Weather Summary - 1968

West Central Experiment Station - Morris

Samuel D. Evans

Month	Period	Precipitation 1968	Precipitation Average 1930-59	Precipitation Deviation from Nor.	Air Temperature 1968	Air Temperature Average 1930-59	Air Temperature Deviation from Nor.	Temp. Soil(10cm.) 1968
January	1-31	.70	.56	+.14	8.4	10.1	-1.7	12.1
February	1-29	.11	.67	-.56	10.1	14.7	-4.6	17.6
March	1-31	.48	1.11	-.63	35.3	27.5	+7.8	31.5
April	1-10	1.55			38.0	37.3		37.9
	11-20	1.33			48.8	43.5		45.0
	21-30	2.00			46.0	48.6		44.9
Total or Average		4.88	2.05	+2.83	44.3	43.1	+1.2	42.6
May	1-10	.81			52.3	53.0		52.0
	11-20	.86			48.8	56.3		50.1
	21-31	.55			54.2	60.2		55.8
Total or Average		2.22	3.07	-.85	51.8	56.5	-4.7	52.7
June	1-10	1.25			72.6	63.6		69.8
	11-20	1.46			61.3	66.3		65.0
	21-30	.80			64.6	68.4		67.4
Total or Average		3.51	3.79	-.28	66.2	66.1	+0.1	67.4
July	1-10	.08			64.9	70.4		70.2
	11-20	.37			75.5	72.0		78.2
	21-31	.61			68.2	72.6		74.8
Total or Average		1.06	3.25	-2.19	69.6	71.7	-2.1	74.4
August	1-10	1.26			73.5	72.3		77.8
	11-20	1.21			63.8	70.1		70.4
	21-31	.49			67.6	66.7		74.8
Total or Average		2.96	2.87	+.09	68.3	69.7	-1.4	72.5
September	1-30	3.46	1.94	+1.52	58.2	59.7	-1.5	60.3
October	1-31	4.12	1.44	+2.68	46.7	48.9	-2.2	48.3
November	1-30	.70	1.09	-.39	32.0	30.4	+1.6	34.3
December	1-31	3.48	.59	+2.89	12.1	17.0	-4.9	25.1
April 1-August 31 (Growing Season)		14.63	15.03	-.40	60.1	61.7	-1.6	62.0
Jan. 1-Dec. 31 (Annual)		27.68	22.43	+5.25	42.0	43.0	-1.0	45.0

Use of Varying Rates of Nitrogen & Starter on Corn in 1968
West Central Experiment Station - Morris

Samuel D. Evans

In the spring of 1967 an experiment was initiated on Doland silt loam to determine the effect of varying rates of nitrogen and starter on corn yields.

Table 1. The yield of ear corn in 1968 at Morris with varying rates of nitrogen and starter fertilizer.

Nitrogen lbs./acre	Starter (6-24-24) applied (lbs./acre) 0	50	100	200	average
0	68.8	56.7	64.7	66.0	64.0
50	58.8	65.1	65.6	70.1	64.9
150	50.0	63.2	59.3	66.6	59.8
Average	59.2	61.7	63.2	67.5	

Nitrogen significantly decreased yields and starter had no effect. There was a highly significant starter x nitrogen interaction.

Variety - DeKalb XL 304 Planting date - May 2

Use of Seed Incorporated (Pop-up) Fertilizer
West Central Experiment Station - Morris

Samuel D. Evans

In the spring of 1967 an experiment was initiated to determine the effect of small amounts of seed incorporated fertilizer on early growth and yield of corn. The experiment was set up on a Doland silt loam on which various broadcast rates were applied annually.

Broadcast fertilizer did not significantly increase yield. Placement of fertilizer either with the seed or in the "2 x 2" position increased yields significantly, but placement was not important. It was the amount of starter used that was of greatest significance. None of the fertilizer treatment had any effect on early growth.

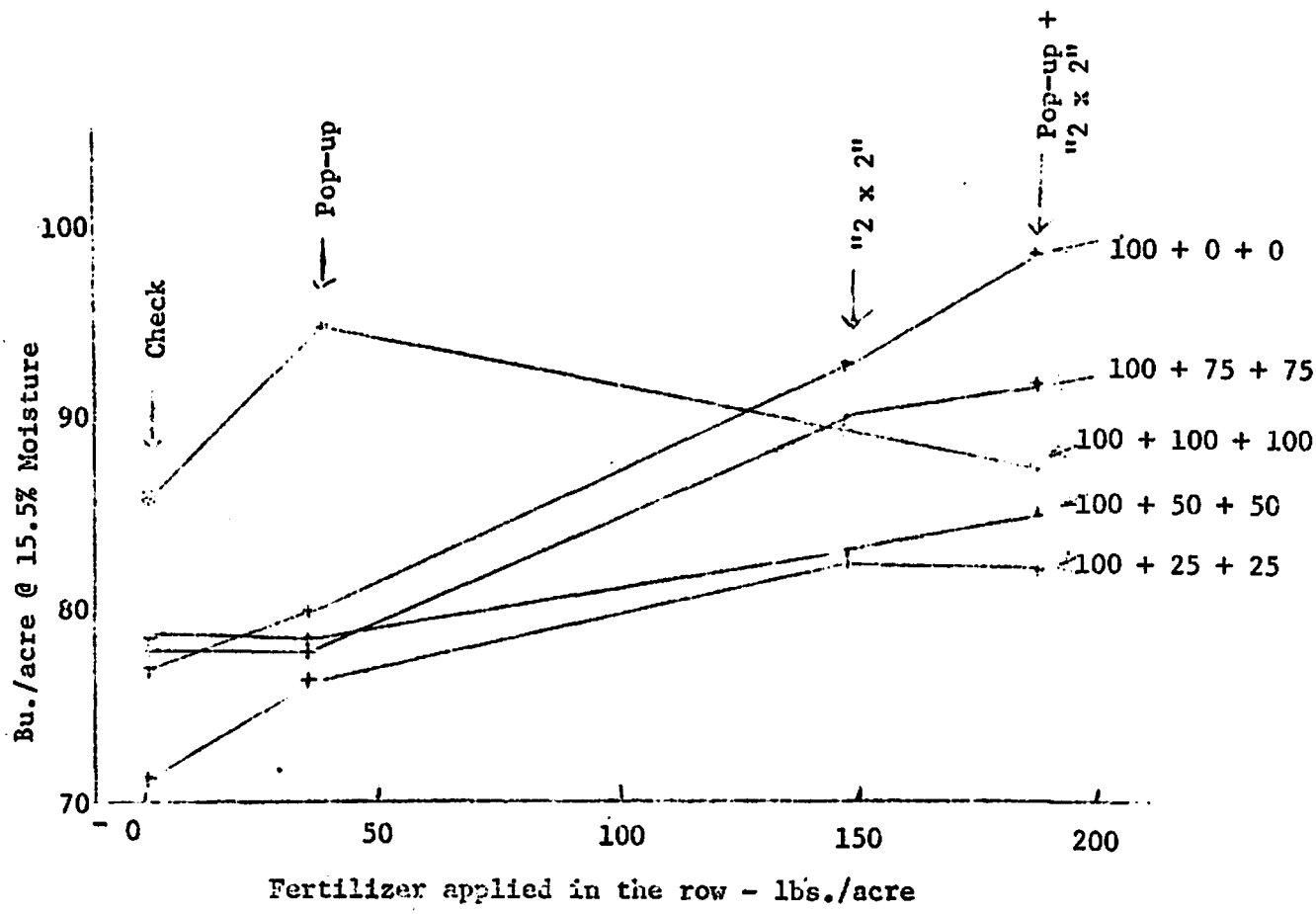
Variety - DeKalb XL 304 Planting date - May 2

Table 1. The effect of fertilizer placement at different broadcast rates on corn yields at Morris in 1968.

	Row Treatment (Yield in bu./acre @ 15.5% moisture)				
Broadcast Treatment	Check	Pop-up(1)	Starter(2)	Pop-up+ Starter	Average
100 + 0 + 0	76.0	79.1	92.6	97.8	86.4
100 + 25 + 25	70.7	75.8	82.0	81.5	77.5
100 + 50 + 50	78.4	77.7	82.6	84.6	80.8
100 + 75 + 75	77.2	76.1	89.8	91.6	83.7
100 + 100 + 100	85.4	94.7	89.3	87.2	89.2
Average	77.5	80.7	87.3	88.6	

(1) Pop-up - 37.5 lbs. of 8-32-16
(2) Starter - 150 lbs. of 8-32-16

Figure 1. The effect of starter rate & placement at five broadcast rates.



Effect of High Rates of Phosphorus With and Without Zinc on Corn Yields
West Central Experiment Station - Morris

Samuel D. Evans

High rates of phosphorus were applied to a Doland Silt loam in the fall of 1967 to simulate phosphorus induced zinc deficiency on corn. The application of phosphorus increased yields and there was no indication of a phosphorus induced zinc deficiency.

Table 1. Soils tests of the experimental area.

Sample No.	pH	O.M.%	Ext. P (lbs./A)	Exch. K (lbs./A)
1	6.9	5.5	12	310
2	6.7	5.5	9	260

Table 2. Yield in bu./acre @ 15.5% moisture for 1968.

Treatment	Yield
Check	91.6
60 lbs. P_2O_5	97.1
120 lbs. P_2O_5	95.0
240 lbs. P_2O_5	98.2
10 lbs. Zinc as zinc sulfate	97.7
240 lbs. P_2O_5 - 10 lbs. Zinc as zinc sulfate	98.7

Variety - DeKalb XL 304 Planting date - May 2

Phosphorus Fertilization of Continuous Corn
West Central Experiment Station - Morris

Samuel D. Evans

In 1965 a phosphorus experiment was set up on Forman clay loam to determine (1) the interaction of row and broadcast levels of phosphorus on corn yields and, (2) the effect of high phosphorus application on the zinc content of corn leaves and corn yields.

All plots received a uniform row application of 10 + 0 + 20. Nitrogen at 120 lbs./acre and potash at the rate of 60 lbs. of K_2O/acre were plowed down in the fall of 1967.

1968 Yield

Broadcast P trt. (lbs./acre)	Row Phosphorus treatment (lbs./acre) 0 P	15 P	30 P	45 P	45 P + 10 Zn	Average
0 P	66.4	68.5	72.5	68.7	70.9	69.4
45 P	74.4	71.6	65.5	62.6	68.2	68.5
Average	70.4	70.0	69.0	65.7	69.5	

There was no significant effect of either row or broadcast phosphorus in 1968.

Variety - DeKalb - Xl 304 Planting date - May 1

Zinc Fertilization of Continuous Corn
West Central Experiment Station - Morris

Samuel D. Evans

In the spring of 1965 an experiment was initiated involving the use of zinc fertilizers on continuous corn. The plots were set up on Forman clay loam and corn grown previously on this soil had not previously shown zinc deficiency, even though leaf samples indicated the zinc content to be below 20 ppm zinc.

Treatment	When Applied	Yield Bushels/acre @ 15.5% moisture
Check	----	71.1
5 lbs. zinc as $ZnSO_4$	1965	64.4
10 lbs. zinc as $ZnSO_4$	1965	67.6
10 lbs. zinc as $ZnSO_4$	yearly	68.2
20 lbs. zinc as $ZnSO_4$	1965	58.4
0.5 lbs. zinc as ZnChel.	yearly	73.3
45 lbs. P broadcast	yearly	69.0
45 lbs. P broadcast - 10 lbs. zinc as $ZnSO_4$	yearly 1965	68.9

As in the past there was no significant differences due to zinc application, but again the annual treatment of 10 lbs. of zinc as $ZnSO_4$ gave the highest yield. The last two years the lowest yielding treatment has been the one receiving the 0.5 lbs. of zinc as zinc chelate.

Variety - DeKalb XL 304 Planting date - April 30

Continuous Corn Silage
West Central Experiment Station - Morris

Samuel D. Evans

In 1965 an experiment was initiated on McIntosh silt loam to determine the effect of removal of continuous corn silage and fertilizer application on corn grain and corn silage yields. Rates of fertilizer used were 74 + 48 + 48 and 148 + 96 + 96. All plots received a broadcast application of 10 lbs. of zinc as zinc sulfate in the fall of 1965.

