Soil Science Research Report - 1989

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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 and fertilizer N use efficiency.
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 June 1st 1989 at a rate of 4.5 kg ha^{-1} in a 0.75 m row spacing. Weeds were chemically controlled wit periodic hand hoeing of weed escapes. Nitrogen was applied preplant on May 25th, 1989 and sidedressed on July 19th, 1989 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 third year of an experiment initiated in 1987. The experiment was conducted on the same plot areas with no treatment modification in all three 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

Table 1. Analysis of variance and contrasts for grain (GY), grain N uptake (NG) and grain fertilizer use efficiency (FUE). 1989. NS= not significant at P> .20.

Effects	df	GY	NG	FUE
			PR > F	
Rep	3			
Till	1	.20	.15	NS
Rep*Till	3			
Time	1	.19	NS	.14
Till*Time	1	.18	NS	NS
NFP	2	.01	.01	.01
(AAvsUK)	1	.01	.01	.01
(UDvsUK)	1	.16	NS	.01
Till*NFP	2	NS	NS	NS
Till*(AAvsUK)	1	NS	NS	NS
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	.16
Till*Time*(AAvsUK)	1	NS	NS	.14
Till*Time*(UDvsUK)	1	NS	NS	NS
Rate	3	.01	.01	.01
NrateL	1	.01	.01	.01
NrateQ	1	.01	.01	NS
Till*Rate	3	NS	NS	NS
Till*RateL	1	.11	.19	NS
Till*RateQ	1	NS	NS	NS
Time*Rate	3	NS	NS	NS
Time*RateL	1	NS	NS	NS
Time*RateQ	1	NS	NS	NS
NFP*Rate	6	.04	.01	.01
(AAvsUK)*NrateL	1	.01	.03	.01
(AAvsUK)*NrateQ	1	NS	.05	.02
(UDvsUK)*NrateL	1	NS	NS	.02
(UDvsUK)*NrateQ	1	NS	NS	NS
Till*Time*Rate	3	NS	.09	NS
Till*Time*NrateL	1	NS	NS	NS
Till*Time*NrateQ	1	NS	NS	NS
Till*NFP*Rate	6	.20	NS	NS
Till*(AAvsUK)*NrateL	1	.05	.04	NS
Till*(AAvsUK)*NrateQ	1	NS	.17	NS
Till*(UDvsUK)*NrateL	1	NS	NS	NS
Till*(UDvsUK)*NrateQ	1	NS	NS	NS
Time*NFP*Rate	6	NS	NS	NS
Time*(AAvsUK)*NrateL	1	NS	NS	NS
Time*(AAvsUK)*NrateQ	1	NS	NS	NS
Time*(UDvsUK)*NrateL	1	NS	NS	NS
Time*(UDvsUK)*NrateQ	1	NS	NS	NS

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 2.52, 2.16, 10.52, 10.57, 4.11 and 12.79 cm respectively (Fig. 1). Despite the dry growing season with some what erratic rainfall distribution, sorghum grain yield averaged 4.18 Mg ha^{-1} (78.8 bu A^{-1}) and ranged between 1.80 and 5.91 Mg ha^{-1} (33.48 and 110 bu A^{-1}) depending on treatment.

Grain yield was influenced by till, N form placement and rate of N application. Grain yield response was linear with rate of N application in both tillage systems regardless of N form placement. However, AA resulted in greater grain yield at low rates of applied N under no-tillage management when averaged over time of N application (Fig. 2). Although there were significant differences in magnitude of grain yield response between AA and UAN sources among tillages, the overall response surface was apparently similar between tillage systems. In previous years on this experiment, we observed tendencies towards greater N requirements for maximum grain yield under no-tillage compared to disk systems with higher grain yields under no-till. Similar trends were also reported by other researchers. However, these results suggest that differences between no-till and disk systems are short term if the tillage regime is established over time. This proposition is supported by long term reports showing equal or greater yields under no-till compared to conventional tillage practices.

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 fertilizer use efficiency (FUE) was estimated by the difference method [$(N_F-N_O)/N_R*100$ where N_F, N_O = N uptake in fertilized and control plots respectively and NR = rate of applied N]. Grain N uptake (Fig. 2) and FUE (Fig. 4) patterns indicated that AA was the most effective method of supplying fertilizer N and therefore achieved maximum grain yield for both tillage treatments at lower rates. In contrast, UD resulted in depressed FUE compared to the injected forms of placement (Table 2). The UD placement was probably more susceptible to volatile and/or immobilization N losses associated with microbial aactivity during residue decomposition while injection synlocalized applied N with the roots system.

Table 2. NFP X N Rate interaction on FUE (%)

	N FORM PLACEMENT		
N Rate	AA	UD	UK
40	54	5	29
80	22	15	25
120	20	12	17

Summary:

Three years into the tillage regime, disk and no-till systems showed similar response in both grain yield and N uptake. However, N form placement differences indicate that AA was the most effective method of supplying N in terms of grain yield, N uptake and fertilizer use efficiency. The injected forms of N resulted in greater fertilizer use efficiency compared to surface dribbled method of N application. The superior performance of injected versus surface dribbled has been observed by other researchers. Although, in this study, greater FUE was not commensurate to greater grain yield between the UAN sources, AA was superior to the UAN sources in both FUE and grain yield. The overall response to injecting versus surface placement of N sources is thought to be the result of a physical placement of N below the soil surface to circumvents volatile ammonia loss. 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. Other workers have explained the greater efficiency of ammonia by reduced microbial activity in the high pH zone of the ammonia band compared to urea ammonium nitrate forms.

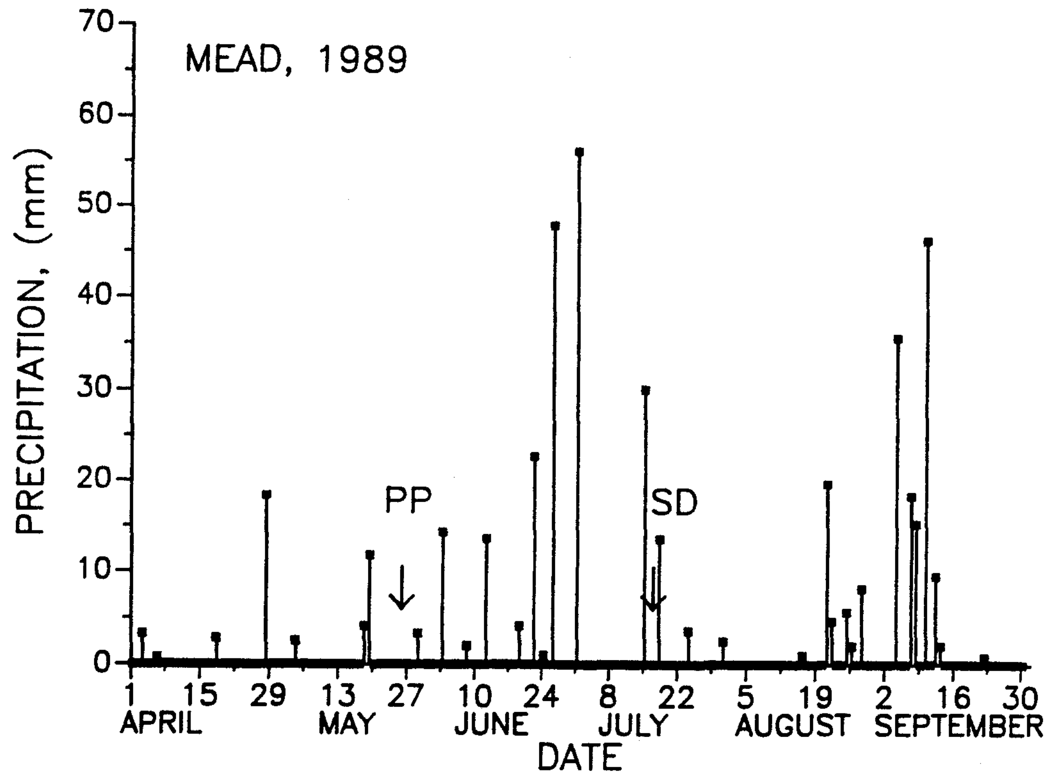


Fig. 1. 1987 growing season precipitation, Mead, Nebraska.

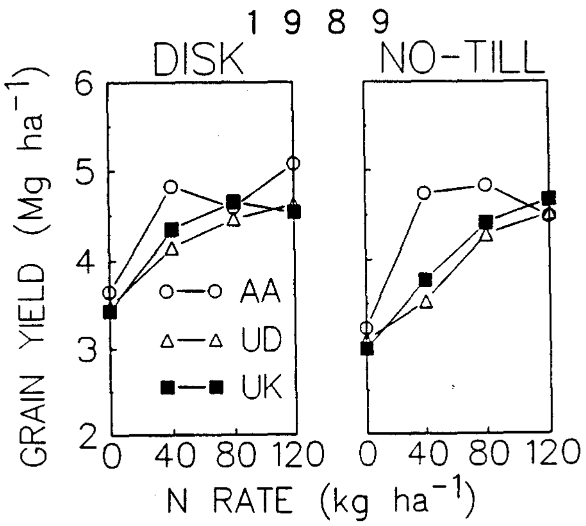


Fig. 2. Tillage x NFP X N rate interaction on grain yield, 1989.

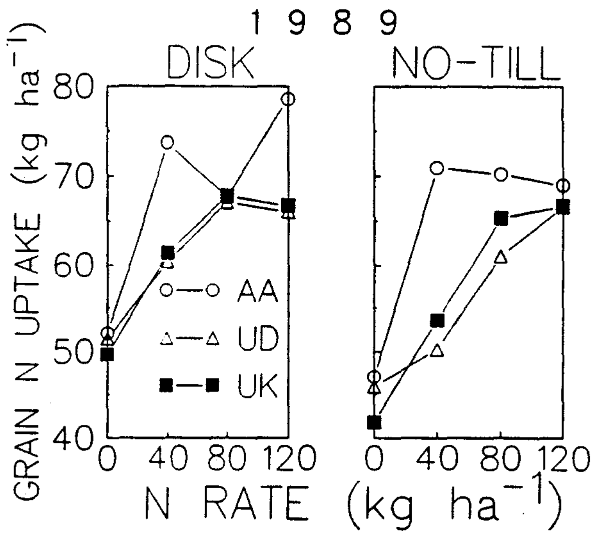


Fig. 3. Tillage x NFP X N rate interaction on grain N uptake, 1989.

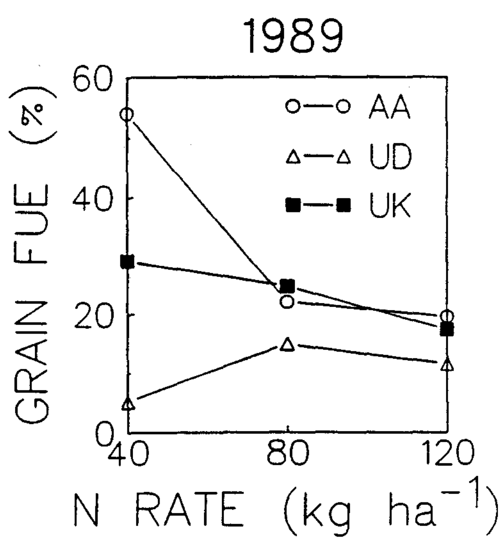


Fig. 4. NFP x N rate interaction on grain fertilizer use efficiency, 1989.

THE EFFECT OF PHOSPHORUS RATE, METHOD OF APPLICATION, AND TILLAGE ON SOYBEAN YIELD IN NEBRASKA

T.A. Essman, D.H. Sander, C.A. Shapiro, R.B. Ferguson, P. Darrow

OBJECTIVE: To determine the effect of applied P on soybean yield, P uptake, and fertilizer P efficiency as affected by different methods of P application and tillage.

