Comparative Effects of Nitrogen Sources on Soil Chemical and Physical Characteristics

By David Whitney, Loyd Stone, Keith Janssen, and Jim Long

Few long-term studies have compared nitrogen (N) source effects on soil physical and chemical properties. Kansas researchers recently summarized 20 years of data comparing the effects of anhydrous ammonia, urea, ammonium nitrate and urea-ammonium nitrate solution (UAN).

OVER A 20-YEAR PERIOD (1969-1988), four N sources . . . anhydrous ammonia, ammonium nitrate, urea, and UAN . . . were applied annually to plots at three Kansas locations. The soil types were Smolan silty clay loam at Manhattan, Woodson silt loam at Ottawa, and Grundy silty clay loam at Powhattan.

Crops grown during the study were corn and grain sorghum at Powhattan; grain sorghum, winter wheat, and soybeans at Manhattan; and grain sorghum at Ottawa. The four N sources were spring-applied, beginning with a rate of 200 lb N/A in the first year. Nitrogen rates were adjusted downward as the study progressed, with recommended applications of phosphorus (P) and potassium (K). Each site also included a zero-N control plot which received recommended amounts of P and K. Soil properties were examined in two soil layers (2.5 to 5.5-inch and 8.5 to 11.5-inch) after 10 and 20 years; only the 20-year data will be reported in this article.

Soil Chemical Properties

Chemical analyses for the two sampled soil layers are shown in **Table 1**. Neither of the soil layers showed significant differences in chemical properties among the four N sources. Nitrogen applications, however, did produce significant differences in several chemical properties when compared to the check treatment. In the upper soil layer (2.5 to 5.5 inch depth), N fertilization had reduced pH, available P and exchangeable calcium (Ca) and magnesium (Mg). Exchangeable K was unaffected by N application. Plots receiving N had significantly higher DTPA extractable iron (Fe), copper (Cu), and manganese (Mn) levels than the check plot. Soil nitrate (NO_3-N) and ammonium (NH_4-N) levels were increased by N fertilization in the upper soil layer, reflecting the high initial rate of application. In the lower soil layer, N fertilized plots compared with the zero-N check showed only reduced pH and higher NO_3^--N levels.

All N sources reduced soil pH compared with the no-N check. There were no significant differences in pH effects among the four N sources. The identical effects of N sources on soil pH confirm the results of studies by Kissel and Betzen. They showed that the theoretical requirement of 3.6 lb pure calcium carbonate to offset the acidity produced by nitrification of each pound of N was the same for ammonia, urea, and ammonium nitrate. The requirement was 7.2 lb of calcium carbonate per pound of N from ammonium sulphate. The reduction in soil pH led to the increased extractability of the micronutrients Fe, Cu, and Mn in the 2.5 to 5.5 layer.

Soil Physical Properties

Results of the analyses of soil physical properties at all locations are summarized in **Table 2**. There were no significant differences among the effects of the four N sources on the physical properties of either

The authors are with Kansas State University. Dr. Whitney and Dr. Stone are in the Department of Agronomy at Manhattan, KS. Dr. Janssen is at the East Central Kansas Experiment Field at Ottawa, KS; Dr. Long is at the Southeast Kansas Experiment Station at Parsons, KS.

Table 1. Chemical properties of two soil layers for all field locations as influenced by 20 years of applications of four N sources.

Nitrogen source	pH	Organic matter	CEC	Avail. P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	DTPA-extractable Zn	DTPA-extractable Fe	DTPA-extractable Cu	DTPA-extractable Mn	NO_3-N	NH_4-N
		%	meq/100g	parts per million (ppm)									
2.5- to 5.5-inch soil layer													
Check (no N)	6.2	2.04	23.3	38	220	2,949	548	1.23	52.8	1.63	14.8	4.0	5.0
Anhydrous ammonia	5.2	1.84	22.7	27	217	2,601	459	1.20	75.9	1.99	39.8	26.6	8.7
Ammonium nitrate	5.2	2.27	21.7	26	220	2,443	432	1.11	70.4	2.14	44.3	20.9	11.2
Urea	5.1	2.28	22.7	24	210	2,566	478	1.07	75.7	2.12	51.2	30.8	11.5
UAN solution	5.2	2.04	22.2	28	204	2,494	425	1.02	77.8	1.89	38.0	20.2	8.4
8.5- to 11.5-inch soil layer													
Check (no N)	6.4	1.52	32.6	8	210	3,893	822	0.48	44.7	1.94	8.9	1.4	4.7
Anhydrous ammonia	6.0	1.28	31.6	6	199	3,823	733	0.36	49.4	1.90	10.4	13.0	4.8
Ammonium nitrate	6.2	1.49	34.0	6	208	4,060	815	0.42	43.1	1.93	7.4	9.3	5.1
Urea	6.0	1.54	32.6	6	212	3,666	719	0.38	45.4	1.99	15.6	10.1	5.9
UAN solution	6.2	1.41	31.0	5	209	3,949	808	0.33	39.0	1.80	7.1	9.0	4.8

soil layer. The only significant physical difference between the no-N check and the N-fertilized plots was an increase with N application in the geometric mean diameter (GMD) of soil aggregates in the upper soil layer and a decrease of GMD in the lower layer. The larger the GMD, the greater the proportion of large, water-stable aggregates.

