5. Stalks broken below the ear - All manure treatments resulted in increased lower stalk breakage.

6. Ear moisture at harvest - The manure treated plots were slightly wetter at harvest.

7. Grain yield - All manure treated plots were slightly higher yielding than the fertilized plots.

8. Silage measurements - All measurements were significant, but there were no clear trends.

B. Insecticide Effects - The insecticide significantly reduced the root rating, root lodging, percent nubbins and increased upper stalk breakage and grain yield.

C. Interactions - The only interaction that was significant was upper stalk breakage at the 90% level.

VI. SUMMARY

Three rates of solid beef manure and three rates of liquid beef manure have been applied for two consecutive years and the yields and soil measurements have been compared to check plots. There are no detrimental effects of the manure on yield and there has been no nutrient movement below 3 feet, except with the high rate of solid beef manure. To the present time the lower rate of each manure is adequate to maintain yields equal to those on fertilized plots.

Table 1. Actual Amounts of Manure Applied in the Fall of 1973.

Treatment	Dry Weight	Wet Weight
	- tons/acre -	
SB1	7.247	28.578
SB2	14.494	57.155
SB3	21.741	85.732
LB1	2.027	18.700
LB2	4.054	37.400
LB3	6.081	56.100

Table 2. Chemical Properties of Solid Beef and Liquid Beef Manures Applied at Morris in the Fall of 1973.[1]

Properties	Units (Dry Matter Basis)	Solid Beef Manure	Liquid Beef Manure
Total Solids	%	25.36	10.84
Total Volatile Solids	%	84.82	8.75
COD	mg/l (wet basis)	294,210	167,337
Conductivity	umho's/cm	3179	4023
Total Kjeldahl N	%	3.21	7.70
NH_4-N	%	1.68	5.17
Org-N	%	1.53	2.53
NO_2-N	%	N.M.A.[2]	N.M.A.
NO_3-N	%	N.M.A.	N.M.A.
Phosphates (PO_4-P)	%	.61	1.75
Chlorides	%	1.39	2.43
pH		7.82	7.69
Emission Spectrograph			
P	%	0.91	2.02
K	%	2.20	2.77
Ca	%	1.16	2.28
Mg	%	0.50	0.87
Na	%	0.57	1.11
Fe	ppm	797	1077
Al	ppm	494	560
Mn	ppm	97	199
Zn	ppm	84	202
Cu	ppm	15	25
B	ppm	17	24

[1] Based on an average of nine samples of each type of manure.

[2] N.M.A. = No measureable amount.

Table 3. Nutrients Applied in 1973 for the 1974 Crop Year.

Element	SB1	SB2	SB3	LB1	LB2	LB3
			- lbs./acre -			
Total Kjeldahl N	465	931	1396	312	624	936
NH_4-N	243	487	730	210	419	629
Org-N	222	444	665	103	205	308
PO_4-P	88	177	265	71	142	213
Cl	201	403	604	99	197	296
P	132	264	396	82	164	246
K	319	638	957	112	225	337
Ca	168	336	504	92	185	277
Mg	72	145	217	35	71	106
Na	83	165	248	45	90	135
Fe	12	23	35	4.4	8.7	13.1
Al	7	14	21	2.3	4.5	6.8
Mn	1.4	2.8	4.2	0.8	1.6	2.4
Zn	1.2	2.4	3.7	0.8	1.6	2.5
Cu	0.2	0.4	0.7	0.10	0.20	0.30
B	0.2	0.5	0.7	0.10	0.19	0.29

Table 4. Effect of Two Types of Beef Cattle Manure and Commercial Fertilizer One Year (Fall 1973) after Application on the NH_4-N, NO_2-N and NO_3-N Content of a Tara-Doland Soil Profile.

				TREATMENT					
Depth	Initial[1]	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				NH_4-N (ppm)					
0-1'	4.5	6.7	5.4	5.2	4.8	4.5	5.1	5.6	5.5
1-2'	2.9	4.5	3.0	3.2	3.1	2.9	2.3	3.0	2.5
2-3'	1.8	3.9	2.1	2.5	3.2	2.6	2.3	2.2	2.3
3-4'	1.3	3.2	2.9	2.9	4.1	2.8	3.4	2.7	5.0
4-5'	1.5	3.1	3.1	2.9	3.0	2.7	4.0	4.4	3.2
5-6'	1.5	5.0	3.0	4.3	2.8	3.0	3.9	4.1	4.2
6-7'	1.8	3.5	4.5	3.8	6.9	3.7	4.3	5.3	3.3
7-8'	2.1	3.0	4.9	4.4	3.7	3.3	4.5	3.7	3.8
				NO_2-N (ppm)					
0-1'	.3	.33	.35	.50	.22	.17	.37	.40	.17
1-2'	.3	.46	.28	.38	.27	.22	.37	.40	.33
2-3'	.2	.34	.28	.27	.20	.37	.18	.23	.18
3-4'	.2	.24	.15	.20	.24	.20	.17	.22	.26
4-5'	.1	.17	.13	.14	.19	.16	.16	.24	.22
5-6'	.1	.16	.12	.14	.20	.20	.19	.22	.20
6-7'	.2	.19	.12	.20	.24	.22	.22	.28	.22
7-8'	.2	.16	.14	.20	.29	.23	.24	.37	.28
				NO_3-N (ppm)					
0-1'	4.3	7.7	5.9	11.0	30.3	37.4	6.5	13.9	16.8
1-2'	5.0	2.6	9.0	7.4	17.8	38.6	6.1	15.3	17.7
2-3'	8.8	8.1	10.6	14.1	11.5	18.6	11.9	14.2	10.9
3-4'	12.2	12.3	11.2	10.5	9.8	11.1	11.0	11.1	7.6
4-5'	12.4	11.9	10.4	7.4	11.5	9.8	9.2	10.5	7.4
5-6'	9.4	8.3	7.5	7.3	9.2	9.9	7.8	6.3	6.2
6-7'	6.7	7.3	7.2	7.2	5.6	7.7	5.8	4.2	5.1
7-8'	5.0	4.6	4.6	5.2	3.4	5.2	3.5	3.4	3.9

[1] Samples taken in the fall of 1972 before manure application.

Table 5. Effect of Two Types of Beef Cattle Manure and Commercial Fertilizer One Year (Fall 1973) after Application on Chloride Content and Conductivity of a Tara-Doland Soil Profile.

Depth	Initial[1]	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				Cl (ppm)					
0-1'	6	4.6	4.1	11.5	22.0	24.7	6.4	6.9	13.0
1-2'	3	2.7	3.3	18.8	39.0	57.0	4.2	12.0	18.3
2-3'	6	9.5	6.8	16.1	17.7	17.2	5.9	10.4	8.7
3-4'	10	9.5	6.6	11.2	10.3	10.6	7.6	10.6	9.2
4-5'	12	13.3	7.0	6.7	9.6	9.0	11.1	11.5	7.9
5-6'	11	10.1	5.5	6.0	7.9	6.2	7.8	8.3	7.3
6-7'	9	6.8	5.8	7.2	4.7	4.0	6.6	6.1	7.9
7-8'	6	6.3	4.0	5.4	4.1	4.3	4.2	6.3	6.2
				Conductivity (mmhos/cm)[2]					
0-1'	.140	.225	.198	.227	.289	.315	.185	.226	.254
1-2'	.174	.224	.230	.232	.319	.377	.199	.247	.282
2-3'	.190	.261	.244	.247	.251	.253	.205	.202	.229
3-4'	.198	.260	.221	.232	.227	.225	.207	.237	.221
4-5'	.203	.252	.218	.195	.238	.213	.213	.233	.219
5-6'	.190	.235	.199	.194	.228	.210	.212	.219	.211
6-7'	.180	.216	.201	.202	.231	.197	.197	.209	.198
7-8'	.176	.224	.187	.194	.232	.187	.190	.221	.199

[1] Samples taken in the fall of 1972 before manure application.

[2] Conductivity is on a sample consisting of 20 g. air dried soil + 50 ml. H_2O.

Table 6. Effect of Two Types of Beef Cattle Manure and Commercial Fertilizer (Fall 1974) on the (NO_3 + NO_2)-N Content, Chloride Content, and Electrical Conductivity of a Tara-Doland Soil Profile.