PROCEDURE: Experiments were conducted at three locations in Nebraska in 1989. Two were located in Southeastern NE in Nemaha and Lancaster Counties on a Marshall sicl and a Sharpsburg sicl respectively, and one was located in Northeastern NE in Cedar County on a center pivot irrigated Crofton sicl. Two tillage systems (disk and no-tillage) were studied at on the Crofton and Sharpsburg soils, while the Marshall soil was disk tillage only. The sites were dryland except for the Cedar Co. site which is irrigated. The experimental design for the sites with both tillage systems was a completely randomized block with a split-plot factorial (treatment arrangement 2 x 5 x 3 tillage x rate x method with tillage as the whole-plot factor). At Nemaha, the experimental design was a randomized complete block design. The P placement methods were preplant broadcast (incorporated in disk tillage), preplant knifing at 15-inch spacings (4-6 inches deep), and row application (1 inch below and 3 inches beside the seed). Phosphorus rates were 0, 18, 37, 55, 74 lbs P_2O_5/acre respectively. All treatments received equal amounts of nitrogen by mixing urea-ammonium nitrate solution (28-0-0, N-P-K) with the ammonium polyphosphate (10-34-0, N-P-K). In the no-till system, soybeans were planted directly into the standing corn/sorghum residue. The disk system involved disking prior to planting and after fertilizer application. Leaf, whole plant, and grain P concentrations and fertilizer P efficiencies were determined. Leaf P samples were taken at the R4 stage and whole plant samples at the R10 stage (see table 1). Soil samples were also taken to determine the band placement location and to determine how tillage affected the band distribution. A template was used to sample 1-2 inches apart and at depth intervals of 1 inch in the 0 and 74 lbs P_2O_5/acre treatments. Soil samples were analyzed by the Bray and Kurtz #1 method.

RESULTS AND DISCUSSION: On the irrigated Crofton sicl soil, soybean yields were not effected by applied P, but plant tissue and grain P concentrations, and plant P uptake were increased (Tables 2 & 5). The leaf P values were well above the critical nutrient value of 3.5 g/kg, thus, there was no P deficiency at this stage. Broadcast application supplied more P to the plant throughout the season, and was also the most efficient method. Tillage did not influence any of the factors studied. Soil samples showed that the bands were still intact with the P concentration due to broadcast being highest in the top 1 inch, the knife band was found between 2-4 inches deep and 4-5 inches from the plant, and the row method was 2-4 inches deep and 1-2 inches from the plant (Fig 1).

On the Sharpsburg sicl soil, soybean yield was not effected by applied P, but plant and grain P concentrations, and P uptake were increased linearly as the P rate increased. This dryland, low P soil test site (9.0 ppm) showed a trend for row application to be a superior method of suppling P to the plant then broadcasting or knife applications (Tables 3 & 5). Tillage affected only the leaf P values, with the knife method suppling more P to the plant than the row or broadcast methods in the no-till system, and the row method suppling more P to the plant than the knife or broadcast methods in the disk tillage system. Soil samples showed that the band was not affected by disking. The row and knife bands were located where they were originally placed, and broadcast samples showed the greatest concentration in the top 2 inches of the soil (Fig 2).

On the Marshall sicl soil, soybean yields were not affected by applied P even though the soil test P level was only 4.2 ppm (Tables 4 & 5). This dryland site responded best to banded fertilizer, especially knifing. Although the grain P concentrations were varied due to method and rate, leaf P, plant P, uptake P, and fertilizer P efficiency all showed that knife method supplied more P to the plant more efficiently than did broadcasting or row applications. Tillage was not studied at this location. Soil samples again showed that there was no band disturbance from the disking (Fig 3).

SUMMARY: The dryland sites tend to show applied P was more effective when the fertilizer was row or knife applied into the soil compared to broadcast-incorporated. However, actual

response to applied P in terms of either yield or P uptake was either none existant or small, making the results inconsistant. The lack of soil moisture may have reduced the P uptake from broadcasted fertilizers because the dry surface layer environment is less conducive to root growth.

The irrigated site in Cedar County had a soil test value higher than 10 ppm (16 ppm) which may explain why it was less responsive to applied P. University of Nebraska Soil Testing recommendations state that soils which test above 10 ppm are not likely to respond to applied P. However, the increased responses due to broadcast compared to band application can be explained by the availability of adequate soil surface moisture. Adequate soil surface moisture will create an environment where root proliferation is very good in the top 3 inches of the profile. This will place the roots in an area where the broadcast P is located, plus the phosphate is in a more available form.

Table 1. Significant Information for all Locations in 1989.

Heading		Auburn	Concord	Lancaster
Cropping History		Corn 1988	Corn 1988	Sorghum 1988
Plot Area		220' x 170'	460' x 170'	240' x 360'
Plot Size		40' x 10'	40' x 10'	40' x 10'
Tillage		Disk	Disk & NT	Disk & NT
pH (W)		6.0	6.3	5.5
P (ppm B-K#1)		**4.2**	**16.0**	**9.0**
K (ppm S. test)		223	303	307
Nitrate (ppm N)		9.9	15.2	2.3
O.M. (%)		2.4	2.5	2.6
Planted		5/25/89	5/26/89	5/16/89
Variety		Chamberlain	Chamberlain	Chamberlain
Herbicide	**Pre:**	None	.4# Sencor 1.33 pt Dual	2 qt Roundup
	Post:	.75 oz Classic 1.5 pt Fusalade Crop oil	1.5 pt Fusalade Crop Oil	2 pt Basagran 1.5 pt Poast Crop oil
Insecticide		None	None	None
Harvest		10/23/89	10/10/89	10/11/89

Table 2. Mean values for Crofton sicl 1989.

	Grain Yield bu ac^{-1}	Grain P	Leaf P	Plant P	Uptake P lb ac^{-1}	P Eff. %
		-------------%-----------				
TILLAGE						
No-Till	45.3	.85	.78	.23	17.1	12.8
Disk	45.9	.85	.75	.23	16.6	3.3
P METHOD						
Broadcast	45.3	.87	.77	.25	18.7	22.0
Knife	45.7	.83	.76	.21	15.5	-5.4
Row	45.9	.84	.76	.22	16.3	7.6
P RATE (kg ha^{-1})						
0	45.8	.84	.75	.20	15.6	---
9	46.0	.84	.77	.22	16.7	14.1
18	45.6	.84	.75	.23	17.2	10.4
27	45.4	.86	.76	.22	16.1	1.9
36	45.4	.86	.77	.23	17.5	5.9

Table 3. Mean Values for Sharpsburg sicl 1989

	Grain Yield bu ac^{-1}	Grain P	Leaf P	Plant P	Uptake P lb ac^{-1}	P Eff. %
		-------------%-----------				
TILLAGE						
No-Till	37.8	.81	.55	.23	12.5	.03
Disk	37.7	.79	.56	.22	12.9	1.8
P METHOD						
Broadcast	37.1	.81	.55	.23	12.5	-2.1
Knife	37.7	.81	.55	.21	12.1	-4.8
Row	38.4	.79	.56	.23	13.7	9.6
P RATE (kg ha^{-1})						
0	36.9	.79	.51	.22	12.4	---
9	36.9	.76	.53	.22	11.9	-6.9
18	38.5	.81	.56	.23	13.4	6.1
27	37.7	.82	.56	.23	12.5	3.1
36	38.0	.83	.57	.22	12.6	1.3

Table 4. Mean values for Marshall sicl 1989

	Grain Yield bu ac^{-1}	Grain P	Leaf P	Plant P	Uptake P lb ac^{-1}	P Eff. %
		-------------%-------------				
P METHOD						
Broadcast	24.4	.81	.49	.22	7.5	1.4
Knife	26.5	.79	.50	.24	9.5	12.1
Row	27.3	.80	.51	.20	7.4	1.1
P RATE (kg ha^{-1})						
0	23.1	.75	.46	.21	7.0	---
9	24.2	.79	.48	.20	7.2	2.2
18	26.4	.79	.51	.22	8.0	6.0
27	27.6	.80	.49	.23	9.0	8.0
36	24.9	.81	.51	.23	8.3	3.7

Table 5. Statistical ANOVAs for 1989 Locations*.

SV	AUBURN (Marshall sicl)	CONCORD (Crofton sicl)	LANCASTER (Sharpsburg sicl)
GRAIN YIELD (bu ac^{-1})			
TILL	--	NS	NS
RATE	NS	NS	NS
METHOD	NS	NS	NS
TILL*RATE	--	NS	NS
TILL*METHOD	--	NS	NS
RATE*METHOD	NS	NS	NS
TILL*RATE*METHOD	--	NS	NS
GRAIN P CONCENTRATION (%)			
TILL	--	NS	NS
RATE	NS	NS	.01
Linear	NS	NS	.01
METHOD	NS	.07	NS
B vs K	NS	NS	NS
B vs R	NS	NS	NS
.K vs R	NS	NS	NS
B vs K&R	NS	.03	NS
TILL*RATE	--	NS	NS
TILL*METHOD	--	NS	NS
RATE*METHOD	.04	NS	NS
B vs R*Quadratic	.07	NS	NS
K vs R*Quadratic	.08	NS	NS
TILL*RATE*METHOD	--	NS	NS
LEAF P CONCENTRATION (%)			
TILL	--	NS	NS
RATE	NS	NS	.01
Linear	NS	NS	.01
Quadratic	NS	NS	NS
METHOD	NS	NS	NS
TILL*RATE	--	NS	NS
TILL*METHOD	--	NS	.03
T*K vs R	--	NS	.01
T*B vs K&R	--	NS	NS
RATE*METHOD	.11	NS	NS
B vs K*Quadratic	NS	NS	NS
B vs R*Quadratic	NS	NS	NS
K vs R*Quadratic	NS	NS	NS
B vs K&R*Quadratic	.11	NS	NS
TILL*RATE*METHOD	--	NS	NS

(cont. Table 5) SV	AUBURN (Marshall sicl)	CONCORD (Crofton sicl)	LANCASTER (Sharpsburg sicl)
PLANT P CONCENTRATION (%)			
TILL	--	NS	NS
RATE	NS	NS	NS
METHOD	**.11**	**.02**	NS
K vs R	**.08**	NS	NS
B vs K&R	NS	**.01**	NS
TILL*RATE	--	NS	NS
TILL*METHOD	--	NS	NS
RATE*METHOD	NS	NS	NS
TILL*RATE*METHOD	NS	NS	NS
PHOSPHORUS UPTAKE (lb ac^{-1})			
TILL	--	NS	NS
RATE	NS	NS	NS
METHOD	**.08**	**.05**	NS
B vs K	**.08**	**.02**	NS
B vs R	NS	NS	NS
K vs R	**.07**	NS	NS
B vs K&R	NS	**.02**	NS
TILL*RATE	--	NS	NS
TILL*METHOD	--	NS	NS
RATE*METHOD	NS	NS	NS
TILL*RATE*METHOD	NS	NS	NS
FERTILIZER P EFFICIENCY (%)			
TILL	--	NS	NS
RATE	NS	NS	NS
METHOD	**.15**	**.01**	**.05**
B vs K	**.11**	**.01**	**.03**
B vs R	NS	**.01**	**.03**
K vs R	NS	NS	**.02**
B vs K&R	NS	**.01**	NS
TILL*RATE	--	NS	NS
TILL*METHOD	--	NS	NS
RATE*METHOD	NS	**.06**	**.07**
B vs K&R*Linear	NS	**.04**	NS
K vs R*Quad.	NS	NS	**.01**
TILL*RATE*METHOD	--	NS	NS

* Significance Level=.15, and Tillage variable is not applicable at the Auburn site.