1968 Silage Yields
Dry matter, tons/acre

On plots harvested as grain 1965-68:

Low fertility	(74 + 48 + 48)	- 4.60
High fertility	(148 + 96 + 96)	- 5.04

On plots harvested as silage 1965-68:

Low fertility	(74 + 48 + 48)	- 4.60
High fertility	(148 + 96 + 96)	- 5.00

1968 Grain Yields
Bushels/acre @ 15.5% moisture

On plots harvested as grain 1965-68:

Low fertility	(74 + 48 + 48)	- 55.43
High fertility	(148 + 96 + 96)	- 65.16

In addition an unfertilized, unreplicated check adjacent to the experimental area yielded as follows:

Grain (0 + 0 + 0) - 34.26 bushels/acre

Silage (0 + 0 + 0) - 3.74 tons/acre

There appears to be no reduction in corn yields after removing silage for 4 years. Higher fertility increased silage yields by 0.4 tons/acre and grain yields by 10 bushels/acre. Yields on fertilized plots were significantly higher than on unfertilized plots.

Variety - Pioneer 3681 Planting date - May 10

Corn Irrigation Experiment
West Central Experiment Station - Morris

L. K. Lindor, S. D. Evans, and R. E. Smith

In the spring of 1967 an experiment was initiated at the station on a Sioux sandy loam (15-18 inches to gravel) to determine the effect of irrigation on corn yields at three populations and three nitrogen levels. Results from the first two years indicate that irrigation of this soil is economically feasible. Irrigation water needed to maintain the soil at 50 percent of field capacity was 11 inches in 1967 and 9 inches in 1968. At a cost of $1.00 per acre inch these amounts are reasonable considering the yield increase obtained. In 1967 the yield on an unirrigated plot at the low population and the 60-pound nitrogen rate was 18.7 bushels per acre. The yield when the same treatment was irrigated was 92.6 bushels per acre. In 1968 the yield on the same treatment unirrigated was 26.2 bushels per acre. When irrigated the yield was 109.3 bushels per acre. So the yield increase on the lowest cost treatment in 1967 was 73.9 bushels per acre and in 1968 it was 83.1 bushels per acre. In 1967 there was a further yield increase due to nitrogen application and in 1968 there was a yield increase due to higher population.

Details of the 1967 treatments are given in Soil Series 82 (March 1968). In 1968 the hybrid used was DeKalb XL 306. The entire plot was fertilized with 0 + 100 + 100 in the fall of 1967 before plowing. Starter fertilizer was used on the entire experiment at the rate of 150 lbs. of 8-32-16 per acre. Yields and measurements made in 1967 and 1968 are given in table 1 and 2 respectively. The corn was planted on May 22 in 1967 and on May 2 and 3 in 1968.

Table 1. Irrigated corn at Morris - 1967

Population Trt.	Yield (Bu/A)	Plants/acre	% Moisture at Harvest	% Barren Stalks	Ear Wt. (lbs.)
Low	99.0a	22,085a	31.0b	7.4a	.418b
Medium	105.1a	25,178b	33.0a	7.9a	.398b
High	105.3a	26,855c	31.1b	6.9a	.368a
Significance	NS	**	*	NS	**
Nitrogen Trt.					
60 lbs.	97.7a	24,459a	31.6a	9.4a	.386a
120 lbs.	106.4b	24,633a	31.2a	5.6a	.402a
180 lbs.	105.3b	25,025a	32.3a	7.2a	.397a
Significance	*	NS	NS	NS	NS
Pop. x Nit. Interaction					
Low x 60	92.6	22,717	31.2	12.4	.411
Low x 120	103.8	21,845	30.5	4.9	.427
Low x 180	100.7	21,715	31.2	4.9	.416
Med. x 60	96.7	24,655	34.7	8.1	.374
Med. x 120	109.9	25,265	32.2	8.6	.421
Med. x 180	108.6	25,592	32.2	7.0	.400
High x 60	103.7	25,984	28.9	7.6	.372
High x 120	105.6	26,789	30.9	3.3	.358
High x 180	106.6	27,770	33.5	9.8	.374
Significance	NS	NS	NS	NS	NS
Unirr. ck. (60# N)	18.7	17,751	29.8	49.7	.176

* Significantly different at the 5% level.
** Significantly different at the 1% level
NS Not significantly different.

Note: Values followed by different letters are significantly different at the level specified by the stars (*).

Table 1a. Soil test results - Fall 1967

Sample No.	pH	O.M.%	Ext. P (lbs./A)	Exch. K (lbs./A)
1	7.3	over 8.5	3	240
2	7.0	over 8.5	3	200

Table 2. Irrigated corn at Morris - 1968

Population Trt.	Yield (Bu/A)	Plants/acre	% Moisture at Harvest	% Barren Stalks	Ear Wt. (lbs.)
Low	110.8a	22,094a	36.8a	16.2c	.420c
Medium	121.6b	25,178b	37.0a	9.2b	.368b
High	123.9b	29,812c	37.6a	4.8a	.307a
Significance	**	**	NS	**	**
Nitrogen Trt.					
60 lbs.	118.2a	25,735a	37.1a	10.0a	.364a
120 lbs.	118.2a	25,596a	37.2a	9.3a	.360a
180 lbs.	119.8a	25,753a	37.0a	11.0a	.371a
Significance	NS	NS	NS	NS	NS
Pop. x Nit. Interaction					
Low x 60	109.3	21,989	36.8	17.9	.424
Low x 120	112.3	22,094	36.9	13.5	.413
Low x 180	110.6	22,216	36.5	17.2	.422
Med. x 60	122.2	24,951	36.8	6.5	.368
Med. x 120	121.9	25,038	37.0	9.4	.364
Med. x 180	120.6	25,561	37.2	11.5	.374
High x 60	123.2	30,283	37.8	5.5	.302
High x 120	120.5	29,673	37.8	4.9	.302
High x 180	128.0	29,481	37.1	4.1	.317
Significance	NS	NS	NS	NS	NS
Unirr. ck. (60# N)	26.2	20,857	45.1	28.7	.189

** Significantly different at the 1% level.
NS Not significantly different.

Note: Values followed by different letters are significantly different at the 1% level.

Table 2a. Soil test results - Fall 1968

Sample No.	uH	O.M.%	Ext. P (lbs./A)	Exch. K(lbs/A)	ppm Zn
1	7.8	high	13	250	2.0
2	7.6	high	16	230	---

Phosphorus and Potassium Fertilization of Alfalfa
West Central Experiment Station - Morris

Samuel D. Evans

In the fall of 1966 an alfalfa fertility experiment was established at the station on Forman clay loam (formerly Barnes). Two cuttings were made in 1967 and 1968. Yields were quite low in both years due to a shortage of moisture.

Table 1. Initial soil test data of the experimental area.

Sample No.	pH	O.M.%	Ext. P (lbs./A)	Exch. K (lbs./A)
1	7.2	5.7	24	370
2	7.2	5.6	13	480

Table 2. First cutting yields - 1968

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Lbs. alfalfa hay/A @ 15% moisture					
0	3850	4050	3850	3550	3600	3780
57	3950	3750	3950	4050	4200	3980
114	4000	4000	4100	4200	4450	4150
229	4100	4050	4150	4150	4400	4170
458	4150	4250	4050	4300	4300	4210
Average	4010	4020	4020	4050	4190	

Table 3. Second cutting yields - 1968

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Lbs. alfalfa hay/A @ 15% moisture					
0	1450	1250	1200	1100	1400	1280
57	1150	1250	1100	1300	1200	1200
114	1150	1350	1400	1250	1250	1280
229	1200	1350	1200	1100	1500	1270
458	1250	1400	1350	1450	1550	1400
Average	1240	1320	1250	1240	1380	

Table 4. Total 1968 yields

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Lbs. alfalfa hay/A @ 15% moisture					
0	5300	5300	5050	4650	5000	5060
57	5100	5000	5050	5350	5400	5180
114	5150	5350	5500	5450	5700	5430
229	5300	5400	5340	5250	5900	5440
458	5400	5650	5400	5750	5850	5610
Average	5250	5340	5270	5290	5570	

Table 5. Analysis of Variance

	1st cutting	2nd cutting	Total
Reps	NS	NS	NS
Phosphorus rates	**	NS	*
Potassium rates	NS	NS	NS
P x K interaction	NS	NS	NS

There was a small significant response to phosphorus in 1968 in the first cutting, but the increase was too small to pay for the added fertilizer.

Foliar Application of Micronutrients
Southern Experiment Station - Waseca

Russell D. Frazier

Several micronutrients were applied to the leaves of soybeans growing in production fields at the Experiment Station and on The Tilney Farms near Lewisville. Treatments included metallic sulfates, chelates, mixtures of chelates and a zinc-containing fungicide. Four replicates of 9 treatments were made in a randomized complete block design. Foliar analysis of the plants is in progress.

Table 1. Foliar Application of Micronutrients--Lewisville, and Waseca.

	Treatment	Rate of material applied per acre, pounds	Yields, bushels per acre	
			Lewisville	Waseca
1.	$CuSO_4$	8	45.5	30.1
2.	$ZnSO_4$	15	47.4	32.7
3.	Zn Chelate	2	47.7	36.4
4.	$FeSO_4$	10	49.3	32.0
5.	Fe 138 Chelate	2	46.8	33.2
6.	$MnSO_4$	8	47.1	38.8
7.	Mn Chelate	1	55.0	36.2
8.	Zn-fungicide	6	52.4	36.9
9.	[Trt 5+3+7]	1 each	49.3	40.9

Analysis of variance using class comparisons as described by LeClerg and others indicated the following information.

Source	df	MS Lewisville	MS Waseca
Treatments:	8	36.21*	48.32**
Comparisons:			
2, 3:1	1	11.34	53.40*
2, 3:4, 5	1	.81	15.41
2, 3:6, 7	1	48.65+	33.93+
2:3	1	.21	28.13+
2:8	1	5.00	35.70+
4:5	1	12.75	3.00
6:7	1	123.25**	13.26
2:9	1	7.41	133.66**
Error	24	12.51	9.51

From this one year's preliminary data it appears that the chelates have a more favorable effect on soybean yield than do the sulfates used. This may be due to rates of sulfates used as much as the nature of the compounds. The information tends to indicate that consideration should be given to both zinc and manganese nutrition.

1968 Zinc Sources Trial for Field Corn
Southern Experiment Station - Waseca

Russell D. Frazier

Various sources and carriers of zinc were applied broadcast to the soil in a randomized block design. Five treatments and 5 reps were used. Pioneer 3582 seed was planted May 2, 1968 at a population of about 25,000 kernels per acre. Soil pH was 6.1, P test 17, K test 230. Since one of the treatments contained ammonium nitrate, all other treatments received an equivalent amount of ammonium nitrate to compensate. Since this soil is slightly acid, a deficiency of available Zn would not be normally expected.

Treatment results are shown in the accompanying table. These data are inconclusive as far as comparing treatments is concerned, but do puzzle one in interpreting the seeming difference in favor of no treatment. There were no significant treatment effects. Further work is anticipated for 1969.

Table I. Treatments and results, Waseca Zn source trial, 1968.

Treatment	Bu/Ac Corn
Liquid	
1. 10 lb. Zn/Ac as $ZnSO_4$	187.4
2. 10 lb. Zn/Ac as $ZnNO_3$ and NH_3 in H_2O	186.8
3. 2.5 lb. Zn/Ac as Na_2Zn	186.4
Granular	
4. 10 lb. Zn/Ac as $ZnSO_4$	183.6
5. No zinc	203.1

Fertilizer Placement Study on Corn, Waseca 1968
Southern Experiment Station, Waseca

Russell D. Frezier

A randomized block design with a split plot feature was used to investigate the effects of broadcast, row and "popup" placement of fertilizer as well as date of planting. Treatments were chosen to dovetail into those of the larger corn management studies begun in 1967. Plots were established in 1968, so broadcast treatment did not have much opportunity to be evident. It is anticipated to continue these plots on the same location for several years to ascertain broadcast effect as well as interactions with row placement.