	TREATMENT							
Depth	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				NO_3-N + NO_2-N (ppm)				
0-1'	3.2	7.9	17.5	59.4	144.0	10.3	27.6	92.4
1-2'	1.8	24.3	7.7	38.9	85.3	20.5	34.5	64.5
2-3'	6.3	15.6	10.8	13.0	23.2	11.9	10.3	12.5
3-4'	10.0	11.1	8.0	10.3	10.6	8.5	9.7	7.1
4-5'	8.8	8.6	6.6	8.7	9.6	6.6	8.1	6.0
5-6'	7.3	7.8	5.5	7.7	10.1	6.4	5.7	5.4
6-7'	5.2	5.1	4.9	4.7	7.4	5.5	4.0	4.6
7-8'	3.2	3.6	3.3	3.0	5.5	4.0	2.6	4.4
8-9'	1.9	2.4	1.7	2.7	3.7	2.8	2.0	3.6
9-10'	2.2	2.9	2.6	2.4	3.3	2.4	1.8	2.7
				Cl (ppm)				
0-1'	5.0	11.0	27.3	84.5	149.7	15.9	30.6	55.4
1-2'	3.7	14.6	36.6	81.6	136.1	24.4	51.9	61.8
2-3'	6.5	6.7	12.4	13.9	44.4	8.8	8.6	12.0
3-4'	8.0	6.3	7.7	7.6	10.7	8.7	8.1	8.8
4-5'	8.7	5.2	7.7	7.7	9.8	7.3	6.4	8.7
5-6'	8.7	5.0	7.6	5.3	7.9	7.0	5.7	7.3
6-7'	7.1	3.5	8.6	5.1	5.3	7.6	5.2	6.3
7-8'	5.2	2.7	6.5	4.6	4.5	5.1	3.6	6.4
8-9'	4.0	2.5	4.9	3.5	3.5	3.7	3.9	6.1
9-10'	4.3	2.0	4.8	3.5	3.0	3.4	2.1	4.9
				Conductivity (mmhos/cm)[1]				
0-1'	.169	.242	.302	.480	.843	.232	.328	.523
1-2'	.223	.327	.279	.390	.587	.287	.383	.480
2-3'	.243	.240	.267	.248	.353	.223	.225	.235
3-4'	.230	.215	.230	.229	.210	.208	.223	.202
4-5'	.222	.196	.220	.222	.195	.199	.209	.193
5-6'	.220	.199	.223	.230	.197	.201	.207	.191
6-7'	.216	.195	.224	.222	.184	.195	.210	.183
7-8'	.212	.195	.211	.218	.186	.191	.217	.186
8-9'	.208	.194	.221	.232	.185	.174	.219	.195
9-10'	.245	.203	.230	.246	.201	.174	.237	.190

[1] Conductivity is on a sample consisting of 20 g. air dried soil + 50 ml. H_2O.

Table 7. Effect of Two Types of Beef Cattle Manure and Commercial Fertilizer (Fall 1974) on the pH, Bray #1 P, Exchangeable Na, and Exchangeable K of a Tara-Doland Soil Profile.

	TREATMENT							
Depth	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				pH				
0-1'	7.4	7.8	7.6	7.1	7.1	7.8	7.7	7.1
1-2'	8.0	8.0	8.0	7.5	7.6	8.0	8.0	7.8
2-3'	8.3	8.3	8.2	8.1	8.0	8.2	8.3	8.2
3-4'	8.3	8.2	8.2	8.3	8.2	8.2	8.3	8.3
				Bray #1 P (ppm)				
0-1'	7.7	8.7	32.0	56.0	132.6	10.3	15.3	64.0
1-2'	1.8	1.2	1.0	2.3	3.2	2.0	1.0	1.4
2-3'	1.3	0.7	1.2	0.7	1.5	1.2	0.8	0.5
3-4'	1.7	1.0	1.5	1.3	0.9	1.2	1.0	0.7
				Exch. Na (ppm)				
0-1'	15.9	15.7	41.1	78.8	100.7	28.4	39.4	74.1
1-2'	24.1	23.2	25.3	27.1	39.2	24.2	27.0	28.1
2-3'	40.1	31.1	39.8	32.9	24.7	36.8	34.1	31.9
3-4'	47.7	38.5	45.9	44.5	35.6	46.9	46.9	41.3
				Exch. K (ppm)				
0-1'	187	154	297	383	572	148	180	293
1-2'	139	106	117	136	142	104	118	121
2-3'	119	99	121	116	110	96	103	102
3-4'	100	107	113	115	108	109	114	102

Table 8. Chemical Analysis of Plant Samples Collected on September 7, 1973.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
FODDER										
CK	.76	.130	1.153	.446	.466	219	12.3	6.5	46.1	8.9
FE	.80	.085	1.317	.487	.532	212	15.0	7.1	64.7	7.5
SB1	.82	.158	1.877	.435	.436	277	8.8	6.4	56.9	7.7
SB2	.94	.186	2.377	.457	.423	259	10.2	7.7	65.4	8.2
SB3	.96	.243	2.653	.425	.334	215	8.4	7.2	66.6	7.4
LB1	.84	.130	1.233	.486	.502	195	10.3	8.5	62.3	8.8
LB2	.90	.171	1.503	.519	.493	236	11.3	9.8	63.0	8.5
LB3	1.01	.174	1.860	.461	.463	238	10.9	8.8	49.3	8.1
Level of Signif.[1]	NS	**	**	NS	*	NS	*	NS	NS	NS
BLSD[2] .10	--	.049	.526	--	.088	--	3.1	--	--	--
.05	--	.059	.624	--	.105	--	3.7	--	--	--
.01	--	.082	.867	--	--	--	--	--	--	--
ROOTS										
CK	.53	.115	1.383	.234	.308	1202	10.0	4.8	42.6	5.0
FE	.60	.083	1.600	.327	.389	818	8.7	4.2	28.8	3.6
SB1	.61	.117	2.180	.284	.370	1006	8.4	4.1	41.8	4.6
SB2	.76	.103	2.370	.277	.370	949	8.2	2.7	37.6	4.8
SB3	.86	.130	2.760	.296	.360	926	8.4	5.0	34.8	4.3
LB1	.60	.121	1.400	.348	.387	1356	10.3	4.3	54.1	5.0
LB2	.80	.103	1.680	.290	.432	825	9.5	3.5	29.3	4.8
LB3	.82	.118	2.030	.269	.413	1220	8.8	3.3	44.8	4.7
Level of Signif.[1]	**	NS	**	+	+	NS	NS	NS	NS	NS
BLSD[2] .10	.16	--	.458	.072	.067	--	--	--	--	--
.05	.19	--	.544	--	--	--	--	--	--	--
.01	.28	--	.755	--	--	--	--	--	--	--

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 9. Chemical Analysis of Grain Samples Collected at Final Harvest on September 20, 1973.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.46	.299	.36		.125	26	19.4			3.0
FE	1.50	.315	.36		.140	26	24.0	Incomplete data;		2.9
SB1	1.58	.376	.39	Less	.145	27	20.8	many values		2.8
SB2	1.63	.390	.40	than	.146	28	21.5	below 0.5 ppm Cu		2.6
SB3	1.63	.365	.38	.01%	.138	27	19.3	and 5.0 ppm Mn		2.6
LB1	1.55	.329	.36		.131	24	18.9			2.8
LB2	1.58	.374	.39		.146	27	21.0			3.0
LB3	1.62	.372	.40		.146	28	22.1			2.7
Level of Signif.[1]	*	*	NS	--	NS	NS	+	--	--	NS
BLSD[2] .10	.15	.050	--	--	--	--	3.1	--	--	--
.05	.19	.060	--	--	--	--	--	--	--	--
.01	--	--	--	--	--	--	--	--	--	--
+ Insecticide	1.55	.346	.38	--	.136	26	20.8	--	--	2.6
- Insecticide	1.58	.359	.38	--	.143	28	20.9	--	--	2.9
Level of Signif.	NS	NS	NS	--	NS	+	NS	--	--	*
Interaction Level of Significance	NS	NS	NS	--	NS	NS	NS	--	--	NS

1 Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

2 Bayes LSD.

Table 10. Summary of Analysis of Early Plant Samples - 1974.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
CK	.40	2.75	.71	.65	386	24.9	10.1	82	9.3
FE	.43	4.21	.61	.42	370	29.0	7.7	98	9.1
SB1	.43	4.11	.55	.44	363	24.3	9.2	91	9.3
SB2	.41	4.51	.57	.42	361	24.0	7.0	81	8.7
SB3	.42	4.31	.59	.40	339	24.5	6.1	87	10.3
LB1	.40	3.38	.71	.60	398	24.3	10.1	94	9.2
LB2	.39	3.54	.66	.54	338	24.8	7.9	86	9.5
LB3	.39	3.97	.63	.48	386	25.4	6.7	90	10.6
Level of Significance[1]	NS	**	**	**	NS	NS	*	NS	NS

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

Table 11. Summary of Analysis of Corn Leaves at Silking - 1974.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CH	2.83	.31	2.16	.82	.75	244	25.4	15.3	92	8.1
FE	3.34	.34	2.19	.88	.79	225	35.7	17.5	134	8.9
SB1	3.34	.39	2.69	.73	.55	223	22.7	15.0	120	8.1
SB2	3.26	.37	2.64	.69	.49	235	25.3	13.0	116	9.2
SB3	3.52	.42	2.53	.80	.49	236	22.6	13.9	146	10.3
LB1	3.34	.40	2.23	.83	.73	237	27.7	16.7	125	10.6
LB2	3.33	.38	2.28	.80	.68	227	24.5	15.8	127	9.0
LB3	3.59	.37	2.13	.83	.56	223	26.9	15.7	159	8.6
Level of Significance[1]	**	**	*	NS	**	NS	**	NS	+	NS

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

Table 12. Summary of 1974 Plant Measurements.