Fig 1. Marshall sicl 1989 Band P Distribution

Sampling Width=3.0 cm

Row Width=66 cm

Numerical values are mg kg-1P by B-K#1

Knife Method

5 15 25 35 45

Depth (cm)															
5.1-7.6	5.6	2.9	4.7	4.5	2.7	3.7	5.3	6.7	5.5	4.8	9.7	6.5	9.2	**194**	7.6
7.6-10.2	3.4	3.5	**59**	4.2	1.8	2.3	2.5	3.7	3.5	2.5	6.6	4.1	**19**	**22**	4.6
10.2-12.7	2.7	2.1	**27**	**184**	1.9	2.1	2.3	2.4	2.1	2.0	3.5	3.1	**245**	6.3	4.0
12.7-15.2	2.0	2.2	2.7	11	2.9	1.6	1.7	2.0	2.0	1.8	2.8	2.3	7.6	3.9	2.7
15.2-17.8	1.8	1.8	2.4	3.2	4.5	1.6	1.6	1.8	1.9	1.6	2.6	2.3	5.0	2.2	2.5
17.8-20.3	2.0	2.4	1.9	2.5	4.6	2.1	1.9	2.2	2.2	2.3	4.5	2.1	3.4	2.7	2.4

Row Method

5 15

Depth (cm)			
0-2.5	9.3	**237**	**20**
2.5-5.1	8.5	**334**	**129**
5.1-7.6	**54**	**306**	**34**
7.6-10.2	6.7	11	7.4

Broadcast Method

5 15

Depth (cm)	
0-2.5	**18**
2.5-5.1	**10**
5.1-7.6	**10**
7.6-10.2	4.1
10.2-12.7	3.7
12.7-15.2	3.4

Fig 2. Crofton sicl 1989 No-Till Band P Distribution

Sampling Width=3.0 cm
Row Width=66 cm
Numerical values are mg kg-1 P by B-K#1

No-Till Knife Method

Depth (cm)		5			15			25			35			45	
5.1-7.6	12	14	35	594	158	12	12	10	14	10	10	12	331	7.3	5.9
7.6-10.2	7.9	8.5	11	252	56	7.9	8.4	7.7	14	9.6	11	12	59	5.2	5.4
10.2-12.7	5.4	8.1	11	26	11	4.9	4.9	6.7	5.1	7.9	6.3	8.4	10	4.7	3.8
12.7-15.2	4.5	8.3	8.5	9.4	7.1	5.2	3.9	5.3	4.0	3.9	5.2	6.2	6.8	3.9	3.8
15.2-17.8	4.3	5.2	7.7	6.4	7.7	4.7	3.5	4.9	4.4	2.9	5.6	10	6.1	2.8	2.3
17.8-20.3	3.4	4.1	4.9	7.3	5.0	3.2	3.7	3.9	3.1	2.8	3.8	3.8	3.8	2.9	2.4

No-Till Row Method

Depth (cm)		5	
0-2.5	22	21	30
2.5-5.1	12	14	14
5.1-7.6	87	41	35
7.6-10.2	84	6.6	14

No-Till Broadcast Method

Depth (cm)	15
0-2.5	25
2.5-5.1	10
5.1-7.6	7.1
7.6-10.2	5.9
10.2-12.7	4.8
12.7-15.2	4.9

Fig 2. Crofton sicl 1989 Disked Band P Distribution

Sampling Width=3.0 cm
Row Width=66 cm
Numerical values are mg kg-1 by B-K#1

Disk Knife Method

Depth (cm)		5			15			25			35			45	
5.1-7.6	11	9.2	9.7	8.4	7.4	7.4	9.7	157	5.4	5.4	8.2	15	7.2	6.6	11
7.6-10.2	6.6	6.9	6.6	6.1	4.5	3.6	4.9	240	3.3	6.1	6.0	10	6.0	5.7	5.7
10.2-12.7	8.3	6.1	5.7	5.1	4.1	2.7	3.5	14	2.5	4.2	5.8	6.3	4.4	5.7	5.9
12.7-15.2	10	6.8	5.7	3.3	2.6	2.1	2.8	4.2	1.7	3.5	4.1	4.7	3.9	4.5	5.4
15.2-17.8	9.7	6.7	8.4	3.4	2.6	1.8	2.1	5.2	1.7	2.6	2.5	4.8	3.2	3.7	5.2
17.8-20.3	7.7	7.3	13	3.8	3.0	1.7	2.1	16	1.4	2.0	1.9	3.5	3.7	3.1	3.8

Disk Row Method

Depth (cm)		5	
0-2.5	17	14	18
2.5-5.1	15	12	12
5.1-7.6	26	10	7.8
7.6-10.2	6.7	6.6	4.6

Disk Broadcast Method

Depth (cm)	15
0-2.5	28
2.5-5.1	20
5.1-7.6	27
7.6-10.2	14
10.2-12.7	7.5
12.7-15.2	4.5

Fig 3. Sharpsburg sicl 1989 No-Till Band P Distribution
Sampling Width=3.0 cm
Row Width=66 cm
Numerical values are mg kg-1P by B-K#1

No-Till Knife Method

5 15 25 35 45

Depth (cm)															
5.1-7.6	5.0	5.1	9.0	5.7	4.9	4.8	4.5	5.5	5.1	5.9	5.6	4.4	4.8	31	161
7.6-10.2	4.2	8.1	15	4.1	3.9	4.3	4.1	4.9	5.6	5.5	4.2	3.4	4.3	7.5	240
10.2-12.7	3.6	8.5	7.7	85	4.9	4.3	4.4	4.3	3.9	5.6	4.6	3.3	3.0	4.3	8.0
12.7-15.2	4.0	11	4.1	11	3.3	3.5	3.8	3.6	3.6	3.8	3.5	3.0	2.7	2.9	6.6
15.2-17.8	3.4	10	2.6	3.5	2.8	3.7	4.3	2.9	12	3.4	2.4	2.6	3.0	2.9	4.1
17.8-20.3	3.7	4.2	2.7	3.1	4.3	4.9	6.5	4.2	5.7	6.0	3.9	3.0	5.0	4.5	5.1

No-Till Row Method

5 15

Depth (cm)			
0-2.5	23	164	69
2.5-5.1	50	234	81
5.1-7.6	124	40	8.6
7.6-10.2	34	10	5.9

No-Till Broadcast Method

5 15

Depth (cm)	
0-2.5	59
2.5-5.1	19
5.1-7.6	9.1
7.6-10.2	6.6
10.2-12.7	6.9
12.7-15.2	6.3

Fig 3. Sharpsburg sicl 1989 Disked Band P Distribution
Sampling Width=3.0 cm
Row Width=66 cm
Numerical values are mg kg-1 P by B-K#1

Disk Knife Method

5 15 25 35 45

Depth (cm)															
5.1-7.6	3.6	4.0	3.4	4.4	6.1	7.3	4.7	7.4	13	5.5	5.5	6.8	6.4	7.6	4.9
7.6-10.2	6.3	3.8	4.0	4.2	4.1	4.3	4.8	410	149	6.5	7.5	6.9	6.1	6.9	4.5
10.2-12.7	3.4	3.7	3.9	4.8	3.8	5.1	4.9	13	7.2	6.1	6.3	6.2	6.3	6.3	4.7
12.7-15.2	2.4	3.7	4.0	4.5	3.4	5.1	4.9	6.6	4.9	4.7	4.9	4.7	4.8	6.6	3.9
15.2-17.8	2.5	3.6	6.2	3.6	3.9	5.5	4.8	3.9	5.5	7.4	4.7	4.5	3.6	4.6	3.0
17.8-20.3	4.4	3.0	5.3	5.4	4.3	12	3.4	7.6	5.1	3.7	3.5	4.4	3.8	4.2	3.0

Disk Row Method

5 15

Depth (cm)			
0-2.5	106	75	144
2.5-5.1	224	84	147
5.1-7.6	101	16	27
7.6-10.2	5.6	11	11

Disk Broadcast Method

5 15

Depth (cm)	
0-2.5	42
2.5-5.1	21
5.1-7.6	12
7.6-10.2	8.9
10.2-12.7	6.9
12.7-15.2	6.6

TILLAGE, ROTATION AND N RATE EFFECTS ON DRYLAND CORN PRODUCTION AND NITROGEN UPTAKE IN NORTHEASTERN NEBRASKA

D.T. Walters and C.A. Shapiro

Objective:

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

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-subplots (20' x 35'). Soil type is a Kennebec silt loam (Cumulic Hapludoll).

Nitrogen fertilizer was not applied in 1989 as residual soil NO_3-N concentrations had built up to levels exceeding 250 kg N/ha. An extreme drought in 1988 also resulted in the recycling of N in stover residue at rates 3 times experienced in normal years. The effects of residual soil NO_3-N on 1989 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 23 at 39,500 plants/ha in 0.75 m rows. Counter was applied to all corn for rootworm control. Century soybeans were planted on May 24 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 12 m of row on October 24. Soybeans were combine harvested on October 5th.

Madison hairy vetch seed was broadcast into standing corn at a rate of 25 kg seed ha^{-1} on August 22, 1988 and a good stand of vetch resulted in the fall of 1988. Vetch dry matter production was evaluated prior to tillage operations on May 11, 1989 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. Vetch was successfully killed prior to tillage by treatment with 2-4-D. Residual soil NO_3^-N was determined to a 1.5 m depth from soil sampled from all plots in the spring of 1989. Gravimetric soil water content was also determined within each tillage/rotation treatment at the time of soil NO_3^--N sampling.

Results:

A very dry fall followed the 1988 drought and growing season precipitation was below normal in 1989. As a result, both corn and soybean yields were suboptimal. Vetch yields prior to planting in 1989 were better than any year to date at this site. Vetch did however result in less soil water content at the start of the growing season in the top 0.9 m of soil than other rotations (Fig. 1). There were no differences in soil water content as a function of tillage system probably owing to significantly greater biomass production under NT in 1988. Both dry matter and N content of vetch in MP was approximately twice that from NT (Table 1). Percent cover reported in Table 1 is that of vetch only and over the course of this experiment it has been found that for each percent of soil cover provided by vetch represents approximately 28 kg ha^{-1} of above-ground biomass. Early studies in Nebraska on the use of Madison hairy vetch as a cover crop had shown that it does best on coarse textured soils that are well aerated. The best vetch production in this experiment have also occurred in the driest springs and this suggests that Madison vetch is somewhat intolerant of wet conditions.

Table 1. Vetch yields and N content, CCV plots, spring 1989. Concord, NE.

	Cover	Above Ground Dry Matter	N	N Content
	%	kg/ha	%	kg/ha
Tillage				
Disk	36	1045	3.53	38
Sp. Plow	35	1320	3.74	51
No-till	27	720	3.51	23
		Analysis of Variance		
		Prob > F		
Source				
Tillage	NS	NS	NS	NS
Sp. Pl vs Rest	NS	NS	NS	.08
NT vs Sp. Plow	NS	.09	NS	.05

Residual soil NO_3^--N (RSN) concentrations were significantly reduced when corn was rotated with soybean, or when vetch was overseeded in the continuous corn system (figure 2). RSN averaged across N rates in the CC and CCV systems was 180 and 147 kg N ha^{-1}, respectively and this difference was approximately equal to the amount of N in the above-ground vetch dry matter (37 kg N ha^{-1}). Both BC and CB rotations depicted in Figure 2 received fertilizer N applications in two of the past four years as compared to four consecutive years for CC and CCV rotations. Very poor grain yields (2.9 Mg ha^{-1}) and poor fertilizer N use efficiency from CB in 1988 resulted in a significant increase in RSN when compared to BC after the 1988 growing season. The slopes of RSN increase as a function of N application rate were, however, significantly different for rotated vs continuous corn systems. These data suggest that the CB rotation will lessen the environmental impact of fertilizer N use on groundwater NO_3-N contamination. Tillage system had no effect on the amount of RSN in the upper 1.5 m of soil. Across all treatments, 90% of all RSN resided in the top 0.9 m of soil.