Table 1. Results of Fertilizer Placement Studies on Corn, Waseca, 1968

	No Broadcast		Broadcast 0+100+100		
	May 2	May 25	May 2	May 25	Ave.
Row: Check	192.0	155.1	233.2	166.6	186.7
2X2 (21+55+72)	223.0	144.1	214.9	170.9	188.2
Seed placement (4+9+12)	237.2	146.7	219.3	153.0	189.0
Ave.	217.4	148.6	222.5	163.5	

Ammonium nitrate was used overall at 150 lb. N rate per acre.

Soil test information:	pH	P	K
	5.5	72	260

Minnhybrid 4201 was seeded at rate of 25,000.

Detailed statistical analysis has not been completed as of January 30, 1969, so specific statements can not be made as to treatment effects. At this point it appears that there is a considerable effect in favor of early planting, and perhaps also in favor of the broadcast fertilization. Little can be said at this point with regards to placement effect.

The Effect of Nitrogen Source, Placement and Time of Application to a Webster Clay Loam at Lamberton on 1960-68 Corn Yields and the Nitrogen Content of the Corn Grain

John M. MacGregor, Wallace W. Nelson, and Gyles W. Randall

A field fertilizer experiment for continuous corn was commenced in the spring of 1960 to determine the relative effectiveness of annually applied N as either ammonium nitrate or as urea. The nitrogen was broadcast and plowed down or simply broadcast and left on the plowed surface over winter, or broadcast in the spring and worked in during the usual seedbed preparation, or broadcast as a sidedressing in late June. Four replications of 18 different annual treatments were applied as a randomized block, each plot being 20 feet wide and 77.5 feet long. A starter fertilizer such as 8-24-12 is applied over the entire field at planting at approximately 175 pounds per acre. The corn seed for several years was drilled lengthwise over each plot at a 40 inch row spacing to obtain about 18,000 - 20,000 plants per acre, but later the row direction was reversed with a 30 inch row spacing to supply the same population. Many different studies have been made during the nine years of continuous corn growing to N application of this experiment, with results reported each year in Soil Series 76-82.

The 1968 growing season at Lamberton was characterized by a relatively dry spring and early summer, but with an extremely wet late summer and fall. Yield samples were taken from 30 feet of row on October 10th and the calculated data are shown in Table 1. Since nitrogen concentrations in the corn grain were determined on only one replication, it was not possible to statistically analyze the amounts of nitrogen and crude protein actually removed.

Table 1. The Effect of Rate, Kind, Time, and Placement of Fertilizer Nitrogen on the 1968 Corn Yield, Nitrogen, and Crude Protein Content of the Grain at Lamberton.

Trt. No.	Annual Treatment Lbs N/A[a]	1968 Bu/A	1968 N in Corn Grain %	1968 N in Corn Grain Lbs/A	1968 Crude Protein in Grain %	1968 Crude Protein in Grain Lbs/A
1	Check	102.4 a	1.12	54.3	7.0	339
2	40 NH_4NO_3 P.D[b] fall	131.6 bcd	1.30	82.7	8.1	517
3	40 urea " "	132.5 bcd	1.29	82.6	8.1	516
4	40 NH_4NO_3 Top[c] "	135.2 bcd	1.23	80.4	7.7	502
5	40 urea " "	134.0 bcd	1.27	82.2	7.9	514
6	80 NH_4NO_3 P.D. "	131.2 bc	1.34	85.0	8.4	531
7	80 urea P.D. "	142.6 bcd	1.47	101.3	9.2	633
8	160 NH_4NO_3 P.D. "	140.2 bcd	1.46	98.9	9.1	618
9	160 urea " "	149.9 d	1.42	102.9	8.9	643
10	40 NH_4NO_3 T.D. spring	128.0 b	1.21	74.8	7.6	468
11	40 urea " "	140.5 bcd	1.22	82.8	7.6	518
12	80 NH_4NO_3 " "	144.7 bcd	1.40	97.9	8.8	612
13	80 urea " "	138.7 bcd	1.46	97.9	9.1	612
14	40 NH_4NO_3 S.D.[d]	133.4 bcd	1.26	81.2	7.9	508
15	40 urea "	132.2 bcd	1.31	83.9	8.2	523
16	80 NH_4NO_3 "	137.7 bcd	1.39	92.5	8.7	578
17	80 urea "	146.9 cd	1.43	101.5	8.9	634
18	160 NH_4NO_3 "	141.5 bcd	1.45	99.1	9.1	620

a approximately 14 lbs/A additional N is applied annually in the starter fertilizer (175 lbs of 8-24-12 per acre).

b P.D. = plowed down
c T = topdressed
d S.D. = sidedressed

It is evident that all of the annual nitrogen treatments significantly increased corn yields, but with little or no significant effect on increasing N rates, time of application, or of placement of the N fertilizer.

The application of NH_4NO_3 for the four placement or time of application (fall plow down, fall on top of plowed soil, at spring planting, or as a mid-June sidedressing) produced an average increase over the no N treatment of 21.6 bu/A (19.3%), whereas the same treatments as urea yielded an average of 22.5 bu/A (20.1%).

The three times of applying 80 lbs N/A as NH_4NO_3 increased average corn yield 24.9 bu/A (22.2%), with equivalent rates of urea N producing 30.9 bu/A (a 27.6% increase).

The fall and sidedressed NH_4NO_3 treatments supplying 160 lbs. N/A increased average corn yield 28.4 bu/A (25.3%), whereas the one fall applied 160 lb N rate as urea increased yields by 37.7 bu/A (a 33.7% increase).

When field corn is grown each year with annual fertilizer N application, it is also important to determine long term average annual corn grain yields. The nine year annual corn yield averages are shown in Table 2. All of the N treatments have significantly increased ear corn yield averages over the 9 year period.

Table 2. The Effect of Rate, Time, Kind, and Placement of Fertilizer Nitrogen on Ear Corn Production from a Webster Clay Loam at Lamberton for Nine Years (1960-68).

Trt. No.	Treatment (lbs N/A)	Year 1960	1961	1962	1963	1964	1965	1966	1967	1968	9 Yr. Avg.
		Bushels of ear corn per acre @ 15.5% moisture									
1	Check	49.5	88.2	26.1	132.6	72.9	33.1	11.1	53.4	102.4	63.3 a
2	40 NH_4NO_3 P.D. fall	42.3	87.5	30.9	148.6	88.3	34.9	26.8	75.7	131.6	74.1 b
3	40 urea " "	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	76.6 bc
4	40 NH_4NO_3 Top "	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	77.4 bc
5	40 urea " "	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	81.6 bcd
6	80 NH_4NO_3 P.D. "	67.4	97.9	43.6	149.6	100.8	63.4	47.3	114.8	131.2	90.7 defg
7	80 urea P.D. "	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	89.5 defg
8	160 NH_4NO_3 " "	69.8	97.9	46.7	147.7	100.9	70.8	38.5	127.4	140.2	93.3 efg
9	160 urea " "	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	98.1 g
10	40 NH_4NO_3 T.D. spring	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	85.5 cdef
11	40 urea " "	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	82.7 bcd
12	80 NH_4NO_3 " "	59.3	90.0	32.7	149.2	112.5	74.2	49.0	128.3	144.7	83.6 bcde
13	80 urea " "	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	95.1 fg
14	40 NH_4NO_3 S.D. "	63.6	92.6	39.5	148.6	90.4	54.8	38.6	96.8	133.4	84.2 cde
15	40 urea "	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	81.3 bcd
16	80 NH_4NO_3 "	50.4	98.4	46.7	140.7	113.0	68.1	43.8	101.6	137.7	88.9 defg
17	80 urea "	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	94.7 fg
18	160 NH_4NO_3 "	40.7	97.4	77.7	151.7	109.5	77.6	51.4	120.2	141.5	96.4 g
Yearly Average		58.6	93.3	39.4	146.7	101.3	60.3	36.3	101.8	135.7	

NH_4NO_3 versus urea N

The four NH_4NO_3 treatments at the rate of 40 lbs N/A annually averaged 80.3 bu/A of corn over the 9 years, whereas similar treatments as urea N averaged 80.6 bu/A.

The three NH_4NO_3 times of application at 80 lbs of N/A averaged 87.7 bu/A, and the comparative urea N average was 93.1 bushels.

The two 160 lbs of N/A rates as NH_4NO_3 averaged 94.9 bu/A, with the one similar rate urea fall treatment 98.1 bu/A.

It would appear that over the nine year period, urea N is fully as effective as NH_4NO_3 - N in continuous corn production at Lamberton.

Rates of N application (40, 80, & 160 lbs/A)

The eight 40 lb N/A treatments averaged 80.4 bushels (17.4 bu increase), the six 80 lb N/A rates produced a 9 year average of 90.4 bu/A and the three annual 160 lbs N/A averaged 95.9 bu/A, showing that the lower N application rates produced proportionally larger yield increases.

Time of N application and Placement (over nine years)

Forty lbs of N/A plowed down in the fall averaged 75.4 bushels, whereas similar amounts spread and left on the surface over winter averaged 79.5 bushels. Similar treatments made in the spring however, averaged 84.1 bu/A and June sidedressing yielded an 82.8 bushel average.

Eighty pounds of N/A plowed down in the fall averaged 85.1 bushels, compared to 89.4 bushels with spring application, and 91.8 bu/A when sidedressed.

The two 160 lbs N/A rates plowed down in the fall averaged 95.7 bu/A, whereas the lone NH_4NO_3-160 lb N/A June sidedressing averaged 96.4 bushels over the 9 years.

There appears to be a small advantage for spring over fall application at the 40 and 80 lb N/A rates but this is not apparent where 160 lbs N were broadcast annually.

The Effect of Eleven Years of Annual Application of Nitrogen for Continuous Corn on Soil Reaction and on Zinc Concentration in the Sixth Corn Leaf at Silking in 1968 (Barnes loam-Morris)

J.M. MacGregor, G.R. Blake, and S. Evans

Commencing in 1957, corn has been grown each year on a Barnes loam at Morris, with annual applications of 0, 40, 80 and 240 pounds of fertilizer N as NH_4NO_3 or as urea. P_2O_5, and K_2O were also applied each year at the rate of 40 pounds per acre.

During the summer of 1967, laboratory analyses of the 0"-6" depth soil indicated a significant lowering of pH with the heaviest N application. Although there was some decrease in the pH of the subsoils with the heavy annual N application, this was not significant.

Since a decrease in soil pH (increase in soil acidity) frequently increases zinc availability, samples of the sixth corn leaves were obtained in 1968 from the five replications of each of the five N treatments and these were analyzed for zinc concentration. The pH of the 0"-6" soil samples collected in 1967 and the zinc concentrations of the 1968 corn leaves are shown below.

The pH of Surface Soil in 1967 and Zinc Concentration in 1968 Corn Leaves at Morris

Annual fertilizer treatment (Lbs/A) (1957-1968)	pH of 0"-6" soil (1967)	Leaf zinc in ppm (1968)
N + P_2O_5 + K_2O		
0 + 40 + 40 (applied in spring)	7.26 a	16.4 a
40 + 40 + 40 (applied in fall)	7.28 a	15.9 a
40 + 40 + 40 (applied in spring)	7.14 a	16.6 a
80 + 40 + 40 (" " ")	7.11 a	21.2 b
240 + 40 + 40 (" " ")	6.50 b	22.2 b

It is apparent that the 240 pound rate of N application every year eventually significantly depressed the pH of the surface soil. The much lower 80 lb N/A annual fertilization depressed soil pH, but not significantly so, but both of the two heavier rates of N significantly increased zinc concentrations in the 1968 corn leaves.

