NITROGEN SOURCE AFFECTS MANGANESE NUTRITION OF NO-TILL CORN

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ABSTRACT

A study evaluating response of no-till continuous corn to different rates of N as injected anhydrous ammonia and broadcasted urea-ammonium nitrate solution (UAN) was conducted on a Canfield silt loam near Wooster, Ohio. Repeated use of anhydrous ammonia on this naturally acid soil resulted in relatively large concentrations of Mn (often > 200 ug/g) in corn plant ear leaves at silking. Ear leaf Mn concentrations were less when UAN was used. For both N source treatments, ear leaf Mn concentrations increased as amount of applied N increased. Analysis of soils in individual plots showed acidification and presence of relatively small, but detectable, quantities of $CaCl_2$-exchangeable Mn at the surface in UAN-treated plots, and zones of low pH and relatively large quantities of exchangeable Mn at the point of repeated injection in ammonia-treated plots. Moisture stress in the latter years of the study precluded evaluation of any deleterious effects of large Mn concentrations on corn yield.

OBJECTIVES

A study was initiated in 1981 near Wooster, in northeast Ohio, to evaluate the response of no-till continuous corn to different rates of several N fertilizer materials, including anhydrous ammonia and UAN. A complete nutrient analysis of ear leaves, conducted in 1986, indicated that N treatment affected ear leaf Mn concentrations, producing concentrations much greater than those normally encountered in corn production in eastern Ohio. The study was modified in 1987 to determine the reasons for these abnormal findings.

METHODS

The study was conducted on a Canfield silt loam, a moderately well drained soil developed in low-lime glacial till. The soil tends to be quite acid, and subsoil pH values of pH 4 are common. The top eight inches (20 cm) of the soil profile had been limed to approximately pH 6 (pH in water) prior to study initiation.

Corn was planted at 33,000 seeds per acre into undisturbed corn residue each year, between May 1 and May 10. Nitrogen was applied immediately before or after planting as anhydrous ammonia or UAN at total N rates of 100, 150, 200, and 250 lb N/A. The UAN was broadcasted over the plot surface using a sprayer with flat fan nozzles. Anhydrous ammonia was injected into row middles at rates 50 lb N/A less than the treatment rate, and the remaining N applied as broadcasted UAN. Plots receiving no N were also included. Plots were 10x80 feet, and contained four corn rows in 30 inch spacing. The experiment was arranged in a randomized complete block with three replications.

Ear leaf samples were taken at silking and analyzed for N by Kjeldahl digestion and steam distillation, and Mn by dry ashing and ICP analysis. Soil samples were taken at approximately the 10-leaf growth stage and refrigerated prior to analysis. Soil pH was determined in 0.01 M $CaCl_2$, and Mn in $CaCl_2$ extracts by atomic absorption spectrophotometry.

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RESULTS AND DISCUSSION

Corn yields during the period 1981-1985 showed responses to N rate which differed between N sources (Table 1). Data from 1983 are not included because severe moisture stress caused total crop loss. Corn yield increased as the quantity of N applied as ammonia increased to approximately 150 lb N/A; however, 250 lb N/A were required as UAN to produce similar yields to those obtained with 150 lb N/A as ammonia. Such findings are not unusual and probably result from excessive immobilization of broadcasted N in the corn residue and loss of N by ammonia evolution in the UAN treatments.

Corn yields increased with addition of N in 1986, 1987, and 1988; however, effects of N source were not as large as noted in previous years (Table 2). No yield differences due to N source were seen in 1986. In 1987 and 1988 ammonia produced higher yields than UAN at lesser N rates (both $P<.05$), but no differences were seen at greater rates. Yields were limited in all years by moisture deficits.

In all years ear leaf Mn concentrations increased with increasing N application and were greater for corn receiving anhydrous ammonia than corn receiving UAN. Corn receiving larger quantities of ammonia consistently showed concentrations much higher than those normally seen in corn grown in eastern Ohio. Any potential toxic effects of such large concentrations could not be determined, however, due to limitations on yield imposed by weather.