Treatment	Early Plant Height inches	Early Plants (10) Dry Weight grams	Root Rating (0-5)	Harvest Measurements: Root Lodged 30° or more %	Stalks Broken Above Ear %	Stalks Broken Below Ear %	Barren Stalks %	Grain: Nubbins %	Ear Moisture at Harvest %	Grain Yield @ 15.5% M. Bu/Ac.	Silage: Dry Matter at Harvest %	Silage Yield (D.M.) lb/Ac.	Ear wt. / Silage wt. %
CK	13.2	12.9	3.4	30.0	5.4	1.3	7.8	25.7	22.3	65.2	55.1	10,800	53.6
FE	13.1	24.9	3.2	11.2	11.3	2.5	2.2	6.2	25.4	91.5	49.7	11,500	55.5
SB1	14.6	19.8	2.8	3.3	12.2	7.4	5.2	4.8	28.1	96.6	47.3	12,600	56.0
SB2	15.9	23.1	3.0	4.0	16.7	14.9	1.2	4.7	28.2	102.6	44.0	12,700	61.7
SB3	15.6	25.5	2.7	2.8	18.6	13.0	0.2	6.5	28.8	101.0	48.4	12,100	57.7
LB1	13.8	14.6	2.9	7.4	13.6	6.1	2.1	5.3	28.8	97.7	46.3	12,700	58.7
LB2	14.4	18.1	3.2	15.0	12.0	6.8	3.8	5.2	28.4	96.0	46.5	12,600	59.4
LB3	13.6	16.5	2.6	4.5	11.8	9.6	3.5	3.3	29.2	100.7	47.9	12,500	59.5
Level of Signif.[1]	+	*	NS	**	*	*	NS	NS	*	**	*	+	*
+ Insecticide	N.M.[2]	N.M.	2.7	5.2	15.1	7.7	2.9	5.9	27.4	95.6	N.M.	N.M.	N.M.
- Insecticide	N.M.	N.M.	3.3	14.3	10.3	7.7	3.6	9.5	27.5	92.2	N.M.	N.M.	N.M.
Level of Signif.			**	**	**	NS	NS	+	NS	+			
Interaction	N.M.	N.M.									N.M.	N.M.	N.M.
Level of Signif.			NS	NS	+	NS	NS	NS	NS	NS			

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS - not significant at the 90% level.

[2] N.M. = not measured on the portion of each plot where insecticide was not used.

Table 13. Plant Measurements - 1974.

Main Plot Treatment	Insecticide	Root Rating[1] (0-5)	Harvest Measurements: Root Lodged %	Stalks Broken Above Ear %	Stalks Broken Below Ear %	Barren Stalks %	Grain: Nubbins %	Ear Moisture at Harvest %	Grain Yield at 15.5% M. Bu/Ac
CK	W	2.9	17.8	6.7	1.6	8.8	21.1	22.0	66.3
	W/O	3.8	42.0	4.1	1.0	6.9	30.4	22.5	64.1
FE	W	2.8	8.9	10.8	2.6	2.2	5.5	26.1	90.0
	W/O	3.7	13.5	11.7	2.4	2.3	6.9	24.7	93.0
SB1	W	2.5	1.5	15.3	6.1	4.6	2.0	27.5	99.7
	W/O	3.2	5.1	9.1	8.8	5.7	7.5	28.7	93.6
SB2	W	2.9	3.4	19.4	12.9	0.9	4.9	27.7	103.4
	W/O	3.1	4.7	14.0	17.0	1.4	4.5	28.8	101.7
SB3	W	2.5	1.1	24.4	13.5	0	5.1	28.6	102.4
	W/O	2.9	4.5	12.9	12.4	0.5	8.0	29.0	99.6
LB1	W	2.4	4.5	15.8	7.1	0.5	2.0	29.2	100.6
	W/O	3.4	10.2	11.4	5.0	3.7	8.6	28.4	94.9
LB2	W	2.9	4.1	16.7	8.6	2.0	4.1	27.9	100.9
	W/O	3.6	26.0	7.3	5.0	5.5	6.2	29.0	91.2
LB3	W	2.5	0.5	11.5	9.0	4.0	2.6	29.9	101.7
	W/O	2.8	8.5	12.2	10.2	3.0	4.1	28.5	99.7

[1] Root rating: 0 = no damage; 5 = severe damage from corn rootworms.

EFFECT OF FERTILIZER ON CORN YIELD AND NUTRIENT CONTENT, AND NITRATE IN SOIL

(West Central Experiment Station, Morris, Minnesota 1974)

S.D. Evans, A.C. Caldwell, and L.L. Goodroad

Plot areas were established in the fall of 1972 on a Barnes soil at the West Central Experiment Station to study the effect of fertilizer treatments on corn yield and nutrient content and on chemical elements added to soils. The studies reported below report some of the observations made during the second crop year, 1974.

A 95-day hybrid was planted at 22,000 seeds/A in the middle of May. Insect and weed control chemicals were used. A starter fertilizer (6-24-24) was applied along the row at 143 lbs/A at planting time. Nitrogen in addition to the starter was applied broadcast as urea at the times indicated in Table 1. An organic source of N was applied as soybean meal, which supplied some P and K as well. The 80 pound rate of meal supplied about 8 and 25 lbs/A of P and K respectively, the 120 pound rate of meal about 12 and 38 lbs/A of P and K respectively. The treatments were replicated 4 times.

The total plant yield was obtained by sampling the corn when it had attained maximum growth and no loss of leaves. Grain yield was determined on matured corn. Grain and plant tissue were analyzed for N. Corn leaf samples were collected for analysis late in August, and the list of elements analyzed for are given in Table 2. Soil analyses reported in Table 3 were obtained in the fall 1972 before application of any fertilizer and again in the fall of 1974 before application of fall N.

TOTAL PLANT AND GRAIN YIELD AND NITROGEN CONTENT OF CORN.

Grain yield and N content and total plant yield and N content are shown in Table 1. It is apparent that for 1974 at least, 80 lbs N/A was sufficient for maximum yields of corn. Spring application of urea resulted in slightly better yields than fall-applied N. Use of 15-N as a tracer showed that spring-applied urea was about 25% more efficient in utilization by corn than fall-applied material, As is reported in more detail elsewhere in this report on field research. The highest grain yield resulted from the use of soybean meal at the heavier rate (120 lbs. N/A). Nitrogen analysis of grain indicates the amount of this nutrient that is removed from the soil. Since the source of the N in the grain was not traced, it is not possible to say what proportion of it came from the fertilizer or the soil.

In general, an increase in total plant yield was correlated positively with greater grain yield. It is of interest to note that to produce the total plant necessary to give a 94 bu/A grain yield required almost twice as much N than was applied as urea at the 80 lb. N/A rate.

MACRO AND MICRO NUTRIENTS IN CORN LEAVES

Table 2 shows the effect of fertilizer treatments on macro and micro nutrients in the ear leaf of corn at tasseling time. Statistically the different fertilizer treatments have not affected the amounts of various elements significantly. The additional P applied at 30 lbs. P/A is reflected in the higher P content in the leaf, which though not of statistical significant, is still worthy of note. The critical nutrient element levels of the ear leaf at tasseling below which the corn plant might be deemed deficient are as follows: N, 3.00%; P, 0.25%; K, 1.90%; Ca, 0.40%; Mg, 0.25%; Mn, 15ppm; Fe, 25ppm; B, 10ppm; Cu, 5ppm; Zn, 15ppm. None of the values given in Table 2 is below these critical levels.

NITRATE-N CONTENT OF SOILS AS AFFECTED BY TREATMENT

Table 3 shows the nitrate-nitrogen (NO_3-N) content of soils from various treatments before and after two annual N applications. In every case the application of some N (even with the starter), has resulted in some increase in NO_3 in the top foot, and at heavier rates of N, some increase in the second foot of soil. Accumulations of N have not occurred beyond the second foot even at the 160 lb. N/A rate.