Concentrations of Nitrate Nitrogen (NO_3-N) in Free Soil Water in Webster Clay Loam Subsoil at Lamberton Under and Adjacent to Continuous Corn With Annual Nitrogen Fertilization

J. M. MacGregor and W. W. Nelson

Early in 1968, a study of the NO_3-N content of free soil water underlying the continuous corn fertilized annually with 0, 40, 80, and 160 pounds per acre of NH_4NO_3 or urea nitrogen was initiated. Approximately 14 lbs N/A is applied annually with ample P_2O_5 and K_2O (175#/A of 8-24-12) in the starter fertilizer over the entire experimental area. Aluminum tubes 3" in diameter and 30, 42, 54, 66, and 78 inches in length were stoppered at one end and a ring of small holes drilled through in a ring around each cylinder 6" from the stoppered end. These cylinders were then sunk some 20 feet inside four of the no nitrogen and within four of the annual 80 lb NH_4NO_3 -N/A plots, so that the ring of small holes would be 2', 3', 4', 5', and 6' from the surface of the soil. These tubes were then also capped at the soil surface end to prevent soil or other materials from falling down these "wells." Free water could then enter through the ring of drilled holes and would be collected in the 6" reservoir below the holes at the lowered stoppered end.

To determine NO_3-N concentrations and possible NO_3-N movement between the ends of the plots and a tile drain some 12 feet distant in the surface roadway, a number of similar wells having the ring of holes 42 inches from the soil surface were sunk midway between the ends of three check, three 40 lb N/A plots, four 80 lb N/A plots, and four plots receiving 160 lbs of NH_4NO_3 annually.

Since 1968 at Lamberton was relatively dry until late in July, there was no water accumulation in any of the wells and the first sampling was available on July 29th. Samples collected were chilled or frozen immediately until NO_3 analysis. A study on sample temperature storage effect

prior to NO_3 analyses, when frozen, refrigerated or maintained at room temperature (for 10 days) showed a small and variable effect, so all samples were then frozen until analysis was possible. A total of five samplings were made from late July to early in November. The results are shown in Tables 1 and 2.

It is obvious that the NO_3-N content of free water in the subsoil of the check plots is relatively low under the continuous corn, since they receive only some 14 lbs N/A annually in the NPK starter fertilizer used. It is doubtful if a lateral movement of N into the subsoil of the plots has occurred from the two adjoining plot treatments, although this may have occurred in Plot 7 where the NO_3-N concentration of the water at 6 feet is considerably more than the same level in the other three check plots. NO_3-N concentrations at the 42" depth midway between the ends of the check plots and the tile lines are higher than within the plots, indicating either some accumulation or a possible movement of the NO_3 toward the tile drains. While there was no increase in NO_3-N concentrations in the wells outside the 40 lb N/A plots, this would not be expected, since most of this N added in such small amounts would be normally removed by the growing corn.

Table 2 shows that the annual application of 80 lbs N/A has increased the NO_3-N concentrations of the free water in the subsoil (Plots 2, 25, 60, and 78) even with much higher corn yields on these plots. Since the NO_3-N content of the wells outside the 80 lb-N/A plots is somewhat higher than those reported in Table 1, it is probable that this rate of N application has resulted in some lateral movement of NO_3-N to the tile drains, which are some 12.5' from the end of each of these plots. Since even higher N concentrations occur in the wells adjacent to the 160 lb rate of N/A

treatment, it appears that some NO_2-N is probably being lost in the drainage waters at these higher rates of N application.

Whereas lateral movement of NO_3-N between plot treatments is probably small or non-existent, (the plots are 20' in width), it is apparent that some NO_3-N of the annual 80 and 160 lb N/A treatments is being carried away by the tile drains in the free water in the subsoil and is thus lost to crop production.

Table 1. Treatment, Nitrate N Concentrations in Soil Free Water, Stalks, Ears, and Corn Yield per Acre in 1968 on NH_4NO_3-Urea Treated Continuous Corn at Lamberton. (Webster Clay Loam)

Plot No.	Annual N/A Rate, time & placement	Plot treatment west side Lbs N/A[a]	Plot treatment east side Lbs N/A	Well depth (feet)	NO_3-N in ppm in H_2O 7/29	7/31	9/25	10/22	11/2	Stalks/A	Ears/A	Ear Corn Bu/A
				Wells within plots								
7	None	160 NH_4NO_3-N(SD)	80 urea-N(fall)	2	—	—	—	1.32	—	22,070	20,328	108.3
				3	—	0.73	0.13	0.53	4.03			
				4	2.44	0.99	0.26	0.46	0.20			
				5	4.55	3.96	1.25	1.45	0.66			
				6	10.69	17.02	6.01	9.97	3.10			
32	None	40 NH_4NO_3-N(SD)	160 urea-N(fall)	2	—	—	—	2.90	—	19,747	19,166	106.3
				3	—	—	—	1.22	—			
				4	—	—	0.73	0.46	0.99			
				5	—	5.94	0.66	0.46	0.79			
				6	—	4.09	1.52	1.25	1.19			
46	None	80 urea-N)SD)	40 NH_4NO_3-N(fall)	2	—	—	—	0.46	—	20,909	18,005	107.8
				3	—	1.12	0.79	0.53	2.18			
				4	5.61	1.06	0.53	1.06	2.24			
				5	2.18	1.91	1.39	1.25	1.91			
				6	2.44	2.84	2.71	1.12	1.98			
73	None	80 urea-N(fall)	80 NH_4NO_3-N(fall)	3	—	—	—	0.59	—	18,005	15,101	87.4
				4	—	0.14	0.07	0.13	1.32			
				5	0.59	0.59	0.07	0.53	0.73			
				6	1.25	1.06	0.20	0.92	0.79			
				Wells at outer end of plots (12 feet distant from tile drain)								
4	None	40 urea-N(fall)	40 NH_4NO_3-N(fall)	3.5	—	1.58	—	8.78	1.98	18,005	18,005	113.6
54	None	40 urea-N(fall)	160 NH_4NO_3-N(fall)	3.5	—	—	—	11.09	22.58	20,909	19,747	110.5
79	None	None	80 NH_4NO_3-N(spring)	3.5	12.41	14.45	—	—	—	19,166	19,166	119.8
15	40 NH_4NO_3-N(SD)	80 urea-N(spring)	40 urea-N(fall)	3.5	—	—	—	7.26	10.43	17,424	17,424	136.9
33	40 NH_4NO_3-N(SD)	160 NH_4NO_3-N(SD)	None	3.5	—	0.73	—	9.04	—	17,424	17,424	135.1
49	40 NH_4NO_3-N(SD)	160 NH_4NO_3-N(SD)	40 NH_4NO_3-N(fall)	3.5	—	—	—	16.17	—	16,843	16,262	110.0

[a]SD = sidedressed

Table 2. Treatment, NO_3-N Concentrations in Soil Free Water, Stalks, Ears, and Corn Yield per Acre in 1968 in NH_4NO_3-Urea Continuous Corn at Lamberton. (Webster Clay Loam)

Plot No.	Annual N/A Rate, time & placement	Plot treatment west side Lbs N/A	Plot treatment east side Lbs N/A	Well Depth (feet)	NO_3-N in ppm in H_2O 7/29	7/31	9/25	10/22	11/2	Stalks/A	Ears/A	Bu/A
				Wells within plots								
2	80 NH_4NO_3-N (spring)	40 NH_4NO_3-N(fall)	40 NH_4NO_3-N (spring)	2	--	16.36	--	15.70	--	21,490	19,166	134.9
				3	15.97	19.94	22.58	21.12	13.66			
				4	18.94	18.74	15.32	20.20	16.56			
				5	11.62	14.52	11.22	15.58	13.13			
				6	15.71	18.48	20.60	17.68	14.19			
25	80 NH_4NO_3-N (spring)	80 Urea-N(spring)	160 NH_4NO_3-N(fall)	2	--	--	--	12.67	--	19,747	18,586	141.6
				3	--	--	--	13.13	14.00			
				4	--	--	6.07	16.50	14.26			
				5	--	4.42	6.47	13.79	13.60			
				6	8.05	5.81	6.47	13.86	16.64			
60	80 NH_4NO_3-N (spring)	40 NH_4NO_3-N(fall)	40 urea-N (spring)	2	--	--	--	1.98	--	21,490	19,747	147.5
				3	--	--	2.57	3.50	5.68			
				4	--	6.53	5.48	5.02	4.42			
				5	5.74	5.54	3.63	3.96	4.22			
				6	6.34	7.06	5.35	6.80	2.77			
78	80 NH_4NO_3-N (spring)	None	80 urea-N(spring)	2	--	3.82	0.79	2.71	--	23,813	21,490	169.3
				3	9.31	8.32	1.45	4.69	2.57			
				4	6.80	10.09	4.36	4.49	2.11			
				5	6.34	10.75	4.95	4.22	2.84			
				6	5.54	5.74	5.21	5.08	5.02			
				Wells at outer end of plots (12 feet distant from tile drains)								
11	80 NH_4NO_3-N(SD)	None	40 urea-N(spring)	3.5	--	1.39	--	12.61	17.16	22,070	22,070	141.6
38	80 NH_4NO_3-N(SD)	None	40 urea-N(SD)	3.5	10.76	14.98	--	--	--	20,909	19,166	140.5
58	80 NH_4NO_3-N(SD)	40 urea-N(spring)	80 urea-N(spring_	3.5	--	--	--	27.46	20.72	20,909	19,166	138.7
63	80 NH_4NO_3-N(SD)	40 urea-N(spring)	40 NH_4NO_3-N(fall)	3.5	--	--	--	28.52	--	19,747	17,424	130.1
8	160 NH_4NO_3-N(SD)	80 NH_4NO_3-N(fall)	None	3.5	--	--	--	39.46	87.64	20,909	19,166	139.5
34	160 NH_4NO_3-N(SD)	40 urea-N(spring)	40 NH_4NO_3-N(SD)	3.5	--	19.40	--	17.16	--	19,747	19,166	150.2
50	160 NH_4NO_3-N(SD)	80 urea-N(fall)	40 NH_4NO_3-N(SD)	3.5	--	--	--	47.52	39.46	19,747	18,586	132.6
68	160 NH_4NO_3-N(SD)	40 urea-N(fall)	160 urea-N)fall)	3.5	--	--	--	71.28	--	23,813	21,490	143.7

Soybean Nitrogen Fertilization Study

G. E. Ham, R. H. Anderson, S. D. Evans, W. W. Nelson
R. D. Frazier and J. R. Lofgren

At the 30 to 60 bushel level, one-third to one-half of the nitrogen in the soybean plant is taken from the soil in the form of ammonium and nitrate ions. A considerable amount of this nitrogen is taken up during the last month of the growing season when the seeds are filling. At about the same time the seeds are filling, the nitrogen fixing ability of the nodules decreases. These facts would seem to indicate that nitrogen fertilization of soybeans should increase seed yield, but such is not the case. Nitrogen applications at planting time or sidedress applications during the growing season have not significantly increased seed yields.

Ammonium nitrate, urea, urea plus sulfur and sulfur-coated urea sources of nitrogen were compared at Lamberton, Waseca and Morris with nonnodulating and nodulating isolines of Chippewa maturity and Chippewa 64 soybeans. The same sources of nitrogen were compared at Crookston and Grand Rapids with Altona, Norman and Portage soybeans. The yields from Grand Rapids, Lamberton and Morris are shown in Table 1, 2 and 3.

The yields from Waseca were erratic due to the effects of phytophthara root rot. The yields from Crookston were low and erratic due to the cool, wet season and a wet spot in the plots,

Table 1. Effect of nitrogen fertilizer additions on 1968 soybean seed yield at Grand Rapids, Minnesota when different sources of nitrogen fertilizers at the rate of 150 pounds of N per acre were disced into the soil in the spring of 1968

Nitrogen source	Soybean variety		
	Altona bu/acre	Portage bu/acre	II-55-14 bu/acre
Check	27.5	29.8	31.3
Ammonium nitrate	31.7	30.6	32.2
Urea	33.2	32.6	31.9
Urea + sulfur[a]	34.6	32.6	30.0
Sulfur-coated urea[b]	33.7	32.8	33.5

[a] Treatment had some N and S as sulfur-coated urea
[b] Provided by Dr. H. L. Meredith, Agronomist, TVA

Table 2. Effect of nitrogen fertilizer additions on 1968 soybean seed yield at Lamberton, Minnesota when different sources of nitrogen fertilizers at the rate of 150 pounds of N per acre were disced into the soil in the spring of 1968.