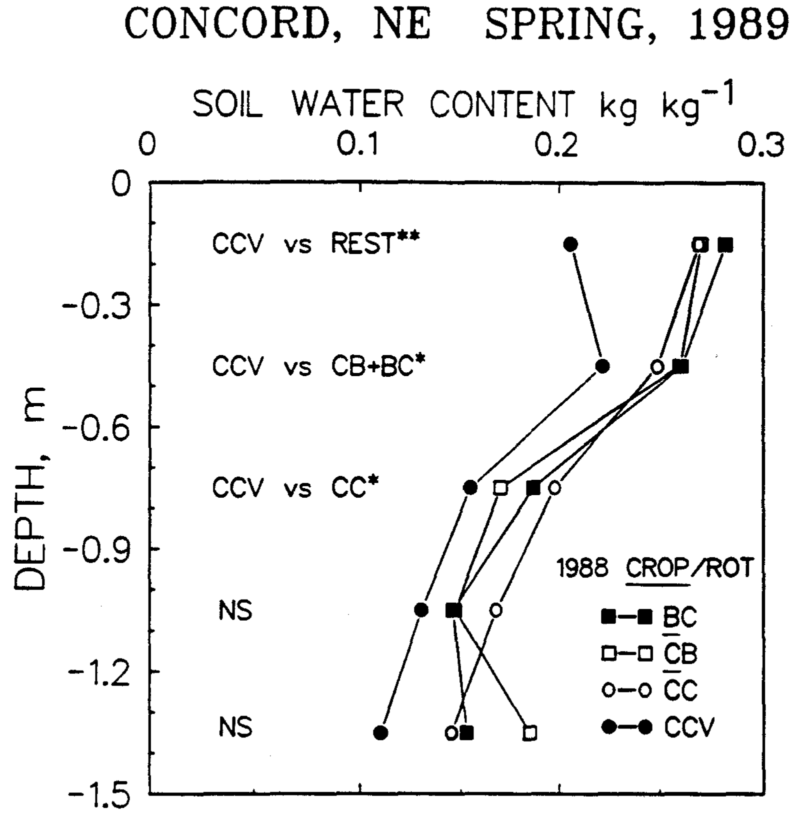
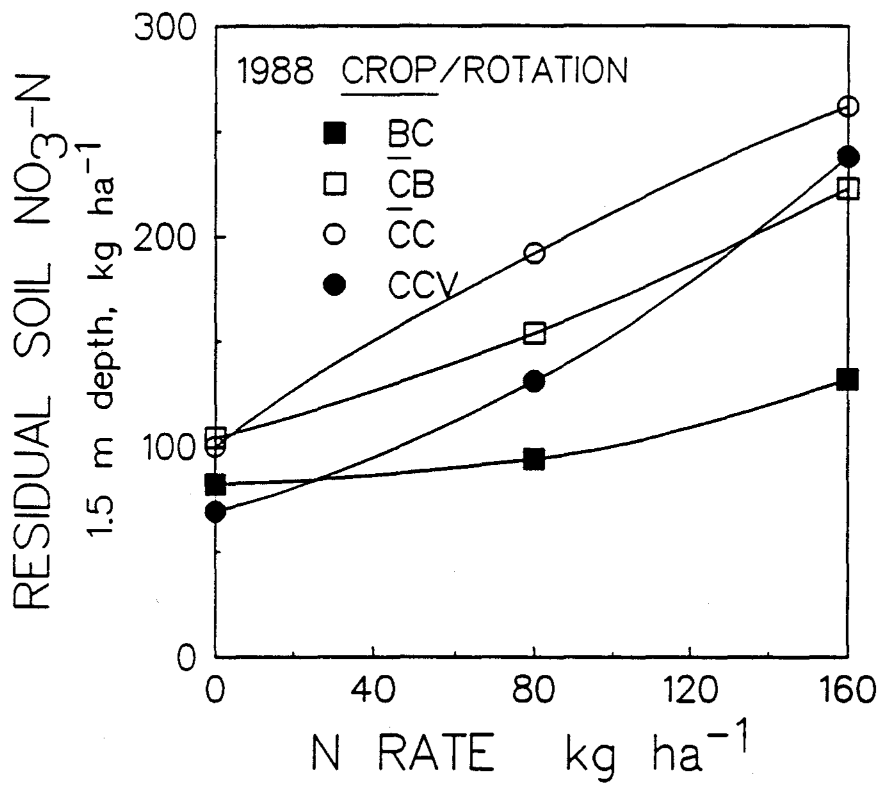


Figure 1. Gravimetric soil water content, spring, 1989 with statistically significant single degree of freedom contrasts for the rotation main effect.

Corn grain yields following soybean have consistently been 1.3 times those in the CC or CCV system in the previous years of this experiment. In 1989, however, both grain and stover yields in the CB system were approximately 20 % lower than the CC system (Table 2). This effect had been reported across eastern Nebraska in 1989 as well as from other rotation experiments conducted by the Agronomy Department. Although 1989 spring soil water content was not significantly lower following soybeans (Figure 1), better early crop growth observed for corn following beans suggests that soil water depletion for the CB system as the season progressed resulted in the observed yield deficit when compared to CC. Grain yield was also significantly lower under NT when compared to DK or MP tillage systems. The failure of early preplant herbicide applications resulted in greater weed competition in the NT system and contributed to this yield reduction. THe use of vetch as a cover crop has not resulted in any yield advantage over continuous corn.

Grain yield response to RSN was only observed under NT and only in the CC and CCV systems (Table 3 and Figure 3). Nitrogen returned in 1988 stover averaged 92 kg N ha^{-1} (2.8% N). It is possible that the incorporation and rapid mineralization of the N in this residue in the DK and MP tillage systems resulted in sufficient N to meet the crop needs. Indeed an average of only 105 kg N ha^{-1} was removed by the crop in grain and stover combined. Without incorporation of these residues under the NT system, RSN became a primary source of N for the corn crop. It is also apparent from Figure 3 and Tables 4 and 5 that the efficiency of RSN utilization was poorer for CCV than CC.

CONCORD, NE SPRING, 1989



Analysis of Variance

Source	df	Prob. > F
Tillage	2	NS
NT vs. Rest	1	NS
DK vs. MP	1	NS
Rotation	2	.002
CCV vs. CC		.05
CB vs. BC	1	.01
Till x Rot	6	NS
NR	4	.0001
NR_L	1	.0001
NR_Q	1	NS
Till x NR	1	NS
Rot x NR	12	.09
(CC vs. CCV) x NR_L	1	NS
(BC vs. CC) x NR_L	1	.001
(BC vs. CB) x NR_L	1	.09
(CB vs. CC) x NR_L	1	.10
(CB+BC vs. CC+CCV) x NR_L	1	.0005

Fig. 2. Residual soil NO_3-N to a depth of 1.5m, spring 1989.

Table 2. Analysis of variance for selected variables, tillage x rotation x N rate. Concord, NE. 1989.

Source	df	Grain Yield	Grain N (%)	Grain N Removed	Popula-tion	Stover Yield	Stover N (%)	Stover N Removed	Barren Stalks(%)	Gr/St Ratio	Soybean Yield
		Prob > F									
<u>Tillage</u>	2	.04	NS	.01	NS	NS	NS	NS	NS	.02	NS
NT vs Rest	1	.01	NS	.004	NS	NS	.06	.03	NS	.007	NS
DK vs Sp. P	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
<u>Rotation</u>	2	.006	.0006	.008	NS	.03	.007	NS	NS	NS	
CB vs Rest	1	.07	.0002	NS	NS	.02	.007	NS	NS	NS	
CC vs CCV	1	.005	NS	.004	NS	NS	.06	NS	NS	NS	
Till x Rot	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	

Table 3. Analysis of covariance 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 HO:parameter = 0								
1. RSN (Till x Rot)	.03	b_1	NS	NS	NS	NS	NS	NS	NS	.02	NS
2. RSN (Till x Rot)	.03	b_1	NS	NS	NS	NS	NS	NS	NS	NS	.002
$(RSN)^2$(TillxRot)	0.3	b_2	NS	NS	NS	NS	NS	NS	NS	NS	.008

Table 4. Main effect and 2-way interaction means for corn grain yield, N content, N removed, population and soybean yield 1989.

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		4.49 (85)	1.63	72	36.6	1.30 (24)
Sp. Plow		4.40 (83)	1.64	72	34.5	1.30 (24)
No-till		3.56 (67)	1.59	59	35.2	1.33 (24)
Rotation						
Corn/Soy (CB)		3.85 (73)	1.68	64	36.0	--
Cont. Corn (CC)		4.73 (89)	1.58	75	35.4	--
Cont. Corn w/Vetch		3.87 (73)	1.60	62	34.9	--
Till x Rotation						
Disk	CB	3.94 (74)	1.67	65	36.0	--
	CC	5.15 (97)	1.61	83	37.1	--
	CCV	4.38 (83)	1.60	70	36.5	--
Sp. Plow	CB	3.94 (74)	1.70	66	34.1	--
	CC	5.09 (96)	1.62	82	35.2	—
	CCV	4.20 (79)	1.60	67	34.2	—
No-till	CB	3.67 (69)	1.68	61	37.9	--
	CC	3.95 (74)	1.50	60	33.8	--
	CCV	3.07 (58)	1.59	49	34.0	--

*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 G/S ratio, 1989.

Source		Stover Yield	N	Stover N Removal	Barren Stalks	Grain/Stover Ratio
		Mg/ha	%	kg/ha	%	
Tillage						
Disk		3.25	1.00	32	2.8	1.4
Sp. Plow		3.19	1.03	33	0	1.4
No-till		3.07	0.89	28	10.1	1.2
Rotation						
Corn/Soy (CB)		2.95	1.04	30	4.2	1.3
Cont. Corn (CC)		3.41	0.91	31	0	1.4
Cont. Corn w/Vetch (CCV)		3.15	0.98	31	4.1	1.3
Till x Rotation						
Disk	CB	2.80	1.05	28	3.9	1.4
	CC	3.46	0.96	34	0.2	1.5
	CCV	3.49	1.00	35	4.5	1.4
Sp. Plow	CB	3.05	1.11	34	0	1.3
	CC	3.38	0.99	34	0	1.5
	CCV	3.14	1.01	32	0	1.4
No-till	CB	3.00	0.97	29	9.2	1.3
	CC	3.38	0.78	27	6.4	1.2
	CCV	2.82	0.93	27	14.7	1.1

