1990

Soil Science Research Report - 1990

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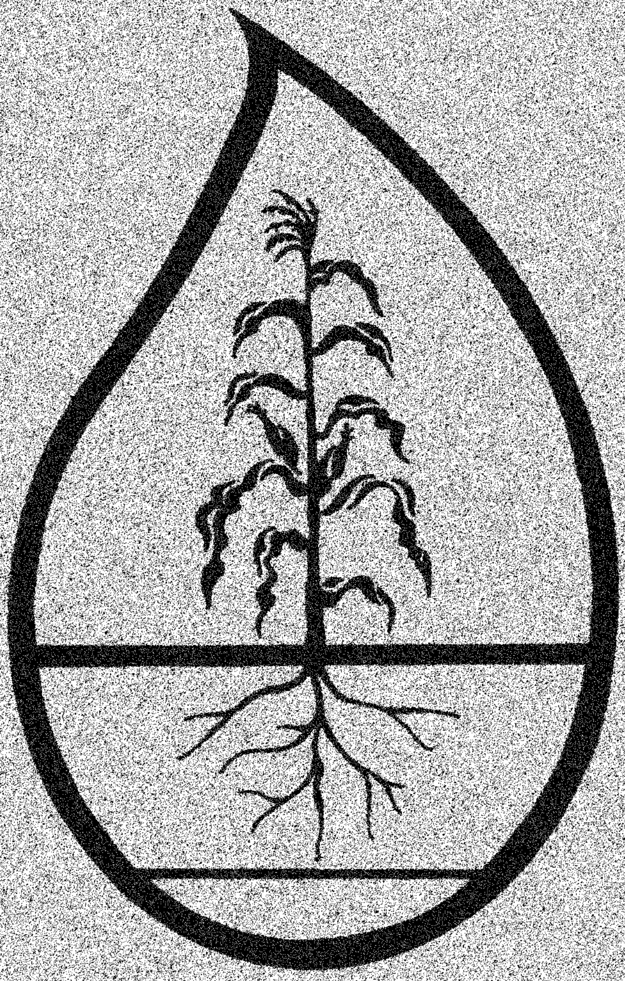
SOIL SCIENCE

RESEARCH REPORT 1990



DEPARTMENT OF AGRONOMY

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Northeast Research and Extension Center
Concord, NE 68728 Weather Data - 1990

Month	Period	Precipitation		Avg. Air Temp.		Growing Degree Days	
		1990	Normal[1]	1990	Normal[1]	1990	Normal[1]
		-----inches-----		-------°F------			
January	1-31	0.92	0.50	30.7	16.7		
February	1-28	0.07	0.53	28.6	21.6		
March	1-31	1.86	2.05	38.6	34.2		
April	1-30	1.80	2.63	47.4	48.2		27
May	1-10	1.40		54.7		98	
	11-20	1.57		53.3		69	
	21-31	1.03		60.8		126	
	Total	4.00	3.91		59.5	293	298
June	1-10	0.46		66.8		171	
	11-20	2.60		75.2		244	
	20-30	0.78		76.5		243	
	Total	3.85	3.43		69.1	658	598
July	1-10	0.29		78.6		259	
	11-20	1.08		71.1		206	
	21-31	1.35		70.0		221	
	Total	2.72	2.19		74.5	686	759
August	1-10	0.10		68.8		187	
	11-20	0.92		71.6		209	
	21-31	1.26		76.7		275	
	Total	2.28	2.63		71.1	671	612
September	1-30	0.85	2.31	66.8	61.8	517	356
October	1-31	1.92	1.81	50.2	49.0		16
November	1-30	0.93	1.34	38.8	34.3		
December	1-31	0.14	0.67	19.2	21.0		
Year	Jan-Dec	21.37	24.01			2825	
Growing Season	May-Sep	13.70	14.47			2650	

[1] 18-year average from 1973-1990 from NOAA weather station.

[2] 50 to 86°F base, May 1 to Sep 30.

Notes: 1. Precipitation from NOAA weather station.
2. Average temp and GDD from automated weather station.

University of Nebraska Agricultural Research Center
Mead, Nebraska 1990 Weather Data

Month	Period	Total Precipitation, in Actual	Total Precipitation, in Normal[1]	Average Temperature °F 1990	Average Temperature °F Normal[1]	Total GDD[2] 1990	Total GDD[2] Normal[1]
Jan	1-31	0.66	0.75	33	20	35	0
Feb	1-28	0.0	0.95	30	27	39	0
Mar	1-31	0.57	2	42	36	112	11
Apr	1-30	0.0	2.82	50	51	241	200
May	1-10	0		55			
	11-20	0		57			
	21-31	1.22		63			
	Total	1.22	4.06	58	62	338	401
June	1-10	1.42		69			
	11-20	1.69		78			
	21-30	1.03		78			
	Total	4.14	4.25	75	72	694	656
July	1-10	0.78		69			
	11-20	0.71		74			
	21-31	5.99		81			
	Total	7.48	3.22	75	77	709	793
Aug	1-10	0.15		78			
	11-20	0.4		66			
	21-31	0.08		60			
	Total	0.63	4.02	68	74	718	747
Sept	1-10	0.04		78			
	11-20	0.51		66			
	21-30	0.04		60			
	Total	0.59	3.16	68	65	537	462
Oct	1-31	1.69	1.98	53	54	316	258
Nov	1-30	0.79	1.07	42	39	122	26
Dec	1-31	0.39	0.75	20	27	24	0
Year (Jan-Dec)		18.16	29.03	52	50	3885	3554
May - Sept		14.06	18.71	70	70	2996	3059

[1] 30 years normal.

[2] GDD, 50°F base.

South Central Research and Extension Center
Clay Center 1990 Weather Data

Month	Period	Precipitation		Avg. Air Temp.		GDD	
		1990	Normal	1990	Normal	1990	Normal
Jan	1-31	0.51	0.61	32.61	22.85	40.64	
Feb	1-28	0.19	0.08	30.54	29.32	37.37	
Mar	1-31	2.21	1.82	41.26	37.84	97.98	21.74
Apr	1-30	0.45	2.74	48.00	50.10	224.45	216.98
May	1-10	2.60	1.24	53.90	58.86	84.57	107.73
	11-20	1.85	1.29	55.38	62.24	80.40	125.51
	21-3	1.26	1.45	63.75	65.71	155.44	172.74
	Total	5.71	3.98	57.87	62.38	320.41	405.98
Jun	1-10	2.05	1.42	67.65	69.46	180.38	194.22
	11-20	1.41	1.40	76.30	72.47	248.37	224.62
	21-31	0.28	1.32	76.29	74.55	228.85	239.37
	Total	3.74	4.14	73.41	72.15	657.90	658.21
Jul	1-10	0.67	1.08	80.61	76.40	260.41	248.08
	11-2	2.05	1.06	70.67	77.55	197.91	253.59
	21-3	1.29	1.10	71.67	77.38	236.25	278.04
	Total	4.01	3.24	74.23	77.12	694.57	779.71
Aug	1-10	4.41	1.09	69.36	76.84	191.81	250.49
	11-20	1.74	1.10	73.26	75.68	227.32	244.66
	21-3	1.30	1.20	78.47	72.97	276.84	250.70
	Total	7.45	3.39	73.85	75.09	695.97	745.85
Sep	1-30	00.43	2.98	67.82	65.85	515.74	480.87
Oct	1-31	1.11	1.64	52.28	54.75	297.23	275.77
Nov	1-30	0.83	0.91	42.77	39.46	151.50	42.12
Dec	1-31	0.60	0.68	20.74	28.66	37.17	
Year	Jan-Dec	28.04	27.01	51.50	51.54	*3070.32	3627.23
Growing Season	May-Sep	21.34	17.73	69.42	70.54	2884.59	3070.62

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* 50 to 86 F base, May 1 until first frost (defined as 32 F or less)

1) Highest temperature on July 2 -- 107.67 F
2) Highest 24-hour precipitation on August 2 -- 3.46"
3) Highest 2-day precipitation on August 2-3 -- 3.54"
4) Last spring frost -- May 1
5) First fall frost -- October 21

West Central Research and Extenison Center
North Platte, NE Weather Data, 1990

Month	Period	Precipitation		Avg Air Temp.		GGD	
		1990	Normal[1]	1990	Normal[1]	1990	Normal
January	1-31	0.39	0.36	31.2	22.9	-	-
February	1-28	0.24	0.51	30.2	27.3	-	-
March	1-31	1.95	0.97	38.4	35.5	-	-
April	1-30	1.81	2.14	48.8	48.0	-	-
May	1-10	1.20		51.5		80	
	11-20	1.25		54.9		94	
	21-31	0.81		62.7		132	
	Total	3.26	3.29	56.6	58.0	306	354
June	1-10	1.06		67.0		181	
	11-20	0.63		72.4		182	
	20-30	T		76.7		234	
	Total	1.69	3.40	72.0	68.3	597	576
July	1-10	0.09		79.8		229	
	11-20	2.13		70.4		171	
	21-31	0.08		70.0		224	
	Total	2.30	2.69	73.3	75.0	624	751
August	1-10	0.36		71.1		186	
	11-20	0.80		71.7		198	
	21-31	0.27		77.6		229	
	Total	1.43	2.15	76.1	73.0	613	668
September	1-30	0.48	1.67	67.7	63.2	493	444
October	1-31	1.94	1.05	50.8	51.3		
November	1-30	1.12	0.57	37.8	36.3		
December	1-31	0.08	0.49	22.8	26.8		
Year		16.69	19.29	50.5	48.8		
Growing Season May/Sept		10.97	13.20	69.10	67.5	2505[2]	2793[3]

[1] 84 year average 1907-1990
[2] 50° to 85°F base May 1 to first fall frost 9/23
[3] 50° to 80°F base May 1 to Sept 30

NOTES:
1. Last spring frost May 10 (27°F)
2. First fall frost Sept 23 (23°F)
3. Highest temp 107°F 7/1 and 7/2

PANHANDLE STATION (P.R.E.C.) 1990

		Precipitation		Average Air Temp			Growing Degree Days
Month	Period	1990	Normal	1990	Normal		1990
Jan.	1-31	0.28	0.28	32.45	27.4		
Feb.	1-28	0.33	0.34	29.60	35.3		
Mar.	1-31	1.80	0.66	37.10	49.3		
Apr.	1-30	1.37	1.16	46.35	60.0		172
May	1-10	0.88		50.00			70
	11-20	0.77		49.40			105
	21-31	0.74		61.20			134
		------		-------			-----
	Total	2.39	1.10 Avg.	54.02	69.3	Total	309
June	1-10	0.28		66.50			178
	11-20	0.16		68.35			168
	21-30	0.00		77.85			210
		------		-------			------
	Total	0.44	1.71 Avg	70.90	72.1	Total	556
July	1-10	1.02		76.00			234
	11-20	.84		68.60			193
	21-31	0.33		68.70			209
		------		-------			------
	Total	2.19	3.15 Avg.	71.10	66.1	Total	636
Aug.	1-10	0.92		69.90			200
	11-20	0.51		69.35			236
	21-30	0.00		72.54			197
		------		-------			-----
	Total	1.43	2.62 Avg.	70.59	56.0	Total	633
Sep.	1-30	1.02	1.26	65.05	45.3		318
Oct.	1-31	0.78	0.62	48.16	34.5		
Nov.	1-30	0.87	0.23	38.44	29.1		
Dec.	1-31	0.06	0.27	20.15	23.4		

Evaluation of Soil Testing for Nitrate-Nitrogen

Edwin J. Penas

Objective:

Demonstrate the validity of using soil tests for nitrate-nitrogen as a guide for determining the amount of nitrogen fertilizer needed to produce a crop of corn or grain sorghum.

Procedure:

Eleven fields were selected for demonstration sites. At five sites, two rates of nitrogen were compared. One of these was planted to soybeans where two levels of residual nitrogen remained after a corn study in 1989. Three rates of nitrogen were employed at three sites and at the other three sites, UNL recommendations based of deep samples were compared with the Iowa State PSNT based on one-foot samples.

Soil samples were collected prior to plot establishment. Fertilizer rates employed were based on soil tests for nitrate-nitrogen, previous crop, and expected yield. Field-length plots were used except in Boone County and the PSNT studies in Washington County. Fertilizer was applied by the cooperating farmer or fertilizer dealer except the two PSNT studies in Washington County.

Grain yields in the field length plots were determined using the cooperating farmer's combine and weighing on a portable weigh wagon except the seed corn study in Butler County. There the plots were harvested with a picker and weighed at a near-by scale. At the three locations where less than full-length plots were employed, samples were hand-harvested, shelled, weighed, and subsampled for moisture.

Results and Discussion:

Data were collected from eleven sites in 1990 and are presented in the following tables.

Two Rates of Nitrogen

At five sites, two rates of nitrogen were compared and data are shown in Table 1. The soil nitrate-nitrogen content at Butler and Lancaster Counties was high enough that no nitrogen was recommended for the expected yield. This zero rate was compared with the application of 50 pounds of nitrogen per acre (69 lbs/ac in Lancaster).

In Cass and Washington Counties, soil nitrate-nitrogen was not high; however, soybeans were grown the previous year. Thus, nitrogen rate was based on expected yield and soil nitrate-nitrogen level and compared to a rate 50 lbs N/ac lower (46 lbs in Cass) to evaluate the contribution from the previous crop of soybeans. Rate of nitrogen did not significantly affect grain yield or grain test weight at any of the four locations. Grain moisture of the grain sorghum in Lancaster County was reduced 1.4% by nitrogen fertilizer.

In Saunders County, soybeans were planted in a field where two rates of nitrogen (60 and 166 lbs N/ac) had been applied for corn the previous year. Soil nitrate-nitrogen was 90 lbs N/ac 4-feet higher on the high nitrogen strips and resulted in 1.2 bu/ac more soybeans (sig. @ 0.12).

Three Rates of Nitrogen

Three rates of nitrogen were employed at three locations and data from these sites are presented in Table 2.

At the site in Boone County, soil nitrate-nitrogen level was high and 30 pounds of nitrogen per acre was suggested for an expected yield of 140 bu/ac. The producer decided to apply rates of 0, 100, and 200 lbs N/ac. No effect of nitrogen was measured at this site.

The study in Butler County was a seed production field. Based on the nitrate-nitrogen content of the soil and an average yield of 140 bu/ac of commercial corn, 80 lbs N/ac was suggested. This rate was compared to 40 and 120 pounds N/ac. Seed yield was not significantly affected by rate of applied nitrogen.

The soil at the Nance County site was medium in nitrate-nitrogen (90 lbs N/ac 4-feet). The suggested rate, based on this soil test and an expected yield of 160 bushels per acre was 100 lbs N/ac. This rate was compared to 0 and 160 lbs N/ac. The 100 lbs N/ac was adequate for 160 bushels per acre; however, the 160 pound rate gave an additional 13 bushels per acre which exceeded the expected yield. Without nitrogen, grain yields were reduced and grain moisture was significantly higher at harvest time.

UNL Deep Tests vs. ISU PSNT

There has been considerable interest in the PSNT (Pre-Sidedress Nitrogen Test) since it was introduced in 1989 by Iowa State University. This approach was compared to the use of the UNL Deep Sample approach at three sites and these data are in Table 3.

The field in Dodge County had a low level of nitrate-nitrogen in the soil (50 lbs N/ac 4-feet); however, the previous crop was soybeans. Based on this and an expected yield of 120 bushels per acre, 60 lbs N/ac was suggested (70 lbs N/ac actually applied). Using the ISU guidelines for this yield on a Moody soil, the suggested rate of nitrogen was 110 lbs N/ac. This higher rate did not increase grain yield in this field.

The two sites in Washington County were on the same farm, but on very different soils. The SW site is bottomland that had been in soybeans and 144 lbs N/ac 4-feet was measured in the soil. No nitrogen fertilizer was suggested using UNL guidelines. ISU guidelines suggested 60 lbs N/ac. Expected yield was exceeded in both cases. Yield was 3 bushels per acre higher where 60 pounds of nitrogen per acre was applied; however, this is not an economical response. Grain moisture at harvest was 0.7% lower where nitrogen was applied.

The NE site is an eroded upland site. Soil samples were taken in June and 98 lbs N/ac 2-feet was found. Although UNL tests are not calibrated for June samples, no nitrogen was suggested when using the UNL guidelines based on expected yield and nitrate nitrogen in the soil. The PSNT test using ISU guidelines resulted in a recommendation of 90 pounds of nitrogen per acre. This application of nitrogen did not increase grain yield, but did result in 0.4% reduction in grain moisture at harvest.

Summary

These data demonstrate that soil tests for nitrate-nitrogen provide viable guidelines to determine the nitrogen fertilizer needs of corn and grain sorghum. The deep samples appear to be more reliable than the one-foot PSNT samples.

Table 1. Influence of nitrogen fertilizer on grain yield, grain moisture and test weight of corn, sorghum, and soybeans at five locations, 1990.

	Low N Rate	High N Rate	Difference
Butler County			
170 lbs N/ac. 4-feet (Expected yield = 140) Corn after corn, irrigated			
Applied Nitrogen, lbs/ac.	0	50	50
Grain Yield, bu/ac.	138	140	2
Grain Moisture, %	15.1	15.1	0
Grain Test Weight, lbs/bu.	60.1	60.2	0.1
Cass County			
45 lbs N/ac. 4-feet (Expected yield = 120) Corn after soybeans, non-irrigated			
Applied Nitrogen, lbs/ac.	80	126	46
Grain Yield, bu/ac.	120	121	1
Grain Moisture, %	12.2	12.2	0
Grain Test Weight, lbs/bu.	57.4	57.5	0.1
Lancaster County			
135 lbs. N/ac. 4-feet (Expected yield = 100) Grain sorghum after sorghum, non-irrigated			
Applied Nitrogen, lbs/ac.	0	69	69
Grain Yield, bu/ac.	90	92	2
Grain Moisture, %	16.1	14.7	-1.4***
Grain Test Weight, lbs/bu.	59.2	59.4	0.2
Saunders County			
90 and 187 lbs N/ac. 4-feet Soybeans after corn, irrigated			
Soil Nitrogen, lbs/ac. 4-feet	90	187	97
Seed Yield, bu/ac.	49.2	50.4	1.2
Seed Moisture, %	9.8	9.9	0.1
Seed Test Weight, lbs/bu.	54.5	54.5	0
Washington County			
33 lbs N/ac. 4-feet (Expected yield = 100) Corn after soybeans, non-irrigated			
Applied Nitrogen, lbs/ac.	50	100	50
Grain Yield, bu/ac.	90	87	-3
Grain Moisture, %	14.6	14.8	0.2
Grain Test Weight, lbs/bu.	55.6	55.6	0

***: Significantly different @ 0.01 probability.

Table 2. Influence of rate of nitrogen fertilizer on grain yield, grain moisture, and test weight of corn at three locations, 1990.

	Rate of Nitrogen			Difference	
	Low	Med	High	M-L	H-M
Boone County					
127 lbs N/ac. 4-feet (Expected yield = 140) Corn after corn, irrigated					
Applied Nitrogen, lbs/ac.	0	100	200	100	100
Grain Yield, bu/ac.	156	157	161	1	4
Grain Moisture, %	18.4	17.9	18.5	-0.5	0.6
Grain Test Weight, lbs/bu.	55.5	55.8	55.7	0.3	-0.1
Butler County (Seed Corn)					
89 lbs N/ac. 4-feet (Base yield = 140) Seed corn after seed corn, irrigated					
Applied Nitrogen, lbs/ac.	40	80	120	40	40
Seed Yield, bu/ac.	47.7	50.9	50.5	3.2	-0.4
Nance County					
90 lbs N/ac. 4 feet (Expected yield = 160) Corn after corn, irrigated					
Applied Nitrogen, lbs/ac.	0	100	160	100	60
Grain Yield, bu/ac.	143	166	179	23**	13*
Grain Moisture, %	18.2	16.5	16.8	-1.7*	0.3
Grain Test Weight, lbs/bu.	54.2	55.5	55.2	1.3	-0.3

*,**: Significantly different @ 0.10 and 0.05 probability.

Table 3. Influence of nitrogen fertilizer based on UNL deep samples vs. PSNT one-foot samples on grain yield, grain moisture, and test weight of corn at three locations, 1990.

	UNL	PSNT	Difference
Dodge County			
50 lbs N/ac. 4-feet (June test = 60 lbs N/ac. 2-feet) June Test: 10.3 ppm NO_3--N(0-12") & Expected Yield = 120 Corn after soybeans, non-irrigated			
Applied Nitrogen, lbs/ac.	70	110	40
Grain Yield, bu/ac.	129	131	2
Grain Moisture, %	16.8	16.6	-0.2
Grain Test Weight, lbs/bu.	57.9	58.0	0.1
Washington County (SW)			
144 lbs N/ac. 4-feet (June test = 98 lbs N/ac. 2-feet) June Test: 16.1 ppm NO_3--N(0-12") & Expected Yield = 120 Corn after soybeans, non-irrigated			
Applied Nitrogen, lbs/ac.	0	60	60
Grain Yield, bu/ac.	138	141	3***
Grain Moisture, %	14.9	14.2	-0.7***
Grain Test Weight, lbs/bu.	56.2	56.0	-0.2
Washington County (NE)			
98 lbs N/ac. 2-feet (June Test) June Test: 13.6 ppm NO_3--N(0-12") & Expected Yield = 120 Corn after corn, non-irrigated			
Applied Nitrogen, lbs/ac.	0	90	90
Grain Yield, bu/ac.	126	124	-2
Grain Moisture, %	13.6	13.2	-0.4*
Grain Test Weight, lbs/bu.	57.4	57.4	0

*, ***: Significantly different @ 0.10 and 0.01 probability.

Dynamics of Water in Rigid and Swelling Soils

D. Swartzendruber

Objective:

The general objective of this report is to analyze and quantify the process by which water flows into and through porous media and soils under both saturated and unsaturated conditions. Swelling and non-swelling soils are considered.

Procedure:

As far as reasonably possible, each flow process is approached as a mathematical boundary-value problem to be solved by classical mathematical means or by computer if necessary. Experiments are conducted in the laboratory with vertical flow columns on which measurements of water content and soil bulk density are obtained by the attenuation of dual-energy gamma radiation. Other flow measurements are taken as needed.

Results and Discussion:

A new three-parameter infiltration equation was examined for its capability in describing the effect of soil-surface-ponded water head h on the cumulative quantity of water infiltrated into the soil with time. The infiltration equation, as reduced to two-parameter dimensionless form, was fitted by nonlinear least squares to dimensionless data as generated from mathematical descriptions of infiltration that included the effect of h in somewhat complicated parametric form. The fitted two-parameter equation gave an excellent description of all the generated data, in terms of both goodness of fit and in recovery of the ponded head h used as an input into the generated data. Recovery of h was achieved within a relative error of 1.4% over the complete range of the generated data, thus validating the new and relatively simple equation in its description of the general effect of ponded head on the cumulative infiltration process. This provides further confirmation of the validity and utility of the infiltration quasi solution from which the new three-parameter infiltration equation was derived exactly. Finally, the relatively simple ponded-depth dependence of the total soil sorptivity, a parameter appearing in the new equation, has been shown to be applicable over a wider range of soils than could be claimed heretofore.

Further work with a new mathematical solution for horizontal water entry into soil, wherein micro-level soil-particle rearrangement appears to induce an auxiliary time-dependence of soil-water diffusivity, appears to justify a new category of soil behavior termed semi-rigid. This category is intermediate between a strictly rigid soil and a soil that swells when wetted.

Atrazine Movement as Affected by Pore Size Distribution in a Silt Loam Soil

J.U. Baer, W.L. Powers, P.J. Shea, D.R. Tupy, and C.L. Stueffer-Powell

The effect of soil tillage on the soil pore size distribution (PSD) is important to solute movement through the soil. A parameter which describes the soil PSD as a whole is desirable over soil pore size groupings because of the interrelatedness of such groupings.

One such parameter is that from the empirical equation

$$\theta_R = \left(\frac{\tau}{\tau_e}\right)^{-\lambda}$$

relating the matric suction head (τ) and the relative soil water content (θ_R), where

$$\theta_R = \frac{\theta_V}{\varepsilon}.$$

θ_v is the volume of soil moisture per volume of soil and ε is the soil porosity. In this equation, λ and τ_e are physical parameters of the soil. The parameter λ has been used as an index of the PSD. It has been reasoned that for media having a uniform pore size, the index would be a large number which theoretically could approach infinity. On the other hand, media with a very wide range of pore sizes should have a small value of λ which theoretically could approach zero. For typical porous media, the usual value of λ is about two, while well aggregated soils in an undisturbed state sometimes have λ less than one.

The purpose of this research was to determine if differences in the soil PSD could explain some of the spatial variability of atrzine solute movement through the soil toward the ground water. Because λ describes the PSD, is affected by soil structure, and is able to discriminate soil texture classes, it was chosen as a soil physical parameter with which to relate solute movement in soil.