Bulk density and clod density analyses did not indicate that N sources had any influencing effect on soil compaction. If chemical dispersion of clay and clay

(continued on page 15)

Table 2. Physical properties of two soil layers for all field locations as influenced by 20 years of applications of four N sources.

Nitrogen source	Compactability analysis: Maximum bulk density	Compactability analysis: Optimum water content for compaction	Clod density	Water content at permanent wilting point	Particle-size distribution: Sand (0.05-2 mm)	Particle-size distribution: Coarse silt (0.02-0.55 mm)	Particle-size distribution: File silt (0.002-0.02 mm)	Clay <0.002 mm)	Geometric mean diameter
	g/cc	kg/kg	g/cc	%	%				mm
2.5- to 5.5-inch soil layer									
Check (no N)	1.60	0.190	1.50	12.5	11.3	26.0	33.8	29.0	0.95
Anhydrous ammonia	1.59	0.193	1.45	12.6	9.5	21.3	39.8	29.5	1.48
Ammonium nitrate	1.59	0.189	1.46	12.7	8.5	25.3	36.8	29.5	1.50
Urea	1.58	0.196	1.46	12.5	10.3	21.5	39.5	28.8	1.75
UAN solution	1.60	0.190	1.49	12.7	10.8	25.5	34.3	29.5	1.57
8.5- to 11.5-inch soil layer									
Check (no N)	1.49	0.220	1.67	18.8	7.5	18.0	33.0	41.5	1.35
Anhydrous ammonia	1.51	0.216	1.66	18.9	7.0	18.3	33.0	41.8	0.90
Ammonium nitrate	1.52	0.217	1.65	19.1	5.8	21.5	30.8	42.0	0.98
Urea	1.50	0.219	1.68	19.2	6.0	17.5	33.8	42.8	0.94
UAN solution	1.49	0.232	1.67	18.7	8.0	17.3	32.8	42.0	1.02

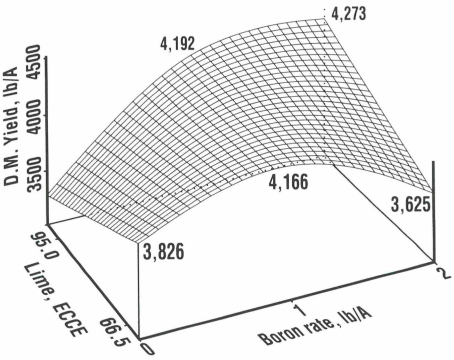


Figure 2. Rose clover response to lime ECCE and rate of B.

availability and increase the need for B fertilization. Research in Texas has shown that use of 100 percent effective calcium carbonate equivalent (ECCE) lime decreased B availability to clover and allowed the plants to tolerate 2 lb B/A (**Figure 2**). The less efficient 62 percent ECCE limestone was not as effective in increasing soil pH and lowering B availability. With the less effective liming material, the 2 lb/A rate appeared to be toxic to the clover, decreasing yield to levels below the zero B treatment.

In summary, liming soil to provide the proper pH for macronutrient availability and activity of legume nodulating bacteria can increase plant needs for micronutrients, including B. For optimum clover production, don't overlook this significant nutrient interaction on highly leached, limed soils. Soil tests for B availability and lime requirement are suggested. ■

Nitrogen sources . . . from page 13

migration result from N source application, then N source should influence soil physical properties such as water content at the permanent wilting point. There were no significant differences in either soil layer in water content (at the permanent wilting point) among the four N sources or between the N treated and the no-N check.

Summary

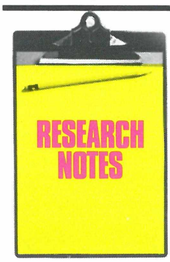
Grain yields at Ottawa and Powhattan during the period 1985 through 1988 indicated that plots receiving N yielded significantly more grain (overall average of 78 bu/A) than no-N check (average of 37 bu/A). There were no significant differences in grain yield among the four N sources.

The primary influence of 20 years of N fertilization has been on soil acidification and associated changes in nutrient availability. Lower nutrient availability probably reflected greater nutrient removal in the higher yields of N-fertilized areas.

Thus, N source selection should be based on:

- cost of N
- adaptability of the N source to the producer's crop-tillage system
- availability of N supply.

Pound for pound, all N sources in this study were shown to be agronomically equal when properly applied. ■



Kansas

Evaluation of Starter Fertilizers for Grain Sorghum Production

THREE YEARS OF FIELD WORK have provided good evidence of the responsiveness of grain sorghum to high phosphorus (P) starter fertilizers on low P soils. Yields were increased an average 21 to 27 bu/A (1,176 to 1,512 lb/A). The magnitude of response is comparable to that of wheat and corn under similar conditions. Results of the studies indicated no differences in effectiveness between a 9-18-9 (N-P_2O_5-K_2O) orthophosphate liquid starter and a polyphosphate containing 7-21-7. Researchers concluded that selection of a starter fertilizer source for grain sorghum should be made on the basis of economics and availability rather than formulation ingredients. ■

Source: R.E. Lamond and D.A. Whitney. Published in Journ. Fertilizer Issues, 8(1): 20-24 (1991).