Nitrogen source	Soybean variety		
	Nonnods[a] bu/acre	Nods[a] bu/acre	Chippewa 64 bu/acre
Check	24.6	30.1	28.2
Ammonium nitrate	29.3	28.9	27.7
Urea	29.1	28.5	27.9
Urea + sulfur[b]	29.0	27.2	28.2
Sulfur-coated urea[c]	30.6	29.5	29.1

[a] Nonnods and nods are isolines of Chippewa maturity. The isolines are very similar in all respects except for the inability and ability to form nodules when the plants are grown in the presence of most strains of *Rhizobium japonicum*

[b] Treatment has same N and S as sulfur-coated urea.

[c] Provided by Dr. H. L. Meredith, Agronomist, TVA.

Table 3. Effect of nitrogen fertilizer additions on 1968 soybean seed yield at Morris, Minnesota when different sources of nitrogen fertilizers at the rate of 150 pounds of N per acre were disced into the soil in the spring of 1968

Nitrogen Source	Soybean variety		
	Nonnods[a] bu/acre	Nods[a] bu/acre	Chippewa 64 bu/acre
Check	16.9	19.6	17.7
Ammonium nitrate	22.1	21.4	19.4
Urea	24.3	25.6	23.7
Urea + sulfur[b]	21.7	20.4	21.2
Sulfur-coated urea[c]	21.8	22.1	20.9

[a] Nonnods and nods are isolines of Chippewa maturity. The isolines are very similar in all respects except for the inability and ability to form nodules when the plants are grown in the presence of most strains of *Rhizobium japonicum*

[b] Treatment has same N and S as sulfur-coated urea.

[c] Provided by Dr. H. L. Meredith, Agronomist, TVA

1968 Polyphosphate Investigations

A. C. Caldwell
and
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Field trials comparing the effects of polyphosphates and orthophosphates on 1) early growth, 2) elemental uptake and 3) yields of soybeans were run at Rosemount, Lamberton, and Morris Experiment Stations. Three different phosphate treatments at two placements were employed at all stations with two rates included at Rosemount as shown in Table 1.

Table 1. Phosphate Treatments

Phosphate Material	Experiment Station	Rate # P_2O_5/A	Application
Check			
Ortho. Dry 11-48-0	L-R-M	62.5*	2 x 2
Ortho. Dry 11-48-0	L-R-M	62.5	Pop-up
Ortho. Dry 11-48-0	R	125.0	2 x 2
Ortho. Dry 11-48-0	R	125.0	Pop-up
Ortho. Liq. 8-24-0	L-R-M	125.0	2 x 2
Ortho. Liq. 8-24-0	L-R-M	125.0	Pop-up
Ortho. Liq. 8-24-0	R	250.0	2 x 2
Ortho. Liq. 8-24-0	R	250.0	Pop-up
Poly. Liq. 11-37-0	L-R-M	81.1	2 x 2
Poly. Liq. 11-37-0	L-R-M	81.1	Pop-up
Poly. Liq. 11-37-0	R	162.2	2 x 2
Poly. Liq. 11-37-0	R	162.2	Pop-up

* 98 # P_2O_5/Acre at Lamberton

At Rosemount and Morris, treatments were replicated five times, with six replications at Lamberton. All locations used Chippewa-64 soybeans. In addition to the phosphate treatments at Lamberton, 200 # N/Acre was broadcast before planting as processed feathers and disked in.

The plants in the non-nitrogen fertilized plots were randomly sampled at two different growth stages, whereas whole plants 5-7 inches high and uppermost fully matured trifoliate leaves were sampled at pod stage.

Total dry matter was determined for both samplings. Elemental analyses were run on all plots, except nitrogen fertilized plots. Yields were determined on all plots.

Yields

Results

Yield data at Lamberton and at Rosemount (Tables 2 and 4 respectively) indicate a response to phosphorus fertilization. Morris yield data, Table 3, show no response to phosphorus fertilization because of atrazine carry-over damage. The only significant difference among treatments was the 2 x 2, 8-24-0 application at 60#/A. The 11-48-0 applied as pop-up reduced yields at Rosemount. Nitrogen fertilization increased Lamberton yields.

Table 2. Effect of Phosphate Fertilizers on Soybean Yields at Lamberton

		Treatments					
		Ortho. Dry		Ortho. Liq.		Poly. Liq.	
Treatment (lbs/A)	Check	2 x 2	Pop-up	2 x 2	Pop-up	2 x 2	Pop-up
		Bu/Acre					
No Nitrogen	25.9a	30.4b	30.6b	29.1bc	28.8c	29.9bc	29.2bc
200 lbs. Nitrogen	27.5	33.6	33.3	31.6	29.7	31.0	30.3

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

Table 3. Effect of Phosphate Fertilizers on Soybean Yields at Morris

	Treatments						
		Ortho. Dry		Ortho. Liq.		Poly. Liq.	
Check		2 x 2	Pop-up	2 x 2	Pop-up	2 x 2	Pop-up
		Bu/Acre					
26.8		25.6	24.3	25.9	25.1	27.7	25.6

Treat. - N.S.

Table 4. Effect of Phosphate Fertilizers on Soybean Yields at Rosemount

		Treatments					
		Ortho. Dry		Ortho. Liq.		Poly. Liq.	
Treatment (lbs/A)	Check	2 x 2	Pop-up	2 x 2	Pop-up	2 x 2	Pop-up
		Bu/Acre					
30# P_2O_5/A	26.1a	33.9b	27.0a	33.2b	33.4b	31.5b	32.5b
60# P_2O_5/A		30.8b	*	38.3c	31.1b	33.0b	33.5b

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

* Salt damage too extensive for yield determination.

ELEMENTAL ANALYSIS

Elemental uptake data on soybean tissue from Rosemount, Table 5, show increases in P uptake by young soybean plants when liquids were applied at rates to supply 60# P_2O_5/A. Significant differences in K, Ca, Mg, Mn and B uptake among treatments were found. Lamberton elemental uptake data, Table 6, show significantly greater uptake of all elements by soybeans fertilized with 11-37-0 applied as pop-up. Morris elemental uptake data showed no significant differences among all treatments. Differences in elemental content of tissue at both Rosemount and Lamberton appeared to have no significant effect on soybean yields.

Table 5. Effect of Phosphorus Sources on Element Uptake by Soybeans at Rosemount

Material	Treatment Rate #P_2O_5/A	Placement	First Sampling Elements: P	K	Ca	Mg	Fe	Al	Zn	Cu	Mo	Mn	B
			Milligrams/Plant				Micrograms/Plant						
Check			1.03a	3.02a	5.24a	3.66a	161	205	22.9	7.21	1.12	17.3a	14.6a
11-48-0	30	2 x 2	1.33a	3.08a	5.46a	4.08ab	146	168	28.8	6.93	1.00	18.7abc	14.6a
11-48-0	30	Pop-up	2.56cd	3.51a	7.29ab	5.52b	160	169	21.6	6.01	1.27	30.7c	18.3abc
11-48-0	60	2 x 2	1.64ab	3.03a	6.01ab	4.44ab	144	164	22.0	7.24	1.18	22.5abc	15.8abc
11-48-0	60	Pop-up		Salt Damage									
8-24-0	30	2 x 2	1.84bc	4.18ab	7.52ab	5.14ab	188	224	28.1	8.63	1.45	25.2abc	21.2bc
8-24-0	30	Pop-up	1.65ab	4.04ab	6.92ab	4.95ab	164	182	27.9	7.79	1.29	26.5bc	18.8abc
8-24-0	60	2 x 2	2.34bcd	5.36b	8.27b	5.60b	174	198	30.1	7.26	1.39	30.4bc	21.9c
8-24-0	60	Pop-up	2.55cd	5.34b	7.65ab	5.11ab	158	172	26.2	7.78	1.32	32.5c	20.0abc
11-37-0	30	2 x 2	1.66ab	3.37a	6.62ab	4.89ab	161	188	20.8	7.91	1.35	23.0abc	18.1abc
11-37-0	30	Pop-up	1.63ab	3.04a	6.18ab	4.61ab	158	174	21.2	6.84	1.17	22.5abc	16.8abc
11-37-0	60	2 x 2	2.38bcd	3.53a	7.66ab	5.52b	177	196	25.7	6.57	1.44	31.3c	20.4abc
11-37-0	60	Pop-up	2.31bcd	3.43	6.91ab	4.89ab	185	207	20.3	7.87	1.37	32.1c	18.9abc
	Significance		*	*	*	*	N.S.	N.S.	N.S.	N.S.	N.S.	*	*

Table 5. (Continued)

Material	Treatment Rate #P_2O_5/A	Placement	Second Sampling Elements P	K	Ca	Mg	Fe	Al	Zn	Cu	Mo	Mn	B
			-----Milligrams/Plant-----				----------Micrograms/Plant----------						
Check			26.5	126.2ab	91.6	45.3	1237.9	342.7	561.1	205.3	11.2	448.5a	461.8
11-48-0	30	2 x 2	29.3	125.3ab	86.8	44.1	1284.0	336.8	542.1	205.9	10.7	458.8a	468.3
11-48-0	30	Pop-up	35.9	147.1ab	103.7	57.2	1666.4	358.2	582.1	198.5	13.1	615.3ab	553.0
11-48-0	60	2 x 2	28.4	117.4a	80.1	40.6	1199.6	223.6	485.4	163.7	11.7	454.1a	446.4
11-48-0	60	Pop-up		Salt	Damage								
8-24-0	30	2 x 2	37.3	157.0ab	112.4	56.3	1632.6	396.3	701.9	239.8	12.9	607.2ab	602.7
8-24-0	30	Pop-up	29.6	138.6ab	93.2	44.5	1248.1	317.6	566.5	201.5	11.5	509.2ab	493.3
8-24-0	60	2 x 2	37.8	155.2b	109.5	51.9	1740.8	331.7	632.5	225.4	15.2	589.7b	600.1
8-24-0	60	Pop-up	38.3	172.0ab	119.9	57.4	1690.4	398.2	655.9	238.6	13.9	686.1ab	634.1
11-37-0	30	2 x 2	35.6	157.8ab	107.2	54.4	1472.8	395.3	654.7	224.2	14.0	578.6ab	581.0
11-37-0	30	Pop-up	38.3	164.3ab	115.2	57.7	1642.0	356.1	665.3	233.1	14.9	615.2ab	623.8
11-37-0	60	2 x 2	33.1	142.8ab	101.0	50.0	1434.7	296.8	550.8	181.5	12.7	593.8ab	519.6
11-37-0	60	Pop-up	37.1	155.5ab	108.2	54.2	1536.0	371.7	596.1	212.7	14.4	604.9ab	584.7
	Significance		N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.