Two tillage treatments were used to induce variation in the soil PSD. One was clean-tillage consisting of fall chisel plow with a spring disc and harrow. The other was slot-plant with no tillage or cultivation. The experimental plots were located at the University of Nebraska's South Central Research Station and Extension Center, near Clay Center, Nebraska. Plots were on a Crete silt loam (Pachic Argiustoll) under a lateral move irrigation system. Corn (Zea mays L.) production was in its fifth consecutive year at the initiation of this experiment.

Undisturbed soil cores were taken from the soil surface (2.5 cm to 10.2 cm) 0.19 m from corn rows by a Uhland sampler mounted to a tractor hydraulic press (Giddings Soil Sampler). An aluminum sleeve inside the Uhland sampler captured a soil core 7.6 cm high by 8.2 cm in diameter. Two additional soil samples were taken beneath each undisturbed surface soil core. The first sample (increment 1) was soil contained in the lower spacer ring and bit of the Uhland sampler and corresponded to the 10.2 cm to 15.2 cm soil depth. The second sample (increment 2) was soil taken from the bottom of the hole created by the Uhland sampler and corresponded to the 15.2 cm to 25.0 cm soil depth. The soils were sampled in June, July, August, and October (at harvest).

Atrazine concentrations at sampling time were determined for increments 1 and 2 of the subsurface soil samples and the undisturbed surface soil cores. The soil PSD index, λ, was calculated by fitting equation [1] to the soil moisture release data.

The PSD index, λ, was used to test partial correlations between the soil core

Table 1. Partial correlation results. λ vs atrazin concentrations in increments 1 and 2

variables	r	p	n
June λ vs June inc 1	-0.28	0.40	11
June λ vs June inc 2	-0.12	0.73	11
June λ vs July inc 1	-0.69	0.02**	11
June λ vs July inc 2	-0.25	0.48	11
June λ vs August inc 1	-0.34	0.37	11
June λ vs August inc 2	+0.44	0.23	11
June λ vs October inc 1	+0.14	0.74	11
June λ vs October inc 2	+0.08	0.85	11
July λ vs July inc 1	+0.24	0.47	12
July λ vs July inc 2	+0.06	0.86	12
July λ vs August inc 1	-0.28	0.41	12
July λ vs August inc 2	-0.67	0.02**	12
July λ vs October inc 1	-0.26	0.50	12
July λ vs October inc 2	-0.26	0.50	12
August λ vs August inc 1	+0.09	0.79	12
August λ vs August inc 2	-0.10	0.77	12
August λ vs October inc 1	-0.15	0.71	12
August λ vs October inc 2	-0.42	0.26	12
October λ vs October inc 1	+0.05	0.91	12
October λ vs October inc 2	+0.49	0.18	12

** indicates statistical significance

PSD and the relative atrazine concentrations in increments 1 and 2. Table 1 below lists all partial correlations tested, where r is the simple linear partial correlation coefficient, p is the level of significance of the simple linear partial correlation coefficient, and n is the sample size.

These combinations reflect the assumed cause and effect relationship between the PSD (as measured by λ) and the relative atrazine concentrations in increments 1 and 2. Of these combinations, two tested significant. They are illustrated in figures 1 and 2.

The negative simple linear partial correlation coefficients of the above partial correlations indicate that some of the variation in the relative atrazine concentration of the subsurface soil can be explained by differences in λ. Forty eight percent ($r^2 = -0.69^2 = 0.48$) of the variation in the relative atrazine concentration in increment 1 of the July samples can be explained by a linear function of June λ. Forty five percent ($r^2 = -0.67^2 = 0.45$) of the variation in the relative atrazine concentration in increment 2 of the August samples can be explained by a linear function of July λ.

The negative partial correlations between λ and the relative atrazine concentrations in increments 1 and 2 of the study suggest that subsurface soil, under surface soil having a greater fraction of large pores had lower concentrations of atrazine. This may be explained by looking at the soil moisture holding capacity of this soil.

The matric suction head of this soil at its soil moisture holding capacity is near 100 cm H_2O. At this matric suction head, all pores with effective radii 1.5 m and greater will be drained. This means that 24 hours after precipitation or irrigation, pores with effective radii 1.5 m and greater will be drained of soil moisture and pores with effective radii less than 1.5 m will remain filled with soil moisture. These smaller, soil moisture filled pores may provide continuous atrazine transport paths over longer periods of time resulting in greater movement of atrazine.

This implies that larger pores may play a lesser role in solute transport in the drier soils of the United States than they have been reported to in the more humid regions of the country. This being simply because the larger pores in drier regions are not filled with soil moisture so much of the time.

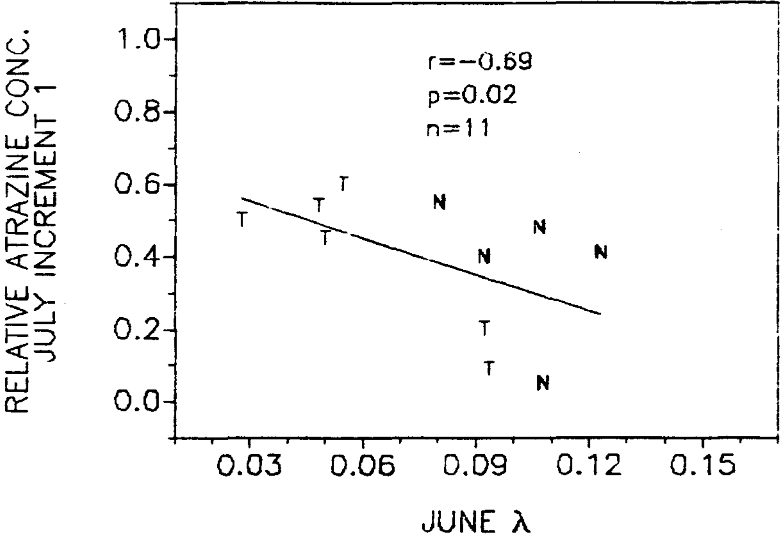

Figure 1. Partial correlation between June λ and the relative atrazine concentration in increment 1 of July samples. T=clean-tillage treatment. N=slot-plant tillage treatment.

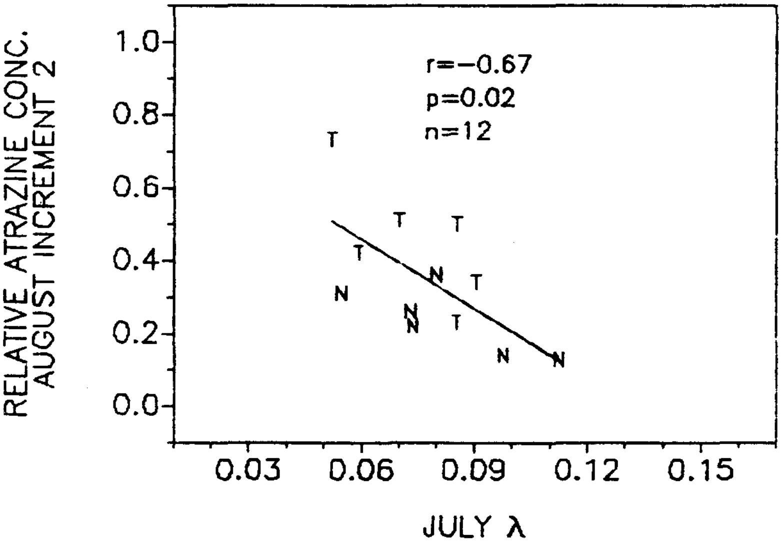

Figure 2. Partial correlation between July λ and the relative atrazine concentration in increment 2 of August samples. T=clean-tillage treatment. N=slot-plant tillage treatment.

Effect of Residual Phosphorus Bands on Crop Yield and Their Persistance in the Soil

Mohammed A. Zerkoune, C.A. Shapiro and D.H. Sander

Objectives:

1. to determine the residual value of undisturbed P fertilizer bands over 4-year period.

2. to develop strategies to evaluate such bands for fertilizer recommendation adjustment.

Procedures:

Three long term experiments were selected in 1988 on the following soils: a Crofton-Nora sicl in Knox County growing continuous corn; a Sharpsburg sicl in Lancaster County growing continuous wheat; and a Crete sicl in Gage County growing a wheat-sorghum-soybean rotation. Soils were selected for low P availability according to the Bray & Kurtz No. 1 soil test (Crofton-Nora = 7 ppm; Sharpsburg - 8 ppm; Crete = 11 ppm).

Five P rates were applied (0, 10, 20, 30, and 40 kg P/ha on the Crofton soil and 0, 7.5, 15, 22.5 and 30 kg P/ha on the Sharpsburg and Crete soils) as ammonium polyphosphate (10-15-0, N-P-K). Phosphorus fertilizer was knifed into the soil to a depth of about 10 cm in 40 cm spacings. Ammonia was applied to provide a total of 100 kg N ha^{-1} on the wheat and sorghum and 120 kg N ha^{-1} on the corn. Tillage was limited to disking on the Sharpsburg and Crete soils for wheat and sorghum. The corn experiment on the Crofton-Nora soil was no-till.

Treatments were established to provide an evaluation of residual P applied 1, 2, 3 and 4 years. Treatments were replicated four times. Weeds were controlled with herbicides. Two rows, 10 and 20 feet long, were harvested at maturity for grain and stover yield for wheat and corn respectively. The 1990 data represents wheat yield after applying P in 1988 only, 1988 and 1989, and 1989 only. Corn yield in 1990 followed P application in 1988 only, 1989 only, 1988 and 1989, 1988, 1989, and 1990, 1989 and 1990, and 1990 only.

Results and Discussion:

Preliminary statistical analysis indicates that wheat grain yield in 1990 was not affected by P application in the fall of 1989 (Table 1). However, P applied in both 1988 and 1989 increased grain yields when averaged across P rates as well as having an apparent rate effect. The soil test for P of 8 ppm (B&K No. 1) would indicate a highly probable yield response to applied P. Subsoil P which is often high in Sharpsburg soils may have influenced results. Stover yields tend to substantiate grain yield effects. The experiment will be continued in 1991 and 1992.

Corn yields were increased in 1990 with applied P but response was also influenced by past P application (Table 2). Higher rates of P seemed to provide somewhat higher grain yields even when applied in 1988 and 1989. However, highest yields were achieved when P was applied in both 1989 and 1990. Data generally indicates knifed in bands have residual values, but is probably mostly limited to bands applied in the previous year.

Table 1. Mean grain and stover yield of wheat as affected by P rate and time sequence 1990.

Year of P application	P rate	Wheat grain	Stover
	kg P ha^{-1}		kg ha^{-1}
1988	0	3376	5510
1988	7.5	3782	7118
1988	15.0	2770	5626
1988	22.5	2836	5626
1988	30.0	3430	5974
Mean		**3204**	**6086**
1988 and 1989	7.5	3523	8457
1988 and 1989	15.0	4145	7412
1988 and 1989	22.5	3992	6676
1988 and 1989	30.0	4753	8095
Mean		**4103**	**7660**
1989	7.5	3501	6710
1989	15.0	4451	7321
1989	22.5	3041	6067
1989	30.0	3160	5490
Mean		**3538**	**6397**

Analysis of Variance

Factor	DF	GY	SY
	----	prob>F	----
Time sequence	2	0.009	0.040
Rate	3	0.342	0.129
lin	1	0.067	0.700
quad	1	0.386	0.571
Time*Rate	6	0.041	0.304

Table 2. Grain and stover yield in Crofton-Nora soil, 1990.

Year of Application	P rate	Grain Yield	Stover Yield
	kg P ha^{-1}		kg ha^{-1}
1988	0	4853	3741
1988	10	5039	3084
1988	20	4946	3652
1988	30	5989	4142
1988	40	5599	4492
Mean		**5393**	**3838**
1988 and 1989	10	4981	4642
1988 and 1989	20	5173	4381
1988 and 1989	30	5248	3733
1988 and 1989	40	5626	3745
Mean		**5257**	**4125**
1988, 1989 and 1990	10	5833	3793
1988, 1989 and 1990	20	5125	3539
1988, 1989 and 1990	30	5740	4159
1988, 1989 and 1990	40	6160	4341
Mean		**5714**	**3958**
1989 and 1990	10	5449	3849
1989 and 1990	20	5900	3526
1989 and 1990	30	5740	4054
1989 and 1990	40	6160	4115
Mean		**5812**	**3886**
1990	10	5247	3373
1990	20	5748	3189
1990	30	5826	4575
1990	40	5213	3624
Mean		**5508**	**3690**
1989	10	5016	3656
1989	20	5312	3991
1989	30	5153	3856
1989	40	5569	3751
Mean		**5262**	**3813**

Analysis of Variance

	DF	GY	SY
Factor		Prob>F	
Time sequence	5	0.064	0.732
Rate	3	0.189	0.239
lin	1	0.046	0.364
quad	1	0.799	0.628
Time*Rate	15	0.119	0.804

Nitrogen Fertilization of Smooth Brome

R.B. Ferguson and G.P. Slater

Objective:

To evaluate the long-term effects of nitrogen (N) fertilizer source, rate, and application method on yield and N use efficiency of smooth brome.

Procedures:

This study was initiated in 1986 at a site located at the USDA Meat Animal Research Center, adjacent to the UNL South Central Research and Extension Center, Clay Center. Soil type is a Crete silt loam. The study evaluates three sources of N (ammonium nitrate, urea, and UAN solution) applied at rates of 50, 100, and 150 lb N/acre. Additionally, UAN solution is applied by three methods (broadcast, knife, and surface-band). Ammonium nitrate and urea are broadcast only. Knife and surface-band applications of UAN are applied on 15 inch centers. Treatments have been re-applied annually to the same plots since 1987. Fertilizer treatments were applied April 2, 1989, and April 12, 1990.

Results and Discussion:

Yield, forage N content, and apparent N recovery for 1989 and 1990 are shown in Tables 1 and 2. Spring and early summer precipitation was considerably below average in 1989, resulting in substantially reduced forage yields in 1989 (Table 1). Although there was a trend for increasing yield with increasing N rate, no significant yield increase was observed with the application of N above 50 lb/acre. Also, no significant effect of N source, or N application method in the case of UAN solution, was observed on forage yield. There was a reduction in forage N content with UAN when the solution was broadcast or knifed-in, compared to surface-band application. Because of the very low yields, forage N content was much greater than in past years. In 1987, for example, forage N content ranged from 1.49 to 1.99% as influenced by N source/application method. In 1989, forage N content ranged from 2.92 to 3.23% as influenced by N source/application method.

Apparent N recovery was calculated based on yield and N content of the forage to give an estimate of how efficiently fertilizer N was used. Apparent N recovery was calculated as:

$$\frac{\text{Treatment N Uptake - Check N Uptake}}{\text{Fertilizer N applied}} \times 100$$

Apparent N recovery values were quite low in 1989, ranging from 9.4 to 18.9% as influenced by N source/application method, with no significant effect of N rate, source, or application method. Yields in 1990 were significantly higher than in 1989 (Table 2), primarily due to greater stored soil moisture and adequate precipitation between April 1 and June 1. Forage yield in 1990 was on average four to five times greater than comparable treatments in 1989. Application of N significantly increased forage yield. As in past years, there was no significant influence of knife operation on yield in 1990, as shown by comparing untreated and knife checks. There was a significant reduction in forage yield at the highest N rate in 1990. This trend was evident across all source/method combinations. One possible reason for yield reduction at the high N rate was lodging of plants which occurred earlier in the season at the high rate. There was no effect of N source/application method on forage yield.

A trend for the knife check treatment to have a higher forage N content has been observed in past years, and this effect was significant in 1990, with the knife check forage N at 1.61% compared to 1.18% for the untreated check. One possible explanation is slightly increased mineralization following the knife disturbance, resulting in increased N uptake and forage N content. However, the knife effect has had no significant effect on forage yield over the course of the study. Forage N content increased with the first two increments of N in 1990, and there was no significant effect of N source/application method on forage N in 1990.

Apparent N Recovery was quite high in 1990 - ranging from 40 to over 70%. These high values may very well reflect carryover N accumulated during the past two years (1988 and 1989) when yields were suppressed due to lack of moisture.

Results in 1989 and 1990 are consistent with past years of this study, suggesting that the optimum N rate is in the vicinity of 100 lb N/acre. No trend towards one N source being superior to another has been noted across years.

Table 1.Comparison of nitrogen rate, sources, and application methods for smooth brome, 1989, Clay Center, NE

Trt	N Rate Lb/A	N Source	Method	Forage Yield LbA @ 12.5% H_20	Forage N	Apparent N Recovery
1	Check	----	----	681	2.01	
2	KN Check	----	----	842	2.21	
3	50	AN	BR	1074	3.14	
4	100	AN	BR	1058	3.28	
5	150	AN	BR	675	3.28	
6	50	UREA	BR	714	3.00	
7	100	UREA	BR	1058	3.29	
8	150	UREA	BR	850	3.32	
9	50	UAN	BR	814	2.80	
10	100	UAN	BR	952	2.91	
11	150	UAN	BR	1077	3.04	
12	50	UAN	KN	755	2.64	
13	100	UAN	KN	694	2.97	
14	150	UAN	KN	1314	3.06	
15	50	UAN	DR	638	3.08	
16	100	UAN	DR	1105	3.03	
17	150	UAN	DR	1145	3.21	
		LSD (0.05		471	0.26	
		F VALUE		1.49	15.56	
		C.V.		36.8	6.3	
Mean Values						
N Rate		50		799 a	2.93 b	14.2 a
		100		973 a	3.10 a	14.0 a
		250		1012 A	3.18 a	10.2 a
		PR>F		0.1575	0.0003	0.495
		C.V.		39.5	6.0	92.6
N Source		AN		936 a	3.23 a	18.9 a
		UREA		874 a	3.20 a	11.9 a
		UAN-BR		948 a	2.92 b	11.6 a
		UAN-DR		962 a	3.10 a	12.2 a
		UAN-KN		921 a	2.89 b	9.4 a
		PR>F		0.9812	0.0001	0.3674
		C.V.		39.5	6.0	92.6

Table 2.Comparison of nitrogen rate, sources, and application methods for smooth brome, 1990, Clay Center, NE

	N Rate Lb/A	N Source	Method	Forage Yield Lb/A @ 12.5% H_20	Forage N	Apparent N Recovery
1	Check	----	----	2813	1.18	
2	KN Check	----	----	2424	1.61	
3	50	AN	BR	5585	1.65	
4	100	AN	BR	5460	1.89	
5	150	AN	BR	4492	2.11	
6	50	UREA	BR	5016	1.13	
7	100	UREA	BR	5007	1.75	
8	150	UREA	BR	4520	1.85	
9	50	UAN	BR	5345	1.33	
10	100	UAN	BR	6108	1.68	
11	150	UAN	BR	5354	1.95	
12	50	UAN	KN	4488	1.17	
13	100	UAN	KN	6492	2.31	
14	150	UAN	KN	4745	2.06	
15	50	UAN	DR	5784	1.51	
16	100	UAN	DR	5507	1.58	
17	150	UAN	DR	5103	1.89	
		LSD (0.05)		1356	0.5	
		F VALUE		4.68	3.79	
		C.V.		19.4	20.9	
Mean Values						
N Rate			50	5244 ab	1.36 b	70.9 a
			100	5715 a	1.83 a	68.7 a
			150	4843 b	1.97 a	38.9 b
			PR>F	0.0278	0.0001	0.0146
			C.V.	18.9	21.2	62.5
N Source			AN	5179 a	1.88 a	72.0 a
			UREA	4848 a	1.57 a	40.6 a
			UAN-BR	5602 a	1.65 a	60.2 a
			UAN-DR	5464 a	1.66 a	64.2 a
			UAN-KN	5242 a	1.84 a	60.7 a
			PR>F	0.4069	0.1797	0.3409
			C.V.	18.9	21.1	62.5

The Effects of a Urease Inhibitor on Volatile Ammonia Loss and Urea Hydrolysis on Irrigated, Ridge Till Corn

Timothy L. Murphy and Richard B. Ferguson

Objectives:

1. To evaluate the potential for yield reduction of irrigated corn due to volatile ammonia loss from a ridge-till system, as influenced by N source, N rate, and placement method.

2. To investigate the potential for N-(n-butyl) thiophosphoric triamide (NBPT), a urease inhibitor, to minimize yield reduction due to volatile ammonia loss, as influenced by N source, N rate, and placement method.

3. To evaluate the effect of NBPT on urea hydrolysis from two N sources.

Procedure:

The first year of this study, located in Clay county Nebraska, has been completed. Two nitrogen fertilizer rates (100 and 200 lb N/acre) were applied using four sources (urea, urea+NBPT, UAN solution, and UAN+NBPT solution). All sources were applied using three placement methods, broadcast (BR), surface banding (SB), or knifed in (KN). Each treatment was replicated four times. The soil was a Crete silt loam.

Pioneer hybrid 3475 was planted on May 18, 1990. Hydrolysis rate cylinders were placed in the 200 lb N/acre, broadcast treatments of all four N sources on three replications. Rain occurred two days prior to applying fertilizer on May 29, 1990. Weather data, prior to and following fertilization, is found in Table 1. The cylinders were removed at day two and nine after fertilization. Their contents were blended and filtered with 1500 ml 2M KCl-PMA solution and then shaken for 30 minutes. An aliquot (120 ml) of each extract was frozen for later NO_3-N analysis. Ear leaf punches and chlorophyll meter readings were taken at tasseling. Samples of the lower stalk were taken 14 days after black layer. These samples will be analyzed for NO_3-N content. Whole plant samples were taken at physiological maturity for total dry matter yield and will be analyzed for Kjeldahl-N concentration. The center two rows of each plot were machine harvested for grain yield on October 22, 1990.

Results:

Grain yields across all treatments were relatively low in 1990. This was caused by several different factors. Delayed planting due to a wet spring and a heavy infestation of corn rootworm beetles at silking were the main reasons grain yield was reduced. Hot, dry weather in late August and early September may have also contributed to the reduced yields. No significant differences in grain yield as influenced by N source, N rate, or method were observed (Table 2). This was also seen in the dry matter yield results.

Percent leaf N was significantly influenced by N rate but not by N source or application method. Figure 1 shows the relationship between percent leaf N and relative chlorophyll content. This study found the same linear relationship between leaf N content and chlorophyll readings observed in other studies.

No significant effect of NBPT on grain yield and dry matter yield was noted. Little effect of NBPT was expected, since the site received 0.59 in of precipitation the day following fertilizer application. It is likely that this amount of rain would have been sufficient to move the fertilizer into the soil and minimize the potential for ammonia volatilization. Grain yield was not limited by N at the lower application rate. Since N was not limiting, practices which conserve N, such as the use of a urease inhibitor, would not be expected to have significant effects. A slight difference was seen in percent leaf

N. Urea+I recorded the highest level of N in the leaf. Analysis of the lower stalk samples for NO_3-N has not been performed at this time. These samples are currently in the lab.

This experiment will be continued in 1991.

Table 1. Weather information for the two week period following fertilization, 1990. Clay Center.

Date	Temperature High	Temperature Low	Soil Temp °F	Precip (in)	Wind Speed (mi/hr)	Relative Humidity %
May 28	75	53	67	0.00	5	76
May 29	74	49	64	0.00	7	79
May 30	66	56	61	0.59	12	97
May 31 **	69	55	62	0.04	8	97
June 01	81	62	68	0.16	14	90
June 02	73	51	65	0.31	14	80
June 03	72	48	66	0.12	11	68
June 04	79	42	68	0.00	10	74
June 05	83	61	74	0.00	9	68
June 06	82	60	74	0.12	9	51
June 07**	78	55	70	0.51	7	85
June 08	80	59	72	0.08	7	84
June 09	88	56	76	0.00	4	75
June 10	78	65	72	0.75	12	93
June 11	93	69	75	0.00	15	74

* Fertilized on May 29, 1990

** Removed cylinders on day 2 and 9 after fertilization.

Table 2.Comparison of nitrogen rate, sources, application methods, and urease inhibitor for NBPT for irrigated, ridge-till corn, 1990, Clay Center, NE

Trt	N Rate Lb/A	N Source	Method	Forage Yield Lb/A @ 12.5% H_20	Forage N	Apparent N Recovery
1	UAN	0	NONE	117.3	2.62	4920
2	UAN	100	SB	129.1	3.10	5756
3	UAN	100	BR	128.2	3.11	6811
4	UAN	200	SB	121.4	3.63	6387
5	UAN	200	KN	137.3	3.38	6138
6	UAN+I	200	BR	120.3	3.54	6219
7	UAN+I	100	SB	126.2	3.28	6413
8	UAN+I	100	BR	123.3	3.24	4765
9	UAN+I	200	SB	119.1	3.67	5560
10	UREA	200	BR	124.7	3.44	5935
11	UREA	100	SB	117.7	3.38	6149
12	UREA	100	BR	127.7	3.34	5982
13	UREA	200	SB	124.2	3.68	5510
14	UREA+I	200	BR	125.4	3.45	5755
15	UREA+I	100	SB	116.9	3.49	5274
16	UREA+I	100	BR	120.8	3.40	6060
17	UREA+I	200	SB	126.9	3.64	6065
18	CHECK	200	BR	130.3	3.62	6245
19	CHECK	0	NONE	125.2	2.47	5156
Treatment Number			F Value	0.49	13.7	1.59
			PR>F	0.9491	0.0001	0.0992
			C.V.	12.6	5.3	14.0
Mean Values Source[1]			UAN	124.7 a	3.34 b	6219 a
			UAN+I	123.3 a	3.42ab	5887 a
			UREA	124.1 a	3.45ab	5803 a
			UREA+I	123.3 a	3.53a	5862 a
			PR>F	0.9938	0.0415	0.4870
			C.V.	12.5	5.1	13.3
N Rate[1]			100	123.9 a	3.29 b	5887 a
			200	123.8 a	3.58 a	6013 a
			PR>F	0.9795	0.0001	0.5408
			C.V.	12.5	5.1	13.3
Method[2]			SB	121.4 a	3.63 a	6387 a
			BR	120.3 a	3.54 a	5922 a
			KN	137.3 a	3.38 b	6487 a
			PR>F	0.3678	0.0278	0.8180
			C.V.	13.8	2.7	21.1

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[1] KN treatment was removed from the source and N rate means for comparison.
[2] Method mean values are for the UAN 200 lb treatments only.