Analysis of soil samples taken in June, 1988 (Table 3) showed that acidification had occurred in locations where N had been applied repeatedly. Soil pH was lower at the surface in plots receiving broadcasted UAN and was relatively very low at the point where ammonia was discharged into the soil, midway between the crop rows. The reader should note that these pH values were measured in $CaCl_2$, a procedure which normally produces pH values which are often several tenths of a unit lower than those determined in water. Exchangeable Mn was detected in positions where soil pH was reduced below pH 5. The highest concentrations of Mn were detected in the ammonia band. The Mn was probably released into an exchangeable form due to acidification resulting from nitrification of applied ammonium nitrogen. No exchangeable Mn was detected in positions where N was not applied. Regression analyses (not shown) indicated a strong correlation between exchangeable Mn in the soil and ear leaf Mn concentrations.

In 1987 the original experiment was modified. Plots previously treated with surface-broadcasted urea began receiving injected ammonia, in an attempt to determine how quickly Mn would be released following inception of ammonia application on this soil. Exchangeable Mn was detected in June, 1987 (data not shown) and 1988 (Table 3). Apparently, acidification of the ammonia band was sufficient to release significant quantities of exchangeable Mn from this soil within a one to two year period. In 1987 and 1988, ear leaf Mn concentrations of corn receiving the short term ammonia treatment were higher than those from long-term UAN treated plots but lower than those from the long-term ammonia treated plots.

This release and uptake of large quantities of Mn could conceivably induce yield-limiting toxicity if not managed properly. Excessive release of Mn could certainly be controlled by surface applications of lime when acidification is concentrated at the field surface as it would be with surface-applied nitrogen. In the case of injection programs, however, surface-applied lime would probably not be effective. Incorporation of lime by inversion tillage will be necessary in such situations. While development of Mn toxicity or other acid-related problems, such as aluminum toxicity, may be rare when N is injected for no-till corn on most Corn Belt soils, the results of this study do indicate that plant tissue composition should be monitored carefully when injected N is used repeatedly on the same field.

Table 1. Corn yield as affected by N source and rate, 1981-1985 average.

N rate	Ammonia	UAN
lb/A	----------- bu/A --------	
0	49	
100	131	100
150	158	126
200	155	136
250	163	156

Table 2. Corn yield and ear leaf N and Mn concentrations as affected by N rate and source.

	N	Yield		Leaf N		Leaf Mn	
	Rate	Ammonia	UAN	Ammonia	UAN	Ammonia	UAN
	lb/A	--- bu/A ----		------ % -----		---- ug/g ---	
1986							
	0	51		1.79		36	
	100	124	117	3.14	2.90	154	56
	150	126	130	3.19	3.06	181	59
	200	118	128	3.21	3.14	185	73
	250	125	120	3.31	3.09	225	123
	LSD.05	ns		0.15		ns	
1987							
	0	51		1.75		38	
	100	108	94	2.26	2.11	128	52
	150	123	110	2.87	2.25	214	51
	200	120	121	3.05	2.81	214	76
	250	122	119	3.24	2.99	273	82
	LSD.05	ns		0.08		34	
1988							
	0	64		3.41		63	
	100	91	81	3.65	3.71	82	66
	150	90	72	3.70	3.66	92	74
	200	84	79	3.88	3.77	169	93
	250	83	85	3.78	3.73	257	125
	LSD.05	ns		ns		ns	

Note: check plot data not included in statistical analyses.

Table 3. Soil $CaCl_2$ pH and extractable Mn as affected by N treatment at 200 lb N/A rate, 1988.

N source and depth	Soil pH		Soil Mn	
	Row	Row middle	Row	Row middle
cm			------ ug/g ------	
UAN - 8 years				
0-4	4.7	4.5	14	11
8-12	5.1	5.2	0	0
12-16	5.3	5.2	0	0
Ammonia - 8 years				
0-4	5.1	4.9	0	11
8-12	4.9	4.5	0	36
12-16	4.8	4.4	1	39
Ammonia - 2 years				
0-4	5.5	5.2	0	0
8-12	5.1	4.5	0	32
12-16	5.0	4.7	0	23

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