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

Table 6. Effect of Phosphorus Sources on Element Uptake by Soybeans at Lamberton

Treatments		P	K	Ca	Mg	N	Al	Zn	Mo	Mn	B	Fe
Material	Placement	Milligrams/Plant					Micrograms/Plant					
First Sampling												
Check		1.77a	13.2bc	8.6bc	3.6bc	30.5bc	919bc	68.8b	2.4bc	25.0a	21.9cd	582bc
11-48-0	2 x 2	1.19a	8.2ab	5.7a	2.5a	20.0a	598ab	39.5ab	1.6ab	16.8a	15.6ab	381ab
11-48-0	Pop-up	1.40a	8.1ab	6.1ab	2.8ab	21.5a	671	34.9ab	1.7ab	19.9a	16.2abc	439abc
8-24-0	2 x 2	1.63a	10.1ab	7.0ab	3.2abc	26.2ab	637ab	42.3ab	1.8abc	25.4a	17.2abc	414abc
8-24-0	Pop-up	1.31a	7.0a	5.5a	2.7ab	21.3a	393a	24.6a	1.2a	20.4a	13.9a	263a
11-37-0	2 x 2	1.83ab	11.6abc	8.7bc	4.0cd	29.5bc	811bc	57.1ab	2.2bc	26.8a	20.3bcd	538abc
11-37-0	Pop-up	2.43b	15.6 c	10.6c	4.8d	36.7c	1075c	68.6b	2.7c	36.9b	25.4d	681c
Significance		*	*	*	*	*	*	*	*	*	*	*
Second Sampling												
Check		46.3ab	202.4ab	98.9ab	46.9ab	705.0ab	178.6a	782.4abc	11.6ab	361.1ab	522.0ab	1147ab
11-48-0		35.8a	164.4a	75.7a	37.4ab	575.0a	198.4a	631.6ab	9.4b	269.4a	404.0a	934a
11-48-0		50.2ab	215.1ab	95.7ab	49.3ab	729.6ab	404.7b	844.1bc	12.7ab	386.2ab	537.0ab	1501b
8-24-0		51.9ab	208.2ab	93.2ab	48.1ab	712.3ab	247.3ab	767.4abc	12.2ab	362.1ab	530.0ab	1207ab
8-24-0		32.3a	131.4a	60.6a	32.1a	456.1a	190.3a	486.8a	7.8b	248.6a	336.0a	814a
11-37-0		47.4ab	205.1ab	96.7ab	47.4ab	717.6ab	222.0ab	756.1abc	11.3ab	357.4ab	522.0ab	1189ab
11-37-0		67.4b	272.6b	131.0b	61.7b	967.2b	254.1ab	1008.7bc	16.2a	491.0b	719.0b	1513b
Significance		*	*	*	*	*	*	*	*	*	*	*

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

Effect of Potassium Fertilizer Sources and Rates on Soybeans

George E. Ham

The plots were located on the University of Minnesota Sand Plain Experimental Field near Elk River in Anoka County. The soil was a Hubbard loamy coarse sand with 0-2% slope. Soil test results are given below:

pH	Extractable phosphorus pp2m	Exchangeable potassium pp2m	Sulfur pp2m	Zinc pp2m
5.6	200(VH)[a]	200(M)	3(L)	2.6(H)
5.9	200(VH)	220(M)	5(L)	2.0(M)
5.1	200(VH)	180(M)	5(L)	2.8(H)
5.3	200(VH)	180(M)	5(L)	3.2(H)

[a]VH=very high, H=high, M=medium, L=low

All plots were treated uniformly with 0+40+0 (elemental basis) and 3 tons of limestone. Then, the potassium treatments were applied, the area was plowed about 12 inches deep and three tons of limestone were applied and disced into the soil.

A split-plot design was used with six replicates and the treatments were applied as outlined in Table 1. Individual plots were six 24-inch rows (12 feet) wide and 30 feet long. Treflan was applied at the rate of one-half pound per acre. Chippewa 64 variety soybeans were planted with a tractor-mounted four row cone planter on May 10, 1968 at the rate of 10 germinable seeds per foot of row. The plots were irrigated as needed with two exceptions when the plot areas became dry enough such that moisture stresses were apparent.

Leaf samples for foliar analysis were taken when the plants were in mid-bloom. The last fully matured leaf from about 25-30 plants in a plot were taken per sample. The leaves from replicates I and II were combined as were the leaves from replicates II and IV. The leaves were dried,

ground and analyzed for P, K, Ca, Sr, Na, Fe, Mg, Zn, Cu, Mo, Mn, B and S by emission spectrograph. The results are shown in Table 2.

Plots were harvested for seed yield on October 10, 1968. A 16-foot section of one of the two center rows was cut, threshed with a small plot thresher, cleaned and weighed. Yields for statistical analysis were based on bushels of soybeans per acre on the basis of 12.0% moisture. The yields are shown in Tables 3 and 4.

The lack of significant yield increases of soybeans when potassium fertilizers were applied to soil in the field at this location this year does not necessarily mean that potassium additions do not effect seed yield. The yields were generally too low and variable due to irrigation problems to measure the effect of added potassium on soybean seed yield.

Summary

The addition of K to soybeans grown in the field had little affect on soybean seed yields. The %K in the leaves was increased somewhat but the increases were not significant at the .05 level of significance. Only %P in the leaves was increased significantly when K_2HPO_4 was added.

Table 1. Amount of nutrients contained in added potassium fertilizers.

Potassium source	Analysis of fertilizer added	Fertilizer Rate in Pounds Per Acre															
		100 K_2O				200 K_2O				400 K_2O				800 K_2O			
		N	P	K	S	N	P	K	S	N	P	K	S	N	P	K	S
	$N - P_2O_5 - K_2O - S$																
KCl	0+0+60+0	0+0+83+0				0+0+166+0				0+0+332+0				0+0+664+0			
KNO_3	13+0+44+0	30+0+83+0				60+0+166+0				90+0+332+0				180+0+664+0			
K_2SO_4	0+0+50+17.6	0+0+83+35				0+0+166+70				0+0+332+140				0+0+664+280			
K_2HPO_4	0+44+48+0	0+34+83+0				0+68+166+0				0+136+332+0				0+272+664+0			
Sul-Po-Mag	0+0+22+22.7	0+0+83+103 +49 Mg				0+0+166+206 +98 Mg				0+0+332+412 +196 Mg				0+0+664+824 +392 Mg			
K_2CO_3	0+0+64+0	0+0+83+0				0+0+166+0				0+0+332+0				0+0+664+0			
KCl+S(K_2SO_4)						0+0+166+70											
KCl+Mg(Sul-Po-Mag)						0+0+166+206 +98 Mg											
KCl+N(KNO_3)						60+0+166+0											
KCl+P(K_2HPO_4)						0+68+166+0											

Table 2. Effect of potassium sources and levels on the nutrient content of field grown Chippewa 64 soybeans. (Emission spectrograph analysis)

Potassium source	K_2O level	P	K	Ca	Sr	Fe	Mg	Zn	Cu	Mo	Mn	B	S
	lb/A	%	%	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%
Check	0	.489	1.97	.704	21.3	182	.317	53.8	11.0	1.01	109	49.6	.339
K_2CO_3	100	.451	2.13	.678	20.0	226	.277	49.1	10.7	1.06	100	43.3	.341
"	200	.462	2.30	.658	19.1	169	.291	52.3	10.5	0.74	96	40.5	.327
"	400	.445	2.26	.655	19.3	175	.262	48.4	11.4	0.82	94	41.5	.305
"	800	.450	2.43	.629	20.1	182	.268	52.3	11.3	0.79	93	40.7	.345
K_2HPO_4	100	.486	2.17	.650	18.4	206	.289	49.2	20.5	0.95	96	42.5	.322
"	200	.520	2.26	.683	17.5	239	.311	51.5	11.7	1.05	101	46.3	.336
"	400	.540	2.25	.647	17.5	249	.276	45.1	7.3	1.04	99	42.0	.342
"	800	.623	2.39	.616	17.0	205	.267	50.7	7.4	0.75	96	40.2	.351
K_2SO_4	100	.483	2.24	.683	19.5	164	.286	55.1	12.7	1.05	113	48.2	.348
"	200	.464	2.29	.714	19.1	180	.306	62.6	12.9	0.83	120	47.5	.347
"	400	.471	2.35	.683	16.8	179	.298	58.4	12.7	0.96	122	47.9	.338
"	800	.437	2.33	.654	16.7	184	.281	59.3	13.1	0.88	117	47.0	.350
$K_2SO_4 \cdot MgSO_4$	100	.479	2.19	.710	21.2	186	.325	57.4	12.1	0.96	116	48.4	.352
"	200	.438	2.27	.633	16.0	166	.301	54.7	12.0	0.97	109	44.7	.362
"	400	.465	2.30	.642	14.7	195	.311	54.2	11.9	1.14	114	49.7	.350
"	800	.466	2.38	.618	13.4	200	.318	59.6	27.5	1.19	130	50.1	.355
KNO_3	100	.484	2.14	.715	21.2	181	.301	48.0	10.6	1.13	105	46.7	.327
"	200	.513	2.24	.724	20.8	185	.319	52.7	10.8	1.03	110	45.2	.330
"	400	.493	2.15	.731	23.5	204	.315	54.8	11.3	0.94	108	45.2	.349
"	800	.486	2.17	.694	21.1	173	.286	48.7	10.2	0.99	100	44.7	.324
KCl	100	.488	2.24	.720	21.5	251	.333	52.0	11.9	1.03	111	47.3	.337
"	200	.498	2.19	.684	20.0	238	.299	49.5	12.6	1.02	98	47.7	.330
"	400	.443	2.16	.621	35.3	234	.265	48.5	10.6	1.08	107	44.4	.336
"	800	.464	2.37	.623	18.0	234	.277	51.9	11.9	0.87	104	42.5	.331
"	1600	.478	2.50	.629	19.0	174	.274	53.9	11.8	0.88	105	46.7	.345
KCl-N	200	.463	2.28	.708	20.4	215	.295	52.4	11.4	1.02	112	46.4	.322
KCl-S	200	.454	2.18	.662	18.2	176	.294	53.5	13.2	0.90	115	42.3	.355
KCl-S-Mg	200	.470	2.14	.673	18.5	220	.285	52.9	11.8	1.24	113	48.4	.345
KCl-P	200	.544	2.30	.735	20.0	212	.312	49.2	8.9	0.93	113	48.8	.347

Table 3. Effect on 1968 soybean seed yield at Elk River, Minnesota when different rates and sources of potassium fertilizer were plowed down in the spring of 1968.

Potassium sources	Pounds K_2O per acre				Means of all rates
	100	200	400	800	
	Bu/acre	Bu/acre	Bu/acre	Bu/acre	
K_2HPO_4	27.4	31.0	26.1	27.1	27.9
K_2SO_4	30.1	28.4	27.8	28.2	28.6
K_2CO_3	33.0	34.3	28.7	30.2	31.5
$K_2SO_4 \cdot MgSO_4$	26.5	32.4	29.5	29.9	29.6
KNO_3	29.3	28.4	30.4	30.4	29.6
KCl	32.1	30.9	30.3	30.7	31.0
Average of all sources	29.7	30.9	28.8	29.4	29.7

Check plot average (5 replicates) 29.6 bu/acre

Coefficient of variation: 12.6

Analysis of Variance for Data of Table 3

Source of variation	Degrees of freedom	Mean square	F value
Replicates (R)	3	88.95	2.13
K sources (S)	5	30.69	0.73
Error (a)	15	41.77	
K rates (Ra)	3	18.26	1.44
Ra x S	15	11.71	0.92
Error (6)	54	12.70	

Coefficient of variability (a): 21.8

(b): 12.0%

Table 4. Effect on 1968 soybean seed yield at Elk River, Minnesota when different sources of potassium fertilizers at the rate of 200 pounds K_2O per acre were plowed down in the spring of 1968.

Potassium sources	Seed yield
	Bu/acre
K_2HPO_4	27.4
K_2SO_4	30.1
K_2CO_3	33.0
$K_2SO_4 \cdot MgSO_4$	26.5
KNO_3	29.3
KCl	32.1
KCl + P (equivalent to K_2HPO_4)	26.6
KCl + S (" " K_2SO_4)	31.1
KCl + N (" " KNO_3)	30.0
KCl + S + Mg (equivalent to $K_2SO_4 \cdot MgSO_4$)	27.8
Average of all sources	29.4
Check plot average	29.6
Coefficient of variation: 10.6%	

Analysis of Variance for Data of Table 4

Source of variation	Degrees of freedom	Mean square	F value
Replicates	3	28.24	1.34
K sources	9	20.74	0.98
Error	27	21.15	

Soybean Fertilizer Placement Study

G. E. Ham, S. D. Evans, R. D. Frazier, and W. W. Nelson

Fertilizer treatments consisting of banded starter, starter in contact with the seed and a combination of banded and seed placement were superimposed on broadcast fertilizer treatments at Lamberton, Morris, Waseca, and Rosemount. The treatments and rates are shown in Tables 1, 2, 3, and 4. The analysis of variance is shown in Tables 5, 6, 7 and 8.