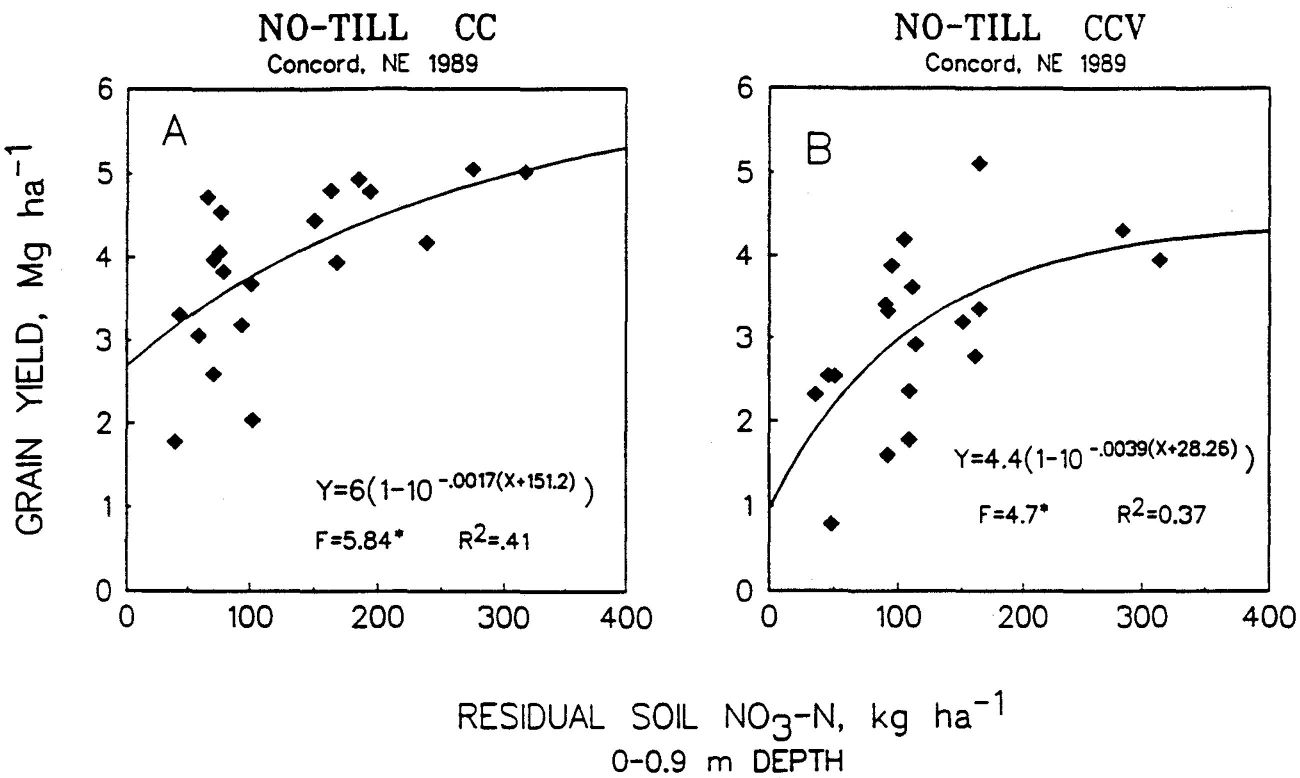


Figure 3. Corn grain yield vs. residual soil NO_3^--N (0.9m depth) for no-till CC (A) and CCV (B) rotations.

EFFECT OF LIME APPLICATION ON SOIL PH AND CORN YIELD IN HOLT COUNTY

C. A. Shapiro and Steve Gottsch

Objective:

Determine the effect of lime on a low pH irrigated sandy soil growing continuous corn.

Procedure:

Rates of pelleted lime (table 1) were applied on April 28, 1988 to a Dunn & Dunday loamy sand approximately 3 miles east of O'Neill. One rate (6 gallon/acre) and two rates (6 & 12 gallon/acre) of a liquid calcium source (8-0-0-8Ca, 11.7 lbs/gallon) was applied on April 29, 1988 and May 26, 1989, respectively. Corn was hand harvested. Soil samples were taken after harvest in 1988 and 1989.

Results and Discussion:

Table one contains the yields and soil pH values. There was no significant effect on yield in either year. Unequal replication caused some problems due to the cooperating farmer changing the row direction from previous years, making selecting harvest areas difficult. In addition, the producer added end rows which fell within part of the experiment.

Lime application increased pH but not to as high a level as would have been indicated by an initial soil test (pH 5.5 and buffer pH 6.3). Our high rate of pelleted lime should have raised the pH close to 6.5 since the calculated equivalent for pelleted lime equal to 7000 lbs ag lime would have been 4,421 lbs pelleted lime (ag lime at 60% ECC and pelleted lime at 95% ECC).

These results indicate that yield response to lime is low and inconsistent on acid sands. In addition, low rates of pelleted lime will not effectively increase soil pH. Soil pH will increase when the correct quantity of neutralizing material is applied. Reducing the quantity of neutralizing material will be less effective.

Acknowledgements:

Partial funding for this research was provided by Alpine Plant Food Company and Agronomic Services, Chambers, Ne. Appreciation is extended to Tom Dorn for his help in conducting the experiment.

Table 1. Effect of 1988 lime application and 1989 liquid calcium treatments on corn grain yield. (O'Neill, NE).

	Yield		-pH+	
Pelleted Lime	1988	1989	1988	1989
lbs/acre	----------bu/acre----------			
500	214	192@	--	5.1@
1000	207	207	--	5.4
2000	203	187	5.5	5.3
4000	208	200	5.7	5.7
0	211	186	5.2	5.0
6 gal/acre#	195	192	5.2	5.1
12 gal/acre	--	193	--	5.1
Significance	NS	NS	***	***
Prob>F	0.89	0.96	0.001	0.0004

+Soil samples taken in fall after harvest.

@LS Means of complete data set.

#Alpine (8-0-0-8Ca).

EVALUATION OF THE INFLUENCE OF STARTER FERTILIZER ON CORN AND GRAIN SORGHUM, 1989

E. J. Penas, R. A. Wiese, and C. A. Shapiro

Objective:

Determine the influence of farmer-applied starter fertilizer on plant emergence, early plant growth, grain yield, grain moisture at harvest and final plant populations of corn and grain sorghum.

Procedure:

Cooperating farmers were selected that use starter fertilizer on their row crops. They were asked to leave five strips without starter fertilizer that were each approximately 150 feet in length. Strips were alternated with strips with starter fertilizer (each one-planter width). Thus, each no-starter strip was bordered on both sides with starter fertilizer. Measurements were made on ten pairs of two-row plots. Information was obtained from each farmer to determine the analysis and rate of fertilizer used. County agents collected most of the data prior to harvest. Soil temperature was determined at planting time and again two weeks after planting. Separate soil samples (0-6 inches deep) were collected from each of the no-starter strips. Plant counts were taken in the starter and no starter rows in each of the ten pairs of plots. Plant height measurements were taken 30-40 days after planting. Grain yields for corn were determined by harvesting two 25-foot lengths of row in each of the ten pairs of comparisons (two 15-foot row for grain sorghum). Grain moisture was determined at harvest time for corn and grain sorghum.

Experimental Results:

Information was collected from nine corn trials and three grain sorghum trials. Data are summarized in Table 1. Locations are listed in order of increasing soil phosphorus. For the corn sites, phosphorus ranged from 9 to 43 ppm phosphorus. For grain sorghum, the range was 10 to 43 ppm phosphorus. The nutrients contained in the starter fertilizer that was used are also given in Table 1.

Corn Experiments. Early growth measurements were obtained at four locations, and at one of these, there was a significant growth response to applied starter fertilizer. This growth response occurred on soil testing sixteen ppm P.

Grain yields were good in 1989 with an average yield of 157 bushels per acre. Grain yields from three non-irrigated sites averaged 102 bushels per acre with a range from 78 to 118 bushels per acre between sites. Grain yields from six irrigated sites averaged 185 bushels per acre with a range from 160 to 201 bushels per acre between sites.

Starter fertilizer increased grain yield at one site out of nine. At this site, soil phosphorus level was 10 ppm.

Grain moisture at harvest time was not reduced by starter fertilizer; however, at one site, grain moisture was increased slightly by starter fertilizer.

Grain Sorghum Experiments. Starter fertilizer increased early growth of grain sorghum at one of three sites. Starter fertilizer did not increase the grain yield of grain sorghum on any of the sites, and reduced grain moisture at harvest at only one site out of three. At one site, grain moisture was increased by starter fertilizer.

Summary. This is the fourth and final year for this study. Results have been very consistent over the four-year period. Early growth responses are common; however, grain yield increases occur mainly on low P soils except for sands. On sands with medium or high levels of soil P, grain yield may be increased by applying a N-S starter.

Table 1. Influence of starter fertilizer applied by producers on early growth, grain yield, and grain moisture of corn and grain sorghum, 1989.

Location	Soil Texture	Soil P, ppm	Soil Zinc Index	Starter Used	Early Growth Increase,%	Yield Increase, bu/ac	Grain Moisture Change,%
			Corn				
Holt (Frerich)	F sandy loam	9	6.3	NS	--	-4	---
Holt (Belik)	Silt loam	10	7.2	NPS	--	6*	---
Washington (Beckman)	Silt loam	15	8.0	NPKZn	0	2	0.6*
Dodge (Parr)	Si clay loam	16	7.4	NPZn	8*	5	0.2
Washington (Lauritsen)	Silt loam	18	5.7	NPK	0	-2	0.1
Holt (Thieszen)	Loam	23	6.9	NPS	--	3	---
Saunders (Sladky)	Si clay loam	26	6.4	NPZn	0	2	0.0
Hamilton (Parpart)	Silt loam	43	12.0	NP	--	8	0.2
Holt (Kurpgeweit)	Loamy f sand	-- 19	--- 13.3	NPKSZn	--	8	---
			Grain Sorghum				
Gage (Acton)	Si clay loam	10	---	NP	0	3	-1.6*
Gage (Thornburg)	Si clay loam	27	---	NP	0	-2	-0.3
Gage (Fisser)	Si clay loam	43	---	NP	2*	-2	2.3*

*Significant effect from starter fertilizer (P = .10)

FERTILIZER P DISTRIBUTION AND WHEAT YIELD

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Tianjia Tang, Graduate Assistant
Department of Agronomy, University of Nebraska-Lincoln

OBJECTIVE

The objective of this research was to evaluate the effect of different liquid P fertilizer droplet spacings in the P band on wheat yield and P uptake.

MATERIALS AND METHODS

Three experiments were established in the fall of 1988 on Sharpsburg sicl and a Pawnee cl, and on eroded Crete Sicl. However, draught destroyed the experiment located on the Crete soil. Soil tests for the Sharpsburg and Pawnee soil are shown in Table 1.

Table 1. Soil Tests for P distribution study.

	Sharpsburg sicl			Pawnee sicl		
Depth	pH	Bray P	OM	pH	Bray P	OM
inches		ppm	%		ppm	%
0 - 6	5.0	13.1	2.5	5.3	8.5	2.2
6 - 12	6.2	1.3	1.0	6.0	5.6	0.9
1 - 2	7.3	0.7	0.7	6.6	12.1	0.5
2 - 3	7.9	1.0	0.2	6.5	15.4	0.4
3 - 4	9.2	0.4	0.1	6.5	16.4	0.3
4 - 5	8.2	0.4	0.1	6.8	14.2	0.2

Treatments included five P rates (10, 15, 20, 25, 30 lbs P_2O_5/acre) as ammonium polyphosphate (10-34-0, N-P-K), with three dilutions (0:0, 1:1, 2:1, water:10-34-0). Distribution of liquid P in the band is shown in Table 2. Fertilizer P was placed with the seed in 12-inch rows with a John Blue squeeze pump. Nitrogen was topdressed to provide a total of 80 lbs N/acre. Brule wheat was seeded with a John Deere hoe drill in the fall of 1988 at a rate of 80 lbs/acre.

Table 2. Spacing between droplets of liquid 10-34-0 as influenced by P rate and dilution with water.

	Spacing between droplets		
P Rate	0:0[1]	1:1	2:1
lbs P_2O_5/ac	------------------	cm	--------------------
10	7.7[2]	3.3	1.8
15	4.8	1.8	0.9
20	3.3	1.1	0.4
25	2.4	0.6	0.1
30	1.8	0.4	Conti

[1] Dilution ration (water:10-15-0)
[2] Based on Eghball and Sander, SSSAJ 51:1350-1354

At maturity, grain and straw was harvested from 2 rows, 10 feet long from each plot. Wheat bundles were air dried, weighed and threshed.