Winter Cover Crop Effects on Nitrogen Management of Irrigated Corn

Richard B. Ferguson, James F. Power, and Glen P Slater

Objectives:

1. To evaluate the effects of winter rye, hairy vetch, and a rye/vetch combination on yield response of irrigated corn.

2. To monitor the accumulation and movement of nitrate-N as influenced by N rate and cover crop.

3. To evaluate if fertilizer N recommendations for irrigated corn need to be altered following winter cover crops.

Procedure:

This study, located at the SCREC Research Farm near Clay Center, was initiated in 1986. The soil at the site is Butler silt loam (fine, montmorillonitic, mesic Abruptic Argiaquolls). The site is sprinkler-irrigated with towlines. Prior to study initiation in 1986, the site was disked twice prior to planting. From 1987 to 1989, the established cover crops were sprayed with glyphosate, then deep chiseled and disked 5-10 days later. In 1990, plots were ridge-planted following dessication of the cover crops. Pioneer hybrid 3475 seed corn has been planted each year of the study. Planting dates have been in the first or second week of May. Herbicides (alachlor [Lasso] and cyanazine [Bladex]) were applied each year following planting.

Nitrogen rates have been sidedressed as anhydrous ammonia, normally at the 5-6 leaf stage. Nitrogen was applied at rates of 80, 160, and 240 kg N ha^{-1}, plus an unfertilized check. Plots have been cultivated each year, followed by a ridge forming operation in 1989 and 1990. Winter cover crops have been hand-seeded by broadcasting seed into the interrow area at the rate of 34 kg ha^{-1} for hairy vetch, 56 kg ha^{-1} for winter rye, and at half rates of each seed for the composite cover crop plots. The study was a randomized, complete block design with three replications. Row spacing was 0.762 m. Plot size was 12 rows (9.14 m) wide by 12.2 m long.

In 1986, cover crops were interseeded into standing corn following the last cultivation. In 1987 and subsequent years, cover crops have been interseeded later, normally in early August. In 1990, because of weed pressure, primarily foxtail, seeding of the cover crops was delayed until after harvest. Glyphosate was applied to the foxtail immediately following harvest, then cover crops were seeded in late September. Yield was measured each year by hand-harvesting four, 3.05 m sections of row from the center four rows.

In 1989 and 1990, yield and N content of the cover crops were evaluated in the spring prior to killing the cover crop chemically. From each plot, three 1 m^2 areas of cover crop were harvested and dried to determine cover crop dry matter yield. Total N content of each cover crop was also determined.

Soil samples were collected from each plot in the spring to a depth of six ft. Two cores were collected, and composited in one ft increments for each plot. Samples were analyzed for ammonium and nitrate-N content.

Results:

Corn grain yield results are shown in Table 1 and Figures 1 and 2. Yields were highest in 1986, and declined each year until 1990, when yields were greater than 1989. In 1986, yields were not substantially influenced by the cover crop. In 1986, the cover crop was seeded relatively early, and shading of the corn canopy killed most of the cover crop by corn harvest. Consequently, very little of the cover crop was present during the spring of 1987. In 1988 and

1989, early growth and consequently yield may have been suppressed due to moisture use by the cover crop prior to planting corn. Yield has also been reduced in later years of the study due to foxtail weed pressure, late planting, and rodent damage to seedlings.

Cover crop effects on corn grain yield have not been significant in any year of the study (Figure 2). In general, yields have been suppressed due to factors other than the cover crop.

In 1989 and 1990, cover crop growth in the spring was adequate to evaluate N uptake by the cover crop. The amount of cover crop growth in the spring was related largely to temperature conditions in the spring, and how long the cover crop was allowed to remain growing prior to spraying. In most years, including those when no quantitative evaluation of cover crop yield was made, top growth of rye was much greater than that of hairy vetch. Nitrogen uptake by vetch was similar to rye in 1989 (Figure 3), since, even though top growth was less, forage N content of the vetch was greater (Table 2). In 1990, forage yields of all cover crops were less than in 1989 (Table 3), and forage N contents of cover crops were similar. Consequently, N uptake by vetch in 1990 was less than for rye or the vetch/rye mix.

Soil profile nitrate-N prior to planting in the spring is shown for 1989 and 1990 in Figures 4 and 5. In general, rye or the vetch/rye mix as cover crops has reduced the amount of nitrate-N remaining in the soil. Vetch as a cover crop has not significantly reduced nitrate-N in the profile, compared to plots with no cover crop.

Summary:

Much of the activity during early years of this study involved learning when and how to interseed cover crops into irrigated corn. Cover crop establishment in the fall, and survival during the winter, was minimal in the first 2-3 years of the study. In years 4 and 5, some general effects of cover crops have been observed, but yields of the corn crop have been suppressed. Starting in the fall of 1990, volumetric soil moisture has been evaluated on a regular basis. Patterns of soil moisture use by the cover crops will be measured in spring, 1991 and subsequent years of the study.

Table 1. Winter Cover Crop - Nitrogen Management Study, summary of yields, 1986 - 1990

Treatment	Cover Crop	N Rate (kg/ha)	Yield (Mg/ha) 1986	1987	1988	1989	1990
1	NONE	0	9.44	5.37	7.21	6.15	7.16
2	NONE	80	11.61	7.99	6.95	6.57	7.34
3	NONE	160	11.09	9.50	7.09	5.87	8.03
4	NONE	240	12.49	10.04	5.34	6.30	8.33
5	VETCH	0	8.57	3.84	5.68	4.87	5.83
6	VETCH	80	11.76	8.78	8.93	5.83	6.80
7	VETCH	160	12.07	9.82	6.86	6.59	8.30
8	VETCH	240	11.97	10.18	9.12	9.29	8.43
9	RYE	0	10.05	4.15	5.12	5.64	5.14
10	RYE	80	10.87	8.00	7.31	6.13	6.25
11	RYE	160	12.35	9.72	8.20	9.63	8.34
12	RYE	240	12.02	9.59	8.45	6.12	8.26
13	V/R	0	9.18	5.37	5.74	4.23	5.91
14	V/R	80	10.77	9.01	6.94	6.11	6.59
15	V/R	160	11.49	9.47	8.04	6.21	7.49
16	V/R	240	12.64	9.36	7.18	6.89	7.75
	CV(%)		----	6.77	25.34	22.80	10.50

Table 2. Comparison of nitrogen rate and winter cover crop effect on corn, 1989, Clay Center, NE.

Mean Values		Corn Yield (Mg/ha)	Cover Crop DM Yield (kg/ha)	Cover Crop % N
NRate (kg/ha)	0	5.22 b	570.5 b	2.34 b
	80	6.16 ab	611.7 b	2.40
	160	7.07 a	899.6 a	2.60 a
	240	7.15 a	1036.5 a	2.96 a
	PR>F	0.009	0.0001	0.0366
	C.V.	22.8	23.9	17.8
Cover Crop	None	6.22 a	----	----
	Vetch	6.64 a	492.1 b	3.57 a
	Rye	6.88 a	856.1 a	1.99 b
	Vetch/Rye	5.86 a	990.5 a	2.17 b
	PR>F	0.03468	0.0001	0.0001
	C.V.	22.8	23.9	17.8

Table 3. Comparison of nitrogen rate and winter cover crop effect on corn, 1990, Clay Center, NE.

Mean Values		Corn Rel. Chlorophyll at Anthesis	Corn Yield (Mg/ha)	Cover Crop DM Yield (kg/ha)	Cover Crop %N
NRate (kg/ha)	0	44.9 c	6.01 c	393.8 a	3.03 a
	80	50.9 b	6.75 b	351.7 a	2.97 a
	160	54.7 a	8.04 a	377.5 a	3.06 a
	240	54.7 a	8.20 a	361.8 a	3.17 a
	PR>F	0.0001	0.0001	0.852	0.7301
	C.V.	5.2	10.5	29.1	12.9
Cover Crop	None	52.9 a	7.72 a	----	----
	Vetch	50.1 b	7.34 ab	127.3 b	3.20 a
	Rye	50.0 b	7.00 b	484.9 a	2.99 a
	Vetch/Rye	52.1 ab	6.94 b	501.4 a	2.98
	PR>F	0.0271	0.0634	0.0001	0.3407
	C.V.	5.2	10.5	29.1	12.9

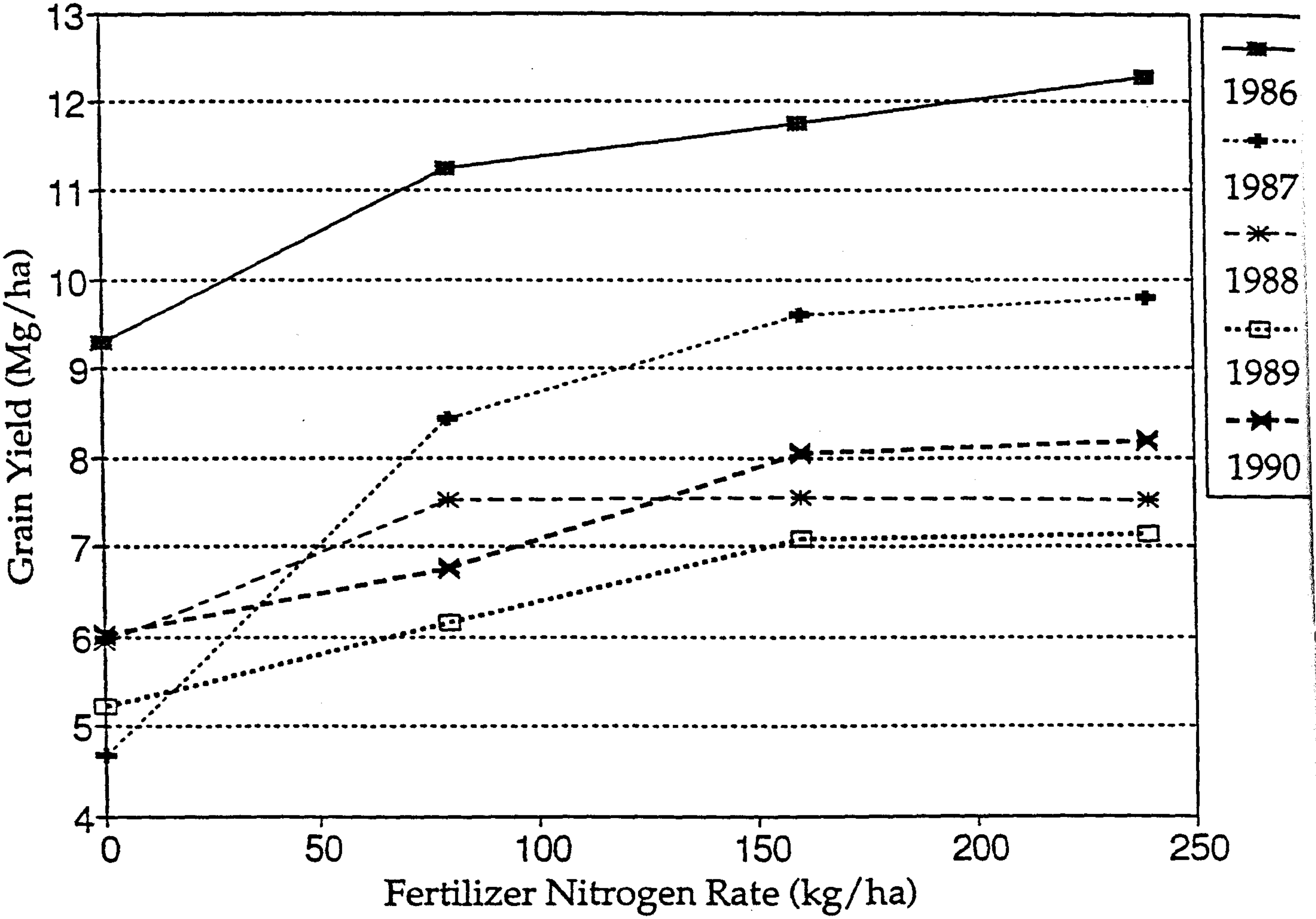


Figure 1. Corn grain yield as influenced by year and fertilizer N rate, 1986-1990.

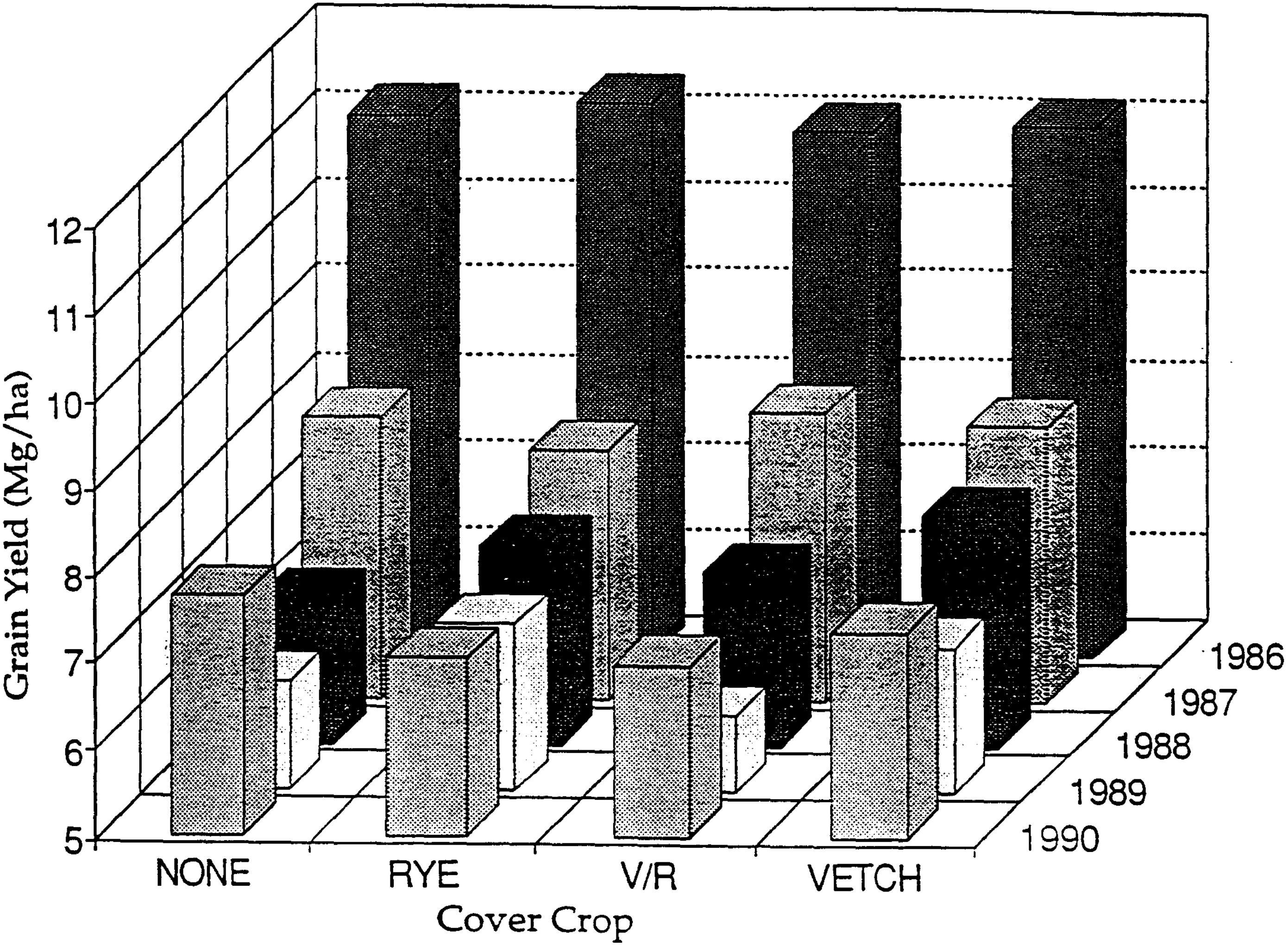


Figure 2. Corn grain yield as influenced by year and winter cover crop combination, 1986-1990.

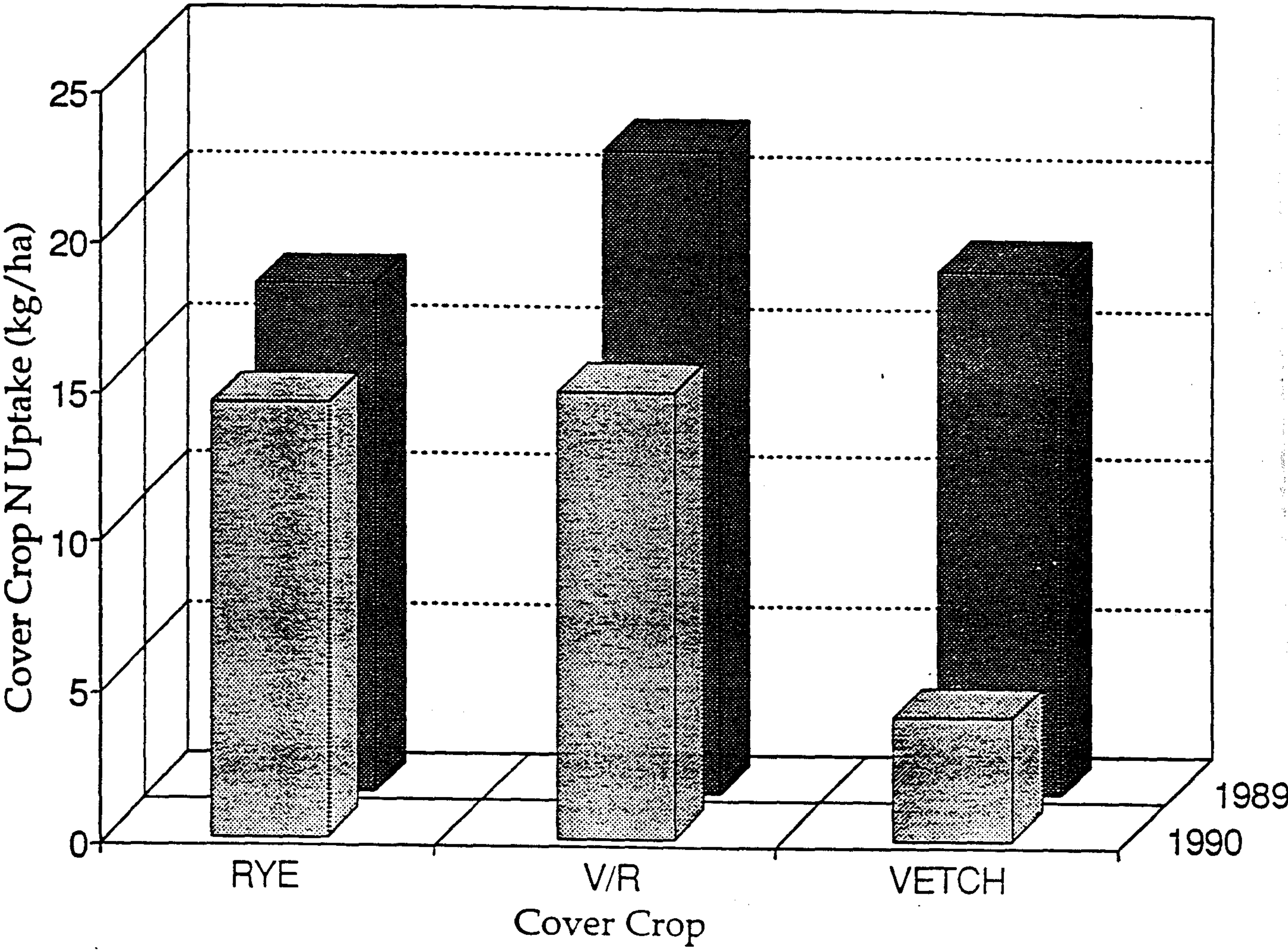
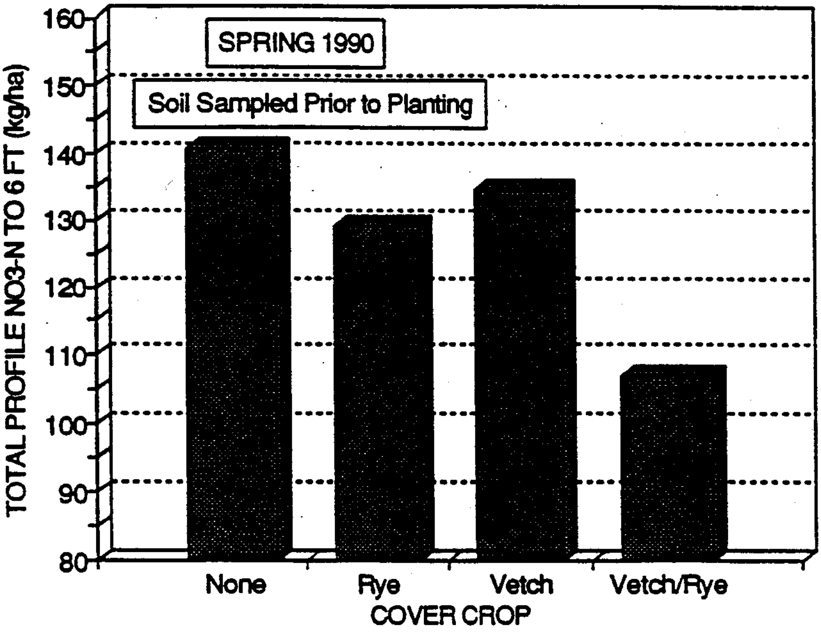


Figure 3. Winter cover crop N uptake, 1989-1990.



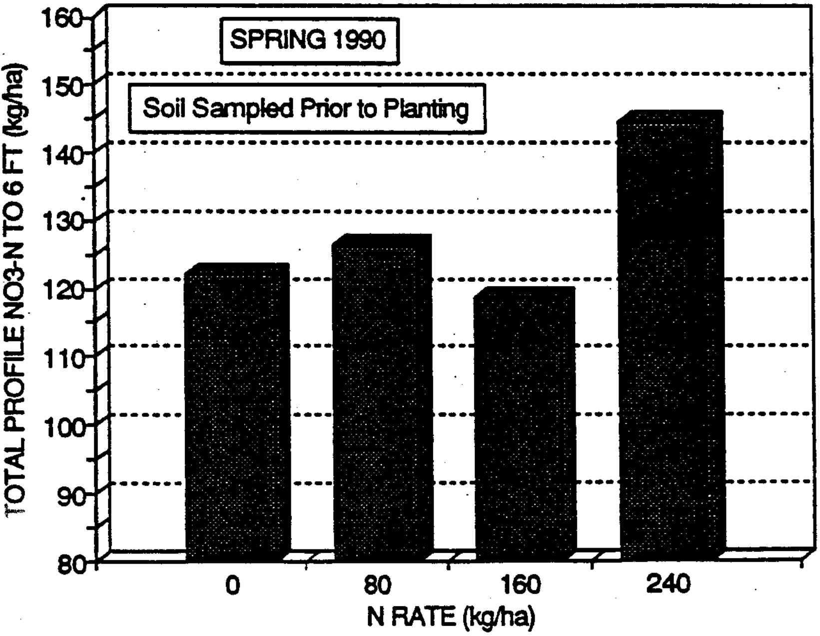


Figure 4. Soil profile NO_3-N, spring 1989, as influenced by winter cover crop and Fertilizer N rate.

