14% of N recovered as ammonium for the urea, urea + ATS, urea + DCD, and urea + ATS + DCD treatments. This suggests that there could possibly be some benefit from having both ATS and DCD together in a liquid fertilizer, but this benefit was only obvious at the Leonard site.

III. Plant disease studies

The drought of 1988 was the most severe drought experienced by North Dakota in over 50 years. Although experiments were set out at 7 sites, only one site could not be considered a crop failure. Thus, only this one site will be discussed.

The one "successful" site was at the same location as the "Davenport" site used for the previous nitrification studies. The experimental design was a combination of three nitrogen rates (0, 75, and 150 kg N/ha), two chloride rates (0 and 50 kg/ha) and two N sources (urea vs. urea + 5% of N as DCD). The fertilizers were broadcast and incorporated shortly before seeding.

The site produced a very poor stand, and so the poor stand was sprayed out with glyphosate and re-seeded about a month later. Thus, the stand was not established until mid- to late May. The lateness of the crop was one reason that it produced a better crop than the other sites, because of better late-season rainfall. Also, the lateness of the crop is one reason that it developed a slight degree of leaf rust.

The wheat was visually under nitrogen stress in the absence of nitrogen fertilization, and this is shown in the low tissue nitrate levels (Table 5). Nitrogen fertilization, as expected, increased the level of plant tissue nitrate and total N. Chloride fertilization, as expected, decreased the nitrate level of the plants, but total N level was unaffected. There did not seem to be any major decline in tissue nitrate by using urea-DCD instead of urea. This would be expected, as the effect of DCD on nitrification was unusually weak at this site (Tables 1-4).

Tissue chloride levels, in the absence of chloride fertilization, were considerably higher than would be expected, based on the soil chloride test. We are re-checking these samples. Chloride fertilization consistently increased plant chloride level.

Leaf rust levels were, in general, increased by nitrogen fertilization. It was somewhat of a surprise that the first increment of nitrogen caused an increase in leaf rust, as the usual case is that plant disease levels are generally reduced as a nitrogen deficiency is corrected. However, the leaf rust data does indicate that the disease does increase as the total N level in the leaf increases.

Chloride fertilization consistently reduced leaf rust. DCD did not produce a consistent effect. There did not seem to be any difference between urea and urea-DCD at the 75 kg rate, but there does seem to be an influence at the 150 kg rate. More studies are justified to see if these effects can be repeated.

Grain yield was consistently increased by nitrogen fertilization. There was no effect of chloride on grain yield in the absence of nitrogen fertilization, but there did seem to be a consistent influence when nitrogen was present.

Table 1. Effect of pellet size and DCD on the nitrification of urea fertilizer, first sampling.

Pellet size	DCD	Apparent recovery of N as urea + ammonium				
		Davenport	Leonard	Carrington	Minot	Average
g	% of N	%				
0.01	0	27	3	16	5	13
	1	26	5	39	26	24
	2	21	10	42	32	26
	5	25	13	48	24	28
	10	34	10	43	25	28
0.10	0	38	9	36	14	24
	1	58	14	51	50	43
	2	52	6	54	51	41
	5	51	13	57	44	41
	10	48	14	60	34	39
1.0	0	65	21	65	53	51
	1	74	25	64	60	56
	2	78	25	64	56	56
	5	68	24	63	55	53
	10	74	23	61	44	51
0.01	NP+	28	6	44	32	28
Signif. of F						
Size		<0.01	<0.01	<0.01	<0.01	
DCD		NS#	0.06	<0.01	<0.01	
Size x DCD		NS	NS	<0.01	NS	
SE++		7	2	2	7	

+NP=0.01g pellets treated with nitrapyrin
#NS=Not significant (Pr >F less than 0.10)
++SE=Standard error

Table 2. Effect of pellet size and DCD on the nitrification of urea fertilizer, second sampling.