Seed yields of all varieties were increased by broadcast fertilizer applications at Lamberton and Morris where soil test levels of P and K were low. Foliar analyses indicated that the response was due largely to P. At Waseca and Rosemount, seed yields were not increased by fertilizer applications when the soil test levels of P and K were medium or high.

These studies showed that seed placement (or pop-up) fertilizer placement can be used with soybeans without significantly decreasing seed yield or stand. However, even with soils testing low in P and K, broadcast applications of fertilizer had a more marked effect on soybean seed yield. Under conditions of low P and K soil test levels, seed placement or band placements may be utilized if small amounts of fertilizer are used. If maximum yields are a goal, larger amounts of broadcast fertilizer should be plowed down, preferably, or disced into the soil before planting.

Table 1. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Soybeans Grown at Morris, Minnesota in 1968.

Starter Fertilizer	Variety								Average of all varieties over no broadcast and broadcast
	Chippewa '64		Merit		Traverse		All varieties		
	No broadcast	Broadcast	No broadcast	Broadcast	No broadcast	broadcast	No broadcast	broadcast	broadcast
	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre
Check	21.4	22.9	18.3	21.0	18.1	21.2	19.3	21.7	20.5
Band (2x2)	19.[illegible]	26.2	19.8	23.6	21.2	22.1	20.3	24.0	22.1
Seed placement	20.3	24.7	18.5	23.4	20.7	22.6	19.8	23.5	21.7
Band & seed placement	21.[illegible]	25.1	19.5	24.6	20.7	22.3	20.7	24.0	22.3
Average of all starter fertilizer	20.9	24.7	19.0	23.2	20.2	22.0	20.0	23.3	21.7

Coefficient of variation: 8.[illegible]%

Fertilizer rates:

Band	10+20+10	
Seed placement	4+8+4	
Broadcast	0+60+30	(broadcast to surface in spring 1968)

Table 2. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Soybeans Grown at Lamberton, Minnesota in 1968.

Starter Fertilizer	Variety								Average of all varieties over no broadcast and broadcast
	Chippewa '64		Corsoy		Hark		All varieties		
	No broadcast bu/acre	Broadcast bu/acre	No broadcast bu/acre	Broadcast bu/acre	No broadcast bu/acre	Broadcast bu/acre	No broadcast bu/acre	Broadcast bu/acre	bu/acre
Check	28.0	32.4	31.1	36.5	28.7	34.0	29.2	34.3	31.8
Band (2x2)	28.1	31.8	30.2	35.5	30.6	33.0	29.6	33.5	31.5
Seed placement	28.6	33.4	33.6	34.8	32.5	33.6	31.5	33.9	32.7
Band & seed placement	31.4	31.4	32.8	33.9	31.4	31.7	31.9	32.3	32.1
Average of all starter fertilizer	29.0	32.3	31.9	35.2	30.8	33.1	30.6	33.5	32.0

Coefficient of variation: 8.7%

Fertilizer rates: Band 10+20+10
Seed placement 4+8+4
Broadcast 0+60+30 (plowed down in fall 1967)

Table 3. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Soybeans Grown at Waseca, Minnesota in 1968.

Starter Fertilizer	Variety								Average of all varieties over no broadcast and broadcast
	Chippewa '64		Corsoy		Hark		All varieties		
	No broadcast	Broadcast	No broadcast	Broadcast	No broadcast	Broadcast	No broadcast	Broadcast	
	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre
Check	36.5	35.4	40.6	39.6	42.5	41.3	39.9	38.8	39.3
Band (2x2)	37.9	34.5	43.1	38.4	39.6	41.3	40.2	38.0	39.1
Seed placement	35.4	33.5	40.8	38.3	42.2	40.0	39.4	37.3	38.3
Band & seed placement	37.2	33.7	39.5	41.1	36.3	37.0	37.7	37.3	37.5
Average of all starter fertilizer	36.8	34.3	41.0	39.4	40.2	39.9	39.3	37.8	38.5

Coefficient of variation: 5.0%

Fertilizer rates: Band 16+40+53
Seed placement 4+8+12
Broadcast 0+100+150 (broadcast to surface in spring 1968)

Table 4. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Chippewa 64 Soybeans Grown at Rosemount, Minnesota in 1968.

Starter Fertilizer	Fertilizer rate lb/acre N-P-K	No broadcast bu/acre	Broadcast[a] bu/acre	Average of no broadcast and broadcast bu/acre
Check	0-0-0	33.4	32.2	32.8
Seed placement	4+8+4	35.9	31.1	33.5
Band 2" x 2"	10+20+10	35.4	32.2	33.8
Band 3" below seed	10+20+10	34.3	33.1	33.7
Band 2" x 2" + seed placement	10+20+10 4+8+4	34.2	30.6	32.4
Band 3" below seed + seed placement	10+20+10 4+8+4	36.1	33.2	34.7
Band 2" x 2"	(0+40+40)	32.5	31.3	31.9
Average of all starter fertilizer		34.5	32.0	

Coefficient of variation:

[a]Broadcast consisted of 0+40+40 applied in spring and disced in about 2 weeks before planting.

Table 5. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Morris, Minnesota in 1968.

Source of variation	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	22.77	1.56 NS
Varieties (V)	2	30.21	2.08 NS
R x V (error a)	6	9.83	
Broadcast (B)	1	259.87	17.86 **
V x B	2	11.76	0.81 NS
R x V x B (error b)	9	14.55	
Starter (S)	3	16.10	5.32 **
V x S	6	21.69	0.72 NS
B x S	3	1.36	0.45 NS
V x B x S	6	4.93	1.63 NS
R x V x B x S (error c)	54	3.02	

Table 6. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Lamberton, Minnesota in 1968.

Source of varieties	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	5.57	0.57 NS
Varieties (V)	2	67.93	6.99 *
R x V (error a)	6	9.71	
Broadcast (B)	1	203.53	43.50 **
V x B	2	2.49	0.53 NS
R x V x B (error b)	9	4.68	
Starter (S)	3	6.59	2.38 NS
V x S	6	2.34	0.84 NS
B x S	3	23.74	8.57 **
V x B x S	6	3.84	1.39 NS
R x V x B x S (error c)	54	2.77	

Table 7. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Waseca, Minnesota in 1968.

Source of variation	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	23.64	1.55 NS
Varieties (V)	2	220.53	1.45 NS
R x V (error a)	6	15.21	
Broadcast (B)	1	49.16	2.32 NS
V x B	2	9.79	0.46 NS
R x V x B (error b)	9	21.20	
Starter (S)	3	17.02	4.61 *
V x S	6	16.53	4.48 *
B x S	3	4.31	1.17 NS
V x B x S	6	9.28	2.52 *
R x V x B x S (error c)	54	3.69	

Table 8. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Rosemount, Minnesota in 1968.

Sources of variation	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	6.51	1.42 NS
Broadcast (B)	1	20.64	4.52 **
B x R (error a)	3	4.57	
Starter fertilizer (S)	6	7.20	1.27 NS
B x S	6	15.84	2.79 *
B x S x R (error b)	36	5.67	

Effect of Winter Versus Spring Fertilization on 1968 Corn Yield

J. M. MacGregor, W. W. Nelson and P. M. Burson

Since there is considerable interest in broadcasting commercial fertilizer for corn during the winter months and the comparative yield with similar applications made a few months later in the spring, a field experiment was designed to determine any marked fertility differences which might occur on three fields, two being on the Soils Unit of the Experiment Station, Rosemount, one located on Ostrander silt loam having a 5% slope (fall plowed) and the second on Judson silt loam with a 1% slope (spring plowed). A third field was located on an essentially level Webster silty clay loam on the Southwest Experiment Station, Lamberton. Four replications of randomized paired time of fertilization plots were measured out, each being approximately 50 feet long and 20 feet wide. The Rosemount treatments included N, P_2O_5 and K_2O at 40 pounds of each per acre, but the K_2O was omitted at Lamberton.

The winter of 1967-68 was characterized by little snowfall, snow depth being approximately 6 inches when the winter fertilization treatments were broadcast on January 17 and 18, 1968. The comparable spring treatments were broadcast at Lamberton on April 2nd and on the two fields at Rosemount on April 26th. Suitable corn hybrids were planted early in May to obtain a population of approximately 20,000 plants per acre.

Precipitation during the 1968 growing season at Rosemount was higher than normal, with the month of June being extremely wet. Rainfall at Lamberton was limited, until late July with an extremely wet late summer and fall. The corn was harvested in late October and ear corn yields are shown in the following three tables.

Table 1: The Yield of 1968 Ear Corn at Rosemount on Ostrander Silt Loam When Fertilized in Mid-January or in Late April

Treatment (lbs/A)	Time fertilizer broadcast	Bushels ear corn/A @ 15.5% moisture I	II	III	IV	Average	Sig.
None		100.1	110.6	116.9	107.7	108.8	a
40+0+0	January 18	109.2	124.6	103.9	113.5	112.8	a
40+0+0	April 26	112.1	99.1	119.8	127.9	114.7	a
0+40+0	January 18	95.2	110.1	108.7	125.5	109.9	a
0+40+0	April 26	112.6	111.6	117.8	119.3	115.3	a
0+40+40	January 18	97.2	115.9	109.7	121.2	111.0	a
0+40+40	April 26	109.2	113.5	127.5	111.6	115.5	a
40+40+40	January 18	116.4	106.8	109.7	117.8	112.7	a
40+40+40	April 26	110.6	118.8	129.4	105.3	116.0	a

It is evident that none of the fertilizer treatments significantly increased corn yields and this renders time of application meaningless.

Table 2: The Yield of 1968 Ear Corn at Rosemount on Judson Silt Loam When Fertilized in Mid-January or in Late April

Treatment (lbs/A)	Time fertilizer broadcast	Bushels ear corn/A @ 15.5% moisture I	II	II	IV	Average	Sig.
None		110.6	124.6	135.6	141.9	128.2	a
40+0+0	January 19	123.6	89.9	146.7	160.7	130.2	a
40+0+0	April 26	115.9	129.9	124.6	147.7	129.5	a
0+40+0	January 19	148.2	139.5	115.4	118.8	130.5	a
0+40+0	April 26	137.6	115.9	122.7	151.0	131.8	a
0+40+40	January 19	148.1	136.1	114.5	151.0	137.4	a
0+40+40	April 26	131.8	147.2	142.4	124.1	136.4	a
40+40+40	January 19	133.7	144.8	132.3	133.2	136.0	a
40+40+40	April 26	140.0	139.0	157.3	137.1	143.4	a

Again it is obvious that none of the fertilizer treatments significantly increased 1968 corn yield.

Table 3: The Yield of 1968 Ear Corn at Lamberton on a Webster Silty Clay Loam When Fertilized in Mid-January or in Early April

Treatment (lbs/A)	Time fertilizer broadcast	Bushels ear corn?A @ 15.5% moisture I	II	III	IV	Average	Sig.
None		105.1	104.1	99.1	67.0	93.8	a
40+0+0	January 17	110.2	109.1	127.8	94.8	110.5	b
40+0+0	April 2	114.4	117.9	113.1	121.5	116.7	b
0+40+0	January 17	97.1	104.3	102.8	102.0	101.6	ab
0+40+0	April 2	105.0	93.2	103.1	71.6	93.2	a
40+40+0	January 17	110.2	118.0	118.1	112.4	114.7	b
40+40+0	April 2	112.0	122.6	104.8	106.4	111.5	b

The N (40+0+0) and the NP (40+40+0) resulted in significant increases in corn yield, with no significant difference between the different times of fertilizer application.

It is unfortunate that the two experimental corn fields at Rosemount failed to significantly respond to any of the four fertilizer treatments since it precludes the possibility of drawing any conclusions at these locations.