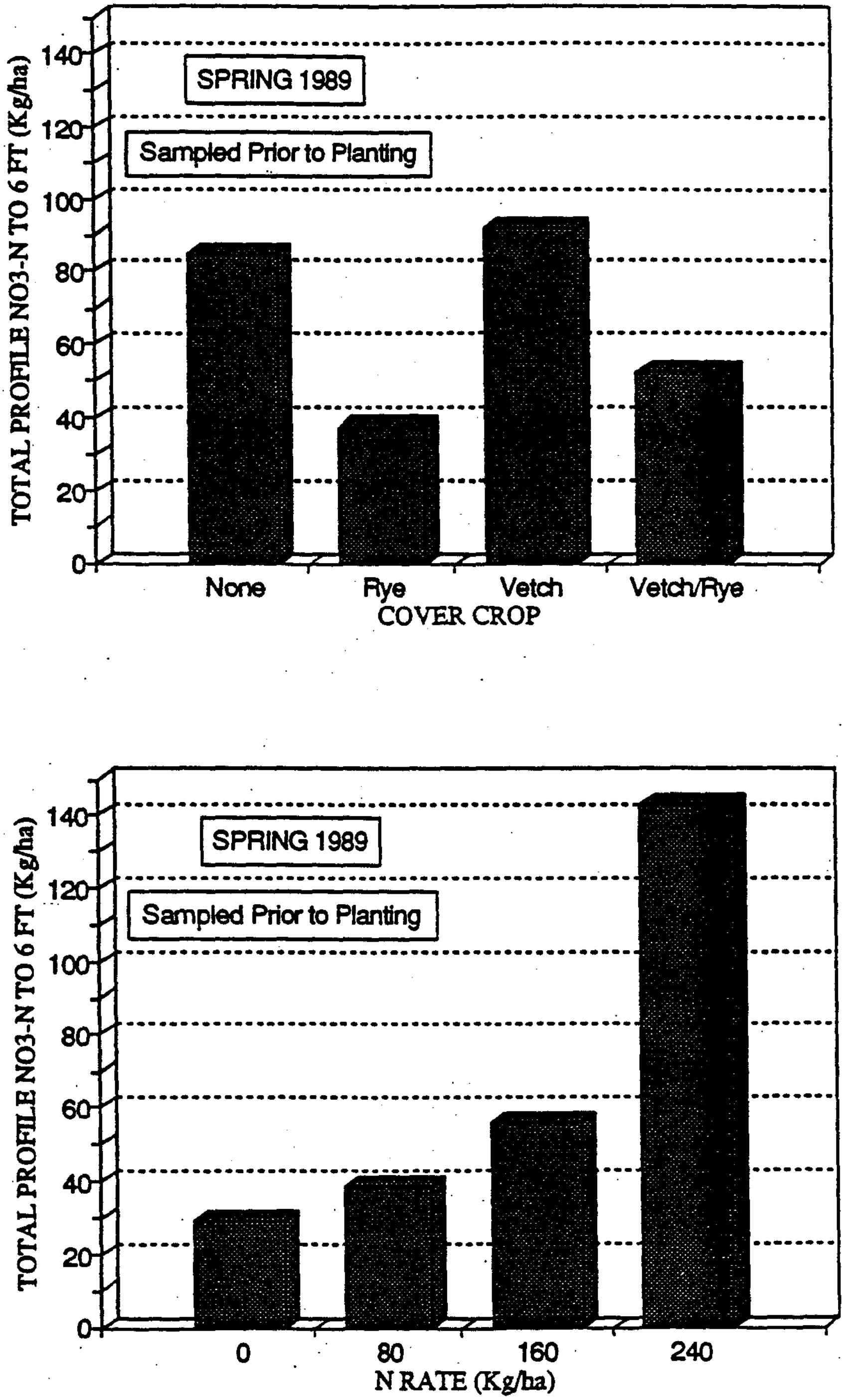


Figure 5. Soil profile NO_3-N, spring 1990, as influenced by winter cover crop and fertilize N rate.

Tillage, Rotation and N Rate Effects of Dryland Corn Production and Nitrogen Uptake in Northeastern Nebraska

D.T. Walters and C.A. Shapiro

Objectives:

1. To determine the effects of tillage on corn yield when grown in rotation with soybeans or continuously with or without a hairy vetch cover crop.

2. To determine the effect of rotation and cover crop on the status of soil nitrate-N under different tillage regimes.

Procedures:

Three corn crop sequences: continuous corn (CC), corn-soybean (CB) and continuous corn with a hairy vetch (Vicia villosa) cover crop (CCV) were established in 1985 under three tillage systems: spring disk (DK), spring plow (MP) and no-till (NT) at the Northeast Research and Extension Center, Concord, NE. Five N rates (0, 40, 80, 120 and 160 kg N/ha) within each tillage x cropping system were applied annually (1985-88) to corn as broadcast NH_4NO_3 prior to tillage in the spring. Nitrogen fertilizer has not been applied to soybeans. This experiment was designed as a split-split plot RCB with tillage as the main plots (100' x 210'), rotations as the subplots (100' x 35'), and N rates as sub-sub plots (20' x 35'). SOil type is a Kennebec silt loam (Cumulic Hapludoll).

Nitrogen fertilizer was not applied in 1989 or 1990 as residual soil NO_3-N concentrations had built up to levels exceeding 250 kg N/ha. The effect of residual soil NO_3-N on 1990 crop yields were determined by including individual plot soil NO_3-N as a covariate nested within tillage and rotation in the analysis of variance (Table 3).

Corn (Pioneer 3475, 110d RM) was planted on May 25 at 44,000 plants/ha in 0.75m rows. Counter was applied to all corn for rootworm control. Century soybeans were planted om May 27 at 90 kg seed/ha. Weeds were chemically controlled on all plots with the addition of a cultivation in the DK and MP treatments in June. Corn grain was hand harvested and stover mechanically harvested from 12m of row on October 24. Soybeans were combine harvested on October 5th.

Hairy vetch was broadcast into standing corn at a rate of 25 kg seed/ha on August 29, 1989 and a good stand of vetch resulted in the fall of 1989. Vetch dry matter production was evaluated prior to tillage operations on May 13, 1990 by taking a 100 point line intersect count in each plot and multiplying the count by dry matter harvested from five 1 ft^2 areas in each tillage block. Residual soil NO_3-N was determined to a 1.5m depth from soil sampled from all plots in the spring of 1990. Gravimetric soil water content was also determined within each tillage/rotation treatment at the time of soil NO_3-N sampling.

Results:

Growing season precipitation was near normal in 1990 however subsoil water storage at the start of the season was below normal, even dryer than the spring of 1989 which followed a severe drought year. As a result, corn grain yield did not exceed 5.9 Mg ha^{-1}. Soil water content was not affected by previous crop, however water content was significantly lower under MP at the 0.6 and 1.2 m depths (Fig. 1) when compared to NT or DK.

Vetch dry matter production and N content in above ground dry matter was very low under NT and highest under MP (Table 1). As in the past, N rate or level of residual NO_3-N had not obvious effect on vetch production. The superior vetch growth recorded under MP has been observed every year however the percent cover provided by vetch has not matched that from reduced tillage.

Residual soil NO_3-N (RSN) concentrations were significantly reduced under NT following CC as compared to soybean,CCV or other tillage systems (Fig. 2). In 1989, grain yield of continuous corn under NT increased with increasing level of RSN. In 1990, the level of RSN had declined following continuous corn relative to other rotations and actually increased following vetch. This was probably due to the record vetch crop of 1989 (1.2 Mg ha_{-1}). Across all treatments, 90% of the RSN in the top 1.5m resided in the top 0.9m depth indicating very low leaching load over the past two years.

Corn grain yields were not significantly increased following soybean as had been observed from 1985-88. A significant grain yield increase was observed following soybean under NT (Table 2 and 4). Analysis of the effect of RSN on 1990 corn grain yield (Table 3) indicated a significant linear decrease in grain yield as a function of increasing RSN for corn following soybean (MP) and an increase in yield x RSN under NT for CCV (Fig. 3). The observed lack of rotation response under DK and MP has apparently resulted from the negative effects of elevated RSN under these tillage systems following the 1989 growing season. Stover yield and N uptake were also increased under NT in 1990 (Table 5.) Soybean yields in 1990 were excellent and averaged 45 bu/acre and were unaffected by tillage or RSN.

Table 1. Vetch yield and N content, CCV plots, spring 1990. Concord, NE.

	Cover	Above ground dry matter	N	N Content
	%	kg/ha	%	kg/ha
Tillage				
Disk	5.9	89	4.71	4.3
Sp. Plow	19.1	332	4.82	15.7
No-till	5.9	55	4.39	2.4
N rate (kg/ha)*				
0	10.1	158	4.72	7.4
40	9.1	177	4.62	8.4
80	11.5	145	4.68	7.1
120	10.6	130	4.72	6.0
160	9.9	181	4.87	8.3
		Analysis of Variance		
Source	Prob>F			
Tillage	.08	.04	NS	.04
NT vs. Rest	NS	.09	NS	.09
MP vs. DK	.05	.03	NS	.04
N Rate	NS	NS	NS	NS
Till x NR	NS	NS	NS	NS

* N rate last applied in spring 1988. Individual N rate plots were harvested in 1990 and ANOVA indicates subsampling variance.

Table 2. Analysis of variance for selected variable, tillage x rotation, N rate. Concord, NE 1990.

Source	df	Grain yield	Grain N (%)	Grain N removal	Population	Stover yield	Stover N (%)	Stover N removal	Barren Stalks	G/S Ratio	Soybean Yield
		---------- Prob F ----------									
Tillage	2	NS	.02	NS	NS	.05	.04	NS	NS	NS	NS
NT vs Rest	1	NS	.01	NS	NS	.03	.02	NS	NS	NS	NS
MP vs DK	1	NS	NS	NS	NS	NS	NS	NS	NS	.06	NS
Rotation	2	NS	.001	.03	.006	NS	NS	NS	NS	NS	--
CB vs Rest	1	NS	.001	.01	.004	NS	NS	.08	NS	NS	--
CC vs CCV	1	NS	.08	NS	NS	NS	NS	NS	NS	NS	--
Till x Rotation	4	NS	.03	.005	.008	.08	NS	.07	NS	NS	--
NT vs Rest x CB vs Rest	1	.05	.04	.001	.001	NS	NS	.02	NS	NS	--
NT vs Rest x CC vs CCV	1	.10	NS	.02	NS	.06	NS	NS	NS	NS	--
MP vs DK x CB vs Rest	1	NS	.10	NS	NS	NS	NS	NS	NS	NS	--
MP vs DK x CC vs CCV	1	NS	.05	NS	NS	NS	NS	NS	NS	NS	--
NR*		NS	NS	NS	NS	NS	.001	.004	NS	NS	NS
Till x NR*		NS	NS	NS	NS	.06	NS	.05	NS	NS	NS
Rot x NR*		NS	NS	NS	NS	NS	NS	NS	NS	NS	--
Till x Rot x NR*		NS	NS	NS	NS	NS	NS	NS	NS	NS	--

* N rates last applied in spring 1988. Individual N rate plots were harvested in 1990 and ANOVA indicates subsampling variance. See Table for variance analysis of residual soil NO_3--N vs yield.

Table 3. Analysis of variance for grain yield with residual soil NO_3-N (RSN).

Model	Prob>F	Parameter	Disk			Sp. Plow			No-till		
			CB	CC	CCV	CB	CC	CCV	CB	CC	CCV
			---------------- Prob>T for H_0: parameter = 0 ---------------								
1. RSN (Till x Rot)	.26	b_1	NS	NS	NS	.01	NS	NS	NS	NS	NS
2. RSN (Till x Rot)	.17	b_1	NS	NS	NS	NS	.03	NS	NS	NS	.003
$(RSN)^2$(Till x Rot)	.04	b_2	NS	NS	NS	NS	.03	NS	NS	NS	.003

Table 4. Main effect and 2-way interaction means for corn grain yield, N content, N removal, population and soybean yield, 1990.

Source		Corn Grain yield*	N	Grain N removal	Population	Soybean yield
		Mg/ha(bu/A)	%	kg/ha	1000/ha	Mg/ha (bu/A)
Tillage						
Disk		5.58(105)	1.62	90	42.0	2.4(44)
Sp. Plow		5.54(104)	1.62	89	40.5	2.5(48)
No-till		6.02(114)	1.48	89	40.8	2.4(44)
Rotation						
Corn/Seg (CB)		5.74(108)	1.63	93	42.5	--
Cont. Corn (CC)		5.72(108)	1.52	87	41.0	--
Cont. Corn w/vetch (CCV)		5.67(107)	1.56	88	39.9	--
Till x Rotation						
Disk	CB	5.44(103)	1.68	91	42.2	
	CC	5.86(110)	1.55	90	42.1	
	CCV	5.42(102)	1.62	88	41.8	
Sp. Plow	CB	5.46(103)	1.64	89	40.7	
	CC	5.61(106)	1.63	91	41.7	
	CCV	5.55(105)	1.60	88	39.2	
No-till	CB	6.32(119)	1.57	90	44.6	
	CC	5.70(107)	1.40	80	39.3	
	CCV	6.04(114)	1.46	89	38.6	

* Grain yield as Mg/ha is for dry matter yield, bu/A adjusted to 15.5% moisture for corn and 13% for soybean.

Table 5. Main effect and 2-way interaction means for stover yield, N content and stover N removal, barren stalks and B/S ratio, 1990.

Source		Stover yield	N	Stover N removal	Barren stalks	Grain/Stover ratio
Tillage						
Disk		4.14	0.78	32	0	1.37
Sp. Plow		3.84	0.80	31	0	1.46
No-till		4.43	0.71	32	0	1.38
Rotation						
Corn/Seg (CB)		4.22	0.78	33	0	1.37
Cont. Corn (CC)		4.06	0.73	30	0	1.43
Cont. Corn w/vetch (CC)		4.12	0.77	32	0	1.40
Till x Rotation						
Disk	CB	3.98	0.81	32	0	1.38
	CC	4.24	0.72	31	0	1.41
	CCV	4.20	0.80	34	0	1.31
Sp. Plow	CB	4.00	0.78	31	0	1.37
	CC	3.88	0.81	31	0	1.47
	CCV	3.64	0.81	29	0	1.55
No-till	CB	4.65	0.76	36	0	1.37
	CC	4.07	0.67	27	0	1.42
	CCV	4.52	0.69	31	0	1.34

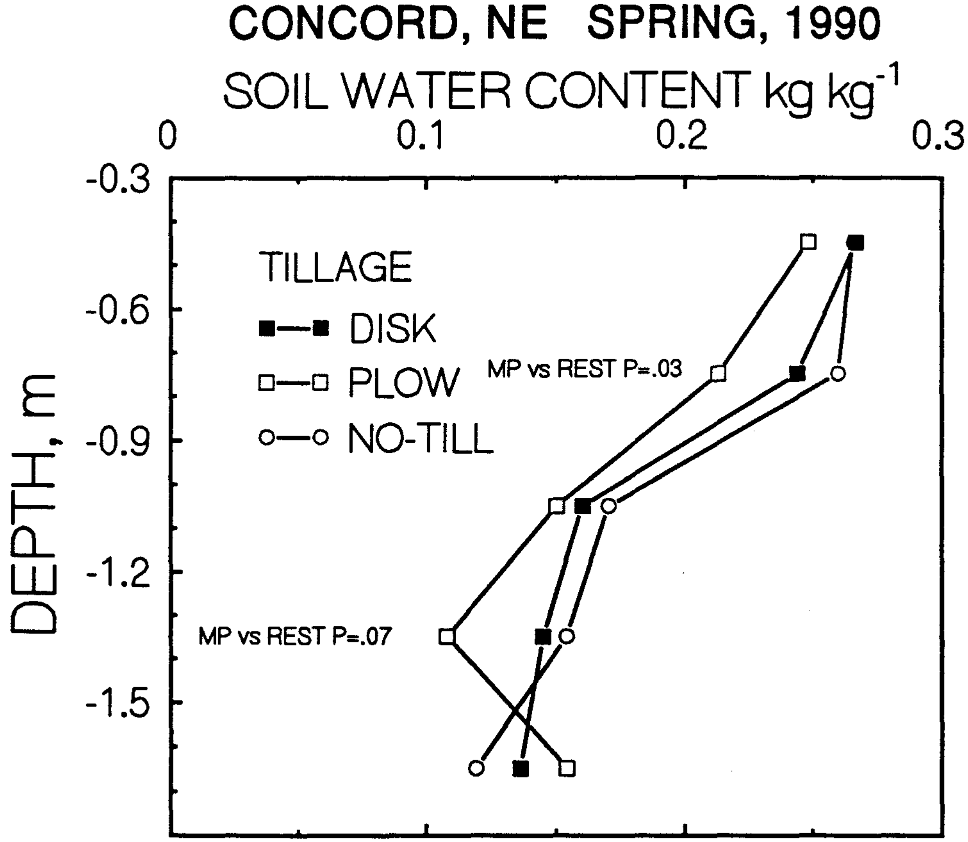


Fig. 1. Gravimeter soil water content, Spring, 1990 with statistically significant single degree of freedom contrasts for the tillage main effect.

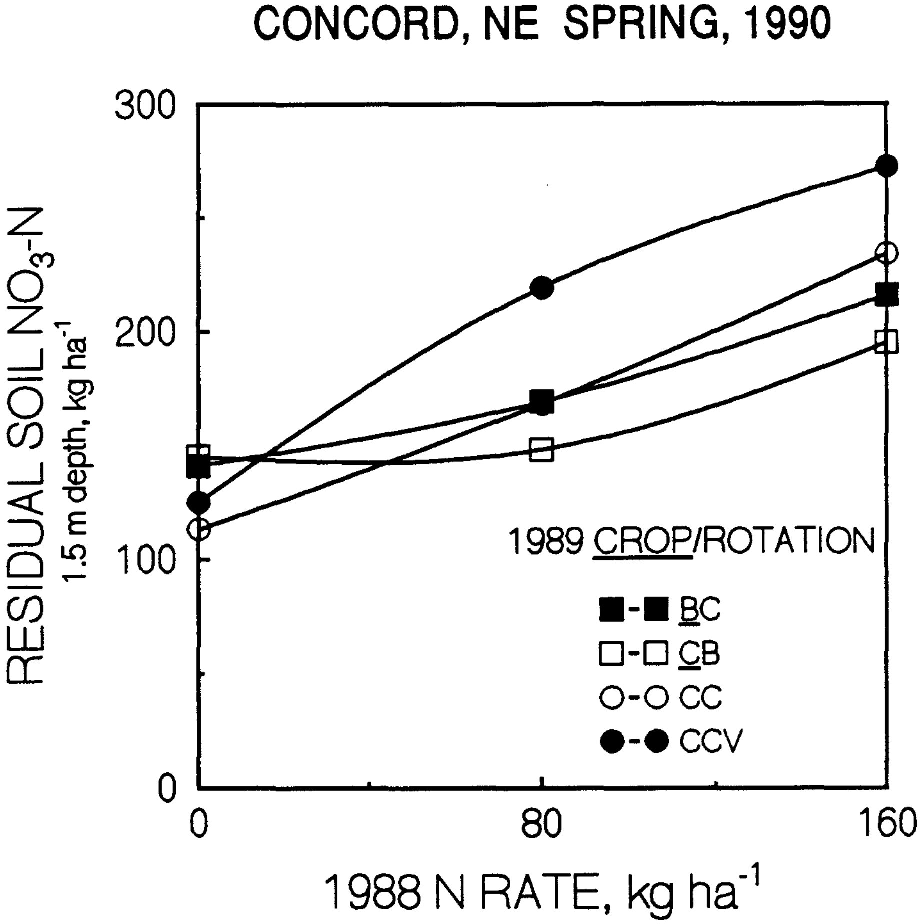


Fig. 2. Residual soil NO_3-N to a depth of 1.5 m, Spring 1990.

Analysis of Variance

Source	df	Prob. > F
Tillage	2	.06
NT vs. Rest	1	.04
DK vs. MP	1	NS
Rotation	3	.003
CCV vs. CC	1	.002
CB vs. CC	1	NS
CB+BC vs. CC+CCV	1	.005
Till x Rot	6	.06
NR	2	.0001
NR_{lin}	1	.0001
NR_{quad}	1	NS
Till x NR	4	NS
Rot x NR	6	0.07
Till x Rot X NR	12	0.03

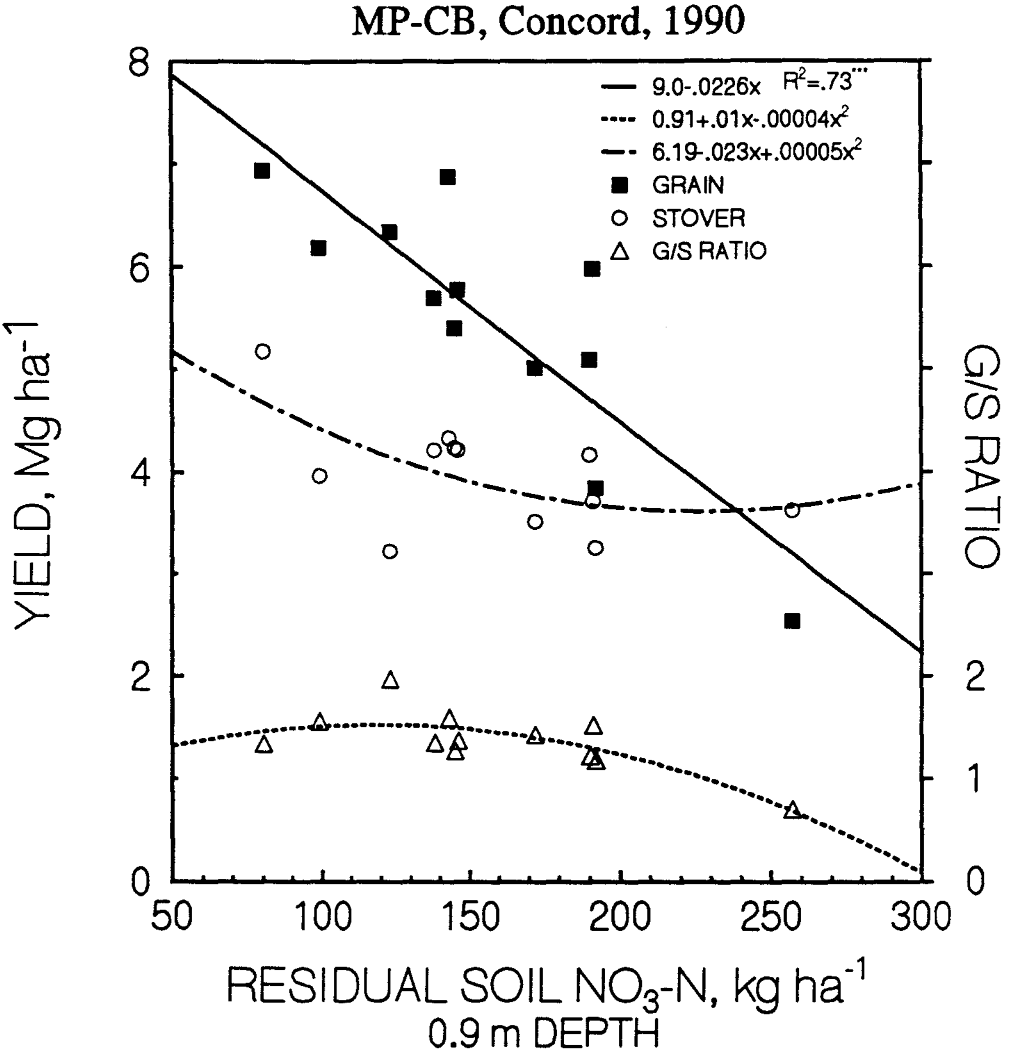


Fig. 3. Corn grain yield vs. residual soil NO_3-N (0.9 m depth) for MP-CB rotation. 1990.

Increasing Nitrogen Use Efficiency by Dryland Sorghum Under Conventional and No-tillage Systems.

M.V. Marake, D.T. Walters and D.H. Sander.

Objectives:

1) To evaluate the effects of no-tillage and conventional disk systems on dryland sorghum production.

2) To determine the effect of different N sources, timing of N application and placement of N on dryland sorghum production under different tillage systems.

Procedures:

The experiment was conducted at the Agricultural Research and Development Center at Mead, Nebraska. The soils at the site were the Sharpsburg silty clay loam (Typic Argiudoll) and Butler silty clay loam (Abruptic Argiudoll). The experiment was replicated four times as a split plot in a randomized complete block design. Blocking was carefully arranged on the basis of soil type. Main plots consisted of 2 tillage treatments (conventional spring disk (D) and no-tillage (NT) (30 m x 30 m)) and a factorial combination of N rate, N source/placement and N application time as the subplot (9.2 m x 4.6 m). The subplot treatments consisted of:

A) N source and placement
1) Urea ammonium nitrate (28% N UAN) solution surface dribbled between sorghum rows (UD)
2) UAN knifed between sorghum rows (UK)
3) Anhydrous Ammonia (AA)
B) N timing
1) Preplant (PP)
2) Sidedress (SD)
C) N rate (kg N ha^{-1}): 0, 40, 80 and 120.