Table 1. Total plant and grain yield and nitrogen content of corn (1974)

No	Fertilizer treatments	In addition to starter N	In addition to starter P	Total plant yield	Nitrogen in tissue		Grain yield	Nitrogen in grain	
		lbs/A		T/A	%	lbs/A	bu/A	%	lbs/A
1	[1]Starter	-	-	5.19	0.95	100.2	74.0	1.41	49.4
2	"	40	-	5.84	1.04	121.2	81.7	1.47	55.2
3	"	80	-	6.04	1.26	152.0	94.0	1.55	69.0
4	"	120	-	4.76	1.41	162.4	91.2	1.58	67.9
5	"	160(SD)	-	5.66	1.41	159.2	91.9	1.56	67.9
6	"	80(F)	-	5.83	1.24	144.1	92.8	1.49	65.2
7	"	120(F)	-	5.38	1.41	151.2	90.2	1.60	67.9
8	"	80(Org)	8	5.84	1.24	144.8	87.8	1.53	63.4
9	"	120(Org)	12	6.14	1.36	166.3	96.9	1.53	70.2
10	"	80	30	6.06	1.23	148.2	91.0	1.49	64.2
11	"	120(SD)	-	5.78	1.31	150.6	90.4	1.50	63.9

[1] Starter (6-24-24) was applied along the row at planting time, at 143 lbs/A.
[2] N-Nitrogen sources were urea except treatments 8 and 9 which were soybean meal. All treatments were spring applied except 6 and 7 which were applied in the fall. Two treatments received split applications of nitrogen: Treatment 5 received 80 lbs. at planting and 80 lbs. sidedressed, and treatment 11 received 80 lbs. at planting and 40 lbs. sidedressed.

Table 2. Effect of fertilizer treatments on macro and micro nutrients in the ear leaf of corn at tasseling time (1974).

No.	Fertilizer treatments In addition to starter	[2]N	P	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B	Al
		lbs/A		%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm
1	[1]Starter	-	-	3.00	0.355	2.50	0.78	0.61	239	38.4	14.9	74	10.0	122
2		40	-	3.26	0.346	2.13	0.76	0.64	236	38.9	14.8	85	10.6	110
3	"	80	-	3.37	0.357	2.21	0.74	0.68	232	38.5	15.4	87	10.8	99
4	"	120	-	3.50	0.375	2.56	0.74	0.63	231	38.1	15.6	81	10.6	102
5	"	160(SD)	-	4.12	0.365	2.19	0.78	0.63	238	39.0	16.2	94	11.2	117
6	"	80(F)	-	3.27	0.363	2.38	0.73	0.56	230	36.6	15.6	79	9.8	116
7	"	120(F)	-	3.46	0.355	2.22	0.79	0.68	247	37.2	16.1	93	10.4	112
8	"	80(org)	8	3.42	0.348	2.19	0.78	0.60	236	37.6	15.0	81	10.2	108
9	"	120(org)	12	3.41	0.370	2.45	0.72	0.56	238	37.6	15.6	83	10.5	130
10	"	80	30	3.36	0.384	2.24	0.82	0.65	242	37.8	15.8	85	10.3	125
11	"	120(SD)	-	3.46	0.364	2.32	0.74	0.63	228	40.3	15.9	84	10.6	106
Significance				NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Starter applied along the row at planting time. For formula see text.
[2]Nitrogen sources were urea except treatments 8 and 9 which were soybean meal. All treatments were spring applied except 6 and 7 which were applied in the fall. Two treatments received split applications of nitrogen: Treatment 5 received 80 lbs. at planting and 80 lbs. sidedressed, and treatment 11 received 80 lbs. at planting and 40 lbs. sidedressed.

Table 3. Nitrate nitrogen content of soil before ('72) and following ('74) two annual applications of fertilizer (West Central Experiment Station, Morris, Minnesota 1974).

[3]Depth in feet	[1]Row Fert. only		80 lbs[2] N/A spring		120 lbs N/A spring		160 lbs. N/A spring		80 lbs. N/A fall		120 lbs. N/A fall	
	'72	'74	'72	'74	'72	'74	'72	'74	'72	'74	'72	'74
	NO_3-N, ppm											
0-1	5	8	5	14	6	18	7	22	8	12	6	13
1-2	4	4	1	11	2	23	2	22	5	12	2	12
2-3	4	4	4	7	5	10	5	9	8	9	3	9
3-4	3	5	7	8	8	9	7	8	10	9	6	9
4-5	-	6	6	8	7	8	8	10	8	11	5	8

[1]Row fertilizer - 6-24-24 at 143 lbs/A
[2]N source - urea, applied annually
[3]Soils sampled in the fall of '72 before fertilizer application and the fall of '74.

EFFICIENCY OF NITROGEN USE BY CORN FROM FALL VS. SPRING APPLIED UREA

(West Central Station, Morris, 1974)

A.C. Caldwell, S.D. Evans and L.L. Goodroad

The efficiency of use of a fertilizer nutrient is commonly determined by yield, or by total nutrient uptake (yield of tissue times percent of the nutrient in the tissue). A more exact measurement of efficiency use is obtained by tagging a nutrient with an isotope (radioactive or stable) than can be traced in the plant and determined quantitatively. A stable isotope of nitrogen (15-N) was used at the West Central Experiment Station, Morris, to determine the relative efficiency of uptake of fall vs. spring applied urea.

The data obtained in this experiment are shown in the accompanying table.

Efficiency of fall vs. spring applied urea on corn.

Treatment N[1], lbs/A	Total N in tissue[2] lbs/A	N in tissue from fert. %[3]	N in tissue from fert. lbs[4]	Efficiency of fert. use %[5]
110, spring	164	37	61	55
110, fall	151	30	45	41

[1]N source was urea

[2]%N x dry matter

[3]Determined by analyzing tissue for 15-N

[4]%N in tissue from fert. x total N in tissue

[5]lbs N in tissue from fert. x N applied

Yield data from 120 lbs/A of nitrogen from urea showed 91 and 90 bu/A corn from spring or fall applied urea, respectively. With such a slight difference we would say that corn yields were the same whether urea was applied in the fall or spring. However, when the nitrogen source was traced, we found that spring applied urea was about 25% more efficient in supplying nitrogen to corn than was that applied in the fall.

EFFECT OF PHOSPHORUS AND POTASSIUM FERTILIZERS ON SOYBEAN SEED YIELDS AT MORRIS

G.E. Ham and S.D. Evans

Phosphorus fertilizer rates of 15, 30 and 45 kg P/ha (13.4, 26.7 and 40.0 pounds P/acre) were applied as broadcast treatments. Row fertilizer rates were 10, 20 and 30 kg P/ha (9, 17.8 and 26.7 pounds P/acres).

In a separate experiment potassium fertilizer rates were 15, 30 and 45 kg K/ha (13.3, 26.7 and 40 pounds K/acre) for row treatments and 30, 60 and 90 kg K/ha (26.7, 53.4 and 80.1 pounds K/acre) for broadcast treatments.

Broadcast treatments were plowed down the previous fall and row fertilizer was applied at planting two inches to the side and two inches below the seed. The experimental design was a factorial with all rates of broadcast (4) in combination with all rates of row fertilizer (4). The soil pH was 8.2, extractable P was 6 pounds/acre and exchangeable K was 246 pounds per acre. Evans variety soybeans were grown in 30-inch row spacing.

Seed yields are shown in Table 1. Yields were not increased with any treatments in these studies.

Table 1. Effect of broadcast and row fertilizer (P and K) on soybean seed yield of Evans variety soybeans at Morris (1974).

Broadcast fertilizer	Row Fertilizer (kg/ha)			
	0P	10P	20P	30P
	----------bu/acre----------			
0P	27.3	30.9	31.6	26.3
15P	28.6	29.3	28.8	28.5
30P	26.3	28.6	28.8	26.1
45P	29.0	28.6	29.4	29.8
	0K	15K	30K	45K
0K	26.2	27.4	27.8	27.7
30K	26.7	28.9	28.0	28.9
60K	28.0	26.8	27.4	29.0
90K	27.0	25.6	28.2	28.7

COMPARATIVE VALUE OF SEVERAL SMALL GRAIN CROPS FOR FORAGE AND GRAIN IN WEST CENTRAL MINNESOTA

MORRIS, MINNESOTA - 1974

C. A. Simkins, S. D. Evans, R. Schoper

In 1974, a study of the comparative value of Era wheat, Dal oats and Larker barley as grain or forage under various levels of fertility was conducted. Three rates of N (0, 80 and 120 lbs/A for wheat and 0, 60 and 90 lbs/A for oats and barley) arranged in a randomized complete block design and replicated three times were broadcast prior to seeding. In addition to the nitrogen treatments, 40 lbs. P_2O_5/A was applied as broadcast. The trial also included an irrigation treatment where the high nitrogen treatments received three applications totaling six acre inches of water.

The soil nitrate nitrogen level at seeding time in the 0-24 inch zone was 77 lbs./A. Both P and K soil test levels were high.

Moisture received during the growing season was below normal, but no increase in yield due to irrigation was noted. This is likely due to above average temperatures during the critical soft dough stage of development. Average temperatures for the first ten days of July were 5.3° F. above normal, and for the second ten days of July were 3.9° F. above normal.