Pellet size	DCD	Apparent recovery of N as ammonium				
		Davenport	Leonard	Carrington	Minot	Average
g	% of N	---------------------%				----------------------
0.01	0	2	3	0	0	1
	1	2	4	9	4	5
	2	3	3	9	7	6
	5	2	8	14	9	8
	10	2	11	9	5	7
0.10	0	1	4	7	3	4
	1	1	7	23	20	13
	2	3	7	26	20	14
	5	2	7	26	30	16
	10	2	16	24	20	16
1.0	0	1	12	29	29	18
	1	1	18	39	41	25
	2	14	19	42	50	31
	5	18	17	43	56	34
	10	18	20	46	55	35
0.01	NP+	2	7	18	5	8
Signif. of F						
Size		0.02	<0.01	<0.01	<0.01	
DCD		NS#	<0.01	<0.01	<0.01	
Size x DCD		NS	NS	NS	<0.01	
SE++		5	2	3	2	

+NP=0.01g pellets treated with nitrapyrin
#NS=Not significant (Pr > F less than 0.10)
++SE=Standard error

Table 3. Effect of KCl, ATS, and DCD on nitrification of urea fertilizer, first sampling, 1988.

Fert. additive			Apparent recovery of N as urea + ammonium				
KCl	ATS	DCD	Davenport	Leonard	Carrington	Minot	Average
			---------------------	----------	%	----------	---------------------
−	−	−	50	6	38	11	26
+	−	−	34	6	42	12	24
−	+	−	35	15	59	22	33
+	−	−	40	22	61	24	37
−	−	+	45	32	57	50	46
+	−	+	53	31	60	36	45
−	+	+	50	28	62	43	46
+	+	+	47	21	59	45	43
Pellets + NP[+]			28	6	44	32	28
Signif. of F							
KCl			NS	NS	NS	NS	
ATS			NS	NS	<0.01	NS	
DCD			NS	<0.01	<0.01	0.01	
KCL*ATS			NS	NS	0.07	NS	
KCL*DCD			NS	NS	NS	NS	
ATS*DCD			NS	NS	<0.01	NS	
KCL*ATS*DCD			NS	NS	NS	NS	
SE[++]			8	5	1	8	

Table 4. Effect of KCl, ATS, and DCD on nitrification of urea fertilizer, second sampling, 1988.

Fert. additive			Apparent recovery of N as ammonium				
KCl	ATS	DCD	Davenport	Leonard	Carrington	Minot	Average
			%				
−	−	−	2	1	11	1	4
+	−	−	2	0	9	1	3
−	+	−	2	10	16	6	9
+	−	−	4	7	19	4	9
−	−	+	1	11	24	11	12
+	−	+	2	9	28	1	10
−	+	+	3	17	30	5	14
+	+	+	3	20	21	11	14
Pellets + NP[+]			2	7	19	5	8
Signif. of F							
KCl			0.05	NS	NS	NS	
ATS			NS	<0.01	NS	NS	
DCD			NS	<0.01	<0.01	0.03	
KCL*ATS			NS	NS	NS	0.06	
KCL*DCD			NS	NS	NS	NS	
ATS*DCD			NS	NS	<0.01	NS	
KCL*ATS*DCD			NS	0.06	NS	NS	
SE[++]			1	1	3	2	

Table 5. Effect of N rate, source, and Cl fertilization on wheat, Davenport west site, 1988.

N Rate	N Source	Cl rate	Tissue[+] analysis NO_3^-	Cl^-	Tot N	LR1[#]	LR2	Yield
kg/ha		kg/ha	ppm	---	---	%---	---	bu/A
0	0	0	62	0.76	1.96	5	9	21.7
0	0	50	55	1.02	1.91	4	6	21.6
75	U	0	1448	0.64	2.68	5	14	25.9
75	U	50	926	1.08	2.56	4	11	27.7
75	UD	0	1243	0.62	2.55	5	13	25.4
75	UD	50	964	1.06	2.52	4	10	27.3
150	U	0	2131	0.60	2.85	7	17	25.1
150	U	50	1629	0.98	2.70	5	15	27.6
150	UD	0	2262	0.61	2.92	6	14	26.6
150	UD	50	1800	1.12	2.89	4	12	28.2
SE[++]			113	0.04	0.06	1	1	0.7

[+] Boot stage

[#] LR1=% leaf rust on flag leaf, LR2=% leaf rust on leaf below flag leaf

[++] SE=Standard Error