The control treatments (0 N rate) were knifed with no fertilizer applied at both times of application for UK and AA N sources. Sorghum (Pioneer 8333-72 day RM) was seeded on May 22nd, 1990 at a rate of 4.5 kg ha^{-1} in a 0.75 m row spacing. Weeds were chemically controlled with periodic hand hoeing of weed escapes. Nitrogen was applied preplant on May 22nd, 1990 and sidedressed on July 24th, 1990 when the sorghum was at the 8-leaf stage (growing point differentiation).

Three rows were combine harvested for grain yield and N uptake. Total nitrogen was determined on all grain by the Kjeldahl method. This experiment was a fourth year of a long term tillage experiment initiated in 1987. The experiment was conducted on the same plot areas with no treatment modification in all four years. Grain yields were calculated on the basis of harvested area (row length). Analysis of covariance revealed a significant quadratic relationship between harvested row length and grain yield was adjusted accordingly. An analysis of variance for treatment main effects, interactions and single degree of freedom contrasts are presented in Tables 1.

Results and Discussion:

Total rainfall for the months of April, May, June, July, August and September was 8.13, 111.8, 125.4, 228.85, 21.34 and 21.34 mm respectively (Fig. 1). Sorghum grain yield averaged 4.02 Mg ha^{-1} (75.8 bu A^{-1}) and ranged between 1.81 and 4.96 Mg ha^{-1} (34.12 and 93.50 bu A^{-1}) depending on treatment.

Grain yield was influenced by till, N form placement and rate of N application. There was no yield response to applied N regardless of source of N under the disk system. However, in the no-till system there was a significant quadratic response to both AA and UK sources with a maximum yield observed with UK at 80 kg N ha^{-1} (Fig. 2). The lack of response to applied N in the disk system is thought to be the result of greater soil N mineralization and organic matter decomposition enhanced by disking operations compared to no-till systems. This observation is consistent with previously observed trends on this experiment with tendencies for greater N requirements to maximize grain yield under no-tillage compared to disk systems.

No-tillage has also consistently resulted in greater grain yield compared to DK in three of the last four years. Similar trends have also been reported by other researchers showing equal or greater yields under no-till compared to conventional tillage practices in long term tillage experiments. Figure 3 shows the results of N placement as function of N rate and timing of application. Despite a series of light precipitation following PP N application on May 17th, grain yield was lower for UD systems compared to the UK. In contrast the SD application was followed immediately by 170 mm of rain. The result was a better performance of UD compared to UK at low N rates. Observations from the previous years of this experiment have also showed that the performance of UD is greatly affected by climatic conditions around the time of N application. Low precipitation precludes the movement of N into the root zone.

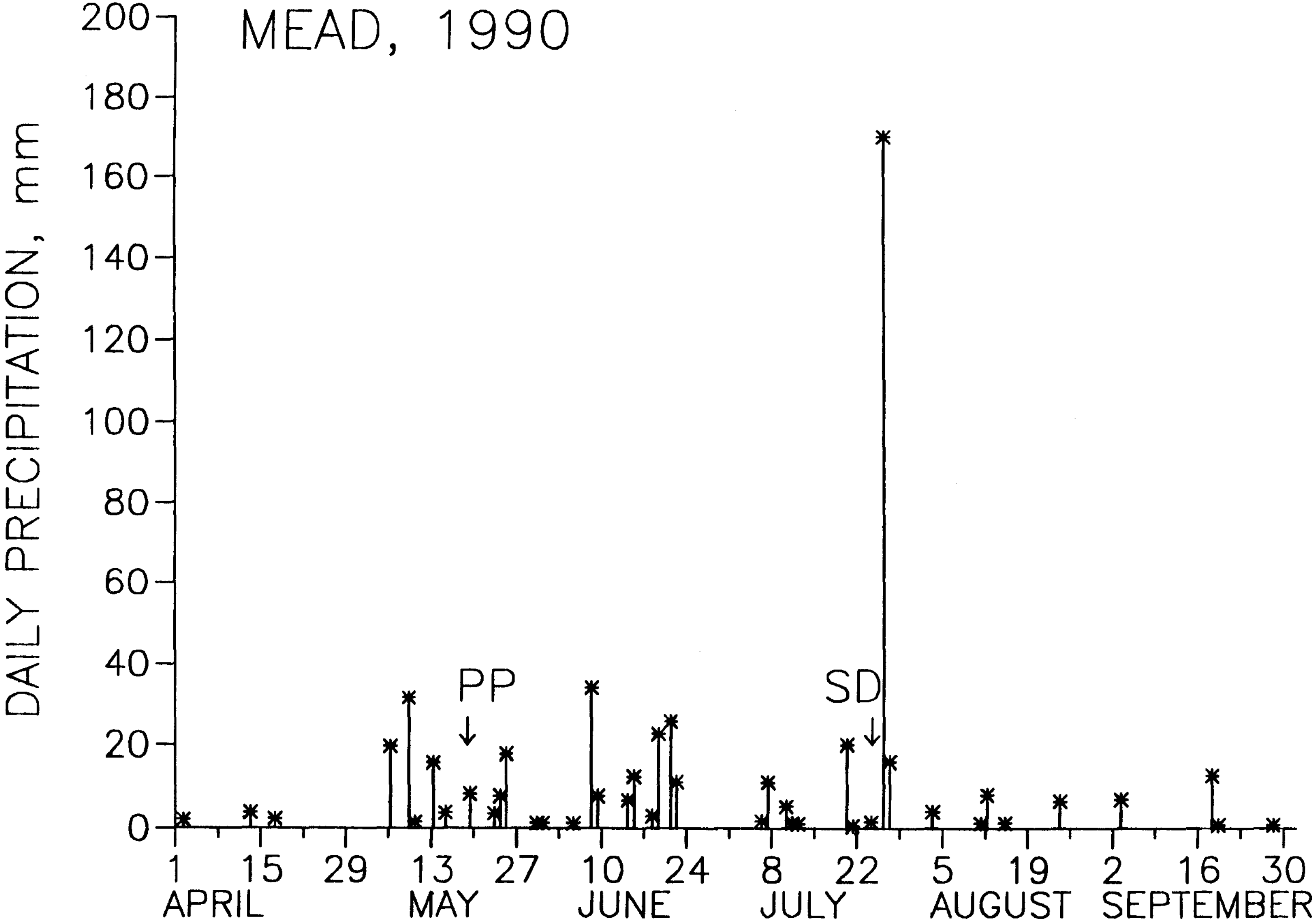
Grain N uptake was similarly influenced by tillage, N form placement and rate of applied N as a function of grain yield components rather than N concentration on the grain N uptake calculations. Grain N uptake patterns (Fig. 4) indicate that applied N was not utilized for grain yield components in DK relative to the no-till systems.

Summary:

Four years into the tillage regime, disk and no-till systems showed different trends of N mineralization and response to applied N in both grain yield and N uptake. N form placement differences indicate that overall AA is the most effective method of supplying N in terms of grain yield and N uptake regardless of tillage systems. Surface dribbled UAN resulted in lower grain yield compared to subsurface placement when precipitation was low following N application. The superior performance of injected versus surface dribbled has been observed by other researchers. The overall response to injection versus surface placement of N sources is thought to be the result of a physical placement of N in the proximity of growing roots precluding the requirement for precipitation to move surface applied N into the into the root zone. High microbial biomass, associated with the residue rich surface zones, has also been shown to be a potential sink for N immobilization during residue decomposition.

Table 1. Analysis of variance and contrasts for grain (GY), grain N uptake (NG) and grain fertilizer use efficiency (FUE). 1990. NS = not significant at P.20.

Effects	df	GY	NG	FUE
			PR> F	
Rep	3			
Till	1	.02	.08	.13
Rep*Till	3			
Time	1	NS	NS	NS
Till*Time	1	.03	.05	NS
NFP	2	.02	.08	.18
(AAvsUK)	1	.01	.03	NS
(UDvsUK)	1	NS	NS	NS
Till*NFP	2	NS	NS	NS
Till*(AAvsUK)	1	NS	NS	.15
Till*(UDvsUK)	1	NS	NS	NS
Time*NFP	2	NS	NS	NS
Time*(AAvsUK)	1	NS	NS	NS
Time*(UDvsUK)	1	NS	NS	NS
Till*Time*NFP	2	NS	NS	NS
Till*Time*(AAvsUK)	1	NS	NS	NS
Till*Time*(UDvsUK)	1	NS	NS	NS
Rate	3	.16	NS	.01
RateL	1	NS	NS	.01
RateQ	1	.03	.10	.01
Till*Rate	3	NS	NS	NS
Till*RateL	1	NS	NS	.17
Till*RateQ	1	.11	.20	NS
Time*Rate	3	NS	NS	NS
Time*RateL	1	NS	.18	NS
Time*RateQ	1	NS	NS	NS
NFP*Rate	6	NS	NS	NS
(AAvsUK)*RateL	1	.06	NS	NS
(AAvsUK)*RateQ	1	NS	NS	NS
(UDvsUK)*RateL	1	NS	NS	NS
(UDvsUK)*RateQ	1	NS	NS	NS
Till*Time*Rate	3	NS	NS	NS
Till*Time*RateL	1	NS	NS	NS
Till*Time*RateQ	1	NS	NS	NS
Till*NFP*Rate	6	NS	NS	NS
Till*(AAvsUK)*RateL	1	NS	NS	NS
Till*(AAvsUK)*RateQ	1	.03	.07	.20
Till*(UDvsUK)*RateL	1	NS	NS	NS
Till*(UDvsUK)*RateQ	1	NS	NS	NS
Time*NFP*Rate	6	NS	NS	NS
Time*(AAvsUK)*RateL	1	NS	NS	NS
Time*(AAvsUK)*RateQ	1	NS	NS	NS
Time*(UDvsUK)*RateL	1	.07	NS	NS
Time*(UDvsUK)*RateQ	1	NS	NS	NS
Till*Time*NFP*Rate	6	.16	NS	NS


MEAD, 1990
DAILY PRECIPITATION, mm
200
180
160
140
120
100
80
60
40
20
0
PP
SD
1
15
29
13
27
10
24
8
22
5
19
2
16
30
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER

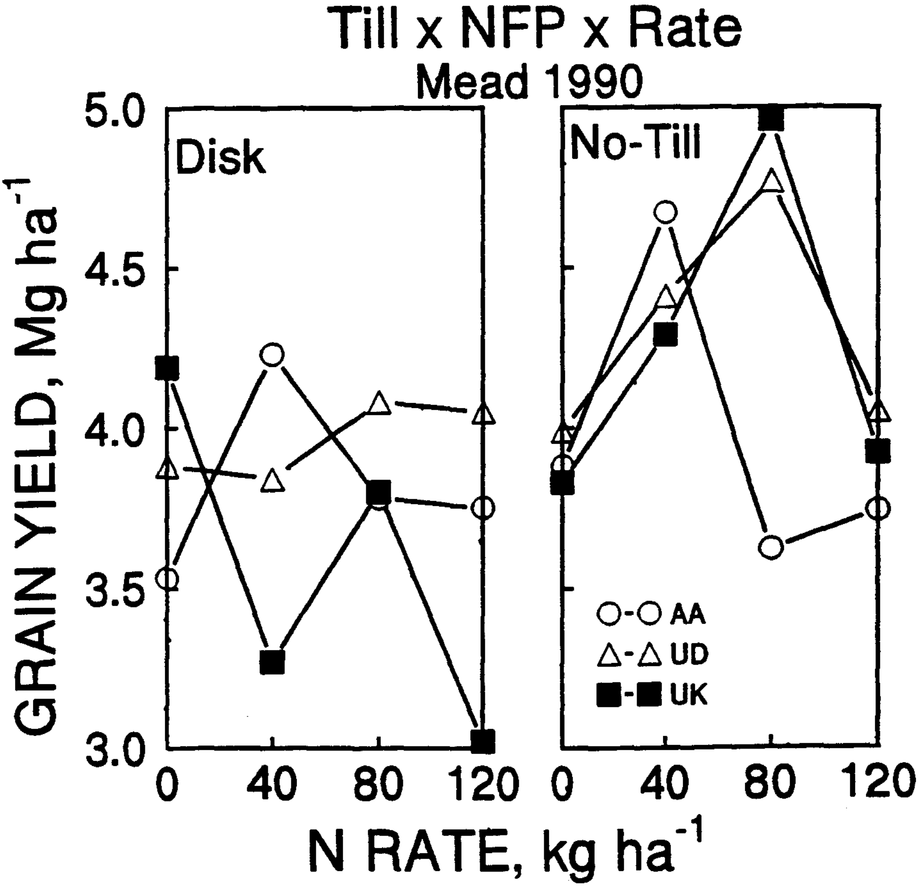


Fig. 2. Till x NFP x Rate effects on grain yield.

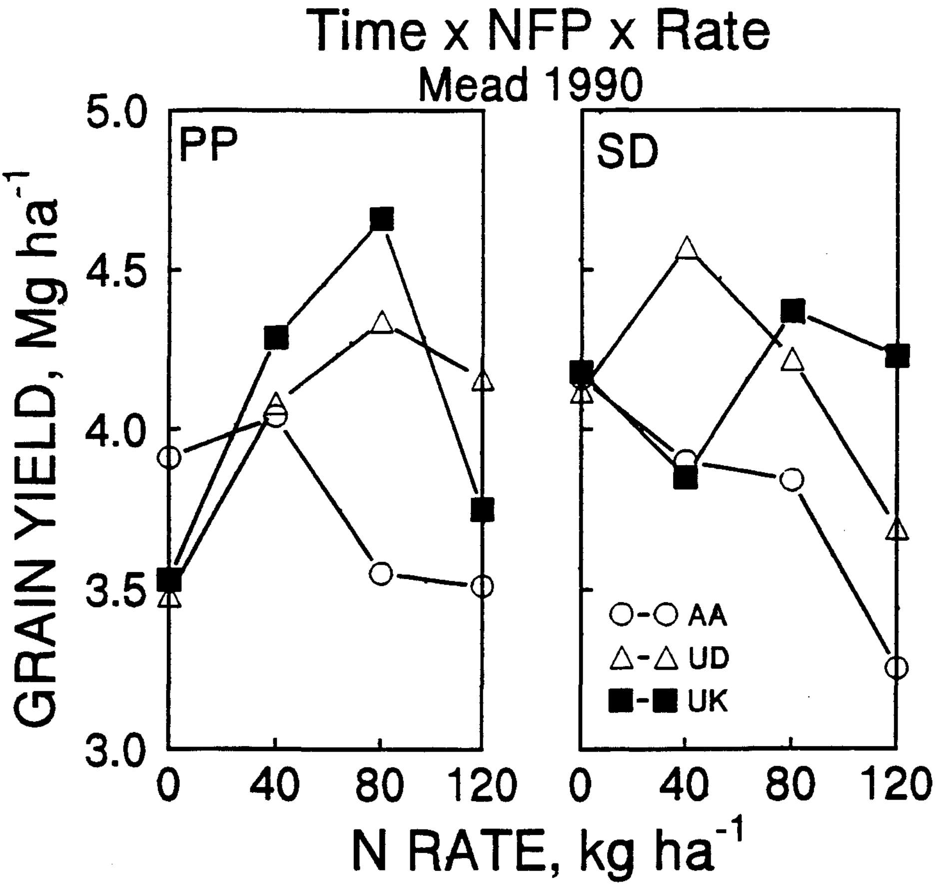


Fig. 3. Time x NFP x Rate effects on grain yield.

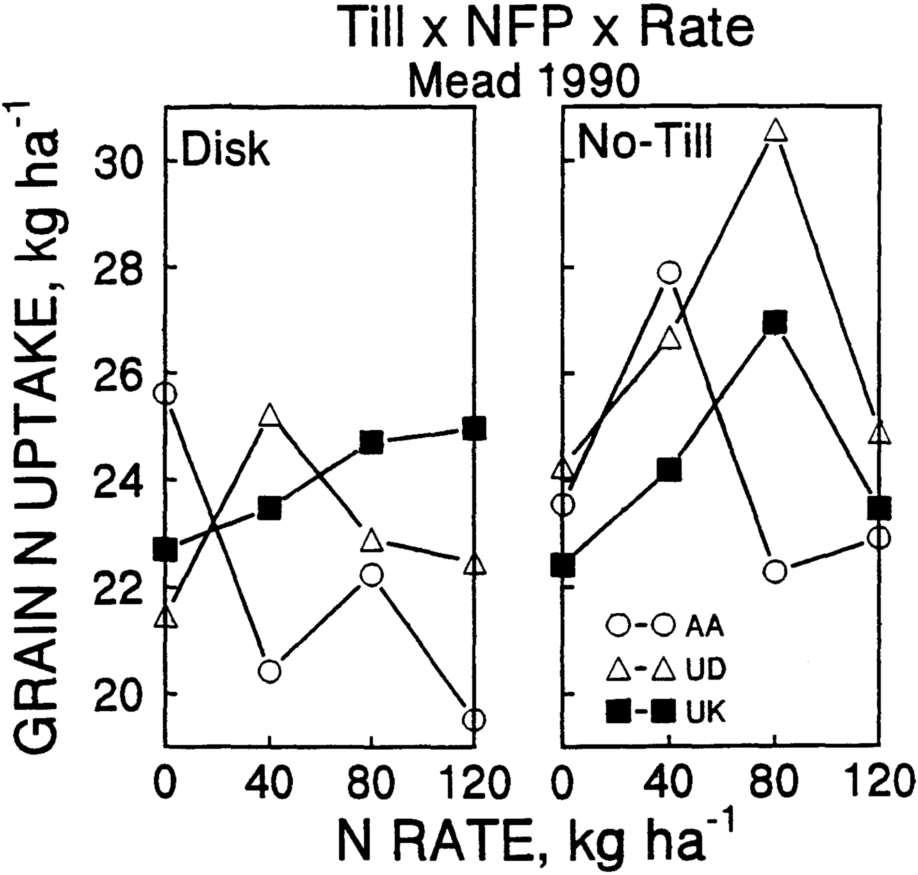


Fig. 4. Till x NFP x Rate effects on grain N uptake.

Residual Effects of Treatments Applied to the Soil Test Lab Comparison Study

Gary W. Hergert, Charles A. Shapiro, and Donald H. Sander

Objectives:

1. The overall objective of the soil test lab comparison experiments was to promote uniform fertilizer recommendations among laboratories.

2. The second objective was to determine if university fertilizer recommendations were adequate to produce optimum economic yields.

This study was discontinued after the 1985 harvest. A completion report and summary through 1984 is available in Agronomy Department Report No. 49.

Procedures:

Since 1986 plots at North Platte, Concord, and Mead have been continued as a residual study. Only nitrogen has been applied to the plots based on yield goal or yield goal and residual nitrate nitrogen. Soil samples have been taken to reflect changes in soil test values over time.

Results:

North Platte

Soil test lab results of particular interest at this location are residual nitrate, phosphorus and zinc. After 1985 nitrogen applications were made based on residual nitrate soil tests. Nitrogen application rates for the 5 years are given in Table 1. Previous N fertilization had provided a wide range of residual nitrate levels. The use of the adjusted nitrogen rates in 1986 produced an amazingly similar residual nitrate carryover shown by the spring 1987 data. The yields all 5 years were exceptional (Table 2). A nitrogen rate study using nitrogen rates of 0, 100, 200, and 300 pounds N/A is also included with the soil test lab study at North Platte and these plots have also been continued. The yields of the higher nitrogen rates on those plots during 1986 through 1990 produced no higher maximum yield than the lab comparison plots indicating the nitrogen rates were adequate.

There were substantial differences in the soil test levels of phosphorus and zinc between the laboratories. Samples from all plots were run by the UNL lab in 1986 (Table 1). Over time the P soil test levels have declined. The UNL plot fell below the current suggested critical level of 15 ppm phosphorus in 1990. This plot received no P from 1974 to 1990. However, this plot produced excellent yields that were equal to those of the other plots which had higher residual phosphorus levels during 1986 through 1990 (Table 2). These data confirm that the UNL philosophy of recommending immobile nutrients such as phosphorus on a deficiency correction basis rather than a soil maintenance and build does not limit yield potential.

Concord

Nitrogen rates were based on yield goal and residual NO_3-N. The plot average NO_3-N in 6 feet for 1988 to 1990 was 94, 85, and 129 lbs/A. The N applied those 3 years was 70, 60, and 50 lb/A.

Plots at Concord were soil sampled from 1986 to 1990 (Table 3). Two of the labs (C and E) had Bray-1 phosphorus levels below 15 ppm but no phosphorus was applied. Even though the phosphorus level was low it did not influence yields (Table 4). The zinc level was adequate for all plots as was the potassium level. Since this is a nonirrigated location variations in yield are due primarily to differences in seasonal rainfall rather than soil fertility level.

Mead

Nitrogen rates at Mead were applied as sidedressed anhydrous ammonia each year. A nitrogen rate of 160 lbs N/A was used. Soil samples were taken in 1985, 1989 and 1990. The range in soil phosphorus showed the previous fertilization history. All plots showed a decline in soil phosphorus level during the residual phase of the experiment. The yields of Lab C and E which had the lower phosphorus levels were not significantly different than those of A, B, and D which had higher phosphorus levels.

The data from this residual phase of the soil test lab study for all three locations indicates that the 15 ppm cut off level for soil phosphorus is adequate for most Nebraska soils to produce excellent corn yields under irrigated or dryland conditions. This study reinforces the fact that the soil test correlations and calibrations developed by UNL researchers 25 years ago are still adequate to meet the yield levels of the higher producing corn varieties grown today.

Table 1. Soil test level at the North Platte, NE site.

Lab	Bray-1 P					DTPA Zn				
	86	87	88	89	90	86**	87*	88**	89*	90*
	ppm					ppm				
A	39	--	25	24	26	1.5	----	1.4	5.6	4.7
B	37	29	29	30	23	2.7	6.9	2.2	9.9	5.9
C	28	22	21	17	19	3.1	14.2	3.9	11.8	9.5
D	35	23	23	19	19	1.3	4.6	1.1	5.0	4.0
E	19	--	16	16	13	1.7	----	1.9	6.3	5.8
Lab	NO_3-N					N applied				
	86	87	88	89	90	86	87	88	89	90
	lbs/A-6 ft					lbs/A				
A	140	99	60	95	134	100	180	180	160	150
B	308	103	56	83	96	0	180	180	160	150
C	187	99	53	100	120	50	180	180	160	150
D	196	98	68	99	121	40	180	180	160	150
E	146	96	60	88	83	100	180	180	160	150

*HCl index
**DTPA

Table 2. Grain yield at the North Platte, NE site.

Lab	1986	1987	1988	1989	1990	Avg
	bu/A					
A	213 a	218 a	224 a	183 a	199 a	207 a
B	206 a	220 a	222 a	188 a	192 b	206 a
C	201 a	222 a	212 a	182 a	195 a	203 a
D	204 a	219 a	209 a	188 a	187 a	201 a
E	200 a	223 a	219 a	186 a	193 a	204 a
CV	7.1%	4.2%	4.6%	3.5%	4.9%	1.8%

*Values followed by the same letter are not significantly different at the 5% level.

Table 3. Soil test levels at the Concord, NE site.

	Bray-1 P					K			
Lab	86	87	88	89	90	87	88	89	90
	ppm								
A	22	19	16	16	19	250	247	236	290
B	21	16	15	17	17	224	252	234	287
C	12	11	11	11	14	227	246	226	284
D	23	19	17	18	17	225	225	217	280
E	13	13	11	14	15	228	246	245	282

Table 4. Grain yield at the Concord, NE site.

Lab	1986	1987	1988	1989	1990	Avg
	bu/A					
A	92**	95 a	55 a	38 a	69 a	70
B	130	98 a	54 a	35 a	64 a	76
C	99	98 a	58 a	42 a	71 a	74
D	127	88 a	54 a	37 a	62 a	74
E	114	101 a	53 a	40 a	62 a	74
CV	---	10.7%	24.0 %	25.6%	18.2%	

*Values followed by the same letter are not significnatly different at the 5% level.
**Statistics not available at publication time.

Table 5. Soil test levels at the Mead, NE site.

Lab	Bray-1 P		
	85	89	90
	ppm		
A	43	31	27
B	41	27	28
C	27	19	18
D	42	26	23
E	24	14	14

Table 6. Grain yield at the Mead, NE site.