The grain yield, forage yield, protein levels and total N removed for each crop is summarized in tables 1, 2 and 3.

Nitrogen fertilizer produced no significant increases in grain yield. In order of greatest poundage of grain produced per acre, Larker barley was highest at 3,216 lbs/A, followed by Era wheat and Dal oats.

Forage yields in all three species were significantly increased by irrigation, but not by nitrogen fertilizer treatments. Dal oats produced the greatest amount of dry matter per acre at 5.03 T/A, followed by Larker barley and Era wheat.

Table 1. Forage and grain yields, protein levels and total nitrogen removed by Era wheat. Morris, Minnesota - 1974.

Lbs. N/A	Grain Bu/A	Grain % protein	Forage Tons/A	Forage % protein	Forage N removed
0	53	15.6	2.40	8.7	67
80	51	16.5	2.37	9.0	69
120	49	16.6	2.37	9.1	73
120 + irrigation	49	17.1	3.50	10.1	107
Significance	ns	ns	**	ns	*
BLSD			0.62		27

Table 2. Forage and grain yields, protein levels and total nitrogen removed by Dal oats. Morris, Minnesota - 1974.

Lbs. N/A	Grain Bu/A	Grain % protein	Forage Tons/A	Forage % protein	Forage N removed
0	90	16.6	2.90	8.0	77
60	75	19.1	3.57	9.8	109
90	82	19.2	3.47	10.4	110
90 + irrigation	98	19.6	5.03	9.2	154
Significance	ns	ns	*	ns	ns
BLSD			1.35		

Table 3. Forage and grain yields, protein levels and total nitrogen removed by Larker barley. Morris, Minnesota - 1974.

Lbs. N/A	Grain Bu/A	Grain % protein	Forage Tons/A	Forage % protein	Forage N removed
0	67	14.1	3.7	8.9	107
60	60	14.5	3.6	10.1	118
90	53	15.1	3.4	11.3	122
90 + irrigation	61	15.0	4.2	11.9	160
Significance	ns	ns	**	ns	*
BLSD			0.2		32

PESTICIDE INTERACTION PLOTS AT ROSEMOUNT

Russell S. Adams, Jr.

An experiment examining the effects of combinations of the insecticide, Furadan, the herbicide, Atrazine, and soil pH, which began in 1973, was continued in 1974. Treatments included 0, 0.5 and 2 pounds per acre, Atrazine at 0, 2, 4, and 8 pounds per acre and soil pH ranging from about pH 5.5 to pH 5.2. Each treatment was replicated four times.

In contrast to 1973 weed infestation, insect damage and corn stands were relatively consistent throughout the plot. However, in 1973, drought and an unusually severe early frost sharply cut yields. Corn yields varied in individual plots from 27 to 100 bushels per acre. In 1974, the corn sustained severe lodging in the absence of insecticide and would have been difficult to recover by machine harvesting. Only modest yield increases were obtained with Atrazine as shown in Table 1, in spite of sharp reductions in weed yields. Furadan application sharply reduced the lodging of corn, but had little effect on corn yields. Furadan, particularly in the absence of Atrazine, demonstrated an herbicidal effect on weeds. Lodging was more severe and Furadan consistently less effective in preventing lodging in high lime plots. As confirmed by tissue analyses zinc deficiency or borderline deficiency appeared in both corn and giant foxtail, the major weed species in the plots. However, with two years data no significant interaction of Atrazine x Furadan x soil pH can yet be detected.

Average data for the two years 1973 and 1974 are shown in Table 2.

Table 1. The amount of lodging, weed growth and corn grain yields in Atrazine--Furadan--soil pH studies at Rosemount, Minnesota, 1974.

Rate of Furadan(lbs/A) Lime Status	Atrazine applied lbs/A											
	None			2.0			4.0			8.0		
	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A
No lime- somewhat acid (∿pH 5.4)												
Weedfree	70	0.01	57									
Furadan, 0 lbs/A	80	0.96	37	92	0.81	44	75	0.11	47	72	0.08	55
½	58	1.25	50	75	0.49	52	55	0.58	56	60	0.05	63
2	10	0.97	52	55	0.28	61	10	0.38	65	27	0.05	66
Moderate lime, slightly acid (∿pH 6.5)												
Weedfree	75	0.00	59									
Furadan, 0	92	0.87	52	92	0.40	52	88	0.19	55	82	0.01	62
½	65	0.68	53	60	0.48	56	62	0.23	61	63	0.00	68
2	25	0.70	54	50	0.45	51	18	0.11	69	28	0.06	70
Well limed, near neutral (∿pH 6.8)												
Weedfree	90	0.01	65									
Furadan, 0	50	0.82	55	55	0.52	49	72	0.11	67	70	0.01	63
½	82	1.12	42	57	0.55	53	65	0.17	67	85	0.01	63
2	25	0.63	63	20	0.29	73	35	0.18	70	28	0.02	71
Heavily limed, slightly calcareous (∿pH 7.2)												
Weedfree	85	0.00	56									
Furadan, 0	90	0.86	44	100	0.09	60	100	0.02	60	95	0.00	64
½	55	0.78	58	45	0.23	69	75	0.07	71	60	0.02	75
2	65	0.38	58	55	0.10	64	52	0.08	54	29	0.00	72

Table 2. The amount of lodging, weed growth, and corn grain yields in Atrazine--Furadan--soil pH studies at Rosemount, Minnesota average of two years.

Rate of Furadan (lbs/A) Lime Status	Atrazine applied lbs/A											
	None			2.0			4.0			8.0		
	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A
No lime--somewhat acid (∿pH 5.4)												
Weedfree	60	0.05	68									
Furadan, 0 lbs/A	58	0.84	74	60	0.62	76	64	0.18	80	46	0.05	84
½	30	1.09	78	45	0.25	87	52	0.32	80	46	0.11	89
2	15	0.85	77	42	0.24	92	8	0.25	86	37	0.03	82
Moderate lime, slightly acid (∿pH 6.5)												
Weedfree	41	0.00	96									
Furadan, 0 lbs/A	56	1.04	80	69	0.22	83	58	0.16	79	60	0.00	85
½	54	0.94	69	48	0.27	84	41	0.12	96	56	0.03	81
2	22	0.91	76	32	0.40	87	15	0.09	89	25	0.04	88
Well limed, near neutral (∿pH 6.8)												
Weedfree	70	0.03	96									
Furadan 0 lbs/A	48	1.03	76	37	0.36	79	55	0.06	85	56	0.02	86
½	55	0.78	81	44	0.61	77	42	0.11	92	52	0.00	97
2	16	0.89	82	14	0.26	102	24	0.20	101	27	0.02	95
Heavily limed, slightly calcareous (∿pH 7.2)												
Weedfree	78	0.00	75									
Furadan, 0 lbs/A	75	0.68	78	77	0.14	89	75	0.03	81	66	0.00	82
½	45	0.81	85	44	0.32	97	46	0.09	92	50	0.04	97
2	38	0.62	90	38	0.13	84	27	0.14	86	34	0.00	94

FERTILIZER TRIALS ON IRRIGATED ALFALFA AND RED CLOVER

Staples, Minnesota - 1974

C. J. Overdahl, Melvin Wiens, R. Schoper and J. Lensing

PHOSPHATE TRIAL (ALFALFA)

In the phosphorus trial, no response was obtained for the third consecutive year. Treatments of 0, 30, 60, 90 and 120 pounds per acre of P_2O_5 were applied with 4 replications. The plot yield average was 5.7 tons per acre in 1974. Soil test phosphorus was 84 pounds per acre (very high) in 1972, 72 in 1973, and 50 in 1974. The potassium tests in these plots were low in spite of annual applications of K.

POTASH TRIAL (RED CLOVER AND ALFALFA)

	Annual treatments of K_2O in lbs/A and time of application						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Significance
	Yields Tons/Acre at 15% Moisture						
Alfalfa							
1972	3.4	3.6	3.8	3.5	3.4	3.6	ns
1973	4.0a	4.8bc	4.6bc	4.6bc	4.3ab	4.8c	5%
1974	5.1a	6.5b	6.4b	6.4b	6.3b	6.5b	5%
Red Clover							
1972	4.2	5.0	4.5	4.7	4.7	4.7	ns
1973	3.3	3.6	3.3	3.4	3.6	3.7	ns
1974*	-	-	-	-	-	-	
	Soil Test K lbs/A						
Alfalfa							
1972	92	258	322	160	165	185	
1973	85	290	210	150	140	195	
1974	60	175	240	95	75	200	
Red Clover							
1972	107	262	230	182	167	162	
1973	90	290	240	160	190	310	
1974	135	180	200	150	155	180	

* red clover failed in 1974, was reseeded August 1 and good stand established for 1975.