Summary

Many factors affect the relative efficiency of fertilizer applied during the winter,--such as steepness and length of slopes; soil type; snow depth; plowed or unplowed land; type, amount, and forms of nutrient elements applied; and weather during the late winter and early spring. In years of limited snow cover there is little or no mechanical problem in winter fertilization, but a heavy snow cover may seriously limit such an operation.

The limited results obtained in 1968 are promising, but are obviously insufficient to generalize on the relative merits of winter fertilization in comparison to similar treatments applied just before spring planting. This investigation is being repeated on the same experimental areas to provide a more definite answer on the feasibility of winter fertilization in Minnesota.

Sulfur Investigations on Soils and Plants in Minnesota

A. C. Caldwell, E. C. Seim and G. W. Rehm

Studies on S in soils and crops were continued in the field, greenhouse and laboratory in 1968. New investigations included NXS interactions, evaluation of a NH_4NO_3-K_2SO_4 fertilizer and the absorption of SO_2 by soils.

Sulfur in the air and in precipitation

The measurement of SO_2 in the atmosphere and precipitation was terminated in September 1968. Over 5 years of data on the possible atmospheric contribution to the S economy of 4 areas in Minnesota are now available. For the 5 year period, S in the atmosphere (H_2S and SO_2 absorbed by a PbO_2 surface) ranged from 5.8 lb/A of exposed surface at Park Rapids, Minnesota to 36.4 lb/A at St. Paul, Minnesota (two sampling sites about 200 miles apart). Absorption in an industrial area like St. Paul increased in the winter months to 14 times the Park Rapids values and dropped in the summer months to 3 times the Park Rapids values. Sulfur in precipitation ranged from an average of 3.6 lb S/A/yr. at Park Rapids to 14.7 lb S/A/yr. at St. Paul. If it is assumed that on the average soils will absorb only 22% as much S from the air as the PbO_2 surface (Alway, 1937), the average annual contribution of S to the soil from atmospheric sources (precipitation and direct absorption) was 4.9 lb S/A/yr. at Park Rapids and 22.7 lb S/Ayr. at St. Paul.

N:S ratios in alfalfa, red clover, corn and timothy

N:S ratios in first cutting red clover ranged from a 17:1 when the clover and the preceding small grain crop had received 50 lb S/A as gypsum to 22.8:1 when no S was applied. A N:S ratio of 17:1 is considered normal for rapidly growing clover.

An analysis of the second cutting of an alfalfa crop for N indicated there was no significant effect of S on the N content of established 5 year old alfalfa. N:S ratios, however, ranged from 16.9 to 1 where no S was applied to 7.4:1 when 100 lb S/A was applied annually.

N:S ratios in corn ranged from 20:1 in the 6th leaf of corn which received no S to 18.4:1 when 10 lb S/A as Na_2SO_4 was applied. N:S ratios in the corn grain were much higher, averaging 29:1 when no S was applied and 23:1 when the corn received 10 lb S/A as Na_2SO_4.

N:S ratios of timothy hay grown on organic and mineral soils in northern Minnesota ranged from 9.5:1 to 17.8:1.

Sulfate-sulfur in small grain and alfalfa

Small grain and alfalfa grown on the experimental field at Park Rapids were analyzed for SO_4-S. Ten lb S/A significantly increased SO_4-S in the whole plant at the rootstage from 0.020 to 0.034% in oats; from 0.019 to 0.028% in barley; and from 0.007 to 0.041% in wheat. In alfalfa, SO_4-S ranged from 0.004% when no S was applied, to 0.168% when 1000 lb S/A as gypsum had been applied 4 years previously.

The effect of new S assemblages on alfalfa

A study of S assemblages was initiated in 1967 involving the effect of powdered elemental S, prilled elemental S, 90% elemental S plus 10% bentonite, and 80% elemental S plus 10% bentonite plus 10% Na_2SO applied at the rate of 50 lb S/A. All of the treatments increased yields of alfalfa, although that treated with the prilled S was not significantly different from the check yields at the .05 probability level. Powdered S and the bentonite mixtures significantly increased alfalfa yields, but there was no significant difference between these materials. Yields ranged from 1.46 tons/A on the check plots to over 3 tons/A for the effective S applications

Evaluation of a NH_4NO_3-K_2SO_4 fertilizer

During the summer of 1968 field experiments were conducted to evaluate the effectiveness for corn of an IMC fertilizer product consisting of 75% NH_4NO_3 and 25% K_2SO_4. In this study the effectiveness of the new product was compared to equal amounts of N, P, and K applied as S-free materials. The IMC material did not significantly influence the yield, moisture content or shelling percentage of the corn. Corn receiving the IMC fertilizer averaged 130.9 bu/A, the S-free fertilized corn 118.7 bu/A, but this difference was not significant at the 5% probability level. There was a significant difference in the S content of the corn plants at the 5-8 inch, and 24 inch growth stages and in the 6th leaf at tasseling. Sulfur content of the tissue decreased with increasing maturity. The S containing fertilizer significantly decreased the N, P and Mo content of the 6th leaf at tasseling, but the reduced levels did not appear to be critical. N:S ratios ranged from 15:1 in the young corn plants receiving the S-free fertilizer to 11.5:1 in the 6th leaf tissue of the plants fertilized with the IMC material. N:S ratios decreased with age of plants for both S-free and S containing fertilizer treatments.

In a greenhouse experiment the growth of barley was significantly increased by N-K-S treatments at early stages of growth. In general, withholding N from the fertilizer produced a great reduction of growth and a reduction in the content and uptake of N, K, S and P. Withholding S or K from the fertilizer treatment resulted in reduction in the content and uptake of these elements respectively.

Effect of source of sulfur on yield and nutrient content of corn in a K rate study

There was no significant difference in the yield or in the nutrient content of corn to which varying levels of K were applied as K_2SO_4 or as KCl plus Na_2SO_4. Increasing rates of K application from 100 to 400 lb K/A increased the yield of corn from 111 to 132 bu/A, but these differences were not significant at the 5% confidence level.

N x S interactions

The effect of the NH_4^+ and NO_3^- ions on $SO_4^=$ uptake by corn was studied in the field as well as in the greenhouse and growth chamber. Uptake of the $SO_4^=$ ion was traced with 35-S and in some experiments the uptake of the N source was followed with 15-N.

When both the N and S sources were applied as a starter to corn in the field, the uptake of SO_4 was significantly increased when NH_4 rather than NO_3 was used as the N source. This effect was observed in young plants up to 7 weeks old. More N was absorbed by the corn when NH_4 rather than NO_3 was the N source. The uptake of fertilizer SO_4 was significantly correlated to the uptake of N from the starter. The N source, however, had no effect on the total S, SO_4-S or total N content of corn tissue. The N source also had no effect on corn yield.

Zinc Trials on Sugarbeets - 1968
Northwest Experiment Station, Crookston, Minnesota

Olaf C. Soine, Soil Scientist

Some interest has developed concerning the effect of zinc on sugarbeets on the highly calcareous soils of Western Minnesota, especially on soils where high rates of phosphate fertilizers are being used. Zinc deficiencies in corn have been observed in this part of the state and the application of this element has given increases of 10-20 bushels of corn per acre. Although no deficiencies have been observed in sugarbeets, it seemed worth while to set up a zinc experiment on this crop.

Two rates of zinc sulfate (36% zinc) were broadcast prior to planting and the same rates were applied in a band after planting. Samples of the leaf blade, petiole and roots were taken on July 3 and September 19 for zinc analysis. The beets were harvested on September 26 for yield, and analyzed for sucrose, purity, sodium, potassium and amino nitrogen.

Table 1 gives the field and laboratory data for the roots at harvest time.

Table 1. Effect of zinc on the yield, percent sucrose, purity and content of sodium, potassium, and amino N., 1968.

Treatment	Yield	Sucrose	Purity	Sodium	Potassium	Amino N.
	T./A.	%	Index			
Check	16.35	12.85	904	666	1595	528
Broad. 30 lb.	18.02	13.25	877	634	1673	523
Broad. 120 lb.	18.56	13.40	824	617	1554	498
Band 30 lb.	18.41	13.18	799	514	1625	464
Band 120 lb.	18.32	13.55	794	580	1681	451
L.S.D.	2.05	0.60	109	N.S.	N.S.	N.S.

The yield of beets varied from 16.35 to 18.56 tons per acre for the check and 120 lb. broadcast treatments, respectively. There were no significant differences in yield between the zinc treatments.

The sucrose content was increased by the zinc treatments when compared to the check, but only the 120 lb. band treatment was significantly different from all the others.

The purity index gives some information about the processing of the beets and the higher the index the more difficult it is to extract all the sugar. The highest index in Table 1 is for the check plot and the zinc treatments were lower but only the 120 lb. band treatment was significant. There were no significant differences between the treatments for potassium and amino nitrogen.

The zinc content of the blades, petioles and roots are given in Table 2 for the 2 sampling dates. The zinc content for the July 3

Table 2. Zinc content of leaf blade, petiole and roots of sugarbeets, 1968.

Treatment	Sampled July 3			Sampled Sept. 19		
	Leaf	Petiole	Root	Leaf	Petiole	Root
	P.P.M.			P.P.M.		
Check	364	131	124	119	8.6	35
Broad. 30 lb.	325	114	90	82	10.8	54
Broad. 120 lb.	362	110	106	205	10.8	48
Band 30 lb.	2.51	87	88	86	10.8	67
Band 120 lb.	300	113	98	291	9.4	63

sampling is very high and also erratic when compared to the sampling on September 19. The above normal rainfall in June and July may have had some effect on the zinc uptake, while the latter sampling gives the zinc content of a more mature beet. This is only one year's data and needs to be substantiated with more field trials at other locations.

The source of zinc used in this trial was zinc sulfate which contains 36% zinc and 12.5% sulfur. The 2 rates, 30 and 120 lbs. per acre, added 3.75 and 15 lbs., respectively, of sulfur to the soil. The question has been asked about the addition of sulfur to the soils in this area and it seemed desirable to run sulfur determinations of the leaf blade, petiole, and roots. The results are given in Table 3.

Table 3. Sulfur content of leaf blade, petiole, and roots of sugarbeets, sampled September 19, 1968.

Treatment	Rate lbs./acre	Percent sulfur Leaf	Petiole	Root
Check	0	0.71	0.13	0.06
Broadcast	30	0.91	0.13	0.06
Broadcast	120	0.88	0.14	0.07
Band	30	0.79	0.14	0.06
Band	120	0.78	0.14	0.06
L.S.D. 5%		N.S.	N.S.	N.S.

There was a slight increase in the sulfur content of the leaf blades when compared to the check plot but the increases were not significant. There were no significant increases in the sulfur content of the petioles and roots.

The soils of this area contain substantial amounts of sulfur in the form of gypsum ($CaSO_4$) and other soil minerals and from the decay of organic matter. The addition of sulfur is not recommended for crop production in this area.

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Effects of the Application of Iron and Zinc Chelates to Flax at Crookston, Minnesota in 1968

James R. Lofgren - Agronomist - N. W. School and Experiment Station

Yellowing of flax has occurred frequently in the Red River Valley. This yellowing has been noted to be associated with cooler temperatures and higher moisture conditions. The condition has been noted on numerous horticultural crops and ornamentals. The yellowing was believed to be an iron deficiency or inavailability of iron to plants associated with cool temperatures. To determine if iron would correct the symptoms on flax and to determine if the symptoms were due to an iron or zinc deficiency the following experiment was performed in 1968.

Methods and Materials

Zinc and iron chelate compounds were provided by Giegy Chemical Co. Four cultivars 'Nored,' 'Bolley,' 'B5128' and 'Summit' were selected so as to span the general range of maturity for flax. Two rates of each chelate were used: ten and five pounds per acre for iron and five and two and one-half pounds per acre for zinc. Plots were ten feet long and consisted of four rows spaced one foot apart. The design of the experiment was a split-plot with treatments as whole plots and cultivars as sub-plots. Four replications were grown on Bearden soil. The plots were seeded on May 13 and the treatments applied on June 5 when the plants were 3-4 inches tall. All plots were harvested on October 10 (killing frost occurred on October 4).