Lab	1986	1987	1988	1989	1990	Avg
	bu/A					
A	174*	94*	155 a	147*	145*	143 a
B	225	82	161 a	136	135	148 a
C	163	89	162 a	154	127	139 a
D	206	94	159 a	154	140	151 a
E	186	84	158 a	149	133	142 a
CV						8.0%

**Statistics not available at publication time.

Using N-serve to Modify Plant Available Ammonium and Nitrate for Corn

Gary W. Hergert

Objective:

Determine the long term influence of using N-Serve on the nitrogen use efficiency of furrow-irrigated corn.

During the last few years there has been considerable interest in the concept of ammonium nutrition and hybrid response in corn. The study was initiated in 1988 at North Platte, Nebraska to investigate the influence of different ammonium/nitrate ratios on corn yield and grain quality.

Methods and Materials

The study was conducted on a site that had previously been continuous corn in a study with and without N-Serve at different nitrogen rates that was initiated in 1985. The soil is a Cozad silt loam. Results of that experiment were reported in the Agronomy Department 1988 Soil Science Research Report.

In 1988 the study was changed to determine the influence of ammonium nutrition on corn yield. The previous nitrogen rates were continued on the same plots used from 1985 to 1987. In 1988, however, 30 pounds of preplant nitrogen was broadcast over the whole area to provide uniform early growth. Nitrogen treatments applied were preplant ammonia without N-Serve and sidedressed ammonia with N-Serve in 40 pound increments to 200 lb/A. This gave nitrogen rates ranging from 30 lb/A to 230 lb/A. Preplant ammonia was applied mid-April 1988. Corn variety BoJac 603 was planted April 29, at a seed drop of 31,000 plants/A. Sidedress ammonia and N-Serve were applied June 17. Soil analysis of the plot area did show that it was somewhat low in zinc and phosphorus and 80 pounds of P_2O_5/A was broadcast in the spring with 5 pounds of actual Zn/A from zinc sulfate.

Because of the results in 1988 the treatments were slightly modified in 1989 and 90. The nitrogen rate increments of 40 pounds/A were maintained on the same plots. Treatments were an early sidedress of ammonia (V-4 stage) with and without the N-Serve. The plots received 8 pounds N/A from row applied 10-34-0 starter at planting. In both years BoJac 603 was the hybrid used. The planting date in 1989 was April 28 with N sidedressed on June 12. In 1990 the corn was planted on May 4 and the ammonia was sidedressed June 18. Fifty pounds of P_2O_5 was broadcast on the area in 1990.

Results and Discussion

In 1988 the ear leaves at silk emergence showed that nitrogen content was higher for those treatments receiving the sidedress application with N-Serve than for the preplant nitrogen (Table 1). The sidedressed nitrogen plots showed less growth compared to the preplant application because of the delayed nitrogen application and nitrogen availability during mid- to late-June.

Grain yields, however, showed a different effect. There was a significantly lower yield where the sidedressed nitrogen was applied with N-Serve compared to the preplant ammonia with none (Table 1). Those treatments receiving N-Serve apparently had sufficiently delayed nitrogen uptake to reduce yield. It is obvious that nitrogen availability can be delayed enough to decrease yield potential. The importance of ammonium nutrition for the hybrid used in this study apparently was not offset by the total uptake of N as it influenced grain yield.

Although there was a significant difference caused by N-Serve on earleaf nitrogen in 1988 there was not a significant difference in the grain nitrogen content

(Table 1). The only significant factor was the nitrogen rate. Nitrogen removal showed that there was a significant difference due to nitrogen rate and N-Serve. There was lower nitrogen removal with the N-Serve primarily because of the difference in yield since there was no difference in grain nitrogen content.

The apparent nitrogen use efficiencies for the experiment can be calculated based on the nitrogen removal in the grain. This was done by subtracting the amount of nitrogen in the check from the nitrogen removed for the different nitrogen rates divided by the nitrogen rate. The nitrogen use efficiency decreased as the nitrogen rate increased and showed that the N efficiency with the N-Serve was lower than that without (Table 2). The nitrogen use efficiency dropped off dramatically once maximum yield was reached at 150 pounds of N/A. Nitrogen rates above this did produce additional yield but at a high cost in terms of nitrogen use efficiency. This data would suggest that the change in nitrate ammonium/nutrition as affected by the sidedress NH_3 with the N-Serve decreased the nitrogen use efficiency of BoJac 603.

Soil samples were taken from the check, the 120 lb/A and 200 lb/A N rates with and without N-Serve in the fall of 1988. Data showed that more nitrate-N was left where the N-Serve was used (Table 3). The additional carryover nitrate-N as influenced by the N-Serve in 1988 (Table 3) and possibly the N-Serve treatments in 1989 showed a significant influence of N-Serve on grain yield and nitrogen removal in 1989 (Table 4). No effect was shown on earleaf nitrogen or nitrogen in the grain other than for the nitrogen rate effect. Apparent nitrogen use efficiencies for 1989 are shown in Table 5. During 1988 and 1989 maximum yield to 95% of maximum yield was attained with about 160 pounds of nitrogen per acre. The apparent nitrogen efficiencies both years was in the range of 48 to 52%. The 120 pound nitrogen rate produced about 90 to 95% of maximum yield with nitrogen use efficiencies that ranged from 58 to 62%. The soil nitrate carryover was also considerably less (Tables 2 and 5).

The analysis of variance for 1990 showed a significant effect on grain yield only for N rate. A single degree of freedom test showed a significant increase when N-Serve was used at the 40 pound nitrogen rate. Yields were maximized with 120 pounds of nitrogen per acre.

Analysis of the data shows that for the 3 years the maximum yields were 203, 190 and 182 bu/A. The nitrogen rates required to produce those maximum yields were 150, 160 and 120 pounds of nitrogen per acre. The 3 year average yield of 192 bushels per acre was produced with an average nitrogen rate of 143 pounds of nitrogen (Table 7). The nitrogen removal in the grain from this plot was 0.62 pounds of nitrogen per bushel when maximum yield was attained. The average nitrogen applied to produce that yield was 0.75 pounds of nitrogen per bushel. The average nitrogen per bushel divided by the average nitrogen required to produce a bushel showed a nitrogen use efficiency of about 80%. This is an excellent recovery of nitrogen for an early sidedress including the nitrification inhibitor. This work shows that if irrigation runs for furrow irrigated corn are short (1/4 mile or less) that nitrogen use efficiencies can approach 70%. The influence of ammonium nutrition could not be determined from this study. N-Serve showed negative, positive, and no effects during the 3 years.

Table 1. 1988 corn yields and plant parameters.

N Rate	N-Serve	Grain	Earleaf N	Grain N	N Removal
----------lb/A----------		bu/A	----------% N----------		lb/A
30	0	125	1.53	1.04	62
70	0	167	2.20	1.16	92
70	0.5	161	2.42	1.19	92
110	0	191	2.51	1.28	116
110	0.5	188	2.66	1.29	115
150	0	200	2.65	1.33	126
150	0.5	192	2.69	1.34	122
190	0	202	2.74	1.35	129
190	0.5	187	2.27	1.34	118
230	0	205	2.77	1.36	136
230	0.5	192	2.80	1.31	120

AOV

Source	Grain	Earleaf N	Grain N	N Removal
	----------PR>F----------			
N Rate	.001	.001	.001	.001
N-Serve	.001	.001	.98	.06
Rate x N-Serve	.50	.01	.77	.49
CV	4.5%	3.0%	6.0%	8.5%

<u>N-Serve</u>	Grain bu/A	Earleaf N ----------%	Grain N ----------	N Removal lb/A
With	185	2.67	1.30	114
Without	193	2.57	1.30	119

Table 2. Apparent N use efficiency at North Platte, NE 1988.

Nitrogen lb/A	With N-Serve	Without N-Serve
	----------%	----------
70	75	75
110	66	68
150	50	53
190	35	42
230	30	36

Table 3. Soil nitrate-N in selected treatments fall 1988.

Depth	Check	120# N W/O N-Serve	120# N With N-Serve	200# N W/O N-Serve	200# N With N-Serve
	ppm NO_3-N				
0-8"	4.6	7.6	8.2	10.3	11.1
8-24"	3.3	5.2	12.6	6.2	17.2
24-36"	2.9	5.3	10.5	5.2	12.3
36-48"	3.1	4.9	6.6	5.0	7.9
48-60"	3.2	3.9	5.1	5.7	6.6
60-72"	3.2	3.3	4.5	6.6	6.7
lbs/6'	71	105	176	136	23

Table 4. 1989 corn yields and plant parameters.

N Rate	N-Serve	Grain	Earleaf N	Grain N	N Removal
lb/A		bu/A	% N		lb/A
0	0	87	1.74	0.94	39
40	0	132	2.69	1.06	66
40	0.5	137	2.63	1.06	69
80	0	165	2.84	1.25	97
80	0.5	175	2.84	1.28	106
120	0	173	2.92	1.30	106
120	0.5	185	2.96	1.30	113
160	0	187	2.94	1.28	113
160	0.5	189	2.86	1.28	115
200	0	190	2.93	1.26	114
200	0.5	194	2.94	1.32	122

AOV

Source	Grain	Earleaf N	Grain N	N Removal
	PR>F			
N Rate	.001	.001	.02	.001
N-Serve	.01	.07	.73	.01
Rate x N-Serve	.70	.16	.96	.58
CV	5.1%	2.7%	6.8%	5.7%

	Grain	Earleaf N	Grain N	N Removal
N-Serve	bu/A	%		lb/A
With	176	2.85	1.25	105
Without	169	2.86	1.23	99

Table 5. Apparent N use efficiency at North Platte, NE 1989.

Nitrogen	With N-Serve	Without N-Serve
lb/A	%	
40	75	68
80	84	73
120	62	56
160	48	46
200	42	38

Table 6. 1990 corn yields.

N Rate	N-Serve	Grain
lbs/A		bu/A
0	0	77
40	0	124
40	0.5	138
80	0	170
80	0.5	166
120	0	179
120	0.5	184
160	0	182
160	0.5	183
200	0	180
200	0.5	183

AOV

	Grain PR>F
N Rate	.001
N-Serve	.34
N Rate x N-Serve	.85
CV	9.3%

N-Serve	bu/A
With	169
Without	165

Table 7. Maximum yield and N required during the 3 years using a quadratic plateau model.

	Nitrogen for Y Max	Y Max
1988	150	203
1989	160	190
1990	120	182
	143	192

Spatial Variability of Nitrate-Nitrogen in Nebraska Corn Fields

Gary W. Hergert, Frank N. Anderson, Charles A. Shapiro,

Richard B. Ferguson, Edwin J. Penas, and Kenneth D. Frank

Project Objectives:

1. Determine the variability of nitrate distributions within farmers fields on selected benchmark soils across the state.

2. Determine the most appropriate number of samples required to estimate the mean nitrate-N value within prescribed confidence limits by classical methods or by regionalized variable techniques.

3. Determine seasonal variation in nitrate levels between fall and spring.

Procedure:

Farmers fields from major corn production areas across the state were selected for sampling beginning in the fall of 1987 and will be concluded in the spring of 1991. Portions of farmers fields generally less than 30 acres were selected by the various principle investigators for sampling. Fields were sampled on a grid basis using a 100 foot lag as the standard spacing. The primary advantage of the grid system is in detecting gradients or directional variation which would be expected especially in furrow irrigated fields in Nebraska. Soil samples were taken in 1 foot increments from the soil surface to 4 feet. A Giddings hydraulic soil probe was used at all locations with a core barrel diameter of 2 inches. Individual cores were bagged separately, air dried, ground and then analyzed for nitrate nitrogen.

Results and Discussion:

The field sites samples during the project are listed in Table Data analysis included descriptive statistics as well as a check for normality of the frequency distributions. Geostatistical analysis of all locations is still being conducted. Semivariograms and Kriged estimates and contour maps will be available in late 1991. A summary of the descriptive statistics is given in Table 2. The average amount of nitrate-N found in a 4 foot depth ranged from 20 to 676 lbs/A. The very high sample was from a field with a long term history of excess manuring. On the sites which have received only commercial fertilizer the values indicate that farmers have been practicing improved nitrogen management because the average nitrate levels are low. In most cases the median value is lower than the mean indicating a somewhat skewed, or in many cases, log normal distribution of the data. Analysis shows that in most instances the data was not normally distributed. The other factor noted from Table 2 is that the coefficient of variation (CV) is very high. This is not unusual for a soil nutrient analysis. The average coefficient of variation was 52%. The complicating factor of a high CV is that more samples are required to obtain a given accuracy or predictability to be within a given amount of the true mean. The range in individual samples shows that there is a great deal of variability in soil nitrate from point to point in a field and it emphasizes the importance of taking an adequate number of samples.

A paired comparison of sites that were samples during both the fall and the spring is shown in Table 3. Very little difference in the mean averaged across 16 different sites was shown. The mean and the median were nearly the same although the coefficient of variation was somewhat higher for the fall sampling than the spring. The data confirms that in dry years as we experienced in the winters of 87-88 and 88-89 very little change in soil nitrate was expected. A comparison of individual values among sites shows a somewhat different picture. Seven of the locations changed very little. Six of the locations showed over a 10% increase in soil nitrate and three showed a significant decrease. The increase in soil nitrate may be attributed to late fall or early spring mineralization between the two sampling times. The decrease in soil nitrate was on sandy sites and was most likely due to leaching from over winter precipitation.

Peterson and Calvin (1968) suggested that an estimate for the number of samples required (n) can be calculated as

$$n = \frac{t^2 s^2.}{d^2}$$

Where t is the tabulated students t value for the desired alpha level with n - 1 degrees of freedom. d is a specified limit of desired precision and s is the sample estimate of the standard deviation based on a prior sampling. The original procedure is an iterative method that requires a previous sampling. The iterative method was not used in this case because of the large sample size. A paper describing the errors introduced by a non-iterative approach is in the publication process (Joe Skopp et al). For this analysis, however, the number of samples calculated should be assumed a first approximation. It may somewhat over estimate the actual number of samples required.

The value of d was calculated using ± 10% or ± 20% of the sample mean. The results are shown in Table 4. The number of samples required to be within a precision of ± 10% at an alpha level of .1 is 60. This number of samples is much larger than any farmer or fertilizer dealer would be willing to take in an average sized field of 30 acres. The number of samples required, however, to be within ± 20% of the mean at an alpha level of 0.1 or 0.2 are within the range of practicality.

Current sampling recommendations provided by the University of Nebraska suggest six to eight cores from an area of 20 acres or less (Penas et al, 1991). An acceptable procedure in more situations would be to take from 12 to 16 cores from an area of 40 acres or less. These general recommendations fall in line with the tabulated values in Table 4. The data point out, however, the range of variability in these samples and the uncertainty in the values when a given number of cores is taken. In most instances soil nitrate levels from farmer samples are only within a range of ± 20% of the mean at a confidence level of 80 to 90%.

An important factor to consider when using residual nitrate-N levels to modify fertilizer nitrogen recommendations is the sampling depth required. The correlation of nitrate-N among different depth increments is shown Table 5. Current UNL recommendations suggest at least a 2 foot sample for residual nitrate before any adjustment is made. A 3 or 4 foot sample is the most desirable (Penas et al., 1991). The average correlation across all sites increases as the sampling depth increases. Knowing the characteristics of root development and crop growth combined with this information strongly suggests the use of 0 to 2 or 0 to 3 foot sample in most instances to quantify residual nitrate.

This sampling work has showed that there is a great deal of variability in soil nitrate in farmer's fields. When making adjustments to an important crop input like nitrogen we need the best value that we can have. The data suggest that because of the high and unknown variability that minimum sampling numbers of 12 to 16 cores from areas 40 acres or less is needed if we want to have confidence in the adjustments we make.

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Table 1. Site characteristics of fields samples in the soil NO_3 spatial variability study.

Site	Year	Fall	Sprg	Cooperator	County	Soil	Size
1	87-88	y*	y*	Marghiem	Scottsblf.	Tripp vfsl	26 x 5
2	87-88	y*	y*	Lofing	Scottsblf.	Mitchell sil	6 x 21
3	87-88	y*	y*	Raun	Wayne	Mdy/Knbc/Sicl	10 x 15
4	87-88	y*	y*	NEREC	Dixon	Nora, Crofton, sil	17 x 8
5	87-88	y*	n	Hoffman	Pierce	Thurman-Loup ls	12 x 14
6	87-88	y*	y*	Fritz	Lincoln	Caruso l	8 x 11
7	87-88	y*	y*	Johnson	Clay	Hastings sil	12 x 12
8	87-88	y*	y*	Krull	Clay	Hastings sil	12 x 12
9	87-88	y*	n	Thompson	Hall	Wann l	12 x 7
10	87-88	y*	y*	Speihs	Hall	Wann l	9 x 11
11	87-88	y*	y*	Henry	Lincoln	Valentine ls	20 x 7
12	87-88	y*	y*	Wahlgren	Lincoln	Cozad sil	20 x 7
13	87-88	y*	y*	Schmadke	Lincoln	Uly-Coly sil	9 x 16
14	87-88	y*	y*	Greeder	Lincoln	Anselmo ls	20 x 7
16	88-89	y*	n	WCREC	Lincoln	Cozad-Hord sil	21 x 9
17	88-89	y*	n	Peterson	Dixon	Mdy-Lsy-Thrm	14 x 8
18	88-89	y*	n	Dahlquist	Cedar	Crofton-Nora sl	14 x 8
19	88-89	y*	n	Eakins	Keith	Bayard sl	13 x 8
20	88-89	y*	n	Perkins	Scottsblf.	Alice vfsl	18 x 4
21	88-89	y*	n	Tripple	Scottsblf.	Keota sl	7 x 5
22	88-89	y*	n	Kramer	Logan	Hord sl	14 x 10
23	88-89	y*	n	Henry	Lincoln	Valentine s	21 x 7
24	88-89	y*	n	Somerhalder	Lincoln	Hord sil	11 x 11
25[2]	88-89	n	y*	WCREC	Lincoln	Hord sil	12 x 12
26[3]	88-89	n	y*	WCREC	Lincoln	Hord sil	12 x 12
27	89-90	y*	y*	Betty	Lincoln	Valentine s	14 x 10
28	89-90	y*	y*	Pickering	Scottsblf.	Tripp vfsl	10 x 7
29	89-90	y*	y*	Marghiem	Scottsblf.	Tripp vfsl	10 x 7
30[1]	89-90	y*	y*	Fiericks	Dixon	Crofton sil	12 x 10
31	89-90	y*	y*	Jacobson	Kearney	Holdrege sil	9 x 12
32	89-90	y*	y*	Rousey	Lincoln	Caruso l	9 x 11
33	89-90	y*	y*	Medinger	Butler	Butler sicl	11 x 9
35	89-90	n	y*	Bonzak	Hall	O'Neill sal	12 x 12
36[1]	89-90	y*	y*	Tuttle	Cedar	Moody scl	12 x 10
37	90-91	y	y	Rousey	Lincoln	Caruso l	9 x 11
38	90-91	y	y	Kinnan 1	Dawson	Cozad sil	21 x 7
39	90-91	y	n	Kinnan 2	Dawson	Hord-Cozad sil	12 x 13
40	90-91	n	y	MARC	Clay	Crete sil	12 x 12
41	90-91	n	y	NEREC	Dixon	Nora, Crofton, sil	17 x 18
42	90-91	y*	n	Mead Co.	Saunders	Sharpsburg sicl	10 x 10
43[4]	90-91	y*	n	Hansen	Saunders	Sharpsburg sicl	10 x 4

*Indicates that soil nitrate analysis has been completed.
[1] 50' grid, [2] 10' x 10' grid, [3] 1' x 1' grid, [4] 120' x 120' grid

Table 2. Descriptive statistics of the sites.

Site	Mean	Median	CV	Range	
				Low	Hi
	---------------lbs-Nitrate-N in the 0 to 4 foot depth---------------				
1F	74	57	65%	22	308
1S	79	66	55%	30	351
2F	39	36	32%	22	103
2S	39	34	43%	17	142
3F	40	38	37%	15	121
3S	55	53	32%	21	119
4F	120	88	79%	23	526
4S	117	92	70%	21	442
5F	62	50	58%	12	236
6F	46	39	57%	20	164
6S	53	48	39%	22	149
7F	44	31	79%	9	206
7S	50	42	51%	17	150
8F	16	14	60%	6	54
8S	20	19	31%	7	39
9F	38	35	37%	11	79
10F*	50	41	74%	9	246
10S*	58	53	46%	18	179
11F	54	51	38%	24	131
11S	36	34	36%	17	112
12F	86	66	81%	22	422
12S	84	65	88%	30	559
13F	78	63	73%	13	287
13S	91	73	70%	13	398
14F	105	96	36%	32	263
14S	50	45	42%	14	128
16F	93	83	47%	32	409
17F	67	56	57%	29	266
18F	96	69	76%	17	368
19F	96	73	72%	18	300
20F	101	69	81%	17	337
21F	90	69	60%	28	235
22F	21	18	47%	4	76
23F	34	31	52%	8	109
24F	24	23	55%	7	111
25S	112	105	30%	53	215
26S	65	63	29%	29	123
27F	24	21	48%	7	70
27S	26	25	41%	7	81
30F	226	210	65%	15	937
31F	134	113	70%	10	350
31S	79	66	66%	17	314
32F	74	64	48%	38	204
32S	89	82	37%	31	205
33F	39	37	34%	16	121
33S	41	40	29%	20	104
35S*	23	21	37%	11	85
36F	47	44	27%	30	132
36S	42	39	32%	3	90
42F	676	629	46%	144	1386
43F	159	142	54%	46	356

*Pounds nitrate-N in the 0 to 3 foot depth

Table 3. Comparison of fall vs. spring site statistics of pounds of nitrate-N in 4 feet.

Site	Fall med	Sprg med	Fall med	Sprg med	Fall CV	Sprg CV	Sample No.
1	74	79	57	66	65	55	130
2	39	39	36	35	32	43	120
3	40	55	38	53	37	32	150
4	120	117	88	92	79	70	136
6	46	53	39	48	57	39	88
7	44	50	31	42	79	51	144
8	16	20	14	19	60	31	144
11	54	36	51	34	38	36	140
12	86	84	67	65	81	88	140
13	78	91	63	73	73	70	144
14	105	50	96	45	36	43	140
27	24	26	21	25	48	41	140
31	134	79	113	66	70	66	108
32	74	89	64	82	48	37	99
33	39	41	37	40	34	29	99
36	47	42	44	39	27	32	120
Avg	63	60	53	52	55	48	128
Range	16- 23	20- 117	14- 113	19- 92	27- 81	29- 88	88- 150

Table 4. Number of soil cores needed to be within plus or minus 10% or 20% of the true mean at alpha levels of 0.1 or 0.2 for a 30 acre field.

Site	Mean lbs N/4'	±10%=0.1	±10%=0.2	±20%=0.1	±20%=0.2
1F	74	113	69	28	17
1S	79	82	50	21	13
2F	39	28	17	7	
2S	39	49	29	12	7
3F	40	38	23	10	6
3S	55	27	16	7	4
4F	120	168	102	42	26
4S	117	134	81	33	20
5F	62	95	57	24	14
6F	46	87	53	22	13
6S	53	41	25	10	6
7F	44	169	102	42	26
7S	50	69	42	17	11
8F	16	62	37	15	9
8S	20	26	16	6	4
9F	38	38	23	9	6

Table 4. (continued)

Mean Site	lbs N/4'	± 10%=0.1	±10%=0.2	±20%=0.1	±20%=0.2
10F*	50*	151	91	38	23
10S*	58*	58	35	15	9
11F	54	38	23	10	6
11S	36	35	21	9	5
12F	86	163	99	41	25
12S	84	207	126	52	31
13F	78	142	87	36	22
13S	91	133	81	33	20
14F	105	36	22	9	5
14S	50	50	30	13	8
16F	93	59	36	15	9
17F	67	89	54	22	14
18F	96	157	95	39	24
19F	96	139	85	35	21
20F	101	183	110	46	28
21F	90	82	49	21	12
22F	21	61	37	15	9
23F	34	74	45	19	11
24F	24	84	51	21	13
25S	112	24	15	6	4
26S	65	23	14	6	4
27F	24	62	38	16	9
27S	26	46	28	12	7
30F	226	116	70	29	18
31F	134	135	81	34	20
31S	79	119	72	30	18
32F	74	63	38	16	10
32S	89	38	23	10	6
33F	39	32	19	8	5
33S	41	23	14	6	4
35S	23	38	23	10	6
36F	47	21	12	5	3
36S	42	29	17	7	4
42F	676	59	35	15	9
43F	159	82	50	21	13
Avg		60	36	15	9

Table 5. Correlation coefficients among soil NO_3-N contents at different depths.