	Plant Analysis %K						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Significance
Alfalfa							
1972							
1st cut	2.05	2.76	2.89	2.20	2.74	2.65	
2nd cut	2.00	2.50	2.46	2.27	1.92	2.34	
3rd cut	2.52	3.44	3.08	2.94	2.85	3.18	
1973							
1st cut	1.74a	2.74b	2.88b	2.40b	2.45b	2.47b	5%
2nd cut	1.58a	2.76b	2.76b	2.48b	2.39b	2.65b	1%
3rd cut	1.64a	2.60b	2.57b	2.45b	2.17b	2.56b	5%
1974							
1st cut	1.37	3.08	3.59	2.17	2.32	3.21	
2nd cut	1.29	2.40	2.85	2.25	1.89	2.60	
3rd cut	1.11	2.18	2.48	2.08	1.62	2.36	
Red Clover							
1972							
1st cut	2.14	3.05	2.83	3.02	2.61	3.04	
2nd cut	2.20	2.86	2.60	2.51	2.21	2.44	
3rd cut	2.65	3.54	2.98	3.32	2.87	2.98	
1973							
1st cut	1.76a	2.63b	2.65b	2.56b	2.42b	2.66b	5%
2nd cut	2.03a	2.84c	2.97c	2.65bc	2.48b	2.92c	1%
3rd cut	1.81a	3.00d	2.53c	2.40c	2.10b	2.66c	1%
1974							
none							

LIME PLOTS (ALFALFA)

	Rates of lime T/A applied July 1971			
	0	2½	5	Significance
	Yield T/A, 15% Moisture			
1972	3.8	3.6	3.8	ns
1973	4.1	4.3	4.2	ns
1974	5.4	5.3	5.4	ns

	Soil pH			
Depth	1972	1974		
0-6"	6.4	7.1		
0-1'	6.2	6.8		
1-2'	6.5	7.1		
2-3'	6.9	7.2		
1973	6.5		6.5	6.6
1974*	7.1		7.1	7.1

The 0-6" sample in July 1971 for plots averaged 5.6.

* Irrigation water contains 280 ppm calcium carbonate, which amounts to more than 1,000 lbs/A of lime added in the water each year, which has made this plot meaningless.

SULFUR (ALFALFA)

	Lbs/acre of sulfur applied spring 1972 as gypsum			
	0	50	100	Sig.
	Yield T/A, 15% Moisture			
1972	4.3	4.0	3.7	ns
1973	4.2	4.3	4.2	ns
1974	5.7	5.7	5.4	ns

Sulfur soil test, 8 ppm 1970.

COPPER (ALFALFA)

	Lbs/acre of copper applied as copper sulfate		
	0	10	Sig.
	Tons/Acre		
1972	0.52	0.60	3rd cutting only
1973	5.3	5.4	ns
1974	6.4	6.9	ns

Tissue analysis of alfalfa in K plot indicates 7 samples out of 12 too low to be recorded by spectrograph. The other 5 samples averaged 1.3 ppm copper at first cutting, while 17 samples averaged 2.5 ppm in red clover (1973). In 1972 (2nd cut), alfalfa averaged 1.6 ppm, while red clover averaged 3.6 ppm. Such comparisons could not be made in 1974. No plant analysis was made on these plots.

PHOSPHATE TRIAL (ALFALFA)

	Lbs/acre of P_2O_5 applied annually					
	0	30	60	90	120	Sig.
1972	3.9	4.2	3.9	4.0	4.0	ns
1973	4.3	4.4	4.4	4.3	4.3	ns
1974	5.8	5.8	5.5	5.8	5.6	ns

GENERAL SUMMARY

Soil test K in the alfalfa K trial continues to decline in the check plot (K=60). All K plots were unusually low, but yields were generally high. Copper in plant analysis of alfalfa is too low to be recorded by the emission spectrograph in 1974.

PLANT AND GRAIN YIELD AND NITROGEN CONTENT OF FERTILIZED CORN UNDER IRRIGATION (CMIDR STATION, STAPLES, MINNESOTA 1974).

A.C. Caldwell, L.L. Goodroad, M. Wiens, and H. Werner

An experiment was established on an Estherville loamy sand at the CMIDR station at Staples, Minnesota in the spring of 1974 to study the effects of time and rate of application of fertilizers on corn yield and to account for those essential nutrients and other elements added to soils by analysis of plant, soil, and materials applied.

An 85-day hybrid was planted at 26-27,000 seeds per acre in early May in 36" rows. Weed and insect chemicals were used. Irrigation water was applied as needed. Fertilizer treatments and rates are given in the table. The urea was not applied at one time, but at 2, 3, or 4 intervals up to tasseling time depending upon the rate required. For example, the 60 pound rate of nitrogen (treatment 2) was split into 20 and 40 pound allotments of nitrogen as urea; the 240 pound rate was split into 40, 80, 80, and 20 pound allotments of nitrogen as urea. Soybean meal was applied all at one time, prior to planting. The treatments were replicated four times.

The total plant yield was obtained by sampling the corn when it had attained maximum growth and no loss of leaves. Grain yield was determined on matured corn. Grain and plant tissue were analyzed for N.

Total dry matter yield increased with increase in N rate up to about 200 lbs. N/A (see the accompanying table). About the same yield was obtained from 40 less pounds of N, but from an additional 150 lbs. K/A. It is possible that the basic application of 150 lbs. K/A may be too low.

Maximum grain yield conincided fairly well with total dry matter yield as can be seen from the figures for plots 5 and 8.

Pounds per acre of N in tissue and grain show the amounts required to produce the dry matter and yields obtained. The highest yield was obtained on treatment 8 (109 bu/A), and the amount of N removed in the grain was equal to about half the amount of N applied, (though there was no wasy in this experiment to determine the source of N in the plant, whether it came from the soil or from the fertilizer).

Total plant and grain yield and nitrogen content of corn under irrigation (CMIDR, Staple, 1974).

	[1]Fertilizer treatments			Total plant yield	Nitrogen in tissue		Grain yield	Nitrogen in grain	
	N	P	K						
No.	lbs/A			T/A	%	lbs/A	bu/A	%	lbs/A
1	18	10	150	4.34	0.70	60.9	51	1.07	26.1
2	78	10	150	5.96	0.94	112.9	89	1.29	54.0
3	118	10	150	5.68	1.14	129.4	98	1.46	67.6
4	158	10	150	5.98	1.22	145.4	101	1.51	72.0
5	198	10	150	6.22	1.22	149.6	107	1.55	78.6
6	238	10	150	5.92	1.22	144.3	107	1.52	76.7
7	158	40	150	5.57	1.17	130.0	100	1.46	69.2
8	159	10	300	6.27	1.25	156.6	109	1.49	76.7
9	158	24	194	6.09	1.06	129.2	97	1.40	64.4

[1]All plots received 18, 10 and 56 lbs/A of N, P, and K, respectively, as starter along the row, plus an additional broadcast application of 94 lbs. of K/A (as KCl). Treatment 7 got an extra 30 lbs. p/A (as superphosphate), and treatment 8 an additional 150 lbs. K/A (as KCl). The soybean meal application, treatment 9, contributed another 14 lbs. P and 44 lbs. K per acre. Sulfur was applied to all plots at 20 lbs. S/A as gypsum.

THE EFFECTS OF FERTILIZER RATES ON NAVY BEANS

A.C. Caldwell, H. Warner, M. Wiens, R. Schoper, J. Lensing

A field experiment was established at the Staples Irrigation Farm in June of 1973 to study the effects of fertilizer on the yield of navy beans. A similar location on the same Hubbard sandy loam soil was selected for experimentation in 1974. A randomized complete block design was used with nine treatments being replicated four times.

Treatment Code	Treatments	$N + P_2O_5 + K_2O + S$
A	Check	0 + 0 + 0 + 0
B	$N_1+P_1+K_1+S$	20 +60 +60 +25
C	$N_2+P_1+K_1+S$	40 +60 +60 +25
D	$N_3+P_1+K_1+S$	80 +60 +60 +25
E	$N_4+P_1+K_1+S$	120 +60 +60 +25
F	$N_3+P_1+K_2+S$	80 +60 +120+25
G	$N_4+P_1+K_2+S$	120 +60 +120+25
H	$N_3+P_1+K_1+S$	80 +60 +60 +25*
I	$N_4+P_1+K_1+S$	120 +60 +60 +25*

* Nitrogen source urea formaldehyde, all other nitrogen applied as urea.

All treatment and rates were applied as follows:

1. N_1 - 20 lbs N/A applied as starter.
2. N_2 - 40 lbs N/A broadcasted preplant.
3. N_3 - 40 lbs N/A preplant + 40 lbs N/A at early flower.
4. N_4 - 40 lbs N/A preplant + 40 lbs N/A early flower + 40 lbs N/A at early pod.
5. P_1 - 60 lbs P_2O_5/A applied as starter.
6. K_1 - 60 lbs K_2O/A applied as starter.
7. K_2 - 60 lbs K_2O/A as starter + 60 lbs K_2O/A broadcasted preplant.
8. S - 25 lbs S/A applied preplant as Sol-u-Sul.