RESULTS AND DISCUSSION

Drought conditions existed in the spring of 1989 with timely precipitation (near flowering) resulting in fair wheat yield (Table 3), especially on the Sharpsburg soil. While applied P had little effect on yield on the Sharpsburg soil, applied P significantly increased grain and total plant weight in the Pawnee soil. Dilution of liquid P fertilizer with water signifcantly increased grain yield and total plant weight on the Pawnee soil, while grain yield was significantly depressed with dilution on the Sharpsburg soil. Analysis for early plant weight and P content has not been completed, but no visual differences were present at any time. It is not known why dilution depressed yields on the Sharpsburg soil when other results appear to be positive. Another experiment was established on this soil for 1990 similar to the experiment in 1989.

Table 3. Effect of rate of applied P and dilution on wheat grain yield and total plant weight. 1989.

Variable	Sharpsburg sicl		Pawnee sic	
	Grain Yield	Total Plant Weight	Grain Yield	Total Plant Weight
	bu/ac	lbs/ac	bu/ac	lbs/ac
P rate, lbs P_2O_5/ac				
0	39	5846	18	2826
10	40	5841	21	2866
15	45	6569	25	3400
20	42	6666	25	3248
25	42	6079	27	3560
30	42	6459	29	3808
Dilution[1]				
0:0	46	6687	23	2884
1:1	42	6213	28	3741
2:1	38	6069	26	3406
		Analysis of Variance		
R Rate (R)	NS	NS	.05	.07
Dilution (D)	.01	.17	.08	.02
R x D	NS	.10	NS	NS

[1] Water:10-34-0

FIELD EVALUATION TO DETERMINE BEST FLUID STARTER FERTILIZER RATIOS FOR CORN

Dr. R. A. Wiese, Project Leader, and
Dr. E. J. Penas, project Co-leader [1]

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 at planting. In an agronomic sense, the primary objective in starter fertilizer use is to stimulate early growth, allow earlier field operations with small corn plants, decrease grain moisture at harvest, and hopefully to increase yields.

Evidence and experience with starter fertilizer used as defined here has varied. Early faster growth has been a common outcome with starter use. The nutrients which in general accounted for the most early growth have been the macro nutrients, (N, P_2O_5 and K_2O). Different soil/climate regimes appear to dictate the amounts of each nutrient needed or the ideal ratio of one nutrient to the other. A very standard practice has been to use manufactured ammoniated phosphate which most often provided an N:P_2O_5 ratio of 1:3. 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 being raised more frequently as agronomists attempt to use nutrients more efficiently. Perhaps there may be an N:P_2O_5 ratio that is ideal for certain soil-climate regimes.

OBJECTIVES

In order to find answers through field research the following objectives were developed:

(1) To compare a range of N:P_2O_5 ratios and rates in complete fluid starter fertilizers for corn production.

(2) To characterize early season N uptake and acquire data concerning the role of ammonium and nitrate nutrition in corn seedling growth.

EXPERIMENTAL PROCEDURE

The starter fertilizer study was conducted at four field locations. Two field locations were in Minnesota with the research supervised by Dr. George Rehm. Two field locations were in Nebraska with the research supervised jointly by Dr. Richard Wiese and Dr. Ed Penas. Additional N_{15} research was conducted at Nebraska field locations under the direction of Dr. James Schepers and Dr. Raun Lohry. This progress report will address the research under the supervision of Dr. Richard Wiese and Dr. Ed Penas in Nebraska

Fertilizer nutrient combinations were selected to provide N:P_2O_5 rates to compare various starters with standard 10-34-0 and to compare rates of starters. Eighteen starters were designed using commercially available materials in the

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fertilizer industry. These liquid starters are listed in Table 1. All 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. Due to manufacturing limitations two treatments were applied at a rate of 40 gallons. The remaining treatments were applied either at a rate of 15 or 25 gallons per acre to meet the nutrient rates specified in each starter.

Table 1. Starter Fertilizer Nutrient Combinations.

N	$P2O_5$	K_2O	S	Zn
---------------------- lb/ac nutrient ----------------------				
0	0	5	4	0.8
8	20	5	4	0.8
20	20	5	4	0.8
40	20	5	4	0.8
16	40	5	4	0.8
40	40	5	4	0.8
80	40	5	4	0.8
8	0	5	4	0.8
16	0	5	4	0.8
20	0	5	4	0.8
40	0	5	4	0.8
80	0	5	4	0.8
0	0	0	0	0
20	20	5	4	0
20	20	5	0	0.8
20	20	0	4	0.8
20	20	0	0	0
6	20	0	0	0

The two field research locations selected to provide contrasting sites. One, a sandy soil, is characterized as a low organic matter very high phosphate soil. The other, a silt loam, is characterized as a low phosphate soil. The sandy soil site has continuous corn for a cropping history and the silt loam represents a corn-soybean rotation. These soils are both level and are classified as a Janude sandy loam and as a Hastings silt loam. The Janude represented a low nitrogen, high phosphate soil site. The Hastings represented a high nitrogen low phosphate soil site. Corn was planted April 24 and 26 on these sites and treatments were replicated 5 times. A pre-emergence herbicide was broadcast following planting. Experimental site properties are shown in Table 2.

Table 2. Experimental Site Soil Characterization.

Soil Property	Butler County	Merrick County
pH	6.3	5.8
Organic Matter (%)	2.9	1.0
P (ppm)	9.6	4.0
K (ppm)	292	264
Zn (ppm)	0.6	7.2
Soil type	Hastings silt loam	Janude sandy loam
Previous Crop	Soybeans	Corn
Irrigation	Sprinkler	Gravity

P-Bray and Kurtz No. 1; Zn-DTPA extraction.

Weekly observation of the research field sites were made for 8 weeks following planting. Stand count was made two weeks after emergence. Small whole plants were collected from each plot, dried at 70°C for 48 hours, weighted and ground in a Wiley mill using a stainless steel 2mm sieve. Plant analysis included N, P, K, S, Zn, Ca, Mg, Fe, Cu, Mo, Cl by infra-red spectrophotometric procedures. Ear leaf samples were collected from each plot at early silk emergence. All plots were hand harvested from two rows, 25 feet long in the center of 4-row plots. Moisture samples and harvested grain weight were collected during field harvest.

RESULTS AND DISCUSSION

$N:P_2O_5$ rate and ratio

The influence of fluid starter $N:P_2O_5$ ratios and rates on early growth, nutrient uptake and upon grain yield and grain moisture at harvest is shown in Tables 3, 4 and 5. At the Butler County research field early growth (Table 3) was the greatest with 1:2.5 and 1:1, $N:P_2O_5$ ratios. At these ratios early growth was 1.7 to 2.0 fold above no starter. No early enhanced growth above control was recorded for $N:P_2O_5$ ratio 2:1 at both rates. This site is characterized as the low P, high N soil site, and may account for a ratio of 1:3 or 1:2 starter to effect early growth.

The Merrick County site, characterized as a high P, low N soil site showed best early corn growth when the ratio of $N:P_2O_5$ was 1:1 or 2:1. An excellent growth increase above no starter occurred at this site with all ratios and rate of N and P_2O_5. Early growth increases at this site ranged from 1.5 to 2.8 fold above no starter.

Early uptake of N and P correlated well with growth. If early growth was greatest than too was N and P uptake. A 2-fold increase in N uptake was measured with 1:2.5, $N:P_2O_5$ ratio at a 16 and 40 lb per acre rate respectively at the Butler County site. Greatest uptake N and P in early corn plants at the Merrick

County site occurred with 2:1, $N:P_2O_5$ ratio. All ratios and rates enhanced nutrient uptake at the Merrick County site.

Yield was not influenced by any NP starter rates or ratios at Butler County (Table 5). It is suspected that yields may be enhanced at the Merrick County site when nitrogen applied was at the rate of 20 or 40 lbs N per acre. Grain moisture was reduced at the Merrick County site with 40 lbs of P_2O_5 in the starter. No effect of starter on grain moisture was recorded at the Butler County site.

Table 3. Effect of N and P_2O_5 rates and ratios on early growth of corn plants.

Starter			
N	P_2O_5	Butler Co.	Merrick Co.
--lbs/ac--		gms/5 plants	gms/4 plants
0	0	22.8	15.5
8	20	34.4	24.4
20	20	38.2	31.4
40	20	23.8	36.6
16	40	45.8	32.8
40	40	35.8	42.8
80	40	23.8	42.6

All treatments received 5 lbs K_2O, 4 lbs S and 0.8 lbs zinc per acre.

Table 4. Effect of N and P_2O_5 starter rates and ratios on early nitrogen and phosphorus uptake.

Starter		Butler Co.		Merrick Co.	
N	P_2O_5	N	P	N	P
--lbs/A --		lbs/A			
0	0	9.06	0.60	4.04	0.53
8	20	13.99	1.03	6.35	0.92
20	20	15.76	1.16	8.41	1.01
40	20	9.82	0.68	11.12	1.14
16	40	19.26	1.61	9.74	1.31
40	40	14.98	1.11	13.92	1.75
80	40	9.96	0.83	16.03	1.73

All plots received 5 lbs K_2O, 4 lbs S and 0.8 lbs Zn per acre.

Table 5. The effect of N and P_2O_5 starter rates and ratios on corn grain moisture and yield.

Starter		Hastings Si Lo Butler Co.		Janude Sa Lo Merrick Co.	
N	P_2O_5	Grain Moisture	Yield	Grain Moisture	Yield
---- lbs/A ----		%	bu/A	%	bu/A
0	0	16.1	170.9	20.9	132.6
8	20	15.8	172.5	20.3	128.8
20	20	15.7	169.4	19.1	109.3
40	20	16.5	174.2	19.1	161.5
16	40	15.5	179.3	18.7	162.5
40	40	16.1	175.8	18.1	150.7
80	40	16.8	169.2	18.5	130.7

All plots received 5 lbs K_2O, 4 lbs S and 0.8 lbs Zn per acre.

N rate

The effect of N rates in starter without P are shown in Tables 6, 7 and 8. Nitrogen rates of 40 and 80 lbs per acre reduced corn growth rate below that of no starter at the Butler County site. This indicates that maximum early growth rate is attained only when P is part of the starter on low P soil sites. The Merrick County site resulted in increased growth with increasing amounts of N in starter. Yields were enhanced some by the addition of P in the starter at the Merrick County site.

Nutrient uptake of N and P by small plants paralleled early growth. If early growth was enhanced by starter than uptake was enhanced accordingly.

Nitrogen alone as a starter did not influence yield at either experimental sites.

Table 6. Effect of N rates in starter on early growth of corn plants.

Starter			
N	P_2O_5	Butler Co.	Merrick Co.
----lbs/a----		gms/5 plants	gms/4 plants
0	0	22.8	15.5
8	0	23.6	23.6
16	0	21.6	22.2
20	0	20.6	24.0
40	0	18.6	30.8
80	0	17.6	39.4

All plots received 5 lbs K_2O, 40 lbs S and 0.8 lbs Zn per acre.

Table 7. Effect of starter N rates on uptake of N and P by whole corn plants at the six leaf stage.

Starter		Butler Co.		Merrick Co.	
N	P_2O_5	N	P	N	P
---- lbs/a ----		---------- lbs/a ----------			
0	0	9.09	0.60	4.04	0.53
8	0	9.33	0.59	7.64	0.63
16	0	8.67	0.58	6.08	0.59
20	0	8.19	0.54	6.62	0.61
40	0	7.33	0.53	10.47	0.81
80	0	6.58	0.40	13.19	0.98

All plots received 5 lbs K_2O, 4 lbs S and 0.8 lbs Zn per acre.

Table 8. The effect of Nitrogen starter rates without P_2O_5 on corn grain moisture and yield.