Site	0-1 vs 0-2	0-1 vs 0-3	0-1 vs 0-4	0-2 vs 0-3	0-2 vs 0-4	0-3 vs 0-4
1F	0.81	0.70	0.60	0.94	0.81	0.92
IS	0.79	0.58	0.52	0.93	0.86	0.97
2F	0.95	0.71	0.59	0.77	0.66	0.83
2S	0.96	0.93	0.90	0.99	0.96	0.98
3F	0.97	0.93	0.83	0.97	0.88	0.95
3S	0.96	0.92	0.82	0.97	0.87	0.93
4F	0.95	0.93	0.90	0.98	0.96	0.99
4S	0.89	0.87	0.87	0.98	0.96	0.98
5F	0.88	0.81	0.77	0.96	0.93	0.99
6F	0.84	0.74	0.71	0.96	0.92	0.98
6S	0.91	0.72	0.64	0.90	0.83	0.98
7F	0.98	0.96	0.92	0.99	0.95	0.98
7S	0.93	0.87	0.81	0.95	0.90	0.97
8F	0.93	0.84	0.76	0.94	0.89	0.95
8S	0.87	0.80	0.75	0.95	0.92	0.98
9F	0.97	0.91	0.81	0.97	0.88	0.93
10F*	0.96	0.93	-	0.98	-	-
10S*	0.84	0.76	-	0.97	-	-
11F	0.89	0.75	0.69	0.91	0.86	0.95
11S	0.94	0.86	0.77	0.97	0.90	0.96
12F	0.90	0.74	0.63	0.92	0.84	0.96
12S	0.73	0.56	0.49	0.89	0.80	0.97
13F	0.83	0.76	0.73	0.95	0.90	0.97
13S	0.73	0.46	0.33	0.78	0.63	0.96
14F	0.80	0.57	0.47	0.83	0.71	0.92
14S	0.80	0.61	0.48	0.88	0.73	0.90
16F	0.97	0.96	0.94	0.99	0.98	0.99
17F	0.85	0.79	0.73	0.87	0.82	0.98
18F	0.93	0.86	0.81	0.96	0.91	0.98
19F	0.85	0.74	0.72	0.91	0.82	0.93
20F	0.92	0.87	0.82	0.97	0.92	0.98
21F	0.98	0.92	0.87	0.96	0.93	0.98
22F	0.98	0.96	0.93	0.99	0.97	0.99
23F	0.81	0.73	0.69	0.95	0.91	0.97
24F	0.98	0.94	0.90	0.96	0.93	0.95
25S	0.98	0.97	0.95	0.99	0.98	0.99
26S	0.96	0.91	0.86	0.98	0.95	0.99
27F	0.92	0.87	0.78	0.96	0.89	0.96
27S	0.90	0.78	0.68	0.92	0.84	0.96
30F	0.89	0.85	0.83	0.99	0.98	0.99
31F	0.92	0.78	0.71	0.94	0.86	0.99
31S	0.78	0.60	0.53	0.90	0.76	0.95
32F	0.97	0.92	0.89	0.98	0.96	0.99
32S	0.91	0.87	0.80	0.98	0.93	0.98
33F	0.92	0.82	0.69	0.94	0.83	0.95
33S	0.88	0.72	0.60	0.91	0.90	0.95
35S*	0.85	0.61	-	0.86	-	-
36F	0.97	0.94	0.92	0.99	0.97	0.99
36S	0.91	0.87	0.84	0.99	0.97	0.99
42F	0.89	0.78	0.72	0.96	0.90	0.98
43F	0.78	0.75	0.72	0.96	0.93	0.99
Avg.	0.90	0.80	0.74	0.94	0.88	0.96

*Pounds nitrate-N in the 0 to 3 foot depth

Soil Test Lab Comparison Experiment on the B-K-R Demonstration Farm

Gary W. Hergert, Dennis Bauer, and Bud Stolzenburg

Objectives:

1. Determine if soil lab recommendations from commercial labs and UNL varied widely on a low fertility sandy soil.

2. Determine if UNL recommendations are adequate to produce economic yields on sandy soils.

A soil test lab comparison study conducted by the University of Nebraska showed a wide range in fertilizer recommendations between a number of laboratories (Dept. of Agron. 1985). These experiments did confirm the accuracy of the laboratories' analytical techniques but, these experiments were conducted on silt loam soils that were high to medium fertility. The University has a major responsibility to provide research information upon which fertilizer recommendations are made to farmers and commercial soil testing labs. These experiments provide a check on the University recommendations.

Procedure:

A composite soil sample from a Boelus-Valentine sand association near Bassett, NE was taken out of the four replications for a given laboratory and sent to the laboratory under a farmer's name. The experiment has been run for 4 years (1987 through 1990). The four laboratories selected were A & L Laboratories, Harris, Servi-Tech, and UNL. The actual soil test results are shown in Table 1. There was fairly good agreement between the different soil test levels before fertilizer was applied in 1987 and the analysis did show that the site was low in most nutrient levels. The biggest variation in analytical values was for sulfur and zinc because of lab methods used.

Soil test levels showed increases over time, but it took 2-3 years for soil P to increase (Table 1). Zinc showed an increase after first year.

Laboratories were provided with information on soil type suggesting a yield goal of 165 bushel/A of corn. The actual fertilizer recommended by the different laboratories is shown in Table 2. To provide for the best nitrogen management between laboratories all of the nutrients plus 40 pounds of nitrogen was applied preplant in 1987 and 1988 to each of the plots. During 1989-1990 only 30 lbs N/A was applied preplant with all other nutrients. The remaining nitrogen was applied as a sidedress application of ammonium nitrate when the corn was approximately 2 feet tall. This method of fertilizer application showed incorporation of broadcast phosphorus, sulfur, zinc, and other micronutrients or secondary nutrients. It also provided a split application for the nitrogen to best utilize the nitrogen that was recommended by the laboratories. Plots were double disked after preplant fertilizer application.

Nitrogen recommendations for two of the labs have decreased significantly during the last 2 years. The factor (F) for yield goal X F = N recommendation appears to have come down from 1.33 to about 1.06. This may reflect national and regional concern about N and ground water quality. Other nutrients (P, K, and micronutrients) still appear to be recommended on a soil test plus crop removal basis for A&L and Harris.

Yield data are shown in Table 3. No differences were shown in 1987.

In 1988 there was a significant yield difference between labs. The 40# preplant N was applied but 40# of N was also applied with the herbicide. Because of heavy early spring rains, leaching occurred. The 90# N left for sidedressing University plots was not sufficient to meet yield demands. The data does emphasize the importance of proper N management and that soluble forms of N can be lost. No more than 40# of N/A as a preplant is recommended for sandy soils when dry or liquid N is used.

There is year to year variation and in 1989 there was a significant yield difference showing Harris Lab recommendations producing the highest yields (Table 3). The 4 year yield average, however, shows no significant grain yield differences among labs. The yield average is very close to the yield goal of 165 bu/A. In 1990 there was a significant difference in yields between the labs. UNL was highest while A&L was significantly different than Harris.

The fertilizer recommendations on the four year average shows a $46 difference between the highest recommended fertilizer program for the lowest recommended fertilizer program (Table 4).

The results from this four year study are not different than those attained over the 15 year history of soil test lab comparison experiments previously conducted by UNL. The information shows that the laboratories are doing a good job of providing analytical results although differences in recommendations remain. Two laboratories (UNL and Servi-Tech) are recommending on a deficiency correction basis and both produced very good yields. The results confirm that the deficiency correction approach does not limit yields or benefits if the yield attained is above the specified yield goal (1987 data). If this were not true, the higher N, P, K, and S rates would or should have produced a higher yield, especially after 4 years. The Servi-Tech Laboratory produced the yield at a similar cost to UNL. The other two laboratories' costs were increased by larger additions of phosphorus, potassium, sulfur, micronutrients and secondary nutrients. Past research on Nebraska soils shows that many of these nutrients often do not provide economic yield increases.

Literture Cited

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Table 1. Soil test results for the B-K-R soil test lab comaprion, 1990

Laboratory	Year	pH	%O.M.	P	K	Zn*	S	Mg	Mn	Cu	B
				ppm							
A & L	1987	5.9	1.8	7	98	0.8	9	--	--	--	--
A & L	1988	5.8	1.3	4	103	1.6	11	76	5	0.4	0.7
A & L	1989	5.3	2.2	21	171	4.3	14	97	17	1.1	1.1
A & L	1990	5.8	2.2	21	192	2.9	20	124	21	1.0	0.9
Harris	1987	6.0	1.4	4	107	0.8	9	--	--	--	--
Harris	1988	6.1	1.4	11	118	2.1	3	81	4.4	0.4	0.5
Harris	1989	5.4	1.5	14	151	2.2	2	67	7.2	0.7	0.2
Harris	1990	5.5	1.5	16	131	1.5	3	81	5.3	0.4	0.5
Servi-Tech	1987	6.2	1.7	5	146	0.8	6	--	---	---	---
Servi-Tech	1988	5.7	1.5	13	138	1.4	10	79	5.6	---	---
Servi-Tech	1989	5.5	2.4	10	128	1.3	5	71	8.4	0.3	---
Servi-Tech	1990	5.5	2.3	14	140	1.2	6	73	6.0	0.3	---
UNL	1987	6.0	1.5	5	125	2.7	1	--	---	---	---
UNl	1988	6.6	1.5	8	123	5.4	3	--	---	---	---
UNL	1989	5.4	2.0	11	187	6.7	-	--	---	---	---
UNL	1990	5.7	1.8	8	125	5.5	2	--	---	---	---

*UNL runs 0.1 N HCl Zn. Other use DTPA.

Table 2. Fertilizer recommended for 165 bu/A corn.

Laboratory	Year	N	P_2O_5	K_2O	S	B	Cu	Mg	Mn	Zn
A&L	1987	220	110	140	25	1.0	1.5	22	3.5	5.0
	1988	210	115	140	14	1.0	1.0	30	3.0	3.0
	1989	190	70	90	11	0.0	0.0	22	0.0	0.0
	1990	175	60	75	0	0.0	0.0	0	0.0	0.0
Harris	1987	195	135	125	35	1.5	2.3	20	5.5	10.0
	1988	195	95	110	35	1.3	0.5	20	2.0	0.0
	1989	180	90	70	35	1.5	0.0	25	0.0	0.0
	1990	175	85	95	30	1.3	0.5	20	0.0	0.0
Servi-Tech	1987	165	95	25	15	0.5	0.0	0	0.0	3.0
	1988	210	65	30	0	0.0	0.0	0	0.0	0.0
	1989	185	75	35	0	0.0	0.0	0	0.0	0.0
	1990	190	60	30	0	0.0	0.0	0	0.0	0.0
UNL	1987	170	100	40	20	0.0	0.0	0	0.0	3.0
	1988	170	40	40	20	0.0	0.0	0	0.0	0.0
	1989	170	40	0	20	0.0	0.0	0	0.0	0.0
	1990	170	40	0	20	0.0	0.0	0	0.0	0.0

Table 3. Grain yields from the B-K-R soil lab comparison experiment.

Lab	1987	1988	1989	1990	4 Year Average
A & L	182 a*	144 a	163 b	154 ab	161 a
Harris	180 a	137 bc	178 a	143 c	159 a
Servi-Tech	184 a	139 b	169 b	150 bc	159 a
UNL	186 a	133 c	168 b	159 a	162 a

*Values followed by a different letter are significantly different at the 5% level using Duncan's new multiple range test.

Table 4. Fertilizer costs for the different lab recommendations.

Laboratory	1987	1988	1989	1990	4 Year Average
A & L	$109	$106	$70	$53	$85
Harris	$121	$ 91	$82	$81	$94
Servi-Tech	$ 62	$ 54	$53	$49	$54
UNL	$ 65	$ 46	$41	$41	$48

Fertilizer cost per pound used were N - $0.15, P - $0.28, K - $0.13, Mg - $0.38, S - $0.20, Zn - $0.90, Mn - $0.80, Cu - $2.50, and B - $2.70.

Field Evaluation to Determine Best Fluid Fertilizer for Corn

Dr. R. A. Wiese and Dr. E. J. Penas

A variety of goals are attained with the use of plant nutrients at the time of planting. Most corn growers see nutrients enhancing early rapid growth. Early rapid growth allows field operations, like cultivation, to occur earlier. A primary goal for the corn grower includes yield increases and yield maintenance. Others report drier corn at harvest and less insect or disease damage. In this field experiment, starter fertilizer is defined as the use of a small amount of nutrient placed strategically in a concentrated zone near the point of seed placement.

The starter nutrients which have accounted for most of the beneficial effects have been the macro nutrients (N, P_2O_5 and K_2O). Soil/crop/climate systems appear to dictate the relative importance of each nutrient. In some systems, zinc or sulfur may be important to corn nutrition. The ideal ratio of N:P_2O_5 in starter has been questioned in recent years. A very standard ratio of 1:3, (N:P_2O_5) has been related to the manufacture of ammoniated phosphate. Fertilizer technology can allow for the manufacture of N:P_2O_5 ratios other than the standard 1:3, (N:P_2O_5) ratio. The question of N:P_2O_5 ratio in starter may also be generated by a wide range of soil phosphate levels. The variable use of phosphate fertilizers over many years has resulted in more soils having very high phosphate levels. Whether an N:P_2O_5 ratio of 1:3 is ideal or whether this ratio should be 2:1 or 1:1 or another ratio is a question to which an answer is needed. Perhaps there may be an N:P_2O_5 ratio that is ideal for each soil/crop/climate system.

Objectives

In order to find answers for the right N:P_2O_5 ratio with field research the following objectives were addressed.

(1) To compare a range of N:P_2O_5 ratios and rates in fluid fertilizer for effects on corn production.

(2) To characterize early season growth and nutrient uptake.

(3) To determine the effect of nitrification inhibitors in fluid starter fertilizer.

Experimental Procedure

Two field locations were selected for this study. The Buffalo county site in the Platte River Valley is gravity irrigated and is under continuous corn production. The Hord silt loam soil at this site occupies a terrace position and ranks at the top of Nebraska soil productivity. The Saunders County site is irrigated with a movable sprinkler and is under a corn-soybean rotation. The Sharpsburg silty clay loam soil at this site occupies rolling landscape positions and is a dominant soil in the semi-humid area of eastern Nebraska. Additional experimental site characterization is given in Table 1. The key differences in the two experimental sites are in the degree of soil acidity, organic matter, soil phosphorus and residual nitrate levels. Soil samples were collected within 7 days of the planting date. Planting dates were April 30th at Buffalo County and May 16th at Saunders County. Spring rains caused a delay in planting at the later site. Corn was planted at a 33,000 seeds per acre at Buffalo County and at 28,000 seeds per acre at the Saunders County site.

A total of 21 fluid fertilizer materials were developed to provide different ratios of N:P_2O_5, rates of P_2O_5, paired N alone starters, and starters with inhibitors. These starter combinations shown in Table 2 and 3 were applied in a randomized block fashion and replicated five times. Nitrification inhibitors were applied at rates commonly used in starter fertilizers. All

Table 1. Experimental site characterization.

Site Information	**Buffalo Co.**		**Saunders Co.**	
Soil Tests*	0-8"	0-16"	0-8"	8-16"
pH	6.5	6.8	5.1	5.6
pH buffer	--	--	6.4	6.6
Organic Matter (%)	1.7	1.0	3.0	2.4
P (ppm)	8	3	14	6
K (ppm)	298	174	294	162
Zn(ppm)	2.4	0.4	1.5	0.4
NO_3--N (ppm)	7.9	6.1	33.0	120
Soil Type	Hord silt loam		Sharpsburg silty clay loam	
Previous Crop	Corn		Soybeans	
Irrigation System	Gravity		Sprinkler	

*P-Bray & Kurtz No. 1: Zn - DTPA Extraction

materials were applied with a John Blue squeeze pump in a concentrated band two inches to the side and one inch below the point of seed placement. All materials were designed for an application rate of 20 gallons per acre except where 60, 80, and 120 pounds of nitrogen per acre were required. One starter with a 150 pound nitrogen application was applied at 50 gallons per acre. Three starters with either 60 or 80 pounds of nitrogen per acre were applied at a 35-gallon rate per acre. Nitrogen was sidedressed at the Buffalo County site to provide each plotwith 160 lbs of nitrogen per acre. A blanket application of 140 lbs of N was sidedressed at the Saunders Co. site.

Table 2. Fluid starter fertilizer treatment on corn: nutrient rates, ratios, N vs. NP.

Starter Treatment Numbers	N	P_2O_5	Ratio	Starter Treatment Numbers	N	P_2O_5	Ratio
	------- lbs/A -------				--------lbs/A ---------		
1	0	0	--				
2	6.7	20	1:3	7	13	40	1:3
3	10	20	1:2	8	20	40	1:2
4	20	20	1:1	9	40	40	1:1
5	40	20	2:1	10	80	40	2:1
6	60	20	3:1	11	120	40	3:1
12	10	0	--				
13	20	0	--				
14	40	0	--				
15	60	0	--				

Table 3. Fluid starter fertilizer treatment for corn: Nutrient rates, ratios and inhibitors.

Starter Treatment Numbers	N	P_2O_5	Inhibitor*	Starter Treatment Numbers	N	P_2O_5	Inhibitor*
	--- lbs/A ---				--- lbs/A ---		
3A	10	20	DCD	8A	20	40	DCD
3B	10	20	N-Serve	10A	80	40	DCD
5A	40	20	DCD				
5B	40	20	N-Serve				

* DCD rate is 4% of treatment N rate with 2% ammonium thiosulfate added just prior to application; N-Serve added to furnish 0.5 lbs nitrapyrin per acre.

Weekly observation of the research field sites were made for 8 weeks following planting. Stand count was made at the 7-leaf stage of growth. Small whole corn plants were collected from each plot, dried at 70°C for 48 hours, weighed and ground in a Wiley mill using a stainless steel 2 mm sieve. All plots were harvested from two rows 25 feet long in the center of 4-row plots. Handharvested ears from each plot were shelled and weighed immediately at the field site. Grain moisture was determined on subsamples within 24 hours after collection.

Results and Discussion

Starter N: P_2O_5 Ratios

The influence of N:P_2O_5 ratios in starter fertilizer on corn early growth, yield, and grain moisture is given in tables 4,5 and 6. Fluid starter nutrients applied at all ratios of N:P_2O_5 enhanced early growth from 50 to 100 percent above no starter. N:P_2O_5 ratios of 2:1 and 3:1 resulted in enhanced early growth, but the enhanced growth was less than the growth recorded for the 1:3, 1:2 or 1:1 ratios of N:P_2O_5. Differences between the 20 and 40 pound per acre rate of P_2O_5 were small. The 40 pound per acre P_2O_5 rate resulted in a 15 percent and 9 percent increase in early growth over the 20-pound per acre P_2O_5 rate. The 15 percent increase was obtained at the Buffalo county site where P soil test was lower than at the Saunders county site.

Table 4. Effect of N:P_2O_5 ratios in liquid starter fertilizer on early corn plant GROWTH.

N:P_2O_5* Ratio	Buffalo Co. Site	Saunders Co. Site	Average Both Sites
	-------------------------	gms/6 plants	-------------------------
1:3	58.3	65.2	61.2
1:2	62.9	61.0	62.0
1:1	68.5	64.8	66.6
2:1	55.0	54.9	55.0
3:1	51.0	54.0	52.5
Check	33.0	40.4	36.7

*Average of both 20 and 40 pound per acre rates of P_2O_5.

Table 5. Effect of N:P_2O_5 ratios in liquid starter fertilizers on corn GRAIN YIELD.

N:P_2O_5* Ratio	Buffalo Co. Site	Saunders Co. Site	Average Both Sites
	bu/acre		
1:3	198.3	169.6	184.0
1:2	187.6	170.1	178.8
1:1	187.2	181.0	184.1
2:1	192.2	177.2	184.7
3:1	189.7	177.4	183.6
Check	171.8	174.0	172.9

*20 and 40 lbs/A rate of P_2O_5 are averaged.

Table 6. Effect of N:P_2O_5 ratios in liquid starter fertilizers on corn grain MOISTURE at harvest.

N:P_2O_5	Buffalo Co. Site	Saunders Co. Site	Average Both Sites
	% Moisture		
1:3	22.5	19.8	21.2
1:2	23.6	19.3	21.4
1:1	22.7	20.7	21.7
2:1	22.8	20.5	21.6
3:1	23.1	20.1	21.6
Check	25.9	21.0	23.4

Both experimental sites exhibited excellent corn plant population. Spacial configuration of plants within the row was very uniform. No starter fertilizer had a depressing influence on plant population.

An increase in yield due to starter was documented at the low P testing site in Buffalo county (Table 5). Yields from starter fertilizer increased from 172 to 198 bushels per acre from no starter to a 1:3, N:P_2O_5 starter at Buffalo county. No real effect of ratios of N:P_2O_5 on yield can be reported at the Saunders county site. This is attributed to a higher soil test P level and a corn-soybean production system.

Grain moisture at harvest was decreased by the use of starter fertilizer at all ratios of N:P_2O_5. No difference in grain moisture can be associated with different ratios of N:P_2O_5.

Starter N vs. NP

A comparison of N and NP fluid starters is given in Tables 7, 8 and 9. Early growth of corn increased much more with NP starters than with N starters. Growth increased from 36.7 gms for no starter to 56.5 gms per 6 plants for NP starters. Increases in early growth from N starter are not clearly documented. Some evidence is present to support a 1:2 or 1:1 as the better N:P_2O_5 ratio for more rapid early growth.

Yield increase was associated with NP starter at the Buffalo county site. No yield increase occurred with N starter at either experimental site. The influence on yield from NP starters at Buffalo county was 188.4 bushels per acre compared to a yield of 174.0 for no starter fertilizer (Table 8).

Grain moisture at harvest was not decreased by N fluid starters. Grain moisture was lower only when NP fluid starters were applied (Table 9).

Table 7. Comparison of N vs. NP fluid starter fertilizer on early corn plant GROWTH.

N:P_2O_5 Ratio	N + P_2O_5* Starter BC	SC	N Only Starter BC	SC
	gms/6 plants			
1:2	59.2	53.8	40.0	42.2
1:1	58.4	61.4	41.0	45.2
2:1	51.6	48.6	37.0	40.0
3:1	53.8	56.8	37.8	40.2
Check	33.0	40.4	33.0	40.4
Site Mean	57.8	55.2	39.0	41.9
Avg Trt Effect	56.5		40.4	
Avg Check	36.7		36.7	

*BC - Buffalo Co.; SC - Saunders Co.

Table 8. Comparison of N vs. NP fluid starter fertilization corn grain YIELD.

N:P_2O_5 Ratio	N/P_2O_5* Starter		N Starter	
	BC	SC	BC	SC
	bu/acre			
1:2	191.5	174.1	178.7	170.4
1:1	184.2	179.3	166.6	169.0
2:1	191.3	176.3	166.8	170.6
3:1	186.8	169.6	170.4	172.4
Check	174.0	171.8	174.0	171.8
Site Means	188.4	174.8	170.6	170.6
Avg Trt Effect	181.6		170.6	
Avg Check	172.9		172.9	

*P_2O_5 applied at 20 lbs per acre.
BC = Buffalo Co. site; SC = Saunders Co. site

Table 9. Comparison of N vs. NP fluid starter fertilizer on corn GRAIN MOISTURE at harvest.

N:P_2O_5* Ratio	N + P_2O_5* Starter		N Alone Starter	
	BC	SC	BC	SC
1:2	23.4	19.4	25.0	21.4
1:1	23.2	21.4	25.7	21.3
2:1	23.2	20.7	25.0	20.8
3:1	23.4	20.1	26.0	20.7
Check	25.9	21.0	25.9	21.0
Site Mean	23.3	20.4	25.4	21.0
Avg Trt Effect	21.8		23.2	
Avg Check	23.4		23.4	

*P_2O_5 applied at 20 lbs per acre.
BC = Buffalo Co. site; SC = Saunders Co site.

Starter With Nitrification Inhibitors

The use of nitrification inhibitors in starter fertilizers is known to maintain the ammonium fraction of nitrogen for a longer period of time. Secondly the presence of ammonium nitrogen in starter has been shown to enhance phosphorusuptake. Plant nutrient analysis of 7-leaf stage corn plants is necessary to ascertain nutrient influences. Such analysis is presently underway. Tables 10, 11, and 12 provide data summaries for the influence of nitrification inhibitors on early plant growth, on yield, and on grain moisture.

Table 10. Effect of nitrification inhibitor in fluid starter fertilizer on early corn plant GROWTH.

Nitrification Inhibitors	$N:P_2O_5$	Buffalo Co. Site	Saunders Co. Site	Average Both Sites
		------------------- gns/6 plants	-------------------	-------------------
0	1:2	71.9	61.0	64.4
DCD	1:2	73.7	65.6	69.6
N-Serve	1:2	68.8	56.4	62.6
0	2:1	63.9	54.9	59.4
DCD	2:1	74.5	64.9	69.7
N-Serve	2:1	70.0	67.2	68.6
Check	--	33.0	40.4	36.7

Table 11. Effect of nitrification inhibitors in fluid starter fertilizers on corn grain yield.