Soil nitrate nitrogen levels in June at the 0-24 inch depth were low at 12 lbs/A. Soil test levels for available phosphorus and exchangeable potassium were very high and low respectively.

Nitrogen fertilizer increased bean yields from 1396-1920 lbs/A (Table 1) with the highest yield being recorded at 120 lbs N/A. Urea formaldehyde, a slow release nitrogen fertilizer source, produced a significantly lower yield than urea at the 80 lbs N/A rate. The 120 lbs K_2O/A rate produced no significant increase in yield over 60 lbs K_2O/A.

Table 1. Yield of navy beans as affected by various fertilizer rates under irrigation at Staples in 1974.

Fertilizer Treatment Code	Yields lbs/A
A 0 - 0	1396 a*
B 20 - 60	1636 b
C 40 - 60	1718 bc
D 80 - 60	1848 cd
E 120 - 60	1809 cd
F 80 - 120	1844 cd
G 120 - 120	1920 d
H	1614 b
I	1726 bc
Significance	**
BLSD	156

* Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

Conclusions

1. Two years of fertilizer research indicates that significant nitrogen responses up to 80 lbs N/A can be attained.
2. Starter fertilizer rates of 60 lbs P_2O_5/A and 60 lbs K_2O/A appear to be adequate for this particular soil type.
3. The use of a slow release nitrogen fertilizer like urea formaldehyde showed no advantage over a conventional nitrogen fertilizer source such as urea.
4. Nitrogen applied as starter fertilizer gave the greatest yield return per pound of nitrogen used.

$\bar{X} = 1723$

NITROGEN TRIALS ON SPRING WHEAT UNDER IRRIGATION AT STAPLES IN 1974

A.C. Caldwell, H. Warner, M. Wiens, R. Schoper, J. Lensing

A time and rate of nitrogen fertilizer experiment was conducted on the semi-dwarf wheat varieties Era and Mn-II-64-33 on a Hubbard sandy loam soil at Staples. A randomized complete block design was used with five nitrogen treatments (0, 50, 75, 100, and 125 lbs/A) replicated four times. At the 50, 75, and 100 lb. N rates, 50 lbs N/A was broadcast prior to seeding, plus 0, 25, and 50 lbs N/A, respectively, were applied at the early boot stage. At the 125 lb. N rate, 75 lbs N/A was broadcast prior to seeding with an additional 50 lbs N/A applied at the early boot stage. In addition to the nitrogen treatments, 20 lbs. P_2O_5/A was applied with the seed.

Soil nitrate nitrogen levels in the 0-24 inch zone were very low at 12 lbs/A. Soil test levels of P and K were very high and medium, respectively.

Wheat yields for the two varieties ranged from 19-62 bushels per acre (Table 1). The variety Era yielded from 24-62 bushels per acre and the variety Mn-II-64-33 yielded from 19-58 bushels per acre. The highest significant yield for both varieties was recorded at the 100 lbs. N/A rate.

Table 1. Yields of Era and Mn-II-64-33 wheat as affected by nitrogen fertilizer rates under irrigation at Staples in 1974.

Fertilizer treatments	Variety	
	Era	Mn-II-64-33
lbs. N/A	----------Bu/A----------	
0	24 a*	19 a
50	40 b	35 b
75	54 c	46 c
100	61 d	52 cd
125	62 d	58 d
Significance	**	**
BLSD	6.8	10.2

*Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

Forage yields for both varieties were collected to determine percent nitrogen, total dry matter, and total nitrogen removal at the various nitrogen fertilizer rates. The results of these measurements are reported in tables 2 and 3.

Table 2. The nitrogen concentration, dry matter production and pounds of nitrogen in Era plant tissue as affected by nitrogen fertilizer rates at Staples in 1974.

Fertilizer treatment	N	Forage yields	N removed in forage
lbs. N/A	%	Tons/A	lbs./A
0	1.11 a*	1.3 a	32 a
50	1.04 a	2.6 b	54 a
75	1.40 ab	3.2 bc	96 b
100	1.58 b	3.8 c	116 b
125	1.44 ab	3.9 c	108 b
Significance	*	**	*
BLSD	.34	.8	38

*Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

Table 3. The nitrogen concentration, dry matter production and pounds of nitrogen in Mn-II-64-33 tissue as affected by nitrogen fertilizer rates at Staples in 1974.

Fertilizer treatment	N	Forage yields	N removed in forage
lbs. N/A	%	Tons/A	lbs./A
0	1.10 a	1.4 a	29 a
50	1.01 a	2.7 b	54 ab
75	1.36 ab	2.9 b	71 b
100	1.61 bc	3.7 c	115 c
125	1.87 c	3.9 c	145 d
Significance	**	**	**
BLSD	.28	.7	25

*Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

The percent nitrogen, dry matter yield and total nitrogen removed was similar for both varieties. The most marked observation was the high degree of response to nitrogen applications at the boot stage of growth. This experiment then indicates that in 1974, under irrigation, 100 lbs. N/A applied in split applications gave the greatest economic returns.

SOUTHERN EXPERIMENT STATION - WASECA
WEATHER DATA - 1974

Month	Period	Precipitation 1974	Precipitation Normal	Avg. Air Temp. 1974	Avg. Air Temp. Normal	Growing Degree Days 1974	Growing Degree Days Normal
		inches		°F			
Jan.	1-31	.22	.73	10.0	12.9		
Feb.	1-28	.61	.96	15.5	17.5		
March	1-31	1.53	1.94	29.5	28.5		
April	1-30	2.47	2.48	45.5	45.6		
May	1-10	1.01		49.2		62.0	
	11-20	1.92		51.3		52.5	
	21-31	.84		60.3		131.0	
	Total	3.77	3.86	53.8	57.7	245.5	326
June	1-10	2.86		62.9		134.5	
	11-20	.38		61.6		127.5	
	21-30	1.72		68.0		177.0	
	Total	4.96	4.75	64.1	67.1	439.0	524
July	1-10	.67		77.0		255.5	
	11-20	.40		75.7		246.5	
	21-31	.73		70.7		226.0	
	Total	1.80	4.02	74.4	71.4	728.0	633
August	1-10	2.37		65.4		153.5	
	11-20	1.33		68.4		183.5	
	21-31	1.72		63.5		161.5	
	Total	5.42	3.60	65.7	69.7	498.5	586
Sept.	1-30	1.01	3.45	55.6	60.3	15.0	322
Oct.	1-31	2.23	1.89	48.4	50.3		45
Nov.	1-30	1.45	1.25	32.8	32.9		
Dec.	1-31	0.45	1.02	21.9	19.0		
Year	Jan-Dec	25.92	29.95	43.1	44.4	1926.	2436
Growing Season	May-Aug	15.95	16.23	64.5	66.5	1911.	2064

Notes:

1) Hail damage on June 18 and June 20

2) Frost - 30° on September 3
   - Earliest on record; previous early frost was September 11, 1955

NITROGEN FERTILIZATION OF CORN

Waseca, 1974

G. W. Randall and W. E. Lueschen

Two field experiments were initiated in the fall of 1971 and spring of 1972 to obtain additional information on nitrogen fertilization of corn in south-central Minnesota. These studies have been continued and, hopefully, will supplement information obtained from long-term experiments initiated in 1969 by Fenster, Overdahl and Frazier. Results from 1972 and 1973 were reported in Soil Series 89 and 91, respectively.

Experiment I

To evaluate various sources of N fertilizer, an experiment involving four sources of N applied at two rates in both the fall and the spring was established at the Southern Experiment Station on a Cordova silty clay loam. The experimental design was a randomized complete-block, replicated four times.

Soil test P (36 lb./A) and K (300 lb./A) were considered high; consequently, starter and broadcast P and K applications were not used. Ammonium nitrate, urea and 28% N solution were fall-applied on 11/1/73 and plowed down. Anhydrous ammonia was applied on 11/6/73. Ammonium nitrate, urea and anhydrous ammonia were spring-applied on 4/24/74 and field cultivated in. The 28% N was applied on 5/4/74 and field cultivated in. Both fall and spring soil conditions were excellent for N application. In 1974, 28% N solution was substituted for aqua ammonia (20% N) because of the unavailability of the latter material.

Corn (Pioneer 3780) was planted at 26,800 ppA in 30" rows on May 4. An insecticide (Dyfonate at 1 lb./A) was applied at planting. Weeds were controlled with 2½ lb./A of Lasso and 2½ lb./A of Atrazine applied preemergence on May 22. The leaf opposite and below the ear was sampled on July 23, and was submitted for Kjeldahl analysis. Final population and lodging notes were taken on October 8. Yields were taken on October 17, by combine harvesting the center two rows from each plot. Soil nitrate samples were taken in 1-foot increments to a depth of 5 feet from all ammonium nitrate and urea plots on October 21.