Starter		Hastings Si Lo Butler Co.		Janude Sa Lo Merrick Co.	
N	P_2O_5	Grain Moisture	Yield	Grain Moisture	Yield
----lbs/a ----		%	bu/a	%	bu/a
0	0	16.1	170.9	20.9	132.6
8	0	16.3	167.1	19.9	130.7
16	0	16.1	162.2	20.6	135.5
20	0	16.1	164.0	19.8	127.3
40	0	16.5	165.9	18.7	135.5
80	0	16.3	166.6	18.5	127.3

All treatments received 5 lbs K_2O, 4 lbs S and 0.8 lbs of Zn per acre.

CONCLUSIONS

- The $N:P_2O_5$ ratio or the NP rates in starter did not influence grain yield compared to no starter.

- Early growth was increased with starter on both sites. Nitrogen was more important for early growth in the sandy site (Merrick Co.) while phosphorus was more important on the low phosphate fine textured soil site (Butler Co.).

- Depressed early growth occurred on a low phosphate soil (Butler Co.) when nitrogen was the only nutrient in starter.

ACKNOWLEDGEMENT

Preparation and donation of all starter materials for this research by Nutra-Flo Chemical Co. of Sioux City, Iowa is gratefully appreciated.

INCREASING ANHYDROUS AMMONIA EFFICIENCY

D. H. Sander and D. W. Walters

Objective: To determine the effect of rate and spacing of anhydrous ammonia application on the performance of anhydrous ammonia in terms of corn yield increase.

Procedure: Two soils were selected from center pivot irrigated farmer a O'Neill sandy loam in Merrick County and a Sharpsburg soil in Saunders County. Soil nitrates in the root zone to a depth of 5 feet were low on the sandy soil (78 lbs NO_3-N) but high (208 lbs NO_3-N) on the Sharpsburg soil. Nitrogen was applied as NH_4NO_3 (broadcast) and anhydrous ammonia at rates of 0, 50, 100, 150, and 200 lbs N/acre. Ammonia was applied in spacings of 15, 30, and 60 inches. Nitrogen was applied at the 6-leaf stage. Grain yield was determined from 2 rows 50 feet long with a plot combine.

Results and Discussion: Corn yield was increased significantly with applied N on the sandy soil in Merrick County where soil nitrates were low but was affected in Saunders County where soil nitrates were high. Spacing of applied ammonia affected N fertilizer performance on Saunders County where the 30-inch spacing was superior to either the 15- or 60-inch spacing. The 60-inch spacing also produced significantly higher corn yield than the 15-inch spacing. Since N was not limiting in this Sharpsburg soil, the effect of spacing was probably due to injury, perhaps root pruning, since the 15-inch spacing had knifes running only 7.5 inches from the row and corn was about 8 inches tall at application time. The 60-inch spacing ammonia appeared to be too wide. Applied in the 30-inch spacing also yielded significantly higher than ammonium nitrate. Spacing did significantly affect corn yield in Merrick County (0.17 level). As spacing increased, yield decreased.

TABLE 1. EFFECT OF AMMONIA SPACING AND N RATE ON CORN YIELD IN MERRICK AND SAUNDERS CO. 1989.

FERTILIZER	N RATE	SPACING	CORN YIELD MERRICK	CORN YIELD SAUNDERS
	LBS/A	INCHES	BU/A	
	0		68	146
AMMONIA				
	50	15	96	134
	100		118	124
	150		135	130
	200		149	141
MEAN			124 a	132 c
	50	30	95	145
	100		125	156
	150		120	154
	200		139	164
MEAN			120 a	155 a
	50	60	77	151
	100		98	148
	150		133	143
	200		140	145
MEAN			112 a	147 b
AMMONIUM NITRATE				
	50		94	143
	100		118	146
	150		127	147
	200		159	148
MEAN			124 a	146 b

MEANS FOLLOWED BY SAME LETTER NOT SIGNIFICANT AT 5% LEVEL

TABLE 2. ANALYSIS OF VARIANCE FOR AMMONIA SPACING ON IRRIGATED CORN. 1989.

SOURCE	MERRICK CO.	SAUNDERS CO.
N RATE (N)	0.01	NS
SPACING (S)	0.17	0.01
N X S	NS	NS

MANAGING NITROGEN MORE EFFECTIVELY FOR REDUCED COSTS AND ENVIRONMENTAL HAZARDS

C.C. HARTWELL, D.H. SANDER, and D.T. WALTERS

Objective:

To determine the relationship between spring and early June soil residual nitrate content and nitrogen fertilizer requirements. To determine the best method of nitrogen application between preplant, split-applied, and sidedress.

Procedure:

Experiments were conducted at 5 locations in 1989. three locations were established in Merrick County and one each in Hamilton and Boone counties. Locations were selected to provide a range of soil characteristics and a range of nitrate levels in the soil root zone. All sites were irrigated with two sites in Merrick and the one in Hamilton being gravity irrigated. The remaining site in Merrick and the site in Boone were center pivot irrigated. In addition, since the spring of 1989 was dry, two sites in Merrick and the one in Boone were irrigated early in the spring to simulate a more typical spring in central Nebraska. Enough water was applied to fill the soil profile to a depth of 5 foot and then additional water was applied for some leaching effect. There were six rates of N applied (0,40,80,120,160,200 lbs/ac) in three basic N management systems (preplant, split-applied, sidedress). Preplant N was applied prior to planting. Split-applied had 40 lbs/ac N applied prior to planting with the remainder applied at sidedress time. Sidedress N was applied in early to mid June when the corn was at the V6 growth stage. Ammonium Nitrate was the N source used at all 5 sites. Soil samples were taken from the 0 rate plots to a depth of 5 feet in 1 foot increments for residual nitrate analysis in early spring and early June.

Table #1. Description of experimental conditions.

Location:	Hamilton	Merrick#1	Merrick#2	Merrick#3	Boone
Soil Type:	Holder Silt Loam	Foner Loam	Hord Loam	O-Neal Sandy Loam	Hobbs Silt Loam
Irrigation:	Gravity	Gravity	Gravity	Center Pivot	Center Pivot
1st Sample	4/28	4/26	4/26	4/28	4/29
2nd Sample	6/15	6/15	6/15	6/16	6/16
Date Preplant Fert. applied	4/28	4/27	4/27	4/28	4/29
Date Sidedress Fert. applied	6/20	6/19	6/19	6/19	6/21
Preirrigation	-	8 inches	-	13 inches	17 inches
Total Irrigation	14 inches	25 inches	15 inches	30 inches	29 inches
N in water	4ppm	5ppm	5ppm	10ppm	0ppm
Rainfall	6.75	7.75	7.5	8.0	9.0

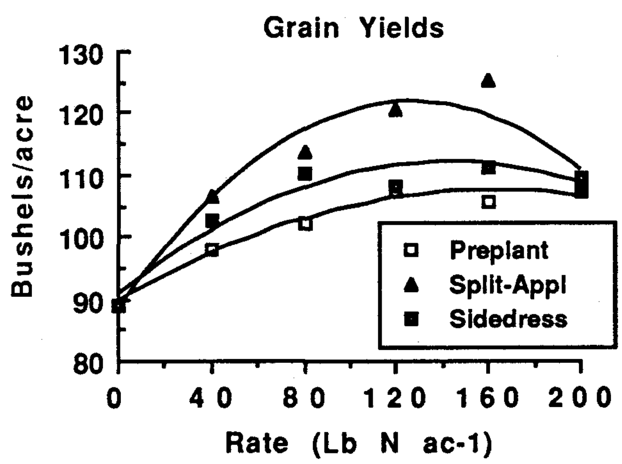
Results:

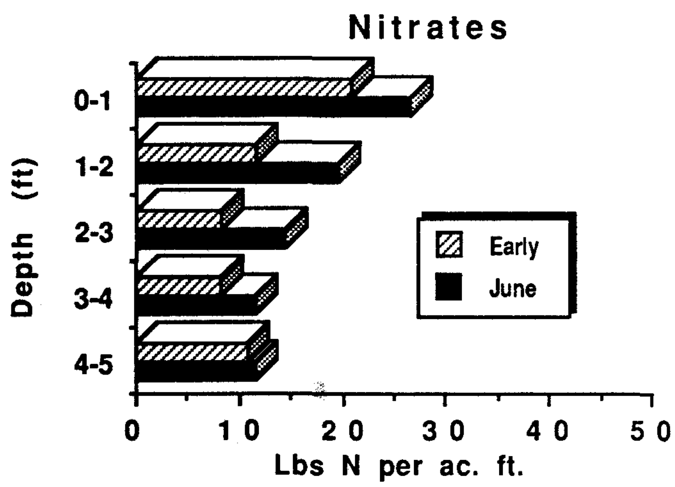
At all five locations the split-applied method of applying nitrogen was better than the preplant method. At four of the five locations split-applied was better than sidedress. At four of the five locations sidedress was better than preplant. At one location there was no difference between sidedress and preplant.

The three locations that were preirrigated to simulate a more typical central Nebraska spring (Boone Co.,Merrick #1, and Merrick #3) had significant amounts of nitrogen that were mineralized between early spring and June and subsequently leached further into the soil profile. One of the two non-preirrigated locations (Hamilton Co.) mineralized a small amount of nitrogen but neither location had any nitrogen leached further into the soil profile.

At four of the five locations (Hamilton, Merrick#2, Merrick#3, and Boone) the June 0-2 foot soil sample was as good if not the best sample to make nitrogen recommendations. At the 5th location (Merrick#1) the early 0-2 foot soil sample was the best. It should be noted that in general the nitrogen recommendations were lower than what they need to be to obtain optimum yield.

Hamilton Co.



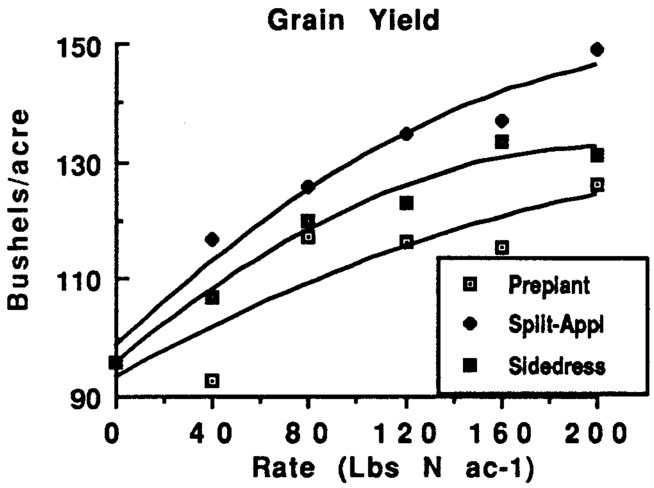


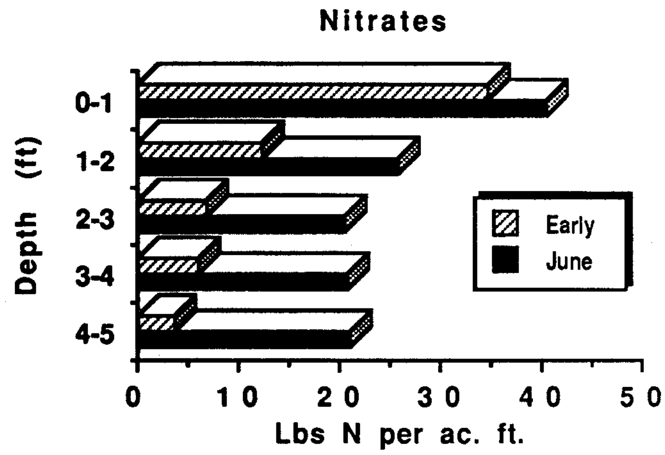
Source	PR>F (.2)
M	.003
R	.001
M*R	NS
C.V.= 10.2	