Nitrification Inhibitor	$N:P_2O_5$	Buffalo Co. Site	Saunders Co. Site	Average Both Sites
		------------------- bu/acre	-------------------	-------------------
0	1:2	189.5	170.1	179.8
DCD	1:2	186.8	169.7	178.2
N-Serve	1:2	188.1	172.0	180.0
0	2:1	185.8	177.2	181.5
DCD	2:1	185.2	173.0	179.1
N-Serve	2:1	188.6	177.3	183.0
Check	---	171.8	174.0	172.9

Table 12. Effect of nitrification inhititors in fluid starter fertilizers on grain moisture at harvest.

Nitrification Inhibitor	$N:P_2O_5$ Ratio	Buffalo Co. Site	Saunders Co. Site	Average Both Sites
		------------------ % grain moisture ------------------		
0	1:2	23.9	19.2	21.6
DCE	1:2	22.7	19.4	21.0
N-Serve	1:2	23.2	20.6	21.9
0	2:1	24.7	20.0	22.4
DCE	2:1	23.0	20.0	21.5
N-Serve	2:1	22.8	20.3	21.6
Check	---	25.9	21.0	23.4

CONCLUSIONS

1. Ratios of $N:P_2O_5$ from 1:3, 1:2 or 1:1 were better in enhancing early growth than ratios of 2:1 and 3:1 on fields where soil P tests are medium or low.

2. Plant population was not affected by any rate or ratio of $N:P_2O_5$ when placed 2 inches away from the point of seed placement.

3. Reduction in grain moisture at harvest is noted for all starter $N:P_2O_5$ ratios. The degree of grain moisture reduction appears to be related to soil P levels.

4. Fluid starters with N only had no influence on grain moisture or yield and had only a very slight effect in enhancing early growth.

5. The use of nitrification inhibitors in fluid starters had no affect on early growth, yield or grain moisture.

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Increasing Anhydrous Ammonia Efficiency on Irrigated Corn in Nebraska.

M.V. Marake, D. H. Sander and D.T. Walters

Objectives:

1) To determine the effect of rate and spacing of anhydrous ammonia (AA) bands on irrigated corn yield.

2) To characterize the nitrification processes

a) nitrification of N in the AA band as affected by concentration of applied N.

b) the effects of soil water and soil temperature on the nitrification processes in the band.

3) To evaluate corn root distribution in the AA band zone.

4) To compare AA and NH_4NO_3 with respect to NO_3 and NH_4 movement in the profile.

Procedure:

Experiments were conducted at two locations in Nebraska in 1990. One was located at the Agricultural Research and development Center at Mead, Nebraska on a Sharpsburg silty clay loam. The other site was located in Merrick county, Nebraska on a Ipage loamy fine sand. The treatments were replicated four times in a randomized complete block design.

The treatments were as follows:

1) 5 N rates (0, 50, 150 and 200 lbs N acre^{-1}) of anhydrous ammonia (AA) and NH_4NO_3 (AN) N sources.

2) Knife spacing (KS): 3 intervals (15, 30, and 60 inches). Nitrogen was applied either as AN (broadcast) or AA at 15 inches (6 knives), 30 inch (3 knives) and 60 inch (2 knives) intervals. Cultural operations at the on farm site were performed by the cooperating farmer except for N treatments which were applied prior to emergence with an N applicator calibrated at each knife outlet. Equivalent N concentrations were determined by N rate at each knife output (N rate/# of knives). A total of nine N concentration gradient treatments were taken over all N rates and knife spacing intervals. The soil samples were taken down to 20 inches depth at every position (0.5 inch intervals) and at alternate depths in the sampling grid. Samples were taken with a 0.75 inch diameter hand probe guided by a steel template. The sample grid is shown in figure 1.

Sampling position

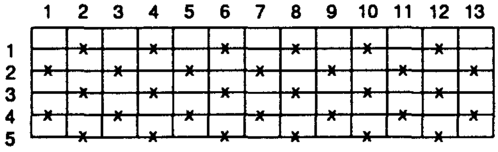

Fig. 1. Sampling pattern for soil NH_4-N and NO_3-N during the growing season. The horizontal axis is the sampling position with respect to the center of the AA band at position 7. The vertical axis is the depth interval from 0 inch to 20 inch at 4 inch increments (coded as 1, 2, 3, 4, and 5). "x" represents the sample point in the sampling grid.

Soil samplesweretaken twice during the growing season when the crop was at 10-leaf stage and at silk stage and analyzed for NH_4-N and NO_3-N concentrations. Root samples were taken in the row and on the band at brown silk stage with a 1.75 inch diameter hand probe. Soil temperature was monitored weekly with temperature gauges inserted at 6 and 9 inch depth within the row. Gravimetric soil water content was also measured weekly. Two rows were combine harvested for grain yield and a 10 ft row length harvested for stover yield. Both grain and stover N content were determined by Kjeldahl analysis.

Results and Discussion

The results reported here are preliminary analysis for the 1990 growing season. Analysis of variance for grain yield in Saunders and Merrick counties are shown in table 1 for ammonia rate and spacing treatments.

In Saunders county, the 15 inch knife spacing (KS) was superior to both the 30 and 60 inch KS at the lowest (50 lb) N rate. This can be explained by the proximity of the 15 inch band to the corn rows thus enhancing N uptake at low N rates. Both N uptake and root distribution data are being processed to ascertain this apparent effects. At the higher N rates, all spacings probably showed similar performance. The 60 inch KS was under applied by approximately 30 percent in the Saunders county location. This is probably responsible for the significant rate by spacing interaction (table 1).

In Merrick county, all KS showed similar performance across all N rates (Table 2). However, the 30 inch spacing was inferior to the either the 15 or 60 inch spacing at high N rates (150 and 200 lb per acre). There is no known reason for the poor performance of the 30 inch spacing at higher N rates. The significant interaction between rate and KS is also thought to be the artifact of poor performance of the 30 inch KS at the high rates of applied N.

There was a significant source by N rate interaction at the Saunders county but not at Merrick county location (Table 3).

However, main effect source was significant (p .05) at the Merrick county location. In the silty clay loam soil (Saunders county), AN was superior to AA (30 in) except at the highest N rate (table 4). This results are hard to explain given the nature of AA effects observed in other studies in comparison with AN. However, this is thought to either be the results of under application of AA due to calibration problems resulting or the effect of volatile N losses at the time of AA application particularly at the low rate of N.

In Merrick county, there was no significant source by rate interaction (Table 3). AA at this location had an overall greater effect on grain yield compared to the AN source. Soil NH_4-N and NO_3-N and root data are being processed and could not be included in this report.

Summary

The main objective of this study was to evaluate the effects of varying concentrations of AA induced by band spacing on the nature of N transformations following AA application. To ascertain this effects, the AA bands have been intensively sampled and the results are being processed for nitrate and ammonium concentration in the soil profile. Nevertheless, the effect of spacing management on grain yield is of great interest in this study for determining any differential yield response induced by AA band spacing. However, these results are preliminary and inconclusive. The 60 inch spacing was inadvertently under applied in the Saunders county location due calibration error. This was possibly confounded with errors due to tank pressure variations which were not considered in the calibration procedure.

Table 1. Analysis of variance for grain yield in (a) Saunders (b) Merrick counties respectively for the 1990 growing season

Source	Df	SS	Pr>F
		(a) Saunders County	
Rate	3	62	.0001
KS	2	25	.004
Rate*KS	6	22	.109
		(b) Merrick County	
Rate	3	118	.0001
KS	2	15	.101
Rate*KS	6	42	.061

Grain yield ranged from 87.55 (4.68 Mg/ha) to 195.69 (10.48 Mg/ha) bushel per acre in Saunders county and 58.10 (3.11 Mg/ha) to 182.42 (9.77 Mg/ha) in Merrick county

Table 2. Effects of knife spacing by N rate on grain yield in Saunders County, Nebraska. 1990.

	Saunders Co.			Merrick Co.		
	Knife Spacing (inches)					
N Rate	15	30	60	15	30	60
lb/A	Grain Yield bu/acre					
0	88	88	88	58	58	58
50	154	106	103	76	88	95
100	146	157	152	109	125	103
150	178	150	122	159	130	171
200	190	196	158	182	107	180

Table 3. Analysis of variance for N source effects on grain yield in (a) Saunders and (b) Merrick Counties. Nebraska, 1990.

Source	Df	SS	Pr> F
	a) Saunders Co.		
Rate	3	18020	.0001
Source	1	1794	.04
Rate*Source	3	3295	.06
	b) Merrick Co.		
Rate	3	5047	.20
Source	1	5219	.03
Rate*Source	3	3295	.51

Table 4. Effect of N source and rate on irrigated corn yield in Saunders and Merrick counties, Nebraska.

	1990.			
N Rate lb N/A	Saunders Co.		Merrick Co.	
	AA	AN	AA	AN
	Grain Yield bu/A			
50	106	137	88	68
100	156	175	125	84
150	150	179	130	88
200	196	177	107	108
Mean	152	167	113	87

Evaluation of Tillage, Rotation, Nitrogen and Cover Crop Effects on Nitrogen Cycling.

K. Anabayan, D. T.Walters and D. H. Sander.

Objective.

To determine the effect of tillage and rotation of soybean on

i. grain and stover yield of corn under increasing N rates.

ii. the percentage of residue cover of the previous crop in each rotation as function of rotation with and without a winter rye cover crop in soybean.

iii. the interaction between and relative contribution of N from different N sources (corn, soybean and rye residues,fertilizer N and soil N) to N nutrition of associated crop.

Procedure.

This experiment was established in 1988 at ARDC, Mead as a randomized complete block split-split plot design under irrigation. The treatments consist of (i). Two tillage systems viz., Conventional disk and No-till systems in main plots with a cultivation in both systems for weed control, (ii). Three rotation systems, continuous corn(CC), corn after soybean (CB) and soybean after corn (BC) in sub-plots and, (iii). Five nitrogen rates viz., 0, 50, 100, 150 and 200 kg N/ha in sub sub-plots. Each soybean plot was split and winter rye was drilled as a winter cover crop after harvest. The soil type is a Sharpsburg silty clay loam (fine montmorillonitic mesic Typic Argiudol).

Corn (Pioneer) was planted on May 1 at 75 cm row spacing. Soybean cultivar Century 84 was planted on May 25 at 75 cm row spacing. Secondary cultivation was given a week after knee high stage for corn and at V5 to V6 stage for soybean. Corn grain and stover were hand harvested from a 20 feet row length after physiological maturity and the yields were estimated on hectare basis. The amount of residue cover of the previous crop on the plots were estimated before (post plant) and after secondary tillage, by line intersect method. Soybean yielded an average 50 bu/ha.

A series of contiguous, replicated microplots, each 1.5 x 1.72 m in size was established in each rotation/cover crop combination at 0 and 150 kg N/ha under disk tillage system. The microplots were so arranged to carry out cross-labelling of different N pools (residue, soil, fertilizer and cover crop) in the second year of the study. The labelling of residue and soil was done as follow.

Nine kg of 99% enriched ($^{15}NH_4)_2SO_4$)-N /ha was applied to single microplot in each treatment for the 0 N rate corn and soybean, while 150 kg of 10% enriched ($^{15}NH_4)_2SO_4$)-N/ha was applied to corn (continuous and rotated) at R1 and V8 stages for soybean and corn respectively to maximize label in the plant tissue. Wire cage was installed around each microplot to collect the soybean and corn residues as it falls and to prevent dilution from or addition of unlabelled residue from adjacent plots. The residues were collected, quantified, mixed and equally applied to different microplots as per the experimental structure. The labelled tissues of corn soybean stover and leaf were separately analysed for the isotope ratio and %carbon. Soil samples were collected from each labelled microplots at 0-15 and 15-30 cm depths for isotope ratio analysis.

Results.

Rotation of soybean with corn resulted in 45% and 31.6% increase in corn grain and stover yield respectively over the continuous corn. Though a quadratic response was observed in the grain yield of corn due to differential N rates, application of nitrogen more than 50 kg N/ha did not produce any appreciable increase in either grain or stover yield of corn (Fig 1). Further, no significant influence of tillage treatments on the grain yield, stover production and N uptake was observed (Table 1). Interaction between rotation and N rates indicated an increase of 18.9% in grain N for corn after soybean compared to continuous corn at 50 kg N/ha (Table 1). As a result of increased grain N content and grain yield, the amount of total grain N uptake was 1.5 times more in the corn following bean than that of the continuous corn. Though the N content in the stover was not influenced by rotation and N rates, the high amount of stover production in CB rotation system led to the recycling of 42.6% more nitrogen through the addition of corn residue than CC rotation system (Table 2). Despite significant influence of the N rate and tillage x N rate effects on the total plant population/ha, no significant difference in the total number of ears was noticed.

The amount of residue cover on the field gives a good measure of soil erosion protection. Tillage and rotation significantly influenced the amount of residue cover on the field. As a result of no-till treatment 2.4 and 1.9 times more residue cover was obtained in CC and CB rotation systems respectively over the disk treatment (Table 2). Similar trend was observed even after one secondary cultivation. This indicates the potential hazard of soil erosion in soybean fields during the periods of heavy rains due to less residue production, which would in turn be aggravated by tillage. However, the crop canopy cover measurement made in soybean showed nearly 10% more canopy cover in the disk than in the no till system.

Adequate labelling with 15-N isotope was acheived both in corn and soybean (Table 4). Application of 10% 15-N enriched fertilizer (@150 kg/ha) resulted in high atom % 15-N in corn residues. Less atom % 15-N in the case of 99% 15-N enriched material might be attributed to high immobilization of applied N. One of the reason for comparitively less atom % 15-N in soybean residues than in corn residues might be its N- fixing ability and its high N need. Further, relatively higher amount of labelling was observed in continous corn than in corn following soybean. This implies that the N fertilizer requirement of corn following soybean may be less due to large amount of easily mineralizable N fraction in the soybean residues by virtue of its low C/N ratio. This has been clearly shown in table 4, separately for soybean leaf and stover. Amount of 15-N removed through grain in soybean range from 2.84 to 3.0962 kg/ha. But due to high amount of total N removal the atom % enrichment in the soybean grain is less when compared to corn grain (table 4). The contribution of N from labelled residues will be measured in the 1991 cropping season.

Table 1. Main effect and 2-way interaction means table for corn grain and stover yield, grain and stover N content, grain and stover N removed, plant population and barren stalk.

	Grain Yield	Stover Yield	Grain Nitrogen	Stover Nitrogen	Grain N Removed	Stover N Removed	Plant Population	Barren Stalk
	Mg/ha(bu/ha)	Mg/ha	%	%	kg/ha	kg/ha	1000/ha	(%)
Tillage								
Disk	8.81 (157)	6.23	1.26	0.65	113	40	66	8
No till	8.91 (159)	6.31	1.23	0.61	112	39	61	5
Rotation								
CC	7.22 (130)	5.41	1.21	0.61	89	33	65	11
CB	10.49 (187)	7.13	1.29	0.66	136	47	62	2
N Rate								
0	7.50 (134)	5.53	1.06	0.59	82	33	58	2
50	8.88 (159)	6.27	1.18	0.59	108	42	67	9
100	9.38 (168)	6.52	1.30	0.66	123	41	58	3
150	9.38 (168)	6.07	1.34	0.64	126	41	69	12
200	9.15 (163)	6.98	1.36	0.68	124	41	59	7
Tillage x Rotation								
Disk CC	6.97 (123)	5.29	1.21	0.64	85	34	70	15
CB	10.65 (190)	7.17	1.36	0.66	141	47	62	1
No till CC	7.38 (132)	5.54	1.21	0.57	93	32	59	7
CB	10.33 (184)	7.08	1.26	0.65	131	46	62	3

Table 1. (Continued)

		Grain Yield	Stover Yield	Grain Nitrogen	Stover Nitrogen	Grain N Removed	Stover N Removed	Plant Population	Barren Stalk
		Mg/ha(bu/ha)	Mg/ha	%	%	kg/ha	kg/ha	1000/ha	(%)
Tillage x N Rate									
Disk	0	8.37 (149)	5.97	1.09	0.57	93	35	64	9
	50	8.91 (159)	5.96	1.19	0.56	110	39	71	11
	100	9.03 (161)	6.6	1.31	0.73	120	43	56	0
	150	9.07 (162)	5.71	1.35	0.67	123	44	73	4
	200	8.67 (155)	6.93	1.37	0.72	119	42	67	7
No till									
	0	6.64 (119)	5.10	1.04	0.60	70	31	52	0
	50	8.85 (158)	6.57	1.17	0.63	105	45	63	6
	100	9.74 (174)	6.43	1.29	0.59	126	39	61	6
	150	9.69 (173	6.42	1.32	0.62	128	39	65	10
	200	9.61 (172)	7.02	1.35	0.64	129	41	63	6
Rotation x N Rate									
CC	0	5.45 (97)	4.49	1.02	0.52	56	24	59	9
	50	6.93 (124)	5.89	1.08	0.55	76	32	69	3
	100	8.25 (147)	5.41	1.26	0.63	104	33	57	2
	150	7.60 (136)	5.81	1.32	0.71	101	41	73	19
	200	7.88 (141)	5.48	1.37	0.64	108	34	67	3
CB	0	9.56 (171)	6.58	1.12	0.66	108	43	57	0
	50	10.83 (193)	7.12	1.28	0.64	139	52	64	5
	100	10.51 (188)	7.23	1.34	0.69	141	49	60	3
	150	11.16 (199)	6.65	1.35	0.58	151	42	65	5
	200	10.41 (186)	8.07	1.34	0.72	141	48	63	0

Grain yield: Mg/ha = on dry wt basis; bu/ha = at 15% moisture content.
CC = continuous corn; CB = corn after soybean.

Table 2. Main effect and 2-way interaction means for residue cover, Mead, NE 1990.

Source		Res I	Res II	Res III
		%		
Tillage				
Disk		31	21	93
No till		63	41	93
Rotation				
CC		58	42	97
CB		24	11	96
BC		59	41	86
Tillage x Rotation				
Disk	CC	40	30	97
	CB	14	8	97
	BC	40	26	86
No till	CC	75	54	96
	CB	34	13	96
	BC	79	55	86

Res I:	Residue cover of previous crop (post planting)
Res II:	Residue cover of previous crop after cultivation
Res III:	Residue cover of the present crop after harvest

CC	Continuous corn
CB	Corn after soybean
BC	Soybean after corn

Table 3. Analysis of variance table for the variables listed in the mean table.

Sources	df	Grain Yield	Grain N (%)	Grain N Removed	Stover Yield	Stover N (%)	Stover N Removed	Popu- lation	Barren Stalk	Res I	Res II	Res III
		------------------------------------ Prob F ------------------------------------										
Tillage	1	NS	NS	NS	NS	NS	NS	NS	NS	*	**	NS
Rotation	1	***	NS	***	***	NS	**	NS	*	***	***	***
N Rate	4	*	***	***	**	NS	NS	***	*			
NL	1	**	***	***	***	*	NS	*	NS			
NQ	1	*	***	**	NS	NS	NS	NS	NS			
Tillage x Rotation	1	NS	NS	NS	NS	NS	NS	NS	NS	*	***	NS
(Disk vs No till) (CB vs CC)	1	--	--	--	--	--	--	--	--	*	***	NS
(Disk vs No till) (CB+CC vs BC)	1	--	--	--	--	--	--	--	--	NS	*	NS
Tillage x N Rate	4	NS	NS	NS	NS	NS	NS	*	NS			
Disk vs No Till by NL	1	*	NS	*	NS	NS	NS	NS	NS			
Disk vs No Till by NQ	1	NS	NS	NS	NS	NS	NS	NS	NS			
Rotation x N Rate	4	NS	**	NS	NS	NS	NS	NS	NS			
CB vs CC by NL	1	NS	***	NS	NS	NS	NS	NS	NS			
CB vs CC by NQ	1	NS	NS	NS	NS	NS	NS	NS	NS			

Res I: Residue cover of previous crop (Post planting).
Res II: Residue cover of previous crop after cultivation
Res III: Residue cover of the present crop after harvest

NL = N rate linear
NQ = N rate quadratic

CB = Corn after soybean
CC = Corn continuous corn
BC = Soybean after corn

***, **, * = level of significance at 0.001, 0.01 and 0.05, respectively.

Table 4. Summary of Isotope-ratio analysis for corn and soybean residues and grain.

Sources	N Rate*	15-N enrichment recycled	Total residue	Total N recycled	15-N recycled	Atom % 15-N in residue	C:N ratio	Total Grain N	15-N in Grain	15-N atom % in grain
	(kg/ha)	(%)	(Mg/ha)	(kg/ha)	(kg/ha)			(kg/ha)	(kg/ha)	
CC	0 (9)	99	5.95	34	0.88	2.40	76:1	54	1.35	2.39
	150	10	6.82	46	1.99	4.02	61:1	92	4.92	5.03
CB	0 (9)	99	8.52	52	1.00	1.79	71:1	99	2.19	2.13
	150	10	7.68	56	1.57	2.63	63:1	139	5.28	3.54
BC										
Leaf	0 (9)	99	1.74	30	0.71	2.23	25:1	200	2.84	1.33
Stover			2.77	24	0.40	1.54	51:1			
Total			4.51	54	1.12	1.92	37:1			
Leaf	150 (9)	99	2.54	45	0.83	1.72	24:1	219	3.09	1.33
Stover			3.43	27	0.39	1.37	56:1			
Total			5.97	72	1.22	1.55	36:1			

CC = Continuous Corn; CB = Corn after Soybean; BC = Soybean after Corn

* Number in parenthesis indicates actual enriched N applied. For BC, N rate indicates previous year N rate on corn.

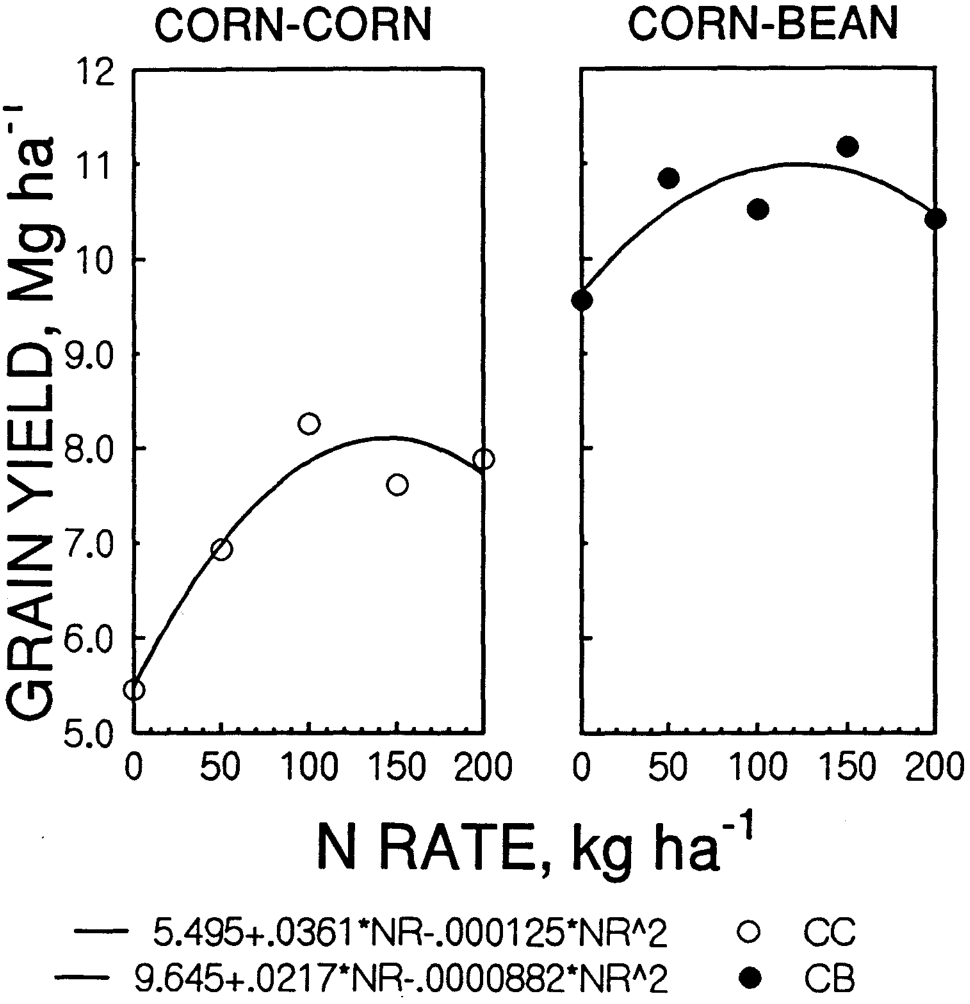

Fig 1. Rotation x N rate effect on Corn grain yield. Mead 1990.