Results

Nitrogen concentrations in the earleaf and grain (protein), yield, lodging and N removal with the grain were affected significantly by the N treatments (Table 1). The final plant population and grain moisture at harvest were not influenced.

Table 1. Continuous corn production parameters as influenced by the source, rate and time of application of N at Waseca in 1974.

Treatment					Grain		
Source	Rate	Time	Leaf N	Lodging	Yield	N	N removal
	lb N/A		%	%	bu/A	%	lb N/A
Anhyd. Am.	75	F	2.66	8.5	103.3	1.40	68.4
"	75	S	2.60	5.3	100.6	1.44	68.6
"	150	F	2.69	6.9	111.1	1.57	82.6
"	150	S	2.83	3.5	112.3	1.57	83.4
Urea	75	F	2.58	11.0	80.4	1.23	46.8
"	75	S	2.68	5.7	95.1	1.29	57.9
"	150	F	2.70	7.3	112.9	1.46	77.8
"	150	S	2.77	2.5	113.0	1.53	82.0
Am. Nitrate	75	F	2.32	20.8	75.6	1.26	45.0
"	75	S	2.60	7.6	96.0	1.34	61.0
"	150	F	2.69	11.9	96.8	1.43	65.3
"	150	S	2.58	9.2	108.9	1.56	80.2
28% N Soln.	75	F	2.63	6.0	84.0	1.33	53.0
"	75	S	2.64	9.7	103.0	1.43	69.5
"	150	F	2.81	2.6	103.7	1.48	72.4
"	150	S	2.65	5.6	113.0	1.54	82.4
Significance:			*	ns	**	**	**
CV (%) :			6.3	105.	9.3	4.9	10.1
BLSD (.05) :			.31		13.1	.09	9.2
Individual Factors							
Source							
Anhydrous Am.			2.70	6.0	106.8	1.50	75.7
Urea			2.68	6.6	100.3	1.38	66.1
Am. Nitrate			2.54	12.4	94.3	1.40	62.9
28% N Soln.			2.68	5.9	100.9	1.44	69.4
Significance:			*	+	**	**	**
BLSD (.05) :			.13	(.10) 5.5	6.8	.05	4.6
Rate							
75 lb. N			2.59	9.3	92.2	1.34	58.8
150 lb. N			2.71	6.2	109.0	1.52	78.3
Significance:			**	+	**	**	**
Time							
Fall			2.63	9.4	96.0	1.39	63.9
Spring			2.67	6.1	105.2	1.46	73.1
Significance:			ns	+	**	**	**
Interaction							
Source X Rate			ns	ns	ns	ns	+
Source X Time			ns	ns	+	ns	*
Rate X Time			ns	ns	+	ns	ns

Anhydrous ammonia was the most efficient and ammonium nitrate the least efficient under 1974 conditions. This conclusion is similar to the 1973 conclusion. Leaf N with 33% N was less than with the 28, 45 or 82% materials. The 150 pound rate significantly increased leaf N over the 75 pound rate. Lodging (combination of stalk breakage and rootworm induced lodging) was increased with the 33% N, perhaps due to the N-deficient conditions of the plants with this material. Grain yields were greatest with 82%, intermediate with 45 and 28% and least with 33% N. Spring-applied 33% was far superior to fall application. Yields from 75 pounds spring-applied N as 33% were equal to those from 150 pounds fall-applied 33% N. Fall applications of 28% and 45% generally were less efficient than spring applications. Time of application of the 82% did not affect yield. The 150 pound rate averaged over all four sources produced significantly higher yields than the 75 pound rate. Source X Time and Rate X Time interactions were significant; largely because of the contrast between 33% and 82% when applied at different times and between the rates applied at the two times. Grain protein (% N) and N removal with the grain were highest with the 82% N, with the 150 pound rate, and with the spring applications. All four materials (28%, 33%, 45% and 82%) when spring-applied at 150 lb. N/A resulted in equal leaf and grain N concentrations, lodging, yield and N removal.

Results from 1973 and 1974 show that nitrate forms of N should not be applied in the fall to the higher rainfall areas of southeastern and south-central Minnesota. In the spring wet conditions can often exist which may lead to denitrification and, thus, loss of N from the nitrate form. However, N applied as ammonium (45% or 82%) has not been fully converted to the nitrate form when these wet conditions occur and, therefore, usually remains in sufficient supply to the plant.

Soil NO_3-N found in the 0 - 5 foot profile after harvest was generally low (Table 2). The residual nitrate amounts between the 33% and 45% N materials were not different. At the 150 pound rate spring-applied N resulted in higher residual nitrate amounts than the fall-applied N. This also suggests some loss of the fall-applied N.

Table 2. Residual soil nitrates following corn fertilized with ammonium nitrate and urea at Waseca, 1974.

	33%				45%			
	75		150		75		150	
Depth	F	S	F	S	F	S	F	S
ft.	- - - - - - - - - NO_3-N (ppm) - - - - - - - - - -							
0-1	6.4	6.0	6.4	9.0	6.2	6.4	6.0	6.6
1-2	4.3	3.5	4.0	8.6	3.4	4.8	3.8	6.0
2-3	2.9	2.4	4.0	5.2	2.8	3.1	3.6	5.4
3-4	3.8	3.5	4.5	6.0	3.9	3.9	5.1	6.5
4-5	4.8	5.4	4.8	6.0	5.5	5.2	5.6	9.1
	pounds NO_3-N in 0 - 5 feet							
	89	83	95	139	87	94	96	134

Experiment II

Excessive rainfall over an extended period of time could result in denitrification reactions in poorly drained, high organic matter soils and subsequently, N-deficient corn later in the growing season. Long periods of high rainfall often occur in the spring in south-central Minnesota, and losses of N do occur. If these losses are great enough to create N deficiency in corn, a yield response from a split application of N may be expected.

To evaluate split applications of N fertilizer on these poorly drained, fine textured, high organic matter soils, an experiment was established on a LeSueur clay loam soil on the Roy Lukken farm, which is the site used by Fenster, Overdahl and Randall in other corn fertilization studies. The site for this experiment has 92% of its area within 50' of tile lines, which should provide adequate internal drainage. The experimental design was a randomized complete-block, replicated five times.

Corn has been grown continuously on this site since 1969. The first application of N was applied and disked in on April 27. Three of the treatments received a split application of N to the soil surface on July 2 and were followed immediately by cultivation to incorporate the fertilizer. Ammonium nitrate was the N source for all treatments.

Corn (Northrup King PX 47E) was planted at 26,000 ppA in 30" rows on April 30. Row fertilizer (13+15+37 lbs. N+P+K/A) and insecticide (1 lb. active Counter/A) was applied at planting time. Weeds were chemically controlled with a combination of Lasso + Bladex applied preemergence plus one cultivation. The leaf opposite and below the ear was sampled on July 22 and was submitted for analysis by Kjeldahl methods. Yields were obtained by hand harvesting 16' of row from each of the center two rows of each plot.

Results

Leaf and grain N, yield and N removal were increased significantly over the check by the N rates (Table 3). Increasing the N rates from 100 to 300 pounds did not result in increased leaf N and yields. However, grain N and N removal were increased by the 200 and 300 pound rates over the 100 pound rate. Differences between the split application and the single application within each N rate were not significant. Yields in 1974 were low due to severe hail damage on June 18, dryness in July and an early frost on September 3.

Table 3. Effect of rate and application method of nitrogen on corn production parameters at Waseca in 1974.

Application Date and Rate				Grain			
4-27	7-2	Total N applied	Leaf N	Yield	H_2O	N	N removed
- - - - lb N/A - - - - -			%	bu/A	%	%	lb N/A
0	0	0	2.62	76.5	22.0	1.33	48.2
50	50	100	2.90	99.5	21.0	1.56	73.6
100	0	100	2.89	95.5	21.5	1.55	70.2
100	100	200	3.02	105.9	21.2	1.64	82.1
200	0	200	2.84	103.8	21.0	1.66	81.8
250	0	250	3.03	97.5	22.2	1.66	76.5
150	150	300	2.97	106.8	20.0	1.64	82.8
300	0	300	3.10	102.3	20.8	1.64	79.3
Significance:			**	**	ns	**	**
BLSD (.05) :			.20	8.4		.09	7.5
CV (%) :			5.2	7.0	7.6	4.6	8.4

Rainfall from 4/26 thru 7/2 totaled 8.73 inches, which was only .12 inches above normal. Apparently this amount was not sufficient to promote denitrifying conditions in 1974 on this well tiled site. Consequently, split applications of N did not improve corn yields over single applications.