Nitrogen Recommendations
Based upon 140 bu/ac Yield Goal

	Early N		**June N**	
Depth (ft)	Residual (lbs)	Recommended (lbs)	Residual (lbs)	Recommended (lbs)
0-2	33	144	46	130
0-6	58	117	89	87

Merrick Co.#1





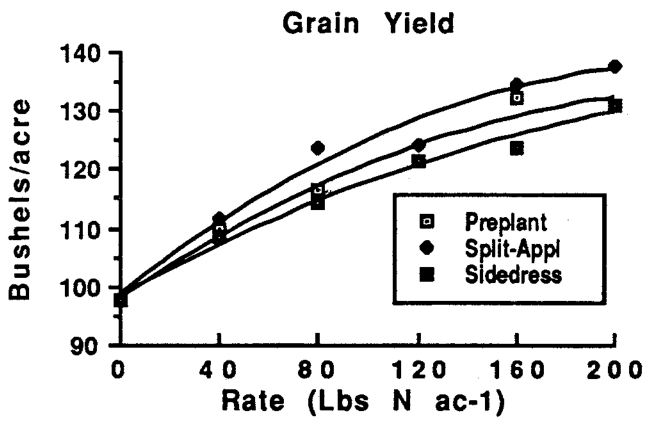
Source	PR>F (.2)
M	.001
R	.001
M*R	NS

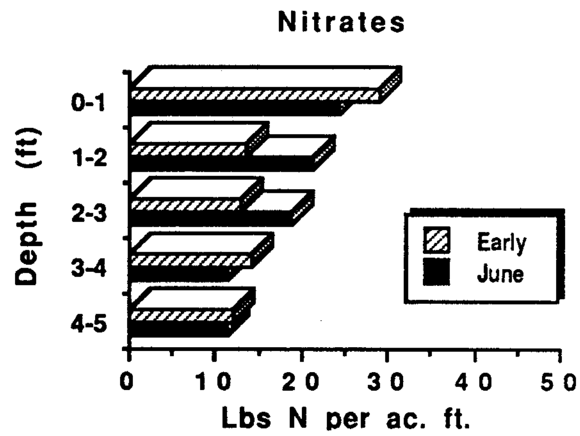
C.V.= 10.7

Nitrogen Recommendations
Based upon 160 bu/ac Yield Goal

	Early N		June N	
Depth (ft)	Residual (lbs)	Recommended (lbs)	Residual (lbs)	Recommended (lbs)
0-2	47	140	66	120
0-6	60	123	120	58

Merrick Co.#2





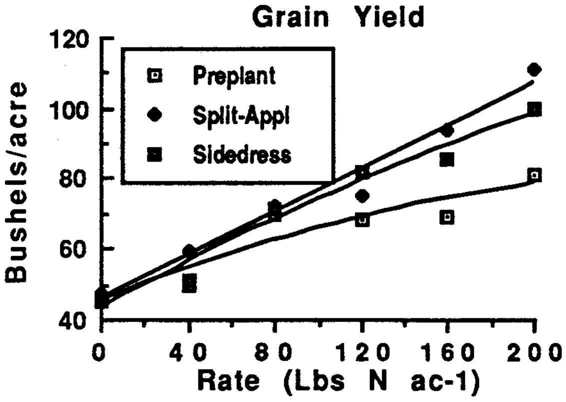
Source	PR>F (.2)
M	.001
R	.08
M*R	NS

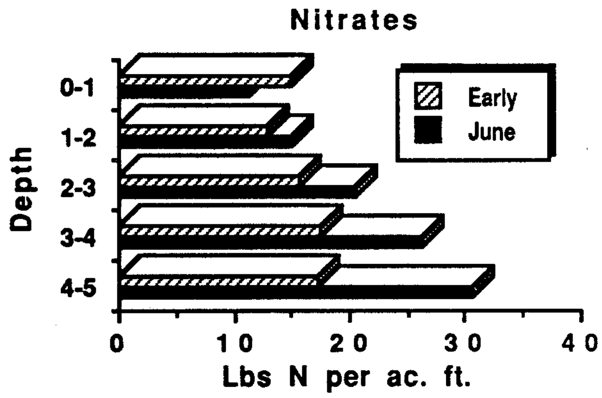
C.V.= 8.5

Nitrogen Recommendations
Based upon 160 bu/ac Yield Goal

	Early N		June N	
Depth (ft)	Residual (lbs)	Recommended (lbs)	Residual (lbs)	Recommended (lbs)
0-2	42	155	46	152
0-6	81	118	87	111

Merrick Co.#3





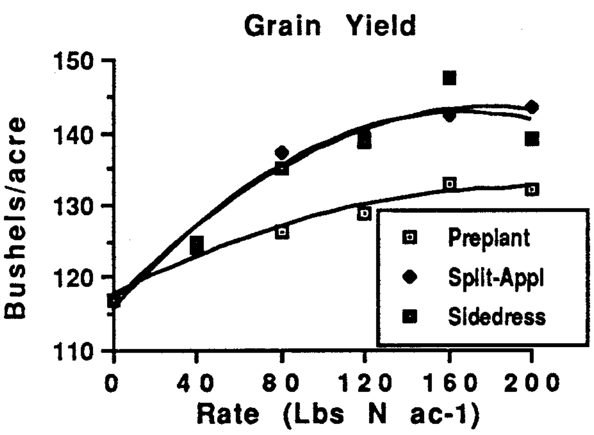
Source	PR>F (.2)
M	.001
R	.001
M*R	.12

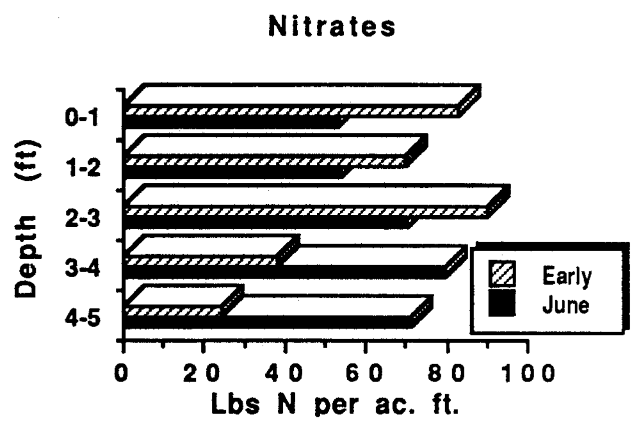
C.V.=13.9

Nitrogen Recommendations
Based upon 170 bu/ac Yield Goal

	Early N		June N	
Depth (ft)	Residual (lbs)	Recommended (lbs)	Residual (lbs)	Recommended (lbs)
0-2	25	149	27	151
0-6	78	99	103	74

Boone Co.





Source	PR>F (.2)
M	.03
R	.001
M*R	NS

C.V.= 7.05

Nitrogen Recommendations
Based upon 160 bu/ac Yield Goal

	Early N		June N	
Depth (ft)	Residual (lbs)	Recommended (lbs)	Residual (lbs)	Recommended (lbs)
0-2	152	63	107	108
0-6	302	0	328	0

USING NITROGEN FERTILIZER ACCORDING TO SOIL TEST

Edwin J. Penas

Objective:

Demonstrate the validity of reducing nitrogen fertilizer rates applied for corn when soil test indicates a high level of nitrate-nitrogen in the soil.

Procedure:

Fields were selected where soil tests indicated that the amount of nitrogen fertilizer applied for corn could be reduced by 100 pounds of nitrogen or more per acre and still achieve normal grain yield levels. The cooperating farmers were asked to apply the rate of nitrogen that they would apply on the field (the rate based on yield goal) and leave alternate strips where the rate was based on yield goal and soil nitrate-nitrogen in four feet of soil.

Grain yields were determined using the cooperating farmer's combine and weighing on a portable weigh wagon. Each strip was split at harvest, which allowed for paired comparisons.

Experimental Results:

In 1989, two demonstrations were established in farmers' fields in east-central Nebraska. Data for these sites are shown in Table 1.

Boone County

This field had been in irrigated corn in 1988. Soil samples taken in early April contained 212 pounds of nitrate-nitrogen per acre four-feet of soil. This amount is adequate to achieve the yield goal of 160 bushels per acre. Thus, the cooperating farmer applied alternating strips of 0 and 160 pounds of nitrogen per acre.

Paired plots were harvested in mid-October by machine, weighed, and sampled for moisture determination. Grain yield was eight bushels per acre lower in the fertilized strips. This reduction was due to ammonia damage to the corn seedlings which reduced final population. Yield checks made in areas where stand was not reduced gave the same yield as the strips that were not fertilized.

Grain moisture at harvest was not influenced by fertilizer treatment. Grain test weight was reduced by nitrogen fertilizer. The reduction was only 0.5 pound per bushel; however, it was statistically significant. These data suggest that excessive levels of nitrogen may reduce the test weight of corn grain. These data show that soil nitrogen can be adequate for maximum corn grain yields.

Table 1. Influence of rate of nitrogen fertilizer on grain yield, grain moisture, and test weight of irrigated corn and residual soil N at two location, 1989.

	Low N Rate	High N Rate	Difference
Boone County			
212 lbs N/ac 4 feet			
Applied Nitrogen, lbs/ac	0	160	160
Grain Yield, bu/ac	164	156	-8.0*
Grain Moisture, %	14.9	14.8	-0.1
Grain Test Weight, lbs/bu	59.4	58.9	-0.5*
Residual Soil N, lbs/ac 4 ft	76	104	28
Saunders County			
129 lbs N/ac 4 feet			
Applied Nitrogen, lbs/ac	60	166	106
Grain Yield, bu/ac	139	142	3.1*
Grain Moisture, %	16.7	16.6	-0.1
Grain Test Weight, lbs/bu	59.2	59.4	0.2*
Residual Soil N, lbs/ac 4 ft	90	187	97

*Significant difference @ .10 probability.

Soil samples were again taken after harvest. Samples taken from strips that received 160 pounds of nitrogen had only 28 pounds per acre more of nitrogen than strips that were not fertilized. Nitrate levels in the soil by strips and by depth within strips were quite variable. This variability may have resulted in the failure to be able to detect treatment effects on the soil nitrate-nitrogen content.

Saunders County

This field had been in irrigated soybeans in 1988. Feedlot manure had been applied prior to growing the crop of soybeans. Soil samples collected in early April contained 129 pounds of nitrate-nitrogen per acre four-feet of soil. Suggested rate of nitrogen on this field for 150 bushels per acre of irrigated corn was 40 pounds of nitrogen per acre if no adjustment was made for the previous soybean crop. The farmer applied alternate strips of 60 and 166 pounds of nitrogen per acre.

Paired plots were harvested in mid-October by machine, weighed, and sampled for moisture determination. Grain yield was 3.1 bushels per acre higher on the high nitrogen strips; however, this difference, although statistically significant, was not enough to cover the cost of the additional fertilizer.

Grain moisture at harvest was not affected by the rate of applied nitrogen. Test weight of the grain was increased slightly by the higher rate of nitrogen fertilizer. This higher test weight may have contributed to the slightly higher yield from the higher rate of applied nitrogen fertilizer. These data suggest that the lower rate of applied nitrogen was very near the optimum amount for this location.

Soil samples collected from the high fertilizer treatment strips (166 lbs. N/ac.) contained 97 pounds more of nitrogen per acre than the low fertilizer strips (60 lbs. N/ac.). This compares favorably with the amounts that were applied. Although there was some variability between strips and at different depths, soil nitrate-nitrogen content was higher in every high fertilizer strip when compared to the adjacent low fertilizer strip. These data for soil nitrogen suggest that a rate lower than 60 pounds of nitrogen per acre may have been adequate.